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Allometry and sediment characters of Mole Crab *Emerita emeritus* at South Java Beach, Indonesia

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ABSTRACT

Mole crabs belongs to the subphyllum of crustaceans and the superfamily of Hippoidae live in swash zones of the intertidal region. One of the most abundant is the species of *Emerita emeritus* at Glagah, Parangtritis and Parangkusumo beach south Java, live in the high-ferrous black beach sediment. The aim of research is to determine the relationship between length-weight, pattern of growth, sex ratio, and the relationship of the length-weight to organic matter, and the grain size diameter of the tree beaches. The research was conducted on April - June 2019 with purposive sampling method. Data analysis are length-weight correlation, content of organic matter, grain size diameter. The results showed that the growth patterns of male and female *E. emeritus* at Glagah, Parangtritis and Parangkusumo beach are allometric negative with a value of slope b <3. Male and female sex ratios at Glagah is 4: 1, Parangtritis is 0: 1, and Parangkusumo is 1:17. The length-weight correlation of *E. emeritus* to the dominant grain size diameter at Glagah with (r) : 0.98. While the correlation of length-weight of *E. emeritus* to organic matter with (r) : 0.55 as moderate correlation.

Key words *: Emerita emeritus, South Java, Length, Weight, Sediment, Organic matter.*

Introduction

Mole crabs crustacea of the Superfamily Hippoidae use to live in the intertidals *wash zone*. That is the highest to the lowest tide of the beach locally called as "yutuk" (Nugraha *et al.*, 2018). There are three species of Hippoidae can be found at south Java beach area *Emerita emeritus, Hippa adactyla*, and *Albunea symmysta*, with the most dominant species in Indonesia *E. emeritus*. Hippoidaeis widely distributed almost at most coastal area of Indonesia. Their distribution along south Java coast are in Pangandaran, Cilcacap, Kebumen, Purworejo and south Yogjakarta Glagah, Parangtritis and Parangkusumo beach. Each coastal has different oceanographic variable such as type of sediment, tide and waves. Specifically at Glagah, Parangtritis and Parangkusumo has a very high content of Fe. Interestingly themole-crab Crustacea *E. emeritus* mostly live in this type of beach sediment. The aims of the research are to determine the relationship between length-weight, pattern of growth, sex ratio, and the relationship of the length-weight to organic matter, and the grain size diameter at Glagah, Parangtritis and Parangkusumobeach south Java beach.

Method

All mole crab crustacean were collected from the blacksih high Fe sediment in Parangtritis (A),

Parangkusumo (B) and Glagah (C) beach as presented in Figure 1. Sample collection at Glagah and Parangkusumobeach using hand digging to 10 cm beach sand in the swash zone. Sample collection atParangtritis beach using wooden sand scraper. Beach sedimen samples were also collected simultaneously at the same sites, and put into a plastic zipper.

Morphometry and length-weight Morphometry measurements using a vernier-calipers with accuracy of 0.05 mm. Main measurements are carapace length (CL). Weight measurements using an electric ballance with accuracy of 0.01 g. The length-weight correlation analysis aimed to growth pattern of the mole-crab crustacean, possible feeding behaviour and environment condition factor (Muzammil, 2015). Length-Weight correlation formula (Effendie, M. I. 2002) :

$W = a L^b$ and $\text{Log } W = a + b(\text{Log } L)$

Where as :

L = carapace length (cm)

W = weight (gram)

a = intercept constant

b = exponential value or slope

Then followed with a logaritmic transformation of the equation, for the value of slope (b). According to Muzammil (2015), Mashar and Wardiyatmo (2013), when exponential value (b) = 3 indicates an isometric growth, if value (b) ‘“ 3, indicates as allometric growth. If (b) > 3, known as positive allometric growth and weight gain is more dominant. If (b) < 3, negative allometric growth where length growth is more dominant. The value of (b) could be different for sample taken at different location or at different sampling time.

Sediment Grain Size Analysis: Grain size analysis using 100 g of sedimen sample, oven dried at 100 °C temperature. Followed with dry-mesh sieve using a sieve shaker with seriesmesh-size of 2.00 mm, 1 mm, 500 µm, 250 µm, 125 µm, and 63 µm based on Wentworth scale (Darusman *et al.*, 2015). Sediment in each sieve-mesh then weighted to represent its each grain size, and converted into per cent.

