Holothurians and other echinoderms of the Glorieuses Islands (Scattered Islands of the Indian Ocean)

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Introduction

As part of an assignment for Agence Nationale pour la Recherche (French National Research Agency), we sampled the echinoderms of the Glorieuses Islands (Fig. 1) from 24–28 April 2008.[3] We particularly surveyed the holothurians found on the reef flats and outer slopes. These islands' reef flats were sampled by Vergonzanne in 1977. Other research on this area relates to holothurians of Mayotte (Pouget 2004, 2005; Conand et al. 2005), the Comoros (Samyn et al. 2005) and the Geyser Bank (Mulochau et al. 2007). Some Reunion Island holothurian data (Conand and Mangion 2002) were also consulted.

The coral reefs of the Glorieuses Islands (Fig. 1) have a surface area of 7 km^2, and have been classified as a Nature Reserve (Gabrié 1998).

The current expansion in the world holothurian fishery is causing overfishing in most countries in the tropical Indo-Pacific (Conand 1999, 2004, in press). As suggested by Uthicke and Conand (2005), research on a site classified as a Nature Reserve and remote from coastal human influences can help us improve our understanding of holothurians and their role within the reef ecosystem, and enable a comparison of the various research sites in terms of anthropic impacts.

Materials and methods

Research site

Together with Tromelin, Juan de Nova, Bassas da India and Europa, the Glorieuses Islands form part of the five Scattered Islands in the western Indian Ocean. They are French territories, lying in various locations around Madagascar and representing an exclusive economic zone (EEZ) of nearly 650,000 km^2 (Gabrié 1998). These islands were classified as nature reserves in 1975 and have been administered as the fifth district of the French Southern and Antarctic Lands since 2007.[4] The Glorieuses Islands are in the northern Mozambique Channel, 258 km northeast of Mayotte and 220 km northwest of Diego Suarez (Madagascar). The group comprises two main coral islands (Fig. 2): Grande Glorieuse, an oval-shaped, incomplete atoll that is 3 km in diameter; and Île du Lys or Petite Glorieuse, which is 0.6 km in diameter. Two rock islands, Roches Vertes and Île aux Crabes, together with two sandbanks that are exposed during low tide, make up the rest of the group.

Figure 1. Location of the Glorieuses Islands within the Indian Ocean.

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3. This assignment is part of a larger project concerning the Glorieuses Islands (Bigot et al. 2007). The project falls under the French National Research Agency's Interface Programme — a multi-disciplinary study on the vulnerability of environments to climate change.
4. Law No 2007-224, dated 21 February 2007 providing for the legal and institutional status of overseas entities

Altogether, this coral island formation amounts to an area of 7 km^2. It is a bank reef that has developed in shallow water (Vergonzanne 1977) and there are no distinct geomorphologic divisions, apart from some fringing formations around the two main islands. Ranges of habitats with different geomorphologic features were investigated at nine stations (Fig. 2) at the outer slope in the north and northwest, and the inner reef flats to the north, south, east and west (Table 1).

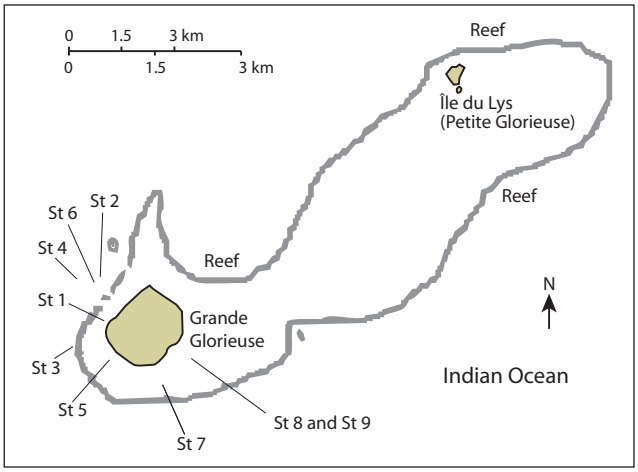


Figure 2. The nine research stations on Grande Glorieuse.

