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# Different species, life form, and complexity of dead coral head affect the species diversity and density of decapods

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**Abstract.** High proportion of dead coral in coral reefs ecosystem are inhabited by a wide variety of associated organisms such as crustacean as a place to live. However, lack of study on the functional of dead corals in high diversity such Indonesian coral reefs. This study aimed to investigate the diversity and density of inhabitant decapod species from two different dead corals with different life form and complexity (*Pocillopora verrucosa* and *Seriatopora hystrix*). A total of 235 individuals consisting of 7 families, 11 genera and 35 species was observed in *P. verrucosa*. While in *S. hystrix*, a total of 74 individuals consisting of 5 families, 6 genera and 11 species were recorded. Index of diversity ( $H'$ ) on dead coral *P. verrucosa* for decapods was higher than on *S. hystrix*. Evenness index ( $E$ ) in both types of dead coral was relatively steady. The domination index ( $D$ ) for *S. hystrix* was significantly higher than on *P. verrucosa*. The species density on *P. verrucosa* was significantly higher ( $25 \pm 11.34$  ind/L) than on *S. hystrix* ( $8 \pm 1.9$  ind/L). This study is explaining the complexity of life form on the dead coral seems potentially inhabited by more and diverse decapods.

**Keywords:** dead coral, decapod, diversity, habitat complexity, species density

## 1. Introduction

Live and death corals provide very different conditions for associated biota. Living coral provides a variety of potential food source for organisms while on the dead coral can provide space for a variety of biota to live, such as sessile plants (e.g. algae) and fauna (e.g. bryozoans, sponges, and foraminifera) [1, 2]. Dead coral has a large proportion of the reef substrate and it has a complex, crevice, and space that can be used by various associated marine biota. Coral life form could be inhabited by different marine organisms as a place to refuge or as a food resource and they are affected by the environment [3, 4]. When a coral colony is dead, the small caves and tunnels can be a perfect habitat for invertebrate species. The average number of cryptofauna individuals on dead coral *Pocillopora damicornis* can reach 135.4 of individual and the living coral *P. damicornis* by 72.8 individuals [2]. Thus, from that can be assumed that the more biodiversity was found on dead coral reefs than in the living.

Cryptofauna are animals that are difficult to distinguish and usually includes macroinvertebrates and some fish. They use cavities and spaces in the reef substrate, either temporarily or permanently. Some



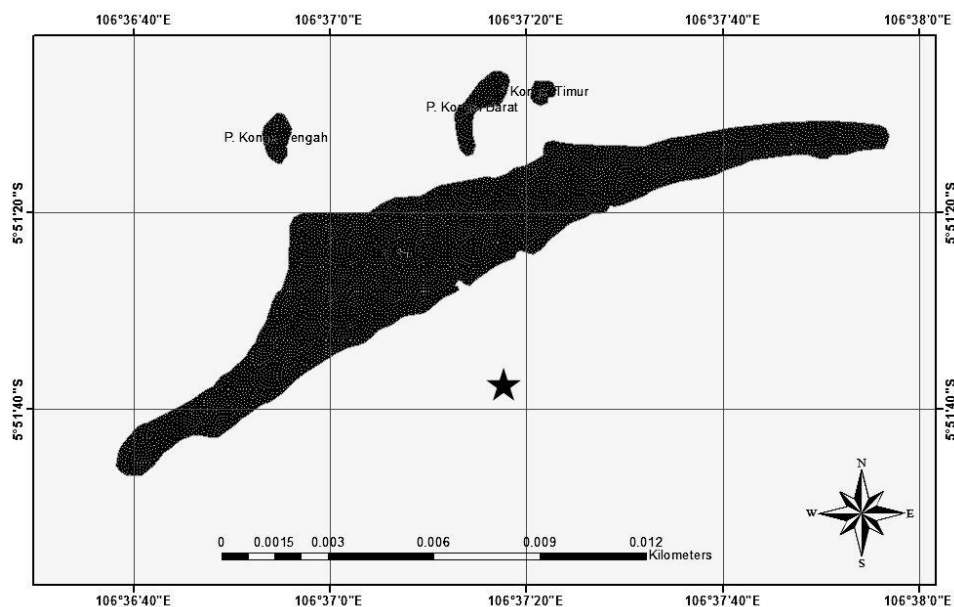
cryptofauna can create their own cavity on coral reefs, while others are opportunistic space invaders [5]. Cryptofauna plays an important part in the food web in the coral reef ecosystem. Cryptofauna is an important food source for carnivores, including fish, gastropods, molluscs, and octopus. Decapod (shrimp, crab, and lobster) is one of the cryptofauna animals where can be found in the crevices of coral reefs both dead and living coral.

