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Study of the sea urchins (*echinoidea*) influence on the coral reef communities in the Nusa Dua Bali conservation area

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Abstract
Coral reef ecosystems are crucial for marine ecosystems as they support various other marine organisms. Sea urchins, such as *Diadema setosum* and *Echinometra mathaei* influence the coral reef communities by consuming algae that disrupt coral growth. This study aims to determine reef star coral media quantity, identify the dominant coral species at three points (BTN, Coral Garden, and Cluster 5) in Nusa Dua Beach, and assess the influence of sea urchins on coral reefs. The sampling method used was Purposive sampling, and visual observations which were conducted from June 27 to June 30, 2022. Results showed the varying sea urchin populations, with *Acropora sp.* and *Pocillopora sp.* dominating at BTN, *Acropora sp.* and *Pectinia sp.* at Coral Garden, and *Acropora sp.* at Cluster 5. The findings suggest that sea urchins play a key role in maintaining coral reefs by consuming macroalgae and supporting coral survival.
Keywords: *acropora sp.*; conservation; coral reef; *pectinia sp;* sea urchin.

1. Introduction

The delicate balance of marine ecosystems, such as coral reefs, is intrinsically linked to the diverse array of species that inhabit them (Hughes et al., 1987; McClanahan et al., 1990). One such species, the sea urchin, plays a crucial role in the conservation of coral reef ecosystems (Hughes et al., 1987; McClanahan, et al., 1989). However, the conservation of these intricate ecosystems and the species within them is a complex process that goes beyond the mere preservation of nature(Glynn et al., 1979). It involves the determination of what is considered as a heritage worth safeguarding and utilizing, while addressing the multifaceted aspects of conservation: the actors involved, the methods employed for preservation and utilization, and the intended beneficiaries(Glynn et al., 1979; Hughes et al., 1987; McClanahan, et al., 1989).

Conservation efforts encompass not only the protection of natural resources but also the preservation of cultural heritage within human civilization(Clemente et al., 2013; Hereu et al., 2005; Nozawa et al., 2020). Coral reefs, often referred to as the "rainforests of the sea," are not only invaluable ecosystems but also hold cultural significance for many coastal communities around the world. These communities rely on coral reefs for sustenance, livelihoods, and cultural practices for generations(Glynn et al., 1979; Hughes et al., 1987; McClanahan, et al., 1989; Nozawa et al., 2020). Therefore, any conservation initiative must acknowledge the interplay between ecological and cultural factors, recognizing the inseparable connection between nature and human society.

Coral reefs are colonial marine animals belong to the Cnidaria class, which symbiotically associated with Zooxanthellae and produce calcium carbonate deposits, resulting in the formation of hard structures (McClanahan et al., 1994; Suryanti et al., 2018; Susiloningtyas et al., 2018). The growth variation of coral colonies is influenced by environmental conditions and food availability. Coral reef ecosystems are crucial for marine ecosystems as they support various other marine organisms(Boakes et al., 2022; Cleary et al., 2008; Nane, 2019; Siringoringo et al., 2022; Williams et al., 2019). They serve as homes for marine organisms such as fish and shrimp, as well as breeding grounds for marine life. Indonesia is known for its diverse coral species, with 80 genera comprising 590 coral reef species(Brown et al., 1990; Sawalman et al., 2021a; Toha et al., 2015). In 2016, the condition of damaged coral reefs (bleaching) reached 63.25%, while 21.34% were stressed, and only 10.14% were healthy.(Razak et al., 2022; Sawalman et al., 2021b; Trialfhianty et al., 2017)

Sea urchins, classified as Echinodermata, are marine organisms characterized by their round shape and spines on their surface(Andrew, 1993; McClanahan, et al., 1989; Sato et al., 2017; Sawalman et al., 2021b). The most common class of sea urchins is Euechinoidea. Sea urchins inhabit the area such as seagrass beds and coral reefs(Carpenter, 1990; Cleary et al., 2005; McClanahan et al., 2002; McClanahan et al., 1988). The presence of sea urchins has been found to have an influence on coral reef communities as balancers since sea urchins are herbivorous animals that can consume algae that disturb coral growth (Allen et al., 2003; de Ruyter van Steveninck et al., 1986; McClanahan, 1995).

In summary, the objectives of this research are to determine the quantity of reef star coral structures at three points, namely BTN, Coral Garden, and Cluster 5, to identify the most abundant coral species at the same three points; and to assess the impact of sea urchins on the coral reef communities at BTN, Coral Garden, and Cluster 5 at Nusa Dua Beach.

2. Methods

The research methodology employed in this research was purposive sampling with the use of Underwater Visual Census (UVC). The tools utilized included an underwater camera, a whiteboard, and a pencil. The coral reef restoration was conducted using the MARRS (Mars Assisted Reef Restoration System) method, which involved the creation of reef star-shaped structures (Figure 1) as a medium for attaching coral fragments and facilitating the attachment of coral larvae to promote natural coral recruitment(Williams et al., 2019). Field observations were conducted over a period of one week, while data identification and analysis took place over three weeks.

