Characteristics of Von Bertalanffy Growth, Allometric, Condition Index and Mortality of Periophthalmus barbarus in Mangrove and Bekantan Conservation Area (KKMB), Tarakan, North Kalimantan

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Submission date: 03-Jan-2021 03:31PM (UTC+0700)
Submission ID: 1482598082
File name: Bekantan_Conservation_Area_KKMB_,_Tarakan,_North_Kalimantan.pdf (511.44K)
Word count: 3796
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Characteristics of Von Bertalanffy Growth, Allometric, Condition Index and Mortality of *Periophthalmus barbarus* in Mangrove and Bekantan Conservation Area (KKMB), Tarakan, North Kalimantan

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Abstract

The Mudskipper (P. barbarus) lives in intertidal mud flats and it becomes an indicator of water quality. The transformation of construction and water pollution in this area is important to investigate due to interaction of fishery industry, home residence, and market area surrounding areas. The aim of this research was to analyze the characteristic of Von Bertalanffy growth, allometric, condition index, and mortality of the P. barbarus in KKMB, Tarakan city. The research was designed by using descriptive quantitative method. The sampling process used purposive sampling. The sampling was conducted for 12 times plot/transect in the extension area of KKMB, Tarakan city with a total area is 12 Ha, transect area is 10x10 m², and distance between each transect is 10 m². Sampling was carried out in survey area and laboratory to identify the gender and calculate total length and weight. The result showed the growth of male mudskipper (L∞=26.545 cm) and female (L∞=17.594 cm). Their size and the total population was decreased. The characteristic of male mudskipper growth was positive allometric, then female was negative allometric. The natural mortality and the catch of male mudskipper were higher than female.

Keywords: *growth, population, mudskipper fish,*

Introduction

Mangrove and Bekantan Conservation Area (KKMB), Tarakan city, is one of the conservation areas in Indonesia. There are many species of aquatic and terrestrial natural resources. This area belongs to the green zone in central Tarakan city and integrated with industry area, home residence, and market area. According to Salim *et al.* (2018), the ecosystem of mangrove forests and coastal is part of the ecosystem, which is influenced by the tide. One of the coastal ecosystems is a muddy beach that consists of a mangrove forest.

Mangrove forest correlates with producer and the nutrient provider for aquatics organisms, such as the mudskipper (*Periophthalmus barbarus).* Jamiludin and Salim (2016), clarify that the mudskipper is an aquatic biota that lives in the coastal area and can survive in the ground around 5 minutes. The specific characteristic of the mudskipper is protruding eyes at the top of the head. According to Jamiludin and Salim (2016), the protuberant head has a relation with the gender of the fish, especially in adult fish. The size of male mudskipper's protuberant is more significant than that of the female.

The existence of *P. barbarus* in the muddy coastal ecosystem could use as one of the quality water indicators in KKMB, Tarakan City. The recent research by Jamiludin and Salim (2016) found that

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ijms.undip.ac.id
DOI: 10.14710/ik.ijms.25.1.31-38
Received : 27-01-2020
Accepted : 24-02-2020

the population of female *P. barbarus* (54.4%) is more than that of males (45.6%). The population density of the mudskipper is around 0.34±0.17 ind.m^{-2}. Salim, *et al.* (2018) reported that the growth properties of male and female mudskipper was negative allometric and the body of them is fat. While Firdaus and Salim (2018), found that the growth properties of them is negative allometric. The body shape of male Atlantic mudskipper is fat, but the female is flat. The maximum length of male Mudskipper was 27.374 cm, and the female was 20.683 cm. The natural mortality of the female and male *P. barbarus* was 11.6% and 18.3%, respectively.

However, study on natural growth and environmental (pollution) effects on the growth and mortality of *P. barbarus* in KKMB, Tarakan city is very limited. This study aims to analyze the Von Bertalanffy growth model, allometric growth, condition index, and mortality of *P. barbarus* in KKMB, Tarakan city.

