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The assemblage structure of large size sea urchins (Diadematidae) in Northern Vietnam

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ABSTRACT

The large sea urchins (Diadematidae) are widely distributed worldwide, from temperate to tropical waters. Diadematidae is an important herbivore in the coral reef ecosystem through herbivore-algal-coral interaction, which maintains the reef's health. Many studies of Diadematidae have been performed around world, but in Vietnam, there is little known about the ecology of this group. Here, we first investigated the assemblage structure of Diadematidae in Northern Vietnam. We observed 43 sites of representative coral reefs in Ba Mun - Co To, Cat Ba - Ha Long, and Hon Me. Based on the surveys, we found four species of considerable size sea urchins, of which the most common species is *Diadema setosum* (79.8% of the total), *Enchinothrix calamaris* (10.1%), *E. diadema* (8.3%), and *D. savignyi* (1.8%). Among three study regions, Hon Me is the most diverse. In addition, Hon Me also has the highest density of sea urchins. However, this value is generally low compared to that in Southern Vietnam and other neighboring countries. Further study is needed to investigate the ecology and reproductive biology of Diadematidae to provide fundamental information for sustainable exploitation and conservation.

Keywords: Sea urchins, Diadematidae, Northern Vietnam, overfished.

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INTRODUCTION

Herbivores have an essential role in the coral reef ecosystem through herbivore-algal-coral interaction, which maintains the reef's health [1–3]. However, overexploitation has long deprived herbivorous megafauna (turtles, dugong, etc.) and certain macrofauna (fishes and gastropods) [4]; this results in altering herbivorous fauna assemblages, and they will be dominated by non-target species such as sea urchins in many coral reef ecosystems, as seen in our study in southern Taiwan [5]. Although many studies have examined the interaction, most studies focused on herbivorous fishes, and fewer attempts have been made for the newly emerging interaction, i.e., the sea urchin-algal-coral interaction.

The most vital component of the sea urchin group is the Diadematidae family, including several genera such as *Diadema* and *Echinothrix*. With its wide distribution in the world's oceans [6], Diadema has been considered an ecologically important herbivore in the ecosystem since the early 1960s, and several studies have been done on the family [7–9]. The best example is Caribbean coral reefs, where *D. antillarum* plays a vital role in algal control [7–10]. The mass mortality event ever recorded *D. antillarum* caused by an unknown pathogen from 1983 led to colossal consequences such as algal blooming and coral coverage decreased sharply; thus, the phase shift from coral-dominated to algal-dominated occurred in many Caribbean reefs [10]. In addition, most studies in the post-1983 focused on *D. antillarum* in this region to explore its role in controlling algal and facilitating coral-dominate state. Recently, recovery of some populations of *D. antillarum* was observed in the Caribbean, reducing algal coverage, and enhancing coral recovery through recruitment [11–13]. The recovery of *D. antillarum* populations after mass death increased the number of juveniles 11-fold in the Caribbean [11].

In recent years, under the explosive development of tourism, large sea urchin has been known as a nutritious food source and is widely consumed in many sea areas of Vietnam, especially Quang Ninh, Phu Quoc, Con Dao. Sea urchins are expensive, ranging from 2–3 USD/individual at restaurants. However, the source of sea urchins for human consumption is mainly caught in the wild, leading to a severe decrease in the resources of sea urchins, and causing an imbalance in the ecosystem (according to our survey results in the Ha Long - Cat Ba and Phu Quoc areas). Therefore, the conservation and restoration of large sea urchin populations to maintain coral reef health are critically important. The objective of this study was to investigate the current status of species composition, distribution, and density of Diadematidae to provide scientific data for the conservation and restoration of coral reefs in Northern Vietnam.

MATERIALS AND METHODS

Materials and study time

The materials of this study are based on various studies from 2018 to 2021. We collected the data in Cat Ba - Ha Long (2019), Co To - Ba Mun (2018 and 2021), and Hon Me (2018, 2020, and 2021).

