Feeding habit, length weight relationships and condition factors of the tropical shortfin eel *Anguilla bicolor bicolor* in Banda Aceh waters, Indonesia

M Sidqi 1, M A Sarong 2, A S Batubara, Zainal A. Muchlisin* 3

1 Master Program of Integrated Coastal Zone Management, Syiah Kuala University, Banda Aceh 23111, Indonesia
2 Department of Biologi Education, Faculty of Education and Teaching Training, Syiah Kuala University, Banda Aceh 23111, Indonesia
3 Faculty of Marine and Fisheries, Syiah Kuala University, Banda Aceh 23111, Indonesia
*Email: muchlisinza@unsyiah.ac.id

Abstract. The objective of the present study was to analysis the bioecology especially on the feeding habit and growth pattern of the tropical shortfin found in Banda Aceh waters. The survey from October 2016 to September 2017 was conducted in Banda Aceh at two locations, namely in the reservoir of Tibang (Banda Aceh) and Lambaro Skep. A total of 45 samples of eel were caught during the study. The minimum size is 31 cm length and 45 g body weight, while the maximum size is 80 cm in length and 1100 g body weight. Histological analysis of the gonad showed that all samples are female and immature fish. The analysis of the stomach content showed that 12 samples are emptied and 33 samples are containing feed, where the fish fed on crabs, shrimps, small fish, and earthworms. In details, the crab was found in 22 fish samples (66.66%), shrimp was found in 18 samples (54.54%), small fish was found in 14 samples (42.42%), and earthworm was recorded in 3 samples (9.09). Analysis of the length-weight relationship showed that the b value was 3.54 indicate a positive growth pattern with Fulton's condition factor (K) ranges 8.32 to 10.35 (average 9.32± 0.42) and relative weight condition factor (Wr) ranges 60.92 to 137.70 (average 101.60±16.67), indicates that environmental condition and predator density is stable.

1. Introduction

Eels (Anguilla sps.) are catadromous they grow in freshwater, and migrate to the sea for spawning then the larvae are return to river for growing [1]. Miller and Tsukamoto [2] stated that there were 19 species of eels in the world and some species of eels are reported to be threatened with extinction due to overfishing and habitat damage, resulted in decreasing the wild population [3]. According to Sugeha and Susanti [4] there were 7 species of eels found in Indonesian waters, where 3 species are recorded in Aceh waters [5] and one of this is shortfins eel *Anguilla bicolor*. *Anguilla bicolor* is widely distributed from the coast of Africa, India, Sri Lanka, Bangladesh, Myanmar, Northwestern Australia, Java and around the Mentawai Islands of West Sumatra [6].

Affandi [7] states that eel is a high-economic fishery commodity. This commodity has been exported to Japan, China, Germany and Italy. Hagesti et al. [8] states that China requires 70,000 tons of eels per year, but local production is only able to meet less than 30% (20,000 tons) of domestic
needs. Affandi et al. [9] states that Japan is the largest consumer of eel in the world. This country requires about 300,000 tons of eels per year.

As already mentioned earlier that there are at least 3 species of eel found in Aceh waters, namely A. marmorata, A. bicolor, and A. bangelensis. These species are of high economic value and have the potential to be cultured [10]. The potential for developing eel culture in Aceh is very large due to the abundance of glass eel in Aceh waters [11].

One area that has potency on eels resources is the north and west coasts of Aceh, including in the city of Banda Aceh, where the conditions of the waters are increasingly shrinking by settlement development and industries, this condition is threatening the eels population in this area. However, unfortunately, there was no record on the bioecology especially on feeding habit and length-weight relationships of eel fish in this area, this information is crucial as a basic information to plan a better conservation strategy. Therefore, the objectives of the present study were to analyze the feeding habits and length-weight relationship of the tropical shortfin eel harvested from Banda Aceh city waters.

2. Materials and Methods
2.1 Site and time
The sampling was conducted in Banda Aceh waters from October 2016 to September 2017. The sample was analyzed in Laboratory of Ichthyology Faculty of Marine and Fisheries, Syiah Kuala University, Banda Aceh, Indonesia.

2.2 Sampling
Sampling was conducted at two locations, namely; Tibang Reservoir and Coastal pond area of Lambaro Skep (Figure 1). While, the sampling points were determined purposively at locations that presumably to be presence of the eels based on information from local fishermen. The sampling was performed during old and new months based on lunar cycle when the night is dark. The fish sample was catches using fishhooks from 06.00 PM to 06.00 AM. The sampled eels were preserved in an icebox contains crush ice (4 °C) then transported to Laboratory of Ichthyology in Syiah Kuala University.

