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Population Structure of *Parasesarma brevicristatum* and *Parasesarma semperi* as an Indicator of Mangrove Replanted Forest Condition in Bintuni Bay, Indonesia

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Abstract. The mangrove forest at Bintuni Bay is one of the largest in Indonesia, and a portion of it is being used as production forest to produce woodchips. Replanting in the production forest results in various ecosystem conditions through ages. Since the Sesarmidae crab is an important component of the mangrove ecosystem and contributes significantly to its energy cycle, it is frequently used as a bioindicator to evaluate the ecosystem's health. In the production mangrove area of Perseroan Terbatas Bintuni Utama Pure Wood Industries, sampling was done using the purposive sample method with circular plots in natural mangrove forests, replanted trees aged 25 and 5 years, and forests that had just been harvested. According to the survey, station 3's five-year-old replanting of *P. brevicristatum* and *P. semperi* crabs had a population density of 139,455 Ind.ha^{-1} while station 4's damaged forest had a population density of 119,047 Ind.ha^{-1}. Both varieties of crabs have a higher male to female sex ratio. It was discovered that young individuals dominated the two species of crabs' size distribution. Both species of crabs' length weight relationships displayed a positive allometric tendency. The density of the saplings was the element of the mangrove vegetation that had the greatest impact on the population structure of both crabs.

Keywords: Replantation, Sesarmidae, mangrove harvest, bioindicator, mangrove crab

Introduction

One of the largest mangrove ecosystems in the world, Bintuni Bay's mangrove ecosystem in West Papua, Indonesia, spans more than 250,000 ha. A 30-year rotation cycle is applied to manage and harvest the 82,120 ha of mangroves and surrounding land in the southern portion of the bay in to produce wood chips [1]. Mangroves that are managed for production often have a different environment due to dominant tree species and the age of plant, which affect all ecosystem components, including crab communities [2]. As a source of food and shelter for the crabs and other fauna that inhabit inside, mangrove vegetation plays an important role in the mangrove ecosystem [3, 4, 5].

Crab is benthic macroinvertebrate fauna that is frequently present in mangrove forest ecosystems [6, 7] and plays a significant role in the nutrient cycle in these systems [8, 9]. One of the most common crab families is Sesarmidae, which contributes to the accelerated decomposition of organic materials. Crabs also serve as "Ecosystem engineers," contributing significantly to the topography and biogeochemistry of sediments [2, 10, 11, 12]. Sesarmid crabs *Parasesarma brevicristatum* and *Parasesarma semperi* were common and abundant in the mangrove forest of Bintuni Bay, West Papua, particularly in the concession area of PT. BUMWI, according to research reports [1].

The community structure of an ecosystem's component species can be used to assess ecological condition [13, 14]. Understanding the function of crabs in a mangrove forest ecosystem requires knowledge of the dynamics of crab populations and the structure of the mangrove vegetation [15]. The determination of the rotating age of producing forests and efforts to restore a mangrove area are some other management decisions that can derive from this information. The number of studies that look into this issue, however, does not match the significance of determining the population structure of crabs in mangrove forest areas. In order to comprehend the population structure of *P. brevicristatum* and *P.*

semperi, the condition of the mangrove vegetation, and their interactions in the replanted mangrove forest in Bintuni Bay, West Papua, study is necessary.

2. Methods

P. brevicristatum and *S. semperi* crab samples were collected from the mangrove forest managed by Perseroan Terbatas (PT.) Bintuni Utama Murni Wood Industries (BUMWI), Bintuni Bay, West Papua (Figure 1). Sampling was done in 2017 between September and November. In this study, vegetation data were collected using a survey method and a modified sampling plot [16]. Purposive sampling was used to select research sites, which were natural mangrove forests (Station 1), replanted mangrove forests aged 25 years (Station 2), replanted mangrove forests aged 5 years (Station 3), and recently harvested mangroves (Station 4).

