

# STUDY ON GIANT CLAMS (CARDIIDAE) POPULATION IN KEI KECIL WATERS, SOUTHEAST-MALUKU

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## ABSTRAK

Penelitian ini dilakukan untuk mengetahui komposisi dan kepadatan jenis, distribusi ukuran, serta kondisi habitat kima pada sembilan lokasi, yaitu Pulau Ohoimas, Dullah, Naam, Laguna Hoat, Warhu, Pasir Panjang, Ohoidertawun, Teluk Un, dan Tandusan, di perairan Kei Kecil. Pengambilan data dilakukan dengan menggunakan metode kuadrat-transek. Penilaian kondisi habitat mengacu pada tipe substrat yang berdasarkan kode bentik (*benthic code*). Hasil penelitian menunjukkan bahwa di perairan Kei Kecil terdapat enam jenis kima, yaitu *T. crocea*, *T. squamosa*, *T. maxima*, *T. derasa*, *T. gigas*, dan *Hippopus hippopus*. Secara keseluruhan kepadatan individu kima di Kei Kecil termasuk sangat rendah. Kima *T. crocea* adalah jenis yang paling dominan, sedangkan *T. derasa* dan *T. gigas* adalah jenis yang paling sedikit ditemukan. Berdasarkan distribusi panjang cangkang, individu yang berada pada fase juvenile jumlahnya lebih sedikit dibandingkan jumlah individu fase remaja dan dewasa. Habitat yang paling bagus di perairan Kei Kecil adalah Ohoimas dengan variasi substratnya dan kekayaan jenis yang tertinggi. Rekomendasi yang diberikan bagi pemerintah lokal dan masyarakat adalah pembentukan daerah konservasi kima melalui pelaksanaan tradisi sasi.

**Kata kunci:** Kimia; *Cardiidae*; *Tridaena crocea*; *Tridaena maxima*; *Tridaena derasa*; *Tridaena gigas*; *Hippopus hippopus*; Kei Kecil; Maluku.

## INTRODUCTION

Giant clams, the largest bivalves in the world, are included in subfamily Tridantinae, family *Cardiidae*.<sup>1,2</sup> They have two conspicuous characteristic, their huge size and the brightly colored expanded mantle harboring symbiotic algae. They can be found living in association with coral reefs throughout the tropical and subtropical waters of the Indo-Pacific region.<sup>3,4</sup> People have been utilized the clams for food and shell craft industries. Recently, the living clams have been also collected for the marine aquarium industry due to the feature of their exotic mantle.<sup>5,6,7,8,9</sup> Unfortunately, the high demand of the clams has driven over-fishing on their wild populations throughout the Indo-Pacific region including Indonesian waters. Their natural stocks have been dramatically declining since 1980.<sup>10</sup> In response, the clams are placed on the 2008 IUCN Red List of Threatened Species.<sup>11</sup> Indonesian government

has stated that the clams are protected species by means of Ministerial Decree No. 12/Kpts-II/1987 and PP No. 7. Th. 1999.<sup>12</sup>

The Kei Kecil Islands is located at S 5°00'–6°00' and E 131°45'–133°15'. It is situated at the southeast of Banda Sea and abuts with Arafuru Sea, Southeast Maluku. It is known as one of few areas in Indonesian waters where wild stocks of giant clams are considered still there. Traditionally, the coastal inhabitants of the islands have utilized the giant clams as a food source, subsistence and other traditional uses. Furthermore, they have conducted a conservation effort to protect the giant clams by practicing a local tradition called sasi. This is a form of local wisdom that assures the utilization of natural resources by means of customary law mechanisms. Sasi controls when somebody is allowed to harvest natural resources, such as clams, with particular limits. In fact, although

the people still implement *sasi*, it is believed that the clams stock is still declining due to the rapid growing of coastal population, water pollution, and improved harvesting methods.<sup>13</sup>

A survey on the wild stock of giant clams is necessary, in order to verify their recent status. Even though Kei waters likely supports the greatest amount of coral reef ecosystem which is the typical habitat for giant clams, there are limited data about the giant clams' population. Several studies on community of mollusca in the Kei waters have been done by Pelu,<sup>14</sup> Dody,<sup>15</sup> Dody,<sup>16</sup> and Kusnadi *et al.*<sup>13</sup> However, no studies focused on the giant clams' population.

