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Notes on Indian Ocean atolls visited

by the Yale Seychelles Expedition

by

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I. The Maldive Islands, with special reference to the coral reefs

The Yale Seychelles Expedition vessel 'Argosy', a llO-foot ketch (Fig. 1), left Colombo 15 September 1957 and entered the lagoon of North Male Atoll on 19 September. The 37-foot fishing cruiser 'Sea Quest' also participated in the Expedition. The scientific staff of three zoologists included Dr. James E. Morrow, Jr., chief scientist (fishes); Dr. Willard D. Hartman (sponges); and the writer (molluscs). The expedition was made possible through the generosity of Mr. Alfred C. Glassell, Jr.

The following notes are taken from the writer's field notebooks. Horizontal distances are given in metric units, but water depths and other vertical distances are in feet to conform with U.S.C.G.S. Tide Tables. In all cases, tidal datum is mean low water springs (MLWS). The few sea temperatures recorded are given in Table 1. For more extensive accounts of the Maldive Islands, reference may be made to Gardiner (1903) and Agassiz (1903).

North Male Atoll

Funidu (YSE Sta. 17)

Following a visit to the main island of Male (described by Villiers, 1957), several days were devoted to surveying the invertebrate fauna of a well-developed coral reef fringing a small island within the lagoon, called Funidu by the Maldivians but unnamed on charts (Fig. 2). A separate report on this study is given in Atoll Research Bulletin 102.

Dunidu (YSE Sta. 18)

Further collections of reef fauna were made at Dunidu I., also entirely within the lagoon. A large tide pool on the east side of the island was poisoned with rotenone for collection of fishes and invertebrates. The shore on this side was mainly of beachrock. An old British rest house on Dunidu provided lodging and laboratory space for Dr. Hartman and myself for four days (5-8 October). During this time we were able to make limited collections of shore invertebrates at night.

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Hulule (YSE Sta. 22)

J.S. Gardiner spent a month on Hulule in 1900, but described the island only briefly (1903: p. 7, 329 ff.). We made two trips to the seaward reef opposite the east side of the island. The reef is extremely broad, 400 m on the chart, but of this the inshore ca. 350 m is a uniform sand flat at about -1'. Near the outer edge, coral and coral rubble increase in abundance. In some areas in the surge zone the blue alcyonarian coral <u>Heliopora</u> is extremely abundant, as it was during Gardiner's visit (1903: p. 477). Extensive areas of flat reef limestone pavement near the outer edge are covered with large chunks of coral rubble, apparently thrown up by waves from the outer reef face (Figs. 3, 4).

A few habitat notes on the molluscs collected were made: In the sandy areas, only a few small specimens of three species of <u>Terebra</u> and a number of empty pelecypod shells were collected. Near the outer edge, several species of <u>Cypraea</u> occurred under coral heads and rubble. <u>C. moneta</u> was common in coral rocks and large pieces of rubble. <u>Cantharus</u> sp. and a large <u>Thais</u> sp. were very common but not collected. <u>Tridacna</u> up to 35 cm in length were also abundant. The species of <u>Tridacna</u> are extremely difficult to determine in the field, and a few of each morphological type were collected. The second collecting trip concentrated in the rubble and coral zone opposite the north end of Hulule. <u>Engina</u> sp. was the dominant mollusc, but members of this phylum were sparser here than on any other reef visited in the Maldives. Gardiner (1903: p. 7) also observed that "Mollusca are not numerous" at Hulule.

While collecting at Hulule, we were joined by many Maldivian children. By placing the entire coral head in the opened sarong and lifting it out of the water, they ingeniously catch reef fishes that dart back into coral heads when startled.