Table 1. Biotopes and communities of the nine research stations on Grande Glorieuse

Station	Depth	Biotope	Biocenosis
Station 1 24.04.08 AM jetty reef flat	1 m	Reef flat north Hard substrate: 20 % Rubble: 10 % Sand: 50 %	5% coral cover 5% algal cover
Station 2 24.04.08 PM GCRMN 1	15 m	Outer slope north Large coral blocks Hard substrate: 70% Rubble: 15% Sand: 15%	30 % coral cover 30 % algal cover
Station 3 25.04.08 AM GCRMN 2	12 m	Outer slope northwest Bottom of smaller slope Hard substrate: 40% Rubble: 30% Sand: 30%	30 % coral cover 20 % algal cover
Station 4 25.04.08 PM Mooring zone	15 m	Outer slope north Bottom of slope – Large coral blocks on sandy bottoms Hard substrate: 50% Rubble: 10% Sand: 40%	20% coral cover 50% algal cover
Station 5 26.04.08 PM Cap vert rocks	1 m	Reef flat west Hard substrate: 20% Rubble: 20% Sand: 60%	1% coral cover 30% algal cover
Station 6 27.04.08 AM Camera testing zone	6 m	Outer slope north Large coral blocks on sandy bottoms Hard substrate: 60% Rubble: 20% Sand: 20%	30% coral cover 30% algal cover
Station 7 27.04.08 AM Ile aux crabes	1 m	Reef flat south Hard substrate: 40% Rubble: 40% Sand: 20%	5% coral cover 20% algal cover
Station 8 28.04.08 PM Reef flat southeast	1 m	Reef flat southeast Hard substrate: 50% Rubble: 30% Sand: 20%	20% coral cover 10% algal cover
Station 9 28.04.08 PM Reef flat southeast	1 m	Reef flat southeast Hard substrate: 50% Rubble: 30% Sand: 20%	20% coral cover 10% algal cover

Sampling technique

Sampling was carried out by scuba diving and free diving at depths of 1–15 m. The nine stations, spread over part of the bank reef (Fig. 2), were surveyed by a diver who followed a random route for one hour and recorded the various species of echinoderms present and the number of specimens per species. This timed dive made it possible to visualise various habitats within the same biotope and to view larger areas than with the more conventional transects or quadrats (Leeworthy ans Skewes 2007; Hart 2006). Nine hours of diving were spent counting and photographing the various species. Sampling at the nine stations comprised systematic investigation of the reef surface, cavities, dead coral blocks that could be turned over, and sediment.

Results

Holothurians

The total density of holothurians recorded during our investigation was 86 specimens in nine hours of diving, or approximately 9.5 specimens per hour. Ten species of holothurians were observed. Table 2 shows the species observed, their relative abundance and the frequency of observation of the various species.

Holothuria nobilis (Fig. 3A1 and A2), with a relative abundance of 75%, is the most abundant species. This species is also the one showing the highest observation frequency (55.5%) and was primarily sampled on the reef flats. *Bohadschia atra* (Fig. 3B1 and B2) is the most abundant species and the most frequently observed on the outer slopes. This species was not seen on the reef flats. Few of the other species were observed more than once.

All the stations sampled had at least one species of holothurian. Station 7, a reef flat station with a large rubble field and low coral cover (Table 1), is the station with the greatest species richness (5 species) (Table 2). Stations 8 and 9, southeastern reef flat stations, had lower species richness than Station 7 with only two species. However, Stations 8 and 9 had the greatest abundance, particularly with species *Holothuria nobilis*. To a lesser degree, Station 4 on the north outer slope appears to offer potential, with three species found.

All species observed are shown in Figure 3. For some species, such as *Holothuria lineata* (Fig. 3I), ossicle examination was required; other identifications, *Labidodemas rugosum*, *Holothuria impatiens* and *Holothuria hilla*, were done by consulting taxonomists (Dr Y. Samyn, Dr C. Massin); other species were easier to identify from photographs, such as *Holothuria nobilis* (Fig. 3A), which needed handling to remove the layer of sediment covering them (Fig. 3B).

