

Gleaning-based assessment of sea urchin density and species composition in Bato-Bato, Indanan, Sulu, Philippines

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Abstract. Gleaning for edible invertebrates on shallow reef flats is a common practice in the Philippines, primarily for subsistence and as a supplementary source of income. Among the species harvested, sea urchins play a vital role in the diets and livelihoods of many coastal communities. This study assessed the population density, distribution, and species composition of sea urchins along the coastal waters of Bato-Bato, Indanan, Sulu, Philippines. Sea urchins were collected every seven days from shallow reef flat areas. A total of 438 individuals were recorded, representing five species across four genera: gracious sea urchin, *Tripneustes gratilla* (Lamarck, 1816); sea egg sea urchin, *Tripneustes ventricosus* (Lamarck, 1816); long-spined sea urchin, *Diadema antillarum* (Philippi, 1845); flower sea urchin, *Toxopneustes pileolus* (Lamarck, 1816); stained collector urchin, *Pseudoboletia maculata* (Lamarck, 1816). The most abundant species was *T. gratilla*, accounting for 58.45% of the total population, with a mean density of 2.56 ± 0.04 ind. 100 m^{-2} . This was followed by *D. antillarum* (17.35%, with an average mean of 7.60 ± 4.15 ind. 100 m^{-2}) and *T. pileolus* (11.87%, with an average mean of 5.20 ± 1.83 ind. 100 m^{-2}). While mean abundance per transect reflects the relative number of individuals encountered during sampling, density values (ind. 100 m^{-2}) provide a standardized measure of population size that allows comparison across sites and sampling periods. Overall, population densities ranged from 0.16 ± 0.01 to 2.56 ± 0.04 ind. 100 m^{-2} . This study provides a baseline assessment of sea urchin populations in the area. It highlights the importance of continued monitoring to support sustainable gleaning practices and marine resource management in the region. These findings establish baseline density estimates that can inform local resource managers in regulating gleaning pressure, identifying vulnerable species, and supporting sustainable harvesting practices in the coastal waters of Indanan, Sulu.

Key Words: gleaning, population density, sea urchin, species composition.

Introduction. The Philippines is an archipelagic country in Southeast Asia, situated in the center of the Coral Triangle (Cabral et al 2013; Muallil et al 2014; Tahiluddin & Terzi 2021; Tahiluddin & Sarri 2022). Consequently, it is not surprising that most of the Philippines' population lives in coastal regions, where food and livelihoods depend on the ocean (De Guzman 2019). The Philippines employs gleaning as a subsistence fishing activity that not only provides food but also helps alleviate poverty in coastal areas. Among small-scale fisheries practices, gleaning is widely used as a subsistence activity,

particularly in shallow coastal habitats such as reef flats, seagrass beds, mangroves, and intertidal zones (Béné et al 2007; De Guzman et al 2019; McWilliam et al 2021). This practice contributes to household nutrition and income but may exert pressure on nearshore resources if left unmanaged.

Echinoderms constitute an important component of gleaning catches in the Philippines (Lopez 2006). Ecologically, they play key roles in benthic food webs by recycling organic matter and regulating algal and invertebrate populations (Hernández et al 2006; Bos et al 2008). Economically, several echinoderm groups, including sea cucumbers, sea stars, and sea urchins, are harvested for food, ornamental trade, and biomedical research (Llacuna et al 2016; Walag & Canencia 2016; Walag & Del Rosario 2018). The Indo-Pacific region, particularly the Philippines, hosts a high diversity of echinoderm species; however, population-level data for many taxa remain limited (Stöhr et al 2012; von Der Heyden et al 2014). Sea urchins are among the most commonly harvested echinoderms due to their edible gonads and market value (Parvez et al 2016). Despite their importance, several sea urchin species in the Philippines face increasing pressure from overharvesting driven by high consumer demand (Nievaes et al 2006). Documentation of sea urchin populations, particularly in southern Philippine waters, remains sparse, with few localized studies available (Jontila et al 2014; Tawasil et al 2021). This lack of baseline information hampers effective management and conservation efforts.

