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Length-weight relationship of Ostreidae in the Kuala Gigieng estuary, Aceh Besar District, Indonesia

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Abstract. Ostreidae is one of the important groups of mollusks found in the Kuala Gigieng estuary, Aceh Besar Dsitrict, Indonesia. This mollusk has been exploited intensively, resulting in a decrease of the wild population. The objective of the present study was to examine the length-weight relationship of the Ostreidae group in the Kuala Gigieng estuary. The samplings were conducted at three locations from August to September 2013. The Linear Allometric model was used to calculate the **b** value. A total of five species of Ostreidae (*Crassostrea virginica*, *Crassostrea gigas*, *Crassostrea iridescens*, *Crassostrea angulata,* and *Ostrea edulis)* were collected during the study. The study showed that the **b** values were 1.86, 1.87, 1.27, 1.48, and 1.48 for *C. virginica*, *C. gigas, O. edulis*, *C. iridescens*, and *C. angulata,* respectively. Hence, the Ostreidae harvested from the Kuala Gigieng estuary displayed an allometric growth pattern.
Key Words: *Crassostrea virginica*, *Crassostrea gigas*, *Crassostrea iridescens*, *Crassostrea angulata, Ostrea edulis*.

Introduction. Oysters belong to the Ostreidae family and the phylum mollusk. This group has rude and irregular shells. They inhabit waters sheltered from waves and storms with a substrate of mud, sand, gravel or stones (Silulu et al 2013). At least six generas of oysters are found in the world (Dance 1974; Winder 2011), with about three generas found in Indonesia (FAO 2015), and an estimated two generas of oyster species found in Aceh waters (Octavina 2014). Some species of Ostreidae have an economic value as a source of protein for local people (Fadli et al 2012).

Kuala Gigieng is one of the estuaries in Aceh Besar District; its waters directly border the Straight of Malacca. The estuary waters have potential fishery resources, including fish and mollusks. According to Fadli et al (2012) the composition of mollusks in the Kuala Gigieng estuary included bivalvia (46%), gastropod (31%) and malacostraca (23%), which indicates that bivalvia was predominant in this area. In addition, *Ostrea* sp. and *Crassostrea* sp. are the most popular species within the group harvested by local fishermen for human consumption.

Several investigations have been conducted in the Kuala Gigieng estuary. For example, Sarinda & Dwiyanti (2013) conducted a study on phytoplankton diversity which indicated that the estuary has been polluted by anthropogenic activities at low to moderate levels. Fadli et al (2012) and Purnawan et al (2012) studied the diversity of macrozoobenthos and sediment characteristics, respectively. In addition, Mulfizar et al (2012) conducted a study on the length-weight relationship of three species of dominant fish in this estuary: *Mugil cephalus, Ambassis koopsii, Leiognathus fasciatus.* They found that *M. cephalus* and *A. koopsii* have an allometric negative growth pattern, while *L.*

fasciatus displayed anallometric positive growth pattern. A study on the length-weight relationship of Ostreidae in the Mandovi River in India was conducted by Nagi et al (2011). However, a study on the length-weight relationship of Ostreidae in the Kuala Gigieng estuary has not been conducted previously. In addition, studies on this topic have been reported by Komala (2012) on *Anadara granosa* in Lada Bay, Sunda Strait, on *Batissa violacea* in Anai River, West Sumatra (Putri 2005) and on *Geloina erosa* in the West Coast of Aceh Besar District, Indonesia (Sarong 2010).

Presently, the Ostreidae in the Kuala Gigieng estuary have been intensively exploited which has decreased its wild population. Information on the length-weight relationship of the Ostreidae is important to understand the growth pattern of the population in order to plan a better conservation strategy (Babaei et al 2010). The present study has examined the length-weight relationship of five species of Ostredae namely; *Crassostrea virginica*, *Crassostrea gigas*, *Crassostrea iridescens*, *Crassostrea angulata, Ostrea edulis* harvested from the Kuala Gigieng estuary, Aceh Besar District, Indonesia.

Material and Method

Sampling sites. Three sampling locations were determined based on habitat characteristics and human activities; Station 1 (6°22'0.19"N-76°53'0.6"E) was representative of the fish landing and settlements, Station 2 (6°21'5.26"N-76°50'9.3"E) was a tidal transition region, and Station 3 (6°21'5.23"N-76°43'5.4"E) was representative of a region with no human activities (Figure 1). The sampling was done six times purposefully at every sampling location from August to September 2013.

