

Field observations of sea cucumbers in Ari Atoll, and comparison with two nearby atolls in Maldives

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Abstract

This paper presents a sea cucumber survey conducted by an International Union for Conservation of Nature mission on the coral reefs of North Ari Atoll for three weeks in April–May 2015. The main result is the extremely low population of commercially important sea cucumbers in North Ari Atoll, consistent with other recent surveys in the country. The assemblage was largely dominated by two species in the family Holothuriidae, *Holothuria edulis* and *Pearsonothuria graeffei*, with strikingly different proportions than the neighbour atolls of Malé and Baa. This study increases the number of holothurian species recorded in Maldives to 28, with 10 records for Ari Atoll, including three new records for the country.

Introduction

The Republic of Maldives has been the scene of extreme beche-de-mer overfishing since 1985 (Joseph 1992), which led to a population collapse of most of the high-value species as early as 1990 (James and Manikfan 1994). This resulted in a tightening of exports but no serious regulation (FAO 2013). The current situation is still one of overexploitation (Purcell et al. 2013), and the local stock is judged to be “depleted” (Naeem 2013). Very little information has been available about the populations of sea cucumbers in Maldives, although some recent studies have shed more light on the region (Muthiga 2008; Ducarme 2015). The geography of Maldives, with wide atolls separated by deep channels, means there is a potential variability in assemblages between regions that is difficult to predict.

Ari Atoll is a wide atoll in the centre-west of Maldives, just southwest of the capital Malé. It has around 14,000 inhabitants on 36 main inhabited islands (along with 26 resort islands), and over 268 coral reefs, which is the highest number of reefs in all Maldivian atolls (Naseer 2006). Ari Atoll is divided into two administrative sectors, North Ari and South Ari.

This paper describes results from the International Union for Conservation of Nature “Regenerate” mission, funded by the US Agency for International Development. This mission was conducted on the coral reefs of North Ari atoll during April–May of 2015. Besides its geographical and economical significance, North Ari was chosen as the study atoll as it is ecologically and socio-economically representative of Maldives, containing a variety of reef habitats, 12 resort islands, 8 community islands

and 7 main uninhabited islands. Ari Atoll echinoderm fauna had not been studied before, and the holothuroid assemblage was compared with the recently surveyed neighbouring atolls of Baa (Ducarme 2015) and Malé (Muthiga 2008).

Materials and methods

Study site

The 12 islands surveyed in North Ari Atoll (Alifu alifu) are exposed to different human impact and management regimes (four resort islands, four community islands and four uninhabited islands). The location of the 12 islands is shown in Fig. 1.

Survey methodology

At each island reef, three sites were surveyed on the cardinal directions closest to the island. At each site, three replicate 50-m transects were laid lengthwise along the reef slope, with a minimum of 3 m separating each transect. Holothuroids were surveyed and quantified in a 50 m by 2 m belt transect, by scuba diving at 10 m depth. At 7 out of 12 sites, this protocol was replicated at 7, 5 and 1 m depths along parallel transects. Large sea cucumbers sighted outside the transects (down to 25 m) were also recorded separately. Additional non-linear night surveys were carried out at most sites at shallow depths to spot potential nocturnal species. All surveys were carried out by examining the benthos, searching under crevices and rocks on the reef, and recording all sea cucumbers encountered. Pictures of each newly encountered species were taken for identification, as no specimen sampling was authorised for this mission. The benthos was surveyed separately, on 10-m depth transects using