Male (YSE Sta. 23)

Collections were made chiefly along the outer edge of the reef flat on the west side of Male I., the eastern edge of the channel between Male and Wilingili. The outer edge slopes rather gently across a zone of living and dead coral heads about 20 m wide to ca. -2' at the steep reef face. This zone was characterized by abundant <u>Cypraea</u> tigris, which is abundant only in scattered locations in the Maldives. The inshore edge of this zone is shallow, about the +1' level, and covered with dead coral and rubble. The broad reef flat from the rubble zone to shore, about 100 m wide, is at about the +0.5' level and covered with a dense mat of turtle grass (Thalassia?) and algae. Sponges were abundant.

Fadiffolu Atoll

In company with the Maldives' official guide, Mr. L. Ibrahim Didi 'Argosy' left Male for Fadiffolu Atoll 24 September and arrived at Naifaro ("prawn reef") Island the following morning. The population of Fadiffolu is about 4,000, most of whom live on Naifaro, a large fishing village, and Inawari. Naifaro boasts several 2-story buildings. Kuredu (YSE Sta. 20)

'Argosy' continued northeastward and anchored in the lagoon off Kuredu, a large island with a small village occupied permanently by only one family. We collected on the seaward reef at Kuredu 26-26 September. The reefs of Fadiffolu have been described by Gardiner (1903: pp. 396-402) and Agassiz (1903: pp. 73-77), but Kuredu is only mentioned briefly by Gardiner.

The seaward reef at Kuredu is about 300 m wide at the southern end of the island, where most of the collecting was done (Fig. 5), narrowing to a virtual absence of reef at the north end. The substrate of the landward half of the reef flat is almost completely sand. A number of completely buried gastropods were exposed by fanning the sand. These included five species of Terebra, 3 of Mitra, and 3 of Conus. About halfway across the reef sparse mainly dead Acropora colonies appear. To seaward, living Acropora and other corals become more abundant. At about 80% of the distance from shore to seaward edge is a shallow (at about the -l' level) zone of coral rubble, followed to seaward by low growing corals. The depth gradually increases, as does the height of the coral heads. At about -3', the bottom is smooth reef limestone between coral heads. This type of substrate slopes gently to seaward for about 50 m to the steep reef face, and blue water occurs to the west. Hence there is no algal ridge at the reef edge. About 120 species of molluscs, of which 17 were Pelecypoda, one an octopus, and the rest Gastropoda, were collected on the Kuredu reef.

On Kuredu are several large, brackish ponds, some of them quite deep. Dense populations of the gastropod <u>Terebralia palustris</u> occupy substratum. The ponds are probably remnants of a former <u>velu</u>, the lagoon of a <u>faro</u> or small atoll. Faros form the outer ring of the several composite atolls that are characteristic of the Maldive Archipelago.

We were able to observe a few changes in configuration of land and reefs in the 50 years since Gardiner's studies. Gardiner (1903: p. 399) reported Kuredu to be washing away to the south but extending to the north by the piling up of rock. At the time of our visit, the southern end appeared more extensive than shown on the chart, apparently due to added deposition of sand (Fig. 7). Gardiner (op. cit.) stated that many islands in Fadiffolu lagoon have washed away, a process that seems to be continuing. The reefs inside the channel between Kuredu and Fehingili Islands charted on Sheet No. 1, Admiralty Chart 66a, shown by Gardiner (1903: Fig. 103, p. 397), and mentioned in the Sailing Directions (U.S. Hydrographic Office Fub. 159, 1951), were not observed. Gardiner noted extensions of reefs from some islands into the channels. Such an extension was observed on the east side of Kuredu. This reef was charted neither on the 1835 Admiralty Chart nor by Gardiner. Gardiner mentioned a south island on Kuredu reef, which had been covered by coconut palms within the memory of people resident in 1899, but which then was "a mere sand bank with three small trees" (Gardiner, 1903: p. 399). There was no trace of this island in 1957 (Fig. 7).

