

No. IX.—DESCRIPTION OF THE EXPEDITION (*continued from p. 55*).

By J. STANLEY GARDINER, *M.A., F.L.S., Fellow of Gonville and Caius College and Demonstrator of Animal Morphology in the University of Cambridge, and*  
C. FORSTER COOPER, *M.A., Trinity College, Cambridge.*

(Plates 14–18 and Text-figures 25–46.)

Read 20th June, 1907.

CONTENTS.

	Page
III.—Part II. Mauritius to Seychelles .....	111
Appendix A. List of the Dredging-Stations .....	163
Appendix B. List of the Stations for Plankton.....	169

Part II.—*Mauritius to Seychelles.*

OF the three Mascarene Islands, so called after the Portuguese navigator Dom Pedro Mascarenhas who discovered them in 1505, Mauritius is the most important. It is, however, the intermediate in size, being 34 miles in a north and south direction by 22 broad, and covering an area of 713 square miles, while Réunion or Bourbon is 39 by 28 miles and Rodriguez 10 by 4 miles. All three lie almost on the same line of latitude (20° S.), Réunion 370 miles to the east of Madagascar, Mauritius 100 miles further east, and Rodriguez another 320 miles still further east. All three are of volcanic formation, but Réunion alone shows recent activity. It is a mass of peaks and cones, the whole centre of the island being over 5000 feet in height, culminating in the Piton des Neiges, 10,069 feet. Fournaise or Grand Brûle, 8613 feet, is still an active crater, frequently throwing up small quantities of cinder and ash, though there has been no lava-flow since 1860. Limestone is said to occur in several places, but whether at any considerable height above the sea is uncertain. Rodriguez with upraised coral at each end has a basaltic ridge, culminating in the centre of the island in Mount Limon, 1300 feet high. It is noted for its beautiful basaltic pillars and for its limestone caverns, which were explored in 1874 by the Transit of Venus Expedition for the bones of the Solitaire and of Land-Tortoises\*.

\* Trans. Roy. Soc. vol. 168, 1879, p. 290.

“On the south-west, the central volcanic ridge gradually descends, the ravines become less deep, and the ground spreads out into a large coralline limestone plain. The demarcation betwixt the limestone and the volcanic rock is very sharp, but isolated patches of limestone are met with on the surface of the volcanic region, in the vicinity of the main mass. The caves from which the bones of the Solitaire and other extinct birds have been obtained occur in

Our first duty on arrival at Mauritius was the packing of our collections from the Chagos Archipelago for transit home and the unpacking of fresh supplies of bottles and other gear. These had been sent from England before we left, and stored for us by M. de Vergé, the Storekeeper-General, in his department. We also ordered frames to be cast for accumulators to relieve the strain on the dredging-wire, as well as some new dredges and other gear to replace such as had been lost. H.E. the Governor, Sir Cavendish Boyle, K.C.M.G., took a personal interest in our work and, besides inviting us to visit Réduit, aided us very greatly in our subsequent tour along the east coast of the island, as did also Mr. D. C. Cameron, then Acting Colonial Secretary. We are also materially indebted to Mr. E. C. Fraser, Mr. Davidson, and M. Couve for their kind hospitality and for assistance in many ways.

The island, when first discovered by the Portuguese, was called Da Cerno, and remained nominally in their possession until 1595. In that year it was annexed by a Dutch squadron and renamed Mauritius, after Count Maurice of Nassau, their Stadtholder, Grand Port to the south-east being termed Warwickhavn, after the Dutch Admiral in command. In 1638 the Dutch established a definite station at Grand Port, which existed till 1712, when the island was finally abandoned. During this period the forests along the coast were largely cleared by slaves introduced from Madagascar, Grand Port becoming a regular port of call for refreshing their ships' crews. The land was planted with Indian plants, sugar-cane, tobacco, vegetables, and fruits. Of animals, monkeys, deer, goats, and pigs were introduced, their presence probably doing more to kill off the Dodo than human agency.

The French East India Company next took possession of the island in 1721, finally in 1767 ceding it to France. During this period a large number of French families settled in the island, and from them the aristocracy of the place mostly trace their descent. The island attained to a considerable degree of prosperity during this period, but appears to have been generally misgoverned. Their one great governor was Mahé de la Bourdonnais, 1735-46, who annexed the Seychelles. He transferred the seat of government to Port Louis on the leeward \* side, where he started ship-building. He also fortified

this limestone plain. Some of them extend for a great distance through the rock, and are rich in stalagmites and stalactites.

"On the southern shore between Rivière Palmiste and Rivière Poursuite indications of raised beaches are seen, reaching about 20 feet above the sea-level.

"The existence of these masses of coralline limestone indicates clearly a former lower level of the island, and the evidence of raised beaches confirms this. But a consideration of the coral-reefs points as clearly to a time when the island stood at a higher level. . . . An older reef exists, now quite submerged in some places to a depth of over 90 fathoms. . . . We have thus proofs of great and intermittent oscillations of the level of the island."

The evidence scarcely warrants the assumption of an older reef off Rodriguez down to 90 fathoms in depth. Probably the shoal water off the island is similar to that off the Seychelles or that forming the Nazareth, Amirante, and other partially or completely submerged banks in the western half of the Indian Ocean. Further, we cannot accept any deductions as to change of level based on still-growing reefs covered with coralline life.

\* The prevailing wind is from the east or south-east.

the place, established large workshops, built roads, cleared the forests, divided up the island, and generally developed its agricultural resources. Like so many of the English empire-builders in the East, he ended his career after his return in persecution and poverty, and his policy was reversed in every particular. Under the French Government the island flourished again, and at the end of the century had a population of about 65,000. It still continued to progress in the first years of the nineteenth century, but during the Napoleonic wars became a favourite station for privateers from which to prey on English commerce, as well as a dockyard for the repair of French vessels. Accordingly, the British Government determined on an expedition for its reduction, and it capitulated in 1810, its possession by England being confirmed finally by the Treaty of Paris in 1814. It suffices further merely to mention that on the emancipation of the slaves in 1834 Indian labour was introduced for the estates, and that the present population of the island is upwards of 390,000. The language and laws are by agreement French until 1910.

Before the opening of the Suez Canal, Mauritius was an island of great importance to this country as a calling-station for ships and as a fortified base on the trade-routes to India and China. Partly owing to the canal and partly to changed conditions of warfare it now has even a less value than the Seychelles. Yet it has always been well-known and full of interest to scientific men. With Rodriguez it was the home of the Dodo and Solitaire, whose deaths have been the theme of many pathetic complaints. In Bourbon too there was a third bird of larger size, which had also lost its power of flight. There is now no question of any land-connection being requisite to explain the presence of these birds in the Mascarenes, their ancestors having been birds of powerful flight; but some students of geographical distribution require a land connection at least up to the Middle Secondary period to explain the existence of land-tortoises, of certain molluscs, and of many plants. In their main characteristics the indigenous land flora and fauna of the three islands are quite peculiar. Their variety of life is relatively large, larger at any rate than would be expected on purely oceanic islands. This is the more remarkable if it owes its existence to marine transport, because the islands are bathed mainly by currents setting west or north-west, so that only exceptionally could animals or plants arrive from Madagascar. The shore-organisms do not differ materially from those of coral-islands in the vicinity, the coast-lands being rich in lime. The island-forms, however, living on the volcanic soil are nearly all of peculiar species and many of peculiar genera.

When first discovered, all the Mascarene Islands were uninhabited, but now Mauritius has a dense population. It is scarcely conceivable that any part of its forests has not been destroyed sometime or other by axe or fire, and in addition introduced animals and plants have largely aided in the destruction of its indigenous life. In such circumstances any proper study of its organisms in relation to their environment would seem useless, but we thought it desirable to see for ourselves, as far as possible, the general structure and condition of the island. Besides excursions into the Pouce Mountains and along the coast from Port Louis, we explored the central tableland up to and around Curepipe (1806 feet), and one of us (Gardiner) made an excursion into the jungle towards the

**Mauritius (after the Admiralty chart). A 1-8, dredgings of H.M.S. Sealark.**



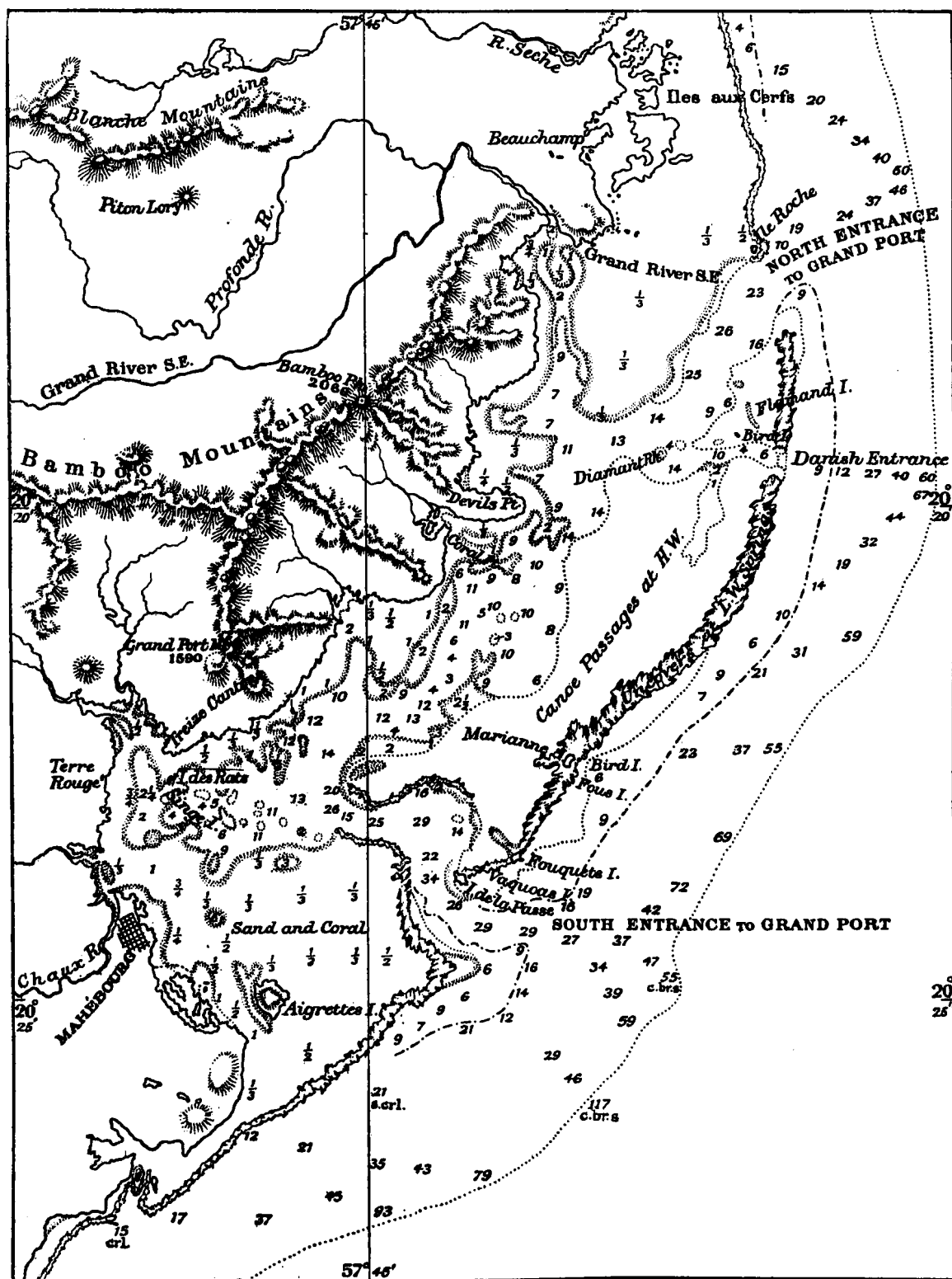
Tamarin Range to the south-west. We then went down to Mahébourg by Grand Port in the south-east and examined its neighbourhood, particularly the reefs and smaller islands in its vicinity. We passed over the reefs in front of the Bamboo Mountains to Grand River S.E., subsequently returning round the north of the island and visiting Iles aux Cerfs, Trou d'Eau Douce, Flacq, and the neighbourhood of Ile d'Ambre, and during our return Pamplemousses, where we saw the beautiful gardens of introduced plants.

The island of Mauritius at the present day gives very little indication of the original scheme of the eruptions to which it owes its formation. It may be said to consist of three ranges of mountains, each with peaks of over 2000 feet—the Pouce behind Port Louis, the Tamarin Mountains to the south-west, and the Bamboo Mountains to the east. These ranges together with their enclosed land form a triangle, which includes three-quarters of the island as a plateau at least 1000 feet above the sea. The remaining land to the north and to the north-east slopes gently into a flat with isolated peaks, such as the Butte aux Papayers, on which the Semaphore Station is situated. While the 100-fathom line elsewhere closely follows the shore at a distance of one or two miles, it runs out to the north-north-east to a distance of 15 miles from the shore, forming a large shallow bank on which are situated a number of islands, Round, Serpent, Flat, Gabriel, and Gunner's Quoin, of which the first-named is 1055 feet high.

Of the mountains, the Pouce, Bamboo, and a small range to the south-west, of which Rempart, 2532 feet, is the highest point, appeared to us to belong to the same period; while the Tamarin Range with its Savane and Rivière Noire sections seemed to have been of a more recent formation tacked on to the south-west and masking the otherwise fairly regular contour of the central mass. The Rempart Range alone appeared to be of doubtful formation, possibly an independent eruption; but to the south of Mare Vacoa the rock of the Tamarin Mountains appeared to overlies that of the central mass. The contour-line of high hills is less marked to the north-east, but there is a clear series of lower hills with steep slopes between Grand River S.E. and Nouvelle Découverte. The Pouce and Bamboo Mountains are both remarkable for the steep buttresses of their outer sides, between two of which the town of Port Louis is situated.

The central plateau is much broken up by supplementary cones and craters, so that its whole structure is masked. Of these the Trou aux Cerfs near Curepipe is well marked, but many more appear to exist. The rainfall here is evidently heavy and the ground is much channelled by streams, of which Grand River (opening near Port Louis) and Grand River S.E. are the most important. Their gorges and cañons, usually 100 feet at least in depth with a width of 200 to 1000 feet, break up the country through which they pass to a remarkable degree. Those on either side of Réduit are particularly noticeable for their depth, but even the smallest stream has a considerable cutting. In these streams waterfalls abound, and, as their sides are clothed with dense vegetation, they often present scenes of remarkable beauty. The hills on the plateau are generally weathered smooth by the rains, though Pouce and Bamboo present a series of jagged peaks of most fantastic shapes. Pieter Both Mountain, behind Port Louis, has a head joined by a narrow neck to its body, and many others have columns and overhanging cliffs, which could scarcely have continued to exist in a land much affected by seismic disturbances.

Fig. 26.

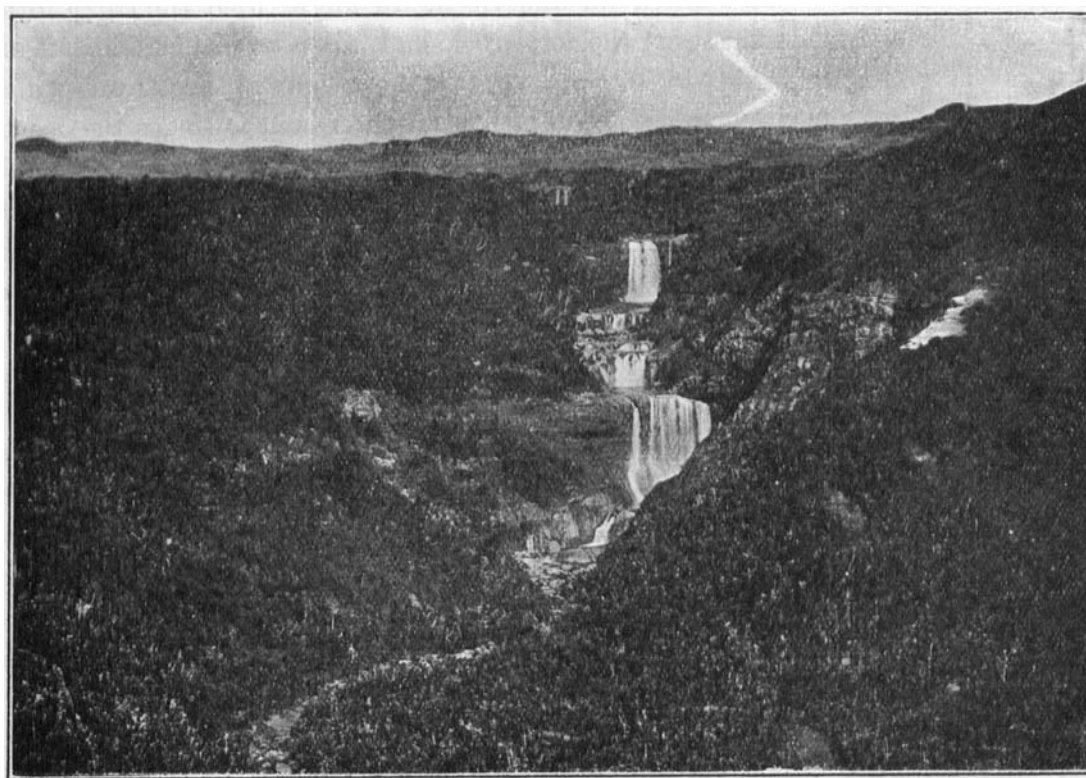


Grand Port, Mauritius (after the Admiralty chart).

The Tamarin Mountains form a crowded series of peaks and valleys, while the area between their eastern limit and the Bamboos forms a fertile plain about 400 feet above the sea-level known as Grande Savane. The high land, wherever it approaches the sea, tends to end in sea-formed cliffs, but in most places there is now a flat of low land of varying width, which separates them from the waves. This in places is overlaid by their débris, and is formed partly by an upwashing from the fringing reefs and partly by an upheaval, of which we found evidence at Grand Port.

The coasts of the island are everywhere fringed by coral-formations, which vary from isolated masses of coral and Lithothamnia, as off some parts of the south and west coasts, to the broad barrier-reefs which form Grand Port. Generally to the south and west

Fig. 27.



Mauritius, Cañon and Falls near Vacoa.

there is a well-defined fringing-flat a few hundred yards broad, while to the east all stages are found up to a barrier-reef two to three miles from the beach. Where the flat is closely fringing, it is broken opposite every freshwater stream from the island, this resulting in the formation of many small ports. To the east, however, where it is broader, it is relatively less broken and there is no such clear connection with the streams. Indeed, many of the passages cannot conceivably owe their origin to the freshwater, noticeably Trou d'Eau Douce and certain passages near the Ile d'Ambre.

The original town of Mahébourg, from which most of the bones of the Dodo, Tortoise, and *Aphanapteryx* have come, was built at the mouths of three streams which arise in

the Bamboo Mountains and which form an alluvial plain a mile and a half across. To the south of this the lava reoccurs at Battery Point, Point d'Esny, and Point Cocos. From Mahébourg we explored the neighbourhood, paying attention more particularly to its reefs and islets. Some small cliffs 50 feet in height to the north, known as Terre Rouge, proved to have been formed of material from the hills above together with rounded masses of basalt, showing concentric weathering, which have fallen out and lie piled at their base. The line of vegetable (humic acid) decomposition at about 8 feet below the summit was everywhere most marked. From there we went to Treize Cantons, where there was a small mound to some degree isolated from the slopes of the Bamboo Mountains behind. It was about 65 feet in height and consisted of a thickness of about 18 feet of the same red earth at its base, overlaid by coral-rock. This earth, being very soft, has washed away in many places, with the result that the coral-rock has been undercut, and large masses have fallen off and lie at an angle with the earth forming small caverns. In one place masses of the coral-rock had fallen on either side, but in the centre it was overhanging for 10 to 15 feet, forming a roof over the strand which in Mauritian legends was the site of a noted duel. The earth is such as forms the coast-flat everywhere within Grand Port, while the coral-rock is made up of similar materials to those which cover the surface of its barrier-reef, *i.e.* sand consisting of foraminifera, broken-up corals, *Lithothamnium*, *Halimeda*, and such-like débris. It is, however, much metamorphosed and contains large crystals of calcite, and will form the subject of a separate report by Dr. Cullis.

From here we sailed backwards and forwards over the channel and reefs, the scene of a famous frigate action in 1810 in which, owing to the intricacies of the channel and unfavourable winds, we lost four fine vessels, though the 'Néréide' covered herself with glory. Ile Singe, on which we found the remains of a small fort, and Ile des Rats both proved to be of coral much weathered and undercut at the sea-level. Ile de la Passe, for the possession of which the above action was fought, was likewise formed of limestone as well as were the other islands on its reef. Ile Aigrette, the highest (45 feet) and largest of all (about 80 acres), was also visited, proving to be a dome-shaped mass of coral-rock undercut for 6 to 8 feet at its base in a manner similar to so many of the Lau Group of Fiji. By the kindness of the customs officer at Mahébourg, we obtained rock-specimens from the other reef-islands in the neighbourhood. All these were likewise of coral-formation. Bird, Fous, and Marianne were evidently once parts of a single island, the horns of which had been cut off, leaving the two smaller islets absolutely on the reef-edge and the larger, Marianne, further back with a fringing-reef in front. Fouquets and de la Passe also are situated on the reef-edge.

The weather was unfortunately too stormy for us to visit the outer parts of the reefs, but from Mahébourg we sailed across and across the south passage into Grand Port and over its reefs on either side in a *pirogue*. The latter is a long flat-bottomed canoe-like craft which is commonly used in the western part of the Indian Ocean. It is made of soft wood, so it cannot be sunk, and, as it draws only a few inches of water, is particularly suitable for work on the reefs. The latter are exposed at low spring-tides, and behind their seaward edge, which is similar to that of coral-reefs in general, muddy flats are formed, covered with more weed than we have ever found on reefs of pure limestone.

Pits, troughs, and hollows varying up to 6 fathoms in depth occur here and there, but they are not generally fringed with corals as are similar pits in the Chagos or Maldives. Indeed, corals only grow close to and on the sides of the entrances, while *Lithothamnium* are almost confined to the breaking edges and outer slopes. The inner parts of the reefs (or mud-banks, as in this situation they might more properly be termed) are really formed largely by detritus from the land of material similar to that which forms Terre Rouge mentioned above. So far as we could see here and elsewhere, the determining factor in coral-growth appeared to be silt, much dead coral slimy with mud and dirt being found in many places.

From Mahébourg we passed in one day's sail along the passage to Grand River S.E. to the Beauchamp Factory. We sounded in places and examined many points of the coast and reefs. There appeared to be no marked changes in progress, but if the strong current which we found sweeping out of the north entrance of Grand Port is of general occurrence, the amount of water-suspended material cleared away must be very great. We found on the coast no further raised limestones, but Coral Point seemed to be formed of deposited material similar to that of Terre Rouge. The views into the Bamboo Mountains presented scenes of great beauty, and clearly showed in deep ravines how long-continued must have been the action of weathering.

Subsequently we devoted three days to the reefs and coasts near Ile aux Cerfs, Flacq, and Ile d'Ambre, at each of which there are passages through the reef suitable for small vessels. The reefs of all three places are intermediate between barrier and fringing. All the islets are purely of volcanic formation, and have been cut off from the mainland by the action of the sea. In each place the passages seemed to be the natural outlets of the tidal waters. The Rivière Seche has no passage corresponding to its mouth, while the Trou d'Eau Douce has no connection with any river. At Flacq the rivers come down from the central plateau and are more considerable. Doubtless they carry a large amount of material in suspension and the passages through the outer edge of the reef partially owe their existence to its prejudicial effects. The half-dozen passages near Ile d'Ambre, however, cannot conceivably be connected with any streams, and opposite the Rivière du Rempart, a relatively considerable stream, there is a large lagoon within the reef, fringed and studded with corals, the reef-edge there attaining a distance of  $2\frac{1}{2}$  miles from the land.

In the north of the island we saw no further evidence of elevation. The country forms a rich plain densely cultivated with sugar-cane and other products. Its coast is ragged, with here and there swamps and pools artificially cut off from the sea to form fish-ponds termed "barachois." Mangroves, principally *Rhizophora*, grow everywhere, but nowhere in any great profusion; their stilt-like roots are often covered with oysters. On the edge of this plain is situated the garden of Pamplémousses, a beautiful pleasure rather than a botanical station of either scientific or economic value. The real care of the government is in the preservation of its forests and in providing such chemical-agricultural assistance to the planters as they cannot themselves be reasonably expected to provide. The cultivation of the cane is carried to the highest pitch, and great care is taken as to the varieties planted on each kind of soil. At Beauchamp, the biggest

estate, the canes are known by the number of their varieties in chronological order. Thus one field may be planted with no. 237 and the next with 405. The methods of crossing and of the production of pure varieties from individuals designed to be self-fertilized in the next generation appeared to us, from the account we were given, to be eminently scientific.

It would be a matter of great difficulty to estimate the age of Mauritius from topographical considerations. During the hot season, from December to April, the island is subject to hurricanes, which, besides their wind-effects, often cause great floods. The effect which these produce is difficult to estimate, but they cause heavy falls of rock along the river-valley. The average rainfall varies from 40 inches on the northern coast to probably 150 inches on the hills. The greater part falls in the hurricane season, then the prevailing south-easterly trades often give place to west, or even north-west, winds. The appearance of the deep river-gorges in the hard basalt is only compatible with considerable age, but the general fringing character of the reefs is opposed to this idea. Grand Port, it is true, is certainly formed by a barrier-reef, which has a deep lagoon between itself and the land, but it is not certain how far the attainment of this condition may have been aided by the elevation which we have traced there. On the whole, we are inclined to think that elevation has exercised a more material effect than at first seems probable. Although we found no indisputable evidence of its occurrence in any other district of the island, many points in the appearance of the coast suggest that the upheaval affected the whole of Mauritius. As far as we investigated them, the coral-reefs of the island are not to be compared with those of the Chagos or Maldives either in extent or in the richness of their fauna and flora, which we had the opportunity of examining in greater detail in the Museum at Port Louis. Indeed, Mauritius, the sea-water of which has an average temperature of about 72°, is not far off the southern limit of coral-builders, so that too much stress must not be laid on the paucity of its reefs. There is a depth of 2160 fathoms between Bourbon and Mauritius and of 2200 fathoms between the latter and Rodriguez. Probably all the three Mascarenes were separate formations, and have been subject to independent local elevations and depressions. Of them, Mauritius perhaps is the oldest, and would certainly seem to be the most stable. That there was any direct land-connection at any time between the three seems to be doubtful, though probably all three obtained their life from the same source.

