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Resource management of coconut crab (*Birgus latro*) in liwo island, north maluku of Indonesia

S.E. Widiyanti[1*], Marsoedi[2], Sukoso[2], D. Setyohadi[2]

[1]*Faculty of Fisheries and Marine Science, Khairun University, Ternate, Indonesia*

[2]*Faculty of Fisheries and Marine Science, Brawijaya University, Malang, Indonesia*

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Abstract

Coconut crab (*Birgus latro*) has ecological and economical value that only found in the islands which influenced by the Pacific and Indian Ocean currents, including Liwo Island. The research was done to describe a resource management of coconut crab (*Birgus latro*) in Liwo island according to the distribution and biological analysis of coconut crab. Data sampling was conducted in February-September 2013, data collection consisted of littoral rainforest vegetation, microhabitat and biological condition of coconut crab (thoracic length, weight, sex and gonad maturity). The result showed that Liwo Island microhabitat condition support the presence of coconut crab. Species diversity of littoral forest vegetation was low**.** Vegetation was dominated by *Calophyllum inophyllum*, *Erythrina variegata, Areca catechu,* Maga *(*Magnoliopsida) *and Pandanus tectorius*. Coconut crab population size was 1153 crabs with population density 5 crabs/Ha. The range of thorax length 3-66.09 mm with average of thorax length 23.46 mm. Growth pattern was included in allometric minor. This population was dominated by adult coconut crab with developing reproduction organ followed by functionally mature reproduction organ. A smaller catchable amount of coconut crab indicated that the resource management sustainability was needed to regulate catchable amount and size that involved of local community and relevant institutions.

***Corresponding Author:** Sri Endah Widiyanti ✉ endah_unkhair@yahoo.com

Introduction

Coconut crab (*Birgus latro*) that has ecological and economical value is the largest terrestrial hermit crab in the world. Distribution of coconut crab is from Indian Ocean to Pacific Ocean. The coconut crab in Indonesia was only found in islands that influenced by the Pacific and Indian Ocean currents, including Liwo Island. Local name of this crab, in Patani and other area in North Maluku, is *Katang kanari* (Murhum and Widiyanti, 2009). This hermit crab is categorized as endangered species in IUCN Red List since 1981, considered rare, and data deficient (Eldredge, 1996; Drew *et al.*, 2010). Coconut crab population in Indonesia was categorized rare (endangered species), and protected according to the Decree of the Minister of Forestry No. 12/Kpts-11/1987 (Pratiwi, 1989). However, the coconut crab demand increased because of coconut crab has become a choice of main culinary at several restaurants in North Maluku. Marketing system of coconut crab is simple, crab sold directly or by collectors seller to the restaurants in Ternate city, Tidore city, and surrounding areas. Abukasim, Floridas Restaurant owner, said that coconut crab price depends on its size, ranging from Rp. 150,000-300,000 per crab serving in 2008. This condition increased fishing effort to fulfill the demand of coconut crabs. Problems are arising when the catch decreased in number and size of crabs for recent years.

Population size of coconut crab in other locations was reported decline and currently under threat of extinction because of over exploitation, for example in the Seychelles, Mauritius and Keeling Islands (Altevogt and Davis, 1975), Niue Island (Schiller, 1992) and Republic of Vanuatu (Lindner, 2004). Although there is no recorded information, the catch decreased in number and size of crabs was also occur in Liwo Island, Central Halmahera Regency. Resource management of coconut crab according biological studies (first gonad maturity size, catchable size, closed catch season) have been conducted in Niue Island (Schiller, 1992), Republic of Vanuatu (Lindner, 2004) and Hatoma Island (Sato, 2012). However, resource management of coconut crab is depended on its geographical and ecological condition of each location (Sato, 2012). Information about biological study for resource management of coconut crab (*Birgus latro*) in Indonesia has not been recorded properly. One of those islands is Liwo Island in the North Patani District of Central Halmahera Regency.