During the stay at Fadiffolu, 'Argosy' was visited by several fishing dhonis, which are engaged in catching bonito. The fishermen wanted cigarettes and tin cans and traded shells for them. Shells used in trading, or given to members of the Expedition as gifts, included <u>Cassis</u> sp., <u>Cypraea tigris</u>, Conus aulicus, and Distorsio anus.

South Mahlosmadulu Atoll

Dunikolu (YSE Sta. 21)

'Argosy' sailed from Fadiffolu to the southwest corner of South Mahlosmadulu Atoll on 30 September, arriving at anchorage off Dunikolu I., on the rim of a faro in the lagoon, in the afternoon. From Dunikolu, a faro reef extends southward in the lagoon toward Warufinur and Turadu Islands (Fig. 8). Its highest point is about datum (MLWS). Many men were on the beach to meet us. One spoke a little English. They knew who we were and the names of our vessels, having learned from residents who had recently been to Male. A turtle nest with eggs was found. We loaned the Maldivians an extra face mask and they were delighted with it. Into the water they went, sarong and all! After our collecting, the Maldivians, mostly fisherman who live on Turadu, visited 'Argosy' and brought a large sack of turtle eggs and some coconuts.

It is a constant source of amazement to the newcomer to see a reef extending quite independently out across an atoll lagoon. The entire faro of which Dunikolu is a part was not investigated but has been discussed by Gardiner (1903). Along the velu side of the faro reef extending south from Kunikolu large specimens of <u>Murex</u>, <u>Chama</u>, <u>Cypraea vitellus</u>, and small <u>Pustularia</u> were collected among coral heads on the velu edge.

The narrow fringing reef on the scuthwest (velu) side of Dunikolu is sandy, followed by increasing numbers of living <u>Acropora</u>. Near the edge facing the main lagoon the reef is completely covered by low, living colonies of many coral species, and collecting is difficult as the depth is about datum. The edge slopes steeply into the lagoon; living coral covers the slope.

The reef opposite the east side of Dunikolu is similar but is separated by a lagoon ca. 50 m wide, the deepest part of which is ca. -5'. Toward the lagcon edge living coral increases in density to a ridge at the 0 - +0.5' level at the outer edge (Fig. 9). Most collecting here was done about halfway across the reef, where the substrate was of sand and rubble areas interspersed with large <u>Acropora</u> colonies and other coral heads. Specimens of several species of <u>Cypraea</u> occurred attached to the undersides of these colonies. <u>Perebra</u> spp. were fo nd completely buried in sand amid rubble inshore.

No marine collecting or serious observations were carried out during the trip from North Male to Addu, 9-11 October, aboard 'Sea Quest'. In the lagoon of Mulaku Atoll, where we anchored in 14 m in a velu, a large number of small porpoises, which made very short, high jumps, were observed.

Addu Atoll

Upon arrival off Gan I., site of a **Roy**al Air Force base, we were greeted and given much aid by extremely helpful RAF personnel. The commanding officer, Squadron Leader R. Schofield, graciously provided us with a motor tour of the island, space for a laboratory tent, meals, and inter-island transportation.

Hitadu (YSE Sta. 24)

This island, at the northwest extremity of the atoll, was visited 13 October in the company of British engineers seeking coral rock for landing strip construction. Holes due to a depth of about 7 m on Hitadu showed little but sand. There are many pieces of coral rock well inland on Hitadu, apparently thrown up by heavy seas. We collected on the seaward reef flat, which is 200-300 m wide and mainly of smooth, solid reef limestone pavement (Fig. 10) and resembles the seaward reef flat on the windward sides of the Marshall Islands (e.g., Emery, Tracey and Ladd, 1954: pl. 38). Loose dead coral rocks occur over much of the flat and many small living colonies of Heliopora occur almost to the beach. A channel is possibly developing along the edge of the beach. It was about 1 m wide with the bottom, a few inches below the lithified platform, of sand and dead coral rocks. At about 75% of the distance from shore to outer edge the amounts of living coral and, especially, coralline algae, increase markedly. In between, the platform is smooth and apparently scoured by the heavy surf. At the time of collection, breakers were usually about 5' high, and the depth of water over the reef was about 1'. The outer edge consisted of low, living coral and a broad but low "Lithothamnion" ridge, about 0.5-0.7' above the level of the main flat. In some areas, coral rocks covered with pink calcareous algae protrude a foot or more up into the heavy surf. In general, mollusks were not abundant. Cypraea moneta was collected under loose coral rocks. Bursa spp. were found inshore, but most of the other specimens collected were near the outer edge.

