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Correlation the Distance of the Location Found With the Size and Dominant Index of Eel in East Nusa Tenggara Waters

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Abstract.
The existence of eels in a freshwater area is influenced by various factors, one of which is the availability of habitats that are suitable for the life of eels. East Nusa Tenggara Province is an archipelago that is mentioned as one of the distribution areas for eel in Indonesia. However, the type and size of eel is strongly influenced by the distance it finds. The farther the river is from the estuary, the larger the size of the eel and the different types. As eurihaline migratory fish, eels can swim far upstream to find a suitable habitat for their life. This study aims to analyze the relationship between location distance and the size and dominance index of eel in freshwater in East Nusa Tenggara (NTT). This research was conducted from October to April. The results obtained are that the three rivers in East Nusa Tenggara province, namely the Tarus river in Kupang district, the Oetona river in Kupang city and the Kamaifui river in Alor district, managed to catch 71 eels at a fishing distance of 0.69 km to 7.86 km. from the mouth of the river. Based on the ano-dorsal analysis, two types of eel caught in the Tarus and Kamaifui rivers were identified, namely Anguilla marmorata and Anguilla nebulosa nebulosa, while in the Oetona river only A. marmorata was found. Based on the calculation of the dominance index, the most dominant species in fresh waters of NTT is A. marmorata.

Keywords: eel, East Nusa Tenggara, dominance index, distance from estuary

Introduction

Eel is one of the important commodities in the world that was spread in almost all of Indonesian waters, from the western part to the eastern part of Indonesia. According to Arai (2016) there are 16 species of eel in the world, while Fahmi (2015) eels are scattered in the waters of Aceh, Sumatra, southern Java, Bali, NTB, NTT, eastern part of Kalimantan, Sulawesi, Maluku and Papua. In the western part of Indonesia, there are three species, namely Anguilla bicolor bicolor, A. nebulosa and A. bicolor pacifica (Fahmi, 2015). Of all the species identified, one of the species is A. marmorata is the most widely distributed in the world (Hsu, 2019).

As catadromous fish, eels will migrate from marine waters to fresh waters. During the migration process, there will be changes in the stadia and size of the eel (Arai & Kadir, 2017), and the spawning process will take place in offshore waters (Arai & Chino, 2018). The eel will continue to swim towards the river area until it gets a part of the river that is suitable for its habitat, so it is often found in one part of the river which is dominated by certain types and sizes. Different types of eels prefer habitats with different salinity (Arai & Chino, 2018; Arai & Chino, 2012; Jellyman & Briand, 2016). Sugianti et al. (2020) found that adult A. bicolor bicolor was more commonly found in waters with a salinity of 0 – 16.8 ppt, while yellow eel A. marmorata was more commonly found in waters with a salinity of 0 ppt, which is about 13 km from the estuary. Starting from the leptocephalus phase to the silver eel phase, eels continue to migrate and settle in different habitats, namely salt water, estuary and fresh water, but in the yellow eel phase, it is a fattening phase so that it is more sedentary (Arai & Chino, 2012).

The distribution of eel and its abundance in an area are influenced by temperature, species origin, habits of glass eel and currents movement (Leander et al., 2012; Cresci et al., 2019), furthermore it is stated that

different water and climatic conditions in each country also affect the migration behavior of eel (Gagnaire et al. 2012; Coˆte´ et al. 2013). Arribas et al. (2012) stated that the abundance of glass eel eels occurs in autumn and spring in southwest Spain. While Hakim et al. (2015) observed that the abundance of glass eels in the Cimandiri river, Palabuhanratu, Indonesia occurred from August to December. In addition, the location of eel fishing is related to the stadia of eel caught, Claud & Malte (2015) stated that the highest yellow eel density was found in open coastal areas compared to inner coastal areas. Eel migration patterns need to be studied with the aim of measuring the abundance of eel stocks at each season so that fishing patterns can be adjusted (Harrison et al., 2014).

The province of East Nusa Tenggara (NTT) has several rivers that are always flooded throughout the year. Some of them are the Tarus river in Kupang district, the Oetona river in Kupang city and the Kamaifui river in Alor district. The mouths of these rivers face directly into the waters of the Kupang Bay and the Sunda Strait which are connected to the Indian Ocean (https://id.wikipedia.org/wiki/Samudra_Hindia). These three rivers have a suitable topography as a place for eel migration, which has a wide and sloping estuary mouth. Based on information received from the local community, eels are often caught accidentally while fishing. The types, sizes and physical characteristics of the caught eels also vary. This is what underlies the determination of the research location, which aims to identify the types and sizes that dominate at the sampling point. The results of this study are expected to be the basis for eel management and development policies in East Nusa Tenggara, sesuai dengan Hsu et al. (2019) which states that the conservation and management of eel is based on the distribution of habitat data.

