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# COMMUNITY STRUCTURE OF ECHINODERMATA IN THE SEAGRASS HABITAT OF SANUR BEACH, BALI

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**Abstract**. This study aims to analyze the community structure of Echinodermata and its relationship with the seagrass ecosystem at the study site. Echinodermata are an important group of organisms in the seagrass ecosystem because they act as nutrient recyclers and detritus feeders, helping maintain ecosystem balance. The study was conducted using the quadrat transect method, observing the types and abundance of Echinodermata as well as seagrass cover, while also measuring water quality parameters such as temperature, salinity, and dissolved oxygen (DO). The results showed the presence of several species of Echinodermata, with diversity and dominance varying between stations. In addition, a positive relationship was found between the abundance of Echinodermata and seagrass cover as well as water quality, indicating that healthy and high-quality seagrass beds support a more abundant and diverse Echinodermata community. This study emphasizes the importance of conserving and managing seagrass ecosystems as habitats and sources of livelihood for Echinodermata and for maintaining the ecological functions of coastal areas.
**Keywords:** Echinodermata, community structure, seagrass, abundance, coastal ecosystem.

## I. INTRODUCTION

Echinoderms are organisms that play an important role in ecosystems, one of which is as detritus consumers. Echinoderms also act as key components in the marine ecological food chain and help maintain ecosystem balance by recycling waste and organic remains that are no longer utilized by other organisms, as well as recycling nutrients that can help cleanse aquatic ecosystems [1]. Echinoderms function as sensitive indicators of changes in aquatic characteristics, making them useful for evaluating the quality and ecological condition of a marine ecosystem [2]. The presence of echinoderms is often found in seagrass ecosystems.

Seagrass ecosystems serve as shelter for various marine biota and provide feeding grounds [3]. One of the organisms that inhabit seagrass ecosystems is the echinoderm. Echinoderms are key components of the ecosystem, contributing significantly to ecosystem functioning [4]. The presence and health of seagrass ecosystems have direct implications for the survival of organisms that inhabit and rely on these habitats. One of the areas where seagrass ecosystems are found is Sanur Beach.

Sanur Beach, located in the city of Denpasar, is one of the coastal areas that has an abundant seagrass ecosystem. The distribution of seagrass meadows stretches approximately 8 kilometers along the coastline, extending across the area between the Grand Bali Beach Hotel and the Mertasari area [5]. Tourism activities along the coastline, especially in seagrass areas, pose a serious threat to the sustainability of the habitat. Environmentally unfriendly tourist behavior—such as carelessly stepping on the seabed or collecting marine organisms—can damage the integrity of the ecosystem. Consequently, the community of organisms, including the phylum Echinodermata found in the seagrass ecosystem, may experience significant disturbances, leading to a decline in both diversity and population abundance, whether due to human intervention or complex natural factors.

This study focuses on the structure of echinoderm communities in Sanur Beach, which has not yet been specifically examined. In general, previous studies have investigated the structure of echinoderm communities in the southern region of Bali, such as in the study by Wahyuningsih (2014) [6]. Additionally, a study by Shabrina et al. (2018) explored the relationship between seagrass density and macrozoobenthos abundance at Sanur Beach, Bali; however, that study did not specifically focus on the Echinodermata phylum, as it was concerned with macrozoobenthos in general [7]. Therefore, it is necessary to conduct a study on the structure of the echinoderm community at Sanur Beach, Bali. This research is expected to provide an updated overview and current information regarding the condition of the echinoderm community structure in the area.

## II. METHODS

### Research Period and Location

This study was conducted in the seagrass ecosystem area of Sanur Beach using 5 research stations. Each station consisted of 3 points with three repetitions of sampling, along with seagrass cover measurement and water quality assessment at each station.

Figure 1. Research Location Map.

Data Sampling Method

This study employed a quantitative descriptive method. Descriptive analysis was used to process data by describing or presenting the collected information as it is, without making generalizations or drawing universal conclusions involving other variables [8]. Sampling of Echinoderms and seagrass was conducted during low tide, from morning to afternoon, using a 1x1 meter quadrat transect method. Each quadrat was further divided into four smaller quadrants, each measuring 0.5 x 0.5 meters.

