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Food habits of three species of mudskippers in the Musi River Estuary, South Sumatra, Indonesia

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Abstract. *Ridho MR, Patriono E, Sholikah M. 2019. Food habits of three species of mudskippers in the Musi River Estuary, South Sumatra, Indonesia. Biodiversitas 20: 2368-2374.* This study provided understanding of morphometric variation and diet composition of three species of mudskippers, i.e. *Boleophthalmus boddarti*, *Periophthalmodon schlosseri,* and *Periophthalmus chrysospilos.* The data obtained can be used for fish cultivation in the future. The relation of weight and length of species *B. boddarti*, *P. schlosseri* and *P. chrysospilos* had a correlation of 72.2%, 98.2%, and 94.5% , respectively with the value of b = 1.474, 3.189, and 2.271, respectively. This suggests that the growth patterns of *B. boddarti* and *P. chrysospilos* are allometrically negative, while *P. schlosseri* is allometrically positive. *B. boddarti* is classified as a herbivore, the main food of phytoplankton from Bacillariophyceae class with percentage 100%; 80% of Chlorophyceae; 95.6% of Cyanophyceae; 13.33% of Desmidiaceae; 13.33% of Euglenophyceae and 37.78% of Xanthophyceae. *P. schlosseri* is classified as carnivores, the main food is *Uca* sp. with IRI of 17.131.45% and complementary food of *Lycosa* sp. with IRI of 80.79%. *P. chrysospilos* is alsoclassified as carnivores with the main food is fish eggs with IRI of 8057.07% and complimentary foods of *Uca* sp. with IRI of 1935.3%.

Keywords: Allometric, estuary area, food behavior, Indonesian waters, mudskipper

INTRODUCTION

Mudskippers or oxudercine gobies are amphibious fishes native to the Indo-West Pacific and tropical western Africa (Jaafar and Murdy 2017), They occur along the muddy shores of the intertidal areas in estuarine habitats and mangrove swamps of the Indo-Pacific region (Tytler and Vaughan 1983). The mudskipper has the form of morphological adaptation to their dry dwellings at low tide. Its behavior is very dependent on the rhythm of the tides. Mudskipper fish's ability to adapt in two different habitats making it more like amphibians (Hong et al. 2007). Based on Al-Behbehani and Ebrahim (2010) mudskipper can survive in tidal areas because it has the ability to safety through the skin and mucous membrane layer in the mouth and throat.

The high nutrition in the meat of Mudskipper fish makes this fish economically valuable in various countries (Akinrotimi et al. 2013). Mudskipper fare also consumed by fishermen in India as traditional medicines to eliminate frequent urination in children (Muhtadi et al. 2016; Kanejiya et al. 2017). According to Purwaningsih et al. (2014), mudskipper fish is known to have nutritional levels in the form of essential amino acids (9.37% lysine; 8.22% leucine, and 4.97% valine) and non-essential amino acids (glutamate 16.92%, aspartate 10.71%. and alanine 6.04%) so it is good for health.

Meanwhile, the use of mudskipper in Indonesia is still very small, even Indonesia has a subtidal region that strongly supports the existence of Mudskipper fish, one of which is in the waters of the Musi River estuary. Sungsang Villages is one of the villages located in the estuary area of the Musi River, where mudskipper is often found. However, the data from the research on the Mudskipper fish in the Sungsang Village estuary are still very limited, a lot of research focuses on the distribution (Pormansyah et al. 2019) and type of species (Iqbal et al. 2018). Especially regarding their food habits be one cause of the lack of utilization of fish Mudskipper. Therefore, it is necessary to carry out research on the food habits of mudskipper in the vicinity of the Sungsang Villages estuary which includes length, body weight, type of fish and food so that it can be seen the type of food from the fish caught in the area. The data obtained can be useful for the development of future fish farming.

MATERIALS AND METHODS

Study area

Sampling was carried out in March-April 2018 in the Musi River estuary of Sungsang II Village, Banyuasin Regency, South Sumatera. Sample analysis was carried out in March 2018 until May 2018 at the Laboratory of Animal Physiology, Department of Biology, Faculty of Mathematics and Natural Sciences, Sriwijaya University, Indralaya, Indonesia.

