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Otolith Morphology and Body Size Relationships of Monopterus albus in Malaysia

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Abstract: Monopterus albus production in Malaysia is widely depends on wild stock. Otolith morphology has been widely used to give additional information that is crucial for aiding the seed production. Otolith morphology of Asian swamp eel, Monopterus albus and its relationships to fish size was examined. A total of 125 samples were collected from the East Coast of Peninsular Malaysia (ECPM) and Sabah for analyses. Otolith descriptions were based on its outline, including otolith length (OL, mm), otolith height (OH, mm) and otolith weight (OW, mm). Fish total length (TL, cm) and body weight (BW, kg) were also measured and recorded. Paired t-test result (p-value > 0.05) showed there is no statistically significant difference between left and right otolith dimensions. Regression models related to otolith morphometric parameters with eel length and body weight were determined. There is no morphological difference between left and right otolith of swam eel observed. Otolith weight is a good indicator of body weight (R^2 =0.8994) and total length of fish (R^2 =0.8707) since the R^2 value is strongest than other relationship. If the otolith weight used to estimate the length and body weight of eel, the regression explains more than 87% of data variation in this Monopterus albus.

***Keywords**: Asian swamp eel, Body size, Monopterus albus, Otolith morphology.*

I. INTRODUCTION

The Asian swamp eel, *Monopterus albus* or popularly known as *belut* in Malaysia which are considered as a food fish and medicine by most locals [1]. Swamp eel is a native to sub-tropical and tropical Asia and is widely distributed in various countries including India, China, Japan, Malaysia, Indonesia, and Bangladesh [2], [3]. It is also found in West Africa and South, North and Central America [4], [5]. People choose this fish as main protein sources as it has a good taste. The annual report released by Department of Fisheries Malaysia [6] showed a total landing of swamp eel from public water bodies (from 2010 to 2015) were estimated around 221.7 tons.

However, the production of swamp eel from natural water bodies suffers a significant reduction as it decreased from 49.98 tons to 33.54 tons from 2010 to 2015 respectively [6]. Also, insufficient information from the hatchery and commercial production is a clear indication that the production Swamp eel is highly depending on wild stock [7]. Hence, aquaculture development on swamp eel is highly recommended not only to fulfill the demands of consumers but also to conserve the wild stock of this species. Thorough study and understanding swamp eel will aid in its future domestic culturing and practice of the species which will reduce the excessive pressure on the wild stock.

In the inner part of fish ears lies the calcareous concretions structure called otoliths (ear stone) and are species specific in nature [8]. The shape of otolith is a widely used tool for taxonomic studies [9], [10], identifying fish stock [11], identifying nursery habitat for fish [12], discrimination between closely related individuals [13], ecological studies [14] and ontogenetic studies [15]. In addition, previous studies provided the useful nature of otoliths in relation to the growth and development in various fish species [16], [17].

There are around 13 *Monopterus* species in Africa and Asia and differentiating them taxonomically might be difficult. Hence, the use of otolith morphometric for identification to species level could be applied to *Monopterus albus*. The information on the biology and otolith study of *Monopterus albus* in Malaysia is still limited despite increasing commercial importance of this species. Therefore, to aid in providing information that will help in identifying good stock for swamp eel species, the current study will focus on the otolith's morphology in relation to the body size of swamp eel in Malaysia.

II. METHODOLOGY

A. Sample Collection

A total of 125 swamp eel samples were collected from the trusted fisherman that are believed to be captured from the paddy and streams of the respective sampling sites. All samples were collected from East Coast of Peninsular Malaysia (Kelantan, Terengganu & Pahang) and Sabah States with a total 7 sampling sites (Fig. 1).

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Kelantan, Terengganu, Pahang and Sabah were selected for this study locations as they are characterized with many paddies, rivers and ditches sites that are favorable and suitable for the production of the swamp eel [7]. The Fishes were then transferred to the aquaculture laboratory of Universiti Sultan Zainal Abidin, Besut Campus Terengganu Malaysia for further analyses.