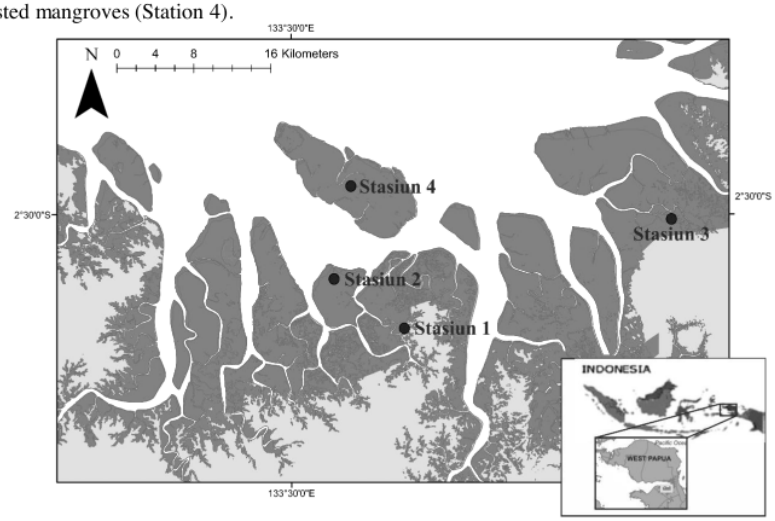

Figure 1. Map of sampling location [17].

Data on the vegetation were collected 165 meters along the transect line from a river or water body. Each transect has six circular plots, each with a radius of 2 meters for seedlings and a radius of 7 meters for trees and saplings (Figure 2). The first plot is 15 meters from the river bank, while the following plot is a further 30 meters. Crab samples were collected during low tide. The enclosure quadrats method, measuring 70 x 70 cm, was used to catch the crabs [8]. Crab samples were collected for 45 minutes. Around the circular plot's center is where the crab harvesting plot is placed.

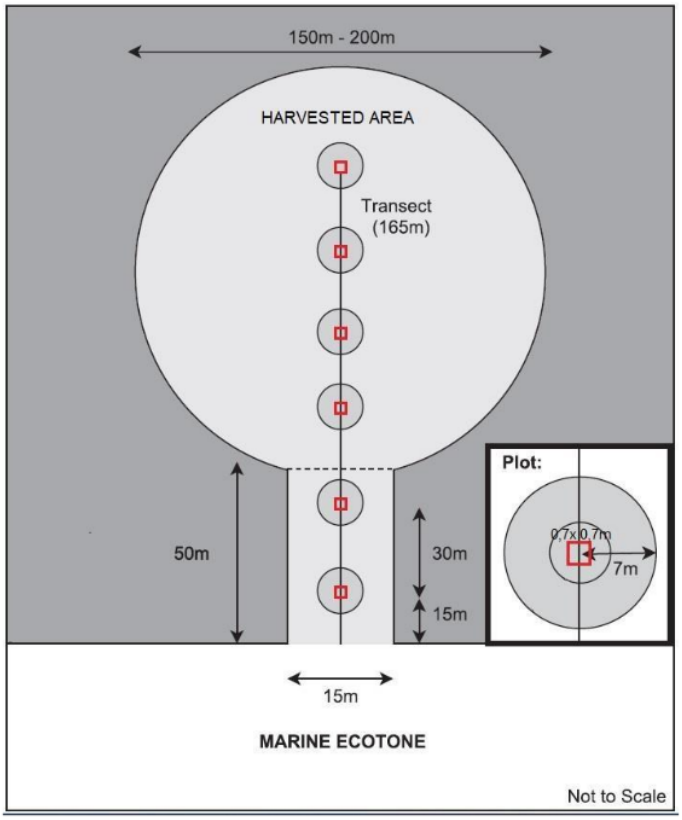

Figure 2. Sampling transect [17].

The samples of crabs were identified, and some of them were transferred to the Indonesian Institute of Sciences Oceanographic Research Center in North Lombok, West Nusa Tenggara, for taxonomic verification. To understand the structure of the crab population, including density, size distribution, the relationship between length and weight, and sex ratio, measurements of the length, width, and weight of the crabs were taken. Using multivariate analysis in the form of Detected Correspondence Analysis (DCA) and Redundancy Analysis (RDA) in the CANOCO 4.5 program, it was able to determine the effect of mangrove vegetation conditions on crab population structure [18].

3. Result and Discussion

In accordance with the observations, 167 male and 90 female *P. brevicristatum* crab specimens totaling 257 were collected. A total of 191 specimens of the *P. semperi* crab, including 124 males and 67 females, were collected. *P. brevicristatum*'s carapace width varied between 1.00 and 23.20 mm for males and 2.50 and 23.50 mm for females, with a median of 7.50 and 10.50 mm at all observation stations. The carapace widths of the *P. semperi* specimens collected ranged between 0.70 and 16.10 mm for males and 3.20 and 13.30 mm for females, with a median of 7.15 and 8.10 mm. The highest density of *P. brevicristatum* is 119,047 ind.ha^{-1} at station 4, which is a mangrove forest that was recently harvested (affected). While the highest density of *P. semperi* crabs was in station 3 which about 139,455 ind.ha^{-1} (Table 1).