Organic Matter of Sediment Analysis. Sediment sample of 20 g were oven dried at 60 °C for 24 hours. Dried sample then crushed using porcelain grinder (Darusman *et al.*, 2015). Portion of 0.5 g porcelain cruscible, thenburned in the furnace with temperature of 500 °C for 24 hours.

Sediment organic matter :

$$\text{Organic Matter} = \frac{(Wt-C)-(Wa-C)}{Wt-C} 5e100\%$$

Where :

Wt = weight (*cruscible* + sample) before drying

C = weight of *cruscible*

Wa = weight (*cruscible*+sample) after drying.

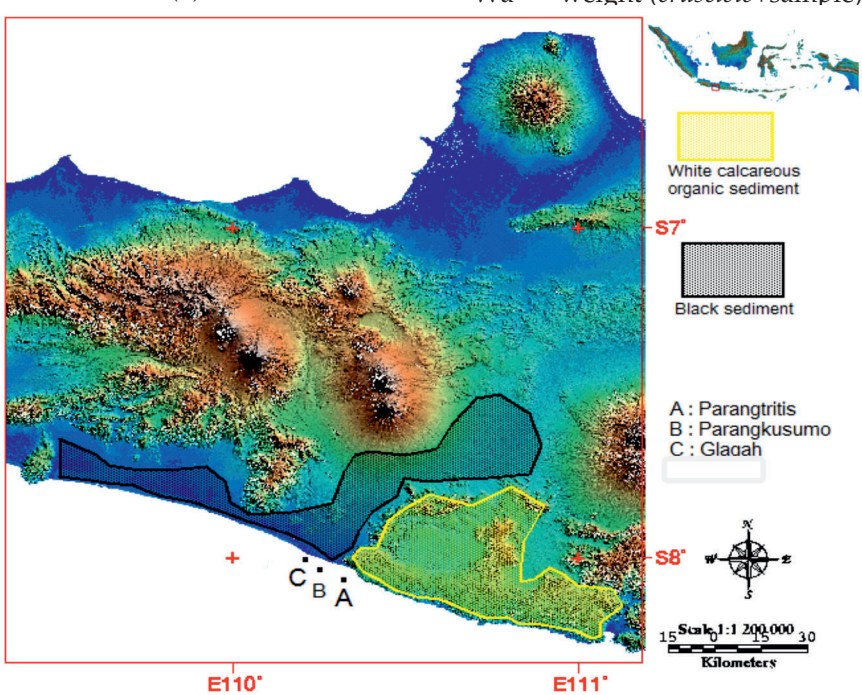

Fig. 1. Sampling sites of Parangtritis (A), Parangkusumo (B) and Glagah (C) beach, south Java Indonesia

Result and Discussion

Systematic of mole-crab Crustacea. The sample of mole-crab is systematically belongs to the sub-phylum of Crustacea such as shrimp, crab and lobster. The systematic classification according to Mashar *et al.*, (2015); Mahapatro *et al.,* (2018); Wittriansyah *et al.* (2018):

Kingdom	:	*Animalia*
Phylum	:	*Arthopoda*
Subphylum	:	*Crustasea*
Class	:	*Malacostraca*
Order	:	*Decapoda*
Family	:	*Hippidae*
Genus	:	*Emerita*
Species	:	*Emerita emeritus*

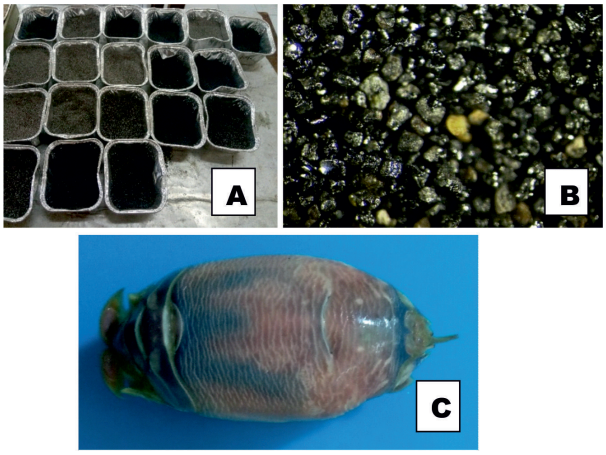

Fig. 2. Sample of sediment (A), photomicrograph of sediment (B) and *Emerita emeritus* (C)