Materials and Methods

This study uses a survey method on three rivers in the province of NTT in the wet month (November to February) and the dry month (October and March). The determination of the location for eel fishing was chosen based on basic information obtained from residents around the perpetrators of fishing and waterlogged conditions throughout the year, so that 3 rivers were obtained, namely the Tarus river in Kupang Regency (ST) which empties into the Manikin estuary, the Oetona river in Kupang City (SO) empties into the Selam estuary, and the Kamaifui river in Alor Regency (SK) empties into the Abawi estuary. Each river consists of 3 observation stations which are presented in table 1.

Table 1. Sampling stations at each research location

Research sites	Station	Distance from estuary
Tarus River, Kupang Regency	1	0.69 km from the manikin estuary
	2	The position on the river body is 1.95 km from manikin estuary
	3	3.66 km from the manikin estuary
Oetona River, Kupang City	4	It is 1.35 km from the Selam estuary
	5	It is 2.35 km from the mouth of the dive estuary
	6	It is 3.72 km from the mouth of the dive estuary
Kamaifui River, Alor Regency	7	3.07 km from the mouth of the estuary kalunan
	8	It is 5.87 km from the mouth of the estuary kalunan
	9	7.86 km from the mouth of the estuary kalunan

Eels are caught using fishing rods with bait in the form of chicken stomachs and also traps made of woven bamboo. The arrests were made at night when the moon was dark. The caught eels were directly weighed to obtain body weight data, then stored in a container containing 90% alcohol for other morphometric data collection needs such as total body length (PT), pre-dorsal length (PD), pre-anal length (PA), the diameter of the body was measured circularly from the anus and the diameter of the head was measured circularly from the eye as well as the identification of the species based on Fahmi et al. (2015).

The variables observed in this study were morphometric data of eel caught, type of eel caught, dominance index and water physicochemical parameters of each station. These variables are calculated using the following equation

a. Morphometric data in the form of
   - Total body weight (WT) was weighed using an analytical balance with an accuracy of 0.00 g
   - Total body length (LT) was measured using a measuring instrument with an accuracy of cm

- Dorsal length (LD) was measured using a measuring instrument with an accuracy of cm
- Anal length (LA) was measured using a measuring instrument with an accuracy of cm

b. Species identification was carried out based on Fahmi et al. (2015) by measuring the distance between anal length (LA) and dorsal length (LD) divided by total length (LT). The AD value is obtained by the following equation:

$$AD\% = \frac{LD - LA}{LT} \times 100$$

c. Dominance index (D) is calculated based on Simpson's dominance index (Odum, 1971 in Jalil et al., 2020):

d. $D = \Sigma (ni/N)^2$

Description: D = Simpson's Dominance Index
Ni= Number of Individuals per species
N = Number of Individuals of all species

The dominance index ranges from 0 to 1, where the smaller the value of the dominance index means that no species dominates, the higher the dominance means that certain species dominate (Odum, 1971 in Jalil et al., 2020).

e. Diversity Index (H')

$$H' = -\sum_{i=1}^{n} pi \ln pi$$

Description: H'= diversity index
Pi= ni / N
ni = number of individuals of the i-th type
N = total number of individuals of all types

The range of diversity indices according to Odum (1971) in Jalil et al. (2020).
H' < 2.3026 = small diversity and low community stability
2.3026 < H' < 6.9078 = moderate diversity and moderate community stability
H' > 6.9078 = high diversity and high community stability

f. Similarity Index (E')

$$E = \frac{H'}{Hmaks}$$

Description: E = similarity index
Hmax = ln S
S = number of species

Similarity index range (Odum, 1971 in Jalil et al., 2020): E = 0 – 1
E is close to 0: the distribution of individuals between species is uneven/there are certain species that are dominant.
E is close to 1: the distribution of individuals between species is even.

The data obtained were analysis using linear regression to see the relationship between the distance from the fishing ground and the size caught. Meanwhile, morfometric data and dominance index were analysis descriptively and presented in the form of tables and figures.

Ethical Statements

This research has fulfilled the basic principles of research ethics, namely respect, beneficiary and justice. The object used in this study is eel, where the results of this study can be a new reference for the development of the potential of eel in East Nusa Tenggara and as well as to preserve these organisms in the waters of East Nusa Tenggara.

