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Marine Invertebrate Inventory at Ai Limung Beach, Teluk Saleh, Sumbawa, West Nusa Tenggara, Indonesia

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ABSTRACT

Saleh Bay, which is a semi-enclosed water body bordering the Flores Sea, is located in the northeast coastal region of Sumbawa Island, West Nusa Tenggara. This area has potential for the utilization of various natural resources such as fisheries, tourism, agriculture, and industry. Increased human activities and ongoing development around the coastal area of Teluk Saleh have put pressure on marine habitats, impacting ecosystem health and water quality. Invertebrate biota, as part of the kingdom Animalia, play an important role in ecosystems as environmental bioindicators and providers of significant ecological services. However, data on the presence and diversity of marine invertebrates in this area are still very limited. Therefore, this study was conducted at Ai Limung Beach, Pungkit Village, Sumbawa Regency, with the aim of identifying marine invertebrate species and evaluating their ecological and economic roles. The results of this study are expected to serve as a reference for stakeholders in managing marine resources in the Teluk Saleh area, supporting conservation efforts, and facilitating sustainable resource utilization policies.

Introduction

Saleh Bay is a semi-enclosed body of water directly connected to the Flores Sea, located in the northeastern region of Sumbawa Island, West Nusa Tenggara. Administratively, the bay covers two districts: Sumbawa and Dompu. As a coastal area, the utilization of Saleh Bay covers various sectors, including fisheries, agriculture, plantations, livestock, industry, services and transportation. Sustainable development requires optimizing the potential of each region, including Sumbawa Island (Radiarta *et al.*, 2004).

The waters of Saleh Bay have long been the site of marine exploration and habitat rehabilitation. Some areas show signs of degradation, such as around Moyo Island, Medang Island, Rakit Island and Ganteng Island (Hartati *et al.,* 2007). Marine habitats face increasing pressure from human population growth, including industrial activities, fisheries and aquaculture, maritime transport, tourism, and coastal urbanization (Garcia *et al.*, 2019). In line with Heriyanto (2012), human activities, both directly and indirectly, affect water quality, which plays an important role in the survival of aquatic organisms. Benthic organisms, which are relatively immobile, are particularly vulnerable to water pollution and can serve as indicators of environmental change.

The kingdom Animalia consists of multicellular, eukaryotic organisms that lack cell walls and mostly reproduce sexually, although some phyla exhibit asexual reproduction. Animals can be categorized into invertebrates (those without a spine) and vertebrates (those with a spine). Invertebrates include phyla such as Porifera, Coelenterata, Platyhelminthes, Nemathelminthes, Annelida, Mollusca, Arthropoda, and Echinodermata. Vertebrates are further classified into Pisces, Amphibia, Reptilia, Aves, and Mammalia (Ruggiero, 2015; Rani, 2023).

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Invertebrates play an important ecological role, especially as bioindicators of water quality. Due to their relatively low mobility, they are directly affected by environmental changes, making them easier to identify and conserve compared to microscopic organisms (Handayani, 2019). Marine invertebrates also exhibit unique regeneration capabilities, with many being able to regrow lost or damaged organs. However, the speed of wound healing and regeneration varies between species, depending on the size and type of injury (Carlson, 2007).

Suwignyo (2005) classifies invertebrates into several phyla, including Protozoa, Porifera, Coelenterata, Platyhelminthes, Nemathelminthes, Annelida, Mollusca, Arthropoda, and Echinodermata. However, data on non-fish marine resources, such as coral reef invertebrates, are still limited. Therefore, scientific studies are needed to assess the presence of coral reef invertebrates in the waters of Saleh Bay, particularly along Ai Limung Beach in Pungkit Village, North Moyo Sub-district, Sumbawa Regency, West Nusa Tenggara. This study aims to provide information on species diversity and the ecological and economic benefits of these invertebrates, as a reference for stakeholders in formulating marine resource management policies on Sumbawa Island.

Methods

This study was conducted in May 2022 along the coast of Ai Limung, Pungkit Village, North Moyo District, Sumbawa Regency, West Nusa Tenggara, Indonesia, and the location is shown in Figure 1. The method used was direct observation and survey in the natural habitat of marine invertebrates. Invertebrate specimens found were collected in containers and identified based on their morphological characteristics.

