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Diversity of Eel (*Glass Eel*) Based on Morphometric Measurements in the Konaweha River, Southeast Sulawesi

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ABSTRACT
Eel has economic value and nutritional content needed by the body. The demand for eel continues to increase both in fresh and processed forms. The activity of using eel in the waters of the Konaweha River is still very low; this is related to the low understanding of the community regarding the economic value, nutritional content, cultivation process and processed eel. This study aims to determine the diversity of species of glass eel caught in the Konaweha River estuary, Southeast Sulawesi. Identification of the species of glass eel is determined based on the morphometric character of the percentage value of the ratio of the length of the ano-dorsal length (AD) and the total length (TL) AD/TL (%). There were two species of glass eel caught during the study, namely *Anguilla bicolor pacific* (49.21%) and *Anguilla marmorata* (50.79%). Counseling related to utilization and management needs to be applied so that eel fish resources can be sustainable and used continuously.

Keywords: *glass eel, Konaweha River, morphometric.*

1. INTRODUCTION

Eel is a fishery commodity that has high economic value and nutrition content. Eel (*Anguilla* spp.) is a consumption fish that has high economic value and is an export commodity from the fisheries sector [1]. The market demand for eel is very high and continues to increase, especially in Asian, European and American countries which reached 600,000 tons per year^{-1} [2]. Eel bio ecological information is very important in the management process: utilization regulation, habitat management and predator management. The distribution area of glass eel is along the west coast of Sumatra, the south coast of Java, the east coast of the island of Borneo, the coast of Sulawesi, the Maluku Islands, Bali, NTT, NTB to the north coast of Papua [3]. Information and data related to eel populations, especially in the waters of Southeast Sulawesi, are still very low. This is related to inadequate infrastructure and public understanding of the economic value, nutritional content, cultivation process and processed eel.

The life cycle of the eel consists of 4 stages, namely the *leptocephalus*, glass eel, yellow eel and silver eel [4]. *Leptocephalus* is an eel larval stage, its shape is like a leaf and its body color is transparent. *Leptocephalus* lives as plankton carried by ocean currents approaching coastal areas [5]. *Leptocephalus* undergoes metamorphosis turning into transparent eel seeds and is called a glass eel [6]. Glass eel body shape already resembles an eel, with transparent body color. Glass eel migrate to freshwaters through river estuaries to further grow and develop into adult eels.

The development of eel fisheries in Indonesia has promising opportunities, both for capturing fisheries for adult size, and for catching seeds for the development of eel cultivation. The definition of seed for eel is glass eel stadia, eel seeds that enter freshwater through river estuary with a transparent body, body length of about 5-7 cm [7, 8]. Indonesia's potential for the development of eel cultivation is quite large, in addition to having abundant seed potential for its seed needs, it is also supported by the availability of large and qualified land, feed raw materials available in large quantities, and supported by appropriate climatic conditions [9].

This study aims to determine the diversity of glass eel species caught at the Konaweha River estuary, Southeast Sulawesi and identified based on morphometric measurements.

2. MATERIALS AND METHODS

The research was conducted in August-October 2021 in the estuary of the Konaweha River, Southeast Sulawesi (Figure 1). The fishing gear used is a pocket set net of 2 different sizes (Figure 2). The size of the first fishing gear is 11.4 meters wide and 2.3 meters long, while the second fishing gear is 9 meters wide and 2.3 meters long. The fishing gear is installed on the left side of the river body and placed in front and back positions sequentially with a distance of 20 meters between the fishing gear. Catch operation was conducted twice a month based on moonlight on day 29, 30, 1 and dark moon on day 14, 15, 16.

Water quality measurements were carried out at the location of the glass eel sampling. Parameters measured include physical parameters: Temperature (°C), Salinity (ppt), total suspended solids (TSS), total dissolved solids (TDS), total organic matter (BOT), chemistry: pH, nitrate, phosphate, dissolved oxygen (DO), ammonia, biology: Chlorophyll-a.