The aims of the study were to assess the species composition, density and size distribution of giant clams in Kei Kecil waters. The obtained data provides baseline information for determining the policy of conservation management. The data is also important as a valid background to the local authorities for implementing *sasi*, so that they can determine some technical factors, i.e. where *sasi* should be settled, how long time should be allocated and what rules should be set.

## MATERIAL AND METHODS

The survey was carried out from April to June 2009 in two phases, the preliminary observation and the population survey. During the preliminary observation, survey site was selected based on information given by local fishermen. There were nine survey sites, i.e. Ohoimas (S5 26 30.0; E132 43 50.7), Dullah Darat (S5 33 37.1; E132 45 54.9), Naam (S5 33 02.9; E132 48 23.5), Laguna Hoat (S5 37 21.9; E132 38 46.0), Warhu (S5 44 24.6; E132 39 30.5), Pasir Panjang (S5 39 43.9; E132 38 11.8), Ohoidertawun (S5 37 41.3; E132 40 14.4), Un (S5 38 58.2; E132 45 55.2), and Tandusan (S5 42 59.2; E132 48 17.7).

The population survey was conducted with SCUBA using a sampling method described by Chambers.<sup>17</sup> A quadrat (50x50 m) was placed randomly over the survey site. Four transect lines were placed within the quadrat at 10 m intervals of each line. All clams found within 5 m on each side of the transect line were identified, counted and measured their shell-length. The species identification was done based on Copland and Lucas<sup>18</sup> and Knop.<sup>19</sup>

The size distribution of clams is evaluated by classifying the shell-length data into classes having a 5 cm-interval. The species composition within each survey area is calculated by counting the number of each species divided by total number of individuals. The density is calculated as the total number of individuals divided by the area sampled. The substrate where the clams attached was assessed using benthic codes defined by English *et al.*<sup>20</sup> The codes are CC (coral covered); DCA (dead coral algae); FAV (Faviidae); POR (Porites); RB (Rubble); and S (Sand).

## RESULT AND DISCUSSION

### Description of study area

The study was conducted in shallow areas at an average depth of 5 m where coral reefs are the main communities. The coral reef communities are in varied conditions, from a very poor to good and healthy condition. At some sites, there are totally damaged coral reefs due to fishing bombs, namely Ohoidertawun, Dullah, and Naam. However, good and healthy coral communities still can be found in other areas, viz. Warhu and Ohoimas. Unfortunately, studies on coral reefs in Kei Kecil waters are incomplete, hence little is known about the present status of coral reefs in Kei Kecil waters. In addition, seagrass beds can also be found along the shores of Kei Kecil islands. This community is commonly distributed in sandy shores which are appropriately adjacent to the coral reefs. Turtle grass (*Thalassia hemprichii*) is the dominant species which can be found in all survey sites. It can form large assemblages on sandy littoral zones. Meanwhile, other ecosystem, the mangroves, is relatively rare in Kei Islands.

Anthropogenic activities are mainly centered in Nuhuroa Island and Dullah Island. The people in the town are mainly traders and governmental officers while the villagers primarily do fishing and farming activities conventionally. Residential areas are scattered along the coastal areas of Nuhuroa and Dullah Island. Pollution in Kei Kecil is particularly caused by household sewage. By far, industrial waste pollution is little known since there are no industries operated in this region. There is only one small company

processing fishery-based products in Dullah Island.

Based on the position to the center of anthropogenic activities, four sampling sites are close to residential areas, those are Un, Dullah Darat, Ohoidertawun, and Pasir Panjang. Another sites (Tandusan, Hoat and Naam) are situated on the shores of Nuhuroa Island, nevertheless they are relatively far to the settlements. While the other ones (Warhu and Ohoimas) are uninhabited islands and far away from daily people activities. Therefore, they face relatively less disturbances than other sites mentioned before.

### Species composition and density

Table 1 shows species composition and density of giant clams found during the survey. From seven species of giant clams known distributed in Indonesian waters,<sup>21</sup> six were found during this survey, namely *Tridacna crocea*, *T. squamosa*, *T. maxima*, *T. derasa*, *T. gigas*, and *Hippopus hippopus* (see Table 1). This finding complements data collected by Kusnadi *et al.*<sup>13</sup> reporting four species, *T. crocea*, *T. squamosa*, *T. gigas*, and *H. hippopus*. Even, previous research conducted by Soemodihardjo *et al.*<sup>22</sup> in the Rumphius Expedition III, reported only *T. crocea* and *H. hippopus*.