The province of Sulu, located in the southern Philippines, contains productive fishing grounds that support the livelihoods of coastal communities (White & Vogt 2000; Alcala et al 2008; Mamalangkap et al 2018). However, biological research in the area has been limited by long-standing security concerns, resulting in gaps in knowledge about the status of marine resources (Banlaoi 2008; Peleo 2015). Bato-Bato Island in the municipality of Indanan is one area where sea urchins are regularly harvested through gleaning, primarily by Tausug communities for subsistence. Continued unregulated harvesting may increase the risk of resource depletion, underscoring the need for baseline ecological assessments. Thus, this study aims to assess the sea urchin resources in the coastal waters of Bato-Bato, Indanan, Sulu, Philippines by (1) determining species composition and (2) estimating population density and spatial distribution across shallow reef flat habitats. The findings provide baseline information that can support sustainable gleaning practices, local fisheries management, and future conservation planning in the Sulu Archipelago.

Material and Method

Study site and duration. The study area where we collected the sea urchin was along the shallow coastal area of Bato-Bato for 2 months (Figure 1). Bato-Bato is a barangay in the municipality of Indanan of the province of Sulu, Philippines (6° 02' 04" N, 120° 56' 47" E). The site has a sandy substrate, a rocky substrate with rubble corals and seagrass beds, and stilt houses in this area. Regarding transect deployment, one transect (20 m × 5 m; 100 m²) was laid per sampling session. Weekly sampling consisted of four sessions per sampling day (two in the morning and two in the afternoon), resulting in four transects surveyed per week, with sea urchins recorded only within the 100 m² area of each transect.

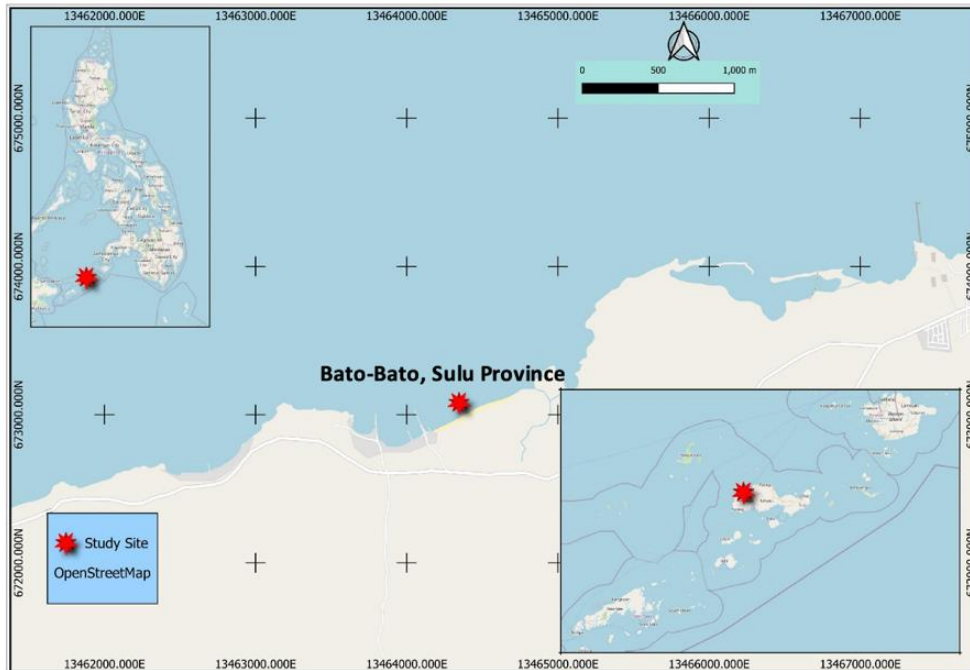


Figure 1. Map of the study site.

Population density, distribution, and species identification. Weekly sampling was conducted four times per week, consisting of two morning sessions (5:30-7:30 AM and 9:30-11:30 AM) and two afternoon sessions (12:00-2:00 PM and 4:00-6:00 PM). One transect line measuring 20 m × 5 m (100 m²) was laid per sampling session, and only sea urchins occurring within the transect area were recorded. The study site featured sandy and rocky substrates with coral rubble and seagrass beds, as well as stilt houses along the shoreline. Because sea urchins are spiny, individuals were carefully collected with a stick-and-scoop net and temporarily placed in a basin for counting and identification (Figure 2). All individuals collected were returned alive to their original habitat immediately after data collection to minimize disturbance and avoid impacts on the local population. The habitat type where each individual was found was also noted. Species identification was based on external morphological characteristics following Schoppe (2012) and was verified using the World Echinoidea Database. Population density was calculated by dividing the total number of individuals recorded by the total area covered (ind. 100 m⁻²).



