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Research Paper

Species Composition and Length-Weight Relationship of Anguillid Eels Habited in Bengkulu Waters, Indonesia

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Abstract
Management of euryhaline species, such as Anguillid eel, is very important. Anguillid eel is an important economic fish which the partly of its life cycle spent in inland waters then migrates into the ocean for spawning. The objective of this study is to identify the morphological diversity and length-weight relationship of Anguillid eels in this province. The total of 148 individuals of elver and adult Anguillid eels were caught was identified using the comparison of ano-dorsal with total length parameter. Cluster analysis was obtained based on measurement of morphometric parameter. The current work used cluster analysis and dendrogram to group the population characteristic of Anguilla eel. It revealed that in the Jenggalu, Kungkai and Manna rivers of Bengkulu province, there are two groups of Anguilla eel with significant difference of ano-dorsal length. The value of the ano-dorsal varied from 2.56 ± 1.54 and 17.78 ± 1.33 for *A.bicolor bicolor* and **A.marmorata**, respectively. The length-weight relationships between total length (TL) and weight (W) for Anguilla *bicolor* and A.marmorata were found to be highly significant (r^2 > 0.94, p < 0.001). The average value of 'b' for length and weight were higher than 3, i.e., 3.2677 and 3.4821 in *A.bicolor* and A.marmorata respectively which indicated a positive allometric growth trend of this species in the studied area.

Keywords
Anodorsal length, LWR, Anguillid eel, Bengkulu

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1. INTRODUCTION

Management of euryhaline species, such as Anguillid eel, is very important. Anguillid eel is an important economic fish which the partly of its life cycle spent in inland waters then migrates into the ocean for spawning. Commercial eel fishery activity is distributed all over the world (De Leo and Gatto, 2001). Based on data from Food and Agriculture Organization, United Nations (FAO), Eel's production significantly increases from 17,775 t in 1950 (only 3% from aquaculture) to 280,000 t in 2007 (96% from aquaculture) and its production stabilized since 2008 to 2010.

There are 19 species/subspesies of Anguillid eel distribute all over the world covering Indopacific, Atlantic and Oceania. Indonesia has 10 species such as *Anguilla bicolor bicolor* (Indonesian short fin eel), *Anguilla bicolor pasifica, Anguilla marmorata, Anguilla nebulosa nebulosa, Anguilla borneensis, Anguilla celebescencis Anguilla megastoma*, and *Anguilla interioris* (Fahmi, 2015; Sugeha and Suharti, 2008).

The geographical position of rivers in the Bengkulu Province which face directly to Indian Ocean is the potential habitat for Anguillid eels. Kungkai, Jenggalu and Manna river are located in the Bengkulu. There are flowing into Indian Ocean directly. Research on the existence and distribution of Anguillid eel in Indonesia has been conducted widely, generally in the Java Island. Whereas in the other areas such as Bengkulu is limited. The existence of Anguillid eel in Bengkulu province results in the high demand of eel seeds from eel farm in the Java Island. Therefore, it is necessary to manage the Anguillid eel resources for its sustainability.

Certainty taxonomy is required for managing the Anguillid eels resources. Therefore, morphological identification is needed for Anguillid eels species in Bengkulu. Furthermore, the knowledge on quantitative aspects such as length-weight relationship, condition factor, growth, and recruitment are important tools for the adequate management of for this species (King, 2007; Ndome et al., 2012). The length-weight relationships also help to figure out the condition, reproduction history, life history, and the general health of fishing species