Species of coral have different growth characteristics that might influence their inhabitants. For example, the colony of species *Pocillopora verrucosa* can reach a large size with branching somewhat upright, fat at the base and slightly widened at the top with a branching impression regular, the colony of *Seriatopora hystrix* has fragile pointed tips with a tangled, slender, and tapering branches [6]. These kinds of life forms provide habitat for different organisms. Decapod is the most abundant macroinvertebrates that inhabit coral branching *Pocillopora* spp. [7-9]. These different characteristics of the two types of coral species are believed to have different species diversity and density. Therefore, this study was conducted to investigate the difference of diversity and density of species of decapod between two dead corals, *P. verrucosa* and *S. hystrix*.

## 2. Materials and Methods

### 2.1. Dead coral heads collection and sortation

The dead coral samples were collected in an expedition on 23-24 December 2012 in Pari Island, Jakarta. In general, the procedures to be taken consist of preparation tools and materials, dead coral sampling, biota collection and sorting, data collection and documentation, and biota identification [10]. Samples of dead coral *P. verrucosa* and *S. hystrix* were taken using scuba gear, chisels, hammers, buckets, and plastic bags. Chisel and hammer are used to release the rock from the substrate, then samples were wrapped in plastic bags so that organisms contained in a sample does not come out when transferred to the bucket.



**Figure 1.** The location of dead coral heads collection (star sign) in Pari Island, Jakarta.

A total of three dead coral heads for each coral species (*P. verrucosa* and *S. hystrix*) with similar-size. A size of a 20-liter bucket was collected underwater from the depth of 5–10 m, and then brought ashore, and directly treated with aeration to prevent the death of biota that will be found on the dead coral. The dead coral heads were bagged and gently broken from the bottom with a hammer and a chisel and quickly placed in a 20-liter bucket underwater. The volume of dead coral measured by using buckets and measuring cups, where the dead coral volume equal to the volume of water that spilled when corals put in. The average volume of dead coral *P. verrucosa* was  $3:11 \pm 0:05$  liter and on dead coral *S. hystrix*

was  $3:07 \pm 0:03$  liter. The size of each dead head photographed and the length, width, and height were measured; the volume was measured based on water displacement. Each branch of a coral head was detached carefully with a hammer and a chisel and examined closely for motile invertebrates.

The remaining rubbles were placed in the bucket of seawater. After all the branches and the base has been broken apart and examined, the fragments were broken into smaller pieces and examined for a second time for the remaining creatures. The seawater, in which the dead heads and coral fragments had been kept, was then filtered through a 2 mm sieve. The remaining organisms captured in the sieve were collected for identification.

## 2.2. Identification and voucher

Each decapod specimen was identified from the family level up to the possible genus or genera following Crustacean Guide of The World [11], and abundance of each was also recorded. The collected decapods from each deadheads were identified and photographed using Nikon DSLR Camera AF Micro Nikkor 60 mm 1:2.8 D and microscope motic, K-Series 700L zoom microscope supported with software camera control pro. Each sample was preserved as a voucher in a tube with ethanol 96% and stored in the laboratory of marine biodiversity and biosystematics.