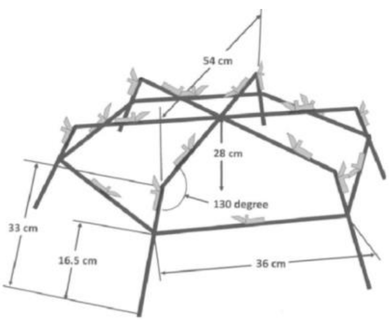

Figure 1. Coral Fragment Reposition on the structure of reef star

This research was conducted at Nusa Dua Reef Foundation Bali, located in the Nusa Dua Tourism Area (Figure 2), BTDC Area, Jl. Nusa Dua, Benoa, South Kuta District, Badung Regency, Bali, 80361, with a specific focus on fieldwork conducted at Nusa Dua Beach. The internship took place from June 6, 2022, to June 30, 2022. Using the coral reef fragment, we have analyzed the population of coral reef and sea urchins' diversity on the selected area. After calculated, the correlation table was arranged to determine the correlation of the variables in this research(Suryanti et al., 2018).

Figure 2. Research location Nusa Dua Tourism Area, Benoa, South Kuta District, Badung Regency, Bali

3. Results and Discussion

Coral reefs hold various ecological and economy values, which often lead to irresponsible usage, causing the coral reef ecosystems in a worrisome condition. Human activities such as water pollution, destructive fishing practices, and environmentally unfriendly practices are the main factors contributing to coral reef degradation (McClanahan et al., 1988). Additionally, coral reefs are vulnerable to damage due to factors such as rising sea temperatures above average levels, excessive sedimentation in the water (79-234 mg/cm^2), and specific compounds like cyanide that can cause coral bleaching and death(Siringoringo et al., 2022). Therefore, conservation and restoration efforts are crucial to restore and preserve the supporting ecosystem, leading to better environmental conditions. Observations conducted over a 7-day period starting from June 7, 2022, revealed the presence of 250 reef star media at BTN, 32 short reef star media and 52 tall reef star media at Coral Garden, and 301 reef star media at Cluster 5. The appearance of reef star media at each location can be seen in Figure 3 and Table 1.

Table 1. Population of the reef star species

Reef Cluster	Area		
	BTN	Coral Garden	Cluster 5
Reef star	250	-	301
Short reef star	-	32	-
Tall reef star	-	52	-