On Monday, Aug. 21, we left Port Louis for the second part of our cruise, and anchored that night in the outer roadstead close to the lightship. Before we left, our dredging-wire arrived by the mail-steamer, but only just in time. On the Tuesday we steamed down to the south-west point of the island to inspect the coast. As this was the most southern point we should visit, we took a series of plankton hauls about 5 miles west of the mouth of Black River. At first we used serial nets at every 25 fathoms down to 150 fathoms, and then continued the same by a second series to 300 fathoms. We also tried our large net of 8 meshes to the inch, letting out 240 fathoms of wire. The wire, however, soon began to jerk and the net to approach the surface. Evidently we had caught a shark, or some other large fish, as such remains of the net as we secured were torn to rags. In the evening we anchored close inshore in Black River Bay, and

took a series of plankton hauls by putting out nets of 60 and 180 meshes to the inch and hauling them in at each hour of the night. The value of the collections of animals obtained in this and other hauls can only be seen after they have been worked out. There was very little current close inshore; but the fauna appeared to be a rich one, practically most groups of animals being represented. Some of the ordinary and more conspicuous forms found to the north were absent, but in exchange, even in the deepest hauls, there was in particular a quantity of small Entomostraca which we had not seen before. Some were true pelagic animals, but others we could not but suspect to be local forms from the slopes of the island; a few may well turn out to be Antarctic forms.

The following morning we went up to Port Louis, when one of us (Gardiner) landed in the steamboat to get mosquito-cloth with which to replace our large plankton net, which we intended to make even longer than before. Meanwhile the other dredged on the outer slopes of the island in front of Port Louis. On the following day both of us continued the same series of hauls up to the north of the island until, opposite Flat Island, we were exposed to the full force of the south-east wind, and further work of that nature was impossible. We also put down a number of soundings, which in general confirmed the depths given in the charts, and showed the bottom to be covered with broken coral and shells, together with stones and crystals of volcanic material from the island. Our dredgings were made more to ascertain the nature of the bottom than to procure specimens. From our soundings it was obvious that the slope from 50 to 100 fathoms was as steep as off coral-reefs, but beyond that we found that it tailed off, the drop for the first three miles outside the 100-fathom line being at the rate of about 400 fathoms per mile. At first we paid attention to the foot of the slope, subsequently working out to 600 fathoms. This was anxious work, as in the shallower water up to 400 fathoms the dredges only moved along in a series of jerks, often compressing the springs of the accumulator for 5 to 6 inches, a strain of 3 to 4 tons. Once the wire was pulled directly off the drum against the winch, and several times the dredges were so caught up in spite of stoppers\* that we had to swing round or go astern and trip them, always a long business. Yet, in spite of all precautions, in eight hauls we lost one dredge, broke up two others, and in every case tore their bags. These disasters clearly show the rough nature of the ground over which we were working. In addition we secured a large quantity of loose rock, the ground at the base of the steep, 100 to 150 fathoms, appearing to be formed by dead masses of coral from the reef above, with an odd boulder of volcanic nature. This coral-rock was much bored into by sponges, worms, crustaceans, and molluscs, some forms of which appeared to be the same as were commonly found on the surface-reefs. Further out the rubble became smaller and smaller, until at 300 fathoms the bottom was apparently hard rock with a few rough lumps. From between 400 and 600 fathoms was brought up a coherent, grey, sandy mud, partly of reef-formation, and partly of volcanic material, smelling strongly of

\* Generally the warp is fastened to one arm of the dredge, the other arms being attached by stoppers of cord. Should the dredge catch up in rocks these stoppers ought to break first, so that it can be hauled free by one end.

sulphuretted hydrogen. The only life obtained off it after a long haul were two Asteroid starfishes of milky-white appearance.

With such a small number of hauls it is hard to be quite sure of the nature of the bottom; but certainly the slope off the reef seemed to be as determinate a talus-slope as we found off the reefs of the Chagos Archipelago. It is difficult, however, to understand the peculiarly hard but irregular bottom between the talus and the mud, *i. e.* at about 300 fathoms; it may, perhaps, have been of purely local occurrence. There appeared to be no incrusting animals on the coral-masses which could consolidate them into rock. The most interesting perhaps of other sedentary forms was an animal represented by thin incrusting sheets of lime of brilliant white colour, often growing on loose coral-masses, forming rounded nodules of 2 inches or so in diameter. In general appearance they looked like the *Lithothamnium* which so commonly form similar nodules in shallow waters, but actually are specimens of a foraminiferan, *Gypsina*, the largest as yet recorded. We also secured specimens of red and other *Polytrema*. Sponges were very abundant, but generally came up much crushed. Alcyonarians were represented by several Gorgonians, mostly small growths, but no living corals were obtained. The Stylasteridæ were represented by the branching *Stylaster* and *Spinipora*, a genus with short, blunt, finger-like branches which had not been obtained since the 'Challenger' Expedition. Free animal-life was very scarce and no plants were obtained.

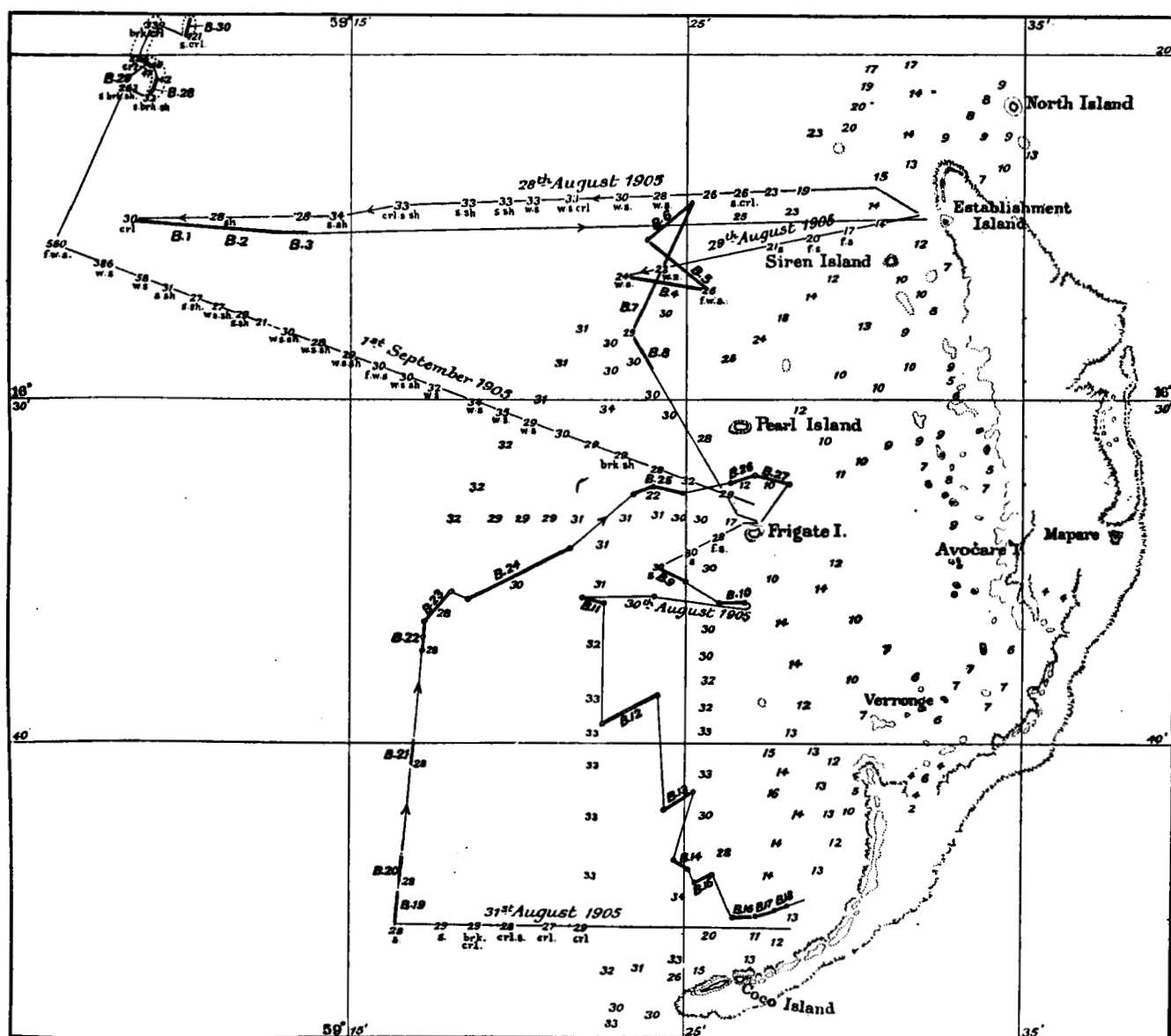
About 9 A.M. on the morning of Aug. 25 we found ourselves about halfway, almost in a direct line, between Mauritius and Cargados, and 1° 38' north of the former, finding bottom at 1962 fathoms. The bottom seemed to slope off gradually from Mauritius, and the depth was about what we expected to find from the previous soundings. The bottom-temperature was 35° F., and serial temperatures showed a gradual fall from 74.4° at the surface to 73.5° at 75 fathoms, and 72.7° at 100 fathoms, a more rapid fall then commencing, *i. e.*, 66.5° at 150 fathoms, and 61.2°, 53.3°, and 46.8° at 200, 300, and 400 fathoms respectively. These temperatures closely agreed with those which we had got on the previous day and excited no comment. Indeed, we assumed that there could be no shallow water in the immediate vicinity, and, as we did not desire to approach Cargados too early on the following morning, we employed our time in taking a series of plankton hauls down to 400 fathoms. Unfortunately we neglected to examine the bottom sample, which was recorded by Captain Somerville as "mud, globigerina, radiolaria," with the significant comment: "Large preponderance of fine washings. The heavy washings are chiefly casts of globigerina, thickly mingled with radiolarian shells. The consistency is muddy; the colour a light buff." It is but justice to add that Captain Somerville evidently appreciated the character of the bottom, and probably would have further investigated its peculiar nature had we not been on board. As it was, we proceeded on our course to Cargados, leaving a bank of 34 fathoms within 30 miles of us, a shoal which Admiral Field informs us was discovered by a merchant steamer a few months later. We ought certainly from the bottom sample to have deduced the existence of such a bank, and we fear the fault lies with us rather than with the method. Bottom samples from upwards of 200 fathoms should certainly indicate



any shallow banks in the open ocean within 50 or 60 miles of themselves by the presence of coral or rock, ground down to the consistency of mud\*.

On the following morning we approached Cargados Carajos Bank, passed along to

Fig. 28.



Cargados Carajos (after the Admiralty chart). B 1-30, dredgings and course of H.M.S. Sealark.

leeward of Coco, Frigate, Pearl, and Siren Islands, and anchored opposite Establishment Island about noon†. This is one of the northern islands on a large crescentic-shaped

\* This mud is to be carefully distinguished from the "red clay" found in the deepest waters of the ocean and consisting almost entirely of the siliceous shells of radiolaria.

† Cargados Carajos is identical with St. Brandon. We learn from Horsburgh (*loc. cit.* p. 123) that the Chevalier Grenier sailed along it in 1769. The existing chart was made by Captain Sir Ed. Belcher, H.M.S. 'Samarang,' in 1846, being partially founded on a chart made by Lieut. Mudge, of the East India Company's Service, in 1825.

reef with its convexity to the east, 26 miles from horn to horn by about 9 miles in depth. It is a continuous reef from point to point, varying in breadth from a mile about the centre to four and a half miles towards the north-east part. In this position there is a pool, or series of pools, of blue water forming little lagoons, said by the manager to extend over 9 miles. The reef to the north-east, where alone we examined it closely, is steep with a well-defined edge, smoothly incrustated with *Lithothamnium*. It is said to continue unbroken, and to be of similar nature, along the whole of the weather-face, but no proper survey of it has ever been made. According to the manager's statement, there are no passages into the lagoons practicable for any vessels larger than open boats. On the reef there are three islands to the north, Establishment and two Bird Islands; one island in the centre, Mapare or St. Pierre, nearer to the eastern edge of the reef; and a series of sand-banks and islets to the south on the western half of the reef, known collectively as the Coco Islands, from one of the southern islands having three coco trees which have managed to survive the frequent hurricanes. Of these islands, those to the south are all of sand piled up from the leeward or west side, similar to islands formed on the lagoonward halves of atoll-reefs. Establishment Island is the same, but represents only the reduced remnant of the southern of the two islands which existed 50 years ago on this part of the reef. The Bird Islands are partially rock and partially sand; and Mapare is said to be a rocky island, owing its formation either to the effects of storms and hurricanes piling up coral from the reef, or to some change of level. Large masses of rock are not uncommon on the reef to the north and elsewhere. Such masses in the Maldives and Chagos generally represented the remains of former land, but here many of them on the western side were undoubtedly true negroheads, similar to those which one of us (Gardiner) had seen piled up by hurricanes here and there on Fijian reefs\*.

On the leeward side of the reef, to the south of Establishment Island, we found a series of bare stony banks, awash at low tide and intersected by channels, through which the water escapes off the reef above. These tail off to the east into a sand-flat, with a considerable growth in places of that peculiar grass-like cotyledonous weed, *Cymodocea*, but otherwise generally bare and almost devoid of life. To the west of the banks there is no definite reef-flat, but an area of growing coral, mainly stag-horn *Madrepora*, with pits from 4 to 8 feet in depth. From this the edge, which is covered with *Lithothamnium* and *Squamariaceæ*, rises a little, so that it is exposed at low spring-tides. It is, though, rather indefinite, being lower opposite each channel in the reef above. In places it overhangs a little, and it is relatively bare, presenting an appearance as if it were being broken down from seawards and washed away.

On our arrival we at once went ashore on Establishment Island, where we found a station with 28 men, most of whom were out fishing. It was merely a fish-curing establishment with scaffolding covered with drying and, as it seemed to us, putrefying fish, a tin-roofed manager's house, a large house for the fishermen, a carpenter's shop, and tanks for turtle and water, the latter being collected off the roofs. The manager

\* "The Coral Reefs of Funafuti, Rotuma, and Fiji," Proc. Camb. Phil. Soc. vol. ix. p. 445 (1898).

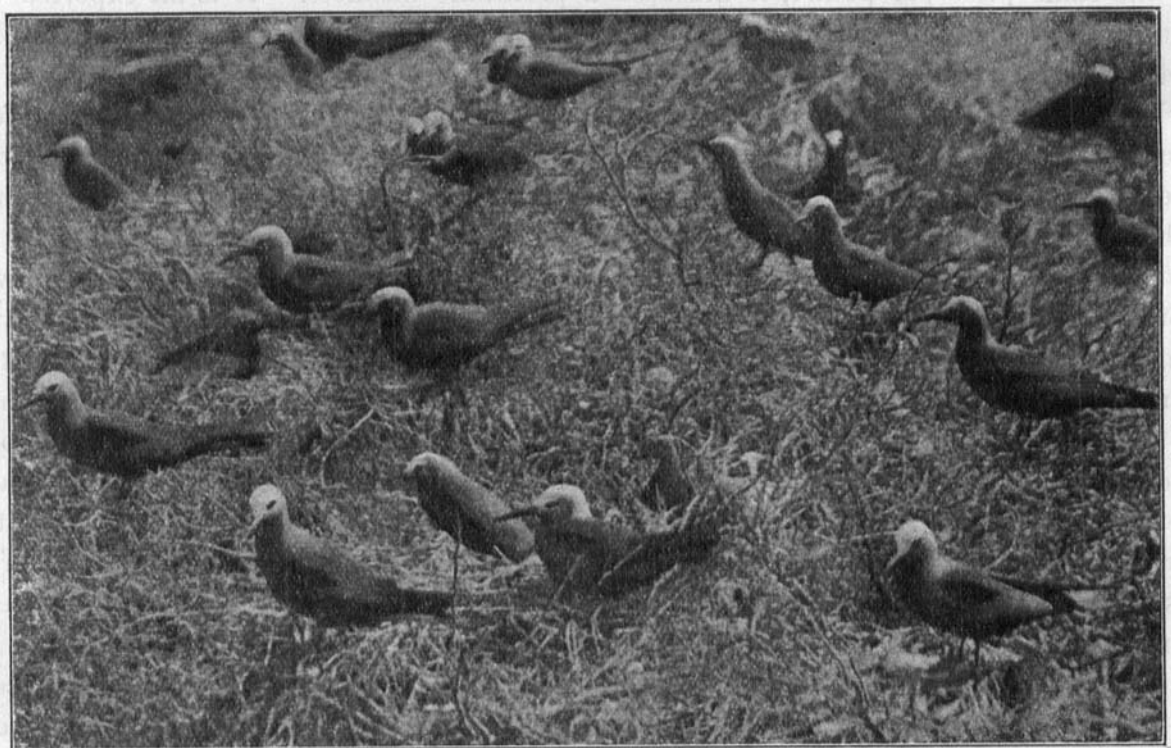
was a half-caste Creole, and the station was of the poorest description, none of the men having brought their wives or desiring to make it their home. An attempt was being made to cultivate a few gourds and marrows, but the soil was evidently of the most inhospitable description, bois manioc (*Scævola*) and balais (*Erythroxylon*) alone flourishing. A few cocos were coming up, and there was a small grove of Casuarinas, a tree which seems capable of withstanding almost any conditions of drought and salinity. Animals of all sorts were scarce, save only such as feed on decaying fish; a few rabbits, however, had run wild, and were somehow managing to eke out an existence on the coarse herbage. Fish seemed to be extraordinarily plentiful, a boat with four men often bringing back three to four cwts. in a day. As the pay with rations of each man is only about half a rupee a day, and as the fish sells, when dried, at the same price per pound, it must be a profitable business. It is all exported to Mauritius, communication being kept up by a small schooner, which sails simply between the group and that island.

We remained for three days at Establishment Island. On Monday, Aug. 28, Cooper dredged in the Sealark, while Fletcher and Gardiner collected on the land and examined the reefs. Siren Island, which was visited in company with Captain Somerville and others, and the two Bird Islands presented an extraordinary appearance. Language is too restricted to give any idea of the vast number of birds which inhabit them. As we got away from the ship, frigate-birds soared overhead, sometimes swooping down almost within reach. Approaching the islands curlews and whimbrel flew out with shrill cries, but the small flocks of little plover (*Totanus fuscus*) and sandpipers feeding at the water's edge seemed reluctant to give up their meal until within gunshot, then too late. Passing over the wave-raised ridge, which bounds a central plateau on all the islands, we saw the ground before us literally speckled with the black-and-white tern (*Sterna fuliginosa*), each hatching a single egg within a foot of its neighbours. As we picked our way through the eggs, the sun's rays were almost hidden by the vast concourse of birds above, passing within a hand's reach of our heads, and often striking down at our helmets, while their raucous cries forced us to shout at the top of our voices if we wanted to be heard. Here and there are clumps of low bush (*Erythroxylon* or *Tournefortia*) matted together by the liane sans fin (*Cassytha filiformis*), a plant peculiar in its absence of leaves, the cells of its thin green stems being the actual starch-producing organs. Their matted surfaces are pressed down where the grey-headed terns (*Anous leucocapillus*) sit likewise on single eggs, close enough to interchange their secrets. Outside all, actually on the surrounding ridge, were a few white terns (*Gygis candida*), their eggs being generally placed on the tops of the larger coral stones. Siren Island was saucer-like and had *Gygis* on the rim which was thrown up for about 12 feet above the tide, *Anous* on a broad circlet of bush within, and then a still broader band, in places a hundred yards or so across, of *Sterna*. The centre was a bare flat, perhaps 8 feet lower than the rim, at that time of the year bare of vegetation and beaten down to a smooth surface by multitudes of young chicks: so numerous were they that it seemed that there must be at least two layings, of which we had found the second (Pl. 16).

Collecting on such islands was a peculiarly unsavoury task. The ground was coral

and sand, consolidated together into a soft rock by the droppings of the birds. Above was a rich soil composed largely of almost pure guano. Digging into it one found countless bones of young and old. The surface of the ground indeed seemed sprinkled with the dead, and scarce one young bird out of four could have ultimately survived. Guano is no doubt excellent for most plants, but strictly in moderation. On these islands we found only ten kinds growing, including the two shrubs already mentioned, together with a few *Scævola* bushes and a single stunted mapou tree (*Pisonia*). Of the rest there was one rush, one true small-leaved succulent and four other herbaceous forms. Many were dead, and all were of stunted and fleshy habit with thick roots,

Fig. 29.



The Grey-headed Tern (*Anous leucocapillus*) breeding on tops of bushes at Cargados Carajos.

adaptations to the peculiar soil. Under these circumstances practically only such insects are found as live on decaying animal-matter in the ground, a few beetles, numerous cockroaches, earwigs, and crickets gradually burying every dead bird, and finally ants and a few flies. Web-spiders were absent, but we got a few jumpers and other predatory forms, as well as some centipedes and millipedes. The *Scævola* bushes were covered with green bugs, and while seated for lunch under some coast bushes of the same we were attacked and hastily put to flight by large black ticks (*Amblyomma loculosum*), which showed up conspicuously as they crawled towards us over the white sand. The only vertebrates were mice and geckoes. On the whole, though at the time we only recorded 42 species of insects, the collections were of great interest, as showing how extraordinarily

dependent is life on environment, and how the greatest care must be taken to study both together in view of questions of geographical distribution, particularly on oceanic islands \*.

While at Cargados we experienced continuously strong winds from the south-east, so that of necessity we confined ourselves to work on the leeward side of the surface-reef. On this side the edge of the reef-flat is very ill-defined, tailing off gradually in the centre to 10 fathoms in three or four miles. In this part there is a series of shoals reaching the surface, on some fifteen of which small islets have formed. Fish abound between them, and on one, Avocare, the main fishing-station of the bank is situated, having a complement of 42 men. Outside this area is a large stretch of shallow water with only six shoals marked on the chart, all of them lying outside a line joining the ends of the crescent. All arise within the 20-fathom line, and three—Siren, Pearl, and Frigate—are covered completely with land; the first is a bird-inhabited island, and the other two have recently been dug for guano. The 25-fathom line is found within five miles west of Establishment Island, and for twenty miles beyond this there stretches out a large, flat area, having 25 to 35 fathoms of water, with no known coral-patches. No shoals are known west of long.  $59^{\circ} 26'$  E., which is almost the position of the 25-fathom line, while the 35-fathom line would be in about long.  $59^{\circ} 8'$  E., opposite Establishment Island, curving round to the south almost to meet the south-west point of the main reef. The 25-fathom line follows the same line of longitude for some distance to the north, Cargados itself really lying on the south of a much larger shoal, the Nazareth Bank. The shallow water near the main reef continues also to the north for about 12 miles, and has two bird-covered islets, North and Albatross, which have seldom been visited by man.

Our dredging was mainly in the area from 25 to 35 fathoms, and gave in the first haul results so interesting that we determined to investigate its fauna as completely as possible. On Monday, Aug. 28, Cooper ran a line of soundings due west from Establishment Island, and took three dredgings near the edge of the bank. On Tuesday we confined ourselves to the area outside Establishment Island and down to Frigate Island, taking five casts. On Wednesday we worked to the south point of the reef with ten hauls. On Thursday we went over the same line but further westward with nine hauls, and on Friday we ran off the bank putting down our nets in three places on its westward edge. During the whole time we watched the nets carefully, so as to ascertain the nature of the bottom and

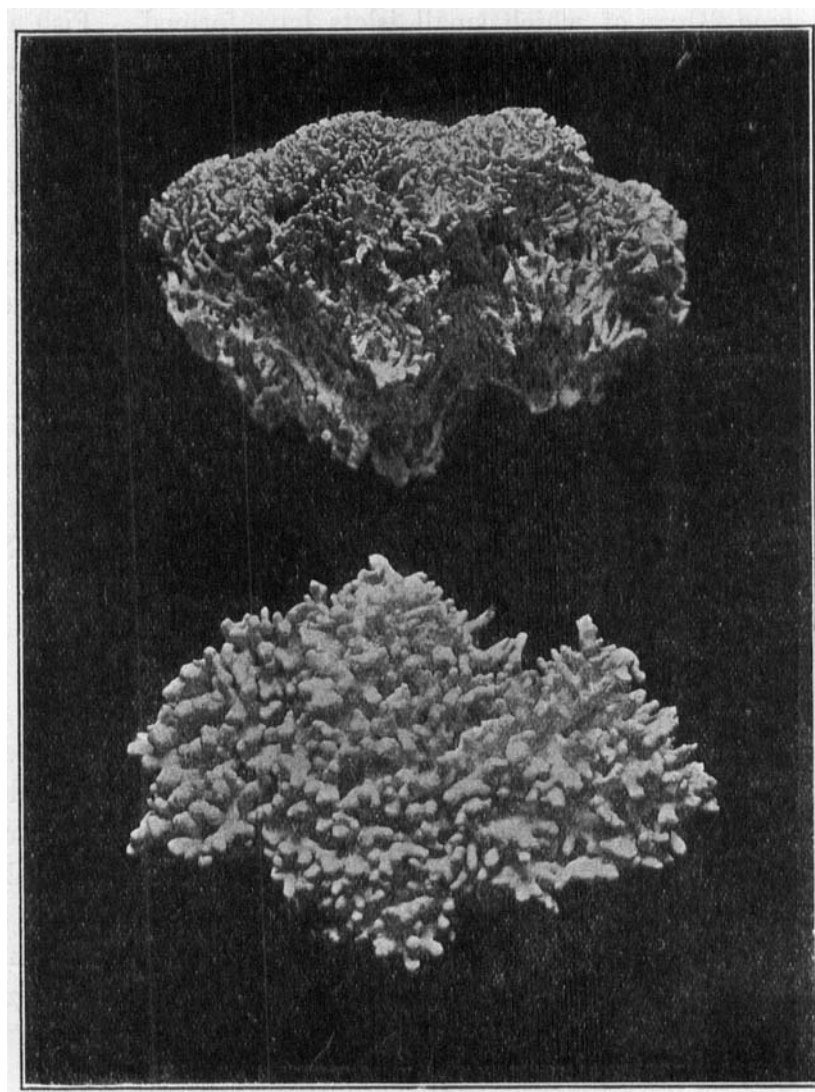
\* We were unfortunately unable to visit Tromelin, which lies in lat.  $15^{\circ} 51'$  S., about halfway between Nazareth and Madagascar. It was surveyed in 1875 by the late Chief Hydrographer, then Commander W. J. L. Wharton, H.M.S. 'Shearwater.' It is a mere sand-bank, a mile long, about 15 feet high, covered with low bush, and surrounded by a fringing-reef about 150 yards wide. It is evidently of coral-formation.

It was discovered by the ship 'La Diane' in 1722; and in 1761 the 'Flute l'Utile' was cast away there. This ship had on board 80 blacks. The whites arrived safe at Madagascar, after a short voyage in a flat-bottomed boat, made out of the wreck; the blacks were left on the island, but all died except seven women. These remained on the island 15 years, living on the shell-fish they could pick up, with now and then a turtle, and having nothing but brackish water to drink. Captain Tromelin, of the ship 'La Dauphine,' had the courage and good luck to land on this dangerous spot and brought them to Mauritius in 1776.—*Abbé Rochon.*

for the same purpose sounded very frequently, using the snapper lead. In all we calculated that in our thirty hauls we covered about forty miles of the bottom with dredge and trawl and put down over 200 soundings. These should be sufficient to enable us to appreciate its character and life.

In the first place we were struck with the peculiarly smooth and level surface of the

Fig. 30.



Typical reef Lithothamnia.