## 2.3. Data analysis

The community Shannon-Wiener diversity index  $H'$  was calculated on a log basis [12]. The diversity criteria following Wilhm 1975:  $H' < 1$  low diversity,  $1 < H' < 3$  moderate diversity, and  $H' > 3$  high diversity. The evenness index was calculated to an individual component in a community [13]. The value of evenness index ranged between 0 and 1 [14]. If the value is close to 0 meaning some species tend to dominate the ecosystem, 0-1. The uniformity index is close to zero, meaning that in the ecosystem there is a tendency for species domination to occur due to the instability of environmental and population factors. If the uniformity index is close to 1, then the ecosystem is in relatively stable conditions, namely, the number of individuals per species is relatively the same. The dominance index value is used to describe the presence or absence of dominance of a species in one community, which is calculated using the Simpson dominance index [15]. The dominance index value ranges from 0-1 [16]. If the index value of the dominance index approaches 0 means that almost no individual dominates and is usually followed by a large uniformity index value. If the value of the dominance index approaches 1, it means that there are one species that dominates and is followed by a smaller index of uniformity value. Type density ( $X_i$ ) is the total number of individuals ( $n_i$ ) in a unit area or volume ( $V$ ) calculated based on the instructions of [5]. Abundance, species richness, and community diversity were compared between two dead corals (*P. verrucosa* and *S. histrix*) using F test in the statistical package STATISTICA 7.0.

# 3. Results

## 3.1. Decapods diversity

A total of 7 decapods families was observed on *P. verrucosa* dead coral heads, while on *S. histrix* was 5 families (table 2). The number of families *P. verrucosa* was statistically higher than on *S. histrix*. The highest number families were observed on *P. verrucosa* ( $6 \pm 0.33$ ), while on *S. histrix* was recorded 4 families. Table 1 shows family composition between two dead coral heads. The highest family composition on *P. verrucosa* was recorded on Hippolytidae (27.78%) and the lowest on Trapeziidae (0.85%). The dead coral heads of *S. histrix* was observed on Pilumnidae as the highest (33.78%) and the lowest on Alpheidae (9.46%).

**Table 1.** The most contributed (%) family observed between two different species of dead corals *P. verrucosa* and *S. histrix*.

Family	<i>P. verrucosa</i>	<i>S. histrix</i>
Hippolytidae	27.78%	10.80%
Palaemonidae	18.37%	31.08%
Porcellanidae	18.80%	14.80%
Pilumnidae	11.97%	33.78%
Galatheididae	10.68%	-
Alpheidae	11.54%	9.46%
Trapeziidae	0.85%	-

Table 2 shows genus composition of identified decapods between two dead coral heads (*P. verrucosa* and *S. histrix*). A total of 11 genera was observed on *P. verrucosa*, including *Petrolistes*, *Lebbeus*, *Galathea*, *Saron*, *Periclimenes*, *Palaemon*, *Chlorodiella*, *Alpheus*, *Synalpheus*, *Trapezia*, and *Hyastenus*. While on *S. histrix*, a total of 6 genera, including *Chlorodiella*, *Periclimenes*, *Petrolistes*, *Palaemon*, *Saron*, and *Alpheus*. The number of genera on *P. verrucosa* ( $9 \pm 1.15$ ) was statistically higher than on *S. histrix* ( $5 \pm 0.3$ ).