Surprisingly, the largest species (*T. gigas*) was found in Ohoimas, whereas Wells<sup>23</sup> believed that this species have been extinct in the western part of Indonesian waters. It was also predicted to be extinct in Japan, New Caledonia (where known only from fossils) and Guam, and possibly extinct in Taiwan, Vanuatu, and Tuvalu (where it

may never have occurred). It was observed that abundant populations were only found in Australia and the Solomon Islands. This species might still occur in the southern waters of Myanmar, Palau, Papua New Guinea, Marshall Islands, Kiribati and on the west coast of Thailand, Malaysia and a few parts of the Philippines.<sup>23</sup> Over-fishing has led a dramatic declining of the wild population in some areas.<sup>24</sup> Therefore, this species has been listed in IUCN Redlist with status A2cd Vulnerable.<sup>11</sup>

Ohoimas have more species number than the other study sites due to its variety of substrates providing suitable habitat for the clams. There are sandy areas, boulder or massive corals and branching corals. Sandy substrates are suitable habitat for *H. hippopus*,<sup>21</sup> boulder or massive corals for *T. crocea* and *T. maxima*,<sup>25</sup> and branching corals or coral rubble for *T. squamosa*, *T. gigas* and *T. derasa*.<sup>19</sup> These substrate varieties were not found in the other study sites.

Compared with other areas in Indonesia, Kei Kecil waters is relatively higher in species number. Taufik<sup>26</sup> reported three species found in Southeast Aru (*T. squamosa*, *T. crocea*, and *H. hippopus*). Biohistorical Expedition of Rumphius found four species (*T. crocea*, *T. squamosa*, *T. maxima*, and *H. hippopus*) in Ambon Bay.<sup>27</sup> Four similar species also occurred in the coral reef of Banyak and Simeleue Islands, Aceh.<sup>28</sup> Reef flat on Pari Island also has similar species with Ambon Bay.<sup>12</sup> In contrast, there is only *H. hippopus* in Bunaken National Park, Sulawesi.<sup>29</sup> Additionally, in Natuna and Anambas was only

**Table 1.** Population Density of Giant Clams (individual/hectare) Found in Kei Kecil

No	Species	Density (individual/ha)								
		A	B	C	D	E	F	G	H	I
1	<i>Tridacna crocea</i>	4	28	72	-	52	256	260	4	232
2	<i>Tridacna squamosa</i>	12	4	8	-	16	-	12	-	4
3	<i>Tridacna maxima</i>	8	16	4	4	12	52	92	-	80
4	<i>Tridacna derasa</i>	8	-	-	-	-	-	-	-	-
5	<i>Tridacna gigas</i>	4	-	-	-	-	-	-	-	-
6	<i>Hippopus hippopus</i>	20	-	-	-	12	16	52	-	-
<b>Total</b>		56	48	84	4	92	324	416	4	316

**Note:** A). Ohoimas; B). Dullah Darat; C). Naam; D). Laguna Hoat; E). Warhu; F). Pasir Panjang; G). Ohoidertawun, H). Teluk Un; I). Tandusan

*T. maxima*.<sup>30</sup> Furthermore, areas having similar species with Kei Kecil waters are Banda and Lucipara Islands<sup>31</sup> while Raja Ampat has higher species number than Kei Kecil waters. Seven species of giant clams can be found in Raja Ampat Islands. The China clam (*H. porcellanus*), which is not found in Kei Kecil, occurs in the coral reef of Raja Ampat.<sup>32</sup>

In each study site, *T. crocea* was found to be the dominant species, indicated by its highest population density, while five other species are much lower. Similar findings were also reported by Chantrapornsyl *et al.*<sup>33</sup> in Andaman Sea, Upanoi and Banchungmanee<sup>34</sup> in Adang Islands, and Eliata *et al.*<sup>12</sup> in Seribu Islands. The facts that *T. crocea* has smallest size in compare with the other species and lives in the manner of embedded totally in a coral boulder make practical difficulties for fishermen to glean. For economic reason, fishermen prefer to glean other species which are much bigger in size and easier to be collected. This species is not the main target for fishermen leading its relatively highest population density.