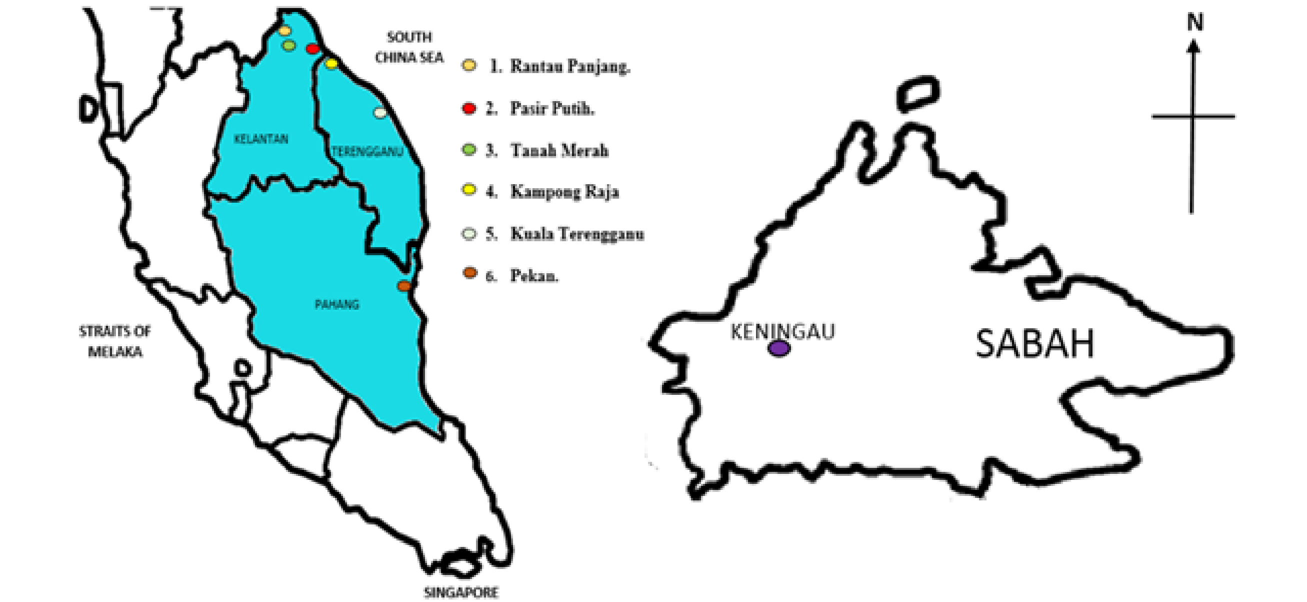

Fig. 1. Sampling sites of the Asian swamp eel, Monopterus albus in East Coast of Peninsular Malaysia and Sabah

B. Fish and Otolith Measurement

All samples were measured (total length TL) and weighed (body weight BW) using measuring tape and weighing scale respectively. The Sagittate (left and right) were removed by a cut through the cranium to expose them for removal with forceps. Successfully isolated otolith was placed in 1.5 ml Eppendorf tubes containing 70% alcohol and labelled as described by Aydin et al. [17]. Specimens with obvious evidence of calcite crystallization or other aberrant formations were rejected [18]. Cleaned otolith were placed in the petri dish using the thumb forceps. The otolith weight (OW), otolith length (OL) and otolith height (OH) were also measured (Fig. 2).

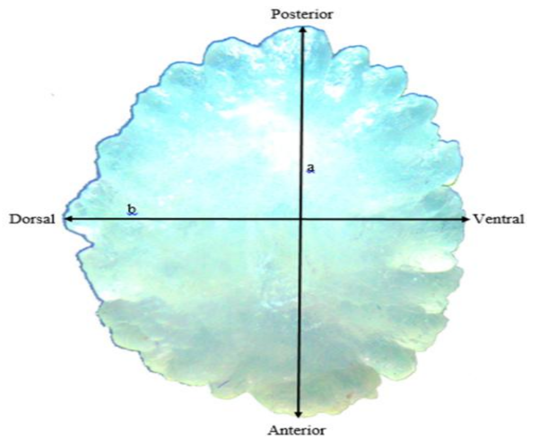

Fig. 2. otolith measurement of *M. albus* under Leica microscope: (a) maximum sagitta length (mm) and (b) maximum sagittal height (mm)

C. Analyses of morphometric characteristics of otolith

To examine the otolith morphology, the right and left sagittate (pattern of otolith) were captured using a digital camera under a Leica Microscope. The image of the internal side (proximal) of the otolith was taken. The side represents the sulcus acusticus that distinguishes right and left otolith. To obtain the good image of the sagittal contour, it was contrasts with a homogeneous black background. The sagittate length (OL), height (OH) were measured to the nearest 0.01 mm using the Leica application software. Otolith weight was recorded with a precision of 0.001 g.

The otolith morphometric (OW; OH; OL) related to body size (TL; BW) of fish were analyzed using the regression models which fit best to the data distribution in Microsoft Excel Software (version 2013) as described by Dehghani et al. [19]. Differences between right and left sagittate were tested using a paired t-test using SPSS software (version 17.0). The sagittate otolith morphological characters such as otolith shape, sulcus acusticus shape, proximal surface, anterior region and posterior region were visually investigated for the left and right otolith.