The research was conducted at five stations, each spaced approximately 100 meters apart. At each station, three observation points were established, with a distance of 20 meters between points. At each point, five transects were laid out, each 20 meters apart, resulting in a total of 15 transects per station (3 points × 5 transects). Observations began as soon as the presence of seagrass was identified in the area.

Each transect, divided into four quadrants, was observed to record the number of individuals of each Echinoderm species, as well as the types of seagrass and their percentage cover. Additionally, substrate characteristics in each transect were also examined. Echinoderm species found were documented and identified based on references and with the assistance of the iNaturalist application. Similarly, seagrass species were documented and identified, supported by the Seagrass Watch method during the observation process.

Data analysis

Abundance

Analysis of Echinoderm abundance was calculated using the abundance index method according to Odum (1996)[9].

$$K = \frac{Ni}{A}$$

K : Abundance of Echinoderms (Individuals/m²)
Ni: Number of individuals of a species
A : Area size (m²)

Diversity Index

The diversity value describes the number of Echinoderm species found within the sampling area. The diversity can be calculated using the Shannon-Wiener index (H'), according to the formula proposed by Krebs (1989)[10].

$$H' = \sum_{i=1}^{n} Pi \ \text{In} \ Pi$$

Pi : ni/N
Ni: Number of individuals of the i-th species
n : Number of species
N : Total number of individuals

According to the Shannon-Wiener (H') species diversity index, the interpretation criteria can be seen in the following table.

TABEL 1
DIVERSITY INDEX RANGE

| No | Index Value Range | Category |
|---|---|---|
| 1 | H' > 3 | High (stable) |
| 2 | 1 < H' < 3 | Moderate |
| 3 | H' < 1 | Low |

Evenness Index

The evenness index describes the variation or dominance of species numbers within a community. The calculation of the evenness index is carried out using the Evenness Index formula, as proposed by Odum (1993)[11].

$$E = \frac{H'}{In\ S}$$

E: Evenness index
H': Diversity index
S: Total number of species

According to Brower et al. (1990), the categories of the evenness index are shown in the following table [12].

TABLE 2
EVENNESS INDEX

| Evenness index (E) | Category |
|---|---|
| 0,0 < E < 0,4 | Low |
| 0,4 < E < 0,6 | Moderate |
| E > 0,6 | High |

Dominance Index

The dominance index is a mathematical measure that describes the composition of a community within a given area. If the dominance value approaches one, it indicates the presence of a dominant species. Conversely, if the dominance index value approaches zero, it means that no species significantly dominates the community. The calculation is carried out using the Simpson dominance formula according to Odum (1993).

$$C = \sum \left(\frac{ni}{N}\right)^2$$

C : Dominance of a species
Ni: Number of individuals of the i-th species
N : Total number of individuals

The categories of the dominance index according to Odum (1993) are shown in the following table.

TABLE 3

DOMINANCE INDEX

| Dominance Index (C) | Category |
|---|---|
| 0 < C < 0,3 | Low |
| 0,3 < C < 0,6 | Moderate |
| 0,6 < C < 1 | High |

## III. RESULT

### Identification of Echinodermata at Sanur Beach

The research conducted at Sanur Beach, Bali, recorded a total of 1,245 individuals from the phylum Echinodermata, which were classified into 4 classes (Astroidea, Echinoidea, Ophiuroidea, and Holothuroidea), 5 orders (Valvatida, Diadematoida, Camarodonta, Ophiacanthida, and Apodida), 8 families (Oreasteridae, Ophidiasteridae, Diadematidae, Echinometridae, Toxopneustidae, Ophiocomidae, Ophiomyxidae, and Synaptidae), 11 genera (Protoreaster, Pentaceraster, Pentaster, Linckia, Diadema, Echinothrix, Echinometra, Tripneustes, Ophiocoma, Ophiarachna, and Synapta), and 11 species (P. nodosus, P. mammillatus, P. obtusatus, L. laevigata, D. setosum, E. calamaris, E. mathaei, T. gratilla, O. scolopendrina, O. incrassata, and S. maculata).Echinoderm Community Structure at Sanur Beach.