Study location

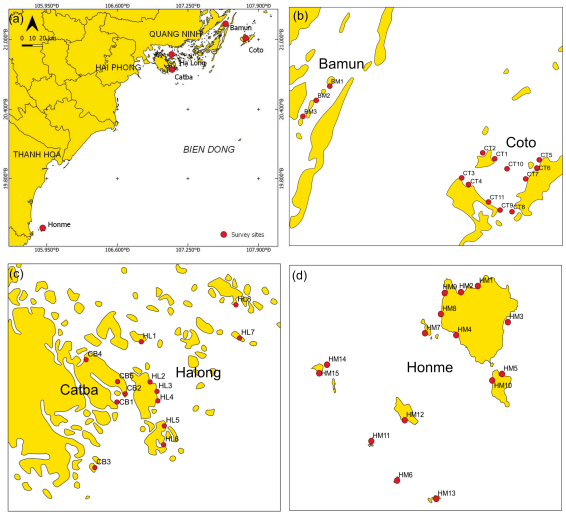

Figure 1. The survey map of large size of sea urchin (Diadematidea) in Northern Vietnam (a: Overview area; b: Co To - Ba Mun , c: Cat Ba - Ha Long; d: Hon Me)

To investigate the taxonomic composition of large-sized sea urchin populations (mainly the family Diadematidae) in Northern Vietnam, we randomly surveyed 43 reef sites, including 15 in Co To and Ba Mun, 13 places in Cat Ba and Ha Long, and 15 sites in Hon Me (Figure 1).

Methodology

The investigation of large-sized sea urchins was conducted following the standard method of the Global Coral Reef Monitoring Network [14], and Reefcheck [15]. Targetted species were examined using SCUBA diving between 1–15 m depth sites. At each site, divers swam along a transect around 400 m^2 (20 m × 20 m), and sea urchins were counted and photographed if they appeared. The abundance of sea urchins was estimated as individual per transect (individual/400 m^2).

In the analysis, species identification was performed based on morphology (the color pattern of body and spine length) [16–18].

RESULTS

Taxonomic composition of Diadematidae

There was a low number of sea urchins recorded through the surveys. Four species belonging to two genera were identified: *Diadema setosum*, *D. savignyi*, *Echinothrix calamaris*, *E. diadema*. Of 109 diadematids counted, Diadema accounted for 81.6% of individuals, and Echinothrix accounted for 19.4% of individuals (Fig. 2).