Upper figure *Goniolithon frutescens* and lower figure *Lithophyllum gardineri*. (Both  $\times \frac{2}{3}$ .)

bottom. We found below 25 fathoms no shoal-patches nor growing areas which could give rise to them. At similar depths, and indeed everywhere except in the immediate vicinity of surface-shoals, the trawls and dredges were never caught up nor torn in any way. Only five specimens of living colonial corals were obtained and Lithothamnia were never of any great importance, though otherwise the hauls were generally rich. In some places the bottom was hard sand, but its general covering was

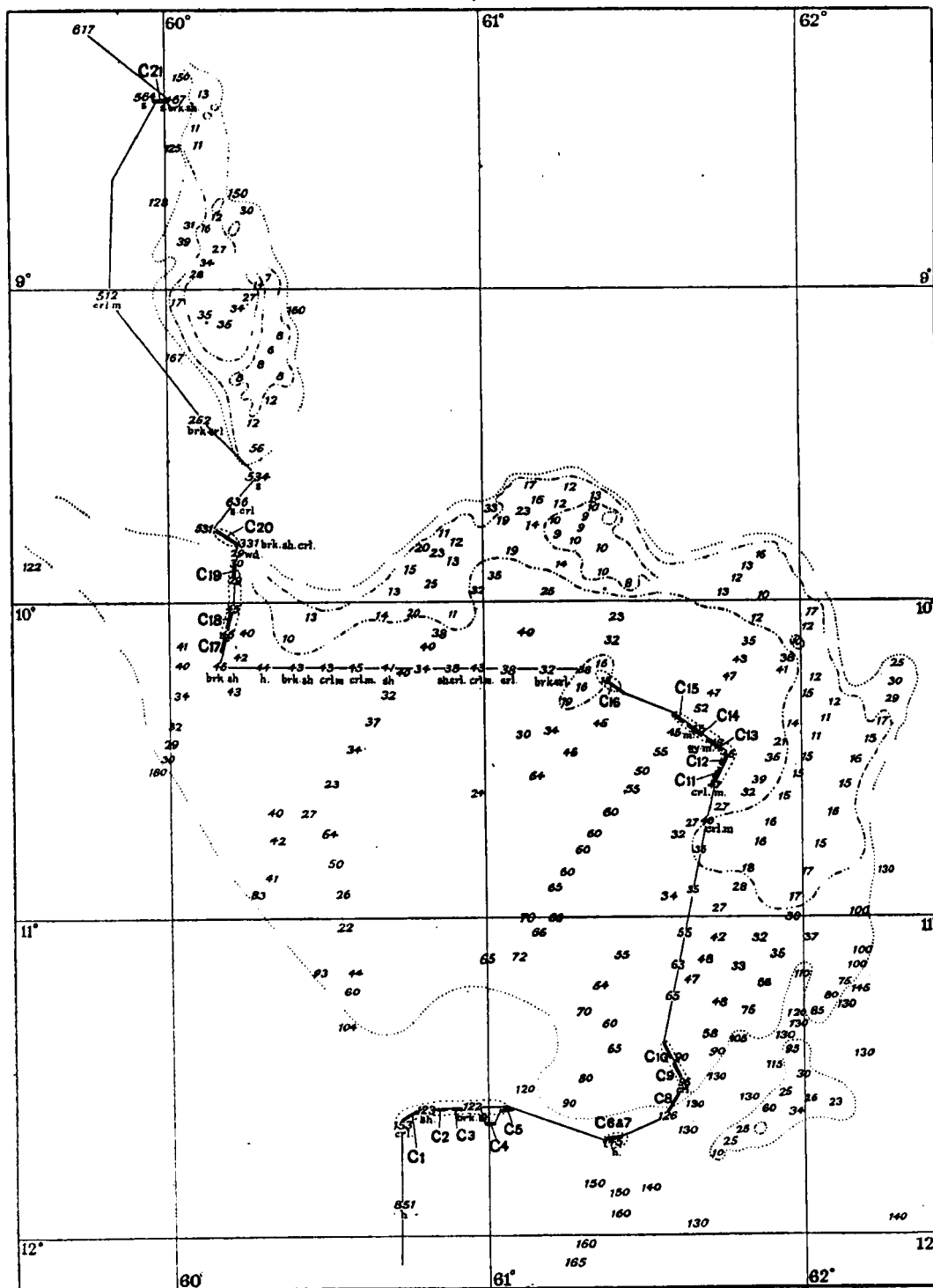
of rather softer foraminiferal nature with broken shells, particularly those of bivalves, which in some places almost formed banks. Towards the edge there was more rubble, formed largely of broken bases of branching corals, evidently carried in from some lesser depth, together with all sorts of sedentary life and generally some molluscs. Everywhere between 25 and 35 fathoms, except near the edge of the bank, quantities of the grass-like *Cymodocea*, one of the Potamogetonacean cotyledonous plants, were growing on the bottom, while in places the creeping alga *Caulerpa* forms submarine meadows. In all we pressed about 25 different kinds of algæ, nearly all green, of which we may perhaps notice the calcareous-leaved *Halimeda*, the network-forming *Shuvea*, and the great flat fronds of *Udotea* and *Avrainvillea*. Most forms of sedentary animals, with the exception of reef-builders, were well represented. The fauna was similar but decidedly richer than that which we got in the Maldivian lagoons. There were 30 species of fish, 7 new species, some being flat-fish, none of edible size. We found that the mollusc *Vermetus* had in one locality made its tubes of sand, though it usually starts on the surface of some growing coral and forms a spiral shell. As the coral grows it becomes imbedded, and to keep its mouth at the surface the animal builds a long straight tube at the same rate as the coral actually grows. Perhaps the sand was accumulating more rapidly than the animal could build. Sponges were very abundant, but were generally little inhabited by animals; a bright orange form was remarkable for a similar coloured Alphæid. At one spot near Frigate Island the prevailing colour of the catch was most striking, ranging from orange to vermilion. As a rule, the contents of the dredge were dull green to grey, caused perhaps by the colour of the weeds. In the haul in question there was, however, no weed, the dominant life being sponge (at least twelve species) orange to purple, alcyonarians, *Vermetus*, crustaceans, molluscs, asteroids, annelids, and crinoids, all being brightly coloured. Crustaceans might directly take on the colour of the environment, as Keeble and Gamble have shown\*, but in other wandering forms its presence is more difficult to explain; if all live on some coloured sponge in the first place, it might be the excretion of its pigment.

When dredging towards the edge of the bank we found some beds of Lithothamnium and a much rougher bottom, the nets getting badly torn. In one haul whose least depth was 47 fathoms, we got a mass of weed, much of it red in colour, eight species of algæ, and the delicate-leaved *Halophila ovalis*, a monocotyledon of the Hydrocharidaceæ, an extraordinary depth for a plant derived from land-living ancestors. From this place the slope was steep, the next sounding about 800 yards further out giving 224 fathoms. We tried to dredge upon it, but got into difficulties at once, drifting off the slope several times and subsequently losing our dredge.

We next proceeded along the west side of the Nazareth Bank to the Saya de Malha Bank, sounding on our way. This area within the 100-fathom line is probably about 240 miles long, and there are no known shoals or dangers, beyond those already mentioned in connection with Cargados, which is situated on its southern extremity. Except near Cargados, the actual soundings upon the bank are few in number, but sufficient perhaps

\* Quart. Journ. Micr. Sci. vol. xlv. pp. 589 *et seq.*

**Fig. 31.**



Saya de Malha Banks (from the Admiralty chart). C 1-21, dredgings and course of H.M.S. Sealark.



to show that, while the greater part is 30 to 40 fathoms deep, there are considerable areas both north and south within the 20-fathom line. The average breadth of the bank is about 50 miles, and it would appear to be steeper to the west than to the east, though it is possible that some of the soundings may be wrongly placed in longitude. Our soundings varied down to 2062 fathoms, a singular feature being that in more than half of them we failed to secure any bottom-samples. Almost midway between Nazareth and Saya de Malha we found 222 fathoms, the bottom being covered with broken shell, but there may have been still shallower water to the east. To the south of the Saya de Malha we then got into a considerable area having a depth between 100 and 150 fathoms, on which we dredged for portions of two days, making seven hauls. We used several kinds of nets, but perhaps got the best results with our modified Agassiz trawls. Here we unfortunately lost our biggest frame together with 300 fathoms of wire, which was cut by the propeller. The area was to some degree a difficult one to work, on account of the strong current running between 60 and 120 fathoms, necessitating specially weighted instruments. The bottom was hard, with patches covered by a white rubble, composed principally of lamellibranch shells, echinoderm tests, dead coral, polyzoa, &c., all of it of a facies which belongs to shallower water and which undoubtedly had been swept off the shoal-banks of the Saya de Malha. In most places it seemed loose with little or no sand, but to the west it was mixed to some degree with casts of Foraminifera, similar to those of greensand but of lighter colour, like those we had found previously in the lagoon of Suvadiva Atoll \*. Most groups of animals were represented, noticeably several species of solitary corals, a clump of the only brachiopod obtained on the cruise, a large pennatulid (*Anthophyllum grandiflorum*)—a rare group in our collection,—and about half a dozen new fish, among them a form which Mr. Regan has named *Halieutea gardineri*, a kind of fishing-frog interesting for tentacles in front of its mouth, set in bony depressions for protection.

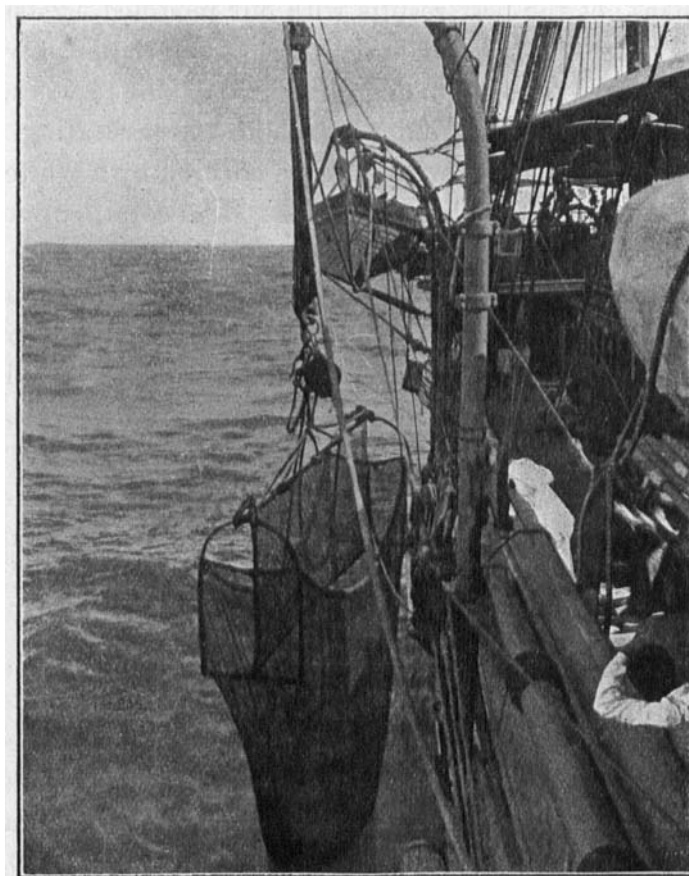
We continued the dredgings on to the main bank of Saya de Malha, finding no marked steep, but a gradual slope to the south. The bottom from 100 to 70 fathoms was evidently quite smooth, very hard, and swept absolutely bare of sedentary life by the currents, which almost prevented our dredges from reaching it and which seemed to increase in strength down to about 100 fathoms. The name Saya de Malha really includes three banks, enclosed in separate 100-fathom lines, about 250, 14,000, and 1200 square miles in extent. The south bank is a flat shoal, and the north one a basin with 40 fathoms in the centre, the rim having less than 15 fathoms. The central bank is about 500 miles round by 120 across in any direction, with a marked rim less than 20 fathoms deep to the north-east for 200 miles, with upwards of 65 fathoms on the bank. It is separated from the south bank by a depth of 130 fathoms, and was the only one dredged by us.

In order to arrive in the north-east part of the bank in the morning we steamed during the first night due north, sounding continually on the way. This being more or less enclosed and protected ground, the dredgings were expected to give an interesting

\* "Lagoon Deposits," Fauna and Geogr. Maldives and Laccadives vol ii. p 581

comparison with the Maldivian lagoons. We took two batches, sounding about every ten minutes. The first five were in water from 40 to 60 fathoms deep, our trawls being used. The ground was muddy to start with, but altered as we went north, until in our last, a very short dredging, the spring showed a great strain. As the trawl came up, its frame was seen to be almost bent double (Pl. 4. fig. 3), while the net beneath the water was bulged out and every moment threatened to burst. At first we tried to rig a tackle round the bag, but only got immersed for our trouble as the ship rolled. Finally, we had to slit the net open and take out its contents in buckets, all the time losing valuable

Fig. 32.



Large Trawl as used on H.M.S. Sealark.

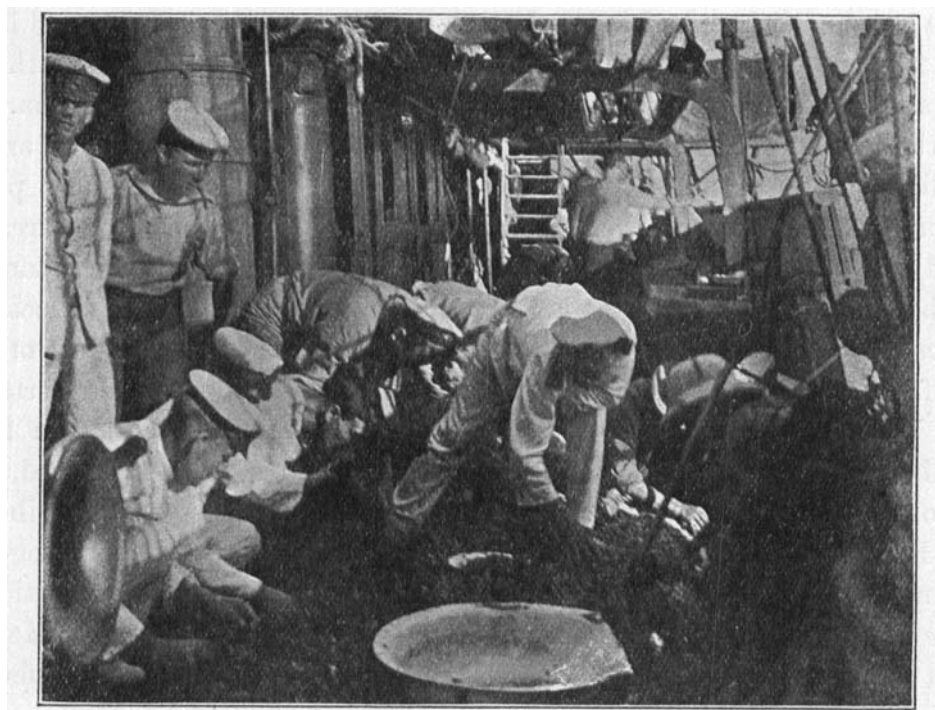
Observe loose ground-ropes attached near the tops of the stirrups.

animals through its meshes, until at last we could get it on board. It was a notable haul, and one of which we could feel quite certain of the depth throughout, as it cannot have covered more than a quarter of a mile of ground. There was an enormous number of animals and a great variety of free-living forms. It was, however, chiefly noticeable for the great bank of *Lithothamnium* and for attached *Halimeda* living at 55 fathoms, the greatest depth obtained for these plants on our cruise.

While clearing up from the last haul we were steaming north-west towards a shoal on the side of which we got one dredging, letting down our big triangular net in 26 fathoms. It was a striking contrast to the last in that it yielded at least 16 genera of corals, most of

them regular reef-builders. The Hydrocoralline *Millepora* and the Alcyonarian *Helio-pora*, as important reef-builders as any, were present both in this and in a subsequent haul in 29 fathoms. The former is particularly interesting on account of the extraordinary different facies which it assumes, incrusting, branching, massive, spreading, close-set leaves, &c. Any facies may be found at any depth and all belong, as Prof. S. J. Hickson has shown, to a single species. The second, the well-known blue coral, decreases in depth of coloration with the increase in depth from which it is obtained, the colour being absolutely in the corallum and not in the living tissues. Its main pigment, known as *helioporin*, is peculiar to the genus and is accompanied by a pigment of a chlorophylloid nature. The upper surface of its leaves is of deeper blue than the lower, and this indicates that the pigment may exercise some function in decomposing the

Fig. 33.



Sorting dredging C 16 on board H.M.S. Scalark, Saya de Malha.

carbonic acid in the water, presumably for the benefit of its living tissues \*. Attached to the dead coral were some low purple *Polytrema* (Foraminifera) and some bluntly-branching, brick-red *Erythropodium* which Prof. J. Arthur Thomson has informed me is growing on a madreporarian axis.

After the last dredging we steamed slowly westwards during the night (Sept. 6-7), so as to dredge the following day over the edge of the bank and to explore the passage towards the northern bank. After some dredgings within the rim, we took one absolutely upon it in 29 fathoms, getting 14 species of corals and much the same forms as in our dredging at 26 fathoms on the previous day. We then passed off the bank, finding a regular coral-reef slope, and got a successful trawling commencing at

\* Vide C. A. MacMunn, 'Fauna and Geogr. Maldives and Laccadives,' vol. i. p. 188.

330 fathoms, passing into deeper water. Two subsequent hauls failed to reach the bottom. We were drifting in each case to the west-north-west, and we heavily weighted our trawls. Each went down almost perpendicularly to about 200 fathoms, but then commenced to draw out to the east or east by north, the wire at 300 fathoms making an angle of about  $45^\circ$  with the surface. We were in the first haul unable to steam, as the trawl at once left the bottom; and in the others (the more northern), in which the dredges did not reach the ground, the angle with the surface was still less. While sounding in the same situations, as well as to the north more immediately between the two banks, there were also indications of some change in current between 150 and 250 fathoms. Trawls with long bags present a considerable amount of surface to the water, and their behaviour in these hauls is only, we consider, consistent with the existence of a surface-current to the west down to about 150 fathoms, and a reversed current to the east from 200 fathoms to the bottom. Of course, it is largely a matter of relation of ship to wire; and it is only fair to add that we are not entirely supported in our view of the directions of the currents by Capt. Somerville and the officers of the *Sealark*, though all at the time admitted the existence of peculiar current-phenomena. There is, of course, the surface-current as moving the ship to be taken into account, and also the fact that all ships sail to some degree under bare poles—the *Sealark* more particularly so, as she presents a large surface of hull and masts to the wind. We were, of course, out of sight of land, and the ship for accurate results under such circumstances should be a fixed body, *i. e.* at anchor, or at least capable of accurately fixing her position every few minutes. Without such observations it may be impossible to convince others of the existence of such deep currents, though the observer may feel absolutely certain of their presence. We ourselves think that relatively deep currents prevail to a far greater extent, both in the open sea and in narrow waters, than is usually allowed, and think that our own observations, with those of Comm. Tydeman of the ‘*Siboga*’\* and Mr. J. Y. Buchanan† (to mention only two observers in coral-seas), together with general considerations relating to topographical and physiological questions, give a *prima facie* case for full investigation. Between the northern Saya de Malha Banks the current seemed reversed below 200 fathoms, perhaps only a temporary phenomenon; but in their nature both of the bottom-samples down to 636 fathoms in the middle of the passage and of animals in the dredgings are only consistent with the existence of currents sweeping the bottom.

The following night we skirted along the north bank of Saya de Malha, stopping in the morning for a dredging near its northern end. Here, again, we were affected by currents, though not to the same degree. The dredging started in 450 fathoms outwards, and the general facies of the animals was the same as those obtained between the banks. They were all either strong-swimming forms, such as fish and crustaceans, or starfishes which can cling well, or attached gorgonians. The only sponges were Hexactinellids, one branching form having the general appearance of an *Oculina*-coral, having associated with it little Palythoid actinians instead of coral-polyps. Corals were

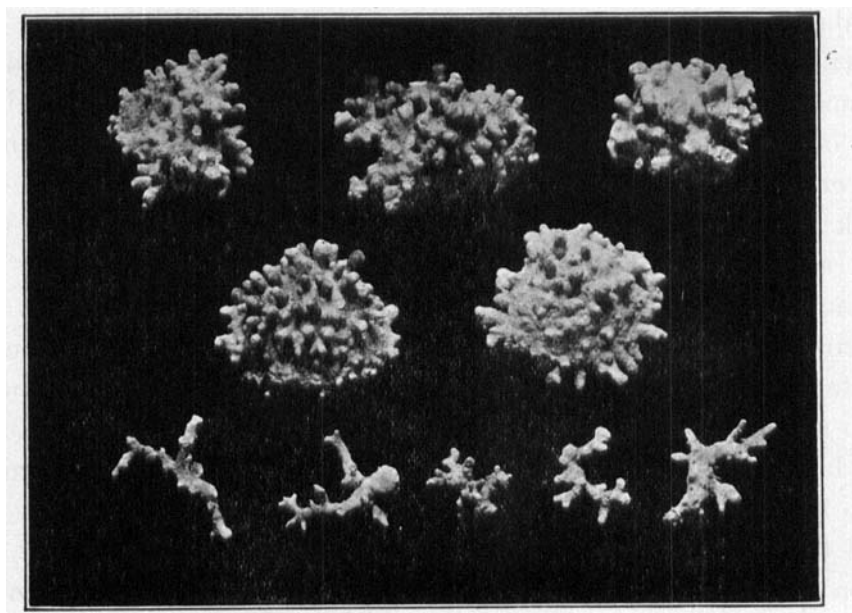
\* Hydrographic Results, ‘*Siboga*’ Reports, pp. 5–6 & 85–86.

† Sixth Internat. Geogr. Congress, p. 25 (1895).

represented by a large, rough, compressed *Flabellum* and several specimens of the delicate disk-like *Stephanophyllia*, both solitary forms. Among the fish was a form called by Mr. Tate Regan *Simonotus acanthorhynchus*, a new large-eyed genus of John Dory with a series of peculiar spines in front of the eyes and snout (probably protective), and a new species of *Macrurus*, a large-headed fish with attenuated body and tail and eyes a third of the length of the head in diameter, essentially a cod adapted for deep-sea life.

We were now (Sept. 8) on our nineteenth day out from Mauritius, during which fires had not been drawn, and the necessity for coaling made a visit to the Seychelles imperative. Unfortunately this made it also necessary that we should give up any idea

Fig. 34.



*Lithothamnion* from dredging C 19, Saya de Malha.

Upper five specimens *Lithothamnion indicum*, and lower five *Lithothamnion australe*.

of visiting the Agalegas, two small coral-islands surrounded by a closely-fringing reef, about halfway from Saya de Malha to the line of shallow banks which connect the Seychelles to Madagascar. As we had heard they were entirely planted with coconuts, and as their shoal is completely isolated, being surrounded by water of over 2000 fathoms, this meant little to us; but it was a serious disappointment to our surveyors. The mischief was really done by the heavy weather continuously experienced until we were actually approaching the Saya de Malha Bank. They must console themselves, however, with the knowledge that the anchorage and landing-place on Agalegas are directly to windward, and that the narrow bank lies north-west and south-east, so that it would have had no leeward side to the south-east trades, and hence no anchorage.

We steamed accordingly from the Saya de Malha towards the south-east part of the Seychelles bank, sounding at intervals, hard bottom, or no indication of its nature, being

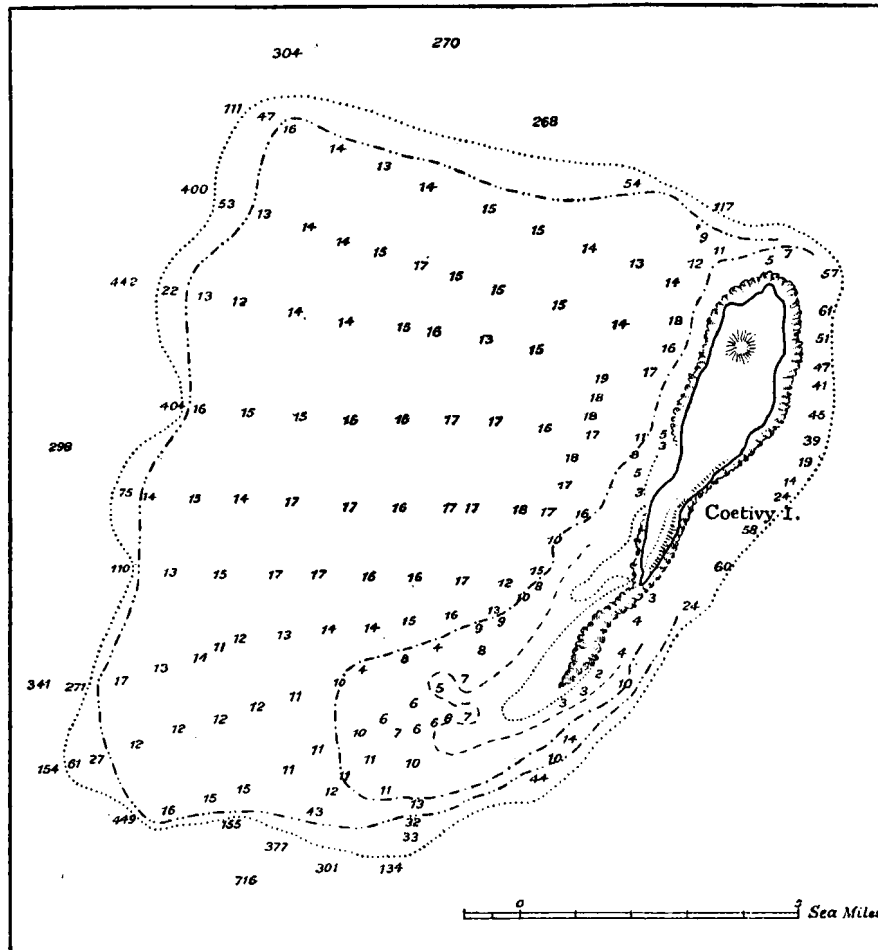
found. We stopped at a point midway between the banks ; but subsequent soundings by the Sealark continued the line, showing that from about our then position the two banks to the north and south gradually shoal upwards. From here we turned westward, skirting the Fortune, another large submerged bank with 10 fathoms or so of water, and anchored off Coetivy about noon on Sunday, Sept. 10. Going ashore, we were most hospitably received by M. G. B. de St. Romain and M. Bernon, the managers for Mr. Chas. Dauban, of Mauritius. The same day we made a preliminary exploration of the island, with Dr. Simpson botanising and Mr. Fletcher entomologising. The results were so satisfactory that we decided to remain while the Sealark went to the Seychelles to coal. We had considerable collections, and accordingly spent the Monday on board, personally seeing to the various points on which their welfare would depend while in transit home. Finally, we made up seven large cases to be left at Mahé, while a similar number of cases were to be brought from there. While doing so, the divers were sent down around the ship in about 10 fathoms for their quarterly dip. They sent up to us a number of reef-corals, some of which when broken up yielded a rich variety of worms and other living forms. There were also letters and reports to be written, and all shore-collecting and camping gear to be carefully selected.