Materials and Methods

The sampling was done with 12 times transect in the extension area of Mangrove and Bekantan Conservation Area (KKMB), Tarakan City. The size of the transect was 10x10m^2. The distance of each transect was 10m. Four coordinate points determinate by GPS. The sample was taken when it was low tide. Sampling was done following *(Salim et al.*, 2018). The sample were put in a plastic bags and kept in the freezer.

The mudskipper was measured its length and weight (Effendie, 1979; Salim *et al.*, 2018). The determination of mudskipper's gender based on research of Jamiludin and Salim (2016).

Variable of Von Bertalanffy Model

Variable of growth used Von Bertalanffy model (Sparre and Venema, 1998):

$$Lt = L\infty\ (1\text{-}e^{-k(t\text{-}t0)})$$

Note: Lt = Length of the mudskipper (*P. barbarus*) with age t (unit of time); L∞ = Maximum length of the mudskipper (*P. barbarus*) theoretically (asymptotic length); K = Coefficient growth of the mudskipper (*P. barbarus*) (per unit of time); t_0 = Theoretical age of the mudskipper (*P. barbarus*) when the length is zero

Variable of age structure

Variable of age structure used modus class shift method that has correlation with Von Bertalanffy based on Sparre *et al.* (1998) as follows:

$$(\Delta L/\Delta t) = (L_2 - L_1) / (t_2 - t_1)$$
$$L_{(t)} = (L_2 + L_1)$$

Note: $\Delta L/\Delta t$= Relative growth; ΔL= Length of the *P. barbarus*; Δt= Difference of sampling time; $L_{(t)}$ = Modus of average length

The equation of the linear curve was obtained by plot between $L_{(t)}$ and $(\Delta L/\Delta t)$ value to obtain the following linear line equation:

$$Y = a + bx$$

Note: $a = ((\Sigma y/n) - (b\ (\Sigma x/n)))$; $b = (n\Sigma(xy) - (\Sigma x)(\Sigma y)) / (n\Sigma x^2 - (\Sigma x)^2)$

The average value of modus length obtained from the regression equation method is used to calculate the asymptotic length ($L\infty$) = –a/b, then the growth coefficient is –b. Age theoretical of *P. barbarus* when the length is zero can be expected separately by empirical equation (Pauly *in* Sparre and Venema, 1998) ;

$$\text{Log}\ (-t_0) = 0{,}3922 - 0{,}275(\text{Log}\ L\infty 1{,}038\ (\text{Log}\ K)$$

Note: L∞= asymptotic length of *P. barbarus* (cm); K= growth rate coefficient of *P. barbarus*; t_0= Age theoretical of *P. barbarus* when the length is zero (year)

Allometric growth model

The allometric growth model was the length and weight value to analyze population growth overall. The estimation based on Effendie (1979) :

$$Y = a + X^b \quad \text{or} \quad \text{Log}\ Y = \text{Log}\ a + b\ \text{Log}\ X$$

Note: Y= Total weight of *P. barbarus* (gram); X= Total lenght *P. barbarus* (mm); a+b= coefficient (intercept)

The value of b was an allometric coefficient that reflected relative growth. When b value=3, allometric growth characteristic was isometric, length growth was the same with weight growth. b value <3 (allometric negative) or b>3 (allometric positive), so length growth was not same with weight growth. The correlation between length and weight calculated by correlation coefficient Effendie (1979).

Condition Index model

Condition in dex of the fish was based on five criteria i.e. very flat fish (0.01-0.50), flatfish boy (0.51-0.99), proportional/ideal fish (1), fat fish (1.01-1.50), and the obese fish (>1.50) (Firdaus and Salim, 2011; Salim, 2013; Salim 2015; Firdaus *et al.*, 2018).