Mole crab *E. emeritus* with a curve body at dorsal, with a billateral simetery abdomen. Tip of posterior abdomen folded ventrally with cephalothorax rather flat and cylindric, small rostrum or reducted, telson under the thorax long and elongated. First leg is chelate or subchelate, the fith leg truely reducted and folded always under the carapace (Wittriansyah *et al.,* 2018). These characters guide for the family of Hippidae. The external body of *E. emeritus* is covered with carapace, have two antenas with a comb like "V" shape. The antenas was used to catch the planktonic prey brings by the wave water mass. The *E.emeritus.* categorized as filter feeder (Wittriansyah *et al.,*2018).

Length-Weight Relationship.Carapace Length (CL)*E. emeritus*at Glagah beach in the range of 23-40 mm, with total sample 442 and the dominant CL of 34mm (146 samples). Other than *E. emeritus*, also found species *Hippa adactyla* and *Albunea symmsta* in minor number less than ten. Carapace Length at Parangtritis in the range of 32- 47mm, with dominant CL of 36 mm with only 10 samples *E. emeritus* can be collected at Parangtritis, but contratry more population of *Hippa adactyla* and *Albunea symmsyta* other beach. Carapace Length of *E. emeritus* at Parangkusumo is in the 23-45 mm with dominant CL of 36 mm (97 samples) out of 277 total samples. Exponential equation of *E. emeritus* Glagah, Parangtritis and Parangkusumo as presented in Table 1.

The length-weight exponential equation of total male and female *E. emeritus* at Glagah W= $0.0103L^{1.7704}$ with correlation coefficient r = 0.7 (Table 1) and Length-weight logaritmic equationis Log W = Log 1.9871+1.7704 Log L(Figure 3). Length-weight logaritmic equation of the male *E. emeritus*is Log W = Log 1.8601+1.6865LogL, or in the exponential equation is W= $0.0138L^{1.685}$, with r = 0.69. Length-weight logaritmic equation of female *E. emeritus* is Log W = Log 2.6516+2.2174 Log L, or in an exponential equation is W= $0.0022L^{2.2174}$ with r =

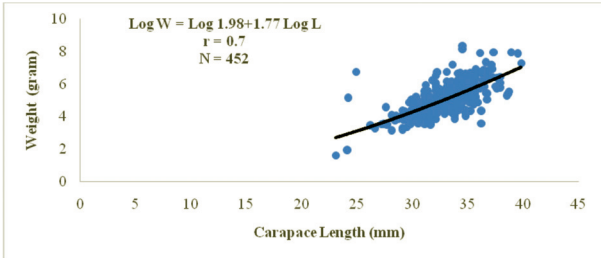

Fig. 3. Total male and female length-weight logaritmic equation *E. emeritus* at Glagah beach

Table 1. Exponential equation of *E. emeritus* Glagah, Pantai Parangtritis and Parang Kusumo beach, south Java

Variable	Sample sites : Glagah	Pantai Parangtritis	Parang Kusumo
N	452	22	277
a	0.0103	0.0161	0.0126
b	1.7704	1.7034	1.7646
Exponential:	W= $0.0103L^{1.7704}$	W= $0.0161L^{1.7034}$	W= $0.0126L^{1.7646}$
r-value:	0.70	0.65	0.74

0.8. The growth pattern of total male-female, male and female samples of Glagah beach based on the value slope (b) are smaller than 3 and categorized as negative allometry. Only female length-weight logaritmic equation of *E. emeritus* at Parangtritis beach as in Figure 4 is Log W = Log1.9851+1.7 Log L, in an exponential equation is W= $0.0161L^{1.7}$ correlation coefficient of r = 0.6. The value of slope (b) = 1.7 category of negative allometry growth pattern *E. emeritus* at Parangtritis beach. Length-weight logaritmic equation of total male and female of *E. emeritus* at Parangkusumo is Log W= Log 1.9001+1.7646 Log L, as in Figure 5. The exponential equation is W= $0.0126L^{1.7646}$. with value of slope (b) : 1.7646 and correlation coefficient r = 0.74.