**Table 2.** The number of individual of genus identified decapods at two different of dead corals.

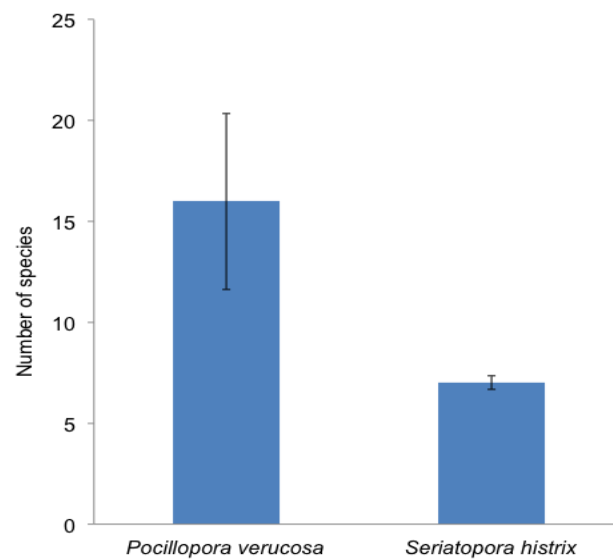
Taxa	<i>P. verrucosa</i>			<i>S. histrix</i>		
	1	2	3	1	2	3
ALPHEIDAE						
<i>Alpheus</i> sp.	-	7	2	-	-	-
<i>Alpheus</i> sp. 2	-	4	-	-	2	2
<i>Synalpheus</i> sp.	-	-	6	-	-	-
GALATHEIDAE						
<i>Galathea</i> sp.	4	-	2	-	-	-
HIPPOLYTIDAE						
<i>Saron</i> sp.	1	-	-	-	-	-
<i>Saron</i> sp. 2	11	5	-	3	5	-
<i>Saron</i> sp. 3	1	-	4	-	-	-
<i>Lebbeus</i> sp.	4	-	-	-	-	-
PALAEMONIDAE						
<i>Palaemon</i> sp.	6	-	-	5	2	2
<i>Periclimenes</i> sp.	19	2	-	6	-	1
<i>Periclimenes</i> sp. 2	-	-	4	-	-	-
PILUMNIDAE						
<i>Chlorodiella</i> sp.	1	-	3	1	-	-
<i>Chlorodiella</i> sp. 2	6	-	3	-	-	-
PORCELLANIDAE						
<i>Petrolistes</i> sp.	19	16	4	4	2	2
<i>Petrolistes</i> sp. 2	1	-	-	-	-	3
<i>Petrolistes</i> sp. 3	1	-	-	-	-	-
<i>Petrolistes</i> sp. 4	1	-	-	-	-	-
<i>Petrolistes</i> sp. 5	2	-	-	-	-	-
Number of individual	77	34	28	19	11	10

A total of 35 decapod species was observed on *P. verrucosa*, while a total of 11 species on *S. histrix* was observed (table 3). The diversity of species on *P. verrucosa* ( $16 \pm 4.37$ ) was statistically higher than on *S. histrix* ( $7 \pm 0.33$ ) (figure 2). A total of 19 species on *P. verrucosa* was unidentified, while on *S. histrix* a total of 7 species were not identified up to species level. A total of 235 decapod individuals belongs to seven families (Hippolytidae, Palaemonidae, Porcellanidae, Pilumnidae, Galatheididae, Alpheidae, dan Trapeziidae), 11 genera, and 35 species were recorded on *P. verrucosa*. While in

*S. histrix*, a total of 74 individual belong to 6 genus and 11 species of five families (Palaemonidae, Pilumnidae, Porcellanidae, Alpheidae, and Hippolytidae) were recorded.

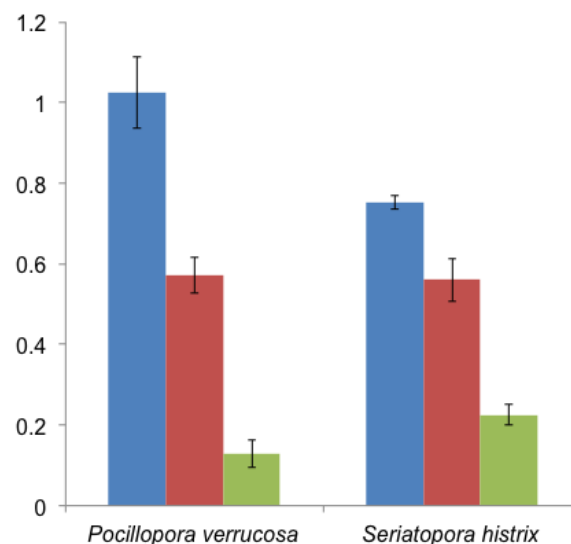
**Table 3.** Species composition and density (ind/L) observed at two different dead coral species.