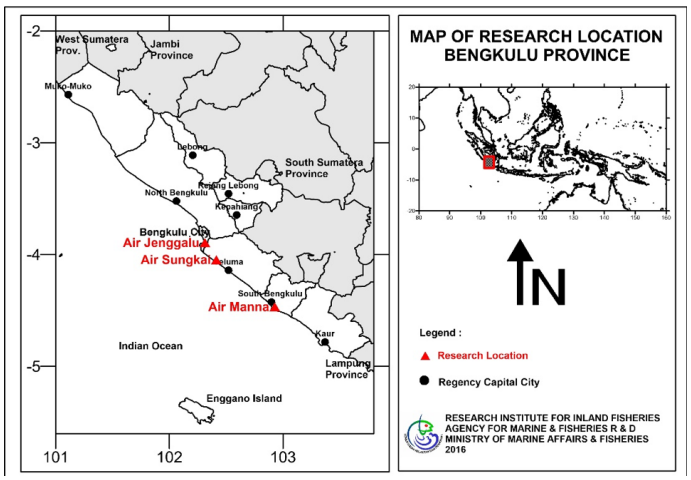

Figure 1. The Sampling site of Anguillid eels in Bengkulu Province, Indonesia

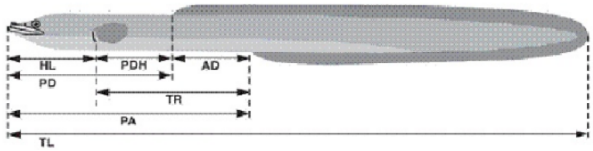

Figure 2. Morphological character of Anguillid eels (TL: Total Length; HL : Head Length; PD : Predorsal Length; PA: Preanal length (Tesch, 2003))

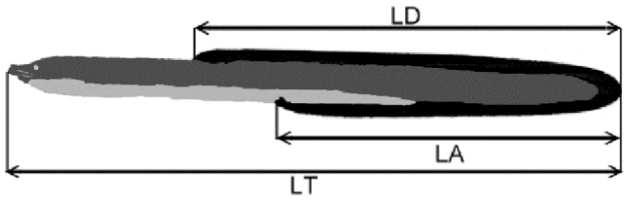

Figure 3. Characteristics of Anodorsal distance measurements on anguilla eel (Hakim, 2015)

(Nikolsky, 1963; Wootton, 1990, 1992; Pauly, 1993) and is also useful in local and interregional morphological and life historical comparisons in species and populations. Therefore, the length-length relations of species under various environmental conditions should be known. The objective of this study is to identify the morphological diversity and length-weight relationship of Anguillid eels in this province.

2. EXPERIMENTAL SECTION

2.1 Description of research location

The research location of Anguillid eel fish was conducted in three locations which is the eel's fishing ground. There were Kungkai, Jenggalu and Manna river in Bengkulu province (Fig. 1). Anguillid eel's sampling was done by using bamboo traps and pole and line (warm bait) in June and July 2016. Laboratory analysis was conducted at the fish biology laboratory, Research Institute for Inland Fisheries.

2.2 Sample analysis

Anguillid eel's samples were collected from the fishermen in each river. There was only yellow eel's stage which was caught and no glass eel found in the research. Glass eel is a seed that has no pigmentation development in the body. The glass eel will become yellow eel when entering the river and rapidly develop pigmentation which stay in freshwater for growth for many years before they become mature as "silver eel" and migrate back to the ocean for spawning. All of samples were preserved by using 90% alcohol for subsequent analysis in the Laboratory of Research Institute for Inland Fisheries.

Morphological identification for freshwater eel is one of the technical requirements for identification. Species determination used the key identification based on literature i.e (Arai and Takaomi, 2016; Tesch et al., 2003; Silfvergrip, 2009). A sharp-jawed vernier caliper graded to 0.1 mm used for measuring the morphological character such as total length (TL), Head Length (HL), Predorsal Head Length (PDHL), Pre Anal Head Length (PAHL), Pre Dorsal length (PDL), Pre Anal Length (PAL) and Anodorsal length (AD) (Fig. 2).

