Progress of the Great Barrier Reef Expedition.

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AFTER four months at its headquarters on Low Island, forty miles north-north-east of Cairns, North Queensland, the expedition is now (Nov. 21) well advanced with its extensive programme of research. Excellent living accommodation, and what is in effect a well-equipped marine laboratory, have been erected and fully established. The island has been well chosen as the site of work. Situated midway between the Barrier and the mainland, here only fourteen miles apart, it possesses a fauna characteristic of both these regions; there is a mangrove swamp with the usual associated fauna and flora, while, exposed on the reef flat at low tides and all around the island beneath low water, there is an abundant growth of corals comprising many genera. There is thus ample material for experimental and observational work, while the island is so small—although thoroughly characteristic of the inner islands or 'cays' which are numerous in the northern portions of the Barrier—that a very detailed ecological survey is possible. The ecological work has been greatly helped by the preparation of a mosaic of the island from a complete series of aerial photographs taken at a height of 2000 feet over the island and reef by an amphibian flying boat belonging to the Royal Australian Air Force. The services of this machine were kindly provided by the Ministry of Defence.

Plankton and hydrographic stations have been taken weekly within the Barrier, at a position three miles east of the island. This work, under the entire charge of Mr. F. S. Russell, who is assisted in his work on zooplankton by Mr. J. S. Colman, is carried out in the *Luana*, a ketch-rigged yacht with a powerful motor, the property of Mr. A. C. Wishart of Brisbane, who is personally in charge of her and is assisted by Mr. C. Vidgen, also of Brisbane. Half-hour oblique hauls are made with the stramin and the coarse and fine silk tow-nets, while vertical hauls are made with the Nansen net. Two similar stations have been taken outside the Barrier, but work there is dependent on the weather; on one occasion a powerful motor launch was hired from Cairns and deep ocean water (150-400 fathoms) was visited. Weekly plankton samples are also taken over the Low Island Reef. A series of hauls, taken in daylight to study the vertical distribution of the zooplankton, showed that, while the surface layers were avoided by most species, there was already a marked increase at 9 metres, the total number of animals rising from 2035 at the surface to 67,822 at 11 metres. A station has also been taken at night to study diurnal changes in distribution.

To date, there have been fluctuations in the zooplankton, but no great changes such as are experienced in temperate waters. It must be remembered, however, that seasons here are far less marked. Similar work on phytoplankton has been carried out by Miss S. M. Marshall, samples of sea water being taken at various depths by means of the water bottle, while vertical hauls with the Apstein net have been taken to compare with work elsewhere. Here, again, the results so far show no startling variations, and the numbers, as compared with British waters, are low. The reason for this paucity in the phytoplankton is revealed by the results of the chemical and hydrographic work carried out by Mr. A. P. Orr. Nutrient salts have been consistently low at all depths, although pH value and oxygen saturation have shown a slight rise throughout since the work was commenced.

FIG. 1.—View of Low Island from south, taken at low tide. Four huts belonging to expedition are seen immediately behind the beach.

There has also been a gradual rise in temperature and salinity. Outside the Barrier similar results have been found for the upper layers, but, instead of mixing taking place throughout as in the inner station (32 metres), there is a well-marked discontinuity layer between 50 and 100 metres over the 100 fathom line. Temperature, pH value, and oxygen saturation all show a marked fall below 50 metres, but nutrient salts are present in appreciable amounts. Farther out, in deeper water, about 400 fathoms, this was still more marked, at 500 metres the phosphate content being 42 mgm. per cubic metre as compared with between 5 mgm. and 10 mgm. above 50 metres.

A series of samples taken at frequent intervals over a twenty-four hour period from over the reef flat, where there is much living coral, have yielded results of great interest. As soon as the tide leaves the flat at night, there is a rapid fall in pH value and in oxygen saturation, the latter dropping so low as 25 per cent. Open sea conditions are quickly restored when the tide returns. During the day, both pH value and oxygen saturation rise considerably in the pools left by the tide, open

sea conditions again prevailing after the tide has risen. When left by the tide, the temperature of the coral pools rises considerably by day and falls by night, the salinity rising slightly by night and more by day. At a depth of two fathoms in the lagoon among rich coral, the tide has little effect, and the changes are related to light and darkness chiefly.