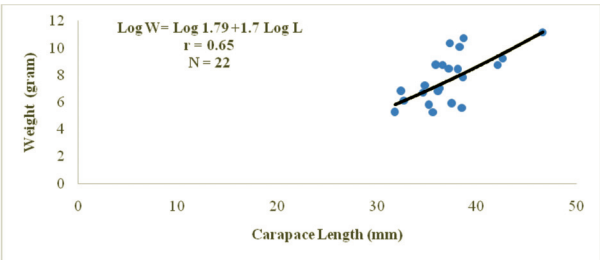

Fig. 4. Female length-weight logaritmic equation of *E.emeritus* at Parangtrtitis beach

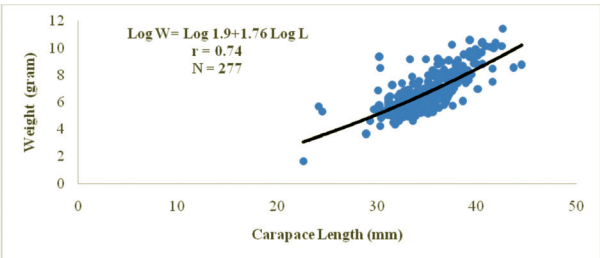

Fig. 5. Total male and female length-weight logaritmic equation of *E. emeritus* at Parangkusumo beach

Length-weight logaritmic equation of male *E. emeritus*is W=Log 2.2527+1.9807Log L, and in the exponential equation is W= $0.0056L^{1.9807}$, with slope(b): 1.,9807 and correlation coefficient r = 0. 8. Length-weight logaritmic equation of female *E. emeritus* is and the exponential equation is W= $0.0155L^{1.7064}$ with slope(b) : 1.7064 correlation coefficient r = 0.7. The result of the three equation have the slope (b) smaller than 3, thus the growth pattern of *E. emeritus* is negative allometry. Result of the grain size analysis of sediment of Glagahbeach (station 1) as presented in Table 1. The sediment of the three beach is dominanted by coarse-sand (1.000 – 0.500 mm), medium sand (0.500 – 0.250 mm) and fine sand (0.250 – 0.125mm). Parangtritis beach (Station 2) is dominated with medium and fine sand (Table 2), and at Parangkusumo beach (station 3) is dominated with coarse, medium and fine sand (Table 3).

Polynomial regression of the carapace length (CL) of *E. emeritus* to the dominant sand fraction of the sediment (coarse, medium and fine sand) at Glagah, Pantai Parangtritis and Parangkusumo beach is presented in Table 4. Correlation coefficient for Glagah beach is with (r) = 0.55, Parangtritis (r) = 0.60 and for Parangkusumo beach (r) = 0.49. Polynomial regression of the weight of *E. emeritus* to the dominant sand fraction of the sediment (coarse, medium and fine sand) at Glagah, Pantai Parangtritis and Parangkusumo beach as in Table 4, correlation coeficient (r) = 0.51 for Glagah beach, Parangtritis beach(r) = 0.45 and (r) = 0.54 Parangkusumo beach.

Polynomial regression of the carapace length (CL) and weight of *E. emeritus*to the organic content of the sediment at Glagah, Parangtritis and Parangkusumo beach as presented in Table 5. In general that the organic content of the sediment give a higher correlation coefficient (r) value than its correlation to the dominant grain size of sediment (sand fraction), with highest (r) value at Parangkusumo beach.