Equation to distinguish the species for adult eel is ano-dorsal length (AD) (Reveillac et al., 2009; Rovara and Amarullah., 2007). The characteristic expressed by Ege's in 1939 have been widely accepted now. This study used species identification by using the Ano-dorsal parameter which cheaper and faster. According to that equation, anguillid eel classified into two group as follows, long fin and short fin. Long fin is the anguillid eel which has the long ano-dorsal length, while short fin is the opposite. Based on differences in ano- dorsal length, body coloration, number of vertebrae combined with genetic cluster, there are 16 species of Anguillid eel in the world (Arai and Takaomi, 2016). In addition to the color pattern, other species distinguishing characteristics in all anguillid eel stadia are performed by measuring ano dorsal parameter which is divided by total lengths as the following equations (Reveillac et al., 2009; Rovara and Amarullah., 2007):

$$A-D\% = \frac{(LD-LA)}{LT} \cdot 100 \quad (1)$$

Where LT is the Total length, LD is the Length of dorsal fin and LA is the Length of anal fin.

Shortfin has ano dorsal value 0-5 while longfin 7-17 (Rovara and Amarullah., 2007). More specific [14] AD/TL for *Anguilla bicolor bicolor* is ranged from 0-3, A. *nebulosa* 7-13 and *A. marmorata* 14-17.

The length-weight relationships for weight were calculated using the equation, W = aLb (Ricker, 1979), where 'a' is a coefficient related to body form and 'b' is an exponent indicating iso-

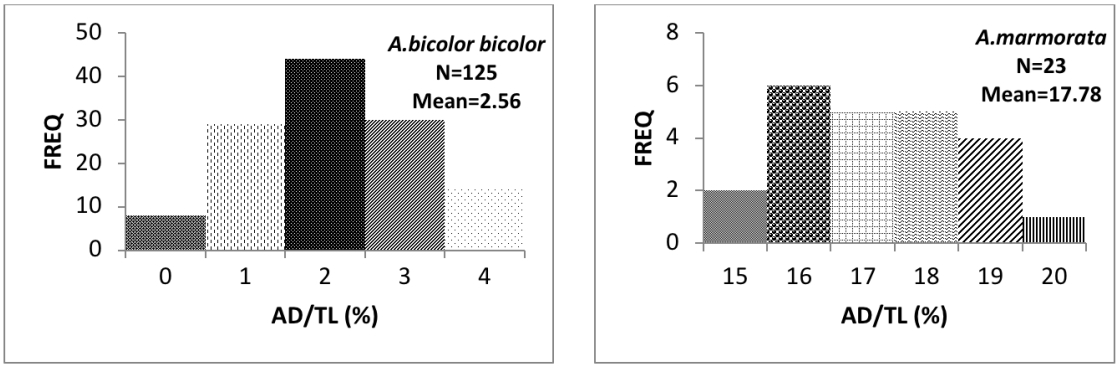

Figure 4. Frequency distribution of ano-dorsal to total length (AD/TL) % Anguilla bicolor bicolor and Anguilla marmorata in Bengkulu province

metric growth when equal to 3. The statistical significance level of r^2 was estimated by linear regressions on the transformed equation, LogBW = log a + b * logTL. The length-weight relationship between males and females were not calculated separately. All statistical analyses were evaluated at $p < 0.05$ significance level.

2.3 Cluster Analysis

Morphometric measurement on anguillid eel is used to decide its population character. Cluster analysis was obtained based on each parameter value on morphometric measurement. This analysis was performed using STATISTICA software.

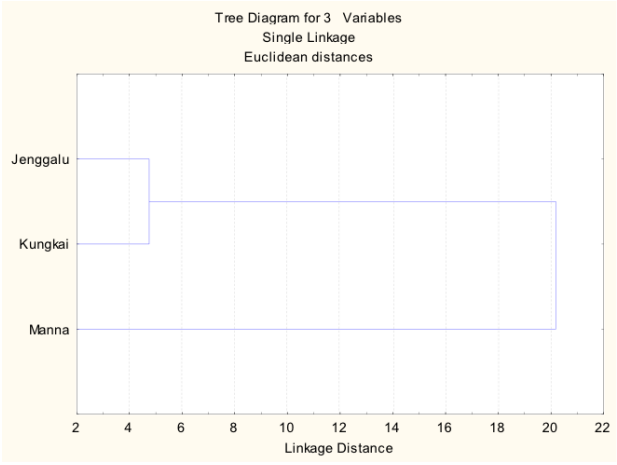

Figure 5. Cluster analysis based on morphometric characterize between A.bicolor bicolor and A.marmorata in Bengkulu province