The Sealark left us at Coetivy on Tuesday, Sept. 12, and returned for us on the 21st. We were not able, however, to leave until the 25th, as she had got her piston-rod slightly bent in the heavy weather experienced on her passage down from the Seychelles. It seemed at first sight to be an accident serious enough to necessitate our sailing down to Mauritius for repairs. Mr. Beer, however, took the engine to pieces and raised it a few inches, so as to relieve that part of the shaft which was bent. He and his staff worked on it day and night for three days ; and on its completion it proved absolutely successful, no further alteration being made until the ship arrived in Ceylon at the completion of the cruise. It was a magnificent piece of work, and one which reflects great credit on the Service. This delay gave us twelve days for the examination of the island and its reefs. The last three days, however, were of no value to us, on account of the unusually hot damp weather and the glare on the white sand-dunes and open land having completely tired us out by the time the Sealark arrived. However, it enabled us to round off our work properly, and Fletcher added a few new insects. During our stay we had managed to visit every part of the reef and had collected over it in eight positions at low tide. We also traversed the whole island, collecting its animals and plants, and examined every part. Day after day the routine was more or less the same ; but the kind of work on land and reef has already been sufficiently indicated. Much of the collecting was a dull grind under unfavourable conditions, since few of the forms of life were new to us, although necessary for the purpose of subsequent comparison (Pl. 17).

Coetivy lies in a north-and-south direction on the east side of a shoal, and is about 6 miles long by  $1\frac{1}{2}$  miles across its broadest part. The village lies on the middle of its west side. The island is fringed by a reef, except for a mile and a half to the south of the village, where there is a series of isolated coral-patches. The reef is very imperfect off the north point, where the mud and sand stirred up by the prevailing set of tides and currents along its east and west reefs have prevented organic growth. To the south

the flat extends out for  $2\frac{1}{2}$  miles, its two sides being quite similar to the reefs of the island, while a bare patch in the centre represents the former position of a sandbank sketched by the late Admiral Sir W. L. Wharton when in the 'Shearwater' in 1875. Shoal patches stretch out from its point for an additional 2 miles, and there are many isolated patches and reefs to the south-west. Elsewhere the bank presents no changes, its rim being very regular with 11 to 14 fathoms of water, and the centre with 15 to 18 fathoms.

Fig. 35.



Coetivy (after the Admiralty chart).

The east, weather or seaward, reef differs in certain points from any reefs which either of us had up to that time seen ; instead of a single line of breakers, there is a broad belt in which the same wave rises and breaks a second time. This is due to the slope to seaward being gradual for the first 10 fathoms or more, even down to the edge of the steep, and also to the bottom being covered with long sea-grass (*Cymodocea*), which by its friction prevents the pounding action of the breakers and certainly goes far to prevent the formation of a distinct edge to the reef. The latter can scarcely be said to exist as a definite structure, although there is an area which shows a number of masses exposed at low tide, broken by relatively broad channels with sloping sides. The

latter represent the perpendicular-sided fissures commonly found in other reefs. They are more free of weed than other parts of the reef, and are regular in proportion to the breadth of the reef, representing no doubt the channels for the rise and fall of the tide. The exposed masses are mainly covered and formed by *Lithothamnium* of fine branching facies intergrown with *Halimeda*, both classes of organisms being richly covered in their lower parts with thin brilliant-green Tunicates. Corals are scarce, small colonies of fine-branching *Madrepora*, *Pocillopora*, and *Millepora* alone being common.

Passing inwards from the edge of the reef, such as it is, a reef-flat and a boulder-zone should be crossed before reaching the shore-flat. Actually one passes on to a flat, on which the *Cymodocea* becomes more and more dominant as the shore is approached. Here, extending from about 35 to 60 yards back from the breakers, are found many loose masses of dead coral, mainly *Madrepora* and *Porites*, more or less imbedded in sand, with colonies of *Heliopora* formed of thick densely-packed laminæ. Some of these may be exposed at low tide; and this area is all that represents the boulder-zone. Behind this the shore-flat is as densely covered with *Cymodocea* as a sown meadow, the soil beneath consisting largely of foraminiferal sand mixed with rubble. While generally it has less than a foot of water at low tide, a series of pools are commonly found at the base of the beach. They average 3 to 6 feet deep, with sandy bottoms, and in most places are only 20 to 30 yards broad; but at the north end of the island, where there is no reef, they are much more considerable, strong tides setting along them and sweeping out the sand and detritus. Elsewhere they communicate with the ocean through the channels. Were some of these latter to enlarge and become definite gaps, the pools would soon form a boat-channel, and ultimately there would be a barrier-reef along the east side of the island. The only other point of interest about the pools lies in the fact that their sides are perpendicular, being held up by living *Porites*, *Madrepora*, *Stylophora*, and *Heliopora*—the corals which, in the dead state, form the boulder-zone.

The whole shoal is doubtless growing seawards by the extension of its talus slope; but the outward growth of the surface-reef appears to be considerably impeded by the dense *Cymodocea*. The latter, on the shore-flat, prevents loss and diminishes the force of the waves so materially that their effect on the coast behind is comparatively small. Indeed it is now only noticeable for a mile at the south end and for a mile northwards from opposite the settlement, where there are extensive formations of beach-sandstone. At the north end of the latter area, where there is a turtle-pond, the sandstone extends diagonally halfway out upon the reef, which in this position is a third of a mile across. This points to the washing away of the island having been responsible for much of the shore-flat. Further, this view is supported by the fact that the beach everywhere is formed of sand without coral-masses, whereas similarly-situated coral-islands are to seaward invariably composed largely of coral-rock or masses of corals. Otherwise it is necessary to suppose that Coetivy is an island of different formation to the Maldives and Chagos, a quite possible view. To the north the beach was interesting in having cliffs formed of dead *Cymodocea* piled up to a height of ten feet and more above the flat.



The west reef, where it exists, has a yet gentler slope than the eastern, on account of the shoaling of the lagoon. It is almost bare of grass, and hence supports more coral, though there is practically no *Heliopora*. Its edge, boulder-zone, and shore-flat are more marked; and the island behind shows in places rather more loss, as is evidenced by many fallen coconuts and other trees.

Not until the collections have been worked out can we give any adequate idea of the fauna and flora of the reef. Most animals were obtained by turning over the corals, and all groups seemed to be more abundant in species than in the Chagos, the Holothuria being perhaps an exception. In Turbellaria and Nudibranchs this great superiority was most noticeable, and even in corals, which we did not attempt to collect, it appeared richer. The dominant species of Sarcophyta, white in the breakers of the east side and purple in those of the west, with yellow incrusting species behind, were not the same as the Chagos forms; and wide differences were noticeable in other groups of animals. Indeed the Chagos resembled the more barren Maldivian reefs, while here there seemed to be a new type of reef altogether. Of course this is partially due to the *Cymodocea*, but there is much more green algal growth generally.

The land is entirely formed either of loose sand or of sandstone (tuffe). Until the specimens are examined carefully, it is impossible to speak definitely of its composition; but we could see no reason why it should not all have been thrown up by the waves and by the wind. Generally its surface is about 10 feet above the high-tide level, and when broken into, as is always done when making pits for coconut-planting, there is found a thickness of 1 to 3 feet of tuffe overlying loose sand. There is a sand-ridge round the east side of the island, generally about 50 yards back from the beach, but becoming rather irregular in the north half, where it lies more inland; it averages 15 to 40 feet high, and culminates at the south in a hill of about 50 feet. Round the north end it is also well marked, and there is in the centre of the island, halfway from the Settlement to that end, a larger dune of upwards of 75 feet high. Low damp areas of land of only 5 feet above the high-tide level are found behind the north point and in two or three other positions; they are notable for the luxuriance of their coconut and other vegetation. The Settlement stands on such an area, separated from the tuffe-land behind by a pool of fresh water, 150 yards long by 50 yards broad, the home of many dragon-flies.

The character of the vegetation was the same as that which we found in the Chagos Archipelago on similar, dry, sandy and tuffe lands. It consisted of low bush formed mainly of *Scaevola* and *Erythroxylon*, the former with thick succulent stems and leaves like the laurel, and the latter with tiny leaves, yellow flowers, and stems covered with mossy lichens. The ground between was mainly covered with isolated plants of a low rush, while struggling clumps of the hairy-leaved *Tournefortia* and of the thinner-leaved *Pisonia* were found here and there. Probably there were not 20 species of plants altogether on this kind of land, but the lower patches yielded a more considerable variety of species. These, when compared, turned out to be almost precisely the same as those obtained from the Chagos. This was to us a source of considerable astonishment, because, from the island being so much nearer to Africa, to Madagascar, to the Seychelles, and to many other islands which might serve as stopping-places from the more distant

lands, we had certainly expected to find a considerably greater variety of plants. Actually we catalogued 92 species as against 85 at Ile du Coin, Peros, the increase being mainly due to rather more plants of cultivation. The only new group of trees were the vacoa (*Pandanus*), of which, though formerly very widespread, there were left only two clumps. The badamier (*Terminalia Catappa*), with its almond-like nuts, was certainly indigenous, whereas it has possibly been introduced into the Chagos. Finally, the gayac (*Afzelia*) was the only absentee that our lists show among the indigenous trees of the Chagos.

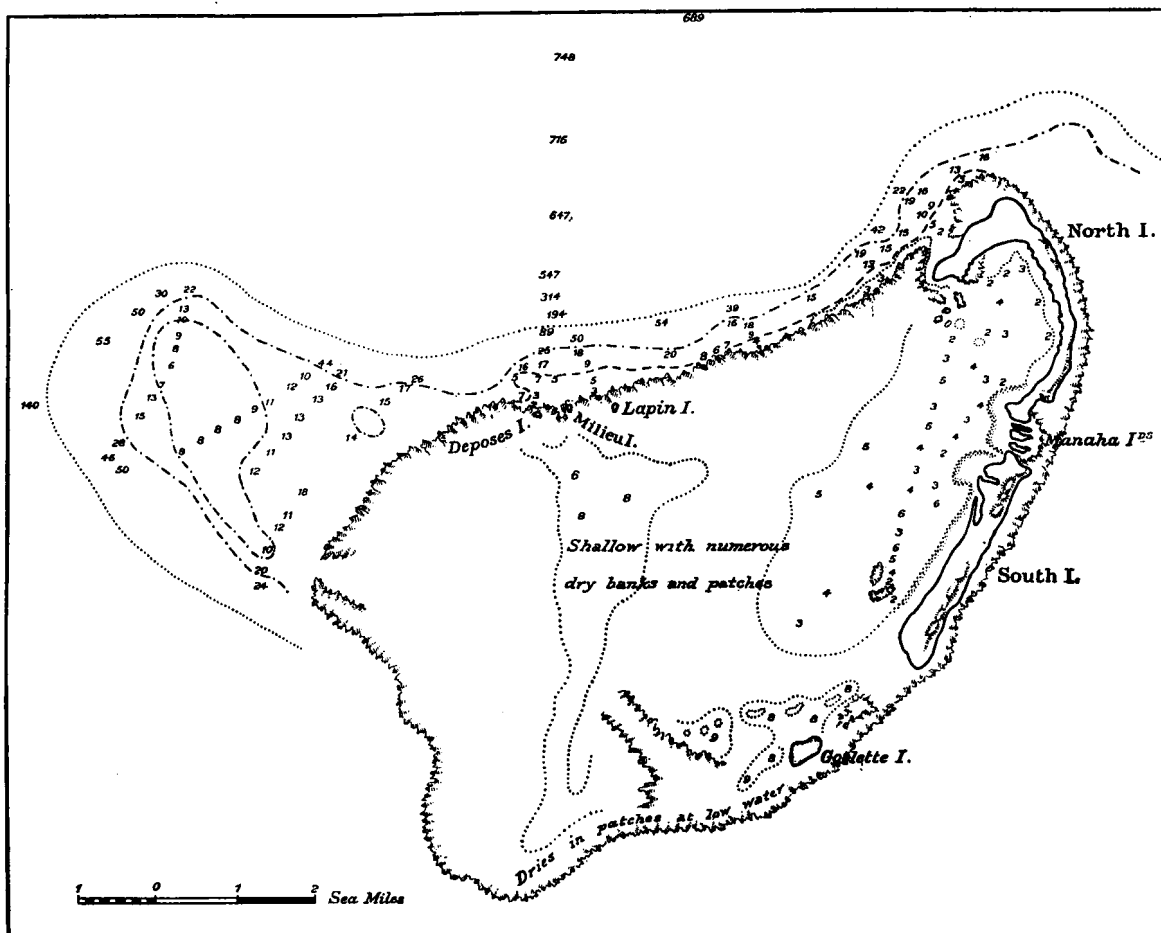
The animals of the land so largely depend, either directly or indirectly, upon the plants, that their general character follows that of the flora, and so they scarcely differ from those found in the Chagos. Some of the land, which seemed to have been at some time or other a breeding-ground for birds, gave a few new beetles, and the large *Hernandea peltata* trees had some new Hymenoptera. The freshwater pool behind the settlement gave four new insects, while it also contained dragon-fly larvæ. In it were found also a few Ostracods, but there did not seem to be any of the Protozoa and Rotifers that might be expected. There was only one land-mollusc, while even in the most distant of the Pacific islands one generally finds several species. Molluscs were similarly rare in all the coral-islands we visited. Probably they seldom cross wide stretches of sea except by human agency, and these islands have become inhabited only quite recently. Another explanation might be that the Madagascan and African shore-forms that can live on the plants of these coral-islands are scarce and few in species; but although we are not acquainted with their molluscan faunas, this scarcely seems probable. Of land-crustaceans, the robber-crab (*Birgus latro*) does not occur west of the Chagos, but the other forms are the same. The vertebrates, too, are the same, with the addition of an introduced partridge. There were also two males of the tortoise (*Testudo elephantina*), which had been brought from the Seychelles many years before; they are sluggish animals, living on succulent plants and roots, hiding themselves in the densest bush by day and coming out to feed at dusk.

We weighed anchor at dawn on Monday, Sept. 25, and steered a straight course to a point halfway between Farquhar and Cape Amber, the north point of Madagascar. Soundings were taken at intervals, of which one, at 1650 fathoms, in spite of no bottom-sample being obtained, was interesting, as the general depth was over 2000 fathoms. Serial temperatures down to 400 fathoms were also recorded, the most rapid fall taking place between the surface and 50 fathoms in the more northern observations, and between 50 and 100 fathoms in the southern. The lowest bottom-temperature was 33.9° at 2438 fathoms, on a bottom of globigerina-ooze\*. On Wednesday, being about 12 miles south by east of Farquhar, we took a series of tow-nettings: firstly, a series of nets on one wire from the surface to 800 fathoms; then our large net, which had not been used since its mishap off Mauritius, drawn vertically from 1000 fathoms to the surface, followed up by six hauls of the Fowler vertical closing net at various depths down to 1000 fathoms. Unfortunately, as the day wore on, the wind and swell

\* The position of these soundings can be easily followed out on the chart (Plate 1).

increased so much that two of the latter were failures. There were strong under-currents affecting the net, and as, in addition, the ship was to a certain degree being drifted by the wind, manipulation on the wire was consequently difficult; the result was that the wire streamed out at a slight angle, and both sets of catches for opening and closing the net were sprung by the first messenger. The collections were very rich in all forms of life—Crustaceans being represented by large dark red prawns and Schizopods, large transparent Phyllosoma and Stomatopod larvæ, as well as by Amphipods, large *Phronima*, and by a variety of Entomostraca, particularly Copepods;

Fig. 36.



Farquhar Atoll (after the Admiralty chart, with corrections by H.M.S. Sealark).

Mollusca by a few Gastropods, at least a dozen species of Pteropods, and *Atlanta* as representing the Heteropods, the genera without shells not being caught so far south; the Cœlenterata were, as usual, represented by Medusæ, Ctenophores, and Siphonophora, with an occasional Actinian; to Tunicates should be credited deep-living *Pyrosoma*, *Appendicularia* in gelatinous houses, and Salps; there were also immense *Sagitta*, a few Chætopods, mostly *Tomopteris*, some Turbellaria, and a few *Amphioxides*. Fish, as is usual in such deep hauls, were represented mostly by a few eggs and larvæ, notable among the latter being the Leptocephalid larvæ of eels with phosphorescent

spots arranged in a looped series of depressions along their narrow ventral sides. Among the adult fish were *Argyropelecus affinis*, a known form allied to *A. sladeni*, the latter a new species secured in the Chagos from 400 fathoms; *Melanostomias valdiviæ* was also taken, an elongated little fish of blue-black metallic appearance, with two rows of phosphorescent spots segmentally arranged along its lateral line and near its ventral surface, and a long barbel with a phosphorescent bulb below its rather lantern-like heavily-toothed mouth.

On the following morning we were in the middle of the passage between Farquhar and Cape Amber. A sounding gave 1818 fathoms, a previous one to the north having given 1858 fathoms. Further south, near the Cape, there were already two soundings of 1478 and 1750 fathoms, so that it was obvious that there could be no close connection of the islands to Madagascar. Here Capt. Somerville swung the ship for variation, finding that the compass pointed  $8^{\circ} 38'$  west of north, a variation of  $8^{\circ} 38'$  W. This was interesting as being nearly the same as that which he found off Mauritius, nearly  $10^{\circ}$  to the south, while in almost the same latitude east of the Saya de Malha Bank he got  $4^{\circ} 59'$  W.\* Probably the difference was due to purely local conditions, perhaps the large land-mass of Madagascar, or perhaps some peculiarity of the rock beneath the sea. In respect to the latter, it is interesting to remember that the variation (not only horizontal, but also vertical) was especially carefully examined at Funafuti by Capt. (now Rear-Admiral) A. M. Field, with a view to finding where rocks, other than limestones, most nearly approached the surface, so that if possible a boring might be made on the spot. The results were encouraging, but the conditions were such that the lagoon-boring had to be made elsewhere. It will be obvious, though, that any future boring should be preceded by a proper magnetic survey of the atoll selected.

On the afternoon of the same day we sighted Farquhar, passing round on the west side of its reefs to our anchorage just outside the passage round the west point of North Island. The bank has no land to the south-west, and of six little islands to the north-west which existed in 1878, only three are now found, the others having been gradually swept away. To the south-west we saw upon the reef the wreck of the 'Hardwick Hall,' and to the north-west that of the 'Aymestry,' two fine steamers, victims probably of the strong currents or of the peculiar variation in this part of the ocean. To the north-west we passed over a shallow bank, where the 100-fathom line extends out for four or five miles from the surface-reef. We had leadsmen in the chains, and for three miles the bottom, varying from 7 to 12 fathoms in depth, was clearly visible. It appeared to consist almost entirely of bare white sand or mud, with patches of weed and soft corals, only one clump of true reef-building coral being seen at a depth of 47 feet as we passed off its northern edge.

We remained at Farquhar for three days, during two of which Cooper with Mr. Alexander went to examine and to run a section of South Island, while Gardiner ran a section off the reef to the north and examined North Island. The third day we

\* These facts illustrate the value of such observations to navigation. The variation also changes slightly year by year, and probably it would repay maritime nations to employ vessels constantly on this work.

both devoted to the lagoon and reefs, but did not attempt to collect over them. Fletcher and Dr. Simpson were indefatigable in collecting the land-animals and plants, and we ourselves also secured a large number of specimens. Every night while at anchor near the passage we put out plankton-nets each hour. The spring-tides were then running, a fact which makes these collections especially valuable as indicating to some degree the extent to which mud in suspension is carried out of the lagoon. The atoll was partially planted about 20 years ago by Capt. Spurs, but recently the whole has been bought by Mr. Souchon of Mauritius, whose manager, Mr. Rey, received us most cordially and gave us every facility at his disposal. South Island was still untouched,

Fig. 37.



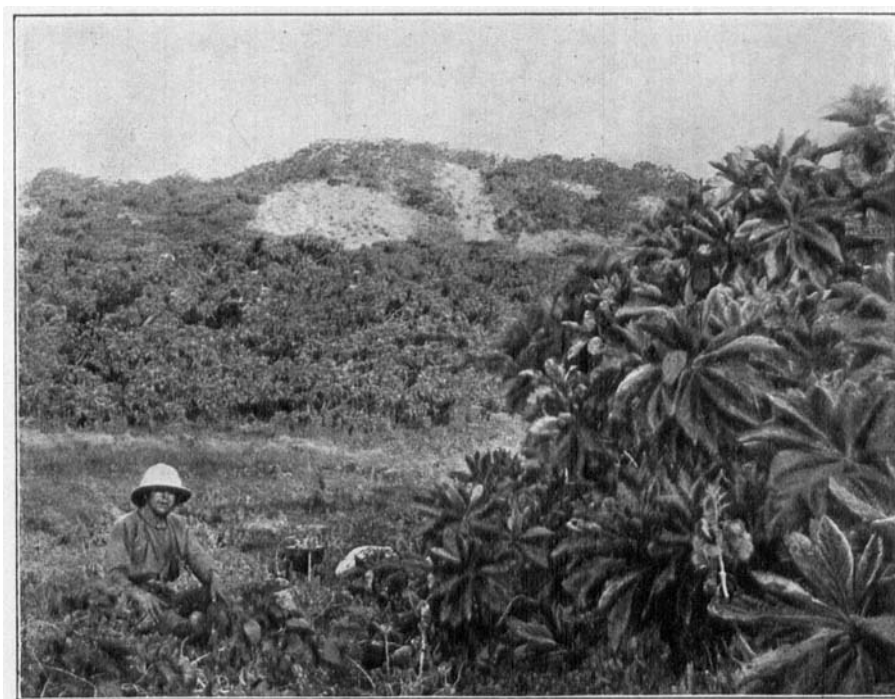
View looking east from top of dune on South Island, Farquhar.  
Observe reef-flat, sand-shore with clumps of *Pempsis* and *Scaevola* in foreground.

so that its flora should, perhaps, be more particularly considered later on. The coral-formations in view of Aldabra, Cosmoledo, Assumption, and Astove, which lie to the west on about the same line of latitude, will likewise receive a more special description.

The general character of Farquhar may best be seen by reference to the chart (fig. 36). Its special feature as compared with other atoll-banks was the peculiarly restricted and shallow nature of its lagoon. Indeed, it only consists of pools of water varying up to 8 or 9 fathoms in depth with bare sandy bottoms, having here and there isolated masses or shoals of coral-formation. The greater part reaches the low-tide level and is covered with sand, having the same grass-like weed (*Cymodocea*) found at Coetivy. This part is joined to the northern reef-edge (which is quite similar to that off other coral-reefs) by an area of great heads of *Heliopora*, with crevices of 1 to 3 fathoms deep, the whole

area resembling somewhat the tidal pool found in the main island at Funafuti before its elevation \*. The land, once probably much more extensive, is now almost entirely of sand formation, with dunes varying up to 75 feet in height. Probably, as suggested in the 'Admiralty Sailing Directions,' it practically owes its existence to elevation, but the evidence on the spot was not very clear. Although the islands are so close to Madagascar, the plants were again the same as those at Chagos and Coetivy. The coconuts of North Island had been nearly all blown down by a hurricane in 1893, but were still growing, having bent up through an angle of  $90^{\circ}$ , leaving 10 to 15 feet of their stems lying prone on the ground. Near them were great groves of *Casuarina*, and some of the land had been cleared for maize. The land animals of course followed the

Fig. 38.



Sand-dune on South Island, Farquhar. *Tournefortia* bushes to right.

plants, doves (*Turtur picturatus*) being additions near the settlement and brilliant green lizards in the groves of papaya which had run wild in North Island.

The islands have a population of about 130 people (56 males), all settled in a single village near the anchorage. They work partially on the coconut-plantations of the north half of North Island, which they are extending, but go out also in pirogues for fish and turtle. Formerly the latter were very abundant, but now are gradually decreasing in number. No doubt they are preyed on by sharks and rays to a considerable extent, but their greatest enemy is man, who kills them just as they come up to breed. According to the manager, Mr. Rey, the shelled variety often returns to the same spot on the beach three or four times before it lays its eggs, and few escape after the second

\* *Vide* Gardiner, *loc. cit.*; also "The Atoll of Funafuti," Trans. Roy. Soc. (1904).

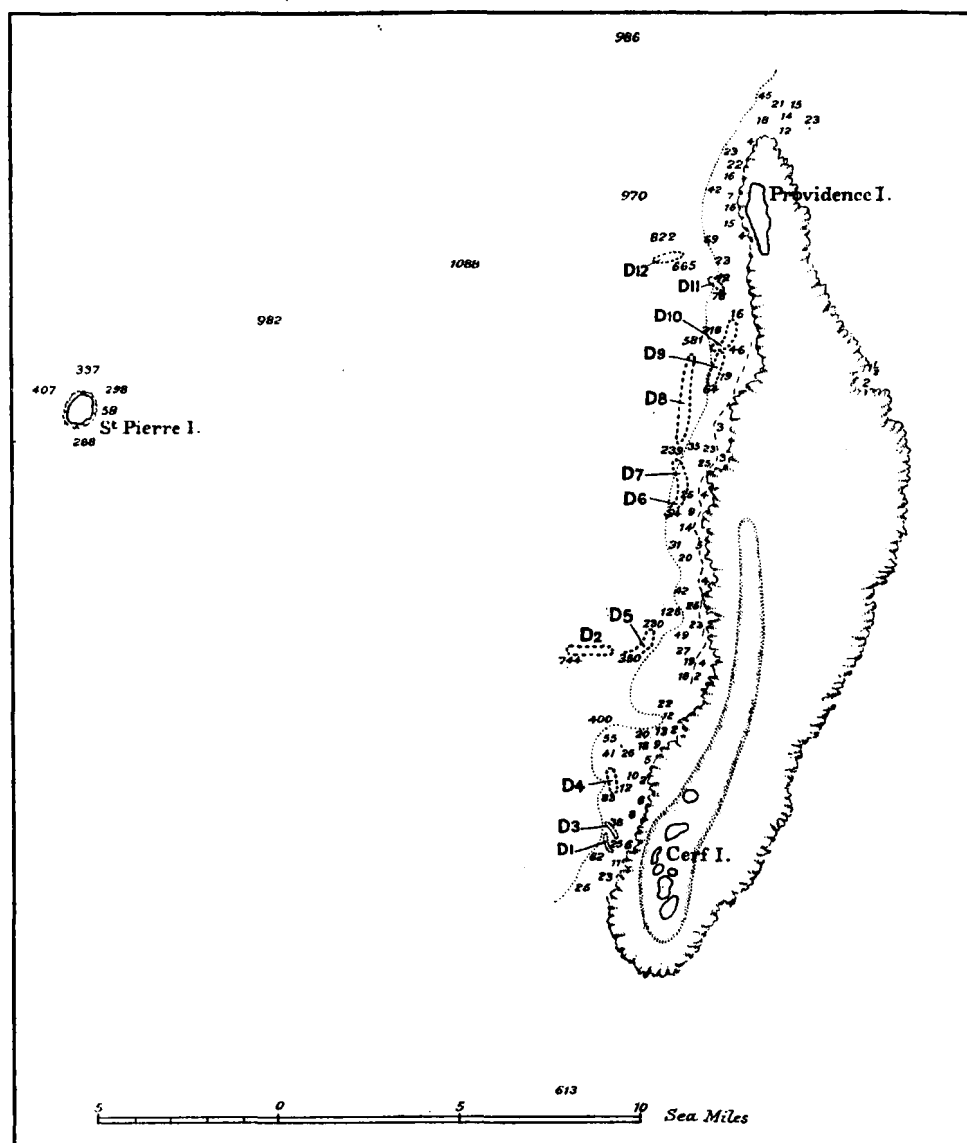
visit. The adults also remain for some weeks on the bank browsing on the "grass," and here again they are open to attack. After laying their eggs they disappear and are said to go off to sea; but this is doubtful, although we did meet with isolated animals far from any land or reef. At present new areas are being opened up and a fair supply of shell is still obtained for commerce. Sooner or later the shelled form will have to be preserved and its young looked after in its early stages, or even grown up to profitable size, which fortunately is an easy matter.

