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# Diversity of Tridacninae in Coral Reef Ecosystem on Gosong Island, Aceh Province, Indonesia

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## ABSTRACT

The aim of the current study was to determine the species diversity and the number and size of giant clams in the coral reef ecosystems of Gosong Island, Southwest Aceh. The survey was conducted in August 2024. Sampling was carried out using the line quadrat transect, consisting of two stations with a plot area of 50 x 50m$^2$ at a depth of 4-10m. The study results presented three giant clam taxa: *Tridacna derasa*, *Tridacna gigas*, and *Tridacna maxima*. The largest size found at the study site was 120cm for the *Tridacna gigas* type. The substrates on Gosong Island, where the giant clams live, consist of six types: porites, alveolar, favorites, sand, dead coral algae (DCA), and macropore branching (ACB). A further finding is that the *Tridacna derasa* type was only found with a slight relative abundance of 0.0001 ind/m2 with a length of 55cm and was found on the DCA substrate. *T. gigas* was abundant on different substrates: porites, alveolar, favorites, sand, DCA, and ACB. The results of the study show that the genus *Tridacna* was found in low abundance on a variety of substrates. It is recommended that *Tridacna* clams in Gosong Island coral reef ecosystem, southwest Aceh, receive more management attention to conserve this rare giant clam.

## INTRODUCTION

The coral reef ecosystem is currently of concern to many stakeholders. This ecosystem is under pressure at local, regional and global scales due to climate change and anthropogenic disturbance **(Xu *et al.*, 2014)**. Ecologically, the coral reef ecosystem is closely related to the surrounding ecosystem **(Najmi *et al.*, 2023)**. The giant clam is one of the animals that can contribute to coral reefs, including feeding, sheltering, building and shaping **(Neo *et al.*, 2015)**. Giant clams (subfamily Tridacninae) are common members of the coral reef community, living in symbiosis with photosymbiotic algae

from the Symbiodiniaceae family, similar to their scleractinian coral group **(Rossbach *et al*., 2019)**.

The dense population of giant clams produces a large amount of calcium carbonate shell material, which is eventually incorporated into the coral reef framework **(Neo *et al*., 2015)**. In Indonesia, the diversity of clams has been reported from several locations. The Raja Ampat Regency area is reported to have eight species, including *Tridacna crocea, T. maxima, T. squamosa, T. gigas, T. tevoroa, T. derasa, Hippopus porcellanus*, and *H. hippopus* **(Wakum *et al*., 2017)**. The Kei Islands, Maluku, have eight species, one of which is a new type, namely *Tridacna noae* **(Triandiza *et al.*, 2019)**. The Anambas Islands were recorded with six species from 23 observation locations **(Harahap *et al.*, 2018)**; Natuna Regency found two species **(Rivanda *et al.*, 2020)**, and Wakatobi detected four species **(Saputra *et al.*, 2022)**. Globally, giant clams are endangered **(Yusuf *et al.*, 2009; Ramah *et al*., 2019)** and have consistently declined in recent years **(Findra *et al*., 2017)**. Anthropogenic impacts and natural disasters increasingly threaten the status of this clam. Almost all tridacnid species are protected under Appendix II of CITES and are included in the IUCN red list **(Neo & Todd, 2013)**. Giant clams are under significant pressure from overfishing, and their removal is likely detrimental to coral reefs **(Neo *et al*., 2015)**. Potential threats to giant clams include the effects of macroalgae and the presence of tourists who may inadvertently step on the clams **(Ecube *et al.*, 2019)**. In addition, habitat loss and a range of other anthropogenic pressures, including climate change, can potentially accelerate the decline of these clam stocks **(Hawkins *et al.*, 2017)** Another stressor affecting the clam is microplastics; As *T. crocea* ingests microplastics through its outer mantle and gut, these microplastics may suppress photosynthesis, organic nutrient transport and detoxification capabilities of symbionts, as well as primary metabolism of giant clams **(Zhou *et al*., 2022)**.