Figure 2. (A) Materials used to collect sea urchins; (B) collecting sea urchins along the coastal area of Bato-Bato, Indanan, Sulu, Philippines.

Data analysis. The data were analyzed using descriptive statistics in Microsoft Excel 2022. Given the exploratory nature of this study, the analysis was intentionally limited to descriptive statistics, and no confidence intervals or temporal/spatial comparisons were applied. This study is expressly presented as a preliminary baseline assessment of sea urchin populations in the study area.

Results. Five species of sea urchins belonging to two families, Toxopneustidae and Diadematidae, were recorded in the coastal waters of Bato-Bato, Indanan, Sulu (Figure 3). These included two species under the genus *Tripneustes*: gracious sea urchin, *Tripneustes gratilla* (Lamarck, 1816), and *T. ventricosus*; one species each under the genera *Diadema*: long-spined sea urchin, *Diadema antillarum* (Philippi, 1845), *Toxopneustes*: flower sea urchin, *Toxopneustes pileolus* (Lamarck, 1816), and *Pseudoboletia* (*Pseudoboletia maculata*). A total of 438 sea urchins were documented during the study period (Table 1). *T. gratilla* was the most abundant species, accounting for 256 ind. (58.46%), with a mean abundance of 25.60 ± 4.23 ind. 100 m^{-2} . This was followed by *D. antillarum* with 76 ind. (17.35%; 7.60 ± 4.15 ind. 100 m^{-2}), *T. pileolus* with 52 ind. (11.87%; 5.20 ± 1.83 ind. 100 m^{-2}), sea egg sea urchin, *Tripneustes ventricosus* (Lamarck, 1816) with 38 ind. (8.68%; 3.80 ± 0.77 ind. 100 m^{-2}), and stained collector urchin, *Pseudoboletia maculata* (Lamarck, 1816) with 16 ind. (3.65%; 1.20 ± 1.07 ind. 100 m^{-2}).

In terms of population density, *T. gratilla* exhibited the highest density (2.56 ± 0.04 ind. 100 m^{-2}), followed by *D. antillarum* (0.76 ± 0.04 ind. 100 m^{-2}), *T. pileolus* (0.52 ± 0.02 ind. 100 m^{-2}), and *T. ventricosus* (0.38 ± 0.01 ind. 100 m^{-2}). *P. maculata* had the lowest recorded density (0.16 ± 0.01 ind. 100 m^{-2}). Sea urchins were observed across multiple habitat types, including seagrass beds, coralline reef areas, sandy substrates, and coral rubble zones. Associated macrofauna, such as starfishes, sea cucumbers, gastropods, crustaceans, and bivalves, were also noted in the sampling area. Temporal patterns in gleaning indicated that the highest proportion of sea urchins was collected during the afternoon (4:00-6:00 PM; 39.57%) and early afternoon (12:00-2:00 PM; 29.46%) sampling periods. Lower proportions were recorded during the morning (9:00-11:30 AM; 17.63%) and early morning (5:30-7:30 AM; 13.33%) sessions (Figure 4).