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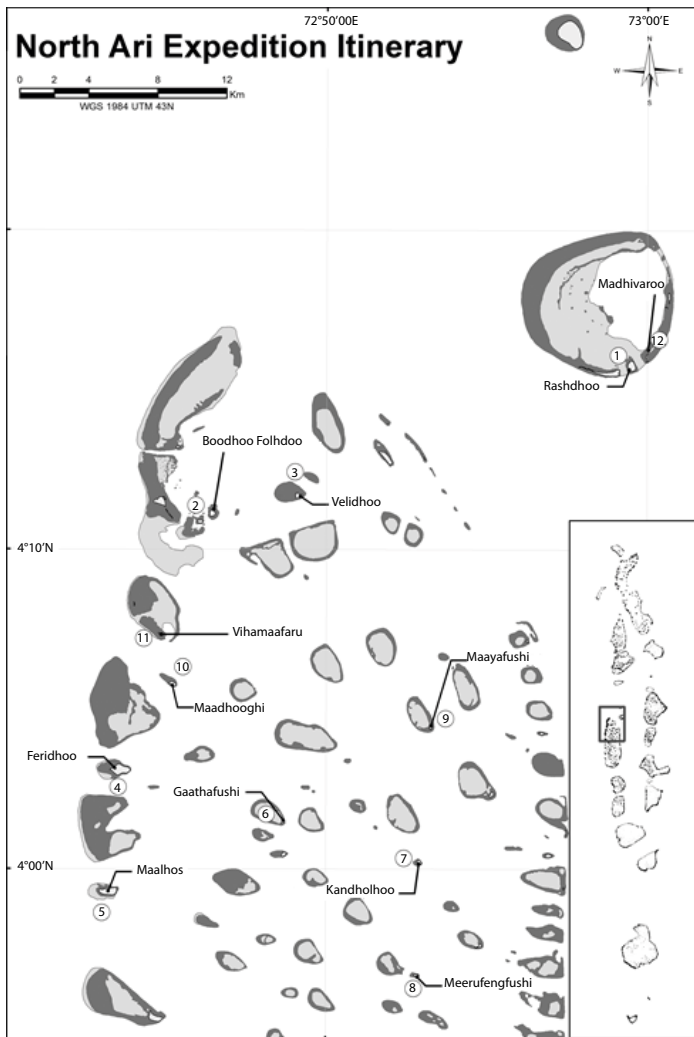


Figure 1. Location of sampling stations (North Ari Atoll), with inset showing North Ari Atoll position within Maldives. (Source: IUCN Maldives.)

a similar method, and the results will be published in a separate publication.

Results

Study site description

Most of the islands are small and surrounded by narrow reef flats. Outer reef slopes are often very steep, going more or less straight down to about 30 m depth. These slopes have a diverse coral cover, ranging from high coral cover to sand-dominated detritic substrate. The current can be quite strong, limiting the substrate complexity at some sites. The structural complexity was found to be quite evenly low at the study sites at 10 m depth. Coral cover was often very high at the reef crest (up to 90%, mostly dominated by big *Acropora* tables) and decreased with depth. Benthic cover at 10 m depth was in the region of 18–27% coral, around 1% macroalgae, 20–30% turf and 5–8% coralline crustose algae, the rest being sand and coral debris. No seagrass bed

or mangrove was observed, and fleshy algae were also very rare. Rugosity, habitat richness and hydrodynamics were highly heterogeneous, resulting in quite a wide variety of ecological niches.

Holothuroidea abundance and diversity

A total of 14 species of sea cucumbers were encountered during the survey (Tables 1 and 2), including one probably unknown species and three new records for Maldives. Between one and six species were observed on each site. Of the 14 species, three were stichopodids, nine were holothurids and two were synaptids. None of the species recorded in this survey was of high commercial value, and only three were reported as commercially exploited in Maldives (*Stichopus chloronotus*, *Holothuria atra* and *Thelenota anax*) (Joseph 1992), despite the fact that nearly all the aspidochirotid species observed are considered edible and fished in some regions (Purcell et al. 2012). The species *Bohadschia marmorata* is also exported, and often confused with a species recorded during the survey: *Bohadschia koellikeri* (new record, but potentially mistaken in the past).

The total number of individual sea cucumbers encountered at all the sites was 692 in 83 standardised samplings. The overall density was 8.3 individuals transect⁻¹, equivalent to 0.16 individuals m⁻². The density of sea cucumbers was highest at Maayafushi with 390 specimens, whereas the second highest density was only 85 specimens at Maadhooghi.

