Feeding habits and length-weight relationship of giant marbled eel *Anguilla marmorata* in the Brayeun River, Aceh Besar District, Aceh Province, Indonesia

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Abstract. Information on the feeding habit and length-weight relationship are crucial for fisheries management. Hence, the objective of the present study was to examine the feeding habit and length-weight relationships of the giant marbled eel *Anguilla marmorata* harvested from Brayeun River, Leupung sub-district, Aceh Besar District, Aceh Province, Indonesia. The survey was conducted from March to June 2017 (Rajab to Ramadhan 1438 Hijri Calendar). The sampling was done four times a month for three months on a dark night at new and old moons according to of lunar cycle (Hijri Calendar) for three months. A total of 38 eels were caught during the study and stomach content analysis showed that crabs and shrimp were the main food items for eel *A. marmorata*, while earth worms was a complementary food. This finding is indicating that *A. marmorata* is carnivorous. In addition, the length-weight relationship revealed that giant marbled eel had an allometric positive growth pattern, and the condition factors indicate the rivers are still in optimum condition and support fish life.

1. Introduction

There are at least 19 species of eels have been described in the world[1]where 7-9 species are found in Indonesian waters[2]. In Aceh, Muchlisin et al. [3]reported three species of eels based COX1 gene analysis, namely *Anguilla marmorata*, *A. bicolor*, and *A. bengalensis*. Eels are the commercial fish in Indonesia[4], the price of fresh eel was about USD 12-15 kg⁻¹ in the international market [5] and the price was increased significantly for processed eel, for example, *unagi kabayaki* the Japanese recipe food. In general, the market demand for eel was about 500,000 tons year⁻¹[6]; however, the supply is limited and very seasonally depending, because most come from the wild. Therefore, the development of the culture technology for the eels is crucially needed to meet the market demand without disturbing their native population.

The domestication process of the brood stock candidateis one of the critical steps in culturing wild fish[7, 8]; therefore, information on feeding habit and growth pattern of the fish in the wild are very crucial to provide suitable feed and monitoring their growth during in the aquaculture system. According Muchlisin et al. [9] stated that length-weight relationship is one of the crucial data to evaluate the ecological relationship among aquatic organisms and growth pattern of the fish in the
habitat as primary data to compare their condition in aquaculture system. While the information on the feeding habit is beneficial to provide and formulate the suitable feed for individual species in the culturing system.

Study on the feeding habit and length-weight relationship of the short fin eel *A. bicolor* in Banda Aceh waters, Indonesia has been reported by Sidqi et al. [10]; however, information for *A. marmorata* was not available. Therefore, the objective of the present study was to examine the feeding habit and length-weight relationship of the giant marbled eel *A. marmorata* harvested from Brayeun River, Leupung sub-district, Aceh Besar District, Indonesia.

2. Materials and Methods

2.1 Time and site
The survey was done from March to June 2017 (Rajab - Ramadhan 1438 Hijri) at three locations along Brayeun River, Leupung sub-district, Aceh Besar district, Aceh province, Indonesia. The first location was closed to downstream (95°15’13.86” E, 5°23’11.34” N), the second location in the middle stream (95°15’51.68” E, 5°22’19.20” N) and the third location in the upper stream at GPS coordinate of 95°17” 5.01 E, 5°22” 3.13 N. The sample was analyzed in Laboratory of Ichthyology, Faculty of Marine and Fisheries, Universitas Syiah Kuala, Banda Aceh, Indonesia.

2.2 Sampling procedure
The fish sample was caught using trap and fishhook. A total of 20 hooks and one trap were utilized in every sampling location. The sampling was done at dark night during new and old moons based on lunar rotation (Hijri calendar) from 18.00 PM to 06.00 AM for three months. The fishhooks and traps were monitored 3 hours interval. The sampled fish was photographed and preserved in the crush iced (4°C) then transported to the laboratory for further analysis.