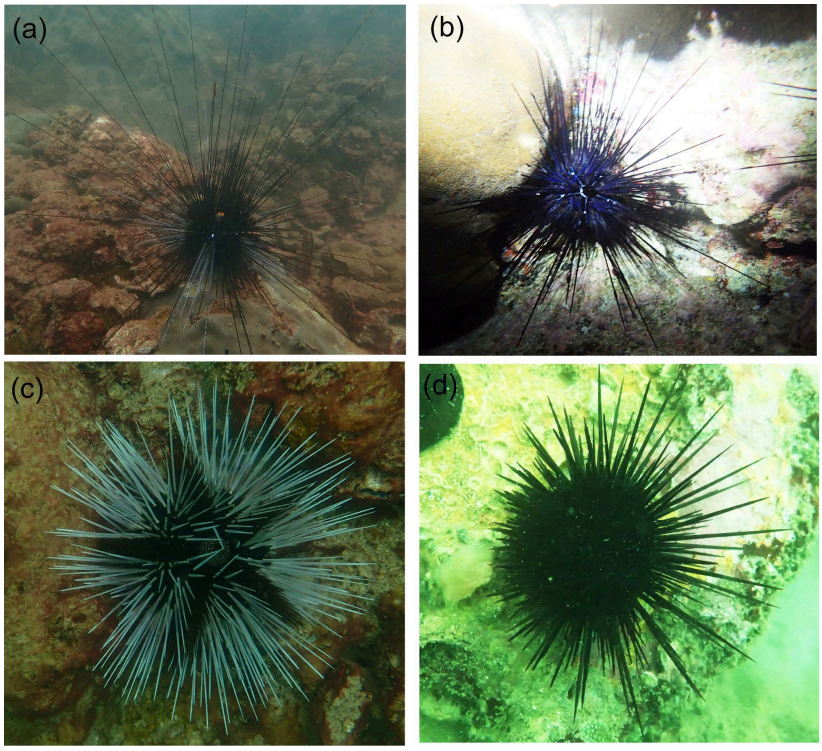

Figure 2. Taxonomic composition of Diadematidae. (a) *Diadema setosum*; (b) *Diadema savignyi*; (c) *Echinothrix calamaris*; (d) *Echinothrix diadema*

In terms of species diversity, Hon Me is the most diverse region with four species, followed by Coto - Bamun (two species), while only one species was observed in Cat Ba and Ha Long (Fig. 3). In all locations, Diadema setosum was dominant with the highest proportion (79.8% of total individuals) followed by Enchinothrix calamaris (10.1%) and E. diadema (8.3%). D.

savignyi was very rare and was only recorded in Hon Me with 1.8% (HM15, Fig. 1).

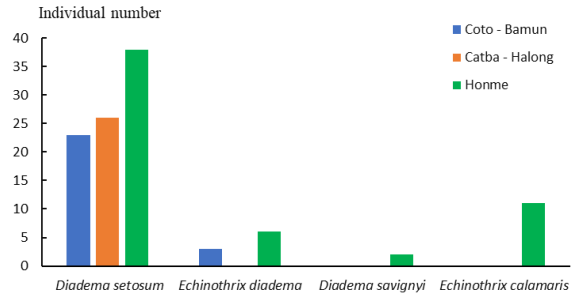

Figure 3. The number of large sea urchin (Diadematidae) in each location

The distribution and abundance of Diadematidae

Sea urchins were unevenly distributed across locations as they were present in 19 over 43 surveying sites. We did not find any sea urchins at Ba Mun (Table 1). Honme had the highest number of sea urchin on a transect (0.01 individual/400 m^2), followed by Cat Ba and Ha Long (0.005 indiv./400 m^2), while the lowest abundance was observed in Co To - Ba Mun (0.004 indiv./400 m^2). The highest sea urchin abundance was recorded at site HM7 in Hon Me, (0.05 indiv./400 m^2) (Table 1).

Table 1. The distribution of Diadematidae in the Northern Vietnam

No.	Location	Code	*Diadema setosum*	*Diadema savignyi*	*Echinothrix calamaris*	*Echinothrix diadema*
1	Co To	CT1				
2	Co To	CT2				
3	Co To	CT3				
4	Co To	CT4				
5	Co To	CT5	+			
6	Co To	CT6	+			
7	Co To	CT7				
8	Co To	CT8	+			
9	Co To	CT9	+			
10	Co To	CT10				
11	Co To	CT11				
12	Co To	CT12				+
13	Ba Mun	BM1				
14	Ba Mun	BM2				
15	Ba Mun	BM3				
16	Ha Long	HL1				
17	Ha Long	HL2	+			
18	Ha Long	HL3	+			
19	Ha Long	HL4	+			
20	Ha Long	HL5	+			
21	Ha Long	HL6				
22	Ha Long	HL7				
23	Ha Long	HL8				
24	Cat Ba	CB1	+			
25	Cat Ba	CB2	+			
26	Cat Ba	CB3				
27	Cat Ba	CB4	+			
28	Cat Ba	CB5				
29	Hon Me	HM1				+
30	Hon Me	HM2				
31	Hon Me	HM3				
32	Hon Me	HM4			+	

No.	Location	Code	*Diadema setosum*	*Diadema savignyi*	*Echinothrix calamaris*	*Echinothrix diadema*
33	Hon Me	HM5				
34	Hon Me	HM6	+			
35	Hon Me	HM7	+			
36	Hon Me	HM8				
37	Hon Me	HM9	+			
38	Hon Me	HM10				
39	Hon Me	HM11				
40	Hon Me	HM12				
41	Hon Me	HM13	+			
42	Hon Me	HM14				
43	Hon Me	HM15		+	+	+
Total			15	1	2	3

Note: +: is recorded.