### Community Structure of Echinoderms

The diversity indices found across all stations indicated a generally low level of species diversity, as shown in Table 4. At Station 1, the diversity varied significantly between replications, with the highest value recorded at 0.36 during the first replication, dropping to 0.11 in the second, and increasing again to 0.39 in the third replication. A similar pattern was observed at Station 2, where the diversity index started at 0.17 in the first replication, decreased to 0.11 in the second, and rose again to 0.25 in the third replication. In contrast, Stations 3, 4, and 5 exhibited better consistency, with diversity index values ranging from 0.53 to 0.73. All replications at these stations maintained relatively stable diversity levels without sharp fluctuations. The evenness index of echinoderms for each replication is also presented in Table 4. The highest evenness value was recorded in the first replication at Station 5, with a value of 1.05, followed by the second replication at Station 3 with a value of 1.03. On the other hand, the lowest evenness values were observed in the first and second replications at Station 1 and the second replication at Station 2, all of which had the same value of 0.16. The high evenness category at Station 5 in the first replication was due to a relatively balanced species composition without the dominance of a particular species. However, at Station 3 in the second replication, the high evenness value was attributed to the dominance of specific species, namely Synapta maculata and Diadema setosum.

TABEL 4

BIOLOGICAL PARAMETERS

| station | | Abundance (Ind/m2) | Diversity (H') | Criteria | Evenness ( E ) | Criteria | Dominance ( C ) | Criteria |
|---|---|---|---|---|---|---|---|---|
| Replicate 1 | 1 | 0,02 | 0,36 | Low | 0,15 | Low | 0,78 | High |
| | 2 | 0,02 | 0,17 | Low | 0,25 | Low | 0,92 | High |
| | 3 | 0,02 | 0,53 | Low | 0,76 | High | 0,45 | Medium |
| | 4 | 0,03 | 0,59 | Low | 0,86 | High | 0,40 | Medium |
| | 5 | 0,03 | 0,73 | Low | 1,05 | High | 0,40 | Medium |
| Replicate 2 | 1 | 0,03 | 0,11 | Low | 0,16 | Low | 0,94 | High |
| | 2 | 0,03 | 0,11 | Low | 0,16 | Low | 0,94 | High |
| | 3 | 0,06 | 0,71 | Low | 1,03 | High | 0,32 | Medium |
| | 4 | 0,05 | 0,53 | Low | 0,77 | High | 0,44 | Medium |
| | 5 | 0,05 | 0,69 | Low | 0,99 | High | 0,37 | Medium |
| Replicate 3 | 1 | 0,01 | 0,39 | Low | 0,56 | Medium | 0,65 | High |
| | 2 | 0,02 | 0,25 | Low | 0,36 | Low | 0,59 | Medium |
| | 3 | 0,03 | 0,58 | Low | 0,83 | High | 0,40 | Medium |
| | 4 | 0,03 | 0,63 | Low | 0,91 | High | 0,38 | Medium |
| | 5 | 0,05 | 0,67 | Low | 0,97 | High | 0,39 | Medium |

### Echinoderm Abundance

### Synapta maculata Abundance

Based on the abundance data of S. maculata across stations (Figure 4.8), it can be observed that the number of individuals of this species fluctuated at each observation site. At Station 4, S. maculata showed the highest abundance compared to other stations, with the average number of individuals reaching the maximum per 19.625 m² transect area. Station 3 also recorded relatively high abundance, although still lower than Station 4. In contrast, Stations 1, 2, and 5 showed significantly lower and nearly stagnant abundance, approaching zero. This pattern indicates that S. maculata was predominantly found at Stations 3 and 4, while its presence was very rare or nearly absent at Stations 1, 2, and 5. Such differences in distribution are likely influenced by variations in environmental conditions and habitat characteristics at each station, such as substrate type and availability of food sources that support the survival of S. maculata in specific locations.