The aim of this research was to describe the resource management of coconut crabs (*Birgus latro*) according to distribution and biological analysis of coconut crabs population in Liwo Island, North Maluku. This information could be expected for consideration of sustainable resource management of coconut crabs (*Birgus latro*) in Liwo Island.

Material and method

Study site

Liwo Island (0°27'48" - 0°29'2" N, 128°51'43" - 128°52'24" E) is a part of Gemia Village in North Patani District of Central Halmahera Regency, North Maluku Province of Indonesia. This island has 215.2 ha area, 6.4 km shoreline length, and 1-2 m in high above sea level. The average of annual temperature ranged between 28-32 °C, and 210 mm for average of annual rainfall. Data collection was conducted in Liwo Island from February to September 2013.

Microhabitat condition

The data collection of characteristics Liwo Island included littoral rainforest vegetation, substrate, topography and micro-habitat conditions (humidity, soil moisture, soil pH, soil and air temperature). Plant morphology of leaf, flower, and fruit was used to plant identification according to Noor *et al.* (2006) and Tjitrosoepomo (2010). Data analysis to determine structure and composition of littoral rainforest vegetation according to Bengen's procedure (Bengen, 2000), was the Dominance Index and Shannon's Diversity Index.

Distribution and biological data of coconut crab

Sampling method for distribution and biological data

of coconut crabs used purposive sampling technique (Fachrul, 2007), which considered the area of coconut crab habitat. Collecting of coconut crab was done once every month, when the dark moon using bait traps (coconut meat) that was placed near crab hiding place in the afternoon. Inspection and catching were carried out 2-3 times at night, when crab sought food. Locations of crabs caught were known by GPS.

The instruments to measure the thoracic length (ThL) was a Kisbrow's digital vernier caliper (accuracy 0.01 mm), and centaurus analytical balance (accuracy 0.01 g) for weight. The data collection of coconut crab included total catch, thoracic length (ThL), body weight (W), sex and crab maturity gonad. Coconut crab sex was determined by observing the presence or absence of pleopod on the left side of abdomen. Gonad maturity of female coconut crab was determined by observing development of secondary reproductive organ (pleopod length, setae length, setae color), egg development and abdomen enlarged. Analysis of coconut crab (*B. latro*) population included frequency distribution of thoracic length (King, 1995; Sparee and Venema, 1999), length weight relationship (Effendi, 1979), sex ratio (Effendi, 1979), and development of reproduction organ (Sato and Yoseda, 2008; Sato *et al.*, 2008).

Data of capture techniques and resource management of coconut crabs were obtained through focus groups discussion (FGD) with fisherman. Sampling procedure to estimate population size of coconut crab was adapted from Kadiri-Jan and Chauvet's procedure (Kadiri-Jan and Chauvet, 1999). The estimation of crab population size used the direct calculation method, that sampled a part of crab population from each sampling point (Schiller, 1992).

Result and discussion

Microhabitat condition

Liwo Island was unpopulated, and a part of littoral rainforest had converted into coconut palm (*Cocos nucifera*) plantations by some people of Gemia Village. The main occupation of people around the Liwo Island was cultivator and farmer, catching crabs was done when they lived in this island for several months on their activities of making copra, coconut oil or coconut virgin oil. The purposes of catching crab were to fulfill the market demand, sold or consumed by their family.

Table 1. Microhabitat conditions of coconut crab (*Birgus latro*) in Liwo Island.