Research methods

This research is a quantitative descriptive study using direct observation methods. Determination of locations was done by exploratory method and sampling was conducted by the random method with direct observation in the field. Data analysis was performed using the relative index method to determine the percentage composition of feed in the stomach.

Procedurs

Sampling and handling

Fish sampling was done in in the Sungsang Village estuary in Banyuasin Regency by using a random sampling method, so that each Mudskipper fish has the same opportunity to be taken as a sample, both from the sex and body size. The number of fish taken 30 individuals. This is related to the standard normal distribution (Z). According to Hanafiah (2006), if the number of samples is more than 30 individuals, it can be assumed that the population and distribution of populations is normal.

Mudskipper fish werecaught using fishing rods, snares and, dikes. The caught Mudskipper fish is then put into a bottle containing 40% formalin. Furthermore, the fish is wrapped in gauze, which functions to absorb formalin. The left and right sides of the fabric are tied using rubber, then put in the cooler box. Food analysis and identification of fish samples were carried out at the Laboratory of Animal Physiology, Biology Department, Sriwijaya University.

Measurement of water physical and chemical parameters

Measurement of physical-chemical parameters of the water was carried out by taking water samples.The water temperatures were measured directly using Thermometer ASTM 1C and TDS pen meter tester 0-9990 PPM. pH value was measured using BFVV Digital PH Meter, DO was measured using Lutron DO-5510 Dissolved Oxygen Meter, and salinity was measured using a Refractometer Brix 58-90%.

Sample analysis in the laboratory

The wrapped mudskipper fish is opened and washed with clean water. Then the length and weight of the fish are measured. The total length of the fish is measured from the tip of the front head until the tip of the tail fin is retarded using a ruler with an accuracy of 0.1 cm. The total weight of the fish is weighed using a digital scale with a precision level of 0.001 grams.

After measuring length and weight, the fish is dissected using surgical scissors. The surgery starts from the anus to the upper part of the abdomen along the dorsal front to the back of the operculum, then ventral to the base of the abdomen. The digestive tract is separated from other organs. The stomach and fish intestines are measured in weight, then put into a sample bottle to be preserved using Gilson's solution. The part of the stomach and intestine is preserved, then the stomach contents are weighed by the weight and volume of the stomach. After that, the gastric contents were examined using a microscope. Then the organisms obtained were identified using a book identifying plankton and benthos by Davis (1955), Yama (1966), Gosner (1971) and Mizuno (1979).

Data analysis

Stomach content analysis

The composition of whole stomach contents and mucus was analyzed, , then the weight of the stomach contents and frequency of occurrence of each type food were measured. According to Pineas et al. (1971), food habits value was determined using an index of relative importance (IRI) formula, as follows:

$$IRI = (N + V)\ F$$

Where: IRI is Index of relative importance, N is numerical percentage, V is volumetric percentage, and F is Frequency of occurrence percentage. Formula of Event Frequency is :

$$F = \frac{\textit{The number of stomachs containing the food type of "A"}}{\textit{The total amount of stomach studied}}\ x\ 100\%$$

Gastric fullness index

Calculation of gastric fullness index (ISC) determined fish feeding activities by calculating the ratio between the weight of the stomach contents and the total weight of the fish for each sampling. The measurement of ingested food weight (FW) is expressed as a percentage of total fish weight (W) according to the formula defined by formula Hureau (1969); Sulistiono (1998), where ISC is the Gastric fullness index (fullness index).

$$\mathbf{ISC = \frac{FW}{W} x100}$$

Long relationship with weight

According to Effendie (1997), the relationship between length and weight is analyzed by the general formula, as follows:

$$W = a\ L^{b}$$

Where: W is weight fish, L is fish length, a and b are constants

Condition factor

The condition factor is defined as the state of the fish which is expressed in the figures based on the data length and weight. The condition factor indicates the state of the fish, both in terms of physical capacity to live as well as for reproduction (Effendie 1997). The condition factor (K) is determined based on the length and weight of the fish. If b $\neq$ 3, then the condition factor is calculated using the calculation formula according to Sulistiono (1998).

$$\mathbf{K = \frac{W}{a\ L^{b}}}$$

Where: K is factor relative conditions of each fish, W is average weight, L is total fish length, a and b are constants

RESULTS AND DISCUSSION

Feed composition and index of relative importance (IRI)

Mudskipper fish has a variety of types but have many similarities in morphology. The difference in the types of Mudskipper fish can be seen from the difference in food. Some types of fish are classified as omnivorous, eat small crustaceans and plant material. However, there are also fish that are including herbivores, benthic algae eaters and carnivores that eat crabs, insects, snails and even other fish.