3. RESULTS AND DISCUSSION

The total number of samples for this study is 148 individuals of anguillid eel in three locations. Then, the samples identified based on morphological characters such as body coloration and ano-dorsal parameter that determines whether the samples are long fin or short fin. The result of initial identification indicated that there are two species of Anguillid eel in Bengkulu which have different characteristic. Table 1 showed the morphological identification of Anguillid eel sample in Bengkulu province. The first species, *A. bicolor bicolor*, showed characteristics of the body coloration is plain (without pattern/un marbled) and has short fin which was found in the Kungkai and Jenggalu Rivers (Northern part of Bengkulu province. A. marmorata, second species, was characterized by marbled body color and has a long fin and was found in the Manna River (southern part of Bengkulu). The result of initial identification based on morphological identification is the initial process to facilitate the next steps for identification the species.

Table 2 showed that *A. bicolor bicolor* in Kungkai and Jenggalu river has the same characteristics of morphometric such as head length (HL) 0.2 to 9.1 (in average: 4.25±1.01) cm, pre dorsal length (PDL) 5.8 to 27.5 (in average: 12.99±2.98) cm, pre anal length (PAL) 7.9 to 29 (in average: 13.89±3.08) cm and ano dorsal length (AD) 0.3 to 4.9 (in average: 2.56±1.54) cm. While A. marmorata in Manna river showed the characterize as follows head lenght (HL) 5.1 to 6.1 (in average: 5.58±0.27) cm, pre dorsal length (PDL) 7.5 to 14.6 (in average: 10.90±1.96) cm, pre anal length (PAL) 12.6 to 294.7 (in average: 18.03±3.07) cm and ano dorsal length (AD) 15.5 to 20.8 (in average: 17.78±1.33) cm.

Comparison of ano dorsal length (AD) to total lenght (TL) used to differentiate the anguillid eel species (Reveillac et al., 2009; Rovara and Amarullah., 2007). Matsui (Rovara and Amarullah., 2007) has devided the anguillid eel into two groups based on the length of the fin as follows, shortfin which 0 to 5 and longfin 7-17. More detailed on (Reveillac et al., 2009) showed that AD/TL for species *A. bicolor bicolor* is 0 to 3, A. *nebulosa* 7-13 and *A. marmorata* 14-17.

The result showed that there were two ano-dorsal length groups in this study. First group was *A.bicolor bicolor* which has 0.3 to 4.9 of anodorsal lenght. Other groups was showed the result 15.5 to 20.8 as *A.marmorata*. Figure 2 described the distribution frequency for that species in this study. The total

Table 1. Morphological identification of Anguillid eel in Bengkulu province

Location	Local name	Common name	Scientific name	Characteristic
Kungkai river	*Sidat*	Indonesian shortfin eel	*A.bicolor bicolor*	Body color is no pattern/un-marbled and has short fin
Jenggalu river	*Sidat*	Indonesian shortfin eel	*A.bicolor bicolor*	Body color is no pattern/un-marbled and has short fin
Manna river	*Pelus*	Giant mottled eel	*A.marmorata*	Body color is marbled and has long fin