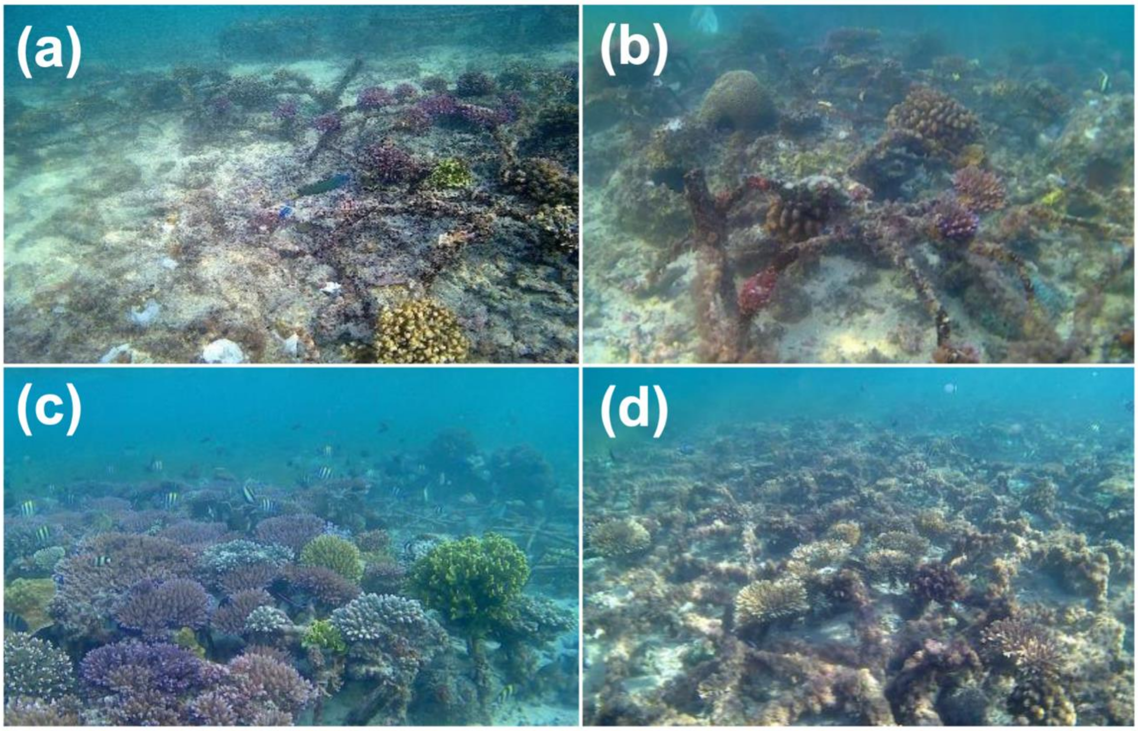

Figure 3. The appearance of Reef Star media at different locations. (a and b), the image depicts the appearance of Reef Star media at BTN, (c) illustrates the appearance of Reef Star media at Coral Garden, and (d) showcases the appearance of Reef Star media at Cluster 5.

Based on the observed field data (Figure 4) and Table 2, different types of coral reefs were identified at BTN, Coral Garden, and Cluster 5. At BTN, the dominant coral species were *Acropora sp.* and *Pocillopora sp*. At Coral Garden, the dominant species were *Acropora sp.* and *Pectinia sp*., while at Cluster 5, *Acropora sp.* was the dominant species. The coral reef community density was highest at Coral Garden, followed by BTN, and lowest at Cluster 5.

Table 2. Population of coral species based on the reef cluster

Coral Species	Area		
	BTN	Coral Garden	Cluster 5
Acropora sp.	√	√	√
Pocillopora sp.	√	-	-
Pectinia sp.	-	√	-

Factors that can influence the differences in coral reef community density include water conditions such as currents and waves, water sedimentation levels, the presence or absence of pollutants, nutrient levels, and seawater temperature(Andrew, 1991; Clemente et al., 2013; Hereu et al., 2005). Based on these environment parameters and the spreading of coral in Table 2, we can conclude that the BTN reef cluster have good environmental parameter for coral growing.