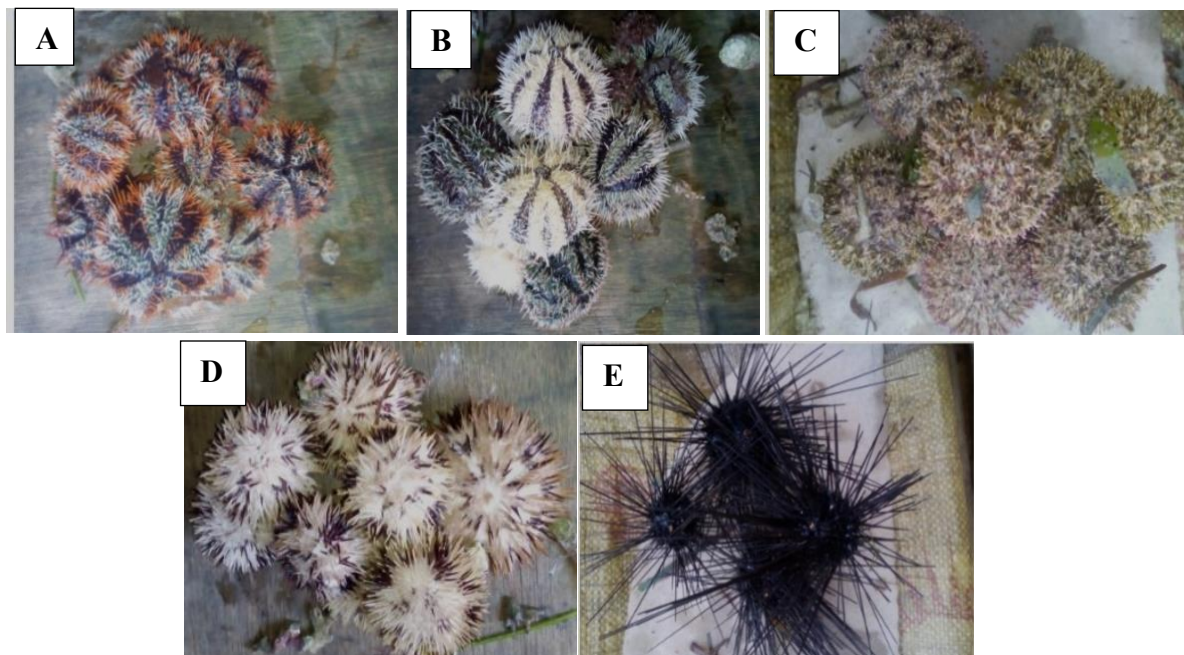


Figure 3. Sea urchin species collected along the coastal area of Bato-Bato, Indanan, Sulu, Philippines. A (*Tripneustes gratilla*); B (*Tripneustes ventricosus*); C (*Toxopneustes pileolus*); D (*Pseudoboletia maculata*); E (*Diadema antillarum*).

Table 1

Population density of sea urchins in the coastal area of Bato-Bato, Indanan, Sulu, Philippines

Common name	Scientific name	Number of sea urchin	Frequency (%)	Mean abundance per transect	Density (ind. 100 m ⁻²)
Gracious sea urchin	<i>Tripneustes gratilla</i> (Lamarck, 1816)	256	58.45	25.60±4.23	2.56±0.04
Long-spined sea urchin	<i>Diadema antillarum</i> (Philippi, 1845)	76	17.35	7.60±4.15	0.76±0.04
Flower urchin	<i>Toxopneustes pileolus</i> (Lamarck, 1816)	52	11.87	5.20±1.83	0.52±0.02
Sea egg sea urchin	<i>Tripneustes ventricosus</i> (Lamarck, 1816)	38	8.68	3.80±0.77	0.38±0.01
Stained collector urchin	<i>Pseudoboletia maculata</i> (Lamarck, 1816)	16	3.65	1.60±1.07	0.16±0.01

Note: Values are expressed as mean ± SE (standard error) of replicated samples. Means and densities were calculated for each sampling unit.