Ecobiology of *E. emeritus* at Glagah, Parangtritis

Table 1. Grain size analysis of sediment (%) at Glagah beach (Station 1)

Fraction	Diameter (mm)	1.1	1.2	1.3	1.4	1.5	1.6	1.7	1.8	1.9
Gravel	>2.000	0.01	0.01	0.00	0.00	0.00	0.00	0.06	0.11	0.56
Very Coarse sand	2.000 – 1.000	1.19	0.31	0.19	0.02	0.05	0.02	2.36	2.87	5.47
Coarse sand	1.000 – 0.500	10.86	5.57	3.92	0.21	0.26	0.16	24.92	25.30	28.37
Medium sand	0.500 – 0.250	48.23	43.10	47.44	5.22	6.74	9.04	51.88	38.21	35.20
Fine sand	0.250 – 0.125	39.25	50.39	47.86	91.13	89.46	88.35	20.27	33.05	30.10
Vey fine sand	0.125 – 0.063	0.44	0.58	0.51	3.23	3.24	2.18	0.46	0.41	0.28
Clay	0.063 – 0.032	0.02	0.04	0.08	0.18	0.24	0.25	0.06	0.05	0.02

and Parangkusumo. One of biological variable in this research is carapace length (CL), which classify to the adultery stage of *E. emeritus*. According to Phasuk and Boonruang (1975), Megawati (2012) that *E. emeritus* with CL bigger than 12 mm categorized as adult size. The firstly catch CL or L50% and invinity length (L^{∞}) areanother variable can be used to analyse the sample population collected the *E. emeritus* from the three beaches whether sample population collected is in overfishing state or not. Analysis of the firstly catch CL of *E. emeritus* at Glagah beach had found L50% is 33mm and invinity length (L^{∞}) is 42mm, and at Parangtritis the L50% is 36mm with L^{∞} is 49mm and at Parangkusumo the L50% is 35mm with L^{∞} is 49mm. Result of the three beaches as above with the criteria L50% ≥ $1/2L^{\infty}$ meaning that the average size catch is the adult size and not in overfishing state, and vice-versa if L50%≤$1/2L^{\infty}$, meaning the average catch is too small and in overfishing state (Wahyuni *et al.*, 2017). Further biological variable of *E. emeritus* is the male – female (M/F) ratio of the sample populations. Sample population from Glagah beach has the M/F ratio = 4:1 with 356 maled and 96 females. The M/F ratio of Parangtritis beach is 0:1 with no male and 22 female, while the M/F ratio of Parangkusumo beach is 1:17 with 15 male and 262 females. Based on the above case had indicated that population of *E. emeritus* at those three beaches is not in an equilibrium state. At Glagah beach was dominated by male population, while at Parangtritis and Parangkusumo were female population domination. Mashar and Yusli (2013a), state that the ideal eco-biological M/F ratio should be 1:1. The cause of non-ideal M/F ratio is the fishing pattern in the area. Also the fact that most female samples collected were in ripe gonade condition, which reflect the adultery population and will affect to the growth pattern, recruitment pattern, the future populations (Zigler and Forward, 2005). In this

Table 2. Grain size analysis of sediment (%) at Parangtritis beach (Station 2)

Fraction	Diameter (mm)	2.1	2.2	2.3	2.4	2.5	2.6	2.7	2.8	2.9
Gravel	>2.000	0.00	0.00	0.01	0.00	0.01	0.01	0.00	0.04	0.00
Very Coarse sand	2.000 – 1.000	0.19	0.55	0.42	0.11	0.24	0.62	0.35	0.83	0.79
Coarse sand	1.000 – 0.500	2.11	0.82	1.00	0.02	0.51	0.79	0.77	1.40	3.95
Medium sand	0.500 – 0.250	**50.23**	**49.67**	**47.78**	**51.62**	**26.06**	**7.94**	**15.07**	**26.77**	**47.84**
Fine sand	0.250 – 0.125	**42.79**	**47.87**	**48.96**	**46.91**	**68.52**	**82.70**	**80.33**	**68.00**	**46.55**
Vey fine sand	0.125 – 0.063	4.65	1.06	1.75	1.28	4.47	7.75	3.43	2.91	0.84
Clay	0.063 – 0.032	0.03	0.04	0.09	0.06	0.19	0.19	0.05	0.06	0.03

Table 3. Grain size analysis of sediment (%) at Parangkusumo beach (Station 3)