Parameter	Value	
	Range	Average
Air temperature (°C)	25.4 – 29.7	27.3 ± 1.01
Soil temperature (°C)	26 - 30	27.8 ± 1.02
Air humidity (%)	85 - 99	94.3 ± 3.57
Soil moisture	3 - 7.4	4.4 ± 1.31
Soil pH	3 – 6.9	5.7 ± 0.77
Soil texture (% fraction of sand, clay, and dust)	sand (75.17 ± 35.20 : 5.67 ± 4.63 : 19 ± 34.71)	
Soil $C_{organic}$ content (%)	6.60 ± 2.68	
Soil organic matter (%)	11.42 ± 4.64	

Liwo Island has white sand, flat topography, and fresh water, with a coastal rainforest vegetation (the southern island) and coconut plantation of private property (the northern island). Coastal rainforest vegetation composed of pescaprae and Baringtonia formations. Shannon diversity index values indicated that species diversity of littoral forest vegetation was low. Those were 0.87 for seedling stage, 0.99 for sapling stage and 0.85 for tree stage. The dominance index values indicated that seedling stage was dominated by *Calophyllum inophyllum* (22.16%) in central region of island. Seedling stage of Coastal area

was dominated by *Erythrina variegata* (15.18%), followed by *Cocos nucifera* (12.96%). Saplings stage were dominated by *Areca catechu* (15.14%) in central region of forest, followed by, *Syzygium* sp. (12.18%), *Pandanus tectorius* (11.72%). Trees stage were dominated by Magnoliopsida (34.90%), followed by *Cocos nucifera* (15.69%) in coastal area. The tree stage in the central region of island was dominated by *Pandanus tectorius* (13.47%) and *Calophyllum inophyllum* (13.16%). Vegetation supporting coconut crab microhabitat conditions, especially as a hiding place were coconut tree (*Cocos nucifera*), Pandanus (*Pandanus tectorius*), weeping fig (*Ficus benjamina*), oil nut tree (*Calophyllum inophyllum*), and guava forests (*Syzygium* sp.). Crab made nest on dead trees, hiding among roots of a large tree or perforating bottom trunk. Coconut was main food of coconut crab, but some fruits of rainforest vegetation like fruit of oil nut tree, guava forest, pandanus, breadfruit (*Artocarpus altilis*), papaya (*Cacarica* sp.), cutnut (*Barringtonia asiatica*), and Indian mulberry (*Morinda citrifolia*) were also another foods of coconut crab. This crab was also found in most islands of North Maluku province that has resemble habitat, such as coastal village of Gemia (Murhum and Widiyanti, 2009), and Sayafi Island (Thalib, 2010). In addition, this species fed hatchlings of sea turtles, and dead mice or another crushed coconut crabs shell when food becomes rare to fulfill Calcium need (Fletcher *et al*. 1991). Wilde *et al.* (2004) added that *Birgus latro* also fed red crab (*Gecarcoidea natalist*) in the Christmas Island.

Table 2. Distribution of coconut crab (*Birgus latro*) in Liwo Island according to thorax length (mm) and weight (g).

No	Group of crab	Thoracic length (ThL, mm)	Weight (W, g)	Frequency (crab)	References for ThL
	Female				
1	Juvenile female	3.00 - 10.99	< 11.10	20	< 10 mm (Kadiri-Jan and Chauvet. 1998)
2	Developing female	11.00 - 24.49	11.11-120.52	144	< 24.5 mm (Sato and Yoseda, 2008)
3	Mature female	24.50 – 34.16	120.53-299	81	≥ 24.5 mm (Sato and Yoseda, 2008)
4	Catchable female	33.11-39.60	300-499	25	
5	Catchable female	≥39.61	≥500	6	≥ 43 mm (Lindner, 2004)
	Male				
1	Juvenile male	3.00 - 10.99	<9.43	18	< 10 mm (Kadiri-Jan and Chauvet. 1998)
2	Developing male	11.00 - 22.49	9.44-100.36	153	< 22.5 mm (Sato *et al*, 2008)
3	Mature male	22.50 – 31.50	100-300	149	≥ 22.5 mm (Sato *et al*, 2008)
4	Catchable male	31.51-38.28	300-499	25	
5	Catchable male	≥39	≥500	25	≥ 43 mm (Lindner, 2004)

Generally, coconut crab lived in rock crevices and dug sand along shoreline, although selection varied among islands, it depended on habitat available. For example, coconut crabs lived in coral stone quarry and in the thick bushes on Olango island (Philippines), while in Guam Island (Oceania), crabs burrowed porous limestone. Coconut crabs inhabit burrows along daylight to protect themselves from drought and predators, and leave their hiding place for seeking food at night (McCormack, 2006).