Boleophthalmus boddarti

Boleophthalmus boddarti has stomach and intestine that can be clearly distinguished. The average gastric length of *B. boddarti* is 2.33 cm, and intestinal length averages is 16.44 cm with the longest intestine reaching 44.3 cm (Figure 1).

Periophthalmodon schlosseri

The body of *P. schlosseri* is brownish with black lines along the eyes to the tail. This species has a large head, wide mouth openings with easily visible sharp teeth. The stomach and intestines cannot be distinguished, short, thick, coated with fat and mucus. The intestine is shorter than the length of the body (Figure 3). Intestinal length ranged from 2.02-9.82 cm while body length ranged from 5.66-21.8 cm. There are two types of food in the stomach of *P. schlosseri*. of the total 30 observed fish, only 9 were filled with hulls, of them 8 hulls contain *Uca* sp. (crabs) and one other stomach containing spider (*Lycosa* sp.). The food habits of the fish gelodok *P. schlosseri* based on the calculation of the index of relative importance (IRI) are presented in Figure 4.

Periophthalmus chrysospilos

Periophthalmus chrysospilos has brownish and golden spots. The wide mouth opening of *P. chrysospilos* with small sharp teeth. The stomach and intestines are indistinguishable, shorter than the length of the body (Figure 5), thick and slimy, but not as thick as the intestine *P. schlosseri*. Intestinal length ranged from 1.55-5.71 cm while body length ranged from 6.55-11.29 cm. According to Meliawati et al. (2014), generally carnivorous fish have pointed teeth, relatively short intestines, eat meat or animals, thick intestinal walls and non-dense gill filters.

There are two types of food in the *P. chrysospilos* type of stomach fish obtained. Of the total 31 caught fish , only 6 were filled with hulls. Where 3 hulls contain *Uca* sp. with a total volume of 0.08 mL and 3 stomachs containing 0.13 mL of fish eggs. The food habits of the fish Mudskipper species of *P. chrysospilos* are determined based on the calculation of the index of relative importance (IRI) present in Figure 6.

Stomach fulfill index

Boleophthalmus boddarti

Value of the relative feed consumption level of *B. boddarti* is presented in Figure 7. The level of feed consumption of, *B. boddarti* has a fluctuating value comparing to the size of the body length. *B. boddarti* with a size of 8-13.99 cm has a relative feed consumption value of 0.702%. While, *B. boddarti* with a medium size is 26-31.99 cm has higher food consumption value (3.256%). Whereas, the largest *B. boddarti* with a size of 44-49.99 cm has thelowest feed consumption value, which is 0.05%.

Periophthalmodon schlosseri

The value of feed consumption level is relatively high in the long fish class of *P. schlosseri*. presented in Figure 8. Based on Figure 8, related to the level of feed consumption based on the size of body length (cm) the type of mudskipper *P. schlosseri*. has a fluctuating value. *P. schlosseri*. with an equivalent size of 5-7.99 cm, the relative feed consumption value is 0.565%. *P. schlosseri*. with a medium size of 11-13.99 cm and 14-16.99 having relative feed consumption values of 1.022% and 0.088%. Whereas *P. schlosseri*. with the largest size, 22-22.99 cm, the value of feed consumption is relatively low, which is 0.480%.