The condition of the waters of Gosong Island, West Aceh, which has a coral reef ecosystem in the excellent category (55%), found 31 genera of hard coral. The percentage of the primary substrate that dominates the living coral is the dead coral, with algae (DCA) of 28%. The average abundance of coral fish in the waters of Gosong Island is 11,260 ind/ha with an average coral fish biomass of 2074,095kg/ yield **(Najmi *et al*., 2022)**. The area of this district is 1,882.05km$^2$ or 188,205.02 ha. Most of the community is active at sea. Management of the sustainability of coastal ecosystems is critical, especially in the waters of Gosong Island, Southwest Aceh Regency, which is one of the waters with giant clams. Gosong Island is an area that has relatively high marine potential, with coral reef ecosystems and giant clams. According to research by **Bahri *et al*. (2022)**, this area is home to three types of clams: the giant clam (*Tridacna gigas*), the small clam (*Tridacna maxima*), and the smooth giant clam (*Tridacna derasa*). The findings indicate that Gosong Island hosts approximately 43% of the clam species found in Indonesia. The species *T. maxima* had the highest relative abundance, which accounted for 66.67%, while the lowest relative abundance was recorded for the *T. derasa* species,

at 6.67%. Furthermore, the *T. maxima* species also exhibited the highest clam density at 0.02 individuals per square meter (ind/m²), whereas the *T. derasa* species had the lowest density at 0.002 ind/m².

The establishment of Gosong Island as a Regional Marine Protected Area (MPA) by the Indonesian Minister of Marine Affairs and Fisheries No.78/KEPMEN KP/2020 highlights the urgent need for focused research on the presence of clams. Previous research by **Bahri *et al*. (2022)** provided valuable insights into the species composition and abundance. However, further research is essential to understand and fully protect this ecosystem. This study aimed to ascertain the species diversity and the number and size of Tridacninae in the coral reef ecosystem of Gosong Island, Southwest Aceh.

## MATERIALS AND METHODS

### Study area

This research was carried out on the island of Gosong in the Regency of Southwest Aceh, Aceh Province, Indonesia (Fig. 1). The sampling location consisted of two stations, namely stations 1 and 2.

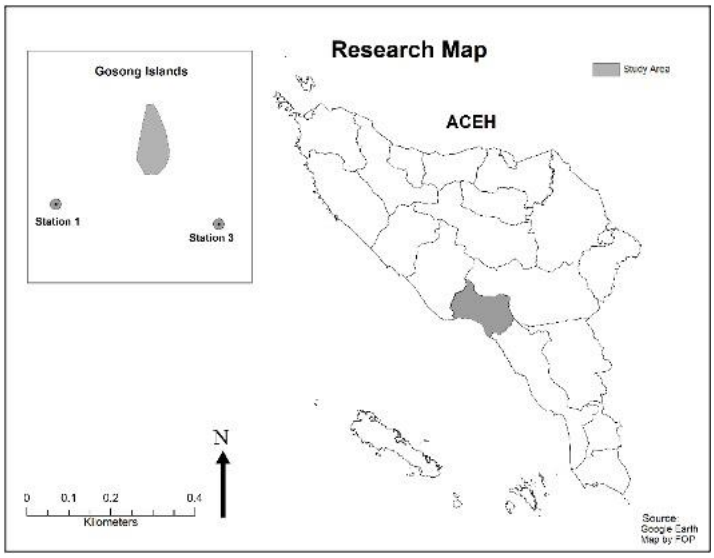


**Fig. 1.** The research location on Gosong Island, Southwest Aceh District

### Sampling technique

Sampling was performed using diving techniques. Samples were taken at several sites where giant clams were found. The sampling technique used was the survey method. A sampling of giant clams used the line quadrat transect method. Transects were drawn randomly in the sampling location, with a square area of 50 x 50m$^2$ at a depth of 4-10m according to the location of the sample. In the quadrat, 5 line transects were placed, with each line spanning 10m apart (Fig. 2). Divers followed the line transects and recorded the

type of each clam found within a distance of 5m left and right and measured the shell's width to determine the clam's length.