Figure 1. Marine Invertebrate Sampling Site

Data Analysis

Data were analyzed descriptively by describing the morphological characteristics and benefits of each invertebrate species found. Taxonomic identification and classification of samples were carried out using supporting literature from books, previous research journals, and online references such as The Taxonomicon and WoRMS (World Register of Marine Species).

Results

This study identified several species of marine invertebrates from Ai Limung Beach, with the phylum Echinodermata being the most dominant, as presented in Table 1. These findings are very important, as the identified invertebrates have essential ecological functions, acting as bioindicators of environmental health and contributing to the stability of marine ecosystems. Each species will be examined further in this section with respect to its role in ecology, economic potential and relevance for sustainable marine resource management.

Table 1. Classification of Invertebrate Data in coastal Ai Limung, Pungkit, Sumbawa Regency, West Nusa Tenggara, Indonesia

Kingdom	Phylum	Class	Ordo	Family	Genus	Spesies
Animalia	Echinodermata	Echinoidea	Diadematoida	Diadematidae	Diadema	*Diadema setosum*
		Echinoidea	Temnopleuroida	Toxopneustidae	Tripneustes	*Tripneustes ventricosus*
		Ophiuroidea	Ophiacanthida	Ophiocomidae	Ophiocomella	*Ophiocomella alexandri*
		Holothuroidea	Holothuriida	Holothuriidae	Holothuria	*Holothuria atra*
		Holothuroidea	Holothuriida	Holothuriidae	Holothuria	*Holothuria scabra*
		Asteroidea	Valvatida	Oreasteridae	Protoreaster	*Protoreaster nodosus*
		Asteroidea	Valvatida	Oreasteridae	Astropecten	*Astropecten sp.*
	Mollusca	Gastropoda	Littorinimorpha	Strombidae	Lambis	*Lambis lambis*
		Gastropoda	Pulmonata	Onchidiidae	Onchidium	*Onchidium stuxbergii*
		Bivalvia	Pteriida	Pinnidae	Pinna	*Pinna muricata*
		Bivalvia	Arcida	Arcidae	Anadara	*Anadara antiquata*
	Arthropoda	Malacostraca	Decapoda	Portunidae	Portunus	*Portunus pelagicus*

Discussion

Echinodermata Characteristics

Echinodermata are a unique group of marine invertebrates that have some distinctive morphological features. They exhibit radial symmetry, often a pentameric (five-part) symmetry, which is most noticeable in adult individuals, allowing interaction with the environment from multiple directions. This symmetry is an adaptation for a generally slow or sedentary lifestyle and is organized by an oral-aboral axis instead of a clear head (Hyman, 1955).

One of the distinctive features of Echinodermata is the water vascular system, which is a network of fluid-filled canals that power the tube feet for movement, feeding and breathing. The tube feet, located on the ventral side, have suction capabilities that facilitate movement and attachment to surfaces (Nichols, 1962).

Their bodies are covered by a calcareous endoskeleton consisting of ossicles (limestone plates), with variations in shape between classes. In sea urchins (Echinoidea), the ossicles are tightly bound to form a rigid shell, whereas in sea cucumbers (Holothuroidea), the ossicles reduce to microscopic spicules embedded in soft tissue, providing flexibility (Brusca and Brusca, 2003). The endoskeleton often has spines or protrusions as a form of protection and to interact with the environment.

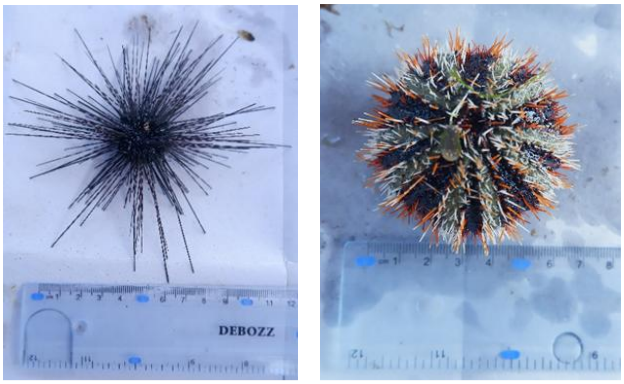
Echinodermata also have remarkable regeneration abilities, allowing them to regrow lost body parts. This ability is particularly prominent in sea stars (Asteroidea) and snake stars (Ophiuroidea), which can regenerate their arms or parts of their central disc after injury (Lawrence, 2013). This ability serves as a defense mechanism and enhances survival in the dynamic marine environment.