Results

Tarus river and Oetona river have characteristics are rocky substrate, sandy mud, large rocky, rocky sand substrate, overgrown tree vegetation and pass through sparsely settlements. Oetona river have

characteristics. At a distance of 2 to 3 km the river has passed through residential areas. Meanwhile, Kamaifui river have characteristics pass through sparsely populated housing; sandy rock substrate and overgrown with vegetation on 3 Km from estuary, wheares on 5 to 7 km from estuary are over the hills and mountain; sandy rock substrate and overgrown with vegetation. The ability of eels to migrate upstream is related to muscle performance, namely the ability to climb and swim, swimming style and speed. (Podgorniak et al. (2015). In addition, the eel migration path is influenced by cognitive function, namely memory of a place that has been visited

The process of catching eels is carried out at night when the moon is dark by using a fishing rod fed with chicken intestines. This is because eels are nocturnal fish that are actively looking for food at night, and eels are carnivorous, the food is a small prawns and the others (Abdalhamid et al., 2017). The size of the caught eels varied with a total weight ranging from 114.96 g to 797.27 g and a total length ranging from 39.5 cm to 85.1 cm. The morphometric data measured were total weight, total length, dorsal length and. anal length. The data on morphometric measurements of eel catches carried out during the study on the Tarus (ST), Oetona (SO) and Kamaifui (SK) rivers are presented in Table 2.

Table 2. Average morphometric data of eel caught at the research site

Research sites	Station	Location distance from estuary (km)	Total weight (g)	Total length (cm)	Dorsal length (cm)	Anal length (cm)
ST*	1	0.69	114.96	39.5	27.2	20.8
	2	1.95	171.4	41.8	28.6	21.9
	3	3.66	308.45	55.3	32.2	25.7
SO**	4	2.35	210.6	50.7	29.9	21.7
	5	3.72	388.82	57.7	37.3	28.1
	6	5.12	509.35	70.5	46.7	35.2
SK***	7	3.07	303.54	52.9	36.3	30.1
	8	5.87	519.44	71.2	49.9	38.3
	9	7.86	797.27	85.1	58.4	44.9

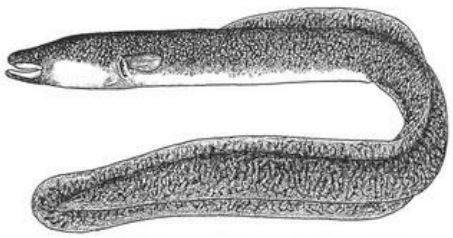
Noted: (*) Tarus Rivers on Kupang Regency
(**) Oetona Rivers on Kupang City
(***) Kamaifui River on Alor Regency

Based on research data obtained at several stations with a distance from the river mouth to the eel fishing location 0.69 km to 7.86 km, it was found that the morphometric size of eel increased with increasing distance from the river mouth. Eel is a type of active swimming fish that has positive rheotaxis in the glass eel stage to yellow eel stage and negative rheotaxis when it will migrate to the sea to spawn, namely the silver eel stage. The eel will continue to swim until it finds a suitable habitat to grow until it reaches the yellow eel stage. Eels are catadromous fish that will migrate from the sea to fresh waters until they reach the silver eel stage and then migrate to the high seas to spawn (Sugianti et al., 2020).

Based on the eel characteristics and ano-dorsal calculations, there were two types of eel caught at the research sites. The eels that were caught at the research location are presented in Figure 1.

(a)

(b)



(c)

(d)

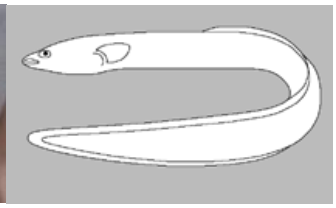


Figure 1. Two types of eel caught (a) A. marmorata caught (b) A. marmorata according to Quoy and Gaimard (1824) (c) A. nebulosa nebulosa caught (d) A. nebulosa nebulosa according to McClelland (1844)

Discussion

The location of the discovery of eel with the largest size is 797.4 g. namely at the upstream of the Kamaifui river which is 7.86 km from the estuary. This river passes through hills that are hard to pass, making it difficult for humans to reach, besides that it is also not a densely populated settlement. This provides an opportunity for eels to live and grow to a size of almost 1 kg with a total catch of up to 40 eels. However, at a distance of 3 to 5 km from estuary in the three rivers, eels that have reached the silver eel stage were also found. It is suspected that the eels will migration to the seas for spawn (Righton et al., 2016). Meanwhile, the Tarus River in Kupang Regency and the Oetona River in Kupang City are locations of densely populated settlements so that it is thought to affect the presence of eel. Although the size found has reached the yellow eel and the silver eel stage, the numbers found were 21 and 10 eels, respectively.