Figure 1.A. Comparison of body length and intestine length of *Boleophthalmus boddarti*; B. Form of teeth and mouth *B. boddarti*

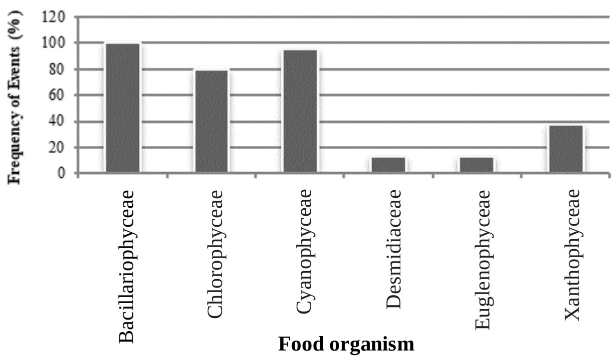

Figure 2. *Boleophthalmus boddarti* food composition

Table 1. The relationship of the length of the weight of the mudskipper fish by type

Species	Equation W	b	R^2	R
B. boddarti	$W = -1.101 \times L^{1.474}$	1.474	0.522	0.722
P. schlosseri	$W = -5.112 \times L^{3.189}$	3.189	0.965	0.982
P. chrysospilos	$W = -13.69 \times L^{2.271}$	2.271	0.892	0.945

Table 2. Mudskipper fish by condition factors

Species	Length average	Weight average	Range of FK	Average of FK
B. boddarti	14.33 cm	18.83 g	0.21-1.84	1.09
P. schlosseri	15.12 cm	45.14 g	0.6-1.7	1.02
P. chrysospilos	8.95 cm	6.63 g	0.78-1.22	1

Periophthalmus chrysospilos

The value of the relative feed consumption level based on the length size of the *P. chrysospilos* is presented in Figure 9. Based on Figure 9, it is known that the level of relative feed consumption based on the body size (cm) of *P. chrysospilos* also has a fluctuating value. The smallest size of *P. chrysospilos* is 6-6.99 cm with a relative feed consumption value of 0.178%. Medium-sized *P. chrysospilos*, 8-8.99 cm and 9-9.99 have relative feed consumption values of 0.377% and 0.191%. While the largest size of *P. chrysospilos*, 11-11.99 cm, has a relatively low feed consumption value, which is 0.277%.

Long weight relationship

Based on the results of the analysis of the length and weight of the type of *B. boddarti* fish (Table 1), it can be seen that the length and weight relationship model is W = -1,101 x L1,474 with a value of b of 1,474. *P. schlosseri* has a model of the equation of length and weight, namely W = -5,112 x L3,189 with a value of b of 3,189. The growth pattern of *P. schlosseri* is classified as positive allometric growth, which means that weight gain is faster than the growth in body length. This is in accordance with the study of Ramadhani et al. (2014) with a value of b = 3.1.

Condition factor

The condition factor shows the good condition of the fish in terms of physical capacity for survival and reproduction. The condition factor is calculated to assess fish health in general, productivity and physiological conditions of fish populations. The results of the condition factor analysis (FK) of Mudskipper fish around the Sungsang II estuary, Banyuasin II Subdistrict, Banyuasin District, South Sumatra ranged from 0.21-1.84 for *B. boddarti*, 0.6-1.7 for *Pn. schlosseri* and 0.78-1.22 for *P. chrysospilos* with a mean of 1. The average condition of *B. boddarti* conditions was 1.09 and *P. schlosseri* of 1.02 (Table 2). The value of the condition factor that approaches or exceeds 1 indicates that the three types of fish are in good condition for survival and breeding.

Feed composition and index of relative importance (IRI)

Boleophthalmus boddarti

Intestinal length in this fish is greater than body size (Figure 1), indicating that *B. boddarti* is a herbivorous fish. According to Kamal et al. (2009), the ratio of intestinal length to body length of herbivorous fish tends to be greater than omnivores and carnivores. By knowing that *B. boddarti* is a herbivorous fish, the analysis of gastric contents is carried out by the method of Event Frequency. The number of one type of food identified was compared with the total number of stomachs studied and expressed in percent. According to Effendie (1979), by looking at the frequency of events it will be known what types of organisms are eaten, but do not pay attention to the quantity or number of organisms eaten. The composition of *B. boddarti* food is based on the results of the analysis using the frequency event method which is related to the food habits presented in Figure 1.