The work of the reef party under Dr. Stephenson has been varied. He has spent the majority of the first three months in the preparation of an elaborate experiment on the growth rate of corals. One hundred square blocks of concrete have been made, and to each has been fixed one or more living corals of many different genera. The blocks, after being photographed with the corals *in situ* by means of an apparatus which ensures that they can be photographed later at exactly the same angle and distance, have been spiked down firmly in two specially chosen areas. To test the effect of

Mr. G. Tandy, the botanist, has collaborated with the other members of the reef party in the general ecological survey now being carried out, and has also done extensive collecting of marine algæ. He has studied in the greatest detail possible the conditions of plant life on the Low Island Reef, illustrating this with as complete a series of photographs as possible. He has also collected some data on the rate of growth of algæ. There is no *Lithothamnion* reef here or in the neighbourhood, but the ubiquity of encrusting corallines is extraordinary, especially on the lower branches of the common staghorn coral.

While the time of the leader of the expedition has been chiefly occupied with details of administration and matters concerning its efficient running, a good beginning has been made on the intensive study of the feeding mechanisms of corals. The extent to which even corals with the least developed

polyps can capture actively swimming planktonic organisms of frequently relatively enormous size is remarkable, while the reversal of the direction of ciliary beat appears to be undoubtedly of common occurrence in corals. Symbiotic algæ in vast numbers have been found in every individual of every genus examined. It is hoped to extend our knowledge of the function of these in the metabolism of the corals. They certainly produce an abundant supply of oxygen; elaborate experiments in which cleaned coral colonies in sealed glass jars have been placed in the sea for periods of nine hours, first in the light and then in the dark, have shown that, whereas in the light the oxygen content of the water may increase by so much as 100

per cent, in the darkness it may decrease almost to zero. The phosphate content decreases to zero usually under both conditions, protein metabolism not being dependent on light. The oxygen and phosphate determinations have been carried out with great accuracy by Mrs. Yonge.

The extent to which the corals with their symbiotic algæ form a closed cycle is revealed by the fact that corals have been kept in sealed glass jars for fourteen days in the sea and have not only lived but the water in some of the jars also contained a higher percentage of oxygen than at the beginning of the experiment. Investigations are proceeding into the part played by the algæ which crowd the exposed mantle surface of the giant clams *Tridacna* and *Hippopus* in the metabolism of these animals.

The effect of starvation and deprivation of light upon the corals and their contained algæ is being studied in the small aquarium attached to the laboratory, a special apparatus having been constructed for this purpose. Investigations of the digestive enzymes of corals show that corals are

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FIG. 2.—Outside of laboratory on Low Island.

different environments on growth, ten further blocks have been provided with the halves of divided colonies and the halves planted out in different habitats. Dr. Stephenson has examined at regular intervals the gonads of the corals *Favia*, *Symphyllia*, and *Lobophyllia*. All are hermaphrodite, and at present have well-developed ova and less-developed testes. Weekly gonad samples of eight common reef animals, and examinations of the spawn and breeding habits of reef animals, have been made by Mrs. Stephenson. It is interesting to record that the common chiton (*Acanthozostera gemmata*) has twice spawned on the night of full moon. Mr. F. W. Moorhouse, of the University of Queensland, has assisted Dr. Stephenson, and has also carried out intensive work on two species of oyster, two of bêche-de-mer, and on the commercial *Trochus* (*Trochus niloticus*). He is making regular gonad samples of all, while the last named is being farmed for observations on the growth rate, which is remarkably rapid. He is also working on a commercial sponge of fair quality common on this and neighbouring reefs.

specialised carnivores, and the manner—if any—whereby the algæ are digested is yet to be ascertained.

Mr. A. G. Nicholls, of the University of Perth, besides rendering great assistance to the leader of the expedition with his work on corals and beginning work on the calcium content of sea water, has taken charge of the work on the life history of the 'black-lip pearl oyster' (*Meleagrina margaritifera*). An area on the reef flat has been marked off with a stout fence of mangrove wood, ample settling surface for spat being provided not only by the mangrove stakes, but also by numerous empty clean clam shells. Some 450 oysters have been placed in this enclosure. Gonad samples are taken fortnightly, and one breeding period, during the first week in November, so far noted. Mr. G. W. Otter is carrying out a survey of the varieties, numbers, distribution, and powers of destruction of the rock borers, especially the lamellibranchs, and is obtaining results of interest. He is also working on the wood-boring Teredinidæ.