Table 1. The density (ind.ha^{-1}) of *P. brevicristatum* and *P. semperi* at the study area

Station	*P. brevicristatum*	*P. semperi*
1	37,414	40,816
2	60,090	10,204
3	74,829	139,455
4	119,047	26,077

The information above shows that *P. brevicristatum* crab density is lower in good mangrove forests than it is in disturbed mangrove forests. According to research by Sastranegara [19] on many factors of the mangrove forest in Segara Anakan, Cilcap, Central Java, the number of species is lower in the undisturbed forest than it is in the degraded forest because one species dominates in the degraded forest. *P. semperi* crabs did not exhibit the mentioned trend because the number of crabs collected varied significantly between locations, particularly at station 2 and station 3, which compromised the results.

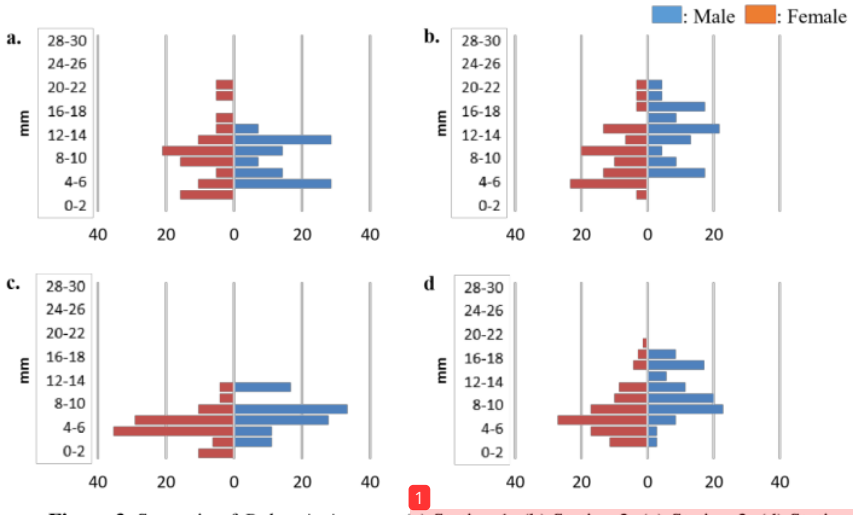

Figure 3. Sex ratio of *P. brevicristatum* (a) Station 1; (b) Station 2; (c) Station 3; (d) Station 4.

The male crab *P. brevicristatum* had a higher sex ratio at every station. The sex ratio of the 25-yearold replanted mangrove forest (station 2) and the natural mangrove forest (station 1), which is 1:0.74, are remarkably similar. At station 3, the mangrove forest has been replanted and is about five years old, similar to station 4, which has a 1:0.38 and 1:0.4[illegible] ratio (Figure 3). *P. semperi* crabs have a male to female ratio of 1:0.64, 1:0.29, 1:0.49, and 1:0.44 at station 1, station 2, station 3, and station 4, respectively. Although there are changes at station 2, the pattern observed in *P. semperi* crabs is highly comparable to that of *P. brevicristatum*. The contrast is considerably different from the conditions at station 1, which are natural forest, due to the small number of crabs acquired, but stations 3 and 4 have comparable conditions that are essentially the same (Figure 4).

The ratio of male to female crabs was never balanced, according to a number of previous studies. The same finding is supported by studies by Chen [20] on crabs from the Grapsidae family in Taiwan and Negreiros-Fransozo [21] on the Portunidae family in Brazil: there are always more male crabs than female crabs. The difference in mortality and growth in each sex, growth rate, sexual maturity, habitat, and season are to answer for the imbalance in the ratio of male to female crabs [22, 23, 24].