We were asked to look at another organism of possible economic value, the black-lipped oyster (*Margaritifera margaritifera*), the shells of which are used largely for buttons and inlay work. They are found scattered over the whole of the lagoon with isolated specimens on the reef. In the latter position they often get so grown over by corals and other growths that they become part of the reef itself, just capable of opening their shells sufficiently to allow a current of water to be created by their gills to bring them food. In the *Cymodocea* they do not flourish, the only specimens found there lying loose upon their sides and having their shells almost clean. As their normal position of attachment is with the free edges of their shells upright, they certainly owed their presence there to currents, which had carried them off certain barer areas where they seemed to flourish. These areas were mostly patches, where the *Cymodocea* seemed unable to root itself properly on account of the ground being relatively hard, owing to abundant stones in the mud; these gave points of attachment for the oysters, which were upright, firmly attached, and healthy, in spite of being overgrown by every kind of sedentary organism to be found on reefs. Most of the shells were bored into by algæ and sponges; some showed quite arborescent growths through the nacre, but in few was it really damaged. A few pearls of small value were found in some, but this is a point of little importance, as their value in this type of fishery is only about a fifth of that of the shells. So far as we could see, fine sand appeared to make but little difference to the oysters. The real reason why they were not much more abundant appeared to be that their spat could not find fixed objects for attachment. It seemed to us to be due to the greater ease of attachment that we found the oysters in areas free of grass. Indeed, we are inclined to suggest that artificial areas for attachment might be erected and certain pools marked off and kept expressly for spawning. The chief enemies of the spat are rays, but this danger could be probably overcome by taking large spawning shells into one of the barachois of South Island and keeping them there surrounded by hurdles, on which the spat might affix itself. For this purpose the barachois might have to be barred up, as is done for fish-preservation in Diego Garcia, where we also found specimens of the black-lip shell. Subsequently the hurdles would of course be transferred to the main lagoon of the atoll.

We left Farquhar at dawn on Oct. 2 for Providence reef, about 40 miles to the north (fig. 39). On our way we took serial temperatures down to 400 fathoms, and sounded in order to fill some blanks on the chart, getting depths of 867, 890, 876, and 613 fathoms on a bottom formed mainly of broken coral and shell. The same evening we anchored to the south-west of the bank, and spent an uncomfortable night on account of the swell which came sweeping round its end. Plankton-nets were placed

out, but the water, which passed through them, had come over the reef and was almost bare of life. The whole bank has much the same appearance as the main bank of Cargados Carajos, but is less convex to the east and has no off-lying reefs or shoals. It is 24 miles long in a north and south direction by 5 miles at its broadest part. To the north is a single island known as Providence, richly planted with coconuts and

Fig. 39.



Providence and St. Pierre (after the Admiralty chart, with additions by H.M.S. Sealark).

D 1-12, dredgings of H.M.S. Sealark. (The Cerf Islands are not corrected.)

having a settlement of workmen from the Seychelles. At intervals are sandbanks along the western half of the reef, mostly covered over at high tide, culminating to the south in eight sandy islets known collectively as Iles aux Cerfs.

The following day Cooper dredged off Iles aux Cerfs, while Capt. Somerville, Gardiner, and Fletcher landed, the first to secure magnetic observations both for variation



(declination) and dip (inclination). The reef in this position is about 3 miles broad, of which the islets and sandbanks occupy the central mile. Six of them lie in a line in the western 700 yards of this area, with spits and sandbanks to the east, in which direction also lay two other islets separated by narrow channels. All consist of sand formed largely of foraminifera, *Orbitolites* being very prevalent. With this is a large quantity of *Cymodocea*, which forms low cliffs to the east. These islands are nowhere more than 4 feet above the tide-level, their sand being too heavy to be much wind-blown. In some islands there are pools shut off from the sea by sand piled up along their eastern sides by storms, to which, indeed, the islands probably owe their origin. To the west they have steep beaches and are perhaps gradually wasting away. Except for its greater breadth, the east reef was the same as the east reef of Coetivy. The west reef was likewise similar to that on the west side of Coetivy, but supported less life and had a still less marked seaward edge. Seven of the islets had vegetation very similar to that of Cargados, 19 plants being recorded, of which the coconut and *Casuarina* were introduced forms: in most it was very patchy, only the two eastern islets being at all well covered, a gorgeous *Hibiscus* and a bean giving pleasing patches of yellow. Grey herons (*Ardea cinerea*) were breeding in numbers on the taller *Scaevola* clumps, forming large nests of twigs, each with three light blue eggs. On one island was a curing-station for fish and turtle, then uninhabited, round which we got a few beetles, the only other insect-life consisting of three kinds of moths and a similar number of cockroaches.

Cooper's dredging did not at first sight seem to be a great success, but the most important haul of the cruise was certainly taken on that day. A start was made in a direction west from the reef with the idea of running a line of dredgings to ascertain the depth and the nature of the bottom on its slope. The second haul with a rather large and light trawl failed to reach the bottom on account of the strong under-current setting outwards, and on the third our largest dredge was lost, probably meeting some rock. In the fourth, let down in 744 fathoms and travelling westwards, a weighted trawl was used and secured about half a ton of rocks and mud. The latter was in sticky, semi-consolidated masses, and appeared to be largely formed of ash. The stones were of three kinds: (1) manganese nodules, formed round nuclei of mud; (2) consolidated mud; and (3) a few pieces of coral-rock from the reef above, coated with manganese. All are now in the able hands of Dr. Flett, and will, we hope, form the subject of a special report. The dredging was a very peculiar one, because round coral-islands the bottom is invariably covered at such a depth with masses of coral-rock or with coral-mud. Off the coral-atolls of the Pacific Ocean there would certainly be a soft deposit, into which a sounding-tube would be driven for several inches. That a large quantity of mud is formed off Providence was obvious to us from the milkiness of the water, and we can only conclude that its absence here was due to strong under-currents, either directly outwards from the reef or passing along the same. This view was supported by most of the rock coming up with a polished surface, to which were attached worms and hydroids, belonging to forms which do not exist on mud. Another interesting feature was the fact that the manganese of one of the nodules was 1 to 2 inches in thickness, proving that it must have lain exposed on the bottom for a long period of time. It is premature,

perhaps, to suggest that here we have secured specimens, exposed by under-currents, of the mound on which Providence is situated, and that we have possibly obtained the first definite evidence of the nature of the foundation on which a regular and typical coral-reef has come into existence.

On Oct. 4 we put nine dredgings down to 200 fathoms along the western side of the reef up to Providence Island, off which we anchored for the night. Our hauls in 200 fathoms were abortive, proving only the barrenness of the ground. Then on going into about 75 fathoms we secured a fine series of Alcyonaria with a few solitary corals and other sedentary animals. In addition, at 50 fathoms flat incrusting calcareous algæ (Squamariaceæ) were common. The colours of the Gorgonians were striking, as were also the perfect adaptations to them of the ophiurids, crinoids, and crabs that live on their branches. The slope had no "steep" such as one usually finds off coral-reefs, but fell very gently to 20 fathoms and then rather more steeply to over 300 fathoms. Foraminiferal sand was secured above 25 fathoms and coral-mud below 50 fathoms, both with masses of coral-rock. Finally, on the following day we ended up with a dredging off the north-west of the reef in 665 fathoms, securing two species of prawns, and a manganese-covered corner off a large mass of coral-rock, on which we were caught up for some time \*.

We next sailed to St. Pierre, which lies 17 miles to the west of the Providence reef, getting on the way a sounding of 1088 fathoms (fig. 39). From the sea St. Pierre presents an appearance remarkably like one of the Tongan or Fijian raised coral-islets. It is surrounded by perpendicular or overhanging cliffs, varying up to about 30 feet in height. A sandy spot to the north-west allowed us to land with Capt. Somerville. As we went ashore, we passed over a flat of about 40 yards in breadth, formed of bare coral-rock and sand with patches of sponges and Alcyonarians. On landing we examined first the rock, and found it to be perfectly solidified and consolidated all over the island, and to consist mainly of corals bound together by sand. The corals were of the regular reef species, with much *Favia* and *Madrepora*. A great part of the rock, especially near the surface, is very crystalline, masses of clear crystals often radiating from the coral-branches. Much of the sand between was hardened into rock and reddened by guano and humus, some of it being very rich in phosphates, while the soil above consisted mostly of guano and vegetable mould †.

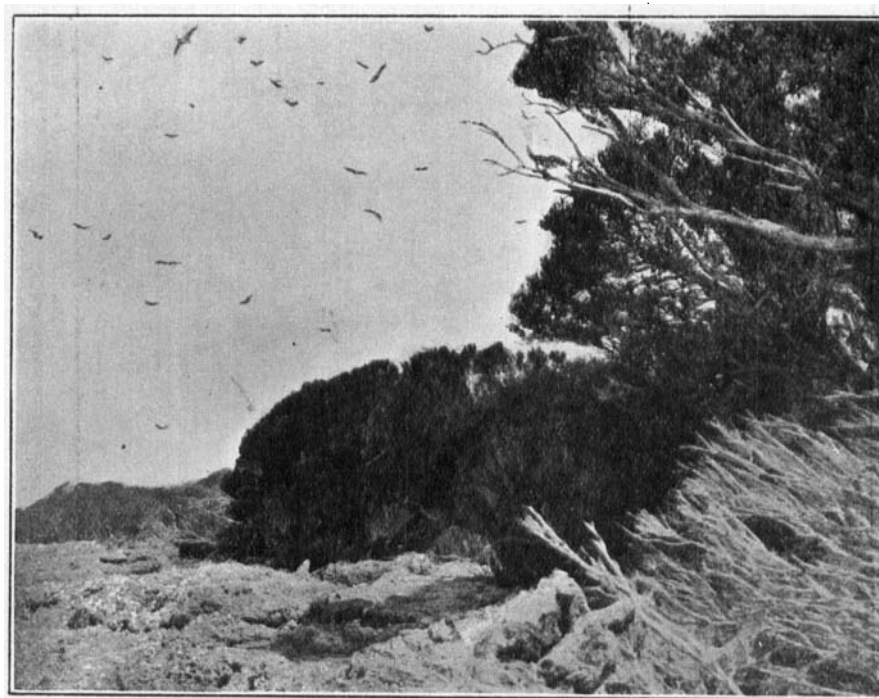
A closer inspection confirmed the existence all round the island of cliffs, with caves driven in underneath for 10 to 25 yards. All the rock near the sea is pointed and pitted, showing that it has been weathered greatly. Its maximum height above the sea is about 40 feet, and this, added to the difference of tides (about 8 feet), gives 48 feet definite elevation. If to this we add loss by rain, erosion, &c., we cannot suppose the

\* Providence, like all the islands except Farquhar, Coetivy, and Cargados, is under the Seychelles Government. The island belongs to an Indian firm in Mahé and is under a half-caste manager. The coconuts are too closely planted for the greatest profit. According to Horsburgh (*loc. cit.* p. 124), even a hundred years ago it was covered with coconuts and other trees.

† St. Pierre has been taken in hand since our return to England and is now being regularly exploited for guano, of which it is supposed to have about a quarter of a million tons of payable quality.

elevation to have been less than about 80 feet. The island, however, proved to be decidedly lower in the centre than on the sides, indeed quite basin-like, with its highest points on the rim, about 20 yards back from the cliffs. Further, there is a shelf at the low-tide level of 40 to 60 yards in breadth, which we can only regard as having been formed by the action of the waves on the land behind. This gives an additional diameter to the island of 100 yards in any line, and it may be that some of its higher parts have been removed. In fact, before elevation we could picture an atoll about a mile in diameter, its rim awash, enclosing a small lagoon of at least 5 to 6 fathoms in depth.

Fig. 40.



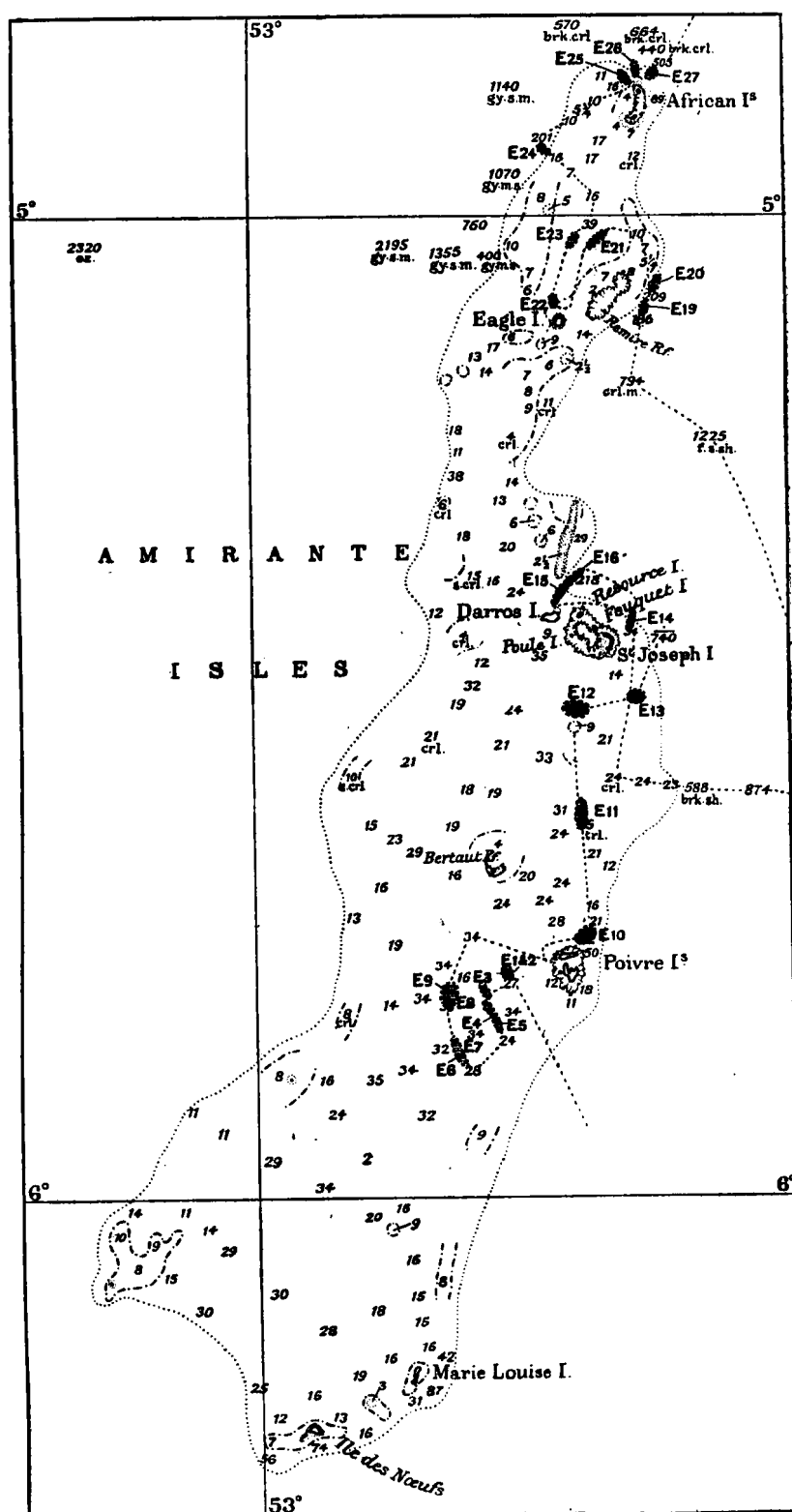
View on the shore at St. Pierre.

Rough coral-rock with bushes of *Pemphis acidula* and boobies (*Sula piscator*) overhead.

At most parts the cliffs are crowned with old gnarled bushes of *Pemphis* (fig. 40). Inside is a dense mass of small trees—*Hibiscus*, with masses of red flowers; *Pisonia*, with stunted stems never able to reach above the general level of 20 feet or so; and the tanghain, the famous poison-tree of Malagasy natives. The latter presented an extraordinary spectacle as of a forest of bare stems; it is completely deciduous, while most tropical trees gradually lose and replace their leaves. Other plants were of the regular species which can stand the guano. Of birds, the booby (*Sula piscator*) was breeding in every tree, an immense guano-forming colony.

After steaming around St. Pierre and sounding on each side, proving only the existence of particularly steep slopes, we proceeded to run a line of soundings to Alphonse, which with François and Bijoutier forms a little group, 150 miles to the north of Providence. Unfortunately at the second sounding the machine which we were using, an old one on the starboard bow, split one of its sides off when reeling in after a sounding

Fig. 41.



Amirante Bank (from the Admiralty chart).  
E 1-16 and 19-27, dredgings and course of H.M.S. Sealark.

of 2170 fathoms, 44 miles north of Providence reef. As the machine on the port side of the Sealark had broken down earlier in the cruise, this accident left us dependent on a small hand-machine situated aft, and we were obliged to abandon all further deep sounding for ten days, being meantime severely handicapped in dredging on account of the slow rate of sounding. At the time it threw some hours on our hands, since we did not wish to arrive in the night, and so enabled us to take a few hauls of the pelagic fauna in spite of the heavy sea running. We arrived at Alphonse on Oct. 7, and as we expected to spend Sunday, Oct. 8, there, did not go ashore. Mr. Alexander and the doctor, however, went off in a steamboat, bringing us back specimens of its rocks. It was fortunate they did so, as our first anchorage to the south-east proved so dangerous that we had to shift, losing an anchor in the process owing to the rough nature of the bottom. Our second position in the passage to the south between Alphonse and Bijoutier was no happier, as, when the tide began to turn between 5 and 6 o'clock, we experienced a rapid change of current. It was preceded by a series of short, steep waves, twice repeated, which, had it not been for the coxswain, would have swamped the steamboat, at that time made fast to the boom. We let out more cable, but soon began to drag; finally, as darkness came on, we drifted into deep water to the east, where we lay-to, steaming dead slow head to wind, as we wanted to swing for variation in the morning. It was a disappointment, but the rocks secured left no doubt but that Alphonse was simply a sandbank, probably of wave and wind formation. Bijoutier and François were similar, and there were other banks awash on their reef. Within the reef to the south of Alphonse Mr. Alexander found a large lagoon of 6 to 7 fathoms in depth, and the half-caste manager of the island, who came off to us in a pirogue, confirmed the existence of a similar lagoon between Bijoutier and François. The islands belong to the same firm as Providence.

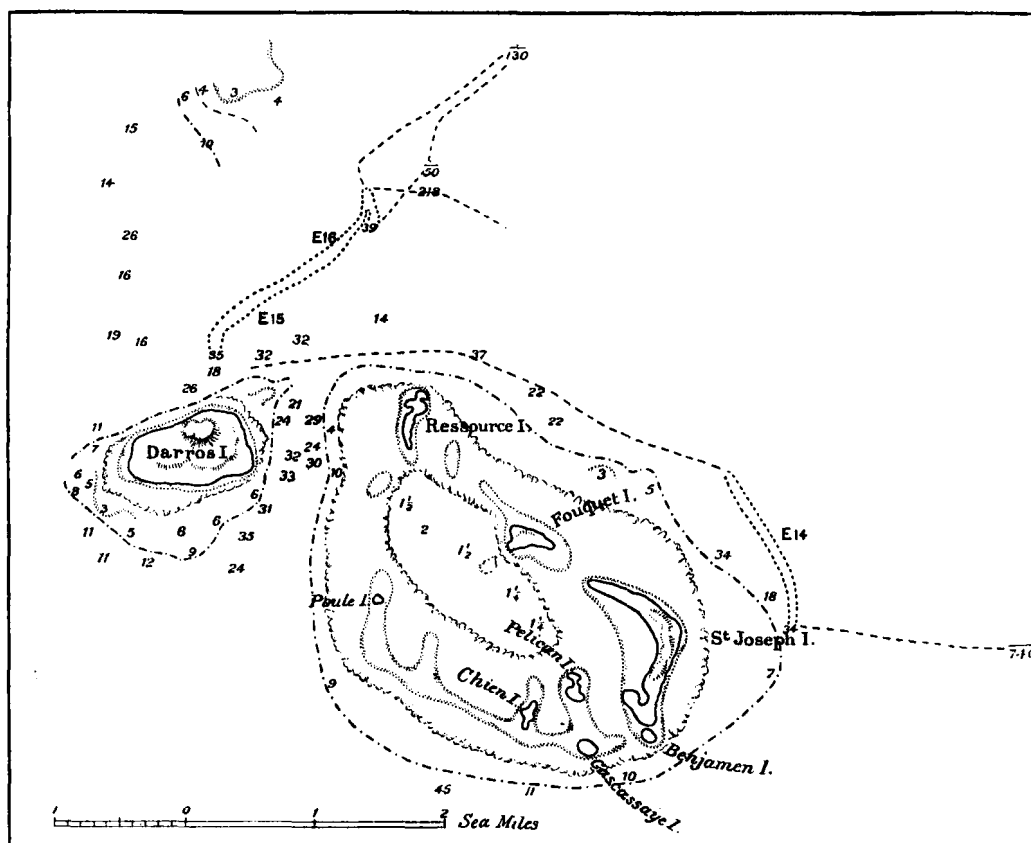
At dawn on Oct. 9 we found ourselves to the south of Poivre in the Amirante Group, having decided to avoid Marie Louise and de Neuf, its southern islands, owing to their lack of suitable anchorage, the only one offering any protection having been ruined by a guano-steamer, which took fire and foundered. That day was devoted to dredging on the bank, mostly in about 30 fathoms, the ship finally coming to anchor in the evening off Poivre Island (fig. 41; see Pl. 18).

In the morning we went ashore with the doctor and paymaster, passing over a shallow stretch to the north-west of the island, mainly sand with patches of weed and a few coral colonies. To the north of the northern island we found a rather tortuous passage to the settlement over a broad reef. It was low tide and we wandered over the flat, examining a series of rocks, which extended along in lines more or less parallel to the present shore. They were all of sand and coral formation, reddened by guano and partially recrystallised. No doubt they were once part of the island, which must in this position have lost a breadth of upwards of 100 yards. At the base of one rock we were interested to observe a large stickleback (*Fistularia*), which was darting in and out of the rock, using its pipe-like mouth for seizing the worms as they pushed out their heads. The settlement behind was of the poorest description, under a half-caste, though the islands were as rich in coconuts as any we saw on the cruise. The whole was overshadowed by a high clump of

bois blanc (*Hernandea peltata*), while casuarinas grew everywhere along the shore. Under the coconuts was a pleasing undergrowth of papayas, acacias, castor-oil plants, and ferns, the first occurrence of the latter in any abundance since leaving the Chagos. The land was all formed of loose sand with some coral below, its surface being hardened for a few inches into stone, called *pavier*, a variety of tuffe.

While the tide was still low we passed to the southern island over a sand-flat, singularly barren save for vast numbers of the black teat-fish, one of the best of Holothurians for making trepang. As we were caught by the tide, we necessarily had time to thoroughly explore the island, finding it in structure little different to its fellow.

Fig. 42.



Darros and St. Joseph Atoll, Amirante Group. E 14-16, dredgings of H.M.S. Sealark.

It consists of three finger-shaped points tapering to the north with deep bays between, and was formed probably by the heaping-up of three sandbanks successively from east to west, a fourth at the south subsequently connecting them. The westward bank is still broadening on its somewhat narrow reef, while the eastern is washing away, having to seaward a broad reef-flat covered with masses of rock (dipping to the west) and loose corals worn out of the same. Probably these about balance, while elsewhere there is little change, though the sand has consolidated into rock near the entrances of the bays. Marine life was everywhere scarce. A solitary mangrove was growing in one of the bays, the sole attempt on the part of this plant to establish itself on any of the coral-

islands we visited, though there are great groves in the Maldives. Land-collecting with the sun overhead was tiring work and monotonous, as there were the same classes of animals and plants as found in all the other islands, our only unusual forms being a land-shell of microscopical size and the green lizard previously obtained at Farquhar.

After a successful day's dredging on the edge of the bank, we anchored to the north of Darros, remaining for two nights. This island, about a mile in length, is a mass of sand and small fragments of coral, piled up by the waves almost to the edge of an oval-shaped reef. To the north was a low casuarina-covered dune, on which the settlement was placed. Against the sea was a thick belt of the usual scrub with a few small coconuts behind; inside it had evidently been burnt. "A thirsty and dry land where no water is."

St. Joseph, which is separated from Darros by a channel of about 4 cables breadth, was a day's excursion. It is an oval-shaped atoll about  $3\frac{1}{2}$  miles long by 2 broad, with eight islets on its rim; the lagoon is a pool in the centre with 1 to 4 fathoms of water,  $1\frac{3}{4}$  miles long by  $\frac{3}{4}$  broad, surrounded by bare muddy flats leading to the lands. We went off in the steamboat, but had to crowd into the skiff, the passage not being sufficiently deep for her to enter. Crossing the west reef, we found outside a certain amount of branching coral and coral-heads, with much weed, sponge, and soft corals. This gradually merged into the reef, which at its very indefinite edge was a mass of grass (*Cymodocea*) holding the sand together at its roots. Its surface behind was all grass up to the lagoon, with sandy pools of 3 to 6 feet deep, their sides held up by roots. It resembled that of Farquhar and Coetivy, but with *Cymodocea* still more dominant.

The islands could all be visited from any point by wading. They were all sand merging into similar reefs outside and mud-flats within. The first one visited was Fouquet, which we could see was washing away on its lagoon side. It was planted all over with coconuts, but the most remarkable surface-feature about it was the extraordinary quantity of small cockle-shells everywhere, even forming up to 50 per cent. of its outgrowing seaward shore. A vast number of black "foquet" (*Puffinus tenuirostris*) had made it their home. They build their nests in the ground, sometimes under heaps of coconut-leaves, but more often in oval burrows excavated in the sand, which they make by scraping with the feet, the curved beak assisting by digging and pulling out roots and small stones. The end part is rather more hollowed out, and in it a single white egg is laid. The bird will not leave easily; when disturbed it rushes over the ground with wings outspread, but does not rise until at the edge of the beach, where it can get a good "take off."