Echinoidea

Sea urchins have round or flattened bodies, covered with movable spines connected to a rigid exoskeleton called a test. Their bodies show pentameric symmetry and use tube feet and spines to move. A unique structure named Aristotle's lantern is used to feed on algae.

Examples such as *Diadema setosum* and Tripneustes ventricosus Figure 2. (a) and (b) play an important role in maintaining the balance of coral reefs by controlling the growth of algae. Without this control, algae can dominate and damage coral health (McAndrews *et al.*, 2019).

Tripneustes ventricosus also has high economic value as its gonads (roe) are a delicacy in many regions. Utilization of sea urchins should be regulated to avoid population decline (McClanahan and Muthiga, 2017). Population monitoring is necessary to maintain reef health and fisheries sustainability.



(a) Diadema setosum *(b) Tripneustes ventricosus*

Figure 2. The class of Echinoidea found on the beach of Ai Limung include (a) *Diadema setosum* and (b) *Tripneustes ventricosus*

Ophiuroidea

Snake stars, such as *Ophiocoma alexandri* in Figure 3. have long, flexible arms connected to a small central disc. Unlike sea stars, the arms of snake stars

are more flexible and allow for rapid movement. They lack an anus and excrete waste through the mouth. Their tube feet function more as sensors than for movement. Snake stars play a role in sediment mixing and nutrient recycling on the seafloor, which is important for benthic ecosystems (Hendler *et al.*, 1995). They are also prey for fish and other invertebrates and are often used in aquariums and scientific research due to their regeneration ability. As bioindicators, their populations reflect ecosystem stability.

Figure 3. Class Ophiuroidea was found on the beach Ai Limung such as *Ophiocoma alexandri*

Holothuroidea

Sea cucumbers, such as *Holothuria scabra* and *Holothuria atra* in Figures 4. (a) and (b), have elongated and soft bodies with leathery skin. *Holothuria scabra* has a cylindrical body that can grow up to 20-30 cm in length. The body color varies from gray to brown, with a rough surface covered by small papillae and short spines (Purcell *et al.*, 2016). This sand sea cucumber actively forages at night by consuming detritus and organic matter on the seabed, so it has an important role in the process of bioturbation or sediment stirring in its habitat (Mercier *et al.*, 2018).

Holothuria scabra helps maintain the quality of the seafloor environment by processing organic matter and recycling nutrients that can improve sediment aeration and fertility, which is important for the survival of seagrass beds and other shallow water habitats (Dissanayake and Stefansson, 2018).

Holothuria atra lacks a rigid skeleton and moves using tube feet. One unique defense mechanism is evisceration, which is the removal of internal organs to repel predators. Sea cucumbers feed on detritus and act as bioturbators that improve sediment quality and support benthic ecosystems (Purcell *et al.*, 2016). *Holothuria atra* has economic value as it is utilized as sea cucumber in culinary and traditional medicine in Asia. However, overexploitation has led to population declines, affecting local fisheries (Purcell *et al.*, 2018). Proper fisheries management and aquaculture development are essential to prevent sea cucumber population extinction.

Holothuria scabra *Holothuria atra*

Figure 4. Class Holothuroidea was found in Ai Limung beach such as *Holothuria scabra* and *Holothuria atra*

Asteroidea

Sea stars, such as *Protoreaster nodosus* and *Astropecten* sp. Figure 5. (a) and (b), show radial symmetry of pentamers with five or more arms radiating from a central disc. Tube feet with suction cups aid movement and foraging. Some species, such as *Protoreaster nodosus*, have thick spiny arms to repel predators.

Sea stars are key predators in marine ecosystems, helping to control populations of bivalves and other invertebrates thereby increasing biodiversity. However, some species such as the crown-of-thorns starfish (*Acanthaster planci*) can cause significant damage to coral reefs (Pratchett *et al.*, 2017).