The substrates were collected using a Peterson Grab (30 cm x 30 cm) and then the collected substrates were sieved and hand sorted. The Ostreidae samples were preserved in 10% formalin in a plastic bag and then transported to the laboratory of the faculty of Marine and Fisheries, Syiah Kuala University for further identification based on Dance (1974), Kozloff (1987), and Winder (2011).

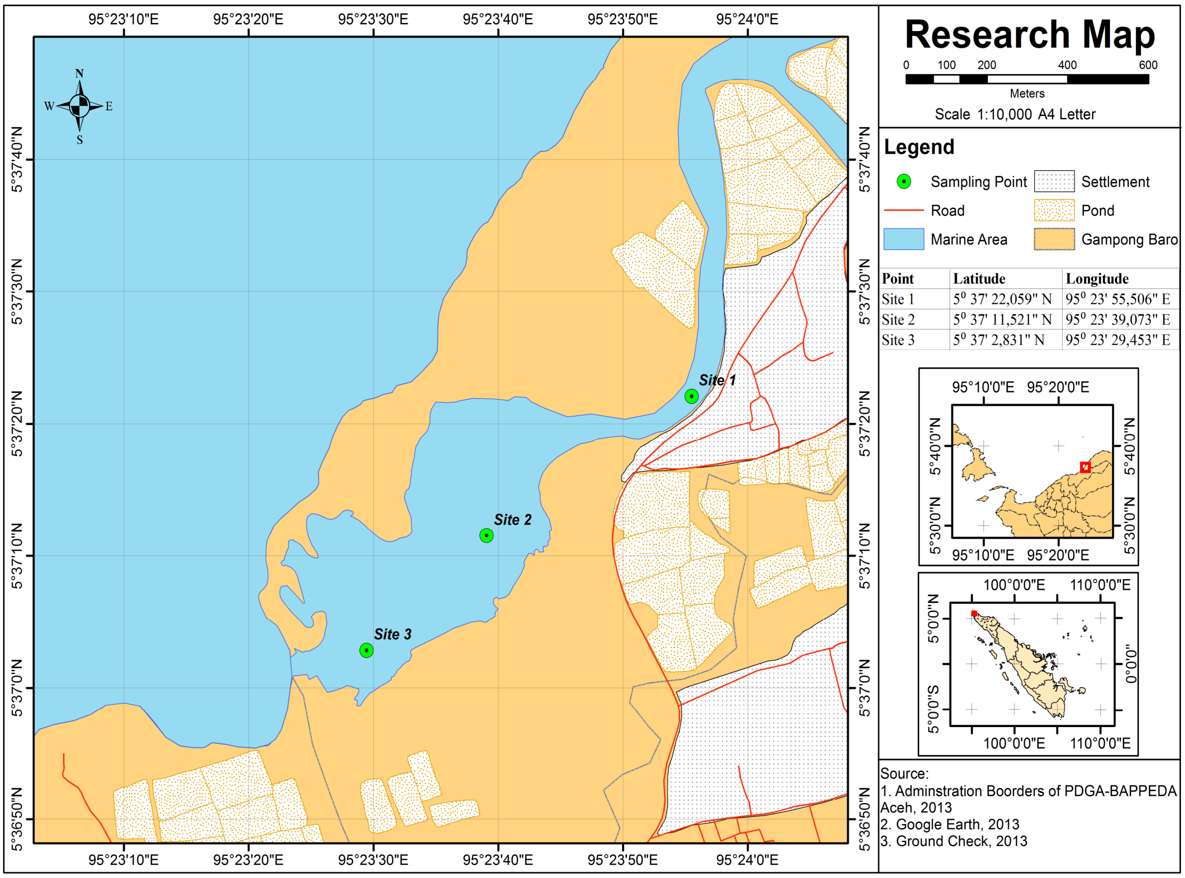

Figure 1. The map of Kuala Gigieng estuary showed sampling locations (green cyrcles).

