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Research Article
Relationship Between Otolith Measurements with the Size of Areolate Grouper, *Epinephelus areolatus* in Terengganu Waters, Malaysia

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Abstract

Background and Objectives: *Epinephelus areolatus* is one of the most dominant grouper species landed in Terengganu waters. However, the information on the population characteristics of this species is still remaining at large. Otolith is a unique structure in fish that can derive a lot of valuable information on population parameters. This study is the first attempt to describe the relationship between otolith dimension and weight with the fish size. **Materials and Methods:** The samples of *E. areolatus* were collected from the main landing ports in Terengganu for 12 months, where 455 otoliths were extracted by up through the gill method. The length and width of otoliths were measured and the weight was recorded. Linear regression was used to analyze the relationship between fish size and otolith weight and dimension. **Results:** No significant differences observed between the size and weight of the right and left otolith of *E. areolatus*. A linear regression was plotted for Total Length (TL) and Total Weight (TW) with Otolith Length (OL), Otolith Width (OW) and otolith weight (OWE), showing strong relationship between otolith dimension and weight with fish size. Strong coefficient determination was observed in the relationship between fish size with otolith weight and width than with the otolith length. **Conclusion:** This study conclude that either left or right otolith would be suitable to use for further study on the age and growth analysis. To identify the diet of piscivores or carnivorous fish based on the relationship between fish length and otolith weight and dimension, the otolith weight and width are more appropriate to be used than otolith length.

Key words: Fisheries management, otolith, long-live species, groupers, population dynamics

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Competing Interest: The authors have declared that no competing interest exists.

Data Availability: All relevant data are within the paper and its supporting information files.

INTRODUCTION

Groupers are a commercially important species globally, received extensive demand due to its taste and resulted in high selling price. One hundred and fifty nine species in 15 genera from the Serranid subfamily Epinephelinae have been found around the world[1] and Matsunuma *et al.*[2] found 16 species of groupers in Terengganu waters, with the most dominant species landed is *Epinephelus areolatus*.

Epinephelus areolatus inhabit around coral reef areas and feed on penaied prawn and fishes[3,4]. About 10,296 t of groupers were landed in Malaysia in 2014 with *E. areolatus* is the most dominant grouper species captured by various fishing gears which include trawl nets[5]. Despite their abundance and commercial value, the information on their population characteristics as well as their conservation status however are very limited. The present study was carried out to investigate the relationships between fish length and otolith measurement for the Areolate grouper, *E. areolatus* in Terengganu waters, Malaysia. Many researchers have investigated the otolith morphology particularly on the relationship between otolith dimension and fish size[6-12]. This study will be the first step in explaining the population characteristics of *E. areolatus*. The data obtained will serve not only as baseline biological information for this species, but also as a guideline for further studies on their food habits or age and growth analysis for the management purpose of this commercially important species.

MATERIALS AND METHODS

Fish sampling and fish measurements: The fish samples were collected at two main fish landing ports in Terengganu, Kuala Dungun LKIM Port and Pulau Kambing LKIM Port for 12 months from December, 2014 to November, 2015. A total of 455 specimens were collected during sampling period. The Total Lengths (TL) of fish were measured to the nearest millimeters and body weights were measured to the nearest 0.01 g.

Otolith extraction and analysis: In this study, the sagittae otolith of *E. areolatus* which is the biggest otolith in fish were extracted by using "Up through the gills method" following the method by Secor *et al.*[13]. The otoliths were cleaned gently with water, air dried, stored in a labeled 10 mL glass vial. The Otolith Length (OL) which is the greatest distance between anterior and posterior otolith margin and Otolith Width (OW) which is the greatest distance from dorsal to ventral otolith margin[14] were measured with an electronic vernier caliper with a precision of 0.01 mm. The weights of otoliths (OWE) were measured with an electronic microbalance with accuracy of 0.0001 g. The left and right otoliths are considered separately. Broken and damaged samples were not included in this study.

The differences between the length, width and weight of left and right otoliths were tested using t-test statistical analysis. When the statistical equation for left and right otolith did not significantly differ, only one otolith (right or left) was used and analyzed for the relationship with fish length and weight. The otolith length, width and weight of fish from two fishing ports also were tested for differences by using t-test analysis. If no significant differences were recorded, the data from the two fishing port was combined for further analysis.

The linear regression model was used to investigate the relationship between the total length and weight of fish and the otolith length, width and weight in the present study. The relationship between otolith length, width and weight and fish length (TL) and weight were established using the following equation:

$$y = a+bx$$

where, y is the otolith length/width/weight, x is the fish length (TL)/fish weight (TW), a is the intercept value and b is the coefficient value (slope). The strength of each of relationships was evaluated from the determination coefficient (r^2).