The large introduced terrestrial gastropod, <u>Achatina fulica</u>, was very common on Hitadu, although we had not seen it on any other atoll. Four specimens were collected on the central part of the island. Three of these showed symptoms of the disease reported by Mead (1961); both tentacles of two specimens, and one of the other, showed bulbous enlargements near the base or distally.

Gan (YSE Sta. 25)

A narrow reef on the lagoon (north) side of the island is about 80-100 m wide from high tide line to raised outer ridge. The outer ridge is composed solely of growing coral and is probably just exposed at spring lows. The reef face drops steeply to the floor of the lagoon. The inshore portion of the reef is characterized by large areas of silty sand, dead coral rocks, and abundant algae and appears to have had coral removed for runway construction. About halfway across, living coral begins and increases in density toward the outer edge. Many species of coral appear to be represented. <u>Cerithium nodulosum</u> was quite common. <u>Tridacna</u> up to about 20 cm were common. It was not certain whether more than one species was present. Shell shape seemed largely determined by the nature of the coral in which the clam was embedded. No <u>Tridacna</u> were observed lying free on the sand.

YSE Sta. 25A. Reef area between the west side of Gan and Faidu. During World War II, a causeway joined the two islands. After the war it was destroyed by the Maldivians, whose two villages on either side, we were told, did not get along very well. Construction of the causeway unfortunately obscured the changes Gardiner (1903: p. 419) noted to have taken place between 1835 and 1900. However, an extremely strong current, flowing into the lagoon at the time of collection, is eroding the west side of Gan, as evidenced by fallen trees. The trunk of one coconut palm lay about 50 m out from shore under 2' of water. Gardiner (1903: p. 419) also observed evidence of erosion in this part of the atoll. The reef flat substrate was predominantly sand, with sparse coral heads and dead coral rocks, and some areas of dense living <u>Porites</u> colonies.

YSE Sta. 25B-C. Reef area on the lagoon side, near the east end of Gan. The width of the reef is about 80 m. Inshore portions consist of sand with areas of <u>Thalassia(?)</u> and dead coral rocks. The central area is of coral rubble, the outer portion of large living and dead corals. The gently sloping outer edge was densely populated with molluscs. Turbo sp. and Vasum turbinellum were especially common.

A turtle grass flat on the east end of Gan, adjacent to Gan Channel, was observed by two members of the crew, P. Melante and J. Blanchard, who collected more than 100 specimens of Cypraea tigris there.

Wiringili (YSE Sta. 26)

The broad lagoon reef, up to 800 m across, on the west side of Wiringili I. was visited 16 October. The substratum is mainly coarse sand, on which isolated coral heads and rather small <u>Acropora</u> colonies rest. <u>Porites</u> is the only abundant coral, but small, sparse colonies of several other corals were present. A transect of the reef from shore to outer edge was observed from the boat. The density of coral heads increases moderately from shore to outer edge. Clumps of coral heads at the outer edge form a ridge probably at about datum level. Behind the ridge is a lagoonlet about 4' deeper. The major (inshore) portion of the reef flat is at about the O to -1' level.