2.3 Stomach content analysis
The fish sample was measured for total length (cm) using a digital caliper (Tricle Brand 150 MM/6”x0.05/1/128, error 0.1 mm), and weighed for body weight (g) using a digital balance (Dickson, TLS Serie, error 0.01 g). The abdomen of the fish sample was dissected using sterile scissors, starting from the anus up slightly upwards then towards the front. The digestive tract was removed carefully and then measured for the length of the intestine and stomach using the digital calipers. Then the gastrointestinal tract was dissected, and the contents were removed, and the materials were grouped according to the type of feed. The identification of the type of food was carried out until the lowest taxon as such as possible. Every type of food was calculated for the frequency of occurrence, volume, and weight.

2.4 Feeding habit analysis
The volume of the stomach content (volume metric) and the feed of incidence were calculated based on Biswas [11]. While the index of preponderance was calculated based on Effendi [12].

2.5 Length-weight relationship analysis
The length-weight relationship analysis was examine based on Linear Allometric Model (LAM) proposed by De-Robertis and William [13] as follow: \[ W = e^{0.56a}(L^b) \] where \( W \) is total body weight (g), \( L \) is total length (mm), \( a \) is an intercept regression, \( b \) is regression coefficient, \( e \) is residual variant of the regression, 0.56 = correction factor. Based on the \( b \) value of regression coefficient, the growth rate of the fish was divided into three categories, namely; allometric positive when the \( b \) value > 3.0, allometric negative when the \( b \) value > 3.0, and isometric when the \( b \) value = 3.0.

2.6 Condition factors analysis
Two types of condition factors were calculated, namely the relative weight and Fulton's condition factors. The relative weight condition factor was calculated based on Rypel dan Richter [14] as
follow: \[ Wr = \frac{W}{W_s} \times 100, \] where \( Wr \) is the relative weight condition factor, \( W \) is body weight (g), \( W_s \) is the prediction of the standard weight as calculated by \( W_s = aL^b \), where the Fulton condition factor was calculated based on Okgerman[15] and Muchlisin et al. [9] as follow: \[ K = \frac{W}{L^3} \times 100, \] where \( K \) is Fulton's condition factor, \( W \) is total weight (g), \( L \) is total length (mm), -3 is total length coefficient to make sure the \( K \) value tends to 1.

2.7 Data analysis
The data were presented in the tables or figures then analyzed descriptively based on previous reports, theories, and other relevant references.

3. Results and Discussion
3.1 Feeding habit
A total of 38 eel samples were caught during the sampling with the total length ranged between 22.0 cm to 59.5 cm resulted in the seven-length classes group (Table 1). The most eel samples had the length class of 28.1 cm - 33.3 cm or within the second length class group. Based on stomach content analysis, three types of foods were detected, namely; crabs, shrimps, and earthworms (Table 2, Figure 1). The study showed that crabs were predominantly based on temporal and spatial samplings (Table 3 and Table 4). There were no significant differences in food variation during the three months sampling where the dominant food item was the crabs followed by the shrimps and earthworms (Figure 1). Based on the length class group that crabs were the most preferred food by the giant marbled eel (Table 5). In addition, based on preponderance index showed that crabs and shrimps are the main food item for the giant marbled eel \( A. \) marmorata in the Brayeun River, Aceh Besar, Indonesia (Table 6) and therefore, the study indicates that the crab is an essential food item for giant marbled eel in Brayeun River.

Table 1. Distribution of fish sample based on the length class group of giant marbled eel in Brayeun River.

| No. | Length class (mm) | Total sample |
|-----|------------------|--------------|
| 1   | 228 – 280        | 5            |
| 2   | 281 – 333        | 17           |
| 3   | 334 – 386        | 6            |
| 4   | 387 – 439        | 9            |
| 5   | 440 – 492        | -            |
| 6   | 493 – 545        | -            |
| 7   | 546 – 598        | 1            |

| Total | 38 |

Figure 1. Stomach content of the giant marbled eel (a) crabs, (b) shrimps, (c) earthworm