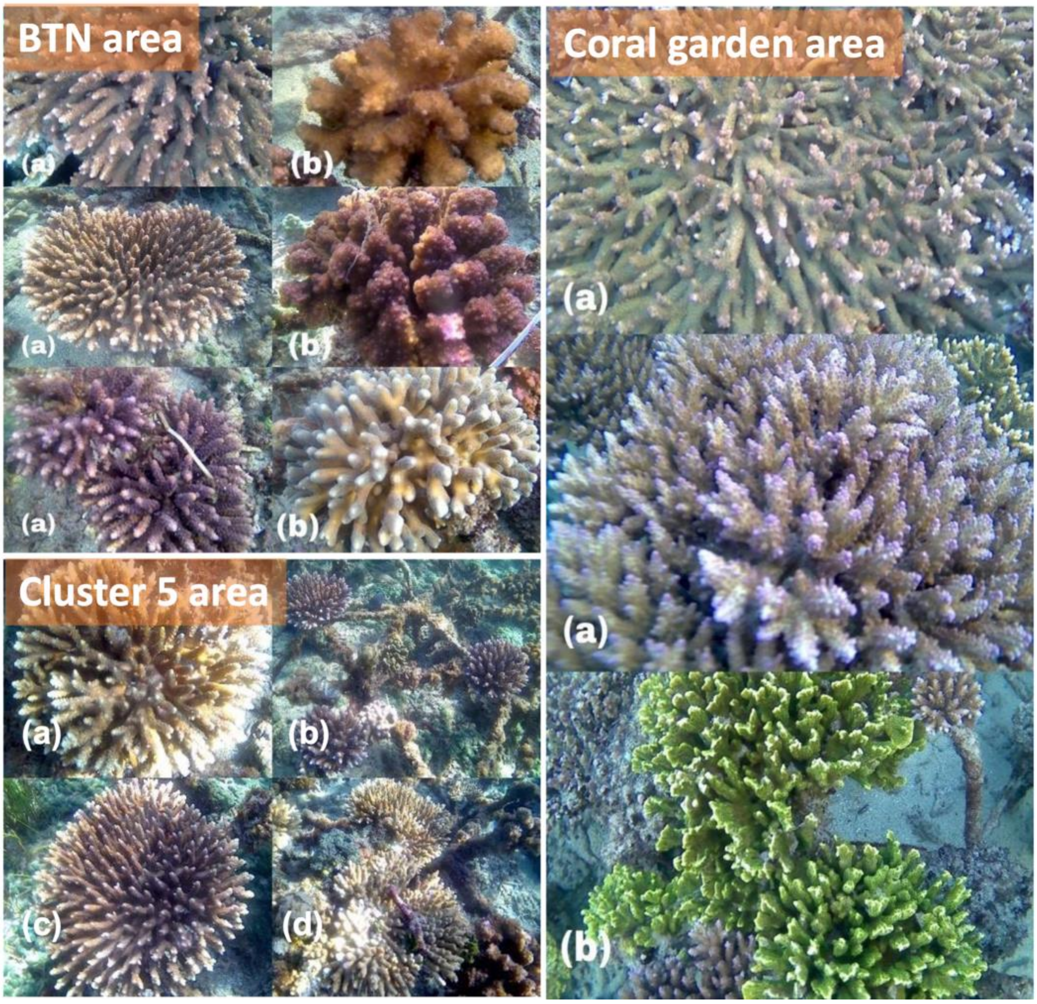

Figure 4. Illustration of the dominant coral species at different locations: (a) the most dominant coral species at BTN are Acropora sp. and Pocillopora sp.; (b) the most dominant coral species at Coral Garden are Acropora sp. and Pectinia sp.; (c) the most dominant coral species at Cluster 5 is Acropora sp.

The dominant species of sea urchins (Figure 5) and Table 3. were *Diadema setosum* (at BTN and Coral Garden) and *Echinometra mathaei* (at Cluster 5). The highest population of sea urchins was found at Coral Garden, followed by BTN, and the lowest population was observed at Cluster 5.

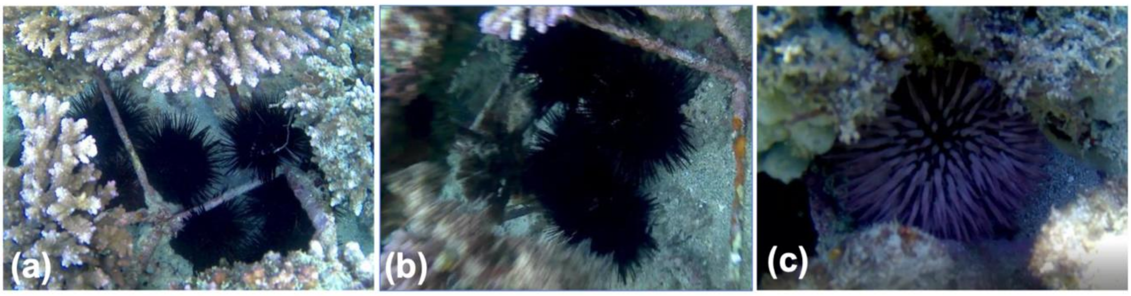

Figure 5. The dominant species of sea urchins at three different locations. In BTN, the most dominant species of sea urchin is *Diadema setosum* (a). Similarly, *Diadema setosum* is also the dominant species of sea urchin at Coral Garden (b). On the other hand, Cluster 5 is dominated by *Echinometra mathaei* (c) as the most dominant species of sea urchin.

The coral reef ecosystem consists of various organisms that interact with each other. One of the balances maintained within the coral reef ecosystem is the equilibrium between corals and macroalgae(Glynn et al., 1979). Macroalgae can compete with coral organisms for sunlight, and to avoid detrimental competition for coral, sea urchins act as an ecosystem balancer(Hughes et al., 1987). Sea urchins play a crucial role in the coral reef ecosystem as herbivores that consume macroalgae. A small population of sea urchins in the coral reef ecosystem can lead to an increase in macroalgae population, resulting in coral mortality(Nozawa et al., 2020). This correlation between sea urchin population density and coral community density can be observed at BTN, Coral Garden, and Cluster 5. However, no correlation was found between the dominant coral species and the dominant sea urchin species at these three points. There are no correlation means that the three different variables (reef cluster, coral species, and sea urchins) do not have an appropriate correlation toward the data. Meanwhile, based on the population mapping it can be concluded that the parameter of sea environmental drives the population of coral reef and also will contribute to the population of the sea urchins.

Table 3. Population of sea urchins based on the reef cluster

Sea urchins species	Area		
	BTN	Coral Garden	Cluster 5
Diadema setosum	√	√	-
Echinometra mathaei	-	-	√

4. Conclusions

Based on the conducted research, the following conclusions can be drawn: There were 250 reef star media in BTN, 32 short reef star media and 52 tall reef star media in Coral Garden, and 301 reef star media in Cluster 5. The dominant coral species at BTN were *Acropora sp.* and *Pocillopora sp*., at Coral Garden were *Acropora sp.* and *Pectinia sp.,* and at Cluster 5 was *Acropora sp*. Sea urchins, as key species in the coral reef ecosystem play a crucial role in maintaining the coral reefs by preventing competition with macroalgae through their ability to consume them. The higher the density of sea urchin populations in the coral reef community, the greater the survival rate of coral reefs.

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Author Contribution

Conceptualization, V.A.; Methodology, V.A. and HN.; Formal Analysis, V.A. and H.N.; Investigation, V.A.; Writing – Original Draft Preparation,H.N ; Writing – Review & Editing, V.A. and H.N.

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Conflicts of Interest

The authors declare no conflict of interestor in the decision to publish the results.

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