RESULTS

A total of 455 *E. areolatus* have been examined in this study with the total length and weight ranged between 137-448 mm and 41.51-1289.86 g with a mean of 279.29 mm and 324.58 g, respectively (Table 1). The otolith length, width and weight of *E. areolatus* examined in this study were in between 5.55-14.25 and 2.78-6.57 mm and 0.0143-0.1855 g, respectively. Linear regression analysis (Fig. 1a-c, 2a-c) showed strong relationship between Otolith Length (OL), Otolith Width (OW) and otolith weight (OWE) with the Total Length (TL) and Total Weight (TW) of the *E. areolatus* fish.

Table 1: Principal parameters of *Epinephelus areolatus* and their otoliths obtained from the Terengganu waters (n = 455)

	Values	
Parameters	Mean±SD	Range
Total length (mm)	279.29±208.32	137-448
Total weight (g)	324.58±59.07	41.51-1289.86
Otolith length (mm)	9.58±1.66	5.55-14.25
Otolith width (mm)	4.60±0.69	2.78-6.57
Otolith weight (g)	0.0593±0.0306	0.0143-0.1855

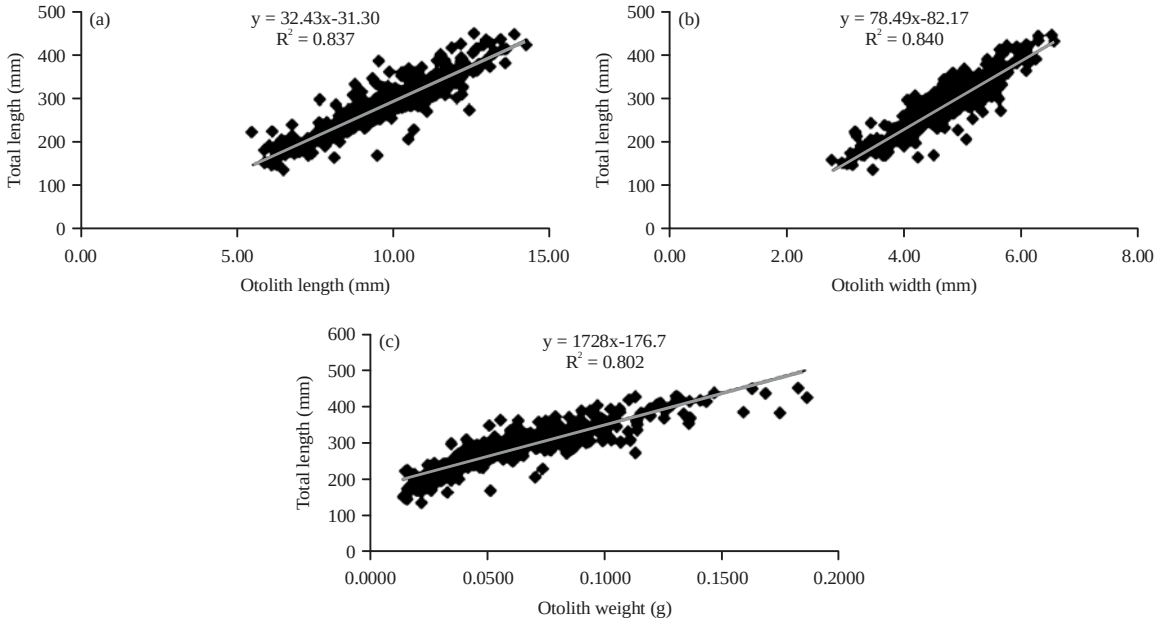

Fig. 1(a-c): Relationship of, (a) Total length-otolith length, (b) Total length-otolith width and (c) Total length-otolith weight in *Epinephelus areolatus* from Terengganu waters (n = 455)