III. RESULTS AND DISCUSSIONS

A. Otolith Morphology

Among 125 individuals *Monopterus albus* used in this study, there is no morphological difference found among the left and right otolith.

The visual observation revealed all sagittal otolith (right and left) have irregular pentagonal shape, the proximal surface has concave shape and the anterior region is tapering for left and right sagittal otolith. Also, the posterior region is slightly round but more to tapering for left and right sagittal otolith (Fig. 3). It is possible to have otolith morphological similarity among same species individuals as reported in the previous study on otolith morphology of the *Nemipterus japonicas*, where no otolith morphological different discovered among the individual samples taken randomly from Northern Oman Sea [16].

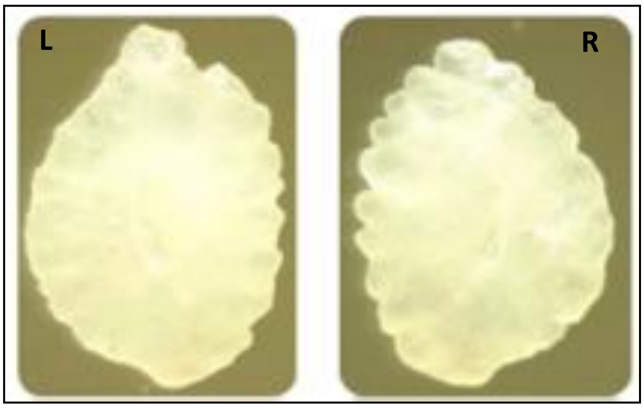

Fig. 3. Left (L) and right (R) sagittal otolith morphology features of *Monopterus albus* in Malaysia

B. Fish and Otolith Measurement

The morphometric characteristic of swamp eel samples body length ranges between 26.50 to 70.00 mm and body weight ranges from 0.020-0.400 kg with the mean of 45.568 mm and 0.109 kg respectively (Table I).

Table- I: The morphometric characteristics of body size and weight of 125 *Monopterus albus* in Malaysia

	Fish length (mm)	Body weight (kg)
Mean	45.57	0.11
Min	26.50	0.020
Max	70.00	0.400
Std.	9.214	0.072

The present study also revealed no significant differences in morphometric parameters between the left and right otolith with *P*-value of 0.877 mm (OW), 0.670 mm (OL) and 0.489 mm (OH) as shown in Table II. Previous otolith studies of various species such as *Sardinella sindensis* [19], *Rastrelliger kanagurta* [18] and 8 Malaysian *Mugilidae* spp. [20] had similar results with no significant differences in morphometric parameters between the left and right otolith.

C. Relationship between Body measurements (Length and Weight) and Otolith Morphometry of *Monopterus albus*

A positive linear regression model found between OH–TL (R^2 = 0.8087); OW-BW with (R^2 = 0.8994); and the OL-TL with (R^2 =0.8098). However, the relationship between OW-TL was exponential and explained 87% of the variances with the (R^2 = 0.8707). While the rest are resulted logarithm relationship between the OH-BW; OL-BW with (R^2 = 0.8117) and (R^2 = 0.8391) respectively as shown in Table III below.

Table 5: linear regression (R^2) relationship between the otolith morphometric and body size of swamp eel

		TL (cm)	**BW** (kg)
OW (g)	Equation	OW= 0.0008x100.0582x	OW= 0.1072BW+0.0014
	R^2	0.8707	0.8994
OH (mm)	Equation	OH= 0.0623TL-0.0092	OH= 8.0296BW + 1.9547
	R^2	0.8087	0.8117
OL (mm)	Equation	OL= 0.0756x + 0.3639	OL= 1.0928ln(x) + 6.4499
	R^2	0.8098	0.8391

OW = otolith weight; OH = otolith height; OL= otolith length; TL = total length BW = Body weight

In the current study, we observed the strong linear regression between the total length of fish and otolith length (TL-OL); total length of fish and otolith height (TL-OH); and body weight and otolith weight (BW-OW) as shown in Fig. 4, 5 and 6 respectively. Otolith length and height are typically linear related to length of fish until the fish rich its maximum size and later the otolith increases in thickness as seen in the previous studies [21], [22], [23]. Also, the linear regression between body length and otolith length and height is stronger in younger than the older fishes. Feeding and habitat conditions of the fish are some of the factors that affect the regression level between fish size and otoliths in most fish species [24], [25]. In addition, many researchers have proved significant linear correlation between body weight and otolith [26], [27]. According to Hunt [21], identifying weight of sagittal otolith is the best indicator for estimating fish length.