In general, according to a population category determined by Plane *et al.*,<sup>35</sup> giant clams population in Kei Kecil is classified into category number 1, meaning as very low density or rare population. This category indicates that the population is endangered to extinction. The situation is predicted as resulted by over-exploitation. If conservation efforts are not

performed immediately, then giant clams will likely be extinct in Kei Kecil waters soon.

### Shell length distribution

In a population study, shell length data are important since they can represent ecological aspects of certain molluscan species, for instance population structure and growth, species composition and recruitment related to environmental factors. Shell length distribution of giant clams population can be used to examine the recruitment pattern and life development whether there is over-exploitation to the population or not.

Result from shell length observation of giant clams in Kei Kecil waters is detailed in Table 2. The smallest shell was recorded in *T. crocea* (24.95 mm), while *T. gigas* shows the largest shell length (740.22 mm). Most of *T. crocea* was found with range of shell length at 51–100 mm (146 individuals). Respectively, *T. squamosa*, *T. maxima*, dan *H. hippopus* mostly have shell size in the range of 151–200 mm (6 individuals), 51–100 mm (27 individuals), and 151–200 mm (14 individuals). Mean of shell length recorded in *T. crocea*, *T. squamosa*, *T. maxima*, dan *H. hippopus*, are respectively 77.09 mm; 213.54 mm; 113.29 mm; and 191.24 mm. Unfortunately, since there is only one individual of *T. gigas* and two of *T. derasa* found during the survey, the distribution data of shell length could not be generated.

**Table 2.** Shell Length Distribution of Giant Clams Kei Kecil Waters.

No	Range of shell length (mm)	Individual number					
		<i>T. crocea</i>	<i>T. squamosa</i>	<i>T. maxima</i>	<i>T. derasa</i>	<i>T. gigas</i>	<i>H. hippopus</i>
1	0–50	38	0	1	0	0	0
2	51–100	146	0	27	0	0	0
3	101–150	43	2	22	0	0	2
4	151–200	0	6	17	0	0	14
5	201–250	0	3	0	0	0	8
6	251–300	0	1	0	0	0	1
7	301–350	0	0	0	1	0	0
8	351–400	0	2	0	0	0	0
9	401–....	0	0	0	1	1	0
Mean of length (mm)		77.09	213.54	113.29	428.65	-	191.24
Max. length (mm)		139.97	356.07	186.5	508.1	740.22	264.35
Min. length (mm)		24.95	131.04	35.91	349.21	-	117.91

Comparing the mean of shell length with several references compiled in the Table 3, it is obvious that most of giant clams in Kei Kecil waters were in an adult-hermaphrodite phase, in exception for *T. maxima* which was observed in post-juveline stage. The number of juveline clams was much lower, indicating that there has been failure in recruitment process. In long term periode, the failure of recruitment may lead overall extinction because regeneration does not occur. Therefore, given the fact that population sustainability is utterly dependent on the recruitment process, and then it becomes important to recover the recruitment into its natural state. In this case, restocking program is needed.

The failure of recruitment might be resulted from several factors related to species characters, genetic patterns, habitats, and other environmental factors. Considering the natural characteristics of giant clams, such as fast growing with high mortality at the larval and juvenile stages, otherwise slowly growing with low mortality at the adult stage, then it is plausible to the failure of recruitment process when over-harvesting is threatening. However, how far these factors influence the recruitment process of giant clams population in Kei Kecil is still not clear.

### Habitat condition

Giant clams in Kei Kecil were found living on five substrate types, CC (coral cover), DCA (dead coral algae), POR (coral *Porites*), RB (rubble), and S (sandy substrate) (see Table 4). No clams are found living on the Faviidae coral (FAV). *T. crocea* are mostly embedded in dead coral boulder which is covered by algae (DCA 82%). Only a few number lives in *Porites* (16%), coral

rubble (1%), and living coral substrate (1%). This finding is appropriate with Mudjiono<sup>25</sup> stating that the living behavior of *T. crocea* is by totally embedded in a coral boulder. This species can burrow hard coral substrates by such drilling movement on the shell hinge. The burrowing process is assisted by chemical substances secreted by the clams. The secret softens calcium carbonate of the hard coral making it become easy to be burrowed.