Table 2. Total volume and proportion of food items in the stomach of giant marbled eel in Brayeun River

| No. | Food type        | Volumetric (Vi) |
|-----|------------------|-----------------|
| 1   | Erath worms      | 9.5             | 14.36 |
| 2   | Crabs            | 34.6            | 52.27 |
Table 3. Frequency of incidence of food items in the stomach based on sampling time according to lunar calendar (Hijri)

| No. | Lunar calendar (Hijri 1438 H and Gregorian 2017) | N | Frequency of incidence |
|-----|--------------------------------------------------|---|------------------------|
|     |                                                  |   | Earthworms (%)         |
|     |                                                  |   | Crabs (%)              |
|     |                                                  |   | Shrimps (%)            |
| 1.  | Rajab (29 March – 27 April 2017)                 | 12| 50                     |
| 2.  | Sya’ban (28 April – 26 May 2017)                 | 13| 38.47                  |
| 3.  | Ramadhan (27 May – 24 June 2017)                 | 13| 38.47                  |

Table 4. Frequency of incidence of food items in the stomach based on sampling location

| No. | Location               | N | Frequency of incidence |
|-----|------------------------|---|------------------------|
|     |                        |   | Earthworms (%)         |
|     |                        |   | Crabs (%)              |
|     |                        |   | Shrimps (%)            |
| 1.  | Lowe steam (estuary)   | 11| 63.64                  |
| 2.  | Middle stream          | 11| 27.28                  |
| 3.  | Upper stream           | 16| 37.5                   |

Table 5. Frequency of incidence of food items in the stomach based on length class group

| No. | Length class (cm) | N | Frequency of incidence |
|-----|-------------------|---|------------------------|
|     |                   |   | Earthworm (%)         |
|     |                   |   | Crabs (%)              |
|     |                   |   | Shrimps (%)            |
| 1.  | 22.8 – 28.0       | 5 | 40                     |
| 2.  | 28.1 – 33.3       | 17| 41.18                  |
3. 33.4 – 38.6 6 16.67 100 66.67
4. 38.7 – 43.9 9 66.67 88.89 33.34
5. 44.0 – 49.2 - - - -
6. 49.3 – 54.5 - - - -
7. 54.6 – 59.8 1 0 100 100

Table 6. Preponderance index (PI) of food items of the giant marbled eel in the Brayeun River

| No. | Food type     | Vi ml | %  | (Oi) Incidence % | Vi x Oi  | PI (%) |
|-----|---------------|-------|----|------------------|----------|--------|
| 1.  | Erath worm    | 9.5   | 14.36 | 16 42.11       | 604.23   | 9.45   |
| 2.  | Crabs         | 34.6  | 52.27 | 30 78.95       | 4126.26  | 64.46  |
| 3.  | Shrimps       | 22.1  | 33.39 | 19 50          | 1669.19  | 26.09  |
| Total|               | 66.2  | 100% | -    -          | 6399.67  | 100    |

Based on direct observation in Brayeun River showed that the crab was very abundant in the river and very easy to find it, and therefore the crab was very frequently found in the stomach of eel *A. marmorata* caught in the Brayeun River. According to Simanjuntak and Raharjo[16]and Muchlisin et al.[17]that the feeding habit of fishes strongly depends on the food availability in the habitat (waters), in this case, the crabs were highly available in the Brayeun River. However, the feed preference of fish is possibly changing seasonally influenced by the age, size and it availability as reported by Syahputra et al. [18] in lontok fish *Ophiocara Porocephala* and Zuliani et al. [19] in *Dermogenys* sp. Sidqi et al. [10] reported that the types of feed of short fin eel *A. bicolor* in Banda Aceh waters were diverse at smaller fish sizes, while larger eel fed only one type of food. However, there was no feeding habit changing in giant marbled eel *A. marmorata* in the Brayeun River as observed in this study where the crab was predominant whether based on class length and sampling time. Therefore, based on preponderance index revealed that the crab and shrimps are the main food for giant marbled eel *A. marmorata* in the Brayeun River.