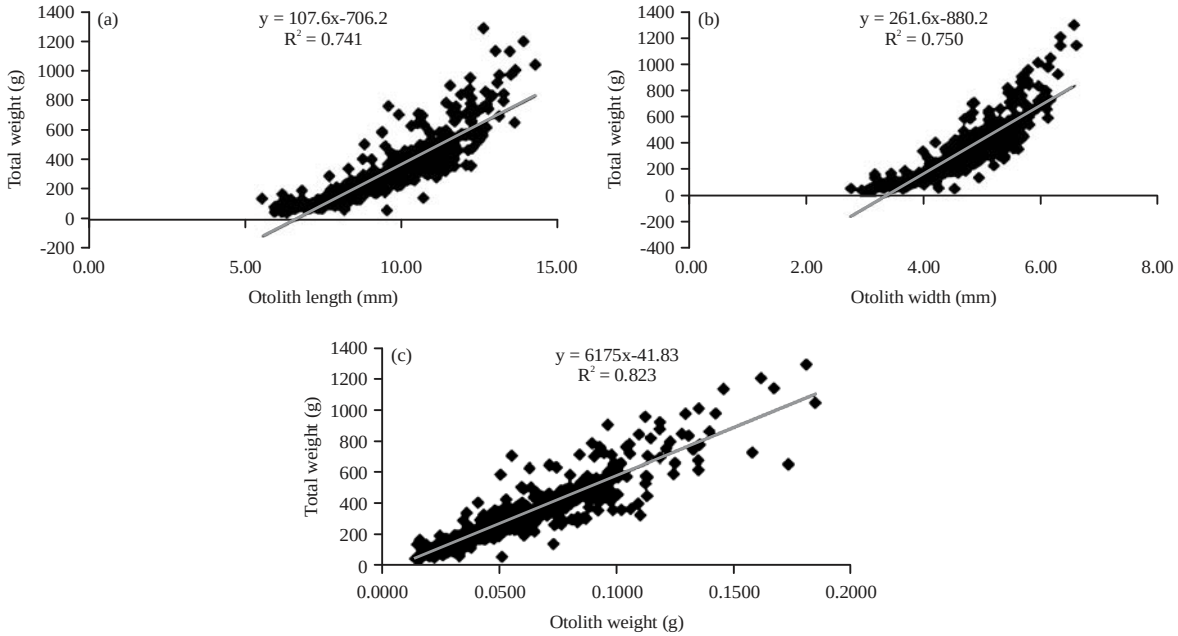

Fig. 2(a-c): Relationship between, (a) Total weight-otolith length, (b) Total weight-otolith width and (c) Total weight-otolith weight in *Epinephelus areolatus* in Terengganu waters (n = 455)

The best fit for the relationship between the total length and otolith dimensions was recorded for TL-OW with the coefficient of determination, r^2 = 0.840 (Fig. 1b). The relationship between the total weight and otolith dimensions showed that the best fit was recorded for TW-OWE (r^2 = 0.823) as shown in Fig. 2c. The lowest value of the coefficient of determination was reported for the relationship between the Total Weight (TW) and Otolith Length (OL) (r^2 = 0.741) as in Fig. 2a.

Figure 3 shows strong correlation for the relationship between Otolith Length (OL) and Otolith Width (OW) with the coefficient of determination, r^2 = 0.887.

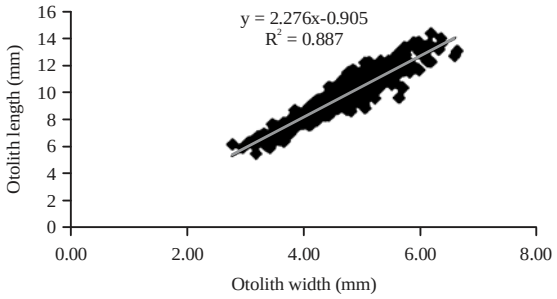

Fig. 3: Otolith length-otolith width relationship in *Epinephelus areolatus* (n = 455)

DISCUSSION

Linear functions are preferred and mostly used method to describe the relationship between otolith dimensions and fish size. A single linear regression was plotted against Total Length (TL) and Total Weight (TW) with Otolith Length (OL), Otolith Width (OW) and otolith weight (OWE) due to no significant differences observed between the size of left and right sagittae of *E. areolatus*. This finding is in agreement with the findings obtained by Al-Mamry *et al.*[8], Battaglia *et al.*[9] and Jawad *et al.*[11] but dissimilar with the findings by Harvey *et al.*[6] and Waessle *et al.*[15]. Harvey *et al.*[6] however mentioned that small samples in their investigation might be the reason why this diversity occurs.

The present study found that there was a positive linear relationship between the total length and total weight of *E. areolatus* with the otolith dimensions and weight of its otolith. Similar results were reported by Jawad *et al.*[11], Basusta *et al.*[12] and Battaglia *et al.*[16]. The results obtained in this study proved the statement by Waessle *et al.*[15] that the otolith dimensions and weight are good indicators for fish length and weight. Looking into the values of the coefficient of determination of the relationship between total length and body weight with otolith dimension and weight, the otolith weight is a better indicator than its length and width. The otolith weight also would be a more precise indicator of somatic growth for five pelagic fish species caught in the Croatium part of the Adriatic Sea[10]. Pawson[17] reported that the otolith size is affected by growth rate of the fish.