2.1. Data analysis

The identification of eel species was determined based on the morphometric character of the ratio of the ano-dorsal length (AD) and total length (TL) AD/TL

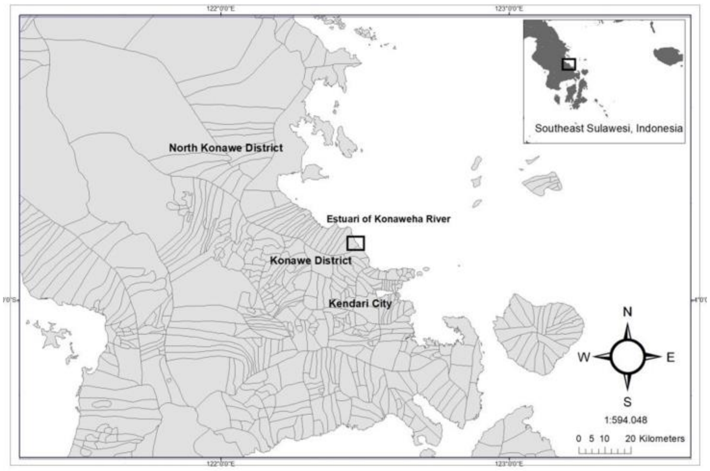

Figure 1. Sampling location

Figure 2. Pocket set net

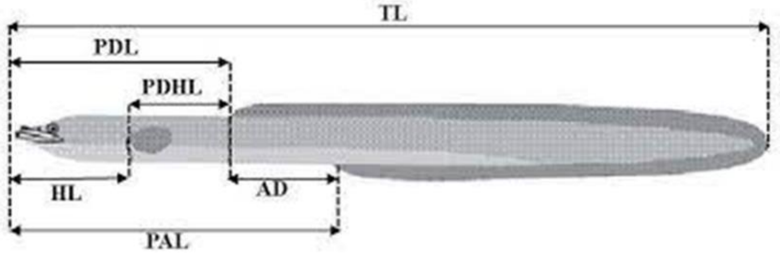

Figure 3. Eel morphometric measurements, information: total length (TL), head length (HL), pre-dorsal head length (PDHL), pre-anal length (PAL), pre-dorsal length (PDL), and ano- dorsal length (AD).

(%) [10,11] and based on their morphological characters [12,13]. Illustration of glass eel morphometric measurement in determining AD/TL (%) is presented in Figure 3.

Analysis of the relationship between weights and condition factors

The length-weight relationship is described in two forms, namely isometric and allometric [14]:

$W = aL^b$

W : individual weight of glass eel in grams;

L : total length of glass eel in mm;

a: intercept (intersection of the length-weight relationship curve with the y-axis)

b : length-weight growth pattern estimator

Linear equation or straight line using the following equation:

$$\text{Log } W = \text{Log } a + b \text{ Log } L$$

Parameters a and b, obtained by using regression analysis with Log W as Y and Log L as X, then obtained the regression equation:

$$Y = a + b X$$

To test the value of b = 3 or b 3 a t-test was carried out, with the hypothesis:

H0 : b = 3, the relationship between length and weight is isometric.

H1 : b $\neq 3$, the relationship between length and weight is allometric, that is

Positive allometric, if b> 3 (weight gain is faster than the increase in long). Negative allometric, if b<3 (Length gain is faster than weight gain).

Condition factors were analyzed to determine the quality of the glass eel based on the comparison between the actual weight and the estimated weight. The condition factor represents the curvaceous body of the fish. The condition factor analysis was determined based on the formulation [15, 16]:

$Kn = W/\hat{W}$

Where:

Kn : condition factor

W : actual weight of glass eel (grams)

$\hat{W}$: estimated glass eel weight ($W = aL^b$)

3. RESULTS AND DISCUSSION

3.1. Species composition and abundance of glass eel

The results of the identification of the species of glass eel based on the character value AD/TL (%) and its morphological character showed that the glass eel in the Konaweha River estuary consisted of 2 species, namely *Anguilla bicolor pacific* and *Anguilla marmorata*. Characters AD/TL (%) glass eel of *A. bicolor pacific* ranged from 0.58-4.35%, and *A. marmorata* 14.29-17.39%. The ratio of the number of glass eels *Anguilla bicolor pacific* and *Anguilla marmorata* was 49.21% and 50.79%, respectively. Glass eel obtained during the study based on the catch in August, September and October as many as 63 individuals. Species composition and value AD/TL (%) glass eel are presented in Table 1. A comparison of the composition of glass eel species is presented in Figure 4.