The allometric growth used Weatherley (1972) and isometric growth used Lagler (1949) and Effendie (1979) method. Based on Lagler (1949) in Effendie (1979) to obtain fish condition factor with isometric growth characteristic can used this equation as follows:

$$K_{(TI)} = 10^5 x \frac{w}{L^3}$$

w= total weight of fish (gr);
L= total length of fish (mm);
10^5 = the equation was taken, so $K_{(TI)}$ value is close to 1.

The fish condition factor with fish allometric characteristic used this equation Weatherley (1972):

$$Kn = \frac{\hat{W}}{W}$$

W = total weight of of fish (gr);
$\hat{W}$= allegation of total weight of fish (gr);
$W = a L^b$ obtained using the regression equation of length-weight) correlation.

Variable of mortality

Natural mortality (M) is estimated using Pauly's empirical formula (1984), which is:

$$\text{Log } M = 0{,}00660{,}279 \log L\infty + 0{,}6543 \log K + 0{,}4634 \log T$$

Total mortality (Z) is estimated using the Beverton and Holt formula (Sparre and Venema, 1998) as follows:

$$Z = K \cdot \left[\frac{L_\infty - \bar{L}}{\bar{L} - L'} \right]$$

Mortality Capture (F) as follows: F = Z – M
The exploitation rate (E) is drawn as follows using the formulation of Baranov (Sparre and Venema, 1998). Note : E = Rate of exploitation; Z = Total mortality; F = Capture mortality; M = Natural mortality

Result and Discussion

Distribution structure

This research obtained 296 fishes which were 147 male (49.66%), and 149 female mudskippers (50.34%). Length distribution of male mudskipper was 4.25±0.45 cm for 68 fish (46.26%), but the size between 10.5±4.5 cm was not found (Figure 1). The majority of female mudskipper length was 6.9±0.6 cm. The length size around 10.3±1 cm is not found (Figure 2). The distribution of female *P. barbarus* is higher than male and the size for male was 10.5 + 4.5 cm and for 10.3 + 1 cm was not found due to the spawning at the time, so the *P. barbarus* were keeping their nests. In accordance with Nash (1984); Silva and Gordo, 1997 explained that during the spawning period, the existence of female and male fish was decreased.

The female mudskipper with the big size is rarely found than that of the small fish. It indicates that there is size degradation cause natural mortality in the male mudskipper as 53.14% and female as 52.54%. The exploitation of male and female mudskipper as medicine is around 83.77% and 80.77%, respectively. See Figure 3 and 4.

Von Bertalanffy model

Von Bertalanffy model based on age structure explain about correlation between total length of male *P. barbarus* and growth rate. The