The results of microhabitat measurement (Table 1) showed that Liwo Island has microhabitat conditions that supported the presence of coconut crab. The coconut crab in Yoi Island (Gebe archipelago, North Maluku) was usually not far from the beach, choose coconut trees area, sheltered from sunlight, shady and moist locations. Micro-habitat condition of Yoi Island were 81-88 % of air humidity, air temperature 26.1 - 26.9 °C, soil temperature 26 °C, soil pH 5.5 - 7. Substrate consisted of 30.94 - 91.83 % sand fraction,

1.74 - 26.08 % dust fraction and 5.22 - 51.23 % clay fraction with 0.41 to 3.12 % $C_{organic}$ content. Land was covered by 70-95% vegetation (Abubakar, 2009). Coconut crabs preferred habitat was characterized by shrub vegetation, coconut tree, banana tree, and variety of coastal plants were quite dense (Rafiani, 2005). They overlaid their shelter by coco fibers. While in their hole, crabs cover the driveway with one of their claws to keep moisture and make them easier to breathe. The crabs sometimes out from their hiding place when moist or rainy day to ease their breathing according to Hicks *et al* (1990).

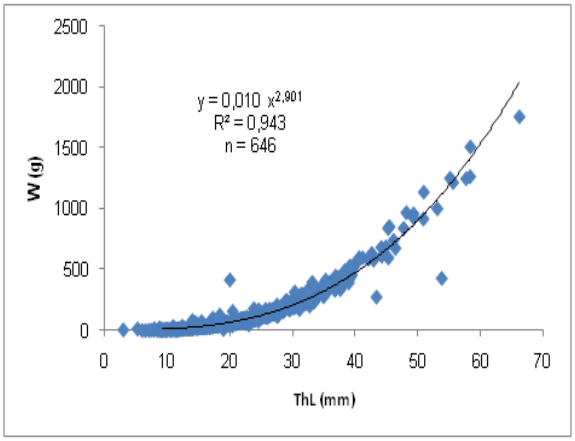

Fig. 1. Relationship between thoracic length (ThL, mm) and weight (W, g) of coconut crab (*Birgus latro*) in Liwo Island.

Distibution and biology of coconut crab

The total catch of coconut crab was 655 crabs for 122.3 ha of observation area, consisting of 374 males and 281 females, but 9 crabs were injured. Therefore, only biological data from 646 coconut crabs were analyzed (370 males and 276 females). Estimated total population of coconut crabs was 1153 crabs and estimation of density was 5 crabs/ha. This density value was lower than those in Christmas Island and Niue. Hicks *et al.* (1990) reported that density of exploited coconut crab in Christmas Island was 67 – 160 crabs/ha. Schiller (1992) also reported that density of exploited coconut crab in Niue was 46 crabs/ha. Thoracic length (ThL) range was 3.00 - 66.09 mm with mean ThL 23.46 mm. Coconut crab distribution depended on nest condition. Small coconut crabs preferred living among gap of Pandanus roots, while large crabs choose crack or dead trunk of weeping fig (*Ficus benjamina*), guava forest (*Syzigium* sp.), oil nut tree (*Calophyllum inophyllum*) and coconut trees for hiding.

According to sex ratio (1.15 : 0.85) showed that amount of male crabs more than female crabs. It happened because of people tend to catch or easier to catch female crabs with carrying eggs when they soaking their eggs in sea water, resulting in decrease of female crabs amount.