Table 1. Composition of species and values of AD/TL (%) glass eel

Research time	Species of glass eel	Value AD/TL (%)	Number of samples (n)
August	*A. marmorata*	15.14-16.20	6
	A. bicolor pasifika	1.63-4.04	3
September	*A. marmorata*	14.58-17.39	20
	A. bicolor pasifika	1.89-4.35	12
October	*A. marmorata*	14.29-17.16	6
	A. bicolor pasifika	0.58-2.04	16

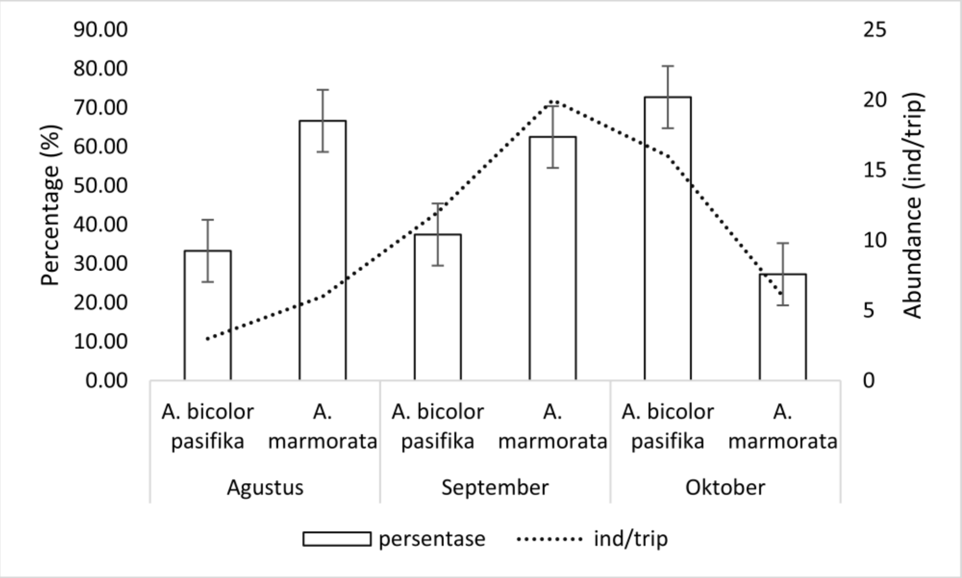

Figure 4. Comparison of species composition and abundance of glass eels at the Konaweha River estuary in August-October 2021

Two species of glass eel were found in the Konaweha River estuary, namely *Anguilla bicolor pacific* (49.21%) *and Anguilla marmorata* (50.79%) indicating that the Konaweha River estuary is the area for the distribution of this eel species. The *Anguilla mamorata* species eel has a wide distribution in Indonesian waters [3]. The catch of eel in the waters of the Lasolo River, Southeast Sulawesi also shows that the *Anguilla mamorata* species dominates [17]

The AD/TL character (%) to identify the species of glass eel, AD/TL characters (%) of *Anguilla bicolor pacific* ranged from 0-3%, *A. marmorata* ranged from 14-17% [18]. Morphologically this reference can provide information quickly in identifying the species of glass eels that exist. However, for more specific purposes, the use of analysis techniques with DNA will be able to produce more complete identification characters.

3.2. Relation between weight length and condition factor

The growth pattern of glass eels based on the analysis of the relationship between length and weight showed a positive allometric growth pattern. The condition factor that represents the condition of the body of the glass eel shows that at a certain time the glass eel enters the waters of the Konaweha River estuary. The relationship between fish body curvature is closely related to the availability of food and environmental conditions. The abundance and species of fish vary each month. This variation in abundance is related to the recruitment process of glass eels that enter estuary waters after passing through the ocean phase. Tropical eels carry out the downstream migration process to reproduce every month. There is a certain period in which downstream migration takes place in large populations of adult eels as indicated by the abundance of glass eels entering estuary waters. In addition to these factors, environmental factors also affect the recruitment process of glass eels entering freshwaters. The recruitment of glass eels into fresh waters is influenced by temperature, salinity, turbidity, river currents, tidal and tidal cycles, moon phases and tends to be phototaxis negatively [6;5]

Table 2. Correlation among lenght weight, growth pattern, and condition factor of glass eel in Konaweha River estuary on August - October 2021

Species of glass eel	Lenght weight correlation	Growth pattern	Condition factor
A. marmorata	$W = 0.0001\ L^{4.4288}$ $R^2 = 0.63$; n=32	Positive allometric	1.2045
A. bicolor pasifika	$W = 0.0004\ L^{3.6094}$ $R^2 = 0.91$; n=31	Positive allometric	1.0418

Table 3. Values of physical, chemical and biological parameters of waters at the Konaweha River estuary, August-October 2021