Morphometric measurement. The Ostreidae were measured for total shell length (TL), total shell width (TW) and shell thickness using digital calipers (Mitutoyo Absolute 500-196-20, standard error= 0.001 mm)based on the proposed procedure by Ferreira et al (2006) and Winder (2011) (Figure 2). Shell length was measured horizontally from the anterior end to the posterior end of the shell; the shell width was measured vertically from the dorsal to the ventral part of the shell, and the shell thickness was measured from the upper edge of the shell to the bottom edge of the shell (Tlig-Zouari et al 2010). The gross and net weight were measured using a digital balance (Toledo, AB-204, standard error = 0.01 g).

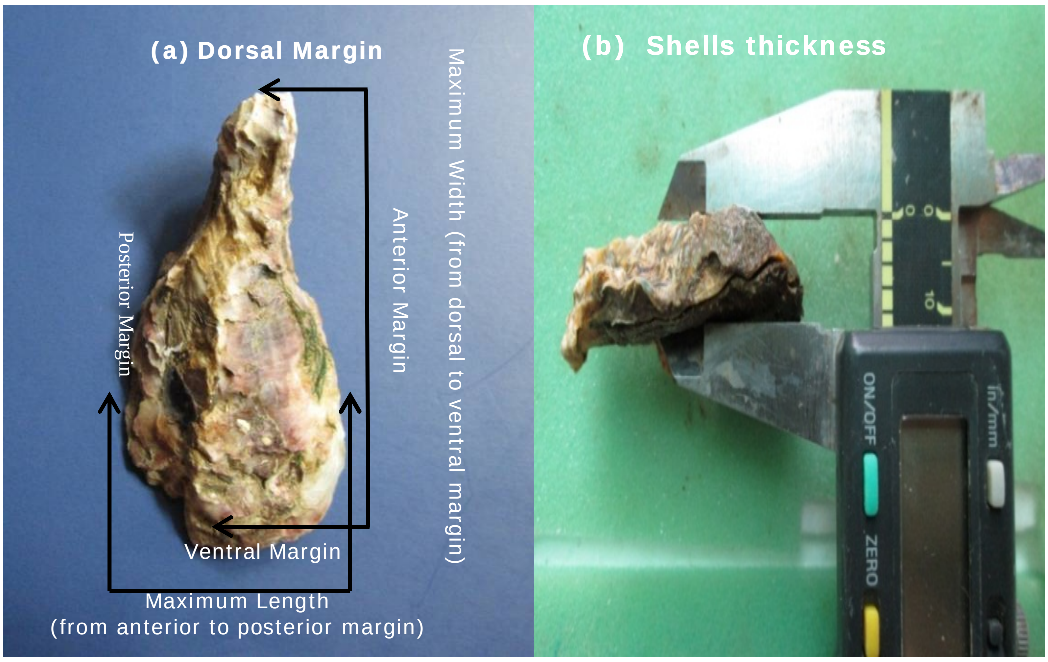

Figure 2. Morphometric measurement of Ostreidae (a) Dorso margin view, (b) side margin view.

Data analysis. The Linear Allometric Model (LAM) was used to estimate the parameters *a* and *b* by log-transformed weight and length measurements. A correction for bias attributable to the back-transformation of mean weights from logarithmic units was applied to predict weight and length from parameters fitted to the allometric equation following De-Robertis & Williams (2008) and Muchlisin et al (2010):

$$W = e^{0.56} (aL^{b})$$

where W is the weight (g), L is the length (mm), *a* is the intercept of the regression, *b* is the regression coefficient and e is the variance of the residuals from the LAM regression. 0.56 is the correction factor of the data sets. The coefficient correlation was calculated to measure the relationship between weight and length as follows:

$$r = \frac{\Sigma(\log L \times \log W)}{(\Sigma(\log L^2) \times \Sigma(\log W)^2)^{1/2}}$$

Results and Discussion. A total of 1857 oysters belonging to five species, namely: *O. edulis* (306 samples), *C. iridescens* (286 samples), *C. angulata* (442 samples), *C. virginica* (377 samples) and *C. gigas* (446 samples), were examined for their length-weight relationship. The coefficient *b* was 1.49, 1.27, 1.49, 1.87, 1.88 for *O. edulis*, *C. iridescens*, *C. angulata*, *C. virginica* and *C. gigas,* respectively. Therefore, the range of *b* values of Ostreidae in Kuala Gigieng was 1.27 to 1.87, indicating an allometric negative growth pattern. These values were lower compared to *G. erosa* in Reulung River, Aceh Besar District, Indonesia (Sarong 2010), but higher compared to *A. granosa* (Komala 2012). The compilation of *b* values of some species of bivalvia are presented in Table 1 for further comparison; the table indicates that the shell lengths are growing faster than the shell weights. This study revealed that the growth pattern of oysters in the Kuala Gigieng estuary is falling into the common range for clams. However, the conditions of this estuary were most suitable for *C. virginica* and *C. gigas* because these species had higher *b* values compared to the three other species.