Wading to St. Joseph Island we made a detour to avoid the current-swept channel around its east end, where the settlement is placed. On our way we picked up several black-lipped mother-of-pearl shells, and large numbers of tiger and other cowries, which were in great demand on board. We then zigzagged along St. Joseph, which has no hills or dunes such as were shown on the chart. It was formed of sand, as, indeed, were all the islands, with small coral- and shell-fragments piled up by the waves, no part being more than 6 or 7 feet above the high-tide level. In some places to seaward it was washing away, but on the whole would appear to be growing outwards. The lagoon side is all

covered with *Pemphis*, many dead stumps standing in the water and indicating loss. The loop at the south end is now more definitely a barachois, and behind in the land we found a slime-covered pool, round which snipe were feeding. Tracing from this we could see how the present island of St. Joseph was formed by the junction of two islets, and it was obvious that a third, Benjamin, would, under present conditions, soon join up\*. St. Joseph is covered with tall coconuts, some of which were weighted down and killed by the large nests of *Pelecanus crispus*, of which there was a numerous colony. How far this bird is a wanderer we do not know. It was its breeding-season, and we saw plenty on the reefs and in the lagoon of the atoll. None, however, were to be seen at Darros or any of the other reefs of the Amirantes that we visited. Another common

Fig. 43.



St. Joseph, Amirante Group. View of east shore of Pelican Island, showing five former beaches.

bird, likewise breeding, was the booby (*Sula piscator*), found so abundantly before at St. Pierre, and wandering daily from St. Joseph over every reef in the group.

Approaching the north-east of Pelican Island we came across a sand-flat with five lines of sandstone, parallel to the beach behind, and showing former beaches which had been washed away one after another (fig. 43). The whole island has quite changed since the chart was made in 1882, and is gradually disappearing, as evidenced in its steep beaches with small cliffs of 2 to 4 feet. Its south end was a mass of puffin-holes, into which one plunged at every step. Chien and Cascassaye are wasting on their lagoon

\* It is possible that Benjamin was once part of St. Joseph. The latter island was then washed through, while now it is apparently joining up again.



faces, but growing as fast to seaward. Poule still exists as a patch of sand with two conspicuous bushes. Our last visit was to Ressource, where we found the greater part of its southern spit gone, while two great accumulations of sand to the north-west had increased its size considerably.

In the lagoon we took a series of soundings, finding a sandy bottom. There were a few coral-patches, noticeably one in the centre. They were not conspicuous, being mostly round masses of *Porites* or *Goniastrea* with branching *Pocillopora* and *Stylophora*. The heads were healthy on the surface, but underneath were rotten with boring organisms. Many had fallen owing to their own weight, and were being broken up into little fragments, which would be triturated up into fine mud by the very abundant Holothurians and other sand-feeders. This then would be removed by the tides, so that the lagoon would be in nowise filled in by their means.

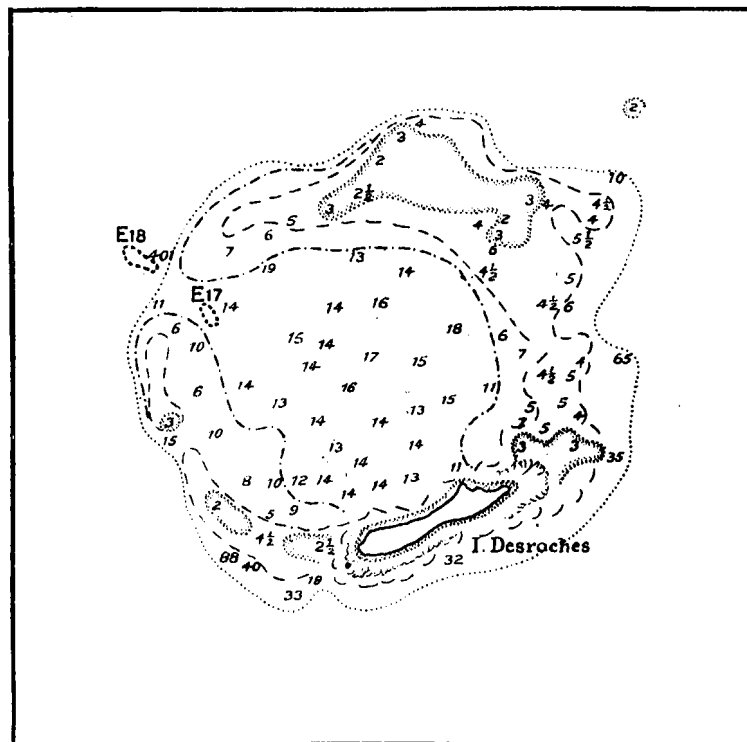
Off Darros we took two successful dredgings in 35 to 40 fathoms, and then proceeded south so as to run a line of soundings due east from the Amirante Bank to the entrance of Desroches, which is really a submerged atoll save for the reef and island of the same name on its southern rim. The distance between its 100-fathom line and that of the Amirante Bank proved to be less than 8 miles. We got soundings of 24, 24, and 23 fathoms, and then in less than a mile dropped off to 588 fathoms, getting 874 fathoms in the middle of the passage and apparently almost as steep a rise against Desroches. We entered through the west passage, passing across the lagoon, which is singularly free from shoals, and anchored off the island, where we spent two clear days.

The island of Desroches is about  $3\frac{1}{4}$  miles long by 500 to 800 yards broad, lying almost east and west. It is hollowed out into small bays with outstanding points to the south, where the shore is largely formed of beach sandstone and there is a wide reef. At the east end there has been some loss, but it is not so extensive as to the west, where the beach ends in a marked cliff on either side of a long point, which continues the seaward beach of the island on to the reef. Off its beach sandstone forms a ridge, gradually decreasing in height for 300 yards further westwards on the reef-flat. The loss at present visible at this end is about 600 yards and may have been much more. How far the land ever extended over the existing reef it is difficult to estimate, but the appearance of the whole rather suggests that it was once almost coterminous with the edge of the broad weed-covered reef-flat to the south, east and west. This reef-flat bends round the ends of the island and is growing along the north side, but still leaves an open coast for about a mile in the centre, where only patches of coral are found. Here the shore is continually growing further and further out, any loss to the south being more than counterbalanced by this gain.

The settlement was situated in the centre of the north side of the island, and consisted of about 30 men employed in preparing coconut-oil. Everything was of the most primitive condition and in decay, a pleasing island, zoologically speaking. Behind the houses is a great clump of *Hernandea* and *Barringtonia*, and from them radiate avenues of *Casuarina* towards each end of the island. These were planted, we were told, about 70 years ago, after which the island was abandoned. Sowing themselves the casuarinas soon covered almost the whole island, until a fresh settlement was made about 1880,

when coconuts were planted. This was abandoned too, and it is only now that the casuarinas are being cut down and the island properly treated. Even yet they form an enormous clump at the west end and extend along the whole south side to the village, with further clumps to the east point. Below them the ground has the smell and appearance of a pine-forest. Little grows, and there is no doubt but that the indigenous flora and fauna have been for the most part killed out. The soil is all a rich red sand, mostly consolidated into tuffe. The water tastes of phosphates, but although there had been no rain for three months all vegetation was flourishing, water being well retained in these semi-guano lands. The animals and plants presented no striking novelties in species, but, of course, many of the insects were pupating in the drought.

Fig. 44.



Desroches Atoll (from the Admiralty chart). E 17 and 18, dredgings of H.M.S. Sealark.

Scale: 4 miles = 1 inch.

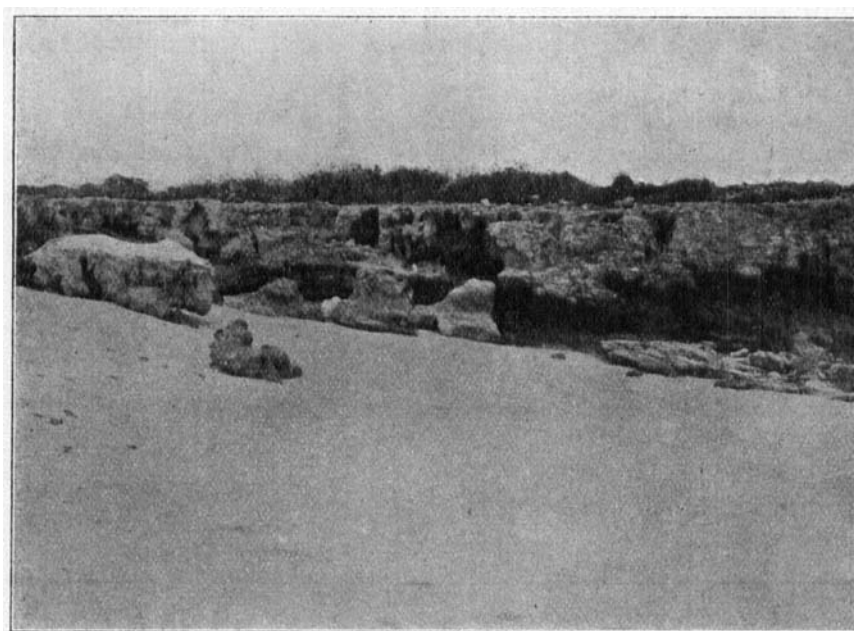
Doves, partridges, and finches had gone wild, as also some cats and rabbits. As in Egmont, wading-birds at the least alarm seemed at once to take to the trees.

We left Desroches on Monday, October 16th, at dawn, and in leaving the atoll took four dredgings, two of which, on account of its steep slope, did not reach the bottom. A haul at 280 fathoms was more successful, yielding a very similar fauna to that off Salomon. We then carried on off the north of the bank until night, with pelagic nets to round off our series for distribution. On the last haul our large net was carried away by some fish. Thanks to Mr. Beer's energy, our sounding-machine had been repaired, and we were again able to sound during the night. At dawn we picked up Remire, an atoll-reef without land on the north-east edge of the Amirante Bank. After some

difficulty in finding the 100-fathom line, on account of the steepness of the slope, we attempted to dredge. Opposite the centre of Remire we found a hard sandy bottom at 180 fathoms, practically without life, but then further north we got into rough coral ground, in which we lost a dredge, breaking up a second, but securing some coral-rubble evidently swept out off the reef above. We then dredged round in shallow water to Eagle Island, to the north of which we anchored at mid-day, going ashore soon afterwards.

Eagle is a round island, about half a mile in diameter, situated on a flat reef about 200 yards wide, broken only in one place to the north. The land is entirely formed of sand-rock. The shore is sandy with layers of beach sandstone. In most parts it ends in a small sand-cliff above, but in some situations in a wall of tuffe-rock 8 to 12 feet high

Fig. 45.



Shore-cliffs of Eagle Island, Amirante Group, with sandy beach below.

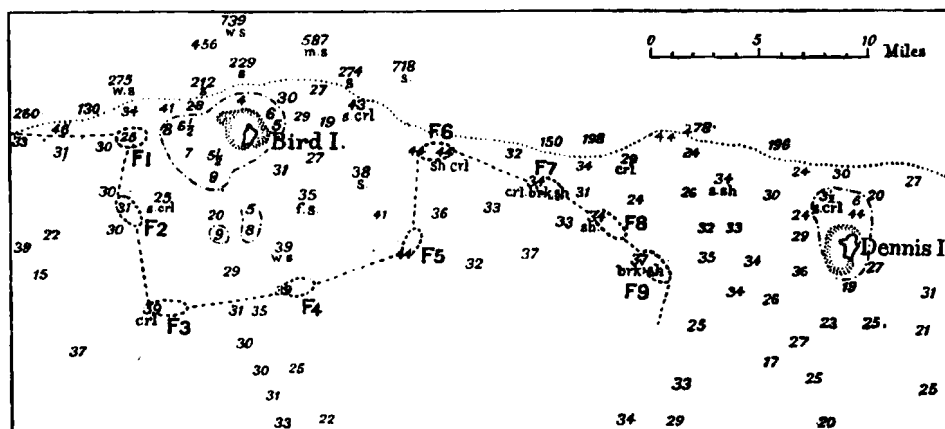
(fig. 45). The land behind this cliff is a few feet higher than that in the centre of the island, but is nowhere more than 16 feet above the level of the reef-flat. Undoubtedly the island was once much larger, but the whole question of the formation and history of all these islands is one which will have to be dealt with later. For the most part the surface presents a bare flat of rock much broken up by the guano-workings. There are as yet no high trees and the shrubs are as small and stunted as at Cargados. A few coconuts have been planted to the north in the last ten years, but it is only recently that the last of the guano has been removed and the island let for cultivation. A clump of screw-pines (*Pandanus Balfouri*) in the centre of the island was an unusual feature, this genus of plants, so common in the Maldives and the islands of the Pacific, apparently having been introduced into the coral-islands of the Western Indian Ocean,

though its light fibrous fruit is generally supposed to be particularly suitable for transport.

We had one day's more dredging on the Amirante Bank before we finally steamed round the north of the African Islands on our course to the Seychelles. It was a wretchedly unsatisfactory day with heavy rain-squalls, but to a certain degree rounded off our work on the bank. So far as organisms were concerned it yielded nothing new, but it gave indications of much more vigorous coral-life than in the south part of the bank. Lithothamnium and flat incrusting calcareous algæ (*Squamariaceæ*) were very abundant down to 40 fathoms, acting as consolidating organisms. The seaward slope of the bank to the north of African Islands was almost entirely formed of coral-blocks and as steep as any slope we met with on the cruise. North African Island, so far as we could see from the ship, appeared not dissimilar to Eagle Island, having much weathered sand-rock, perhaps due to elevation.

From the Amirantes we set a course towards Bird Island, Seychelles, putting down a few soundings and taking serial temperatures *en route*. On the night of October 19th

Fig. 46.



North part of Seychelles Bank with Bird and Dennis Islands. F 1-9, dredgings of H.M.S. Sealark.

we anchored to the west of Bird, where there is a considerable bank within the 10-fathom line. It was formerly a guano island, but now the cream of its deposits has been quite skimmed and it has been relegated to coconuts. About its formation there is no doubt, the whole being low and very definitely coralline, the beaches pure coral-sand, and the deposits in the neighbourhood pure carbonate of lime. In this it resembles Dennis Island, which lies about 27 miles further east. Together they share the distinction of being the only lands on the rim of the Seychelles Bank, the other 27 islands lying close together in its centre. They were both discovered about 1773, and were then covered with land-tortoises, sirenians, and birds. The tortoise was doubtless *Testudo elephantina*, now found only in Aldabra, and the birds were probably mainly *Sula piscator*, now so common in St. Pierre. The "Vaches Marines," often referred to in connection particularly with Dennis, can only have been a species of dugong (*Halicore*), but there is no record of their occurrence in the group within the

memory of man. We saw the manager of Bird, and subsequently people who knew both islands well. Their descriptions showed that they were mainly of sand-formation with resemblances to Eagle and African Islands. We visited neither, as time was peculiarly valuable, owing to our work in the main islands, and as we did not get any indications which led us to believe that we could settle whether their mode of formation was by upheaval, or by piling-up of sand on coral-shoals, or by other means. It is particularly interesting to note that not only are they the only islands on the rim of the bank, but that their reefs are the only ones on the rim which reach the surface.

Leaving Bird we had a long day's dredging round its west and south sides, ending up by a series of hauls on the edge of the bank between it and Dennis. These showed a rough area, rich in corals, at 20-30 fathoms to the west of Bird, while to the south there was coral and algal rubble, tailing into hard sand with plenty of dead *Cycloseris* and living *Heteropsammia*, the latter each with an associated *Aspidosiphon* in its base. In the passage towards Dennis at 34 to 44 fathoms we found a similar bottom of hard sand, but with more weed, and in places small lumps of Lithothamnium and dead coral incrustated with Squamariaceæ. In five consecutive hauls we obtained as great a variety of life as in any other five dredgings of the cruise. Attached animals were represented by Polyzoa, Sponges, Gorgonians, Antipatharians, and Tunicates, while among free-livers may be noticed Crinoids, Asteroids, and Echini, molluscs of many sorts, including several Nudibranchs, and vast numbers of Crustacea. Turbellaria alone were absent, as, indeed, they were from practically all the dredgings. A holothurian was brought up with a *Fierasfer* and kept for some hours in a bucket, the little fish as it darted in and out of the cloaca of the holothurian being an interesting sight to all. The only corals obtained were the solitary *Flabellum* and *Heteropsammia*. Taken together the dredgings must be held to indicate the absence of any well-defined edge to the bank between Bird and Dennis, while the hard nature of the bottom shows the existence of not inconsiderable currents between the two islands.

On arrival at Port Victoria, Mahé, on October 20th, we at once commenced to prepare for our work on the lands and reefs of the Seychelles. Our first four days, however, were occupied in seeing after the collections made since leaving Coetivy, which were very considerable, and in checking charts and in discussing various points with Capt. Somerville and the officers of the Sealark. We also bade good-bye with great regret to our messmates of the last six months, whose kindness had been unvarying. His Excellency the Governor, W. E. Davidson, Esq., C.M.G., offered us hospitality and placed a part of his house at our disposal, while Mr. H. A. Pare, of Messrs. Beatty, Bergne, & Co., Engineers, procured us servants and collecting-"boys," and assisted us in many ways. Mr. R. Dupont, the vigorous Director of the Botanic and Economic Stations of the Group, advised us generally, showing us carefully the indigenous and introduced plants on several short excursions. Our first acquaintance with the indigenous jungle was with Fletcher over Morne Seychellois, the highest peak in the group, 2993 feet, on which we got lost for several hours. We then had two days also with Fletcher on the islets and reefs off Port Victoria, *i. e.* Cerf, Long, Mayenne, and St. Anne. On October 29th we took advantage of the Governor's visit to transfer our

quarters to Praslin, an island much less known and less collected than Mahé. Here we remained for 17 days, camping on the coast in Côte d'Or Bay by kind permission of M. Bouton, Manager for M. Boullé.

Côte d'Or gives its name to the chief estate in Praslin, where the far-famed double coconut or coco-de-mer (*Lodoicea seychellarum*) is found growing. It is perhaps the noblest known palm, and it occurs in the wild state in Praslin only, being supposed to have been transported to the neighbouring islet of Curieuse by human agency. Its growth and natural history are too well-known to need any special description. The nut takes about 3 years to germinate. The male tree bears its first flowering-spike when about 45 years old and the female its first bunch when about 65 years. The nut takes 7 to 9 years to ripen, remaining attached to the parent tree. It then falls and its husk, which is relatively thin, splits off. Thus a generation takes 75 to 80 years. The nuts themselves are of two kinds, the dividing-groove of the one form being straight, the other branched in a Y-shaped manner. These nuts are known respectively as the male and female, being believed to give male and female trees, though this rests, so far as we could ascertain, on no direct evidence. In the storehouse at Côte d'Or, M. Bouton showed us 337 nuts, of which he classified 182 as belonging to the first kind and 155 to the second, there being no intermediates. Both kinds are said, and indeed appeared to us, to grow on the same tree, but it is uncertain whether they hang on the same bunches. Nuts which were shown to us as fertile are incapable of floating in sea-water, while dead nuts commonly float. This fact prevents the tree from being transported to other lands, even the nearest. Supposing the tree to have been originally ocean-borne to the Island of Praslin from some other land, it must have had a much lighter nut. It would then have acquired on the steep slopes of Praslin its great weight and probably size as well, these putting an end to its power of being further dispersed.

Praslin itself is entirely of granitic formation, as, indeed, are all the other islands on the centre of the Seychelles Bank\*. This granite, together with that of Mahé, Silhouette, and other islands, will form the subject of a separate Report by Dr. Flett. The land fauna and flora of the Seychelles and their interrelations will likewise have to be considered subsequently in dealing with the question of their original peopling with animals and plants. So far as possible we collected the fauna of Praslin and studied it in relation to the vegetation of that island, but our results were disappointing, as nearly all parts of the island seemed to have been devastated at some time or other by forest-fires. Further, we found no area of more than a few acres which had not formerly been cleared for economic products. Lastly, the maximum height of Praslin is only 1261 feet, and it is hence much drier than the more elevated islands of Mahé (2993 feet) and Silhouette (2467 feet). Our stay also was at the end of a long drought, which only began to break after our return to the more western islands.

From Praslin we visited the neighbouring islands of La Digue, Round, Félicité, Curieuse, N. Cousin, and S. Cousin (Pl. 14). We also examined a number of the isolated

\* Further information as to the geography, history, forests, and economic conditions of the Seychelles may be obtained from "The Indian Ocean," *Geogr. Journ.*, Nov. 1906, pp. 456 *et seq.*, and "The Seychelles Archipelago," *Geogr. Journ.*, Feb. 1907, pp. 148-174; both articles by the senior of us.

granitic masses which lie scattered in the seas of the vicinity, and such reefs or flats as occur round the islands. A glance at the chart shows that these latter exist here and there around all the granite-formed islands of the Seychelles, especially in bays. In ordinary language it would be said that they generally possess scattered *fringing-reefs*. Where of any size, as off Côte d'Or and St. Anne's Bay, both Praslin, and off La Digue, parts which we especially examined, these reefs are, so to speak, supported by islets or masses of granite in their edges or extending out within them for some distance from the land; the same statement is also true of the reefs off the northern half of Mahé. Their surfaces are covered over with several species of *Cymodocea* and large green algæ. At their seaward edges corals grow, but they are generally rather isolated and of relatively small size. Lithothamnia practically do not enter into their composition, and hence the well-consolidated and distinct edge, characteristic of what are usually termed coral-reefs, is absent. Most have actually owed their origin to the piling up of calcareous and siliceous sand in bays, or to the cutting down and removal of the granite above the sea-level. They are not *fringing-reefs* in the ordinary acceptance of the term, such as we found round most parts of Mauritius and such as commonly occur in tropical waters fringing continents or isolated volcanic and other islands, the slopes of which tail off rapidly to some hundreds of fathoms. Praslin, Mahé, and the other granitic islands of the Seychelles are mere peaks on the centre of a large bank, and their flats at the low-tide level should rather be compared to the shore-flats round islets within barrier-reefs, such as are frequently found in Fiji and other groups. In situation they are similar to shoals within the lagoons of the Chagos Atolls, and to shoals and the shore-reefs round islets within Maldivan lagoons\*. These, however, have a different origin, and the reefs round Mahé, &c., have no real homologues in the Indian Ocean. Caution will hence have to be exercised in making any deductions from the presence on or absence from them of any species or genera of animals or plants as compared to other reefs†.

After our return to Mahé we visited North and Silhouette Islands. Cooper remained on the latter for three weeks, occupying a house on the shore, placed at his disposal by Mr. Chas. Dauban, who owns the island. He devoted himself particularly to an examination of its physical and geological features, also searching unsuccessfully for traces of the crocodiles stated to be formerly common on its shores. In five places around its coast he found masses of coral attached to the granite at various heights up to 30 feet above the sea, proving a recent elevation of the island of at least that amount. Gardiner meantime explored Mahé, finding traces of a similar elevation as well as of an earlier one of upwards of 200 feet.

We collected in both Silhouette and Mahé, but conditions were much more favourable in the latter, as there were better tracks up to the jungles of Morne Seychellois

\* *Vide* pp. 158-171 of 'Fauna and Geogr. Maldives and Laccadives.' Also "The Coral Reefs of Funafuti, &c.," Proc. Camb. Phil. Soc. vol. ix. pp. 438-443 for a typical fringing-reef, and pp. 464-6 for a barrier-reef with shore-flats round an island.

† Before leaving Praslin we must express our obligations to Dr. Laidlaw and Mr. Tregarthen for assistance on that island.

(2993 feet), Mt. Harrison (2257 feet), and Mt. Sebert (1803 feet). Chateau Margot, where H.E. the Governor has a country residence, proved an excellent collecting-station, yielding among other animals a land-Nemertean (see p. 57, *suprà*) as well as a Planarian. The house is situated on the watershed at 1500 feet, halfway between Morne Seychellois and Mt. Harrison, to both of which it has good paths. From there Gardiner went to Cascade, the property of Mr. H. P. Thomasset, a most accomplished naturalist and botanist, as well as the chief English planter in the Archipelago. He collected daily over Mt. Harrison and Mt. Sebert with Mr. Thomasset, whose great knowledge of the country and of the distribution and habits of its animals largely increased our collections. His knowledge also of the plants, to which he has added many new species, was invaluable, and we are also indebted to him for many specimens, separately collected, of all groups of land-animals. Particular attention was paid to the smaller Mollusca. Insects were, generally speaking, disappointing, the season not really being damp enough for them.

Throughout our stay in the Seychelles our object in collecting land-animals was to obtain those which belong to the indigenous jungle of the group, rather than those which live on the cultivated lower-lying lands, these seeming already sufficiently well known. This jungle grows on the granite, and most of its plants belong to species and many to genera peculiar to the Archipelago. Of most of its groups of animals we believe that we obtained fairly representative collections, but the insects are so difficult to collect in such isolated islands of the ocean that we fear we may have as yet secured only a small sample of them. Little of this fauna, so far as insects are concerned, would appear to have been known before our visit, if we may judge by Mr. Cameron's account of the Hymenoptera other than ants (see pp. 69-89). Twelve species were known before our visit, of which we obtained 11, while we further secured 12 new species, one the representative of a new genus. To M. de Gaye we owe many specimens, especially of Lepidoptera, and we have also received, since our return home, additional specimens from Mr. Thomasset and Mr. Dupont\*. To these two gentlemen must be ascribed whatever credit may be due for our collections in Mahé. Their knowledge enabled us to start from a plane to which otherwise we could scarcely have expected to attain in the time at our disposal for that island.

The arrival of the Messageries Maritimes Mail Steamer on December 8th brought the fieldwork of the Expedition for the time being to an end. To others belongs the duty of passing judgment upon it. We are ourselves painfully conscious of its many shortcomings. In particular we regretted leaving the Seychelles, as we then felt that in endeavouring to collect its land-animals we had attempted a task quite beyond the time at our disposal there. However, we still hope that we may be enabled to secure more complete collections from that group before we address ourselves to the necessary task of working out its affinities to other lands.

\* These gentlemen have also visited Aldabra, from which they have also sent us specimens.



## APPENDIX A.—LIST OF THE DREDGING-STATIONS.

In addition to the dredgings mentioned below, there were a considerable number of hauls in different localities between Mauritius and the Seychelles of which we kept no record, as no specimens were secured, and they gave no information as to the nature of the bottom, &c. The Chagos dredgings are not recorded in our list. There were altogether seventeen hauls outside Salomon Atoll. They gave a good idea of the nature of the bottom around it, though few specimens were secured. In addition, a considerable number of dredgings were put down in the lagoons of Salomon, Diego Garcia, and Egmont Atolls in connection with their formation. Their precise positions within these lagoons we have not deemed it necessary to record. The positions of the dredgings between Mauritius and the Seychelles are all marked on the maps of the different banks visited and embodied in the "Summary" of our cruise. References are given under each locality.

The dredges and trawls employed have already been described (p. 17). They consisted of rectangular dredges with swords of 5, 4, 3, and 2 feet, triangular dredges with swords of 4, 3·5, and 2·5 feet, and double-sided trawls of 9, 6, and 4·5 feet.

The positions of the dredgings will be seen by reference to the text of Part II. of this Report, figs. 25, 28, 31, 39, 41, 44, and 46.