Furthermore, the type of substrate around the clam was recorded visually to distinguish its category. Observation of substrate conditions refers to the category of **English *et al.* (1994)**. Observation of giant clam substrates can be done visually, namely by directly seeing the type of substrate where the giant clams are buried/attached when observations are made. The substrate categories recorded were coral covered (CC), dead coral overgrown with algae (DCA), faviidae (FAV), porites (POR), rubble (Rb), and sand (S). The giant clam species was identified as outlined by **Copland and Lucas (1988)** and **Knop (1996)**.

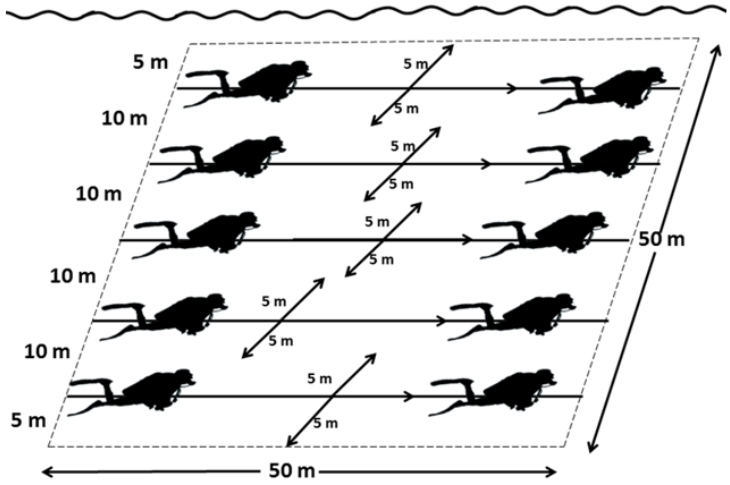


**Fig. 2.** Giant clam sampling method

Two divers carried out sampling; the first diver was tasked with taking samples of the density and distribution of the length of giant clams. The second diver took data on the condition of the bottom habitat of the waters. Other team members collected water quality samples. The density and distribution of the length of giant clams was examined by identifying the type of clam found and documenting the sample. Further identification was assessed by referring to the giant clam (Tridacna) identification guide available on the Australian Museum Lizard Island Research Station website on the web https://lifg.australian.museum/Group.html?groupId=OoAFMEQj.

**Data analysis**

Disclosure analysis of giant clams found at the sampling site was performed using the **Snedecor and Coachran (1980)** equation: $K = N / A$, where K: Density (individual / $m^2$); N: Total number of individuals in the transect; and A: Area of the sampling area. The density of giant clam species was determined by dividing the number of individuals of each species by the total number of individuals at a given sampling site. The size of the giant clams was measured by collecting data on the length of each shell. Length

measurements were carried out by measuring the length of the giant clam using a meter roll.

## RESULTS

### Species composition

On the basis of the research results, the ecosystem of Gosong Island, Southwest Aceh, has three types of giant clams: *Tridacna derasa*, *Tridacna gigas*, and *Tridacna maxima* (Figs. 3-5).

**Fig. 3.** *T. derasa* (Station 1; P: 55cm)

**Fig. 4.** *T. gigas* (Station 2; P: 120cm)

**Fig. 5.** *T. maxima* (Station 1; P: 33cm)

The types of clams found in the research location have been recorded in the IUCN. The study results indicated that *T. gigas* was the most abundant species in the research location, compared to the other two species. Based on the presence of all clams found during the study, there were 30 individuals. The relative abundance of the *T. gigas* species was 87.30%, for *T. maxima* was 9.13%, and for *T. derasa* was 3.57%.