Fraction	Diameter (mm)	3.1	3.2	3.3	3.4	3.5	3.6	3.7	3.8	3.9
Gravel	>2.000	0.00	0.00	0.02	0.00	0.02	0.00	0.01	0.04	0.04
Very Coarse sand	2.000 – 1.000	0.37	0.20	0.24	0.10	0.30	1.61	0.20	2.25	2.53
Coarse sand	1.000 – 0.500	**19.72**	**10.23**	**4.35**	**1.31**	**0.61**	**28.34**	**7.08**	**32.44**	**35.21**
Medium sand	0.500 – 0.250	**59.73**	**62.00**	**40.15**	**54.13**	**46.27**	**51.07**	**61.15**	**53.55**	**52.21**
Fine sand	0.250 – 0.125	**19.66**	**26.24**	**51.66**	**42.61**	**51.91**	**17.53**	**30.04**	**11.11**	**9.54**
Vey fine sand	0.125 – 0.063	0.46	1.26	3.47	1.80	0.84	1.42	1.45	0.58	0.44
Clay	0.063 – 0.032	0.07	0.07	0.11	0.05	0.05	0.02	0.07	0.02	0.02

Table 4. Correlation coefficient of CL and weight of *E. emeritus* to dominant grain size of the sediment at Glagah, Parangtritis and Parangkusumo beach

Variable	Glagah (r)	Parangtritis (r)	Parangkusumo (r)
CL	0.55	0.60	0.49
Weigth	0.51	0.45	0.54

Table 5. Correlation coefficient of CL and weight of *E. emeritus* to organic content of sediment at Glagah, Parangtritis and Parangkusumo beach

Variable	Glagah r	Parangtritis r	Parangkusumo r
CL	0.66	0.67	0.85
Weight	0.72	0.70	0.81

very speciafic of sediment associate organism of *E. emeritus*, the population is also affected by their adultery stage. Where the more adult population live in deeper beach with more high wave (Kusumawardani, 2013). Availability of organic matter in the beach sediment is one crucial factor for the life and growth of the benthic crustacean (Mashar *et al*., 2014). More specifically will also affect to the gonade growth (Yusuf *et al.*, 2018).

Growth pattern of *E. emeritus*. The growth patternof *E. emeritus* is primarily reflected by the length and weight data, since the growth as the function of the length and weight in a period of time. The analysis of growth pattern based on the exponential and the transformatted into logaritmic equations. Type of the growth pattern is determined by the value of slope (b) of the logaritmic equation, if b=3 is categirized as isometric growth pattern. When the slope b<3 meaning that the growth of length faster than the weight or negative allometric growth, and if the slope b>3 meaning that the weight growth is faster than the length growth or positive allometric growth (Effendie, 2005 *in* Mashar and Yusli, 2013). The result of total male and female at Glagah beach was found the slope b = 1.77, for male with slope b = 1.68 and female slope b= 2.21 thus categorized as negative allometric growth of *E. emeritus.* At Parangtritis baech only female samples of *E. emeritus* with slope b= 1.70 as negative allometric growth. Then at Parangkusumo beach, for the total male and female sample have the slope b = 1.76, for male samples the slope b = 1.99 and for the female samples have the slope b = 1.70 thus the growth pattern of *E. emeritus* is negative allometry. Based on the slope b value of both male and female samples at the three beaches has the negative allometry growth pattern. Where the growth of length is bigger than the growth of weight (Kusumawardani, 2013; Megawati, 2012). Mashar and Wardiatno (2013b) the food consumption is used mainly for the growth to adult stage. The female will use the food consumption for growth and for the gonade growth.

Morphology and oceanography variables at Glagah, Parangtritis and Parangkusumo beach. Glagah and Parangkusumo with a more gentle slope but have a bigger wave, while at Parangtritis beach is protected with a rock clift and have a smaller wave. In general the three beaches is dominated by sandy in grain size diameter of 1-0.5 mm (coarse sand), 0.5-0.25 mm (medium sand) and 0.125-0.063 mm (fine sand). In a sand dominated sediment will have higher oxygen supply due to seawater flushing (Darusman *et al.,* 2015). Riniatsih and Edi (2009), in a sand dominated sediment will have less type of attaching organism. The value of organic matter in Glagah beach is 0.25%, at Parangtritis in the range of 0.53-2.03% and at Parangkusumo beach in the range of 0.88- 1.57%. This was since a sand dominated sediment or called as poreous sediment has a very limited capacity to hold for organic matter (Nugraha *et al*., 2018).

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