Based on the regression analysis, it was found that there was a positive correlation between the distance found and the total body weight of the eel r = 0.7851. According to Bruce et al. (2017) the value of r ranges from -1 < r < 1, if the value of r is close to 1 then there is a strong positive relationship. The relationship between the length of the body of the caught fish and the distance of the location caught from the river mouth is presented in Figure 2.

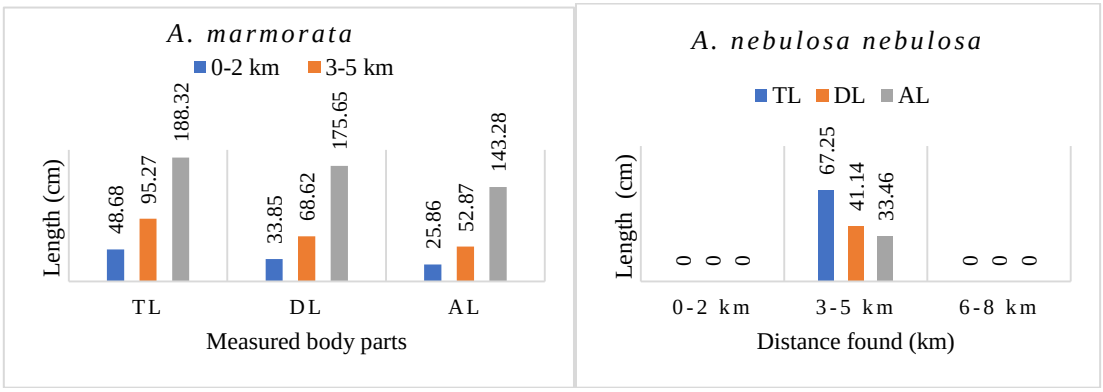


Figure 2. The relationship between distance and body length of eels found

Based on the results of the analysis obtained that the correlation coefficient between the distance found and the body weight of the eel found to form the equation y = 98,841x – 86,265. The correlation coefficient graph is presented in Figure 3.

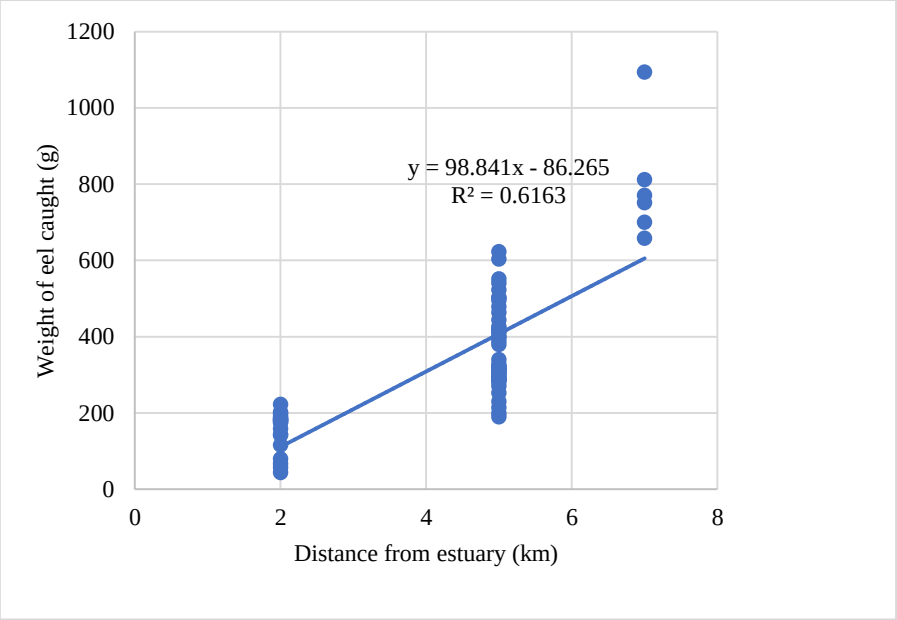


Figure 3. Linear regression between distance found and body weight of eel

Based on the results of the regression analysis, the largest eel distribution occurred at a fishing distance of 3 to 5 km from the estuary was in the yellow eel and silver eel stage. The dominance of the size of the yellow eel at a distance of 3 to 5 km is thought to be because at that location there is a suitable habitat for eel growth, that is, there is a stone hole as a hiding place and also enough food (Rudershausen et al., 2019). However, the largest size is found at a fishing distance of 6-8 km from the river mouth and is about to enter the silver eel stage.