### Size and substrate

The results showed that the largest giant clams in the coral reef ecosystem of Gosong Island were the *T. gigas*, reaching 120cm in length, while the smallest observed clam was 10cm. The *T. derasa* was the only one found during this study, measuring 55cm in length. Meanwhile, *T. maxima* had a size range between 20 and 33cm. On average, the

*T. gigas* species found in this ecosystem had a length of 29.19cm, while *T. maxima* had an average length of 28.67cm, with *T. gigas* generally being larger than the other species.

The reef ecosystem of Gosong Island hosts various types of clams that inhabit different substrates, including porites, alveopora, favites, sand, DCA, and Acroporan Branching (ACB) (Table 1). The *T. derasa* was found on the DCA substrate, while *T. maxima* was located on Porites, sand, and Favites substrates. The *T. gigas* species was found across a broader range of substrates, including Porites, Favites, DCA, sand, ACB, and Alveopora.

**Table 1.** Substrate types of clam species found in Gosong Island, Aceh

| Species | Substrate type | | | | | |
|---|---|---|---|---|---|---|
| | POR | DCA | SAN | ALV | FAV | ACB |
| *T. derasa* | - | + | - | - | - | - |
| *T. gigas* | + | + | + | + | + | + |
| *T. maxima* | + | - | + | - | + | - |

Description: POR=Porites, DCA=Dead Coral Algae, SAN=Sand, ALV=Alveopora, FAV=Favites, ACB=Acroporan Branching

In the research location, *T. gigas* is predominantly found attached to DCA and sandy substrates (Fig. 6). *T gigas* was found in significant numbers on the DCA substrate, with at least nine individuals present. In contrast, only three individuals were observed on the Porites substrate, while the remaining substrates (ALV, FAV and ACB) were found to have less than or equal to two. For *T. maxima*, only one individual was recorded on each of the POR, SAN and FAV substrates. Additionally, for *T. derasa*, only one individual was found on the DCA substrate. This illustrates that different proportions of clams are found on different types of substrate.

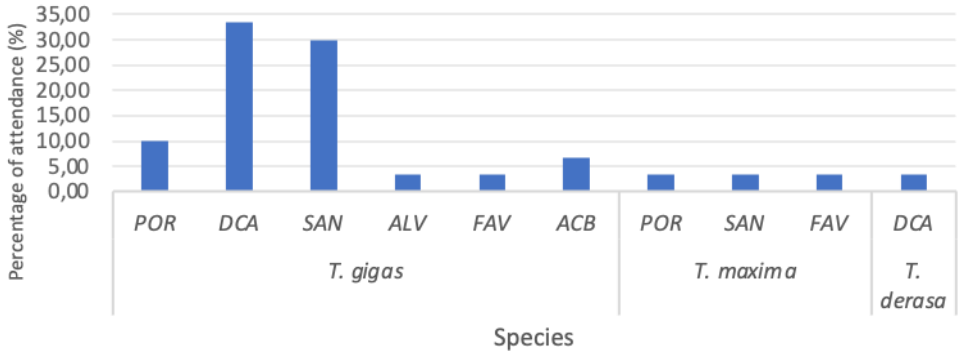


**Fig. 6.** Percentage of giant clams present by substrate

Description: POR=Porites, DCA=Dead Coral Algae, SAN=Sand, ALV= Alveopora, FAV=Favites, ACB=Acroporan Branching

*T. gigas* was found in less than 5% on Alveopora and Favites substrates. While, other species such as *T. maxima* were found on Porites, Sand and Favites substrates. In the research site, *T. derasa* was only found on DCA. The results of this study show that of the three, *T. gigas* was the most adaptable to a wide range of substrates (Porites, Dead Coral Algae, Sand, Alveopora, Favites, and Acroporan Branching) although with varying amounts.