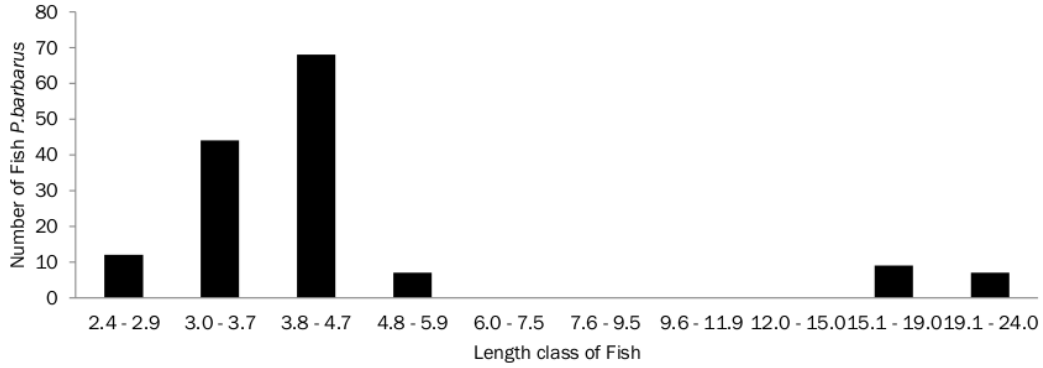

Figure 1. Distribution structure length of male *P. barbarus* in KKMB

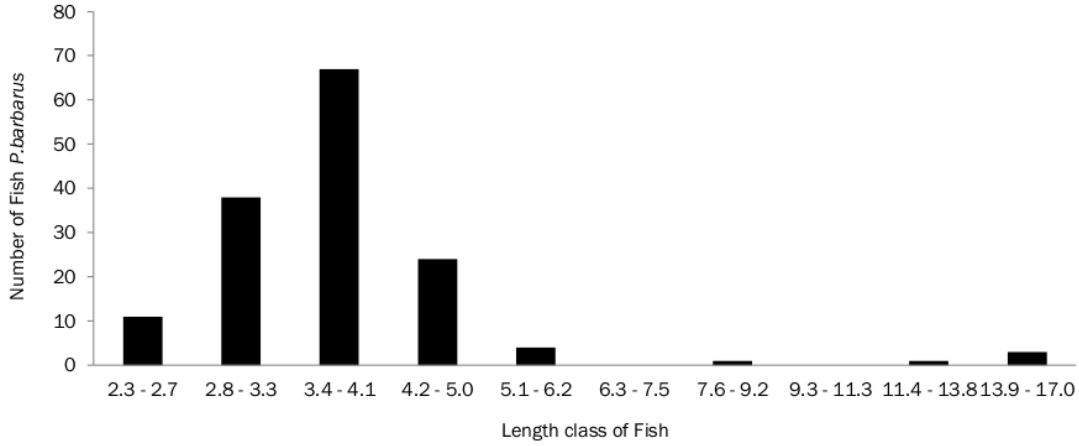

Figure 2. Distribution structure length of female *P. barbarus* in KKMB

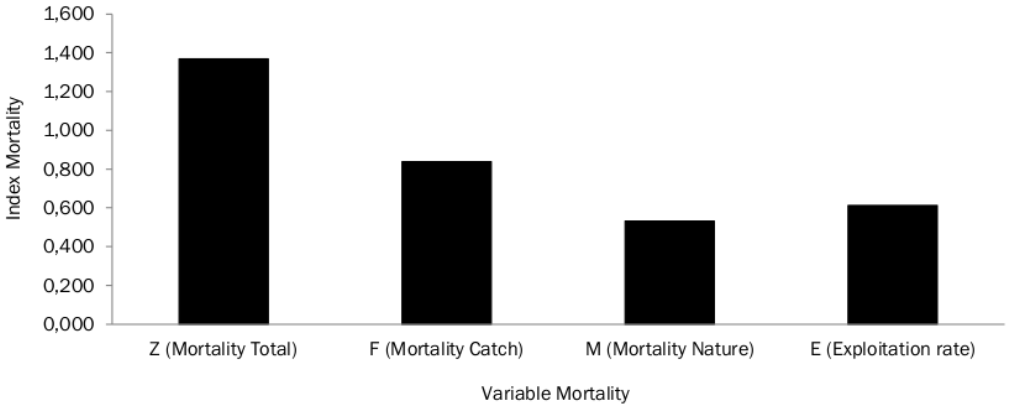

Figure 3. Mortality variable of male *P. barbarus* in KKMB

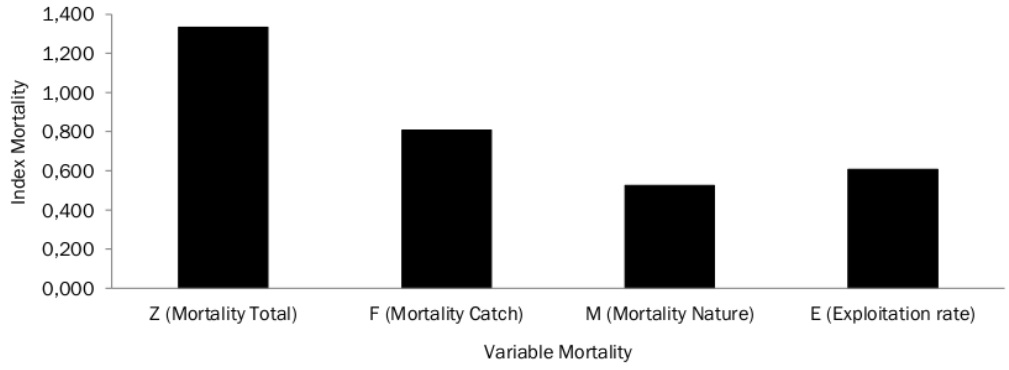

Figure 4. Mortality variable of female *P. barbarus* in KKMB

result of regression linier between of them was y = -0.0593x+1.574 with 69.79% correlation (Figure 5) and The orthogonal polynomial equation 6th type was $y = -1E\text{-}11x^6+1E\text{-}08x^5-3E\text{-}06x^4+0.0004x^3-0.032x^2+1.3449x+2.1525$ with 99.99% correlation (Figure 6). Then, for female *P. barbarus*, the regression equation between total length and growth rate was y = -0.0719x+1.265 with 75.68% correlation (Figure 7). The orthogonal polynomial equation 6th type was $y = -1E\text{-}11x^6+1E\text{-}08x^5 - 3E\text{-}06x^4 + 0.0004x^3 - 0.032x^2 + 1.3449x+2.1525$ with 99.99% correlation (Figure 8).

The regression graphic in figure 5 and 7 leads toward the axis. It indicates that the maximum length of male *P. barbarus* was 26.545 cm, with growth rate was 0.0593cm.day^{-1} (Figure 5.). The maximum length of female *P. barbarus* was 17.594 cm, with growth rate was 0.0719 cm.day^{-1}. However, the previous research by Firdaus and Salim (2018) about the maximum total length of male mudskipper was 27.374 cm with growth rate 0.0147cm.day^{-1}. The maximum of female mudskipper was 20.683 cm, with growth rate 0.00262 cm.day^{-1}. The comparison of data in 2015 and 2017 explain that growth of male and female mudskipper degrades. Furthermore, the degradation of maximum length growth of male