3.2 Length-weight relationship and condition factors
The total length of the eel sample ranges from 22.8 cm to 59.5 cm with average length was 33.8±74 cm, body weight ranges from 21.4 g to 465 g with average body weight was 101.4± 82.2 g (Table 7), and the average b value was 3.23 indicate the positive allometric growth pattern (Figure 2). In comparing prediction growth versus observation, growth showed a similar trend (Figure 3) indicate that the *A. marmorata* is growing well. Based on a linear model showed that the determination coefficient (R²) was 0.963, this value indicate that this model can explain 96.3% of the variant and only 3.7% cannot be explained. The correlation coefficient (r) was 0.981, indicating a strong and positive correlation between length and body weight. In addition, the relative weight condition factor (Wr) ranged from 19.1 to 132.3 with the average value was 101.1± 13.2, and the Fulton condition factor ranged from 9.0 to 11.2 with the average value was 10.4± 0.4 (Table 7).

The similar finding was reported by Hartanto et al. [20] in *A. marmorata* caught in the Kabur River North Minahasa that had the allometric positive growth pattern, and in *A. bicolor* from Banda Aceh waters[10]. However, the contrary finding was reported in *Anguilla* sp. from Mosolo River Konawe isle that the eel had allometric negative growth pattern[21]. Differences in b value (growth pattern) are influenced by physiological conditions such as gonadal development and food availability [22], and environmental and geographical [23]. According to Muchlisin [9, 24]and Perdana et al. [25], that the coefficient of b is also influenced by the behavior of fish, for example, active swimming fish (pelagic fish) show the value of b tends to be lower when compared to fish that swim passively (mostly demersal fish), this may be related to the allocation of energy spent on swimming and growth.
Figure 3. (a) The linear model of the length-weight relation of the eel A. marmorata in Brayeun River showing $R^2 = 0.963$ and $r = 0.981$. (b) The prediction and observation growth patterns of the eel where one sample with the body weight higher than 44 cm is excluded from this analysis, and therefore only 37 samples are included in the analysis.

The condition factors indicate that the Brayeun River provides sufficient food stocks to the eel population and the prey-predator density is balanced [14]. According to Richter[26]and Batubara [27], the condition factor is one approach that is used to determine the pattern of fish growth, health, productivity and physiological conditions of fish populations. Furthermore, Rypel and Richter [14]stated that the condition factor also reflects the characteristics of the body morphology and fat content.

In addition to being influenced by food availability and predator density, the condition factor is also influenced by water quality and waters status, managed or not managed [28]. The measurement of dissolved oxygen and water temperature showed that these parameters were still relatively good, dissolved oxygen ranged from 6.55 to 8.22 ppm, temperatures ranged from 27.2 °C to 28.4 °C. According to Samsundari and Adhy[29]that eel is very fond of conditions of clear waters with the dissolved oxygen content of 7.5 - 9.0 ppm, the temperature is around 26.91 °C - 29.04 °C.

Table 7. The condition factor, b value, determination and correlation coefficients of the eel A. marmorata harvested from Brayeun River, Aceh Besar District, Indonesia

| No. | Parameters                                      | Values                          |
|-----|------------------------------------------------|---------------------------------|
| 1.  | Total length (cm)                               | 22.8 – 59.5 (33.8 ± 7.4)       |
| 2.  | Body weight observation W (g)                   | 21.4 – 465.0 (101.4 ± 82.2)    |
| 3.  | Body weight prediction, Ws (g)                  | 24.1 – 533.6 (101.3 ± 88.7)    |
| 4.  | The relative weight, Wr                         | 19.1 – 132.3 (101.1 ± 13.2)    |
| 5.  | The Fulton condition factor, K                  | 9.0 – 11.2 (10.4 ± 0.4)        |
| 6.  | The Determination coefficient, $R^2$            | 0.963                           |
| 7.  | The correlation coefficient, r                  | 0.981                           |
| 8.  | The slope coefficient of LAM model, b           | 3.23                            |
4. Conclusion
The giant marbled eel A. marmorata in the Brayeun River is carnivorous with main food is crabs and shrimp, while complementary food is an earthworm. The length and weight relationships showed a positive allometric growth pattern, and the condition factors indicate that the waters of the Brayeun River can support the existence of eel because the waters provide enough food and good water condition.

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