*Tridacna maxima* was found living in DCA (46%) and POR (45%). The rest (9%) were attached on coral rubble (RB). The living behavior of *T. maxima* is almost similar with *T. crocea*. The difference is that the *T. maxima* shell is partially embedded in the hard substrate.<sup>25</sup> Therefore, this species is still able to live in coral rubble, as long as there is available space for attaching its byssus and partially embedding its shells.

Meanwhile, most of *H. hippopus* were observed to live in sandy substrate (72%), and the rest live in coral rubble (28%). In Ohoidertawun, some individuals were found living in seagrass beds. This may seem different with many studies about the clam's habitat mainly reporting on the coral reef.<sup>12,19,21,25,33,34</sup> However, this can be explained by Harzhauser *et al.*<sup>36</sup> revealing that Tridacnid's ancestors did not live in coral reefs; indeed they lived in seagrass beds. Moreover, experiences in giant clams cultivation showing that giant clams can grow and develop well either in seagrass beds or coral reefs as long as the water condition is still good. Lastly, *T. squamosa*, *T. gigas*, and *T. derasa* were observed mostly living in coral rubble, especially branching corals. These species have different living behavior with *T. crocea* and *T. maxima*. They do not burrow into

**Table 3.** Development Phases and Lenght Size of Giant Clams Based On Fitt<sup>37</sup>

No	Species	Development phases/shell length		
		Juvenile	Post-juveline	Hermaphrodite adult
1	<i>Tridacna crocea</i>	<2 cm	2–4 cm	>4 cm
2	<i>Tridacna squamosa</i>	<10 cm	10–20 cm	>20 cm
3	<i>Tridacna maxima</i>	<4 cm	4–15 cm	> 15 cm
4	<i>Tridacna derasa</i>	<15 cm	15–26 cm	>26 cm
5	<i>Tridacna gigas</i>	<18 cm	18–35 cm	>35 cm
6	<i>Hippopus hippopus</i>	<7 cm	7–13 cm	>13 cm

**Table 4.** Species Percentage of Giant Clams Found Living on Each Substrate

No	Jenis	Species percentage for each substrate						
		CC	DCA	FAV	POR	RB	S	Total
1	<i>Tridacna crocea</i>	0.88	81.94	0	16.3	0.88	0	100
2	<i>Tridacna squamosa</i>	0	14.29	0	0	57.14	28.57	100
3	<i>Tridacna maxima</i>	0	46.27	0	44.78	8.96	0	100
4	<i>Tridacna derasa</i>	0	0	0	0	100	0	100
5	<i>Tridacna gigas</i>	0	0	0	0	100	0	100
6	<i>Hippopus hippopus</i>	0	0	0	0	28	72	100

the hard substrate, but only attach their byssus on the substrate.

### Recommendation

Considering the density and shell length distribution, conservation program for giant clams is necessary to prevent their extinction in Kei Kecil waters. It is recommended to establish protected areas for giant clams, such as *no-take areas* practiced in Tuamotu, French Polynesia.<sup>38</sup> The customary system known as *sasi* may be used as a framework for the conservation program in Maluku, since customary marine management, such as *sasi*, has been proven to be an effective conservation tool.<sup>39</sup> The proposed area which may be the most best for giant clams conservation is Ohoimas, considering its high variety of substrates and its location far away from anthropogenic activities. The implementation of *sasi* can be applied in all study sites, with a minimum period for five years. This period is based on the time needed for giant clams to reach their hermaphrodite maturity.<sup>37</sup>

### Conclusion

- 1) There are six species of giant clams in Kei Kecil waters, *Tridacna crocea*, *T. squamosa*, *T. maxima*, *T. derasa*, *T. gigas*, and *Hippopus hippopus*.
- 2) Giant clams population in Kei Kecil is classified into the category of very low population, indicating its vulnerability to be extinct.
- 3) The number of juvenile giant clams is much lower than the adult indicating that there has been failure of recruitment process.

- 4) It is recommended to establish such protected areas through implementing *sasi* with a minimum period for five years.
- 5) The most suitable area for protecting giant clams' population is Ohoimas, due to its high variety of habitat and the remoteness from anthropogenic activities.

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