and female mudskipper was 0.829 and 3.089 cm, respectively. The amount of mudskipper population in 2015 and 2017 was 375 and 296, respectively. It indicates that there is a degradation population. This is in accordance with Salim *et al*., (2018) stated that there was decreasing of species amount and for body shape of *P. barbarus* was allometric negative due to competition in looking for food. However, the condition of Aquatic environment can affect the degradation of the species amount, one of them was in KKMB, Tarakan, there was a changing of river shape, like sedimentation and water pollution around the area cause the accumulation of plastic waste.

Variable growth of allometric and index condition

The result of allometric growth about correlation between length and the total weight of male mudskipper dominated with positive allometric (b value >3). The allometric growth of the female mudskipper is dominated by negative allometric (Figure 9) due to the feed competition in the habitat and energy to avoid the predator. Haris *et al*. (1999), explain that the growth of *P. barbarus* is affected by the environment system, like food availability, salinity, pH, and temperature. The research of Firdaus and Salim (2018) explain that characteristic of male and female mudskipper is negative allometric. Latif (2016) clarifies that the research result of male and female mudskipper in KKMB, Tarakan City is positive allometry. Based on (Effendie, 1979), Figure 9 shows that if b value = 3, the growth characteristic is isometric. If b value < 3, the growth characteristic is negative allometric. If b

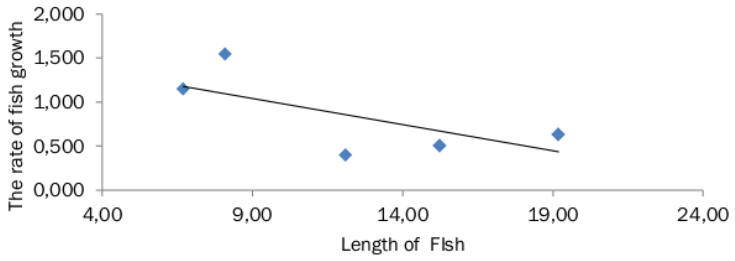

Figure 5. Von Bertalanffy relationship growth model and length of male *P. barbarus*