Based on Figure 2, it can be seen that *B. boddarti* fish stomach contained phytoplankton from Bacillariophyceae, Chlorophyceae, Cyanophyceae, Desmidiaceae, Euglenophyceae, and Xanthophyceae. The six types of food have different frequencies, including 100% for Basillariophyceae; 80% for Chlorophyceae; 95.6% for Cyanophyceae; 13.33% for Desmidiaceae; 13.33% for Euglenophyceae and 37.78% for Xanthophyceae. This is in accordance with the results of Wilis (2012) and Ravi (2013) who stated that *B. boddarti* including herbivorous fish because of stomach contents dominated by benthic algae, mainly diatoms.

A B

Figure 3.A. Comparison of intestine length and body length of *Periophthalmodon schlosseri*; B. Form of teeth and mouth *P. schlosseri*

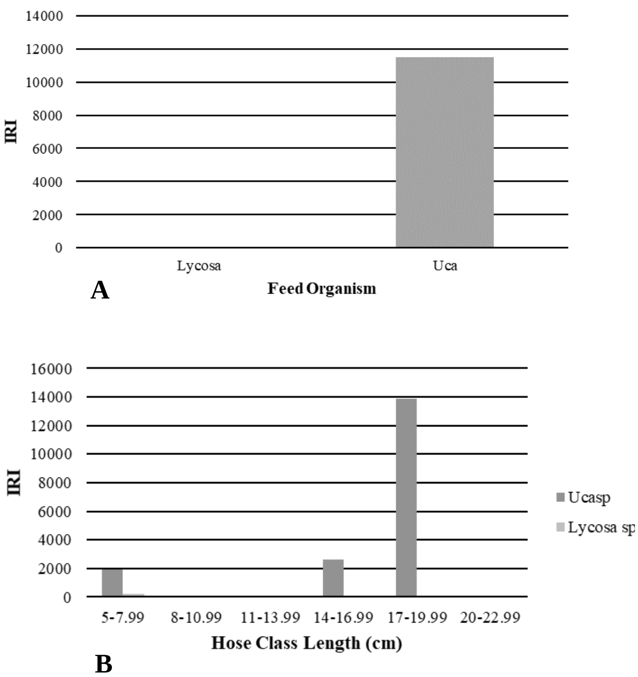

Figure 4. Relatively important index of *Periophthalmodon schlosseri*. A. Overall; B. Based on body length

Periophthalmodon schlosseri

This species has a wide mouth opening with sharp teeth that are clearly visible. According to Meliawati et al. (2014), pointed teeth and small intestines are characteristic of carnivorous fish. The index of relative importance (IRI) of the population of *P. schlosseri* shows that the composition of *Uca* sp. amounting to 11872.19 and *Lycosa* sp. amounting to 71.53 %. In grouping long-size class hoses, *Uca* sp. is found in the intestine of *P. schlosseri* with an IRI of 1833.7 in the range of 5-7.99 cm, 2704.2 in the long-range 14-16.99 cm and 13970.6% in the long-range 17-19.99 cm. Whereas *Lycosa* sp. only in the range of 5-7.99 cm with an IRI of 242.4. Zulkifli et al. (2012) reported that the most gastric contents of the *P. schlosseri* are fish and crabs, which are identified as *Uca* sp., *Oryzias* sp., and juvenile fish.

Uca sp. is much eaten by *P. schlosseri* because the amount of this species is abundant and has the same habitat on muddy substrates. Although the results of benthos sampling in Sungsang II Village were zero (no organisms were obtained, including *Uca* sp.), This was due to benthic sampling carried out in water-submerged mud, while *Uca* sp. in mud that is not submerged in water. According to Hidayaturrahmah and Muhamat (2013), the main food source of *P. schlosseri* is crabs for fish found in watersheds. This is supported by the presence of hives and activities of *P. schlosseri* adjacent to the nest and crab activity.

Periophthalmus chrysospilos

Periophthalmus chrysospilos has the first dorsal fin tip is white-black. Muhtadi et al. (2016) stated that in the first dorsal fin *P. chrysospilos* has black on the upper part then white on the bottom, the second dorsal fin has gold colored spots accompanied by black lines (Figure 5). Based on Figure 6, it can be seen that the results of the calculation of the index of relative importance (IRI) of *P. chrysospilos* indicate that the composition of *Uca* sp. amounting to 1935.30 and fish eggs at 8057.07. The size of the body length of the six individuals is in the class interval 6-7.99 to 9-10.99 cm. This is in accordance with the results of Gosal et al. (2013) and Chukwu and Deekae (2013) that the genus *Periophthalmus* including the type of carnivorous fish with its dominant food are crustaceans, insects, fish eggs, and other fish larvae.