![Figure 1. The map of Banda Aceh city showing the sampling location (green cycles)
2.3 Feeding habit analysis

Feeding habit was analyzed based on stomach content. The stomach was removed from body cavity then the stomach was opened using a sterile scissor. The stomach content was put in a petridish then moved to a tissue paper to remove the water. The stomach contents (feed) were identified by eye naked and loupe, and then grouped based on the types. Each food item was identified to the lowest possible taxonomic level. Then after, the feed was weighed the weight and measured the volume. The gravimetry of the feed was calculated based on Aggrey et al.[12] as follow:

\[ \text{Gravimetry index} = \left( \frac{\text{weight of respective feed (g)}}{\text{total weight of the feed}} \right) \times 100 \] (1)

While, the feed volumetry was calculated based on Azadi et al. [13] as follow:

\[ \text{Vi} = \left( \frac{\text{volume of respective feed type}}{\text{Total volume of all feed types}} \right) \times 100 \] (2)

The frequency of occurrence was calculated based on Prasad and Rao [14] as follow:

\[ O_i = \left( \frac{N_i}{\sum N_i} \right) \times 100 \] (3)

Where, \( O_i \) is the percentage of frequency of occurrence of respective feed type, \( N_i \) is total of feed type-i, \( \sum N_i \) is total number of all feeds in the stomach.

The index preponderance was calculated based on Saikia et al. [15] as follow:

\[ I_i = \left( \frac{\text{Vi} \times O_i}{\sum \text{Vi} \times O_i} \right) \times 100 \] (4)

Where, \( I_i \) is index of preponderance, \( \text{Vi} \) is percentage of respective type-i feed item, \( O_i \) is Frequency of occurrence of one type of food, \( \sum \text{Vi} \times O_i \) is total \( \text{Vi} \times O_i \) of all type of the feeds.

Based on feed quantity in the stomach, the feed can be classified into three types, namely: (a) primary feed, when the Ii> 25%, (b) secondary feed, when Ii between 5-25%, (c) tertiary feed, when Ii< 5%.

2.4 Growth pattern and condition factor analysis

The fish sample was measured for the total length using a digital caliper (Mitutoyo, CD-6CS. Error = 0.01 mm) and weighed for body weight using a digital balance (Toledo, AB-204. Error= 0.01 g). The growth pattern was analyzed using Linear Allometric Model (LAM) based on De-Robertis and William [16] and Muchlisin et al. [17] as follow:

\[ W = e^{0.56 \frac{a}{L^b}} \] (5)

Where, \( W \) = body weight (g), \( L \) = total length (cm), \( a \) is the regression intercept, \( b \) 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. There are two condition factors calculated in this study, namely Relative weight condition factor (Wr) based on Rypel & Richter [18] and Fulton’s condition factor based on Muchlisin et al. [17].

3. Results and Discussion

A total of 45 samples of eels were caught in the Banda Aceh waters with the total length ranges from 31 - 80 cm and 45 -1100 g in body weight. Of these, 33 samples of their stomach contained feed and 12 samples was emptied. The stomach content analysis showed that there were four type of feed found in eel stomach, namely crab, shrimp, small fish and worms. Therefore, the eel \textit{Anguilla bicolor} is carnivorous fish. The crab was predominant (it was found in 18 eel samples or 66.66%) followed by
shrimp (it was found in 14 eel sample or 54.54%), and small fish (it was found in 14 eel samples or 42.42%) and worms (found in 3 eel sample or 9.09%) (Table 1 and Figure 2).

Based on sampling time, the crabs were found in all months of survey, except in November. Similarly, the shrimp were found in almost sampling months except in August and November, while worms were only found in January, February and May. In general, the highest types of feed were found in January to February and the lowest type of feed were found in August and November (Table 2). Based on the length class of the fish sample showed that crabs are the dominant type of food in length class I and II, but in the class III and VII the fish was predominant (Table 3). The results also showed that the types of feed were more diverse at smaller fish sizes, while those at larger eel were found only one type of food, fish (Table 3).

The field observations showed that crabs were found abundantly at the research location. According to Simanjuntak and Raharjo [19] that fish preference for food is influenced by the availability of these foods in waters. Based on the the preponderance index showed that crabs are the most important food item for eel in the waters of the city of Banda Aceh. A similar finding was also reported in the A. marmorata harvested from the Kabur River, East Likupang, North Minahasa [20]. Feeding habit of fish is possibly changing, it is influenced by age, availability and abundance of food sources in the water [21]. Research by Rupasinghe and Attygalle [22] on A. bicolor in the Bolgoda Estuary, Bandaragama, Sri Lanka showed that the eel fed on invertebrates when they are at smaller size and changes to piscivorous when they are larger.