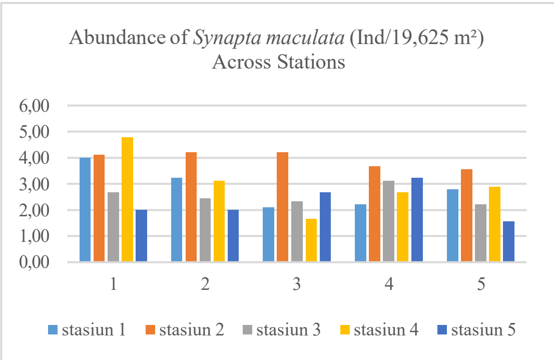
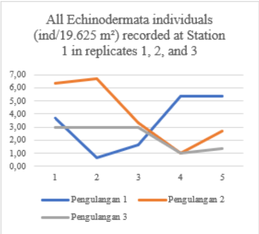
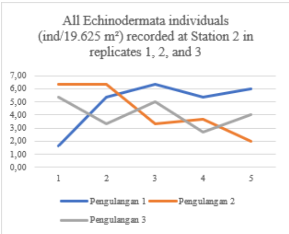



Figure 2. Abundance of Synapta maculata Across Stations.

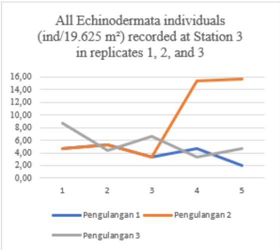
### Abundance of all Echinoderms

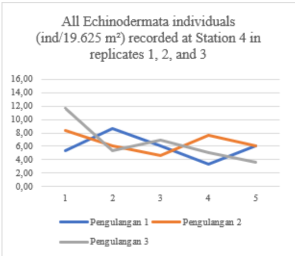
Based on the results of the Echinodermata study conducted at Sanur Beach with three replications at five stations, the findings revealed a clear and consistent pattern across the entire research area. A prominent result was the progressive increase in echinoderm abundance. At Stations 1 and 2, the number of individuals found tended to be lower compared to the other stations. The recorded values ranged from 0 to 7.00 ind/m² in each replication, indicating relatively low echinoderm density, which may be due to less favorable environmental conditions. In contrast, Stations 3, 4, and 5 showed higher individual counts, ranging from 0 to 16.00 ind/m² in each replication. This suggests that the environmental conditions at these stations were more optimal for the growth and development of Echinodermata.



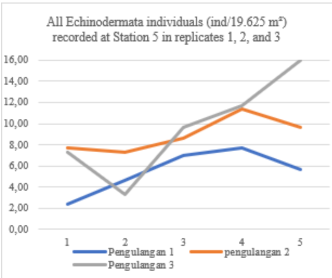




(a) (b)




(c) (d)




(d)

Figure 3. Percentage of Abundance of All Echinodermata Station 1 (a), Station 2 (b), Station 3 (c), Station 4 (d), Station 5 (e).

Seagrass cover

Based on the research conducted at Sanur Beach, four species of seagrass were identified, namely Enhalus acoroides, Thalassia hemprichii, Cymodocea rotundata, and Syringodium isoetifolium. At Station 1, all four species were found: Enhalus acoroides, Thalassia hemprichii, Cymodocea rotundata, and Syringodium isoetifolium. However, at Stations 2, 3, 4, and 5, only three species were observed: Enhalus acoroides, Thalassia hemprichii, and Cymodocea rotundata, with Syringodium isoetifolium absent at these stations.The five stations showed varying percentages of seagrass cover for each species observed, namely E. acoroides, T. hemprichii, and C. rotundata. Overall, the highest seagrass cover was found at Station 3, followed by Stations 4 and 5, while Stations 1 and 2 showed lower percentages. The species E. acoroides and T. hemprichii were dominant at most stations, particularly at Station 3 where their coverage was the highest. Meanwhile, C. rotundata generally exhibited lower coverage across all stations compared to the other two species.This variation in seagrass cover among stations may be influenced by differences in environmental factors and substrate conditions at each site, which in turn affect the density and dominance levels of specific seagrass species at each station.