The abundance of holothuroids was very variable, ranging from 1 to 390 individuals per island (0 to 225 per transect). While *Holothuria atra* was the most recorded species, 94% of *H. atra* observations were made on one site, and the species was observed only 13 times otherwise. *Pearsonothuria graeffei* was the second most abundant species, with 279 observations (35% of all observations, or 56% when the *H. atra* “hot spot” was removed), and was present on all islands and 80% of transects. It was followed by *Holothuria edulis* (22%). Shallow sites with a high live coral cover (and significant relief) had notable populations of *P. graeffei*, whereas *H. edulis* was mostly observed between 5 and 10 m, in more sloping and less complex coral landscape. *H. atra* was observed mostly on sand patches on reef tops (often in association with, *S. chloronotus*), or sometimes deeper on sandy banks with abundant detritic material (including under functioning sewage pipes). Both *Actinopyga lecanora* observations were made around 10 m depth in complex coral systems. *T. anax*, *Bohadschia atra* and *Actinopyga* cf. *miliaris* were rarely observed, mostly deep on sandy bottoms. In contrast, *Bohadschia vitiensis* was observed only once on a shallow sand bank, and *B. koellikeri* and *Stichopus* sp. were observed only once, in shallow reef flats at night. The latter species

Table 1. Abundance of holothuroid species at the seven multiple-survey sites on Ari Atoll. Species recorded only out of linear transects (side sightings, control night dives or non-standardised additional observations) are reported as “extra records”.

Survey site	Species													Total observations	Species diversity	
	<i>Actinopyga lecanora</i>	<i>Actinopyga cf. miliaris</i>	<i>Bohadschia atra</i>	<i>Bohadschia koellikeri</i>	<i>Bohadschia vitiensis</i>	<i>Holothuria atra</i>	<i>Holothuria edulis</i>	<i>Holothuria insignis</i>	<i>Pearsonothuria graeffei</i>	<i>Stichopus chloronotus</i>	<i>Stichopus sp.</i>	<i>Theleotaanax</i>	<i>Opheodesoma sp.</i>			<i>Synaptula sp.</i>
Gaathafushi						8	9		22				4		43	4
Kandholhoo							8		33			1	2		44	4
Meerufengfushi						1	19		39						59	3
Maayafushi			2			297	26		64	1					390	5
Maadhooghi			1			2	32	2	43	5					85	6
Vihaamafushi							6		9						15	2
Madhivaroo						2	35		19						56	3
Extra records	1	1		1	1						1			1		+6
Total	1	1	3	1	1	310	135	2	229	6	1	1	6	1	692	13

Table 2. Abundance of each holothurian species at 10 m depth at the 13 survey sites on Ari Atoll.²

Survey site	Species							Total observations	Species diversity
	<i>A. lecanora</i>	<i>B. atra</i>	<i>H. atra</i>	<i>H. edulis</i>	<i>P. graeffei</i>	<i>Theleotaanax</i>	<i>Opheodesoma sp.</i>		
Rashdhoo	1		1	18	13		1	34	5
Boodhoo Folhdoo				8	13			21	2
Velidhoo			1	7	10	1		19	4
Vihamaafaru	1			7	8			16	3
Feridhoo					5			5	1
Maalhos					1			1	1
Gaathafushi				8	11		1	20	3
Kandholhoo				7	10	1	2	20	4
Meerufengfushi				14	10			24	2
Maayafushi		1	4	6	10			21	4
Maadhooghi		1		9	7			17	3
Vihaamafushi				4	1			5	2
Madhivaroo			2	11	4			17	3
Total	2	2	8	99	103	2	4	220	7

² Vihaamafushi and Vihamaafaru are two adjacent survey sites on the same island (“fushi” means submerged reef and “faru” means sand bar). Twelve islands were surveyed, representing a total of 13 survey sites.

shared resemblance with a previously signalled unknown *Stichopus* species, currently under phylogenetic analysis and determination (Ducarme 2015). *Opheodesoma* sp. was observed seven times, and constitutes a new record for Maldives. This species was extremely long (up to >1.30 m), with a uniformly solid greyish brown body and 15 bright white pinnate tentacles. All specimens were found hidden in bushy *Acropora muricata* colonies.