Starfish are also collected for souvenirs and aquariums. In addition, research on the regeneration ability of sea stars offers potential in biomedical applications (Carnevali and Bonasoro, 2001). To preserve the reef, management of *Acanthaster planci* populations through manual removal or other methods is required (Bos *et al.*, 2013).

(a) Protoreaster nodosus *(b) Astropecten* sp.

Figure 5. Classes of Asteroidea was found on the beach of Ai Limung includes *(a) Protoreaster nodosus* and *(b) Astropecten* sp.

Characteristics of Mollusks

The phylum Molluscs is a group of invertebrates that have soft bodies usually protected by calcium carbonate shells, although some molluscs, such as octopuses and squids, have reduced or lost their

shells through evolutionary processes. The body of a mollusk is generally divided into three main parts: the head-foot, mantle, and visceral mass (Hickman *et al.*, 2019). The head-foot section contains sensory organs and is involved in movement, while the mantle produces the shell (in species that have shells) and covers the visceral mass that contains internal organs. Molluscs have a variety of body forms and ecological roles, ranging from sedentary bivalves (e.g. clams) that filter food, to highly mobile cephalopods (e.g. octopus, squid) known for their intelligence and complex behaviors (Anderson, 2017).

Shell structure varies between molluscs; in gastropods, the shell is a single spiral structure, while in bivalves, the shell consists of two valves joined together. This shell serves as protection but can also be modified for movement, defense, and support, depending on the species (Brodie *et al.*, 2015). A distinctive feature of molluscs is the radula, a specialized feeding organ used to scrape or cut food, found in most molluscs except bivalves. The radula consists of rows of chitinoid teeth, and its structure can vary significantly depending on the feeding habits of the species, from herbivorous snails to predatory carnivorous gastropods (Denny, 2012).

Molluscs are also known for their diverse reproductive strategies, which include external fertilization in many marine species to internal fertilization in some terrestrial and aquatic species. This phylum plays significant ecological roles, such as filtering water (bivalves), being a food source for many predators, and contributing to marine and terrestrial ecosystems as decomposers (Jackson and Williams, 2011). In addition, mollusks found in coral reef ecosystems play an important role in maintaining the health and stability of these environments (Suyanto and Mulyani, 2020).

Gastropods

Lambis lambis in Figure 6. (a) has a large shell with horn-like protrusions or spines on the edges, which is a unique characteristic of this species. The shell color varies, often brown, cream, or pink with patterns that aid in camouflage in coral reef environments (Zhuang and Hu, 2018). This gastropod has a pair of long tentacles on the head, which serve to detect the surrounding environment, as well as large muscular legs that allow it to move slowly on the coral surface (Li and Wang, 2017).

Lambis lambis plays an important role in helping to control algal blooms, thus supporting the overall health of coral ecosystems (Chen and Liu, 2019). Lambis lambis' sensitivity to environmental changes such as temperature and marine pollution makes this species an effective ecosystem indicator (Matsumoto *et al.*, 2020). *Onchidium stuxbergii* in Figure 6 (b) is a gastropod species of the family Onchidiidae found in tropical coastal ecosystems, especially in mangrove areas and rocky substrates in the intertidal zone (Goulding *et al.*, 2021). This species has an elongated body without a shell, protected by a mucous layer that helps fight dehydration and predation (Dayrat *et al.*, 2019). In general, the dorsal part has a darker color compared to the ventral part, where the notum in *Onchidium stuxbergii* is orange (Setyawati, 2022). *O. stuxbergii* is the only species in the genus Onchidium that has a spot on the hyponotum, which is a distinguishing character from other species (Dayrat *et al.*, 2017; Goulding *et al.*, 2018). As detritivores and herbivores, these species play an important role in recycling organic matter and controlling algal growth (Sabri & Singh (2018). As hermaphroditic animals, they reproduce through cross-fertilization (Nambiar and Kannan, 2017).