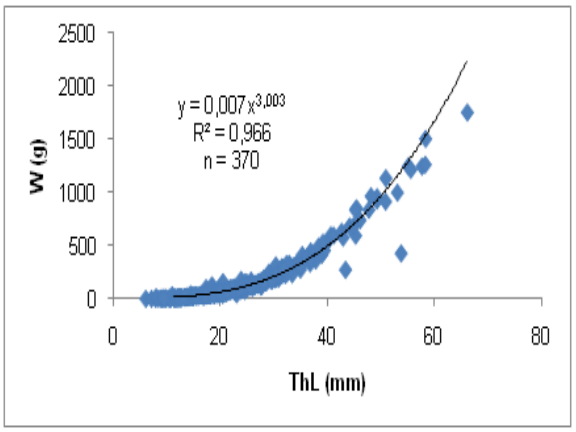

Fig. 2. Relationship between thoracic length (ThL, mm) and weight (W, g) of male coconut crab (*Birgus latro*) in Liwo Island.

The equation of thoracic length and weight

relationship analysis was W = 0,010 $ThL^{2,901}$ (see Figure 1). It showed that growth pattern of *Birgus latro* was minor allometric (b < 3). Based on their sex difference, thoracic length and weight relationship of male coconut crab was W = 0,007 $ThL^{3,003}$ and W = 0.016 $ThL^{2,773}$ for female crab (see Figure 2 and Figure 3). It indicated that weight increase of female coconut crab was faster than that in male, however growth pattern of male coconut crab was more isometric (b> 3).The difference of b value in female and male coconut crab may occur in connection with sex, crab size and food availability. The linear regression analysis of carapace length (CL, mm) and weight (W, g) of coconut crab in the coastal of Gemia village, suggested that coconut crab has minor allometric for growth patterns (Murhum and Widiyanti, 2009). There are two components of crustacean growth, those were growth at each molting, and time interval between each stage of

molting. Both of these factors depend on sex and size variations. Studies of coconut crab have been conducted in laboratory conditions using a small individual (Amesbury, 1980), and according to study of growth of male crabs in captivity for 18 months by Reese and Kinzie (1968) was reported that it takes five years to reach a size about 1 kg.

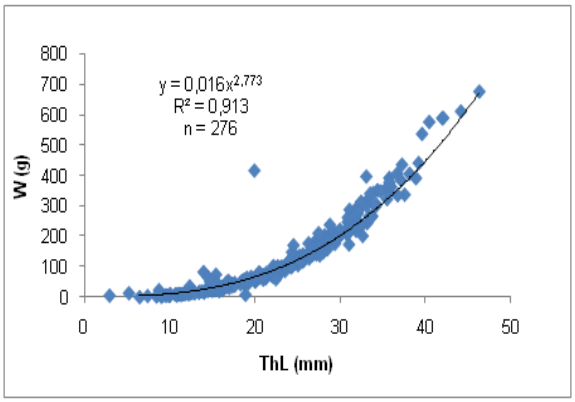

Fig. 3. Relationship between thoracic length (ThL, mm) and weight (W, g) of female coconut crab (*Birgus latro*) in Liwo Island.

The number of female *Birgus latro* (%) based on secondary development of reproductive organ (Figure 4) showed that the highest number of female coconut crab was non-ovigerous female (52.90%), followed by developing female (22.83%), immature female (21.74%) and ovigerous female (2.54%). The ovigerous female number was low, it was occur in March (4.76%), May (8.33%), June (4%) and July (2.94%). According Sato *et al.* (2008), the first gonad maturity of male crab was crab with ThL 22.2 mm. The highest number (%) of male crab was mature male (50.54%), followed by developing male (45.68%) and immature male (3.78%). Although Schiller *et al.* (1991), Fletcher (1993), Rafiani (2005), and Sato and Yoseda (2008) research results showed that peak of coconut crab reproductive activity was occur around January and February, the peak of it in Liwo Island could not be predicted. Schiller *et al.* (1991) suggest that coconut crab reproductive activity in tropical region was occur throughout the year, with reproductive activity peak during December until February. Rafiani (2005) and Abubakar (2009) also showed that the reproductive activity of male and female *Birgus latro* was occur throughout the year.