Stomach fulfill index

The index analysis of gastric fullness was used to determine the relative consumption of fish feed by comparing the weight of gastric contents with the total weight of fish. According to Sulistiono et al. (2010), the gastric fullness index is relatively different for each type and size of fish determining the level of activity in foraging. The smaller the standard deviation value, the smaller the difference in gastric content or the more empty stomach contents.

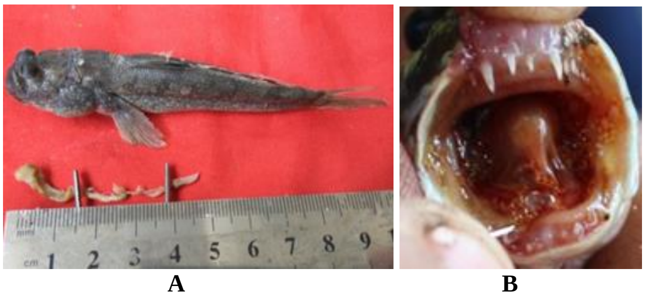

Figure 5. A. Comparison of the length of intestine with the body length of *P. chrysospilos*, B. Shape of the teeth and mouth of *P. chrysospilos*

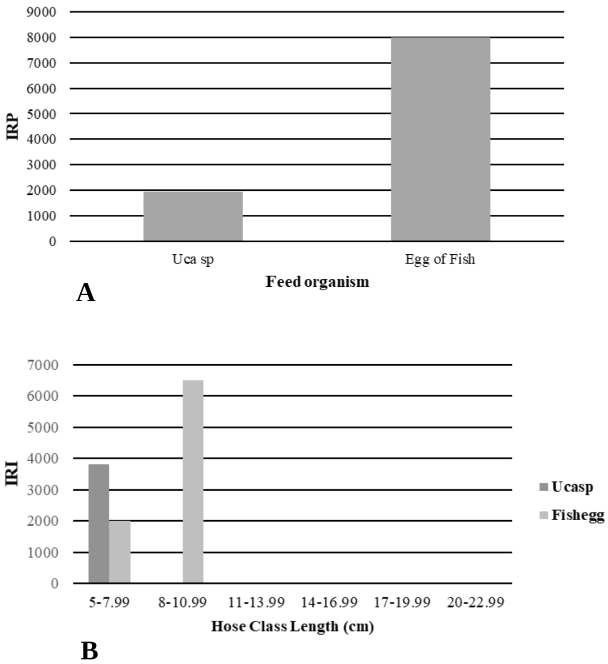

Figure 6. Relatively important index of *Periophthalmus chrysospilos*. A. Overall; B. Based on body length

Long weight relationship

Boleophthalmus boddarti fish has a length and weight relationship model is W = -1,101 x L1,474 with a value of b of 1,474. The value of b < 3 indicates a growth pattern of *Boleophthalmus* bod, which is classified as negative or long faster than the weight gain. This is in accordance with the results of the research by Bidawi et al. (2017) in Pulau Sembilan Village, Langkat Regency, North Sumatra Province with results of b = 2.7367 which states that long growth is more dominant than weight. However, this is different from the results of the study of Ramadhani et al. (2014) on Bali Beach, Masjid Lama Village, Talawi District, Batu Bara Regency, North Sumatra Province, which states that the growth pattern of *B. boddarti* is positive with a value of b = 3.06.