Table- II: Summary of descriptive statistics and paired (t-test) for the right and left sagittal otolith measurements of Monopterus albus

Otolith Measurement		Mean	SE	SD	Min	Max	P value
OW	Right	0.013054	0.00072370	0.00809129	0.0032	0.0538	0.877
	Left	0.013215	0.00074288	0.00830564	0.0032	0.0538	
OL	Right	3.766640	0.07005766	0.78326852	1.5	5.87	0.670
	Left	3.808640	0.06922449	0.77395335	1.51	5.89	

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OH	Right	2.828640	0.05706638	0.63802156	1.05	4.7	0.489
	Left	2.883840	0.05548877	0.62038332	1.09	4.63	

OW = otolith weight; OH = otolith height; OL= otolith length; SE = standard error and SD = Standard deviation

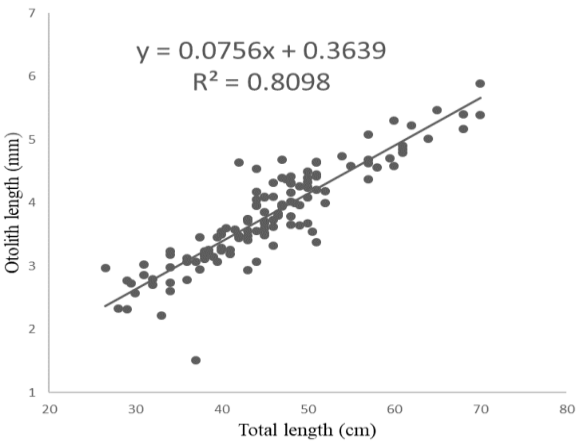

Fig. 4. TL-OL linear relationship of *Monopterus albus*

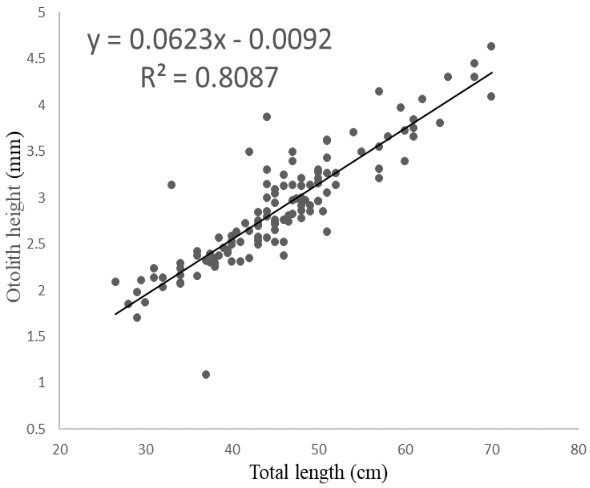

Fig. 5. TL-OH linear relationship of *Monopterus albus*.

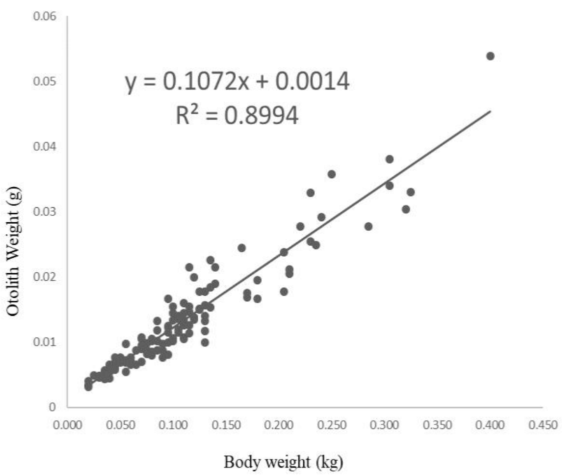

Fig. 6. BW-OW linear relationship of *Monopterus albus*.

On the other hand we observed the non-linear regression between the total length of fish and otolith weight (TL-OW); body weight of fish and otolith height (BW-OH); and body weight and otolith length (BW-OL) as shown in Fig. 7, 8 and 9 respectively.