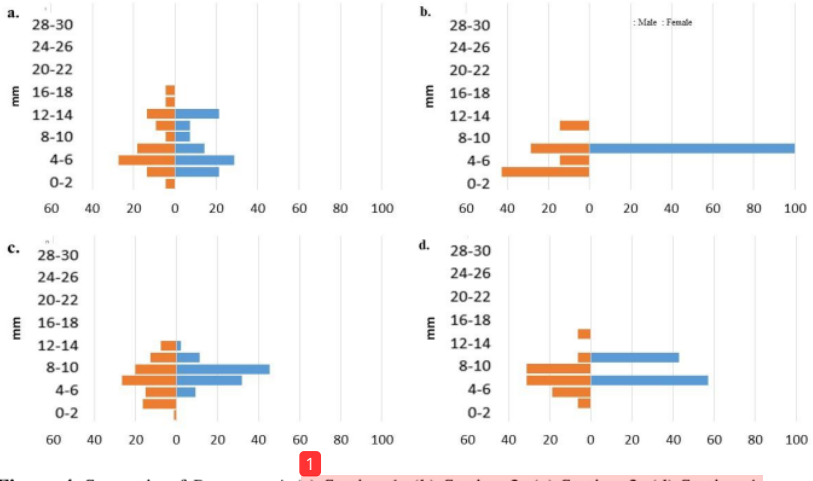

Figure 4. Sex ratio of *P. semperi* (a) Station 1; (b) Station 2; (c) Station 3; (d) Station 4.

The data *P. brevicristatum* and *P. semperi* crabs are categorized by the width of the carapace. The crabs were separated into 16 groups based on size, with a 2 mm difference between each group. According to Silva & Chacur [23], crabs are classified as adult if the carapace width is greater than 18 mm, and as young if the size is less than 18 mm. The results (Figures 5 and 6) demonstrated that both species' crabs were more certain to be juveniles than adults.

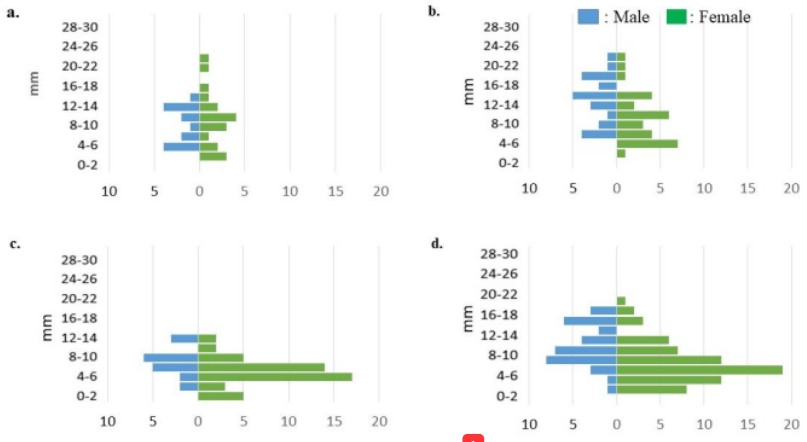

Figure 5. Size distribution of *P. brevicristatum* (a) Station 1; (b) Station 2; (c) Station 3; (d) Station 4.

The simple regression equation for the length and weight of the crabs *P. brevicristatum* and P. *semperi* found that the value of b > 1 was positive allometric, meaning that the crabs' weight increased faster (W) than their carapace length grew (CL).

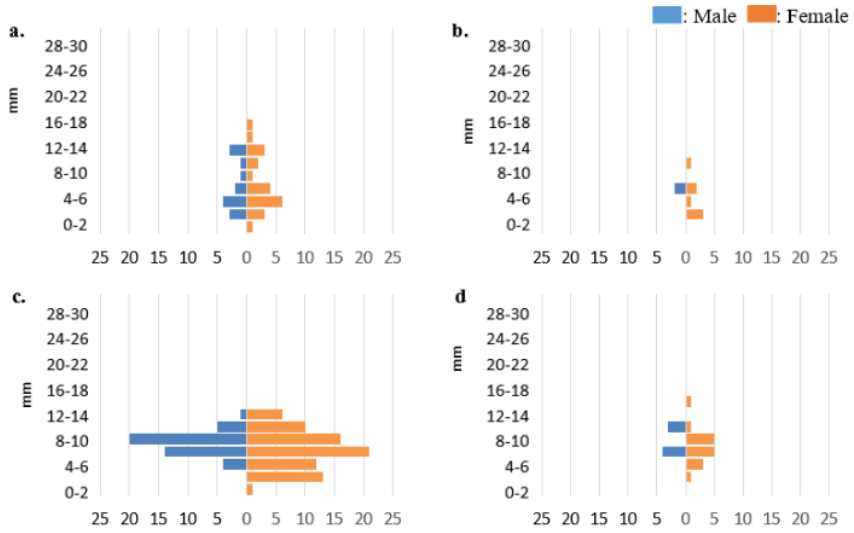

Figure 6. Size distribution of *P. semperi* (a) Station 1; (b) Station 2; (c) Station 3; (d) Station 4.