C. gigas and *C. virginica* are the main constituents in the oyster reefs (Cuddington & Hastings 2004), and they are able to live in extreme water conditions, which is why these species have been cultivated extensively worldwide (Cardoso et al 2013; Bartol et al 1999). According to Cardoso et al (2007) *C. gigas* is commonly found in estuaries and dominates the feeding activity, and therefore inhibits the growth of other species which occupy a similar habitat due to lack of food sources.

The *r* value (coefficient correlation) indicates the relationship between weight gain with increasing shell length. The results showed that the *r* values of *O. edulis*, *C. iridescens*, *C. angulata*, *C. virginica*, *C. gigas* were 0.81, 0.84, 0.82, 0.83 and 0.87, respectively. This indicates a strong relationship between the length and weight, where increasing shell length tends to correlate with increasing body weight. In addition, the coefficient determinations ranged between 0.65 and 0.77 (Figure 3). This means that about 65 to 77 percent of the total variation in *y* (body weight) can be explained by the linear relationship between length and weight. The other 23 to 35 percent of the total variation in *y* (gonad weight) remains unexplained from the model.

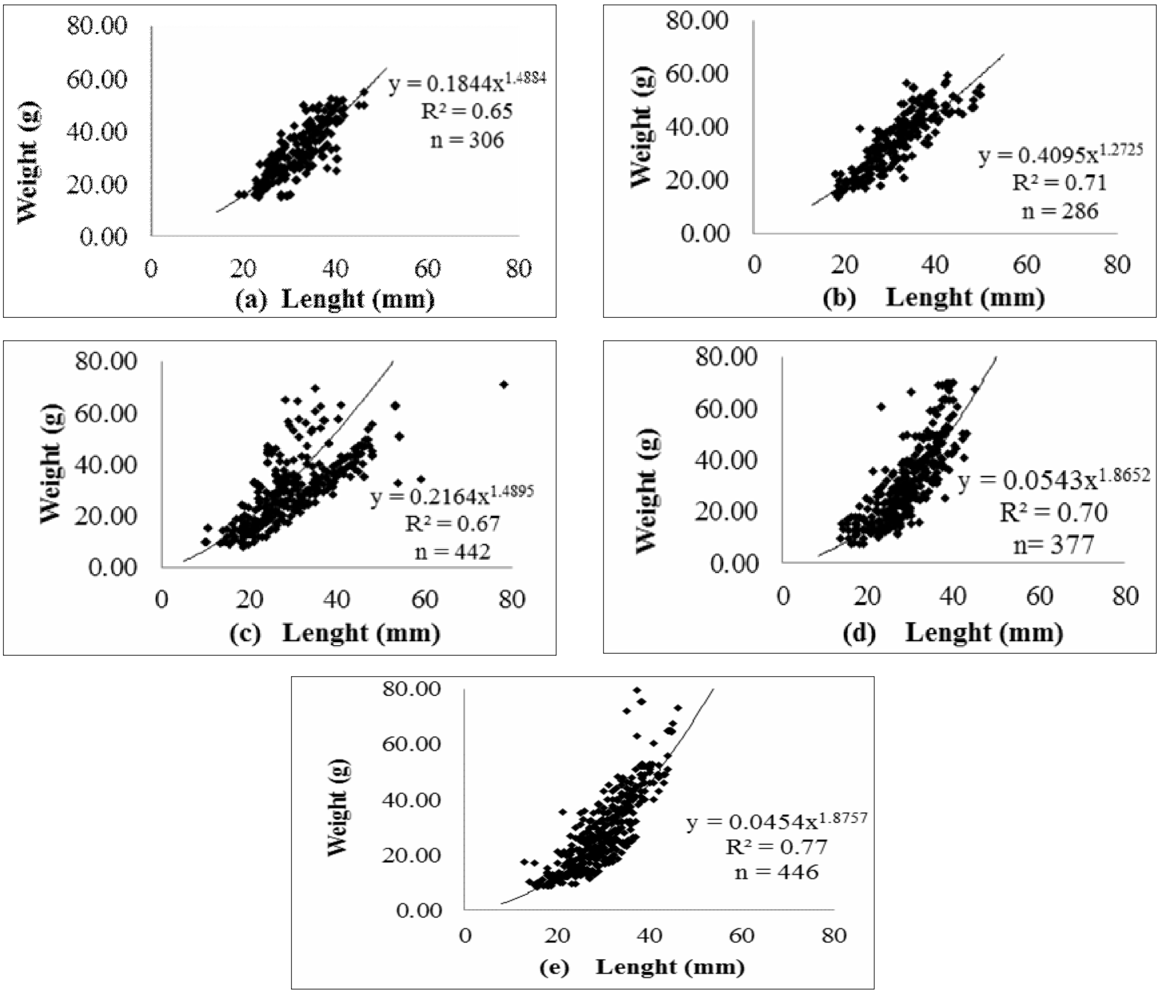

Figure 3. The lenght weight relationship of Ostreidae harvested from Kuala Gigieng estiary; (a) *O. edulis*; (b) *C. iridescens*; (c) *C. angulata;* (d) *C. virginica;* (e) *C. gigas*.

Table 1

The coefficient *b* values of some species of clams

No.	*Species*	*b*	*r*	*Source*
1	*Anadara granosa*	1.20-2.72	0.75	Komala (2012)
2	*Batissa violacea*	1.40-1,91	0.93	Putri (2005)
3	*Crassostrea madrasensis*	1.06-2.07	0.78	Nagi et al (2011)
4	*Crassostrea gryphoides*	0.76-1.99	0.74	Nagi et al (2011)
5	*Geloina erosa*	2.60-2.77	0.95	Sarong (2010)

According to Babaei et al (2010), and Abelha & Goulart (2008) clam growth is affected by abiotic (environmental) factors, for example water quality, depth, water current, turbidity, and sediment type, and biotic (physiological) factors, for instance food availability (prey), population density, sex, age, and size. In addition, habitat perturbation, pollution and overharvesting are significant threats for the oyster population. For example, Sarong et al (2015) reported that *C. gigas* muscles harvested from the estuary of Lamnyong River, Banda Aceh City have