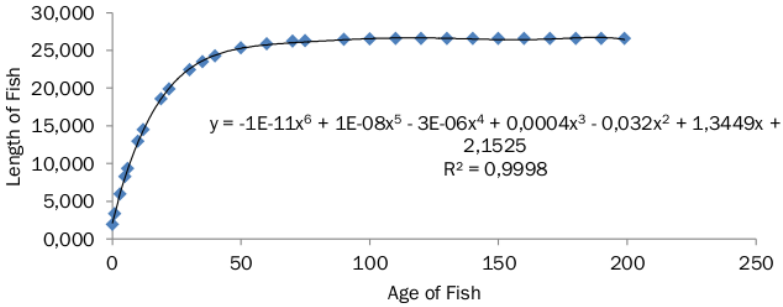

Figure 6. Von Bertalanffy polynomial orthogonal type 6 model of male *P. barbarus*

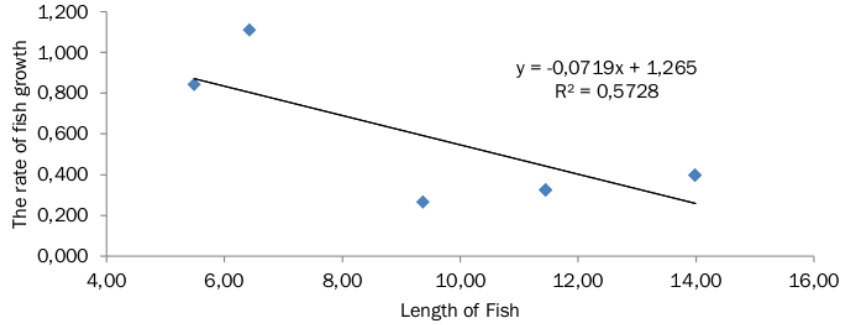

Figure 7. Von Bertalanffy relationship growth model and length of female *P. barbarus*

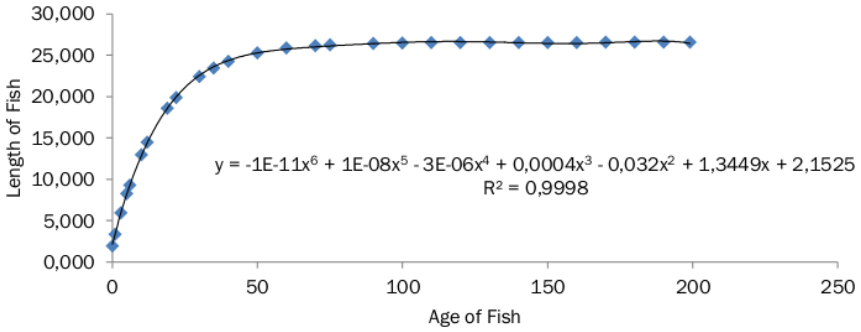

Figure 8. Von Bertalanffy polynomial orthogonal type 6 model of female *P. barbarus*