According to the observations, there are nine different species of mangroves, including *Rhizophora apiculata, R. mucronata, Bruguiera gymnorrhiza, B. parviflora*, *Ceriops decandra, C. tagal, Xylocarpus granatum, X. moluccensis,* and *Nypa fruticans*. In the consensus area of PT. BUMWI, mangroves like *Rhizophora* sp., *Bruguiera* sp., and *Ceriops* sp. are commonly observed. More than 53% of all mangroves encountered are *R. apiculata*, giving it the most prevalent mangrove species (Table 2).

Table 2. Data of Mangrove vegetation

Parameter	Station 1	Station 2	Station 3	Station 4
Age	Natural forest	25 years	5 years	Recently harvested
Canopy cover (%)	82.46	77.86	48.77	11.76
Trees density (ind.ha^{-1})	1115.73	2003.99	108.32	108.32
Sapling density (ind.ha^{-1})	1874.00	1007.41	3000.56	194.98
Seedling density (ind.ha^{-1})	6767.52	7032.91	5440.55	4378.98
Index Shanon Wiener (H')	1.45	1.07	0.94	0.53
Spesies richness (R)	8	6	7	5
Spesies	Ra, Rm, Bg, Bp, Xe, Xm, Cd, Ct	Ra, Rm, Bg, Bp, Xm, Cd	Ra, Rm, Bg, Bp, Xg, Xm, Nf	Ra, Bg, Bp, Xg, Cd

Note:
Ra: *Rhizophora apiculata*, Rm: *R. mucronata*, Bg: *Bruguiera gymorrhiza*, Bp: *B. parviflora*, Xg: *Xylocarpus granatum*, Xm: *X. moluccensis*, Cd: *Ceriops decandra*, Ct: *C. tagal*, Nf: *Nypa fruticans*

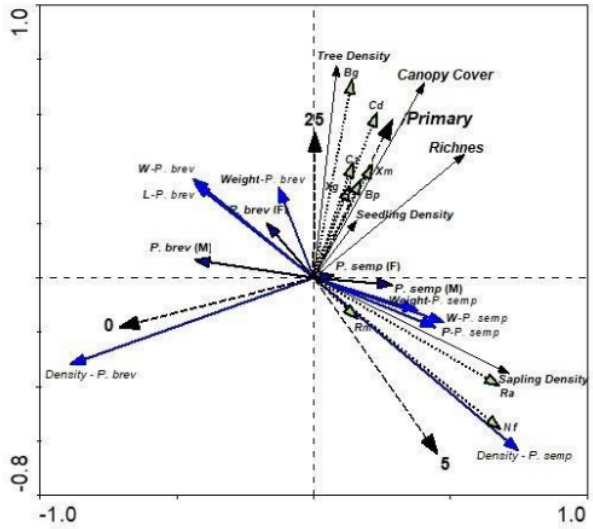

Figure 7. Result of Redundancy Analysis (RDA) between mangrove vegetation and crabs population by using CANOCO software [25]. Note:

As a result of the DCA results, which show that the measured gradient lengths are 1.189, the RDA method is used to process the remaining data. The RDA's findings (Figure 7) indicate that the condition of the restored mangrove forest at 25 years old is nearly similar. The density of saplings in the *P. semperi* population was the mangrove vegetation characteristic that had the biggest impact on the state of the crab population structure, but it had no impact on the *P. brevicristatum* population structure. Mangrove forests with an older age and a dense canopy cover are preferred by *P. brevicristatum* crabs (Stations 1 and 2), whereas mangrove forests with a younger age and an open canopy cover are preferred by *P. semperi* (Station 3 and 4).

4. Conclussion

According to the results and discussions, younger mangrove forests had the highest crab densities. At station 4 (damaged forest), crab *P. brevicristatum* had the maximum density, amounting to 119,047 ind.ha^{-1}. Only at station 3 (age 5 years) did *P. semperi* crabs reach their peak density, which was 139,455 ind.ha^{-1}. All varieties of crabs have a higher male to female sex ratio. The two species of crabs are dominated by young individuals, according to the size distribution. According to the link between length and weight in both types of crabs, the weight of the crab increased faster than the length of its carapace (positive allometric).

The highest mangrove species diversity, tree density, seedling density, and canopy cover were found in research sites with mature mangrove forests. It also has the highest density of saplings. *Rhizophora apiculata* constitutes 53% of the species in mangroves.

P. brevicristatum crabs prefer conditions in older mangrove forests, whereas *P. semperi* crabs prefer conditions in younger mangrove forests. The density of the sapling is the aspect of the mangrove

vegetation that has the greatest impact on the structure of the crab population. Sapling density had a significant impact on the population structure of *P. semperi* but had no impact on *P. brevicristatum*.

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