Table 2. Characteristics of two species of Anguilla eels in Bengkulu

Species	Site	N (ind)	Character	HL (cm)	PDL (cm)	PAL (cm)	AD/TL(%)
A. bicolor bicolor	Kungkai	91	Range Average± SD	0.2 – 6.8 4.17 ± 0.87	7.2 – 19.3 12.92 ± 2.40	7.9 - 22 13.68 ± 2.6	0.3 – 4.5 2.99 ± 0.93
	Jenggalu	34	Range Average± SD	3 – 9.1 4.84 ± 1.89	5.8 – 27.5 14.25 ± 5.82	Oct-29 15.40 ± 5.33	1.4 – 4.9 3.08 ± 1.02
	TOTAL	125	Range Average± SD	0.2 – 9.1 4.25± 1.01	5.8 – 27.5 12.99 ± 2.98	7.9 – 29 13.89 ± 3.08	0.3 – 4.9 2.56 ± 1.54
A. marmorata	Manna	23	Range Average± SD	5.1 – 6.1 5.58 ± 0.27	7.5 – 14.6 10.90 ± 1.96	12.6 – 24.7 18.03 ± 3.07	15.5 – 20.8 17.78 ± 1.33

125 individual of anguillid eel was *A.bicolor bicolor* with percentage of ano-dorsal length 2.56 % and 23 individual sample of *A.marmorata* with the ano-dorsal length 17.78 %. Percentage of ano-dorsal length 2 was dominant with the frequency 44 individual. While for *A.marmorata* species is dominated by 16 of ano-dorsal length with the total number of individual 6 (Figure 4).

There are 3 species of Anguilla eel in Bengkulu (Fahmi, 2015) such as *A. bicolor bicolor*, *A.marmorata* dan *A. nebulosa nebulosa* by using the analysis of the glass eel/juvenile stage. Meanwhile, there are only two species of anguilla eel which are identified by elver and yellow eel stage which morphological identified based on ano-dorsal length (AD/TL) as *A.bicolor bicolor* and *A.marmorata*. AD/TL is the useful for distinguish the species of anguilla eel in the rivers that leads to Palabuhan Ratu bay (Sugeha et al., 2001). It was supported by this study that this method can also be applied to distinguish the anguillid species in Bengkulu province.

Overlap of the AD/TL percentage did not occur on this study because between *A. bicolor bicolor* and *A. marmorata* has significant difference on this characteristic. The examples of the overlapping on this character occur between two sub species *A.bicolor bicolor* and *A.bicolor pasifica* (Sugeha and Suharti, 2008). Therefore, Watanabe (Watanabe and Tsukamoto., 2004) suggested that identification based on Ege must be supported by the existence of geographic data information. Geographical information of the source of the Anguillid eels makes it easier to identify the species of the Anguillid eels. For instance, *A.bicolor bicolor* distributed on Indian ocean coast from South Africa, The Arabian peninsula, Srilanka to the west of Indonesia and the western part of Australia (Robinet et al., 2003). This species is thought to be spawning in the eastern Indian Ocean precisely on the west cost of Sumatera island.

Cluster analysis by using the dendrogram showed that there were 2 groups of Anguilla eel based on grouping of characterized population. These characteristics described by the line which divided the sample into two groups of population. Cluster analysis showed (Fig.5) that *A.bicolor bicolor* has significant difference on percentage of anodorsal (AD/TL) with *A.marmorata*. This result was supported by the Dendrogram that there was one group of *A.bicolor bicolor* in Jenggalu and Kungkai River. This indicated that sample from the adjacent rivers will have the same morphological characters. Meanwhile, the sample from Manna river which is located far apart from another station show different species of Anguilla, *A.marmorata*. The differences are also related to the habitat characteristics of the three rivers.

Length-weight relationships for anguillid eesl and the total sample population were determined and shown in Table 3 and Figure 6. Analysis of covariance revealed significant differences between sexes for the slopes (b) of the regression lines ($p < 0.05$).