Discussion

Overall diversity of sea cucumbers

The assemblage found on Ari Atoll was quite diverse compared to Baa Atoll (Ducarme 2015), but similarly striking was the absence of high-value species. Even during non-standardised additional surveys, we were never able to record any *Actinopyga echinites*, *A. mauritiana*, *Holothuria fuscogilva*, *H. fuscopunctata*, *H. nobilis* or *Thelenota ananas*. This constitutes half of the 12 species listed as exploited locally by Joseph (1992), and none of the others was found abundantly (except *H. atra* in some particular sites). Marine biologists based in Baa Atoll found only one specimen of *T. ananas* in one and a half years of daily surveys over many sites (personal communication), and no “teatfish” (subgenus *Holothuria* (*Microthele*)). This may be due to overfishing, as suggested by Naeem (2013), although spatial variation may also be involved.

Comparison with results from neighbouring atolls

The assemblage of holothuroids was found to be very different from those found in previous studies in other atolls (Table 3) (methods and seasons were comparable), whereas reef type and fish assemblages are believed to be similar. Three new records were made for Maldives. One of them was quite

common and obvious (*Opheodesoma* sp.), but it may have been confused with similar species in previous studies (especially *Synapta* or *Synaptula*). *B. koellikeri* is also a common confusion with *B. vitiensis* or *B. marmorata* (Kim et al. 2013), which were both recorded by previous studies; *B. vitiensis* was also observed separately in the present survey. *Bohadschia argus* is probably not present in the region (Conand 2008), and this name was given to *B. atra* in the Indian ocean before its description (Massin et al. 1999). *H. insignis* is a small and cryptic species, easily overlooked.

Relative abundance of the species found differed strikingly from previous quantitative studies on the neighbouring atolls of Malé and Baa (Fig. 2). The assemblage of Ari Atoll was found to be dominated by *P. graeffei*, *H. edulis* and *H. atra*, while Baa Atoll was found to be overwhelmingly dominated by *P. graeffei*, followed by *S. chloronotus* and *T. anax* (Ducarme 2015). Malé Atoll was dominated by *S. chloronotus* and *H. atra*, followed by *P. graeffei* (Muthiga 2008). Such variations were suggested by Joseph (1992), and may be even more striking on more remote atolls.

High-value species (*T. ananas*, *H. nobilis*, *A. echinites* and *H. fuscogilva*) were rare in all atolls: *A. echinites* has not been recorded by scientific surveys since 1999, and *H. nobilis* since 2008 (however there is a high risk of confusion with *H. fuscogilva*). As understanding of the ecological importance of sea cucumbers for tropical ecosystems is rising, there is an urgent need to set up proper fishing regulations in Maldives (Purcell et al. 2013), all the more since the whole country depends on the good ecological state of its reefs. Improving governance appears critical for maintaining both the fishery and the good ecological state of the ecosystem (Eriksson et al. 2015).