Taxa	<i>P. verucosa</i> (n=3) ind/L	<i>S. histrix</i> (n=3) ind/L
<b>ALPHEIDAE</b>		
<i>Alpheus</i> sp.	0.98±0.69	-
<i>Alpheus</i> sp. 2	0.44±0.44	0.44±0.21
<i>Alpheus pacificus</i>	-	0.22±0.11
<i>Alpheus pavirostris</i>	-	0.11±0.11
<i>Alpheus malleodigitus</i>	0.22±0.22	-
<i>Alpheus rostratus</i>	0.31±0.31	-
<i>Synalpheus</i> sp.	0.63±0.63	-
<i>Alpheus lottini</i>	0.33±0.20	-
<b>HIPPOLYTIDAE</b>		
<i>Lebbeus polaris</i>	3.31±3.11	-
<i>Saron marmoratus</i>	0.86±0.70	-
<i>Saron</i> sp.	0.12±0.12	-
<i>Saron</i> sp. 2	1.73±1.02	0.87±0.48
<i>Saron</i> sp. 3	0.52±0.35	-
<i>Lebbeus</i> sp.	0.43±0.43	-
<b>GALATHEIDAE</b>		
<i>Galathea</i> sp.	0.64±0.37	-
<i>Galathea platycheles</i>	0.65±0.37	-
<i>Galathea balssi</i>	0.75±0.75	-
<i>Galathea aegyptiaca</i>	0.42±0.42	-
<i>Galathea pilosa</i>	0.12±0.12	-
<i>Galathea bonimensis</i>	0.12±0.12	-
<b>PORCELLANIDAE</b>		
<i>Petrolistes</i> sp.	4.22±1.50	0.87±0.21
<i>Petrolistes</i> sp. 2	0.12±0.12	0.32±0.32
<i>Petrolistes</i> sp. 3	0.12±0.12	-
<i>Petrolistes</i> sp. 4	0.12±0.12	-
<i>Petrolistes</i> sp. 5	0.21±0.21	-
<b>PALAEMONIDAE</b>		
<i>Palaemon serenus</i>	1.07±1.07	-
<i>Periclimenes cf. grandis</i>	0.21±0.21	0.75±0.28
<i>Palaemon</i> sp.	0.64±0.64	0.97±0.32
<i>Periclimenes</i> sp.	2.25±1.92	0.75±0.60
<i>Periclimenes</i> sp. 2	0.42±0.42	-
<b>PILUMNIDAE</b>		
<i>Chlorodiella</i> sp.	0.42±0.28	-
<i>Chlorodiella</i> sp. 2	0.95±0.55	-
<i>Chlorodiella nigra</i>	1.38±0.56	2.57±1.30
<i>Chlorodiella xishaensis</i>	0.10±0.10	-
<i>Hyastenus planasius</i>	0.11±0.11	-
<b>TRAPEZIIDAE</b>		
<i>Trapezia lutea</i>	0.12±0.12	-
<i>Trapezia cymodoce</i>	0.12±0.12	-
Average (mean ± SD)	0.68±0.22	0.50±0.11



**Figure 2.** Species richness of decapod between dead coral of *P. verrucosa* and *S. hystrix*.

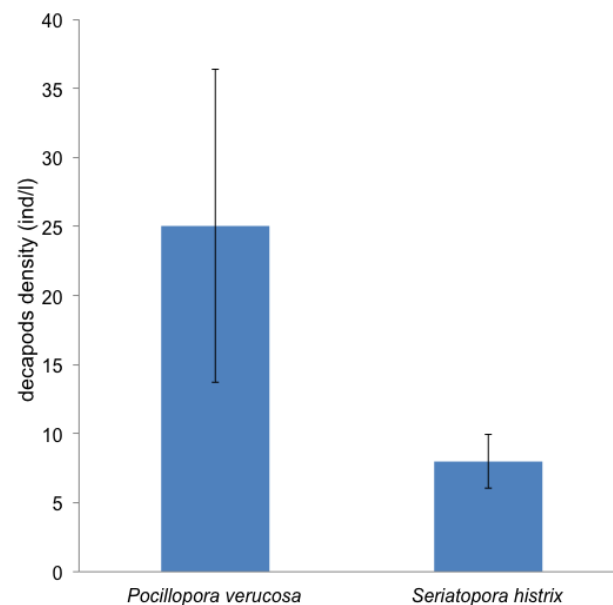
The diversity index on *P. verrucosa* and *S. hystrix* were categorized moderate (1.03) and low (0.75), respectively (figure 3). The dominance index on both dead coral heads showed value close to zero, meaning no individual dominance in habitat. The diversity index on *P. verrucosa* was significantly higher than on *S. hystrix*. The individuals in *S. hystrix* tend to be dominant compared to individuals in *P. verrucosa*.