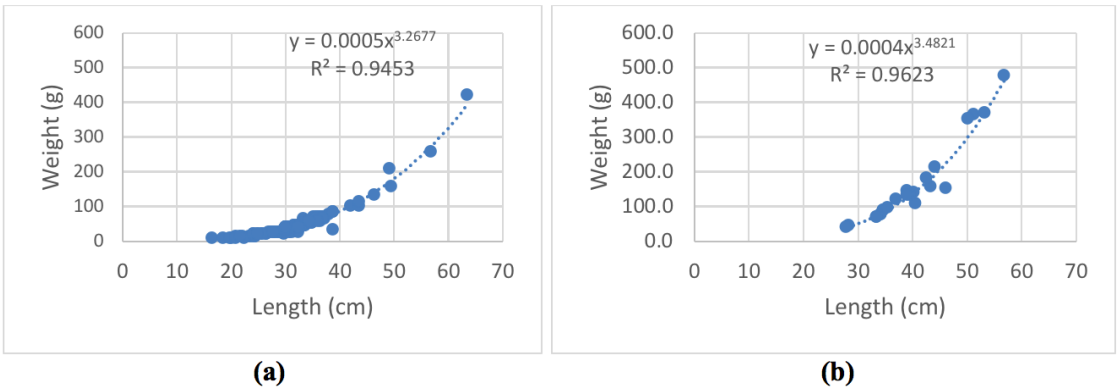

Figure 6. Length-Weight Relationship *A.bicolor bicolor* and *A.marmorata* in Bengkulu province

Table 3. Add caption

Species	N	Total Length (cm)		Total Weight (g)		Relationship parameter		
		Range	Mean±SD	Range	Mean±SD	a	b	r
A.bicolor bicolor	125	16.5-63.5	32.1±6.6	6.0-420.9	50.3±47.7	0.0005	3.2677	0.9453
A.marmorata	23	28.1-56.8	40.0±7.6	38-477	161.2±118.2	0.0004	3.4821	0.9623

According to Le Cren (1951) since fat and water content of fish may vary according to temperature therefore the length-weight relationships in fishes are related to the seasonal variation. Sinha (1973) stated that the change in 'b' value shows allometric growth of the body due to the influence of numerous factors such as seasonal fluctuations, changes in physiological condition during spawning periods, gonad development, sex, physicochemical conditions of the environment and nutrition conditions of the environment. Sekharan (1998) have also observed an inter specific for 'b' that remains constant at '3.0' for an ideal fish. The result showed that values for 'b' for length and weight were higher than 3, i.e., 3.2677 and 3.4821 in *A.bicolor bicolor* and *A.marmorata* respectively, which were of expected range and indicated that the growth is almost positive allometric on Anguillid eels. However, Wootton (1992) opined that $b < 3$ indicates that the fish gets relatively thinner as they grow larger while $b > 3$, it is plumper as it grows larger. The values of coefficient of determination (r^2) calculated for LWR relationships TL-Wt *A.bicolor bicolor* and *A. marmorata* (Tables 3) were 0.9453 and 0.9623, respectively which are highly significant ($p < 0.001$). Regression coefficients obtained from length-weight relationships (L-W) which are indicatives of isometric or allometric growths differ not only between species but sometimes also between stocks of same species. The development of fish involves several stages, each of which has its own length-weight relationships. There may also be differences in the relationships due to sex, maturity, season, and environmental conditions (e.g. pollution).

4. CONCLUSIONS

The current work successfully used cluster analysis and dendrogram to group the population characteristic of Anguilla eel. It revealed that in the Jenggalu, Kungkai and Manna rivers of Bengkulu province, there are two groups of Anguilla eel with significant difference of ano-dorsal length. The value of the ano-dorsal varied from 2.56 ± 1.54 and 17.78 ± 1.33 for *A.bicolor bicolor* and *A.marmorata*, respectively. Furthermore, the present study provides an important contribution to baseline data on the length-weight relationships of the *A.bicolor* and *A.marmorata* which are important tools for the adequate management of the fish stocks and populations. The provided data on the LWR would be beneficial for fishery biologist's managers to impose suitable regulations for sustainable fishery management and conservation programs in the region.

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