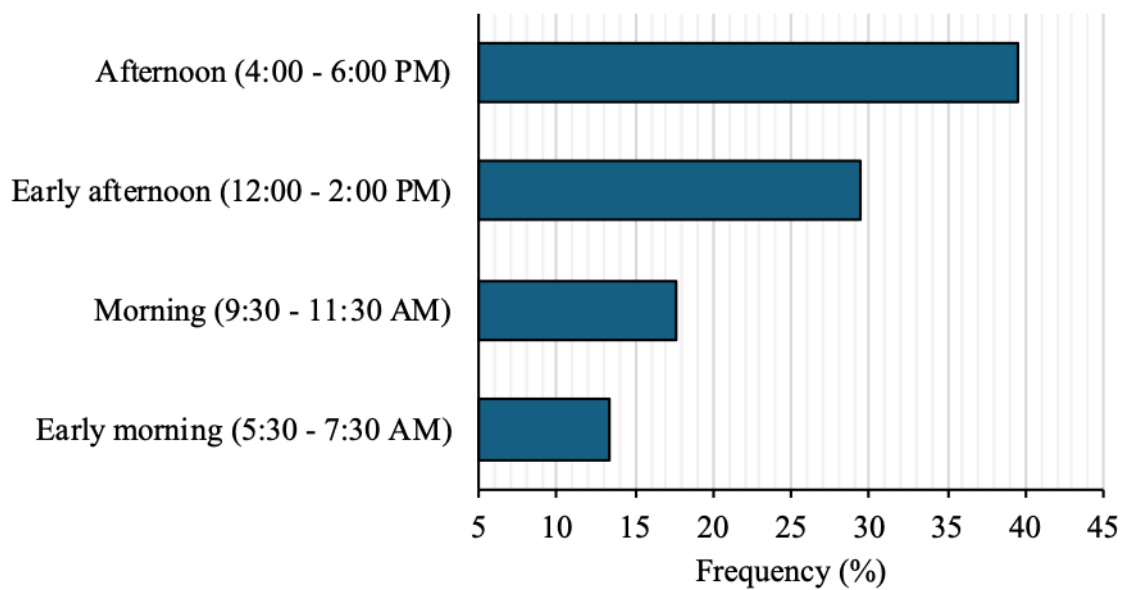


Figure 4. Time-frequency of gleaning of sea urchins along the coastal area of Bato-Bato, Indanan, Sulu, Philippines.

Discussion. The species richness observed in the present study is comparable to previous reports from Sulu Province, particularly from Manubul Island (Tawasil et al 2021), suggesting a relatively consistent composition of nearshore echinoid assemblages within the province. Although the Philippines is widely recognized for its high echinoid diversity (Kelly 2005; Mooi & Munguia 2014), localized comparisons remain essential for understanding spatial patterns in data-limited regions. The occurrence of sea urchins across multiple habitat types, including seagrass beds, coralline reef areas, sandy substrates, and coral rubble zones, supports earlier findings that echinoids occupy a broad range of shallow coastal environments (Shamsuddin et al 2010; Zhang et al 2014; Mudiyansele 2017). This habitat flexibility likely contributes to the persistence of sea urchin populations in areas subject to both natural variability and anthropogenic pressure.

The dominance of *T. gratilla* aligns with patterns reported from several Philippine localities, including Ilocos Sur, Ilocos Norte, Northern and Southern Mindanao, and Manubul Island, Sulu (Bangi et al 2013; Tawasil et al 2021). Such repeated dominance across geographically distinct areas suggests that *T. gratilla* possesses ecological traits, such as broad habitat tolerance and adaptability, that facilitate its success under diverse coastal conditions. The presence of *D. antillarum* and *T. pileolus* is also consistent with records from Guimaras, Cebu, and Pangasinan (Barrett et al 2019), indicating that these species are stable components of Philippine echinoid communities. In contrast, the relatively low abundance of *P. maculata* may be attributed to species-specific habitat preferences or differential exposure to harvesting pressure, as suggested in other coastal studies.

Temporal differences in sea urchin observations between morning and afternoon sampling periods may reflect behavioral responses or environmental influences rather than true population changes. While environmental drivers such as temperature and light have been linked to echinoid activity in previous studies, the absence of physicochemical measurements in the present study precludes direct attribution of these temporal patterns. Alternative factors, including tidal conditions, water visibility, and harvesting efficiency, may have contributed to the observed variation and should be considered in future investigations. The prominence of commercially valuable species, particularly *T. gratilla*, underscores the importance of sea urchins to local subsistence fisheries. Although overexploitation was not directly assessed, continued reliance on unregulated gleaning may increase the risk of population decline, as documented in other Philippine coastal systems. The baseline information generated by this study provides a reference for local government units and coastal resource managers in formulating site-specific management strategies, such as regulated gleaning schedules, size limits, and community-based monitoring programs to promote sustainable resource use. The relatively short duration of the study and the lack of seasonal coverage limit the ability to assess long-term population trends and ecological drivers. Additionally, the absence of environmental parameters such as temperature, salinity, and nutrient concentrations constrains the interpretation of factors influencing species distribution and abundance. Future studies incorporating longer sampling periods, seasonal comparisons, and environmental monitoring are recommended to enhance understanding of sea urchin population dynamics in the Sulu Archipelago.

Conclusions. Five sea urchin species were recorded in Bato-Bato, Indanan, Sulu, totaling 438 individuals. *Tripneustes gratilla* was the most abundant (256 ind.; 58.46%) and densest (2.56 ± 0.04 ind. 100 m^{-2}), followed by *Diadema antillarum* (76 ind.; 17.35%; 0.76 ± 0.04 ind. 100 m^2). Sea urchins occurred across seagrass beds, coral reefs, sandy substrates, and coral rubble, with the highest collections in the afternoon (4:00-6:00 PM; 39.57%). The predominance of *T. gratilla* suggests that this area functions as a key recruitment and spawning habitat, highlighting the need for targeted habitat management to support sustainable populations.

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Conflict of interest. The authors declare that there is no conflict of interest.

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