Table 1. Frequency of occurrence of feed type based on monthly sampling.

| No | Months    | ∑Sample | ∑contain ed feed | Frequency of occurrence | ∑Feed type |
|----|-----------|---------|-----------------|-------------------------|------------|
| 1  | January   | 6       | 5               | Small fish  | %  | Worman | %  | Crab | %  | Shrimp | %  | %     |
|    | February  | 5       | 4               | Small fish  | 20 | 3      | 20 | 5    | 100 | 2      | 100 | 4     |
| 2  | March     | 5       | 3               | 75           | 1  | 0      | 0  | 50   | 100 | 1      | 100 | 3     |
| 3  | April     | 5       | 0               | 0            | 0  | 0      | 0  | 0    | 0   | 0      | 0   | 0     |
| 4  | May       | 5       | 0               | 0            | 0  | 0      | 0  | 0    | 0   | 0      | 0   | 0     |
| 5  | June      | 2       | 0               | 0            | 0  | 0      | 0  | 0    | 0   | 0      | 0   | 0     |
| 6  | July      | 2       | 0               | 0            | 0  | 0      | 0  | 0    | 0   | 0      | 0   | 0     |
| 7  | August    | 2       | 0               | 0            | 0  | 0      | 0  | 0    | 0   | 0      | 0   | 0     |
| 8  | September | 3       | 0               | 0            | 0  | 0      | 0  | 0    | 0   | 0      | 0   | 0     |
| 9  | November  | 4       | 0               | 0            | 0  | 0      | 0  | 0    | 0   | 0      | 0   | 0     |
| 10 | December  | 5       | 0               | 0            | 0  | 0      | 0  | 0    | 0   | 0      | 0   | 0     |
| 11 |           | 45      | 33              | 14           | 42.4 | 3     | 9.09 | 22   | 66.66 | 18 | 54.5  |

| No | Length class interval (cm) | N | ∑ Contained feed | Fish (%) | Worms (%) | Crab (%) | Shrimp (%) | ∑ Feed type |
|----|---------------------------|---|-----------------|----------|-----------|----------|------------|-------------|
| 1  | 31 - 38.5                 | 23| 12              | 8.33     | 8.33      | 92.30    | 91.66      | 4           |
| 2  | 38.6 - 46.1               | 7 | 6               | 0        | 50        | 0        | 0          | 0           |
| 3  | 46.2 - 53.7               | 3 | 2               | 100      | 0         | 0        | 0          | 1           |
| 4  | 53.8 - 61.3               | 4 | 4               | 75        | 0         | 75       | 75         | 3           |
| 5  | 61.4 - 68.9               | 7 | 7               | 100      | 0         | 0        | 0          | 0           |
| 6  | 69 - 76.5                 | 0 | 0               | 0        | 0         | 0        | 0          | 0           |
| 7  | 76.6 - 84.1               | 1 | 1               | 100      | 0         | 0        | 0          | 1           |
The results of the analysis of the length-weight relationships obtained the b value was 3.54, indicating a positive allometric growth pattern. It means that body weight is growing faster than body length and the fish look plump. A contrary finding was reported on *Anguilla* sp. in Mosolo River, Wawonii Islands, Southeast Sulawesi that the b values ranged from 2.778 to 3.041 [23].

According to Muchlisin [24], beside effected by environmental factor, the coefficient b value is also influenced by the behavior of fish, for example the active swim fish (pelagic fish) indicate the b value tends to be lower when compared to passive swimming fish (most demersal fish), this may related to the allocation of energy spent on movement and growth. Jenning and Kaiser [25] also argue that the difference in value of b depends on physiological growth conditions such as gonadal development and food availability.

The Fulton (K) condition factor ranges from 8.32 to 10.25 (mean 9.32 ± 0.42) and the Relative weight (Wr) condition factor ranges from 60.92 to 137.70 (mean 101.60 ± 16.67). The scatter plot of growth pattern showed that the observation data is almost the similar with the predictive data (Figure 3). The coefficient of determination was 0.968 means that 96% of variants can be explained by the used model (Figure 4). In general the Relative weight condition factor tend to 100, indicates that the balancing of the prey and predator, or sufficient food sources.
Figure 3. The growth pattern of the female eel *Anguilla bicolor* harvested from Banda Aceh waters

Figure 4. Comparison of observed and predicted growth of female eel *Anguilla bicolor* harvested from Banda Aceh waters