Other echinoderms

Concerning other organisms, we recorded eight species of ophiuroids, four species of echinids, no species of asterid and no species of crinoid. Table 3 shows the species of ophiuroids observed, their relative abundance and the frequency of observation of the species in this class.

The total density of ophiuroids recorded during the survey was 53 specimens per seven hours of diving, or approximately seven specimens per hour. Eight species of ophiuroids were sampled (Table 3).

All the species of ophiuroids were found on the reef flats of Grande Glorieuse and none on the outer

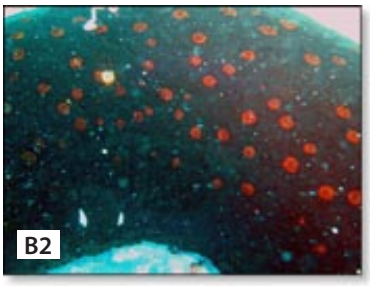
Table 2. Abundance of the various species of holothurians sampled by station on Grande Glorieuse in nine hours of diving (one hour per station), relative abundance (number of specimens of a species/total number of holothurians) and frequency of observation (number of stations at which the species was observed/total number of stations) as a % of total.

Station (St)	St1 **	St2 *	St3 *	St4 *	St5 **	St6 *	St7 **	St8 **	St9 **	Relative abundance	Frequency observed
Holothuria nobilis	2			1			8	24	28	73 %	55.5 %
Bohadschia atra		3	1	6		1				13 %	44.4 %
Bohadschia subrubra			1	1				1		3.5 %	33.3 %
Synapta maculata							1		1	2.3 %	22.2 %
Euapta godeffroyi							2			2.3 %	11.1 %
Holothuria hilla							1			1.2 %	11.1 %
Holothuria cf. *impatiens*							1			1.2 %	11.1 %
Holothuria lineata					1					1.2 %	11.1 %
Holothuria cf. *pardalis*								1		1.2 %	11.1 %
Labidodemas cf. *rugosum*							1			1.2 %	11.1 %

* Outer slope stations; ** Reef flat stations

Holothuria nobilis

Holothuria nobilis covered with sediment



Details of *Bohadschia atra*

Bohadschia atra

Holothuria hilla (id. confirmed by Dr Y. Samyn)

Bohadschia subrubra

Holothuria cf.impatiens (identified by Dr Y. Samyn)

Labidodemas cf. rugosum (identified by Dr Y. Samyn)

Euapta godeffroyi

Synapta maculata

Holothuria lineata (identified by Dr Y. Samyn after examination of the ossicles)

Holothuria cf. pardalis

Figure 3. The various species of holothurians sampled on the reef at Grande Glorieuse.

Table 3. Abundance of the various species of ophiuroids sampled by station on Grande Glorieuse over seven hours of diving (1 hour per station), relative abundance (number of specimens of a species/total number of ophiuroids) and frequency of observation (number of stations at which the species was observed/total number of stations).

Station (St)	St 1	St 2 *	St 3 *	St 4 *	St 5	St 6 *	St 7	Relative abundance	Frequency observed
Ophiocoma brevipes	11				7		2	38 %	43 %
Ophiocoma shoenleini							15	28 %	14 %
Ophiarthrum pictum	3				1		8	23 %	43 %
Ophiocoma erinaceus	2							4 %	14 %
Ophiocoma valenciae							1	2 %	14 %
Ophiarachnella gorgonia							1	2 %	14 %
Macrophiothrix longipeda							1	2 %	14 %
Ophiuroidea							1	2 %	14 %

* Outer slope stations

slopes (Table 3). All these species inhabit the same kind of rubble environment with few living coral colonies, a lot of coral rubble and a lot of sediment. *Ophiocoma brevipes* and *Ophiarthrum pictum* were seen at all the reef flat stations (cf. Fig. 2). Station 7 was the one where the abundance and diversity of ophiurids were the greatest.