DISCUSSION

This study provides the first detailed information on the assemblage structure of diadematid sea urchins in Northern Vietnam. Four sea urchins were identified from our research among the prevalent species in Southeast Asia region. Currently, eight species of *Diadema* are recognized in the world [19], and four species are known to be distributed only in certain areas: *D. antillarum* in tropical Atlantic [6], *D. mexicanum* in tropical eastern Pacific [20], *D. africanum* in west Africa [21], and *D. palmeri* in the north of New Zealand [22] and the south of Australia (Rowe and Gates, 1995). Lessios et al., [6] reported that, of 57 study sites globally, 45 sites (~80%) had only a single *Diadema* species. Therefore, the diadematid assemblage in southern Taiwan that included 3–4 *Diadema* species out of four common species could be considered a taxonomically diverse assemblage, together with two *Echinothrix* species (Dang et al., data unpublished). The *D. setosum* was dominant in Northern Vietnam, and *D. savignyi* was rare, by contrast, in southern Taiwan (Dang et al., data unpublished). A similar pattern found in the neighboring countries, *D. setosum* is dominant in Malaysia [23], Singapore [24, 25], Thailand [26], Hongkong [27], and the central Philippines [28]. Lessios et al., [6] reported that the distribution of *D. savignyi* is more oceanic around the central Pacific, whereas that of *D. setosum* is more coastal along the Western Pacific. The result of the present study may reflect this difference in habitat conditions between the oceanic region (clear and warmer waters) and the coastal region (turbid and colder water). In Cat Ba and Ha Long, the long-time accumulation of suspended sediment from large rivers results in turbid water. It is similar to Peng-Hu Islands in the Taiwan strait, where water is more turbid and becomes cold in winter. In this area, the dominance of *D. setosum* was observed in diadematid assemblages (Dang et al., unpublished data).

The density of sea urchins was low in most studied sites, and we could not find any sea urchins in some places. Compared to the previous data in these areas and other areas in Southern Vietnam [29–31], the density remarkably decreased. One of the main reasons we assumed for this decline is overfishing, especially in tourist areas such as Co To, Ba Mun, Cat Ba, and Ha Long. In these areas, the fishermen catch sea urchins during the breeding season to get eggs for export at a very high price (60 $/kg) or sell alive individuals to restaurants. Hon Me island is far from land; local people are not allowed to live there as the island is a military area, so local fishermen rarely catch sea urchins around the island.

Moreover, coral reefs in these areas are still better than other places, so they are suitable habitats for sea urchins. In a very alarming situation, declining sea urchin populations can lead to algae blooms and coral decline [5].Our data also showed that a lack of herbivores

control caused macroalgae development in Co To. Therefore, managers need to consider that, and the strategy to solve this problem is urgent.

CONCLUSION AND RECOMMENDATIONS

Conclusion

Our study showed a low number of large urchin families in Northern Vietnam. Of four observed sea urchins, the most common species were *Diadema setosum* (79.8% of the total), *Enchinothrix calamaris* (10.1%), *E. diadema* (8.3%), and *D. savignyi* (1.8%). Also, species composition in Hon Me is the most diverse compared to the other two regions.

The density of sea urchins is generally very low compared to Southern Vietnam and other neighboring countries and the most concentrated area is Hon Me.

Recommendations

It is necessary to expand more studies to the central and southern regions of Vietnam. Moreover, seasonal monitoring, together with the investigation of abiotic and biotic factors to determine which factors affect the distribution of sea urchins, is also essential. Finally, it is urgent to protect sea urchins in low-density areas because the resources in these areas have been exploited to an alarming level.

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