Table 3. Total length and condition factors of the female eel *Anguilla bicolor* harvested from Banda Aceh waters

| Parameter                          | *Anguilla bicolor* |
|------------------------------------|--------------------|
| Total length, TL (cm)              | 31 - 80 (44.3 ± 12.7) |
| Body weight, W (g)                 | 45 - 1100 (23.2 ± 249) |
| Predicted body weight, Ws (g)      | 46.54 - 1341.15 (235.25 ± 267.75) |
| Relative weight, Wr                | 60.92 - 137.70 (101.60 ± 16.67) |
| Fulton’s condition factor, K       | 8.32 - 10.25 (9.32 ± 0.42) |
| Coefficient determination, $R^2$   | 0.968               |
| $B$ value                          | 3.545               |
4. Conclusion
The eel Anguilla bicolor in Banda Aceh waters was fed on crab, shrimp, small fish and worms, where the crab is the primary food. Therefore, the A. bicolor is carnivorous fish. The b value was 3.545, indicate an allometric positive growth pattern and the condition factor tend to 100 indicate the balanced between prey and predator or the food source was sufficient.

References

[1] Denoncourt C E, Stauffer J R 1992 *Journal of The American Midland Naturalist* 129(1): 301-308.
[2] Miller M J, Tsukamoto K 2004 *An introduction to leptocephali biology and identification* Ocean Reeserch Institute, The University of Tokyo, Tokyo
[3] Silfvergrip A M C 2009 *CITES identification guide to the freshwater eels (Anguillidae) with focus on the European eel Anguilla Anguilla* (Stockholm: Conservation on International Trade in Endangered Species, Sweden)
[4] Sugeha H Y, Ayoma J, Tsukamoto K 2006 *Journal Limnotek* 23(1):18-26
[5] Muchlisin Z A, Akyun Q, Rizka S, Fadli N, Sugianto M N 2015a *Check List The Journal of Biodiversity Data* 11(2): 1-9
[6] Watanabe S, Aoyama J, Nishida M, Tsukamoto K 2005 *Coastal Marine Science* (29): 165-169.
[7] Affandi R 2005 *Jurnal Ilktiologi Indonesia* 5(2): 77-81
[8] Hagesti R A W, Kusharto C M, Budywiryawan, Wiyono E S, Sugengherisuseno 2014 *Jurnal Sains Kesihatan Malaysia* 12(1): 41-46
[9] Affandi R, Budiardi T, Irawan R W, Azbas A T 2013 *Jurnal Ilmu Pertanian Indonesia* 18(1): 55-60.
[10] Muchlisin Z A 2013 *Jurnal Iktiologi Indonesia* 13(1): 91-96
[11] Muchlisin Z A, Maulidin M, Muhammadar A A, Putra D F 2016 *Aceh Journal of Animal Science* 1(2): 58-61.
[12] Aggrey J F, Korsah, Appiah N 2013 *Journal of Applied Ecology* 21(I): 87-96
[13] Azadi M A, Nasiruddin M, Rahman A S M S 2009 *The Chittagong Univ, J. B. Sei.*, 4(1&2) ; 53-6
[14] Prasad R D, Rao Y P 2015 *International journal of Advanced Research* 3(7): 1578 - 1584
[15] Saikia A K, Abujam S K S, Biswas S P 2012 *Bulletin of Environment, Pharmacology and Life Science* 1(5): 10 - 15
[16] De-Robertis A, William K 2008 *Journal of Transactions of the American Fisheries Society* 137(1): 707-719.
[17] Muchlisin Z A, Musman M, Siti-Azizah M N 2010 *Journal of Applied Ichthyology* 26: 949-953
[18] Rypel A L, Richter T J 2008 *North American Journal of Fisheries Management* 28(1): 1843-1846
[19] Simanjuntak C P H, Rahardjo M F 2001 *Journal Iktiologi Indonesia* 1(2): 11-16
[20] Hartanto F, Bataragoa N E, Lohoo A V 2015 *Jurnal Ilmiah Platax* 3(2): 54-62
[21] Fitrinawati H 2004 *Kebiasaan makan ikan rejung (Sillago sihanta) di Perairan Pantai Manyangan,* Subang, Jawa Barat Undergraduate thesis Institut Pertanian Bogor, Bogor
[22] Rupasinghe H, Attygalle M V E 2006 *Food and feeding of brown-stage eels of Anguilla bicolor in the Bolgoda Estuary Annelida* p.1–8
[23] Kardin, Sara L, Pangerang U K 2016 *Jurnal Manajemen Sumber Daya Perairan* 1(4): 355-365
[24] Muchlisin Z A 2010b Diversity of freshwater fishes in Aceh Province, Indonesia with emphasis on several biological aspects of the Depik (Rasbora tawarensis) an endemic Species in Lake Laut Tawar. *Ph.D* thesis Universiti Sains Malaysia, Penang
[25] Jenning S, Kaiser M J, Reynolds J D 2001 *Marine fishery ecology* Blackwell Sciences, Oxford