Collecting both on the reef and from the bottom near reefs by dredges and the Agassiz trawl—the latter from a 20-foot whale-boat with a 6 h.p. engine purchased locally—has proceeded apace, but intensive collecting is being held over until after the

summer, when it is hoped that an additional boat will be chartered, and excursions can be made far afield. For the time being, the expedition is doing its best work by concentrating on the intensive study of the conditions on and around this small reef, and from the various lines of research so vigorously being prosecuted there is every indication that, at the end of the year here, there will be available for publication the most complete account to date of the conditions under which this type of coral reef exists.

Mr. J. A. Steers, assisted by Mr. M. Spender and Mr. C. Marchant, who constitute the geographical section, have cruised northward from Townsville in a launch chartered there, to Flinders Islands (north of Cooktown) and back, calling at Low Islands for several days on both outward and return trips. They have examined many reefs and coral cays in this long stretch, and have been able to form a very clear idea of the vastness of the problem confronting geographers in this region. Mr. Steers is now on his way back to England, but Mr. Spender and Mr. Marchant are to arrive at the Island shortly, the latter for two months only, the former, with periods of surveying on selected cays and on the mainland opposite the island, for the remaining period of the expedition.

Obituary.

PROF. BASHFORD DEAN.

DR. BASHFORD DEAN, who died at Battle Creek, Michigan, U.S.A., on Dec. 6, 1928, was equally eminent as an ichthyologist and as a student of medieval armour. He acquired both interests in early boyhood in circumstances which fostered them, and he continued to pursue both until the end. For several years he was the active curator of fishes in the American Museum of Natural History, New York, where he planned the public exhibition of fossil and existing fishes. For a still longer period he was curator of arms and armour in the Metropolitan Museum of Art, New York, and likewise planned the installation of the collection. In each case he largely added to the collection by the acquisitions he obtained during his numerous and extensive journeys in the Old World.

Dean was born in New York on Oct. 28, 1867, and was educated first at the College of the City of New York, where he made good progress in zoology. Next, in 1886, he entered Columbia College, where he studied geology and fossil fishes under Prof. J. S. Newberry, whose researches on Devonian fishes he afterwards continued. In 1890 he graduated as Ph.D. with a thesis entitled "Pineal Fontanelle of Placoderm and Catfish," which was published by the New York State Commission of Fisheries. Meanwhile, he had already become tutor in natural history in the College of the City of New York, and had also been appointed assistant on the Fisheries Commission. He thus had early experience both of teaching and of research. In later years he was for a time one of the professors of zoology in

Columbia University, where he had some brilliant pupils; but most of his energies were devoted to research and the enlargement of the collections of which he had charge.

Dean's training led him to take the widest view of ichthyology, and he was equally well versed in the methods of embryology and of palæontology. His outlook is well shown in his useful handbook on "Fishes, Living and Fossil," which was published in the Columbia University Biological Series in 1895. It deals mainly with the lower and older groups of fishes, which are of the greatest interest from the evolutionist's point of view. It regards them in all aspects, and facilitates comparisons by adequate synoptical tables and pages of clear figures drawn by himself. It summarises the knowledge and ideas of the time, expressing several opinions which Dean's own researches afterwards caused him to modify. His latest and most important volume, on "Chimæroid Fishes and their Development," published by the Carnegie Institution of Washington in 1906, displays the same wide scope. It combines embryological observations on specimens which he collected in Japanese seas with extensive anatomical research and numerous descriptions of important fossils. It reaches the conclusion now generally accepted, that the chimæroids are highly specialised sharks.

Among Dean's papers on fossil fishes may be specially mentioned those on the Devonian shark which he named *Cladoselache*, and those on the armoured Devonian fishes commonly known as *Arthrodira*. He showed that the fins of *Cladoselache* could only be explained on the theory that