During the last six days at Addu (14-1) October) the weather was quite cocl (daytime temperatures about 80° F) and rainy. Winds were light and variable. Rain squalls were large, moved slowly, and often blew back again after they once passed the island. Climatic conditions thus agreed with those reported by Agassiz (1903). They are due to Addu's location near the southern limit of the southwest and northeast monsoons, and north of the tradewind zone. Rainfall figures we were given ranged from 100 to 190". It is not unusual to have 2" in one day. At Addu also, local boys often presented us with shells, e.g. Cypraea arabica. A shell appears to be a usual gift when a Maldivian greets a foreigner. Beyond the initial gift, the usual price for each shell is one cigarette. A number of cowries were added to the Expedition's collection in this way. At work in or outside our laboratory tent we were constantly surrounded by a number of Maldivians, chiefly children. They have picked up considerable English, and some of the men read English well.

The Expedition departed from the Maldives on 20 October 1957.

II. Peros Bahnos Atoll, Chagos Islands

The Yale Seychelles Expedition vessel 'Argosy' sailed south from Addu Atoll at 09:20 on 20 October 1957, gradually entering the region of the northwest monsoon, and entered the lagoon of Peros Banhos at 06:00 on 22 October. Although the northwest monsoon is said to be characterized by long periods of calm (Bourne, 1888), the weather was stormy, and seas were heavy in the broad, open lagoon, into which there are twelve large passages.

We went ashore only at Ile du Coin, the main settlement and headquarters of the well-kept copra plantation. We were informed that 7.05"of rain had fallen in the past 2^{4} hours. Annual rainfall is 120-130".

It is of interest to compare our observations of the island with those of J. Stanley Gardiner and C. Forster Cooper (1907), who visited Ile du Coin in June, 1905. The main change in the past 50 years seemed to be that oil for export is no longer made from copra. In 1905, 65,000 gallons of oil were exported annually to Mauritius on three trips of a brig. Now, about 60 tons of copra are shipped each month on a small freighter to Mauritius, where the oil is pressed. Coconut oil is milled at Coin only for local consumption, although the very large old millstone used testifies to the formerly large production.

The human population of Peros Banhos is now 500, against 200 in 1905. Many of the people have lived all their lives in the Chagos, but although Gardiner and Cooper predicted that increase in numbers of these "enfants des îles" would eliminate the need to import laborers, many laborers continue to come from Mauritius. During the rainy periods of our visit, women were engaged in making coir rope. In good weather each woman splits 700 coconuts per day, a task requiring less than half a day, for 10 rupees per month, about the same wage paid in 1905.

Prominent cultivated trees are mapou (<u>Pisonia</u>), breadfruit, banana, and a few papayas. Flowers are grown, and the laborers have vegetable gardens. As was the case in 1905, pigs and chickens are kept for food and fed on coconuts. Ducks, not noted by Gardiner and Cooper, are now also raised. Donkeys were also present, but we saw no mules. The people and livestock appeared very healthy, a condition also remarked on by Gardiner and Cooper (1907).

Lagoon reef, Ile du Coin, (YSE Sta. 27)

The most conspicuous feature of the reef is the abundance of a single species of zoanthid which forms a broad inshore zone. Seaward of this is a zone of smooth reef limestone with a few low <u>Porites</u> heads and some zoanthids. The reef flat is at about 0 to -l' tide level (0 = MLWS). The seaward edge of the reef slopes rather gently. It is a region of heavy surge with few coral heads.

Molluscs collected included <u>Cypraea</u> <u>caputserpentis</u>, <u>C</u>. <u>arabica</u> (commonly in pairs on undersides of coral rocks, some with egg capsules); and members of the genera <u>Cantharus</u>, <u>Mitra</u>, <u>Conus</u>, <u>Thais</u>, <u>Vasum</u>, <u>Amphiperas</u>, and <u>Tridacna</u>.