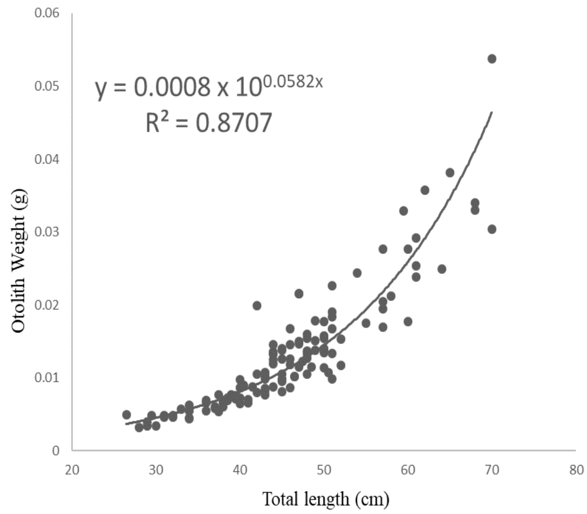

Fig. 7. TL-OW of logarithmic relationships of *M. albus*

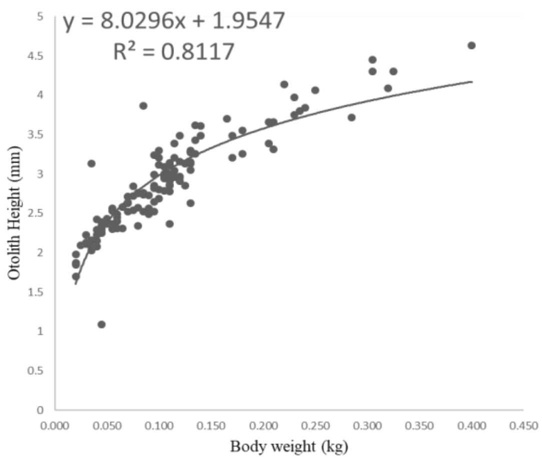

Fig. 8. BW-OH of logarithmic relationships in *M. albus.*

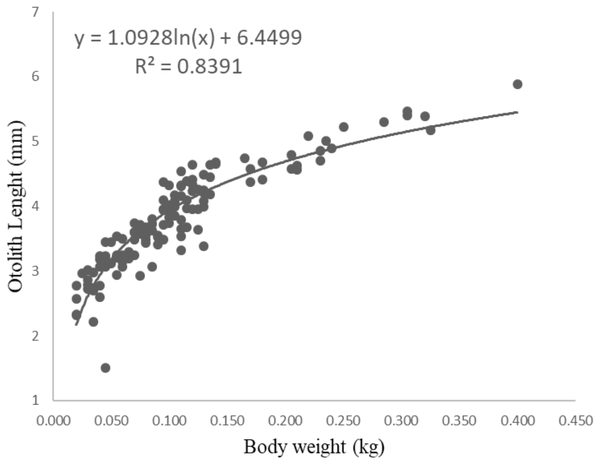

Fig. 9. BW-OL of logarithmic relationships in *M. albus*

Otolith weight and fish length are useful tool for determining the age of the fishes [27], [28].

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However, it was noticed that for two identically sized fish of different ages, the older and slower-growing individual have a heavier otolith than younger fish. This is because, the different amount of deposition of otolith materials as it continued deposited for a longer time.

The otolith size changes related with body growth, habitat depth and temperature [28], [29]. They added that species that lives in cold waters will have smaller, thinner and less sculptured shells than species in warmer water. Therefore, the otolith growth has different response to environmental factors than somatic growth. The decreasing of otolith size with increasing depth is a slowing down the chemical and metabolic processes involved in the incorporation of calcium carbonate. This slowing was produced by reduction of water temperature [30]. Naturally, the temperature and habitat conditions of Malaysia is the same across the country. This could be the reason why swamp eels in the current study shared unique pattern of otoliths across sampling sites.

All equation relating the otolith morphometric and body size of fishes were explain as above, it could be said that otolith weight is a good indicator of fish length and body weight of fish [18], since that the R^2 value for both relationships is higher compare to the others relationship. If otolith weight used to estimate length and weight of fish, the regression explains more than 87% of data variation in this species. According to previous authors, the OW is also the best indicator of fish fork length, fish weight and otolith perimeter [16], [29].

IV. CONCLUSION

There are no statistically significant differences observed between left and right sagittate otoliths for the swamp eel. Besides, the otolith morphology in this study provide a preliminary information regarding the identity, classification and species-specificity of swamp eel in Malaysia. Based on the current study sampling sites, we concluded that Malaysia has single species of *Monopterus albus.* Therefore, it could be possible to select brood stock for the seed production from all sampling sites. Although, other studies such as molecular genetic diversity of swamp eel is needed for more information before brood stock selection. The equations relating otolith variables to fish length and body weight for swamp eel specimens explained a relatively large proportion of the variance in the data analyzing the morphometric relationships. It is finally concluded that otolith weight is a good indicator of body weight and total length of fish since the R^2 value is strongest than other relationship.

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