## DISCUSSION

The presence of giant clams on Gosong Aceh Island, which is located in western Indonesia, is an evidence of the distribution of this species of clam. The distribution of giant clams in Indonesia is quite wide. It is discovered not only in eastern regions but also in western Indonesia, although the species composition varies. This could be because giant clams, the largest living bivalves, closely associate with coral reefs throughout the Indo-Pacific **(Soo *et al.*, 2014)**. On the Anambas Islands, for example, six species of giant clams were recorded in 2018, including *Tridacna gigas, T. squamosa, T. derasa, T. maxima, T. crocea,* and *Hippopus hippopus* **(Harahap *et al.*, 2018)**. Three of these species are found in the research location. The following year, four species were identified on the Kei Islands, Maluku, namely *T. maxima, T. crocea, T. squamosa,* and *T. noe* **(Triandiza *et al.*, 2019)**, with only *T. maxima* common to the research location. Meanwhile, the coastal area of Kali Lemon, Kwatisore, Papua reported six species: *Tridacna crocea, Tridacna squamosa, Tridacna gigas, Tridacna maxima, Hippopus hippopus,* and *Hippopus porcellanus* **(Tapilatu *et al.*, 2021)**. In this location, two species were found that were the same in Kali Lemon, but the *T. derasa* species was not found on the Kali Lemon Coast. A recent study in 2024 from Ambon waters in eastern Indonesia identified four species consisting of *Tridacna gigas, T. squamosa, T. maxima,* and *Hippopus hippopus*. Compared to the overall diversity of giant clams in Indonesia, Gosong Island has fewer species. This is believed to be due to the conditions of the Indian Ocean, which include high waves and strong currents. Additionally, the sampling location may be limited, so it is possible that the distribution was not recorded during the observation. The three types have species in common with the research location except *H. hippopus*. *T. derasa* is listed as Endangered (EN) on the IUCN Red List **(Neo & Li, 2024a)**, while *T. gigas,* observed during the field survey, is classified as Critically Endangered (CR) **(Neo & Li, 2024b)**. In contrast, *T. maxima* is categorized as Least Concern (LC) **(Wells, 1996)**. Other types of *Tridacna* clams recorded in the list are *Tridacna squamosa,* reported to be included in less concern (LC) **(Neo & Li, 2024c)** included in the vulnerable (VU) category (IUCN 2015c), and *T. crocea* included in the least concern (LC) category **(Neo & Li, 2024d)**. The Indonesian government carried out conservation of the *Tridacna* genus in 1987 through the Decree of the Minister of

Forestry Number 12/Kpts/II/1987, which was then strengthened by Government Regulation Number 7 of 1999, which includes seven species of giant clams that live in Indonesia to be protected. Next is the regulation of the Minister of Environment and Forestry Number P.92/MENLHK/SETJEN/KUM.1/8/2018, which amends the previous Regulation No. P.20/MENLHK/SETJEN/KUM.1/6/2018 on Protected Plants and Animals. In the regulation, there are four families of the protected mollusk group, and one of them is the Tridacna family, namely *Hippopus hippopus* (horse hoof clam) and *Hippopus porcellanus* (Chinese clam).