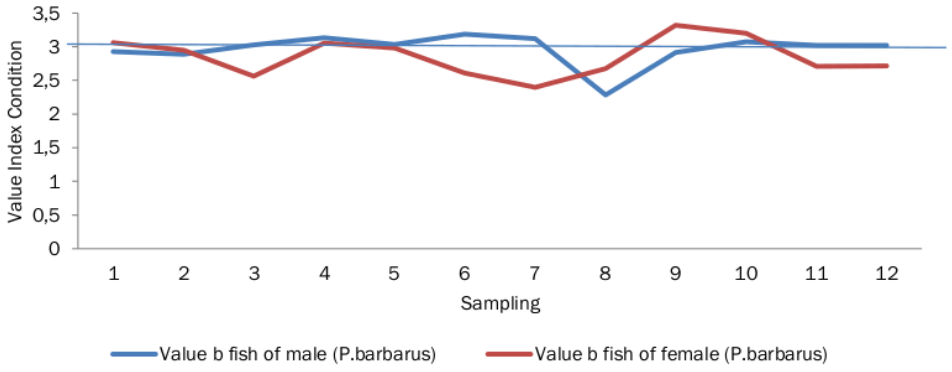

Figure 9. The Comparison of allometric growth in male and female

value >3, the growth characteristic is positive allometric. Figure 9 indicates that the average of the male *P. barbarus* growth is positive allometric; it corresponds to the condition index in figure 10. The average of male mudskipper body shape is fat. It is the difference with female *P. barbarus*, which has negative allometric, has fat and flat body shape. (Muchlisin *et al*., 2010) explained that fish growth patterns were influenced by food availability and water conditions. The coefficient value (b) was influenced by fish behavior, where the active one showed value of (b)<3 than passive (b>3). Probably, it related to the allocation of energy expended for its movement and growth (Muchlisin *et al*., 2010).

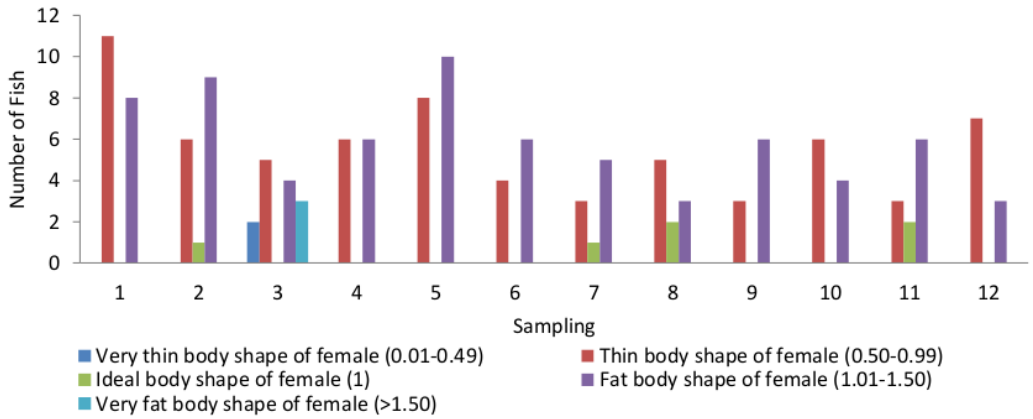

Figure 10. The body shape of female *P. barbarus*

Mortality variable

Mortality variable of the mudskipper consists two kinds. There are fishing and natural mortality. The requirement of *P. barbarus* as medicine and research object increased fishing mortality. In this research, the fishing mortality of male and female mudskipper was 83.77% and 80.77% every year, respectively. Natural mortality is caused by environment pollution, virus, bacteria, and predator. The natural mortality of male and female mudskipper is 53.14% and 52.54% every year, respectively. The exploitation rate of male and female mudskipper is 61.19% and 60.59% every year. The fishing category of *P. barbarus* is allowed, based on Nikijuluw (2002). The Maximum Sustainable Yield (MSY) is 80%.

Conclusion

The conclusion of this research about the mudskipper in Mangrove and Bekantan Conservation area, Tarakan city are the male and female mudskipper growth sustained size degradation and amount of population. The length maximum of male *P. barbarus* was 26.545 cm, with the growth rate was 0.0593 cm.y^{-1}. The length maximum of female *P. barbarus* was 17.594 cm, with the growth rate was 0.0719 cm.y^{-1}. The growth characteristic of male mudskipper was positive allometric with fat body shape. The growth characteristic of female mudskipper was negative allometric with round body shape. The natural and fishing mortality of male mudskipper is higher than that of the female. The category of exploitation rate of male and female mudskipper is allowed.

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