We also observed 3 species of Echinoids represented by 1 specimen of *Eucidaris metularia* at stations 5 and 7; 1 *Echinothrix calamaris* at Station 5 and a number of specimens of *Echinostrephus aciculatus* at stations 2, 3, 4, 6, 7, 8, and 9.

Discussion

Holothurian diversity, as observed in this study, is low (10 species) compared to that recorded at other research sites in the Comoros (Samyn et al. 2005), Mayotte (27 species, Conand et al. 2005) and Reunion Island (Conand and Mangion 2002). However, intensified sampling effort could make it possible to increase specific richness, although Vergonzanne in 1977 also only found 10 species despite extensive surveys, but his work was restricted to the reef flats of Grande Glorieuse.

Holothurian density for the surface area investigated also seems very low in comparison with some areas of other Indian Ocean islands. The data relate mainly to reef flats, like those of the fringing reefs of Reunion Island, where they may reach levels of several hundred specimens per station per hour (pers. comm.). This scarcity could be explained by the lack of favourable biotopes, because the organic matter concentration needed to sustain holothurians could be too low. However, it can be assumed that the Glorieuses Islands reef environment is much less subject to human influences and that the holothurian diversity and abundance noted during the study reflect the circumstances of an oceanic reef as compared to a reef receiving organic matter deposits from human activities, such as the Reunion Island one.

Holothuria nobilis (Fig. 3A), a species with high commercial value (Conand 1999), occurs abundantly on the reef flats of the Glorieuses Islands in comparison with other nearby sites like the reef flat of the Geyser Bank (Mulochau and Conand 2007), Grande Comore (Samyn et al. 2006) or Mayotte (Pouget 2005). This species is one of the most collected in Mayotte and the Comoros (Pouget 2005; Samyn et al. 2006) and Samyn reports that this very sought-after species no longer occurs in the upper 20 m in the Comoros. In the Glorieuses Islands, a site classified as a Nature Reserve, this species is frequently encountered on the reef flats on coarse sandy bottoms and rubble beds containing occasional coral colonies. We have not observed any preferential distribution patterns on the reef flats.

Bohadschia atra (Fig. 3B), a recently described species (Massin et al. 1999) in the southwestern part of the Indian Ocean, shows relative abundance similar to that observed in Mayotte (Pouget 2005) and, as on that island, also characterises the outer slopes of stations sampled around Grande Glorieuse.

It can also be noted that *Thelenota ananas*, a species quite frequently observed on the Geyser Bank (Mulochau and Conand 2007) situated 135 km southeast of the Glorieuses Islands was not found on this reef.

We sampled a number of species that burrow into the sediment under coral formations or blocks of dead coral, in particular *Holothuria lineata* (Fig. 3I); this species, often confused with *Holothuria pardalis* or *Holothuria verrucosa*, is characteristic of shallow lagoons and has already been observed in Mauritius, Mozambique and the Red Sea (Pearson 1910)

as well as in Australia (Rowe and Gates 1995). The other burrowing species observed are: *Holothuria hilla* (Fig. 3D), *Holothuria* cf. *impatiens* (Fig. 3E), *Labidodemas* cf. *rugosum* (Fig. 3F) and *Holothuria* cf. *pardalis* (Fig. 3J). Only *Holothuria lineata* was identified from examination of its spicules. It would be desirable to observe the spicules of these other species to confirm the identifications. Also, the abundance of these species may be under-estimated because of their behaviour.

Lastly, it can also be noted that the holothurian species *Holothuria pardalis*, the most abundant to be observed by Vergonzanne (1977), was seen only once during our work.