Identification based on the calculation of the Ano-dorsal percentage to determine species based on size, it was found that the types of eels caught in fresh waters in East Nusa Tenggara consisted of two types, namely A. nebulosa nebulosa and A. marmorata. According to Hakim et al. (2015), if the AD value is close to 16.3%, it can be identified as type A. marmorata, while if the AD value is close to 11.7%, it is identified as type A. nebulosa nebulosa. This is in accordance with the statement of Sugianti et al. (2020) that Indonesian waters have 9 species/subspecies, one of which is A. marmorata and A. nebulosa nebulosa, which are spread in Sumatra, Java, Kalimantan, Sulawesi, Bali, Nusa Tenggara, Maluku and Papua (Fahmi, 2015). Ano-dorsal percentage values at the three study sites are presented in Table 3.

Table 3. A/D value of % of eel caught

Station	Tarus River (%)	Station	Oetona River (%)	Station	Kamaifui river (%)
1	16.52	4	16,14	7	11,03
					16.57
2	16.50	5	16.34	8	16,83
3	16.91	6	15.81	9	17.91
	11.76				

Eel species A. marmorata is a type of long-fin eel, has stripes on the skin so it is known as the Giant mottled eel, thick and fleshy lips with a blunt snout and protruding lower jaw, rounded pectoral fins and no pelvic fins (Pike et al. 2020). While the type of A. nebulosa nebulosa is a long-finned eel and has stripes on the skin, but the maximum body length is only 121 cm with a head shape that is shorter than A. marmorata (Pike et al. 2020). The two species found in the three rivers in the province of East Nusa Tenggara are also listed as endangered species according to the IUCN.

Based on the data of fish caught, at a fishing distance of 0.69 km to 7.86 km from the estuary, eels of the species A. marmorata were obtained. While the A. nebulosa nebulosa was found at a distance of approximately 3 km from the mouth of the river. Fahmi (2015) stated that A. marmorata inhabits rivers in the lowlands and upland tributaries and is a cosmopolitan eel species. Furthermore, Fahmi (2015) stated that

the largest habitat of A. nebulosa is in the southern part of eastern Indonesia and inhabits waters with a depth of 3-10 m with a muddy substrate with large rocks as a hiding place (Pike et al, 2020).

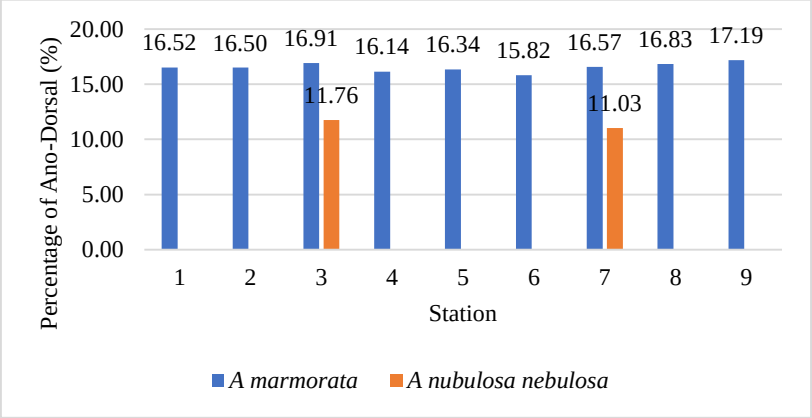


Figure 4. Types of eel caught at each observation station

Figure 4 shows that the species A. marmorata was caught at all observation stations at the three research locations. This is in accordance with the results of the calculation of the dominance index of eel in the waters of East Nusa Tenggara which is dominated by the species A. marmorata, which is 0.1037. According to Odum (1971) in Jalil et al. (2020) if the dominance index value is less than 2.3026 then the diversity is small. While the similarity index value is 0.1496, if the similarity index value is close to 0 then the distribution of species is not evenly distributed. The species A. marmorata was found at all research sites from 0.69 km fishing distance to 7.86 km from the estuary. Meanwhile, A. nebulosa nebulosa was only found at a distance of about 3 km from the river mouth at station 3 of the Tarus river, Kupang city and station 7 of the Kamaifui river, Alor Regency.

Conclusion

Based on the results of the study it was found that there are two types of eel found in the Tarus and Kamaifui rivers on East Nusa Tenggara province, namely A. marmorata and A. nebulosa nebulosa while in the Oetona river only A. marmorata was found. The type of eel that dominates the waters of East Nusa Tenggara is A. marmorata with sizes ranging from 114.96 g to 797.27 g. Species of A. marmorata was caught at a distance of 0.69 km to 7.86 km from the estuary, while A. nebulosa nebulosa was only caught at a fishing distance of approximately 3 km from the estuary.

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