Table 2 showed that coconut crab (*B. latro*) in Liwo Island was dominated by developing coconut crabs (144 females, 153 males), followed by mature coconut crabs (81 females, 149 males). The amount of catchable crabs caught was lower (31 females, 50 males). This indicated that coconut crab population of Liwo Island was dominated by uncatchable coconut crabs (245 females, 320 males), and it needed sustainably resource management to arrange total catch and catch size limit.

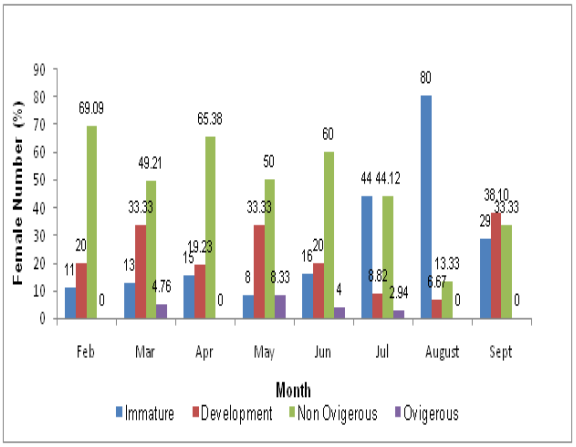

Fig. 4. Number of females *Birgus latro* (%) based on development of secondary reproductive organ.

Recommendation for resource management of coconut crab

Coconut crab on Liwo Island easily caught because crabs tend to motionless when exposed to flashlight during catching operations. Moreover, Liwo Island conditions made people easier to catch when crabs try to escape toward their hiding place or climb a tree. There was arrangement of coconut crab catching by a little part of local community, such as released or did not catch crabs with weight less than 300 g (ThL < 35 mm) because of a little edible crab. Unfortunately, local community still caught berries female because it has higher selling price. There was no local wisdom and written rules in village and local government related to crab resource management, that arrange catchable size and amount limit. Coconut palm plantation in Liwo Island was private property, therefore catch arrangement of coconut crab was

depended on them. This is important to keep catching arrangements that have been made by local communities. The selective catching should be conducted only on medium sized crabs. Based on relationship between thoracic length and weight, coconut crab reached weight approximately 300 g at ThL 35 mm and 500 g at ThL 42 mm. The amount of coconut crab in weight approximately 300 g were 50 male crabs and 31 female crabs. Compared to total catch (646 crabs), the number of catchable coconut crab was only 81 crabs (12.5%). This indicated that Liwo Island was dominated by uncatchable crabs (87.5%). Management options that could be considered was temporary ban or restriction on catching crabs for reaching catchable size.

Protection was conducted on large males and ovigerous females which had higher reproductive potential. These will contribute to maintain the level of population reproduction. Protection was also carried out on small crabs (under consumed size) to give opportunity to grow. Determination of catch size limits can be implemented to *Birgus latro* because this crab can be released unharmed after being captured. Establishing a closed season for catching coconut crabs during peak of reproductive activity until egg releasing time to the sea (early December to late March next year).

The most of local community did not understand the importance of maintaining ecological or crab habitat. The approach has been carried out by giving knowledge about coconut crab bio-ecology during this research by focus group discussion with local community. It has been growing concern some people among them on keep existence of this species, especially coconut plantation owner on Liwo Island. This people will help to control crab catch in their land that became coconut crab habitat.

Conclusion

Liwo Island has littoral rainforest and microhabitat conditions that support the presence of coconut crab (*Birgus latro*). Distribution of coconut crab in Liwo Island was according to microhabitat condition and vegetation distribution as hiding place and food sources. Coconut crab population was dominated by coconut crabs with developing reproductive organ, followed by mature crabs functionally. The number of catchable crabs size was lower. This showed lack of monitoring and did not follow by conservation and breeding, so the coconut crab still hunted. This indication required sustainability resource management immediately.

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