(a) Lambis lambis *(b) Onchidium stuxbergii*

Figure 6. Gastropod was found at Ai Limung beach include *(a) Lambis lambis* and *(b) Onchidium stuxbergii*

Bivalvia

Pinna muricata in Figure 7 (a) has a long, slender, curved shell with a rough surface covered by marine sediment or particles. The shell varies in color from light brown to grayish, with both shell valves symmetrical and sharp edges. One distinctive feature of this species is the presence of spines or protrusions on the outside of the shell, which provide additional protection (Hakim *et al.*, 2019). *Pinna muricata* is found in tropical waters and often attaches to hard substrates such as rocks or corals, and functions as a filtrator that filters plankton and organic matter from the water (Kim and Chang, 2018).

Anadara antiquata has a thicker, heart-shaped or rounded shell with a rougher surface and a stronger appearance. The shell is cream or brown in color with clear radial lines (Goh and Tan, 2017). The shell has two slightly symmetrical valves with sharper edges. This species is found on sandy or muddy substrates in shallow waters and also functions as a filtrator that

helps maintain ecosystem balance (Rahman and Zainuddin, 2022). Apart from its ecological role, this species is more often utilized in the seafood and handicraft industries (Alim *et al.*, 2021).

(a) Pinna muricata *(b) Anadara antiquata*

Figure 7. Bivalve was found at Ai Limung panta include *(a) Pinna muricata* and *(b)Anadara antiquata*

Arthropod Characteristics

Arthropods are the largest phylum of animals in the world. The main features of Arthropods are a segmented body, an exoskeleton of chitin, and jointed legs that allow for highly flexible mobility in a variety of environments (Smith and Jones, 2018). This exoskeleton provides significant physical protection and a place for muscles to attach, but it also limits body growth so they must go through molting to grow larger (Brown *et al.*, 2017). In addition, the open circulation system in arthropods, in which hemolymph surrounds organs in a body cavity called the hemocoel, is an important adaptation that allows them to survive in a variety of habitats (Lee and Kim, 2016).

Other morphological and physiological adaptations also allow arthropods to occupy various ecological niches. For example, various foot shapes in arthropods such as specialized feet for walking, swimming, or digging, greatly support them in exploiting different environments (Taylor and Green, 2020). The sensory systems of arthropods are highly advanced, with compound eyes in many insects allowing 360-degree vision and antennae serving as key sensory organs to detect chemical changes and vibrations in their surroundings (Garcia and Patel, 2019). The diversity of their digestive systems also supports variation in diet, from herbivores to carnivores and detritivores, contributing to the evolutionary success of this phylum (Anderson and White, 2021).

Malacostraca

Portunus pelagicus (Figure 8) is a species of crab found in tropical and subtropical waters, particularly in the Indo-Pacific region. The crab is best known for its shell, which is bright blue in males and more brownish in females. These crabs have good swimming ability due to their paddle-like hind legs (swimming leg morphology) that allow them to move quickly in the water (Chande and Mgaya, 2019). They live in coastal environments such as estuaries, lagoons and seagrass beds, where they forage for small fish, molluscs and detritus (Ghosh *et al.*, 2017). As a predator and scavenger, *Portunus pelagicus* plays an important role in maintaining the balance of the marine ecosystem. The crab helps control small prey populations and plays a role in recycling organic matter on the seafloor (Ebrahimi *et al.*, 2015). On the other hand, *Portunus* pelagicus is also an important fishery resource for many coastal communities due to its high economic value as a seafood product (Johnson *et al.*, 2020).

Figure 8. Malacostraca were found at Ai Limung beach such as *Portunus pelagicus*

Conclusion

An inventory of marine invertebrates at Ai Limung Beach, Teluk Saleh, Sumbawa, revealed significant biodiversity and highlighted the crucial ecological and economic roles of these organisms in marine ecosystems. Several species from the Echinodermata phylum were identified, demonstrating their dominance in the region. This research emphasizes the importance of marine invertebrates as bioindicators of environmental health and their contribution to nutrient cycling, sediment stability and the sustainability of marine habitats.

As human activities continue to affect coastal ecosystems, understanding the diversity and ecological functions of these invertebrates is critical for implementing sustainable management practices. These findings serve as an important reference for stakeholders in Sumbawa, encouraging informed decision-making in marine resource management and conservation efforts. Further research is recommended to monitor invertebrate populations and assess the impact of anthropogenic pressures, to ensure biodiversity conservation and support the

livelihoods of local communities dependent on marine resources.

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