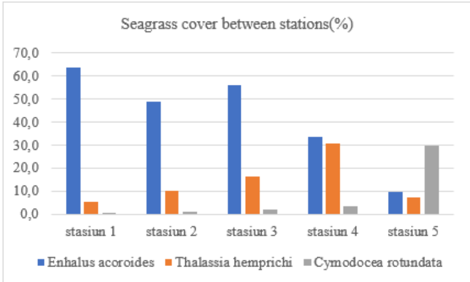



Figure 4. Percentage of Seagrass Cover Between Stations.

Water Quality at Sanur Beach

The water quality parameters obtained from the study at Sanur Beach are still categorized as normal, with temperature ranging from 28°C to 30°C, salinity ranging from 29–34 ppt, pH values between 7 and 8.5, and dissolved oxygen (DO) levels between 4.3–6.7 mg/l. These measurements were taken at each station during every replication to directly assess their influence on the survival of Echinoderms. The results of water quality parameter measurements at Sanur Beach can be seen in Table 4.

TABEL 4
WATER QUALITY MEASUREMENT RESULTS

| Station | | parameter | | | |
|---|---|---|---|---|---|
| | | Temperature (C) | Salinity (ppt) | pH | DO (mg/l) |
| | | 20-36°C | 30-36 | 7-8,5 | >5 |
| Replication 1 | 1 | 28,2 | 32 | 7,2 | 6,6 |
| | 2 | 28,6 | 34 | 7,3 | 6,6 |
| | 3 | 28,6 | 33 | 7,4 | 6,7 |
| | 4 | 28,6 | 34 | 7,3 | 6,4 |
| | 5 | 28,4 | 34 | 7,3 | 6,7 |
| Replication 2 | 1 | 28 | 29,7 | 7,1 | 5,35 |
| | 2 | 29 | 30 | 7 | 5,3 |
| | 3 | 29 | 30 | 7,2 | 5,3 |
| | 4 | 30 | 29 | 7,2 | 5,37 |
| | 5 | 30 | 29 | 7 | 5,2 |
| Replication 3 | 1 | 29 | 29 | 8,2 | 4,3 |
| | 2 | 30 | 30 | 8,3 | 5,2 |
| | 3 | 30 | 30 | 8,3 | 5,7 |
| | 4 | 30 | 30 | 8,5 | 4,8 |
| | 5 | 30 | 30 | 8,5 | 4,6 |

Based on the visual observations conducted, the substrates found at each station were categorized into two types: sandy and coral rubble. The presence of sandy substrate and coral fragments provides living space and feeding grounds among the sand grains and coral pieces for marine organisms, including members of the phylum Echinodermata such as sea stars and sea urchins.\

## IV. DISCUSSION

The study conducted at Sanur Beach identified four species of seagrass, namely Enhalus acoroides, Thalassia hemprichii, Cymodocea rotundata, and Syringodium isoetifolium. The distribution of these species varied among stations. Station 1 contained all four species, while Stations 2 to 5 only contained the first three, with S. isoetifolium absent. According to Duarte (2002), such distribution differences are likely influenced by varying environmental and physicochemical conditions at each station[13]. S. isoetifolium prefers stable substrates with specific salinity and depth conditions, possibly only met at Station 1. Anthropogenic disturbances, sedimentation, and water quality changes may also affect the presence of sensitive seagrass species (Laba & Widjanarko, 2015)[14], along with factors such as light penetration, water currents, and nutrient availability (Short et al., 2007)[15].

The structure of the Echinodermata community in Sanur's seagrass ecosystem shows a strong correlation with seagrass cover and type. Areas dominated by E. acoroides and T. hemprichii tend to support more diverse and evenly distributed echinoderm communities due to stable substrates, protection from predators, and higher nutrient availability from detritus accumulation (Haddad et al., 2014)[16]. In contrast, areas dominated by C. rotundata, with lower cover, show reduced echinoderm diversity and abundance due to limited habitat complexity and fewer nutrients (Unsworth et al., 2018)[17]. A total of 1,245 echinoderm individuals were identified, belonging to 11 species, 11 genera, and 8 families. This demonstrates the adaptability of Echinodermata to various environmental conditions, such as sandy, rocky, or muddy substrates (Smith, 2005)[18]. Their presence indicates that Sanur Beach still provides a supportive habitat for benthic organisms, in line with Sulistiyani et al. (2017), who highlighted echinoderms as important indicators for assessing benthic ecosystem health [19].