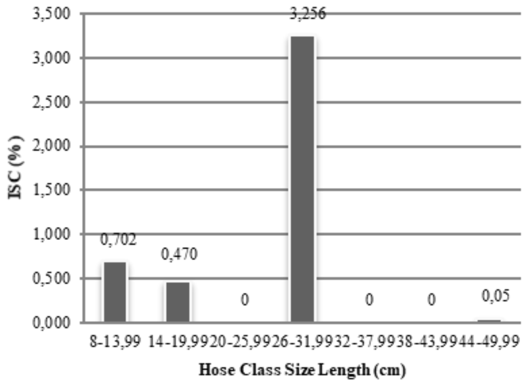

Figure 7. Value of the relative feed consumption level *Boleophthalmus boddarti*

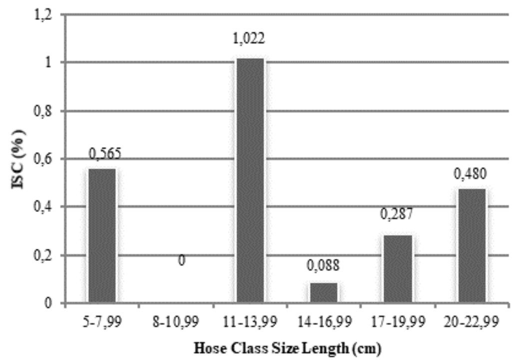

Figure 8. Value of relative feed consumption rate *Periophthalmodon schlosseri*.

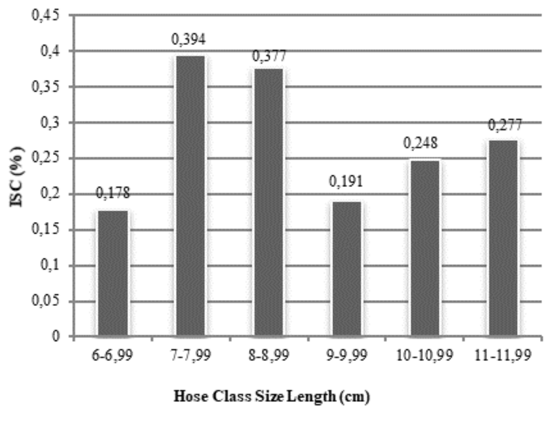

Figure 9. Value of relative feed consumption rate *Periophthalmus chrysospilos*

The equation model of the relationship of length and weight of *P. chrysospilos* is W = -13.69 x L2,271 with a value of b of 2,271. The pattern of growth of *P. chrysospilos* is classified as negative allometric growth, where the value of b < 3, which means long growth is more dominant than the weight gain. This is in accordance with the results of the research by Bidawi et al. (2017) that the pattern of growth of *P. chrysospilos* is negative allometric, with a value of b of 2,953. But the results of the study of Ramadhani et al. (2014) showed that the pattern of growth of *P. chrysospilos* was positively allometric with b = 3.26.

Condition factor

The biggest condition factor is the type *B. boddarti* which is the most found. According to Bidawi et al. (2017), the condition of fish conditions is not fixed. if in a water there is a sudden change in the condition of the fish, it can affect the condition of the fish condition. Poor conditions can be caused by overcrowded fish populations, so the possibility of a population reduction or food availability in the waters is quite abundant so that the population spreads. The condition factor can describe the loss of the condition of the fish. The plumpest fish of the three species obtained were *B. boddarti*, and *P. schlosseri*. The value of the condition of the conditions obtained from each type of Mudskipper fish shows a less flat body. According to Effendie (1997) in Ramadhani et al. (2017), if the condition factor ranges from 1-2, it shows the body of the fish is less flat.

The relationship between the length and weight of *B. boddarti*, *P. schlosseri*, and *P. chrysospilos* fish has a correlation of 72.2%; 98.2% and 94.5%, respectively, with a value of b = 1.474 for *B. boddarti*, b = 3.189 for *P. schlosseri* and b = 2,271 *P. chrysospilos*. This showed that the growth pattern of *B. boddarti* and *P. chrysospilos* is negative allometric, while *P. schlosseri* is allometric positive.

Boleophthalmus boddarti is classified as an herbivore, with different food frequencies, including 100% for Basillariophyceae; 80% for Chlorophyceae; 95.6% for Cyanophyceae; 13.33% for Desmidiaceae; 13.33% for Euglenophyceae, and 37.78% for Xanthophyceae. *P. schlosseri* is classified as a carnivore with main food is *Uca* sp. with the index of relative importance (IRI) of *Uca* sp. amounting to 11872.19 and *Lycosa* sp. amounting to 71.53%. *P. chrysospilos* types of fish are classified as carnivores, which mainly feed other fish eggs with an IRI of 8057.07 and complementary foods *Uca* sp. with an IRI of 1935.3.

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