The relative abundance of clams on Gosong Island was recorded to be different from the previous two years; namely, the highest density was for *T. maxima* (66.67%), and the lowest was that of *T. derasa* (6.67%) **(Bahri, 2015)**. This difference in composition is thought to be due to different observation locations. The average density of *T. gigas* from the two observed stations was 0.0039 ind/$m^2$, *T. maxima* had a density of 0.004 ind/$m^2$, and *T. derasa* had a density of 0.0001 ind/$m^2$. The density of giant clams in the research location tended to be low compared to that in other locations in Indonesia. The density of *T. maxima* in the research location was low, almost the same as that of the same type of giant clam in the Sepempang Waters, Natuna Regency, 0.002-0.007 ind/$m^2$ **(Triska *et al.*, 2020)**. In general, the presence of giant clams on Gosong Island is also lower when compared to the Kei Islands, Maluku (0.0428 ind/$m^2$) **(Triandiza *et al.*, 2019)**, Aceh Besar, Aceh (0.041 ind/$m^2$) **(Fazillah *et al.*, 2020)**, and Kali Lemon Location, Kwatisore, Papua (0.0073 ind/$m^2$) **(Tapilatu *et al.*, 2021)**. The difference in density is likely due to different environmental conditions supporting this type of giant clams. In the study of **Rossbach *et al.* (2019)**, the authors identified key geographic factors, particularly latitude and distance from shore and essential local environmental elements, including depth and reef zone, as key influences the density of *Tridacna* spp. This strong evidence underscores the importance of these parameters in understanding and managing Tridacna populations. For comparison, the size of *T. gigas* in the Palawan Reef of the Philippines ranges from 42 to 109cm, with an estimated age span of 5 to over 76 years **(Mecha *et al.*, 2020)**. A study on the growth of giant clams (*Tridacna maxima*) kept in sea cages in the Red Sea, Egypt, found that the specific growth rate was highest among the smaller clams and decreased as the clams increased in size. The group of clams measuring 50-70mm exhibited the highest specific growth rate at 0.35% per day, while the group measuring 150-170mm had a lower growth rate of 0.09% per day. The growth of shell length showed a negative allometric growth (b=2.35), whereas clam weight exhibited a positive allometric growth (b = 3.28) **(Mohammed *et al.*, 2019)**. In this context, the growth of giant clams requires a long time, which highlights the importance of collaborative conservation efforts to ensure the sustainability of the giant clam population on Gosong Island.

The presence of *T. gigas* on all types of substrates suggests that this species is highly adaptable to various substrate conditions. Substrates are a critical factor that

supports the life of clams; however, not all species occupy the same type of substrate **(Rizkifar *et al.*, 2019)**. The substrate found at the research location differs from those in Kali Lemon Papua; *T. Gigas* was found on coral reefs, but *T. maxima* clams were found on Favites and Porites substrates **(Tapilatu *et al.*, 2021)**. The results of another study on Mauritius Island showed that 90% of *T. maxima* were located within *Porites* spp. colonies. This condition makes this species more resilient to natural pressures **(Taleb-Hossenkhan *et al.*, 2017)**. In addition, *T. maxima* are known to inhabit hard corals, with an Ivlev Electivity Index ranging from 0.01 to 0.22 **(Endang *et al.*, 2024)**.

In previous research, DCA in the Gosong Island area accounted for 28%, while sandy areas made up 1% **(Najmi *et al.*, 2022)**. Additionally, *T. gigas* was observed on two other substrates, Alveopora and Acroporan Branching. The variation in substrates used by giant clams on Gosong Island is believed to be influenced by morphological differences among clam species, aligning with the idea that morphology plays a role in substrate selection. This is in line with the opinion that differences in morphology are one of the factors influencing the choice of substrate **(Taleb-Hossenkhan *et al.*, 2017)**. The close relationship between coral reefs and giant clams on Gosong Island is further supported by findings that the island's waters are a critical coral reef area, providing essential food sources such as plankton **(Najmi *et al.*, 2022)**. Environmental parameters measured at the research site showed an average pH of 7.83, dissolved oxygen (DO) of 7.33, and a temperature of 29.13°C. The salinity ranged from 30.25 to 31.75ppt, with water clarity up to 15.06 meters **(Najmi *et al.*, 2022)**.

This study highlights the impressive presence of *T. gigas*. This giant clam can grow to 120cm and thrives on a variety of substrate types at the research site (Fig. 6). Although other species of giant clams are less abundant, they are present in limited numbers, and they still have the opportunity to grow and develop at this site. This underlines the urgent need for dedicated conservation efforts in this area, which provides a highly suitable habitat for giant clams.

## CONCLUSION

This study identified three species of *Tridacna* clams on Gosong Island, with *T. gigas* being the largest, reaching 120cm. Overall, the relative abundance of giant clams on Gosong Island is very low. The dominant substrate on which giant clams were found to be living is DCA. The knowledge from this study provides a basis for future research and development of conservation efforts. This study is a recommendation from previous studies to periodically update the conditions of this conservation area.

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