The objective of this project was to sample the holothurians, but we were also able to sample 8 species of ophiuroids. According to Vergonzanne (1977), ophiuroids represent the most abundant and diversified class of echinoderm with 17 species recorded on the reef flats of Grande Glorieuse. The same sampling technique as that used on the reef flat (turning over blocks, searching through sediment, etc.) did not enable us to find any specimens on the outer slopes; in this environment and because of the negative phototropism of ophiuroids (Fell 1966), a night sampling effort might make it possible to observe other species.

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Bibliography

Bigot L., Bourmaud A., Chabanet P., Pennober G., Andrefouet S., Frouin P., Naim O., Yamano H., Banton O., Join J-L. 2007. Integrated Research Program to assess vulnerability of reef islands and coral reefs to climate change based on groundwater observation. 5th Western Indian Ocean Marine Science Association Conference, Durban, Afrique du Sud (abstract).

Conand C. 1999. Manuel de qualité des holothuries commerciales du Sud-Ouest de l'Océan Indien. Commission Océan Indien. 39 p.

Conand C. 2004. Present status of world sea cucumber resources and utilisation: an international overview. p. 13–23. In: Lovatelli A., Conand C., Purcell S., Uthicke S., Hamel J-F. and Mercier A. (eds). Advances in sea cucumber aquaculture and menagement. FAO Fisheries Technical Paper No. 463. 425 p.

Conand C. et Mangion P. 2002. Sea cucumbers on La Reunion Island fringing reefs: diversity, distribution, abundance and structure of the populations. SPC Beche-de-mer Information Bulletin 17:27–33.

Conand C., Dinhut V., Quod J-P and Rolland R. 2005. Sea cucumber inventory in Mayotte, southwest Indian Ocean. SPC Beche-de-mer Information Bulletin 22:19–22.

Fell H.B. 1966. The ecology of ophiuroids. In: Physiology of Echinodermata (Boolootian, ed.). John Wiley, New York. 129–145.

Gabrié C. 1998. L'état des récifs coralliens en France Outre-Mer. ICRI. Document du Secrétariat d'État à l'Outre-Mer et Ministère de l'Aménagement du Territoire et de l'Environnement. 136 p.

Hart A.M. 2006. Review of paua research surveys. Unpublished report to the New Zealand Ministry of Fisheries. 20 p.

Leeworthy G. and Skewes T. 2007. The hip-chain transect method for underwater visual census (UVC). SPC Beche-de-mer Information Bulletin 26:5–6.

Mulochau T., Conand C et Quod J.P., 2007. Sea cucumbers and other echinoderms at Geyser Bank, Mayotte (Indian Ocean). SPC Beche-de-mer Information Bulletin 26:7–13.

Pearson J. 1910. Littoral marine fauna of Kerimba Archipelago, Portuguese East Africa. Holothuroidea. Proceedings of the Zoological Society. London. p. 167–182.

Pouget M. 2004. Sea cucumber fisheries in the Mayotte reef system, Indian Ocean. SPC Beche-de-mer Information Bulletin 19:35–38.

Pouget M. 2005. Abundance and distribution of holothurians on the fringing reef flats of Grande Terre, Mayotte, Indian Ocean. SPC Beche-de-mer Information Bulletin 21:22–26.

Rowe F.W.E. and Gates J. 1995. Echinodermata. In: Wells A. (ed.). Zoological Catalogue of Australia: vol. 33(i-xiii):1–510. CSIRO Australia, Melbourne.

Samyn Y., VandenSpiegel D and Massin C. 2005. Sea cucumbers of the Comoros Archipelago. SPC Beche-de-mer Information Bulletin 22:14–18.

Samyn Y., VandenSpiegel D. et Massin C. 2006. Taxonomie des holothuries des Comores. ABC Taxa – Vol 1. 130 p.

Uthicke S. and Conand C. 2005. Local examples of beche-de-mer overfishing: An initial summary and request for information. SPC Beche-de-mer Information Bulletin 21:9–14.

Vergonzanne G. 1977. Étude sur les mollusques et les échinodermes récifaux des îles Glorieuses. Thèse Océanographie Biologie. Université de Bretagne Occidentale. 159 p.