Seaward Reef, Ile du Coin (YSE Sta. 28)

Collections were made on the broadest part of the reef, which is 250-300 m wide. Areas of fine sand, rough coral or reef rock, and smooth reef rock pavement characterize the inshore portion, which probably represents a region formerly occupied by the island. The proportion of smooth pavement increases, and it is covered by an algal mat of increasing thickness, to seaward. About 200 m from shore the substrate has a gently rolling appearance, and ranges in level from about -1.0' to +1.0'. Smoothed coral rocks typically occur in the depressions, and some rubble and occasionally sand is found underneath them. The number and size of such coral rocks increase toward the outer edge, where they are typically covered with pink coralline algae. The typical "Lithothamnion ridge" reported by Gardiner (1936) could not be visited because of the heavy surf. Although the tide was a low spring (+0.2' about two hours prior to our observation), the strong northwest wind had apparently prevented the reef from drying completely. Only portions of the outer ridge could be seen protruding through the surf. We were told by the plantation sub-manager that the reef often dries at low tide.

Just inshore from the Lithothamnion ridge the algal turf is 2-3 cm deep. Cup sponges (<u>Phyllospongia foliascens</u>) were extremely numerous on it. <u>Conus</u> was more abundant here than at any station visited in the Maldives; 189 specimens of 12 species were collected in 2½ hours. One specimen of Thais armigera (?) was observed feeding on <u>Nerita plicata</u> in the typical <u>Nerita</u> zone of inshore rock. In all, about 50 species of gastropods and 7 species of pelecypods were collected.

Gardiner (1936) concluded that the land of **Peros** Banhos was washing away, and that the atoll was progressing toward a submerged bank or drowned atoll, of which there are several in the Chagos Archipelago. We made no observations relevant to this hypothesis, except that the amount of dead reef and exposed reef rock observed was generally confirmatory.

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Table 1

Sea Surface Temperatures Over Maldive Coral Reefs, 1957

YSE Station	Location	Date	Time	Temp. (^O C)
17	Funidu I., North Male Atoll (lagoon)	19 Sept.	17 :1 5	29.5
		20 Sept.	10: 45	28.7
23	Male I., North Male Atoll (channel)			
	near outer edge over coral	6 Oct.	11:00	28.9
	on inshore turtle grass flat		12:00	31.7
24	Hitadu I., Addu Atoll (seaward reef)	13 Oct.	10:00	29•5
25	Between Gan and Faidu Is., Addu Atoll	15 Oct.	10:30	29.5

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Figure captions

Figure 1. Yale Seychelles Expedition vessel 'Argosy' off Addu Atoll.

- Figure 2. View from Male Harbour approximately northeast to Funidu Island, North Male Atoll (YSE Sta. 17). The large island in the background is Hulule.
- Figure 3. View south along outer edge of seaward reef of Hulule Island, North Male Atoll (YSE Sta. 22), showing coral heads apparently thrown up by waves.
- Figure 4. View east across outer edge of seaward reef of Hulule Island, North Male Atoll (YS2 Sta. 22).
- Figure 5. View south along southern portion of seaward reef flat, Kuredu Island, Fadiffolu Atoll (YSE Sta. 20). The island and beach are to the left, the sandy, inshore portion of the reef in the center foreground, and coral increasing toward the outer edge, right background.
- Figure 6. Large brackish water pond on the central portion of Kuredu Island, Fadiffolu Atoll.
- Figure 7. View southwest from southern tip of Kuredu Island, toward Kudadu Island in distance, Fadiffolu Atoll. Seaward reef to right, lagoon to left.
- Figure 8. View southwest from south shore of Dunikolu Island across faro reef (YSE Sta. 21) to Warufinur Island in distance, South Mahlosmadulu Atoll. Velu to right, main lagoon to left.
- Figure 9. View southeast across reef on east side of Dunikolu Island, South Mahlosmadulu Atoll (YSE Sta. 21). Beach in lower right corner, sandy inshore portion of reef in foreground, darker areas of coral and main lagoon beyond in background.
- Figure 10. View northwest across seaward reef flat, Hitadu Island, Addu Atoll (YSE Sta. 24).