No.	Parameter	Range
	Physical	
1	Temperature (°C)	25-26
2	Salinity (ppt)	5-16
3	TSS (mg/L)	0.353-0.465
4	TDS (mg/L)	6.8267-7.4067
5	BOT (mg/L)	64.210-70.220
	Chemical	
6	pH	7-7.5
7	Nitrate (mg/L)	0.390-0.393
8	Phosphate (mg/L)	0.027-0.0310
9	DO (mg/L)	2.900-3.700
10	Ammonia (mg/L)	0.034-0.048
	Biology	
11	Chlorophyll-a (mg/L)	0.445-0.736

3.3. Ecological conditions

The location for glass eel catching at the Konaweha River estuary is at coordinates -3°48´45”- 3°55 00”IS and 122°26°15”- 122°31´45”BT. The estuary of the Konaweha River is an estuary area. The downstream characteristics of the Konaweha River do not have large vegetation, the color of the water is cloudy, and the substrate is sandy mud. Activities around the Konaweha River include settlements, fisheries, agriculture, and tourism. Assessment of water quality condition of Konaweha River estuary.

The range of water quality parameters of the Konaweha estuary during the study is presented in Table 4. Measurement of water quality conditions was carried out to analyze the ecological conditions of the glass eel based on the physico-chemical and biological parameters of the waters.

Fluctuations in water quality conditions occur and affect the glass eel population. Several parameters have a positive correlation, one of which is the TSS value. The content of organic matter can trigger the growth of natural feed, which glass eels need as a food source. TSS is a suspended solid in the form of organic particles and can cause the water to become cloudy. Water conditions with a certain TSS value can cause a positive response. The opposite condition is seen in the brightness variable which has a negative correlation. As a negative phototaxis animal, the glass eel likes water that tends to be cloudy. This condition can stimulate the movement of the glass eel more actively and can protect from predators because of the limited viewing distance. The speed of the current affects the movement of water that can carry food and the energy of its motion can be used by the glass eel to swim to reach freshwater areas.

One of the glass eel recruitment processes is assisted by the degradation of salinity and temperature differences that occur in estuary waters. Large river water discharge causes changes in salinity offshore. The difference in the temperature of the lower river water also causes a change in temperature. These two variables become a groove that guides the entry of glass eels into estuary waters. Other variables that have a negative correlation are TDS and N-NH4. The high TDS value indicates high solids solubility so that the turbidity level of the waters is low. Conductivity has a relationship with mineral content such as salinity, so high conductivity occurs at high salinity. N-NH4 is toxic in waters so high values will cause disturbance to the biota that lives in these waters. The variables of pH and chlorophyll-a have very low correlation values so the variation in the measurement results found in the Konaweha River estuary can be said to not affect the glass eel.

Currently, the fishing of eel in the waters of the Konaweha River is in the juvenile to adult size. The activity of catching glass eel size has not been carried out as a livelihood for the community. However, management related to catching glass eel needs to be considered, considering the rate of seed utilization in some areas that have high abundances, such as in the waters of Java and North Sulawesi, shows over-exploitation. The number of glass eel catches was adjusted to the needs [19]. Several other strategies/efforts in conserving eel resources can be carried out. Maintaining eel seedling areas and reproductive routes so that the recruitment process is not disrupted, limiting the number of catches so that there is no over-exploitation and efficient use of eel seeds [20]. Aquaculture activities by improving cultivation technology are needed so that the survival value of cultivated eel seeds is high so that the use of seeds becomes more efficient. The application of restocking of eel must be carried out continuously, considering that until now eel spawning activities in culture media have not been carried out [21]. Restocking-based management is considered important management to increase eel populations [22]. Maritime authorities and research institutes in Sweden stated that based on an analysis of 75 years of data, restocking activities contributed to 90% of the silver eel population in Sweden in 2014 [23].

4. CONCLUSION

Glass eel caught during the research and identified based on *morphometrics* produced two species, namely *Anguilla marmorata* and *Anguilla bicolor pacific*. Counseling related to utilization and management needs to be applied so that eel fish resources can be sustainable and used continuously.

AUTHORS' CONTRIBUTIONS

Authors contribution about conceived the ideas or experimental design of the study, performed experiments/data collection, data analysis and interpretation, primary author: wrote most of the paper or drafted the paper, provided revisions to scientific content to the manuscript, provided stylistic/grammatical revisions to the manuscript.

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