been contaminated by lead, cadmium and zinc and are not safe for human consumption. The Lamnyong River estuary is situated close to the Kuala Gigieng estuary and it is very likely the Kuala Gigieng has also been polluted. Therefore, further study to evaluate pollution in the region is very crucial. However, nowadays the most significant issue is overharvesting by local people.

Therefore, good and comprehensive management strategies should be arranged to conserve the Ostreidae population in Kuala Gigieng, including harvest size and harvest time, the development of cultivation technology and domestic waste management. For these purposes, we proposed three management strategies. First, the restriction of timing, size and location must be determined immediately. Second, cultivation technology must be developed and local fishermen must be trained on oyster culture practices. For example, local fisherman could utilize natural collectors which are cheap and easy to prepare. Gangnery et al (2004) proposed an oyster culture technique using oyster shell rubble that hung on a polyethylene rope as media for oyster larvae (spats) settlements. An oyster cultivation technique was also introduced by Coakley (2004) where the oysters spawned in a container basin and the oyster spats were introduced into wire cages and cultured until the spat reached a size of 0.5 inches (young oyster). Then the young oysters moved into the sea in order to grow. After reaching the time of harvest, the wire cages were towed and harvested. In addition, Latama (1997) introduced an alternative collector for oyster growing using concrete blocks and bamboo sticks. The third management strategy involves developing a simple waste disposal treatment for rural people by providing treatment ponds planted with mangroves and other plants as bioremediators and discharging the clean waste water into the river.

Conclusions. The Ostreidae harvested from Kuala Gigieng displayed an allometric negative growth pattern, where the shell lengths are growing faster than the body weights. Among five species of Ostreidae, the *Crassostrea virginica* and *Crassostrea gigas* had higher *b* values compared to *Ostrea edulis*, *Crassostrea iridescens*, *Crassostrea angulata*, which indicates that the Kuala Gigieng estuary's conditions are most suitable for *C. virginica* and *C. gigas.*

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