The most dominant group was from the class Holothuroidea, which is highly adaptable to various substrates and prefers seagrass habitats. Yanti et al. (2014) reported high densities of Holothuroidea (sea cucumbers) in southern Bali, especially on sandy substrates with coral fragments and algae[20]. Purcell et al. (2016) also noted their preference for seagrass meadows and structurally complex sandy substrates for food and protection[21].

The Shannon-Wiener diversity index showed a low diversity level of echinoderms at Sanur Beach, indicating species dominance and community imbalance[22]. This may result from dynamic environmental pressures and human activities, such as frequent marine tourism that damages seagrass beds—primary habitats for echinoderms [23].

Evenness index values also varied. Stations 1 and 2 showed low evenness (0.15–0.36), indicating uneven species distribution and dominance by one or more species [24]. In contrast, Stations 3, 4, and 5 showed high evenness (0.76–1.05), suggesting stable and balanced communities [25].

Dominance index values ranged from moderate to high. The highest recorded dominance value was 0.94, primarily due to the dominance of Synapta maculata, a species well adapted to group living in seagrass habitats and sandy substrates. As a detritivore, S. maculata plays a vital role in recycling organic matter and oxygenating sediments [26].

Synapta maculata dominated the echinoderm community across all stations, with consistently high individual numbers in each transect. Its wide distribution reflects its strong adaptability and ecological suitability in the habitat. According to Yusron (2003), S. maculata often dominates tropical seagrass beds due to limited human exploitation[27]. Aziz (1987) noted that its preferred habitat is muddy sand substrates in seagrass beds and shallow lagoons, where detritus is abundant. Its ability to thrive in changing environments and role as a detritivore helps it maintain dominance [28]. Studies in Enggano and Pramuka Islands have similarly found S. maculata to be the most abundant echinoderm species in areas with minimal harvesting pressure. Mardia et al. (2023) supported this finding, explaining that S. maculata thrives in muddy, organic-rich substrates that support its detritivore activity in seagrass ecosystems[29]. Echinoderm abundance in seagrass beds varied between stations, influenced by environmental characteristics. Stations with high abundance indicate favorable habitat conditions—suitable substrates, abundant detritus, and dense seagrass cover—while lower abundance elsewhere reflects limiting factors such as human disturbance, competition, or unfavorable physicochemical conditions. This aligns with findings by Safitri et al. (2021) who also reported that seagrass density and water quality affect echinoderm abundance[30].

Notably, Stations 3 and 5 recorded the highest echinoderm abundance, indicating optimal habitat conditions. This supports Rahmad and Purnomo (2010), who stated that substrate type and pollution levels significantly influence echinoderm presence[31]. Complex habitats such as coral reefs and seagrass beds provide shelter and food [32]. Water quality parameters such as salinity, temperature, and dissolved oxygen also affect distribution, where stable conditions support higher populations (Sulistiyani et al., 2017). However, anthropogenic disturbances and pollution reduce echinoderm diversity, especially in areas with high human activity [33]. Therefore, monitoring echinoderm abundance over time can serve as an effective tool for assessing the health of marine ecosystems.

## V. CONCLUSION

The seagrass cover at Sanur Beach is categorized as moderate to high, with Enhalus acoroides dominating in several stations and a varied distribution of other species across different locations, indicating that the seagrass meadows are still in relatively healthy condition. The structure of the Echinodermata community in the Sanur Beach seagrass ecosystem demonstrates a fairly good level of species diversity, with individual distribution tending to be more even in areas with high seagrass cover. Synapta maculata stands out as the most abundant species from the class Holothuroidea, especially in seagrass habitats with sandy and coral rubble substrates. The abundance of S. maculata is influenced by minimal human exploitation and its adaptability as a detritivore, which often allows it to dominate the echinoderm community in those areas.

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