**Figure 3.** Communities' indices (diversity, evenness, and dominance) between dead coral of *P. verrucosa* and *S. hystrix* (■ diversity index; ■ evenness index; ■ dominance index).

### 3.2. Decapods density

The mean species density of decapods on *P. verrucosa* was significantly higher ( $25 \pm 11.34$  ind/L) than on *S. hystrix* ( $8 \pm 1.9$  ind/L) (table 3). The highest species density found on dead coral heads of *P. verrucosa* and *S. hystrix* was species *Petrolistes* sp. and *Chlorodiella nigra* respectively.



**Figure 4.** The mean decapods density (ind/L) between two different species of dead corals (*P. verrucosa* and *S. hystrix*).

#### 4. Discussion

The decapod diversity and density were found higher in *P. verrucosa* compared to *S. hystrix*. This happened because in dead coral *P. verrucosa* with submassive growth forms which provided a lot of empty and complex space. In *S. hystrix* with the branching pointed tips lifeform that provides a narrow space for biota. *Pocillopora* sp. provide habitat for numerous Trapeziidae [12]. Associated Decapods in *Pocillopora* sp. are more abundant where the influence of predatory fish is decreased [17]. Another study found more than 107 species living in a single colony *P. damicornis* [2]. While other species, *S. hystrix*, has characteristics of the top of the columella to the wall and the corallite unclear and lower downhill slope outwards, sturdy secondary center with a large blunt tooth [6]. On the Northern Line Island were found about 110 species of decapods from 22 dead coral *Pocillopora* spp. [10]. This occurs due to several factors, including the availability of empty space and food resources such as plant soils (for example, calcareous crustose and seagrass moss) and fauna (for example, Bryozoa, sponges, and foraminiferans) [1, 18].

The high and low diversity index shows that in a community there is an interaction between each type. So in a community that has high species diversity, there will be types of interactions that involve energy transfer, predation, competition, and niche distribution which are theoretically more complex [19]. However, this study observed difficulties to identify until species level due to the lack of information available about the identification of decapod biota.

The average value of Evenness index in *P. verrucosa* and *S. hystrix* was  $0.56 \pm 0.04$  and  $0.55 \pm 0.05$ , this stated that the Evenness index value approached 1 and explained that the ecosystem was in relatively stable conditions, namely the number of individuals per species is relatively the same [20]. Thus, when viewed the Evenness index value on both dead coral species is relatively stable.

The decapod density seemed affected by the availability of empty and complex spaces on the dead coral, as observed large density in *P. verrucosa*. The reef coral has a different type of growth form that causes the availability of space for decapodal animals. Species density in each species occurs due to several factors, including the availability of empty space and food resources such as plant sprites (for example, calcareous crustose and seagrass lichens) and fauna (for example, Bryozoa, sponges, and foraminiferans) [1, 18]. The limited space on dead coral can lead to a battle and competition between



biota of decapods to get space to protect from predators. In addition, the effects of predation on the biota living on dead corals have been explored in several coral cavities, thus suppressing the density and distribution of cryptofauna (decapods) [21]. This study concludes that there are differences in decapod diversity in both dead coral species, higher species in *Pocillopora* spp. than *Seriatopora* spp. was observed, but no differences were found in species density.

## 5. Conclusion

A total of 235 individuals consisting of 7 families, 11 genera and 35 species was observed in *P. verrucosa*. While in *S. histrix*, a total of 74 individuals consisting of 5 families, 6 genera and 11 species were recorded. Index of diversity ( $H'$ ) on dead coral *P. verrucosa* for decapods was higher than on *S. histrix*. Evenness index ( $E$ ) in both types of dead coral was relatively steady. The domination index ( $D$ ) for *S. histrix* was significantly higher than on *P. verrucosa*. The species density on *P. verrucosa* was significantly higher ( $25 \pm 11.34$  ind/L) than on *S. histrix* ( $8 \pm 1.9$  ind/L). This study is explaining the complexity of life form on the dead coral seems potentially inhabited by more and diverse decapods.

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