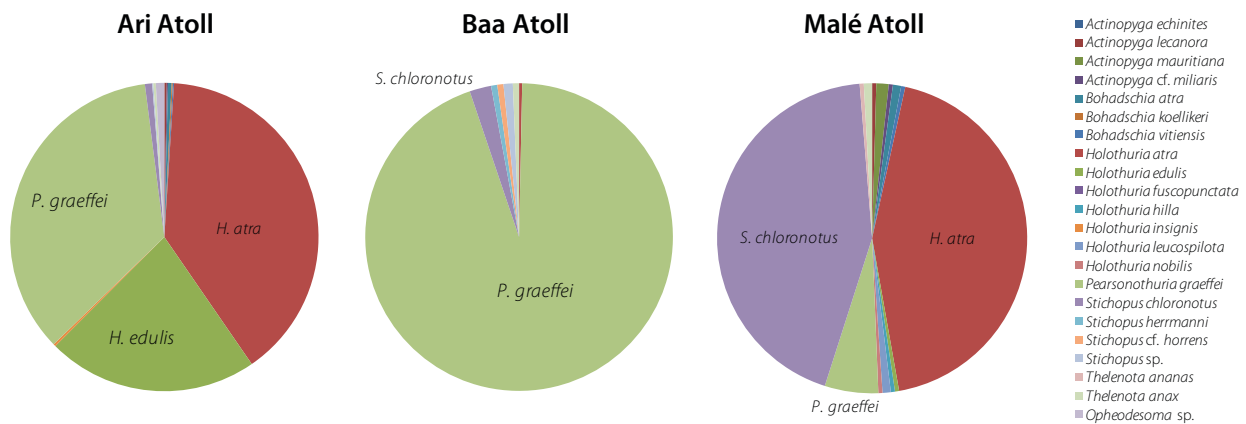


Figure 2. Assemblage comparison between the three atolls, using present results for Ari, Ducarme (2015) for Baa and Muthiga (2008) for Malé.

Table 3. Comparison of the present results with previous inventories. Stars indicate occurrence. Double stars mean first reports, and “?” indicates specimens that could not be identified with certainty. “Reported” means that the species is reported in the paper but was not directly observed by the scientists. Locally targeted species are indicated in bold.

Species	Present and previous inventories						
	Present study (Ari Atoll)	Ducarme (2015) (Baa Atoll)	Andréfouët (2012) (Baa Atoll)	Muthiga (2008) (Malé Atoll)	Reichenbach (1999) (Malé and Laamu Atolls)	James and Manikfan (1994) (Maldives)	Joseph (1992) (Maldives)
<i>Actinopyga caerulea</i>		Reported					
<i>Actinopyga echinites</i>					*	*	
<i>Actinopyga lecanora</i>	*	Reported	*	*		*	*
<i>Actinopyga mauritiana</i>			*	*	*	*	*
<i>Actinopyga miliaris</i>	?	Reported		*	*	*	
<i>Actinopyga</i> sp.							*
<i>Bohadschia argus</i> (dubious)			*				
<i>Bohadschia atra</i>	*			*			
<i>Bohadschia koellikeri</i>	**						
<i>Bohadschia marmorata</i>			*			*	*
<i>Bohadschia vitiensis</i>	*			*			
<i>Holothuria atra</i>	*	*	*	*		*	*
<i>Holothuria edulis</i>	*	Reported	*	*	*		
<i>Holothuria fuscogilva</i>			*		*		
<i>Holothuria fuscopunctata</i>		Reported			*	*	*
<i>Holothuria hilla</i>				*			
<i>Holothuria insignis</i>	**						
<i>Holothuria leucospilota</i>				*			*
<i>Holothuria nobilis</i>				*		Reported	*
<i>Pearsonothuria graeffei</i>	*	*	*	*			
<i>Stichopus chloronotus</i>	*	*		*		Reported	*
<i>Stichopus herrmanni</i>		*			*		
<i>Stichopus</i> cf. <i>horrens</i>		*					
<i>Thelenota ananas</i>		Reported	*	*	*	*	
<i>Thelenota anax</i>	*	*	*	*	*	*	
Unidentified stichopodid	?	*					
<i>Opheodesoma</i> sp.	**						
<i>Synaptula</i> sp.	?	Reported	*				
<i>Synapta maculata</i>						Reported	*

Besides the absence of commercially important species, this surprising diversity of assemblages may be the sign of overlooked ecological differences between atolls, which do not affect fish but have an effect on benthic invertebrates. Cross-studies with other organisms (such as corals or gastropods) may confirm this hypothesis, and increase the status of holothuroids as easy-to-survey indicator species.

This study increases the number of holothuroid species recorded in Maldives to 28 when *B. argus* is removed, but the final number depends on the determination of ambiguous observations.

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