*List of the Dredging-Stations.*

(1) No.	(2) Date.	(3) Locality.	(4) Depth.	(5) Net employed.	(6) Nature of Bottom.	(7) Remarks.
A 1.	Aug. 23.	Mauritius. (Chart, fig. 25.)	100–200 fms.	Dredge rectangular, 3 ft.	Rubble and a few volcanic stones.	Stopper carried away, net badly torn.
A 2.	Aug. 23.	„	Below 100 fms.	Dredge triangular, 3·25 ft.	Coral - rubble, sponges, &c.	Bottom very hard, dredge constantly catching up.
A 3.	Aug. 23.	„	100–200 fms.	Dredge triangular, 3·25 ft.	Rough.	Came along in jerks, net torn away.
A 4.	Aug. 23.	„	500–600 fms.	Dredge triangular, 3·25 ft.	Sandy coherent grey mud.	Evidently a smooth bottom.
A 5.	Aug. 23.	„	Below 80 fms.	Dredge rectangular, 3 ft.	?	Very rough ground, dredge carried away.
A 6.	Aug. 24.	„	Below 250 fms.	Trawl, 4·5 ft.	Hard rock with rough lumps.	
A 7.	Aug. 24.	„	Below 300 fms.	Trawl, 4·5 ft.	Sand on frame.	An irregular area, net badly torn.
A 8.	Aug. 24.	„	Below 208 fms.	Dredge triangular, 3·25 ft.	Rough bottom.	Fouled and came up empty.

(1) No.	(2) Date.	(3) Locality.	(4) Depth.	(5) Net employed.	(6) Nature of Bottom.	(7) Remarks.
B 1.	Aug. 28.	Cargados. (Chart, fig. 28.)	30 fms.	Dredge triangular, 4 ft.	Coral-rubble and <i>Halimeda</i> .	Near western edge of bank.
B 2.	Aug. 28.	"	30 fms.	Dredge triangular, 4 ft.	Rubble mainly Litho- thamnia and weed.	Net badly torn by weight of rubble.
B 3.	Aug. 28.	"	30 fms.	Trawl, 9 ft.	Sandy.	Large quantity of oyster-spat.
B 4.	Aug. 29.	"	24 fms.	Trawl, 9 ft.	Smooth, hard, sandy mud.	Large quantity of weed <i>Cymodocea</i> .
B 5.	Aug. 29.	"	24-30 fms.	Trawl, 9 ft.	Same.	Same.
B 6.	Aug. 29.	"	30 fms.	Dredge triangular, 3-25 ft.	Much weed and Polyzoa.	
B 7.	Aug. 29.	"	29 fms.	Dredge triangular, 4 ft.	Similar.	
B 8.	Aug. 29.	"	30-32 fms.	Dredge triangular, 4 ft.	Similar, with some broken shell.	
B 9.	Aug. 30.	"	30 fms.	Dredge triangular, 4 ft.	Broken shell, with coral-lumps.	Everything coloured from orange to vermilion.
B 10.	Aug. 30.	"	30 fms.	Dredge triangular, 3-25 ft.	Apparently white sand.	
B 11.	Aug. 30.	"	30-33 fms.	Dredge triangular, 3-25 ft.	White sand, minute white lamelli- branches and fora- minifera.	Green weed.
B 12.	Aug. 30.	"	30-33 fms.	Dredge triangular, 3-25 ft.	White sand and foraminifera.	
B 13.	Aug. 30.	"	30 fms.	Trawl, 4-5 ft.	Coarse coral-rubble and sand.	Everything coloured red.
B 14.	Aug. 30.	"	30 fms.	Trawl, 4-5 ft.	Shell - rubble, with large foraminifera.	Much weed.
B 15.	Aug. 30.	"	30-33 fms.	Trawl, 4-5 ft.	Sandy bottom and shells.	Much weed, <i>Ver- metus</i> with sand- tubes.
B 16.	Aug. 30.	"	30 fms.	Trawl, 4-5 ft.	White sand.	
B 17.	Aug. 30.	"	30 fms.	Trawl, 4-5 ft.	Shell-rubble.	
B 18.	Aug. 30.	"	20-25 fms.	Dredge triangular, 3-25 ft.	Rough coral-rubble bottom.	Much <i>Halimeda</i> and other weed.
B 19.	Aug. 31.	"	28 fms.	Dredge triangular, 3-25 ft.	Coarse coral-rubble.	Polyzoa and sponges.
B 20.	Aug. 31.	"	28 fms.	Dredge triangular, 3-25 ft.	Coarse coral-rubble.	With much Polyzoa.

(1) No.	(2) Date.	(3) Locality.	(4) Depth.	(5) Net employed.	(6) Nature of Bottom.	(7) Remarks.
B 21.	Aug. 31.	Cargados. (Chart, fig. 28.)	28 fms.	Dredge triangular, 3·25 ft.	Mainly hard.	Large lump of rubble.
B 22.	Aug. 31.	„	28 fms.	Trawl, 4·5 ft.	Hard white sand and weed.	
B 23.	Aug. 31.	„	28 fms.	Trawl, 9 ft.	Hard sand and mass of weed.	
B 24.	Aug. 31.	„	30 fms.	Trawl, 9 ft.	Sand and weed.	
B 25.	Aug. 31.	„	22 fms.	Dredge triangular, 3·25 ft.	White sand and weed.	Solitary corals.
B 26.	Aug. 31.	„	12 fms.	Dredge triangular, 3·25 ft.	Very rough ground, with living corals.	
B 27.	Aug. 31.	„	10 fms.	Dredge triangular, 3·25 ft.	Hard coral ground.	
B 28.	Sept. 1.	„	32 fms.	Dredge triangular, 3·25 ft.	Algal rubble, ground rough.	
B 29.	Sept. 1.	„	47 fms.	Dredge triangular, 3·25 ft.	Large lumps of rubble, ground rough.	Much <i>Halimeda</i> and <i>Lithothamnium</i> ; net badly torn by weight.  8 soft algæ, with <i>Lithothamnium</i> and much <i>Squamaria</i> - <i>riaceæ</i> .
B 30.	Sept. 1.	„	121 fms.	Dredge triangular, 2·5 ft.		
C 1.	Sept. 4.	Saya de Malha. (Chart, fig. 31.)	150 fms.	Dredge triangular, 4 ft.	White rubble of dead coral, Polyzoa, and shell.	
C 2.	Sept. 4.	„	123 fms.	Dredge rectangular, 3 ft.	Echinoderm tests, Lamellibranch valves, and Gastropod shells.	Brachiopods and solitary corals.
C 3.	Sept. 4.	„	125 fms.	Trawl, 4·5 ft.	Shell and broken Echinoderm - test rubble.	
C 4.	Sept. 4.	„	150 fms.	Trawl, 4·5 ft.	Largely oyster - valves.	
C 5.	Sept. 4.	„	125 fms.	Trawl, 9 ft.	Shell-rubble.	Some fish.
C 6.	Sept. 5.	„	145 fms.	Trawl, 4·5 ft.	Shell-rubble.	
C 7.	Sept. 5.	„	145 fms.	Trawl, 9 ft.		A few small corals; net fouled.
C 8.	Sept. 5.	„	85 fms.	Dredge triangular, 3·25 ft.	Hard.	
						Five species of solitary corals.
						Warp cut by screw and trawl lost.

(1) No.	(2) Date.	(3) Locality.	(4) Depth.	(5) Net employed.	(6) Nature of Bottom.	(7) Remarks.
C 9.	Sept. 5.	Saya de Malha. (Chart, fig. 31.)	90 fms.	Trawl, 4·5 ft.	Hard, a little broken shell-rubble.	
C 10.	Sept. 5.	„	90 fms.	Trawl, 4·5 ft.	Bottom evidently very hard.	
C 11.	Sept. 6.	„	47 fms.	Trawl, 4·5 ft.	White sand and mud.	
C 12.	Sept. 6.	„	47 fms.	Trawl, 4·5 ft.	Shell-rubble and mud.	
C 13.	Sept. 6.	„	49 fms.	Trawl, 6 ft.	Mud.	Fragments of weed.
C 14.	Sept. 6.	„	58 fms.	Trawl, 6 ft.		
C 15.	Sept. 6.	„	55 fms.	Trawl, 6 ft.	Bank of loose Litho- thamnia-rubble.	2 to 3 tons of material obtained.
C 16.	Sept. 6.	„	26 fms.	Dredge triangular, 3·25 ft.	Living corals and rubble.	17 species of true corals obtained.
C 17.	Sept. 7.	„	45 fms.	Dredge triangular, 3·25 ft.	White sand, rather sticky.	
C 18.	Sept. 7.	„	46 fms.	Dredge triangular, 3·25 ft.		
C 19.	Sept. 7.	„	29 fms.	Dredge triangular, 3·25 ft.	Corals, rubble, and algæ.	14 species of corals.
C 20.	Sept. 7.	„	331-500 fms.	Trawl, 4·5 ft.	Hard ground.	A few solitary corals, &c.
C 21.	Sept. 8.	„	450 fms.	Trawl, 4·5 ft.	Small white shell and coral-rubble.	
D 1.	Oct. 3.	Providence. (Chart, fig. 39.)	39 fms.	Dredge rectangular, 3 ft.	Dead coral, covered by encrusting algæ and Lithothamnia.	Next 2 hauls in about 400 fms. failures, 4 ft. tri- angular dredge lost.
D 2.	Oct. 3.	„	744 fms.	Trawl, 9 ft.	Blocks of tenaceous clay covered with manganese.	Some manganese nodules and coral coated with man- ganese.
D 3.	Oct. 4.	„	29 fms.	Dredge triangular, 3·25 ft.	Coral-rock.	2 genera of corals.
D 4.	Oct. 4.	„	50-78 fms.	Dredge triangular, 3·25 ft.	Hard rough lumps of coral.	
D 5.	Oct. 4.	„	230 fms.	Dredge rectangular, 5 ft.		A previous haul like- wise empty.
D 6.	Oct. 4.	„	74 fms.	Dredge rectangular, 5 ft.	Rough hard ground.	Dredge lost.

(1) No.	(2) Date.	(3) Locality.	(4) Depth.	(5) Net employed.	(6) Nature of Bottom.	(7) Remarks.
D 7.	Oct. 4.	Providence. (Chart, fig. 39.)	70 fms.	Dredge triangular, 3·25 ft.	Loose rock from reef above with cal- careous algæ.	
D 8.	Oct. 4.	„	125 fms.	Dredge triangular, 3·25 ft.	Coral and rock from reef above.	
D 9.	Oct. 4.	„	77 fms.	Dredge triangular, 3·25 ft.	Rough and rocky.	Caught up foul, stoppers carried away.
D 10.	Oct. 4.	„	?	Dredge triangular, 3·25 ft.	Rough.	Empty, caught up once. Sounding 300.
D 11.	Oct. 4.	„	58 fms.	Dredge triangular, 3·25 ft.	Rough.	
D 12.	Oct. 4.	„	637-667 fms.	Trawl, 9 ft.	Hard, with some coral-sand.	A piece of rock covered with man- ganese torn off the bottom.
E 1.	Oct. 9.	Amirante Bank. (Chart, fig. 41.)	29 fms.	Dredge triangular, 3·25 ft.	Polyzoa forming a rubble and a few dead shells.	A little <i>Cymodocea</i> .
E 2.	Oct. 9.	„ „	29 fms.	Trawl, 4·5 ft.	Rubble, largely <i>Lithothamnia</i> , and much weed.	Algæ dried.
E 3.	Oct. 9.	„ „	25 fms.	Dredge triangular, 3·25 ft.	Same as last.	
E 4.	Oct. 9.	„ „	32 fms.	Trawl, 4·5 ft.	Hard, with sponges.	A few solitary corals.
E 5.	Oct. 9.	„ „	32 fms.	Dredge triangular, 3·25 ft.	Sandy.	Much <i>Cymodocea</i> .
E 6.	Oct. 9.	„ „	28 fms.	Dredge rectangular, 4 ft.	Polyzoa and <i>Pecten</i> - valve rubble.	Many free solitary perforate corals.
E 7.	Oct. 9.	„ „	28 fms.	Dredge rectangular, 4 ft.	Same.	Same.
E 8.	Oct. 9.	„ „	33 fms.	Dredge rectangular, 4 ft.	Hard sand, with some broken sand.	
E 9.	Oct. 9.	„ „	34 fms.	Dredge rectangular, 4 ft.	Polyzoa and shell- rubble.	Many Gastropods.
E 10.	Oct. 11.	„ „	22-85 fms.	Dredge triangular, 3·25 ft.	Rubble of dead coral, with <i>Lithothamnia</i> and <i>Squamariaceæ</i> .	Much <i>Halimeda</i> .
E 11.	Oct. 11.	„ „	25-80 fms.	Dredge triangular, 3·25 ft.	Hard rough ground.	A dredging down the outer slope.
E 12.	Oct. 11.	„ „	32 fms.	Dredge triangular, 3·25 ft.	Coral-rubble.	

(1) No.	(2) Date.	(3) Locality.	(4) Depth.	(5) Net employed.	(6) Nature of Bottom.	(7) Remarks.
E 13.	Oct. 11.	Amirante Bank. (Chart, fig. 41.)	20-25 fms.	Dredge triangular, 3·25 ft.	Rubble, covered with <i>Halimeda</i> and cal- careous algæ.	Some corals.
E 14.	Oct. 11.	" "	36 fms.	Dredge triangular, 3·25 ft.	Hard rough rock.	Much <i>Halimeda</i> .
E 15.	Oct. 13.	" "	35 fms.	Dredge triangular, 3·25 ft.	Hard, with coral- rubble.	Much Polyzoa.
E 16.	Oct. 13.	" "	39 fms.	Dredge triangular, 3·25 ft.	Lithothamnium-rubble.	
E 17.	Oct. 16.	Desroches Atoll. (Chart, fig. 44.)	18-12 fms.	Dredge triangular, 3·25 ft.	Hard bottom, with some living corals.	In entrance-passage to Desroches.
E 18.	Oct. 16.	" "	280 fms.	Dredge triangular, 3·25 ft.	Coral - rubble, some shell, dead cal- careous algæ, and echinoderm tests.	
E 19.	Oct. 17.	Amirante Bank. (Chart, fig. 41.)	180 fms.	Dredge rectangular, 5 ft.	Hard sand.	
E 20.	Oct. 17.	" "	209-160 fms.	Dredge rectangular, 4 ft.	Hard, rough with rubble.	A previous haul in same depth, tri- angular 3·25 lost.
E 21.	Oct. 17.	" "	30 fms.	Dredge triangular, 3·25 ft.	Quantities of <i>Hali- meda</i> and Litho- thamnium-rubble.	Squamariaceæ and living corals.
E 22.	Oct. 18.	" "	16 fms.	Dredge triangular, 3·25 ft.	Coral-ground.	13 genera of corals obtained.
E 23.	Oct. 18.	" "	23 fms.	Dredge triangular, 3·25 ft.	Coral-ground.	Net badly torn.
E 24.	Oct. 18.	" "	20-100 fms.	Dredge triangular, 3·25 ft.	Coral - masses very bare.	
E 25.	Oct. 18.	" "	44-20 fms.	Dredge triangular, 3·25 ft.	Rough with masses of coral.	2 genera of reef- corals.
E 26.	Oct. 18.	" "	30-100 fms.	Dredge triangular, 3·25 ft.	Coral-rubble.	
E 27.	Oct. 18.	" "	45-60 fms.	Dredge rectangular, 2 ft.	Hard.	A few pieces of <i>Lithothamnium</i> .
F 1.	Oct. 20.	Seychelles. (Chart, fig. 46.)	20 fms.	Dredge triangular, 3·25 ft.	Coral-ground.	3 genera of reef- corals.
F 2.	Oct. 20.	"	31 fms.	Dredge triangular, 3·25 ft.	Coral-, shell-, and <i>Lithothamnium</i> - rubble.	Much <i>Halimeda</i> and algal growth.
F 3.	Oct. 20.	"	39 fms.	Trawl, 6 ft.	Hard sand.	
F 4.	Oct. 20.	"	39 fms.	Trawl, 6 ft.	Hard sand.	Polyzoa abundant.

(1) No.	(2) Date.	(3) Locality.	(4) Depth.	(5) Net employed,	(6) Nature of Bottom.	(7) Remarks.
F 5.	Oct. 20.	Seychelles. (Chart, fig. 46.)	44 fms.	Trawl, 6 ft.	Shells, Polyzoa, and coral-rubble.	
F 6.	Oct. 20.	„	44 fms.	Trawl, 6 ft.	Sand.	Some algæ.
F 7.	Oct. 20.	„	34 fms.	Dredge triangular, 3.25 ft.	Sand, with weed.	<i>Heteropsammia</i> abundant.
F 8.	Oct. 20.	„	34 fms.	Dredge triangular, 3.25 ft.	Sand, shell, with weed.	
F 9.	Oct. 20.	„	37 fms.	Trawl, 4.5 ft.	Hard sand.	Frame bent and net badly torn.

## APPENDIX B.—LIST OF THE STATIONS FOR PLANKTON.

In collecting the pelagic fauna on the cruise five kinds of net were used, *i. e.*:— (1) *Fowler vertical closing-net*, mouth 36 inches across, square, bag 108 inches long and formed of silk cloth, 60 meshes to the inch, such as is used for sifting flour in mills and known as *bolting-cloth* (fig. 5); (2) *Wolfenden horizontal closing-net*, mouth 3 feet when closed, bag about 3½ feet long, of similar bolting-cloth to last; (3) *large square open net*, mouth 4 feet square, net 30 feet long, made of best mosquito-netting, 8 meshes to the inch; (4) *open nets*, our *regular* pattern, 13 inches in diameter, bolting-cloth 60 meshes to the inch, 6 feet long; (5) *open nets*, 7 inches diameter, bolting-cloth 180 meshes to inch, 3 feet long. For nos. 1 and 3 tins of upwards of 1 gallon were used and for nos. 2 and 4 light aluminium vessels each holding about 1 quart. To no. 5 bottles of 4 oz. were attached, their catch being brought home in the same vessels without being decanted.

Nets of 180 meshes to the inch (no. 5) were particularly intended to catch the small unicellular life, both animal and plant, which passes through nets of larger mesh. They were used in series with no. 4 down to about 100 fathoms to ascertain the depth at which such plant-life floats in the water during both the day and night, but their main purpose was for purely distributional work; single nets of our *regular* pattern (no. 4) fitted with a long bridle were employed while sounding and for any odd purpose. While the ship was at anchor during the night one of these nets was generally placed out over the stern and hauled in each hour, being generally given 10 to 20 fathoms of warp, so as to clear the ship. They were also used in series down to 800 fathoms, being clamped on to the wire as different amounts had run out. (See also pp. 18, 19, 23–25.)

The positions of the hauls have been given as accurately as possible to the nearest minute. They can be seen at once by reference to Plate 1. The force of the wind and the strength of the swell are given on the Beaufort notation.

*List of the Stations for Plankton.*

(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Letter.	Date and Time.	Position.	Nets.	Depth.	Weather.	Temp. of Sea- surface.	Remarks.
A.	May 16, 2.58-3.43 P.M.	Lat. 3° 31' S., long. 72° 27' E. (north of Chagos). Depth 2008 fms.	Regular in series.	0, 25, 50, 75, 100, 125, 150 fms.	Blue sky with light clouds. W.S.W. wind (force 2).	84	Confused swell, drifting.
B.	May 17, 2.20-2.55 P.M.	Lat. 4° 16' S., long. 71° 53' E. (north of Chagos). Depth 2082 fms.	Regular in series.	0, 25, 50, 75, 100, 125, 150 fms.	Blue sky with light clouds. S. wind (force 1).	86	Slight swell, drifting.
C.	May 17, 3.30-6.30 P.M.	Same.	Large square.	1200-0 fms.	Same.	86	Same. The wire got entangled and net was only brought on deck at 11 P.M.
D.	May 18, 12.5-1.5 A.M.	Same.	Regular.	Surface.	Clear sky with moon. S.S.W. wind (1).	82	Drifting slightly to west.
E.	May 17-18, 11.45 A.M. to 1 A.M.	Same.	Wolfenden.	250 fms.	Same.	Same.	Same.
F.	May 18, 2.10-3.10 A.M.	Same.	Regular in series.	0, 25, 50, 75, 100, 150 fms.	Clear sky with light clouds. Wind changing to S.S.E. (2).	82	Same.
G.	May 18, 4.30-5.45 A.M.	Same.	Wolfenden.	500 fms.	Same.	82	Same. More swell. Messengers caught up twice.
H.	May 18, 4.30-5.30 A.M.	Same.	Regular.	Surface.	Same.	Same.	Drifting slightly to west. Same swell.
I.	May 18, morning down 2 hours.	Same.	Wolfenden.	500 fms.	Clear sky with light clouds. Calm.	84	Acted well, but caught very little.
J.	May 18, 3.58-5.40 P.M.	About lat. 4° 30' S., long. 71° 15' E. (N.E. of Chagos). Depth about 2000 fms.	Fowler.	1000-500 fms.	Sky overcast with clouds. S. wind (1).	84	
K.	May 20, 10.30-11.30 A.M. and 2-3 P.M.	At anchor off Dia- mant, in lagoon of Peros Banhos, Chagos.	Regular.	9 fms.	Sky overcast with clouds and rain, clearing in after- noon. S.E. wind (6-3).	..	Tide one-third flood and high. A third at two- thirds ebb, nets empty.



(1) Letter.	(2) Date and Time.	(3) Position.	(4) Nets.	(5) Depth.	(6) Weather.	(7) Temp. of Sea- surface.	(8) Remarks.
L.	June 6, 8.40-9.40 P.M.	On course from Peros to Diego Garcia, N.E. Gt. Chagos Bank.	Regular.	50, 75, 100, 125, 150 fms.	Clear sky, dark night. Calm.	79	Slight S.E. swell.
M.	June 30, noon-12.40 P.M.	7 miles N.W. of Yëyë, Peros Atoll.	Regular in series.	0, 25, 50, 75, 100, 125, 150 fms.	Bright sky with light clouds. S.E. wind (3).	81	Swell (strength 3).
N.	June 30, 1-2.45 P.M.	Same.	Large square.	600-0 fms.	Same.	Same.	Same.
O.	June 30, 4.30-5.10 P.M.	1-2 miles N.W. of passage into Salomon Atoll.	Large square.	180-0 fms.	Same.	80	Towed 1 mile.
P.	June 30, 6.30 P.M.; July 1, 6.30 A.M.	At anchor off passage into Salomon Atoll.	Regular.	10 fms.	Generally bright with squalls of rain. S.E. wind (3-5).	..	Nets taken at each hour during night.
Q.	July 4, 7.15 P.M.; July 5, 7.15 A.M.	Same.	Regular.	Surface.	Overcast sky with rain. E.S.E. wind (1-3).	..	Same.
R.	July 25, 1 hour in afternoon.	On Wight Bank, S. of Chagos.	Regular.	Surface.	Bright at times with clouds and rain-squalls. E. & S. wind (3).	79	
S.	July 26, 1 hour in morning.	On Centurion Bank, S. of Chagos.	Regular.	Surface.	Cloudy, wind, rain- squalls. S.E. wind (4-5).	79	
T.	July 27, 11.15-noon.	Lat. 6° 0' S., long. 69° 16' E. (W. of Chagos). Depth 1822 fms.	Regular.	Surface.	Bright clear sky. N.E. wind (1).	82	Swell from S.E. (2). No catch beyond a quantity of fine weed.
V.	July 28, 10.20-11.20 P.M.	Lat. 4° 48' S., long. 67° 22' E. (246 miles W.N.W. of Chagos). Depth 2173 fms.	Regular.	Surface.	Clear sky. E. wind (3).	81	Swell, S.E. (3).
a.	Aug. 22, 1.43-2.30 P.M.	Mauritius, 5 miles W. of Black River.	Regular in series.	0, 25, 50, 75, 100, 125, 150 fms.	Clear, with passing showers and rain. S.E. wind (4-6).	73	Heavy southerly swell.
b.	Aug. 22, 3-4 P.M.	Same.	Large square.	200 fms.	Same.	Same.	Net carried away by shark.
c.	Aug. 22, 4.40-5.20 P.M.	Same.	Regular in series.	200, 225, 250, 275, 300 fms.	Same.	Same.	Piece of a large <i>Pyrosoma</i> clinging on wire from 300 fms.

(1) Letter.	(2) Date and Time.	(3) Position.	(4) Nets.	(5) Depth.	(6) Weather.	(7) Temp. of Sea- surface.	(8) Remarks.
d.	Aug. 22, 7 P.M., to Aug. 23, 5 A.M.	Mauritius, anchor- age in Black River Bay.	Regular.	Surface.	Overcast with showers & squalls. Wind varying, about S.E. (0-2).	73°-70	Nets taken each hour during night.
e.	Aug. 25, 1.30-3 P.M.	Lat. 18° 09' S., long. 58° 21' E. (between Mauri- tius & Cargados). Depth 1962 fms.	Regular in series.	0, 50, 100, 150, 200, 300, 400 fms.	Bright, with passing showers and squally. Wind E.-S.E. (4-5).	75	Swell from E. (4).
f.	Aug. 26, 8 P.M., to Aug. 27, 6 A.M.	Cargados, at anchor off.	Regular.	Surface.	Clear night with a little cloud. S.E. wind (2-3).	..	Nets taken at each hour during night.
g.	Aug. 28, 10 P.M., to Aug. 29, 6 A.M.	Same.	Regular.	Surface.	Slightly overcast with squalls and rain. S.E. wind (3-4).	..	Nets taken every 2 hours of night. 2 miles N. of last.
h.	Aug. 29, 8 P.M., to Aug. 30, 6 A.M.	Cargados, at anchor off Pearl Island.	Regular.	Surface.	Clear, clouding at times, no rain. E.S.E. wind (3-4).	..	Nets taken every 2 hours of night.
i.	Aug. 30, 8 P.M., to Aug. 31, 6 A.M.	Cargados, at anchor off Coco Island.	Regular.	Surface.	Overcast with squalls and rain. S.E. wind (3-5).	..	Same.
k.	Sept. 2, 10.30-11.20 A.M.	Lat. 14° 38' S., long. 60° 01' E. (off Nazareth Bank). Depth 330 fms.	Regular in series.	0, 100, 150, 200, 250, 300 fms.	Bright sky with little cloud. S.E. wind (4).	75	S.E. swell (3).
l.	Sept. 2, 11.45-12.30 A.M.	Same.	Large square.	250-0 fms.	Same.	Same.	Same. Slow speed ahead.
m.	Sept. 4, 5.30-7 P.M.	S. of Saya de Malha Bank. Depth about 80 fms.	Large square.	50-0 fms.	Generally bright with occasional showers. S.E. wind (4).	76	Towed 30'. S.E. swell (4).
n.	Sept. 8.	N. of N. Saya de Malha Bank.	Regular.	Surface.	Bright clear wea- ther. S.E. wind (3-4).	77-80	Odd surface col- lections while sounding.
o.	Sept. 10, 8 P.M., to Sept. 11, 6 A.M.	Coetivy.	Regular.	Surface.	Clear S.E. wind (2).	..	Nets taken every 2 hours.
p.	Sept. 27, 7-9.30 A.M.	Lat. 10° 27' S., long. 51° 17' E. (S. by E. of Far- quhar). Depth 1938 fms.	Regular in series.	50, 100, 200, 300, 400, 500, 600, 700, 800 fms.	Bright and clear, S.E. wind (3-4).	77	S.E. swell (4).

(1) Letter.	(2) Date and Time.	(3) Position.	(4) Nets.	(5) Depth.	(6) Weather.	(7) Temp. of Sea- surface.	(8) Remarks.
q.	Same.	Same.	Large square.	1000 to 0 fms.	Same.	Same.	Same. On end of wire, below lead of last.
r.	Sept. 27, 9.30-10.30 A.M.	Same.	Fowler.	500-250 fms.	Same.	..	
s.	Sept. 27, 10.30 A.M.-5 P.M.	Same.	Fowler.	0-250, 250- 500, 500-750 750-1000 fms.	Same.	..	
t.	Sept. 28, 7 P.M., to Sept. 29, 7 A.M.	Farquhar, anchor- age, N. of North Island.	Regular.	Surface.	Generally bright with occasional squalls. S.E. wind (2-4).	..	Nets taken every hour.
u.	Sept. 29, 7 P.M., to Sept. 30, 7 A.M.	Same.	Regular.	Surface.	About same.	..	Nets taken every 2 hours.
v.	Sept. 30, 7 P.M., to Oct. 1, 5 A.M.	Same.	Regular.	Surface.	About same.	..	Taken in connec- tion with tides.
w.	Oct. 1, 8 P.M., to Oct. 2, 5 A.M.	Same.	Regular.	Surface.	About same.	..	Same.
x.	Oct. 2, 8 P.M., to Oct. 3, 6 A.M.	Providence, at anchor off Cerf Island.	Regular.	Surface.	Clear and bright. S.E. wind (3-5).	..	Taken every 2 hours.
y.	Oct. 4, 8 P.M., to Oct. 5, 6 A.M.	Providence, 1 mile W. of North Is- land.	Regular.	Surface.	Clear and bright. S.E. wind (3-5).	..	Same.
z.	Oct. 6, 11.30 A.M.-1.30 P.M.	Lat. 8° 16' S., long. 51° 26' E. (Between Provi- dence and Al- phonse.)	Regular in series.	100, 200, 300, 400, 500, 600, 700, 800 fms.	Bright with strong sun. S.S.E. wind (4).	79	S.E. swell (4), making it more or less a failure.
aa.	Same.	Same.	Large square.	900-0 fms.	Same.	Same.	On end of wire, below lead of last.
bb.	Oct. 6, 3-3.30 P.M.	Same.	Large square.	140-0 fms.	Same.	Same.	Towed 30' at slow speed.
cc.	Oct. 7, 11-11.30 A.M.	Anchorage, S. of Alphonse Island.	Regular.	Surface.	Bright clear day. S.E. wind (3).	79	In connection with tidal currents.
dd.	Oct. 7, 4-5.30 P.M.	Same.	Regular.	Surface.	Same.	80	Same.
ee.	Oct. 7, 9 P.M., to Oct. 8, 6 A.M.	10 miles S.E. of Alphonse.	Regular.	Surface.	Clear night. S.S.E. wind (3).	78-79	Very unsatisfactory and poor hauls.

(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Letter.	Date and Time.	Position.	Nets.	Depth.	Weather.	Temp. of Sea- surface.	Remarks.
ff.	Oct. 8, 4-4.30 P.M.	Lat. 6° 35' S., long. 53° 03' E. (be- tween Alphonse and Amirante Groups).	Regular.	Surface.	Bright. S.E. wind (2).	80	Slight swell.
gg.	Oct. 9, 8 P.M., to Oct. 10, 6 A.M.	Amirante, at anchor N.W. of Poivre Island.	Regular.	Surface.	Clear night. S.E. wind (2-3).	..	Taken every hour during night.
hh.	Oct. 12, 8 P.M., to Oct. 13, 6 A.M.	Amirante, at anchor N. of Dar- ros Island.	Regular.	Surface.	Clear night with cirrus clouds. S.E. wind (4-5).	..	Same.
jj.	Oct. 13, 8 P.M., to Oct. 14, 6 A.M.	At anchor N. of Desroches Island.	Regular.	Surface.	Clear generally with passing showers. S.E. wind (1-2).	..	Same.
kk.	Oct. 16, about 8-9.30 A.M.	3 miles N.W. of entrance into Desroches Atoll.	Regular in series.	50, 100, 150, 200, 250, 300 fms.	Bright with cirrus clouds. S.E. wind (2-3).	81	
ll.	Oct. 16, morning, 1½ hours.	1 mile further N.W.	Large square.	750-0 fms.	Same.	Same.	Steaming very slowly to N.
mm.	Oct. 16, about noon, 1½ hours.	1 mile still further N.N.W.	Large square.	400-0 fms.	Same.	82	
nn.	Oct. 16, afternoon.	6 miles N.N.W. entrance of Des- roches.	Large square.	200-0 fms.	Cloudy with squalls of rain. S.E. wind (3-4).	81	Large square net lost in a subse- quent haul on Oct. 16.
oo.	Oct. 17, 8 P.M., to Oct. 18, 6 A.M.	Amirante, at anchor off Eagle Island.	Regular.	Surface.	Overcast with heavy rain- squalls. S.E. wind (1-4).	..	

## EXPLANATION OF THE PLATES.

## PLATE 14.

Map of the Seychelles Archipelago, on the scale of 1 : 250,000, or 1 inch = 3·94 statute miles.

## PLATE 15.

Mauritius.

Fig. 1. Port Louis, with the Pouce Mountains behind.

Fig. 2. Sugar-Factory at Vacoa, with the Bamboo Mountains behind.

## PLATE 16.

Cargados Carajos.

Fig. 1. Coast of Siren Island, with the White Noddy (*Gygis candida*) breeding on the rim.

Fig. 2. " Fan " of Wide-awakes (*Sterna fuliginosa*).

## PLATE 17.

Coetivy.

Fig. 1. Sand-dune, coconuts and casuarinas.

Fig. 2. West shore, launching a pirogue.

Fig. 3. North-east end, with cliffs of *Cymodocea*.

Fig. 4. Settlement, oil-mills and large casuarinas.

## PLATE 18.

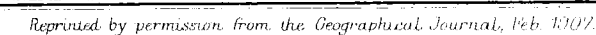
Poivre, Amirante Group.

Fig. 1. North end of South Island.

Fig. 2. View into North Bay of South Island.

Fig. 3. East shore of South Island : coral-rock dipping to west.

Fig. 4. Landing-place, north of North Island.



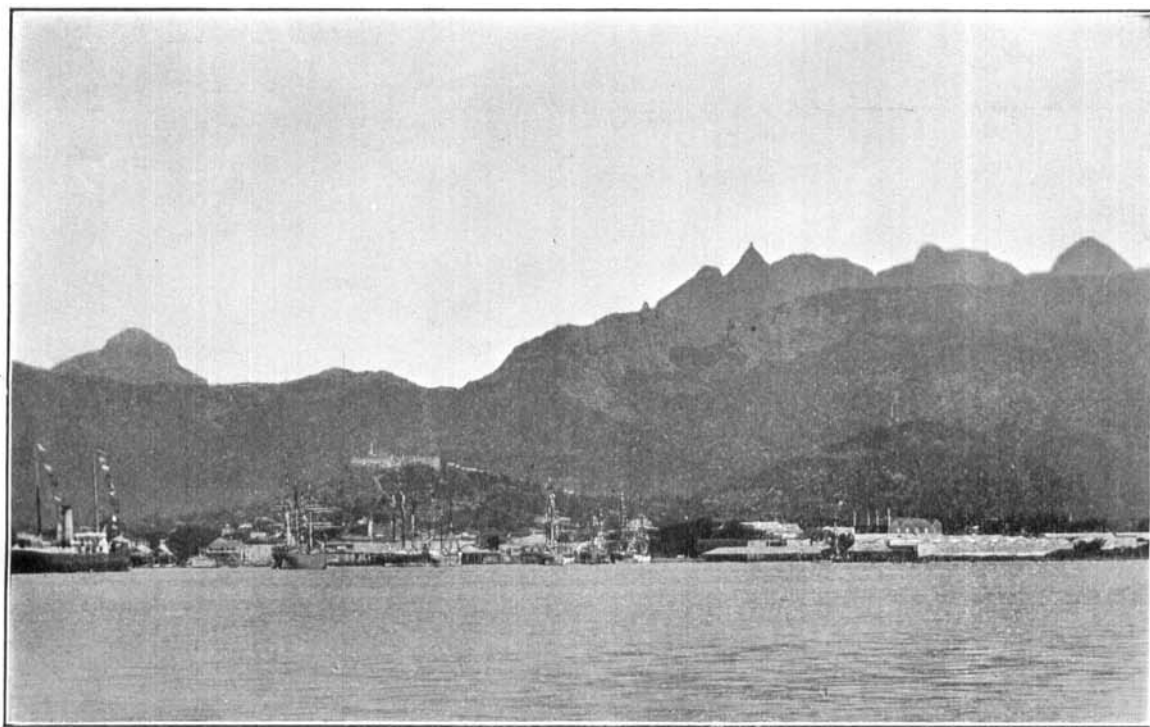


FIG. 1.—Port Louis, with the Pouce Mountains behind.

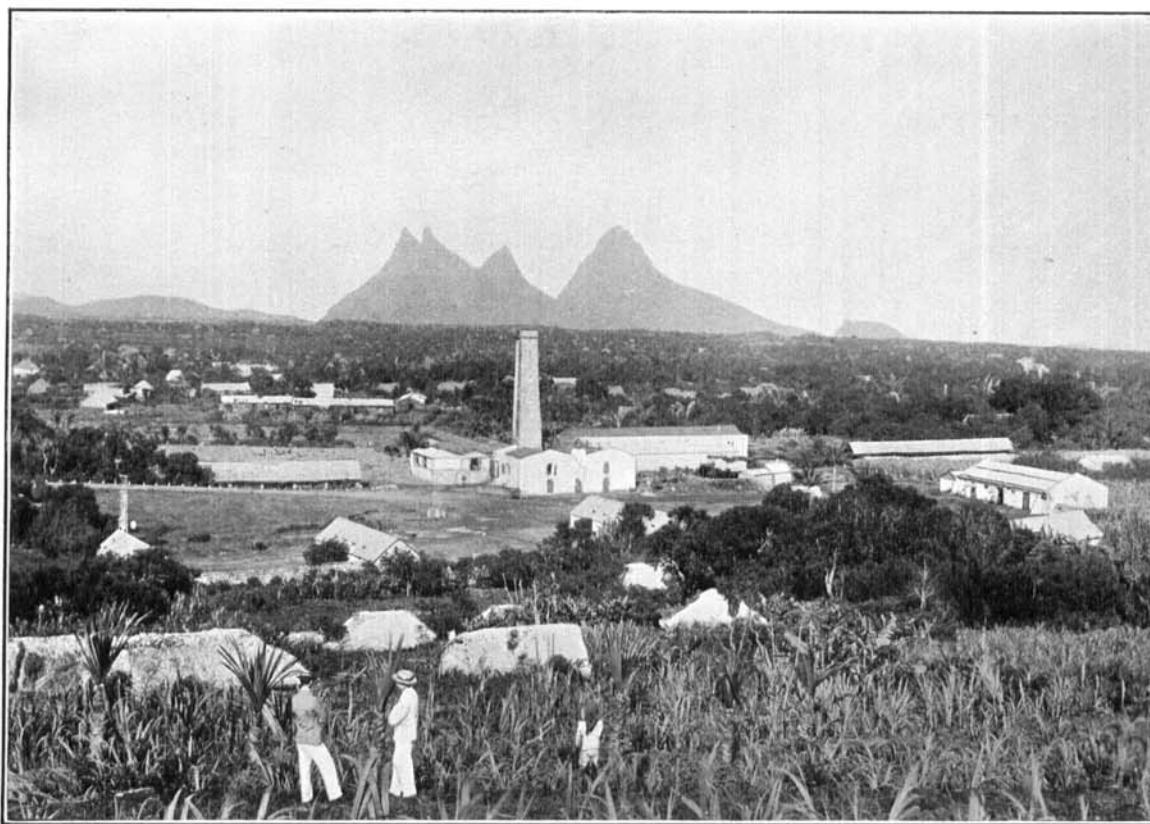


FIG. 2.—Sugar-Factory at Vacoa, with the Bamboo Mountains behind.

MAURITIUS.



FIG. 1.—Coast of Siren Island, with the White Noddy (*Gygis candida*) breeding on the rim.

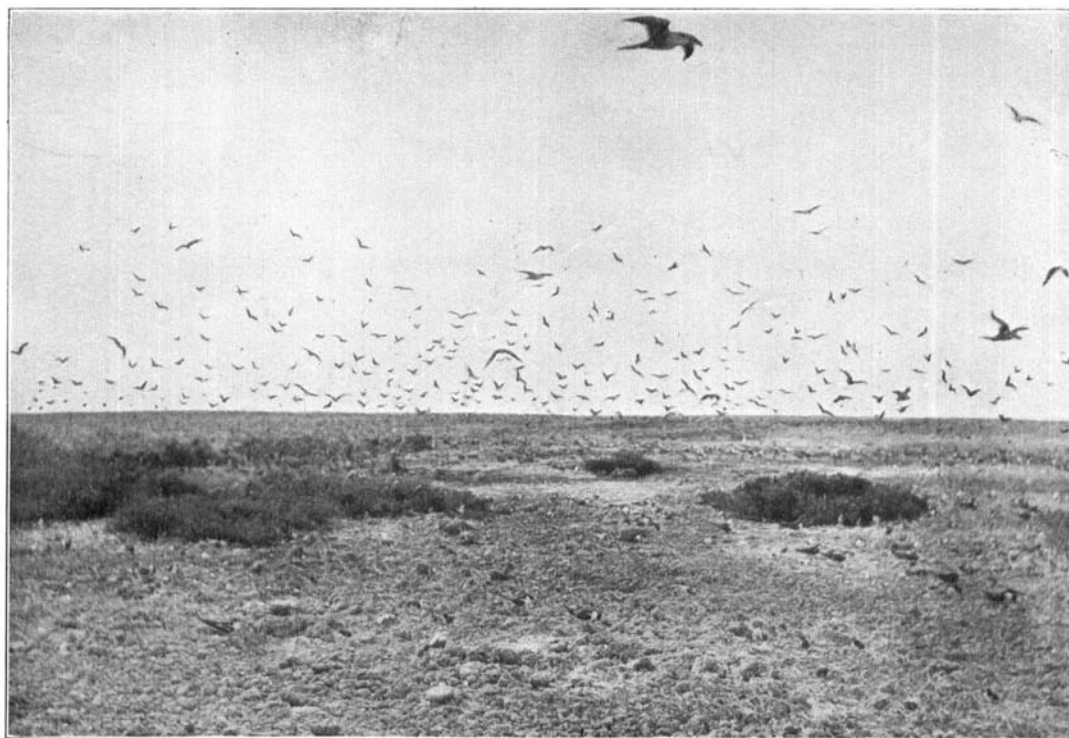


FIG. 2.—“Fan” of Wide-awakes (*Sterna fuliginosa*).

CARGADOS CARAJOS.



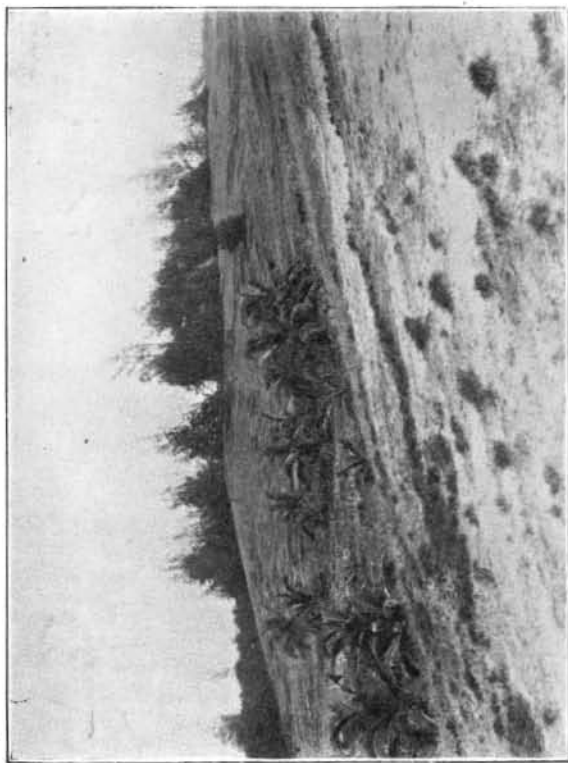


FIG. 1.—Sand-dune, coconuts and casuarinas.

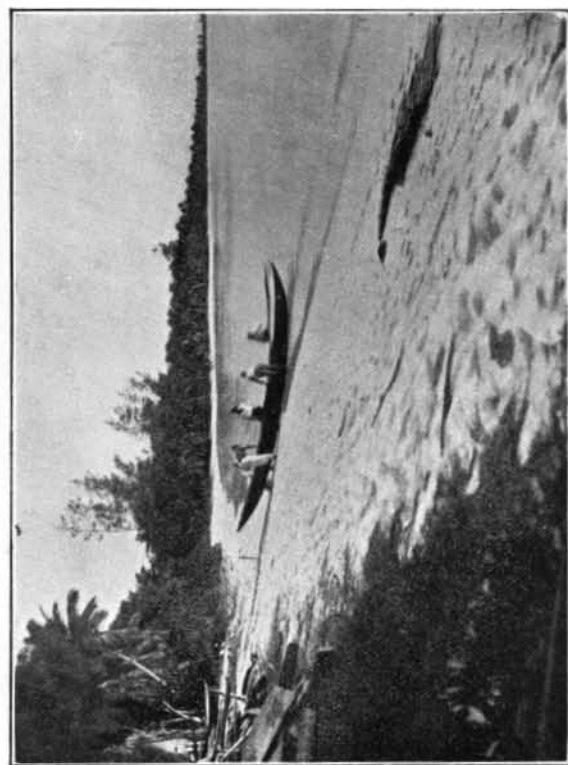


FIG. 2.—West shore, launching a pirogue.

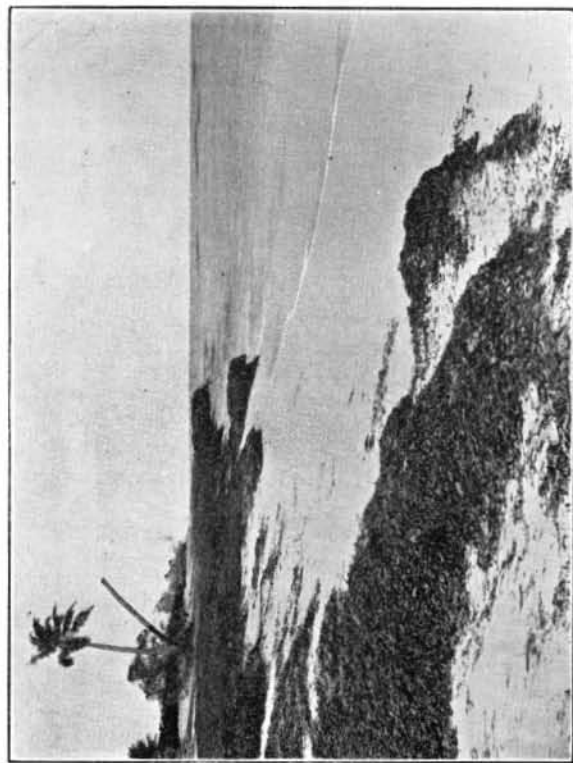


FIG. 3.—North-east end, with cliffs of *Cymodocea*.

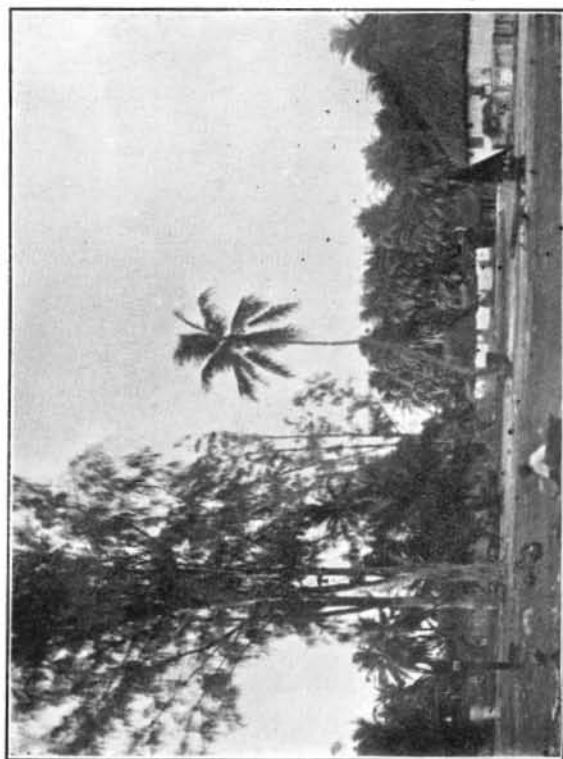


FIG. 4.—Settlement, oil-mills and large casuarinas.

COETIVY.

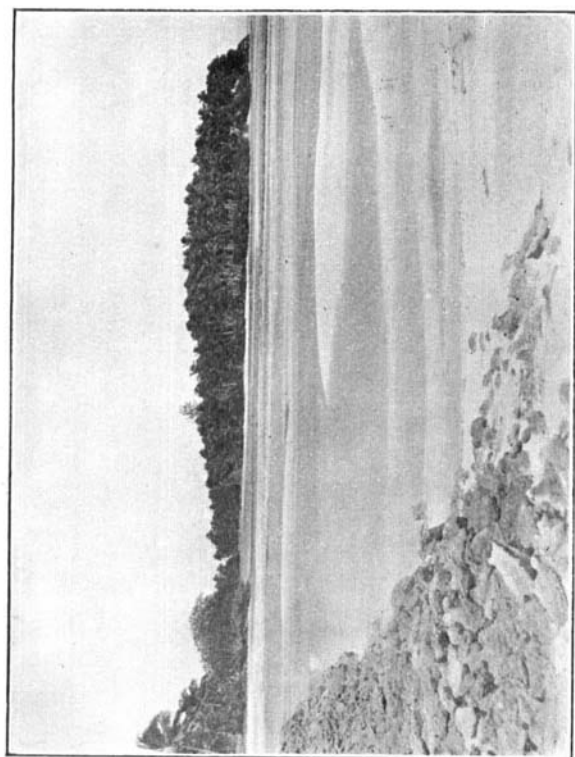


FIG. 1.—North end of South Island.

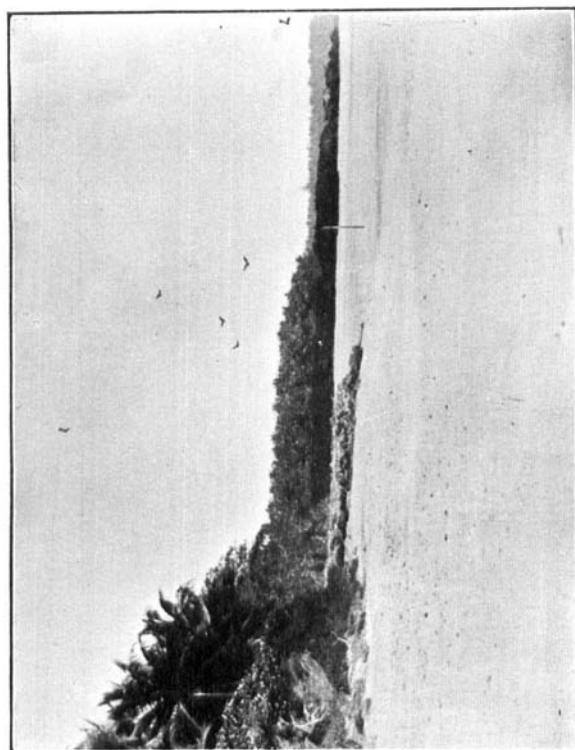


FIG. 2.—View into North Bay of South Island.

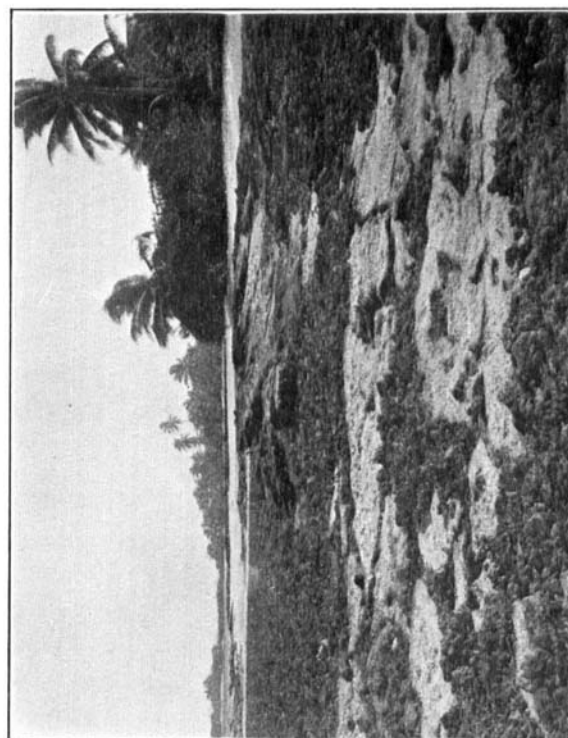


FIG. 3.—E. shore of S. Island: coral-rock dipping to W.

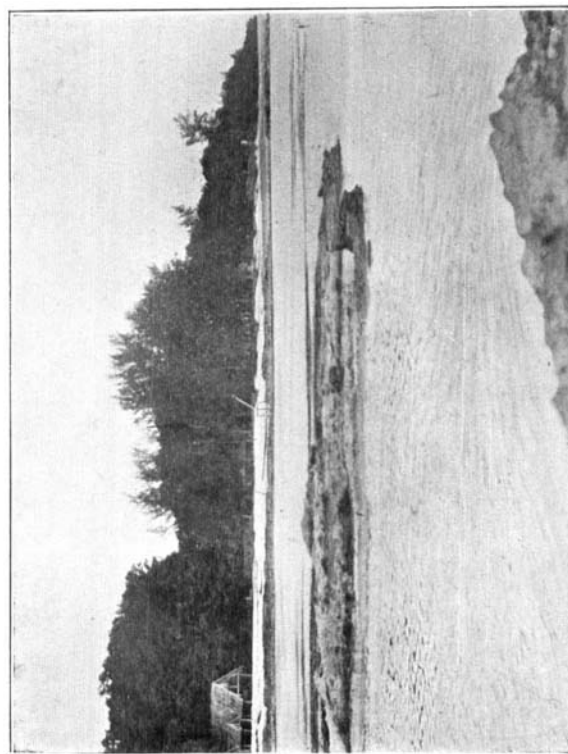


FIG. 4.—Landing-place, north of North Island.

POIVRE. AMIRANTE GROUP.