Otoliths are powerful feature for fish identification because of their high-specific variability in shape[9] and have been used to identify fish species found in the stomach or feces in piscivores and marine predator like seabird and marine mammals[18-20]. Jobling and Breiby[21] however found that by measuring the dimension and weight of the otolith from fish consumed by piscivores fauna or marine predators to identify the fish may be biased because of exposure of the otolith to chemical and mechanical abrasion in the stomach.

Jawad *et al.*[11] proposed to use only one otolith measurement for the estimation of fish length even though the otolith weight and length dimensions were strongly correlated with the length of fish. Aydin *et al.*[7] added that the linear relationship between the length of the fish and otolith dimension is stronger in younger fishes than that of the older fishes, due to the fact that the otolith length is linearly related to the fish length until the fish reaches maximum size, thereafter the otolith increase only in thickness which also supported by Williams and Bedford[22]. In this present study on *E. areolatus*, the otolith weight and width would be more appropriate for species determination of the older or long-lived species like groupers.

CONCLUSION

This study concludes that both left and right otolith can be used for further study especially on the age and growth analysis. The relationship between fish length and otolith dimension is useful to examine food habits of piscivores and others marine mammal from the length and width of recovered otoliths but care should be taken in analyzing the complete and perfect otolith. It is also suggested that otolith weight and width is more appropriate to be use when studying the relationship of otolith morphology with the length or weight of grouper species or other long-lived species.

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REFERENCES

1. Heemstra, P.C. and J.E. Randall, 1993. FAO species catalogue. Vol. 16. Groupers of the world (Family Serranidae, Subfamily Epinephelinae). An annotated and illustrated catalogue of the grouper, rockcod, hind, coral grouper and lyretail species known to date. FAO Fisheries Synopsis No. 125, FAO, Rome. http://www.fao.org/docrep/009/t0540e/t0540e00.htm

2. Matsunuma, M., H. Motomura, K. Matsuura, N.A.M. Shazili and M.A. Ambak, 2011. Fishes of terengganu-east coast of malay Peninsula, Malaysia. National Museum of Nature and Science, Malaysia Terengganu and Kagoshima University Museum.
3. Ambak, M.A., M.M. Isa, M.Z. Zakaria and M.A. Ghaffar, 2012. Fishes of Malaysia. 2nd Edn., Penerbit Universiti Malaysia, Terengganu, Malaysia.
4. Craig, M.T., Y.J.S. de Mitcheson and P.C. Heemstra, 2012. Groupers of the World: A Field and Market Guide. 1st Edn., Taylor & Francis, South Africa, ISBN: 9781466506022, Pages: 424.
5. DoF., 2014. Annual fisheries statistics. Department of Fisheries, Malaysia.
6. Harvey, J.T., T.R. Loughlin, M.A. Perez and D.S. Oxman, 2000. Relationship between fish size and otolith length for 63 species of fishes from the Eastern North Pacific Ocean. U.S. Department of Commerce, NOAA Technical Report NMFS 150, http://aquaticcommons.org/2511/.
7. Aydin, R., M. Calta, D. Sen and M.Z. Coban, 2004. Relationships between fish lengths and otolith length in the population of *Chondrostoma regium* (Heckel, 1843) inhabiting Keban dam lake. Pak. J. Biol. Sci., 7: 1550-1553.
8. Al-Mamry, J., L. Jawad, H. Al-Busaidi, S. Al-Habsi and S. Al-Rasbi, 2010. Relationships between fish size and otolith size and weight in the bathypelagic species, *Beryx splendens* Lowe, 1834 collected from the Arabian Sea coasts of Oman. Quaderni Museo Storia Natturale Livorno, 23: 79-84.
9. Battaglia, P., D. Malara, T. Romeo and F. Andaloro, 2010. Relationships between otolith size and fish size in some mesopelagic and bathypelagic species from the Mediterranean sea (Strait of Messina, Italy). Sci. Marina, 74: 605-612.
10. Zorica, B., G. Sinovcic and V. Cikes Kec, 2010. Preliminary data on the study of otolith morphology of five pelagic fish species from the Adriatic Sea (Croatia). Acta Adriatica, 51: 89-96.
11. Jawad, L.A., A. Ambuali, J.M. Al-Mamry and H.K. Al-Busaidi, 2011. Relationships between fish length and otolith length, width and weight of the Indian mackerel *Rastrelliger kanagurta* (Cuvier, 1817) collected from the Sea of Oman. Ribarstvo, 69: 51-61.
12. Basusta, A., H. Bal and E. Aslan, 2013. Otolith biometry-total length relationships in the population of Hazar bleak, *Alburnus heckeli* (Battalgil, 1943) inhabiting Lake Hazar, Elazig, Turkey. Pak. J. Zool., 45: 1180-1182.
13. Secor, D.H., J.M. Dean and E.H. Laban, 1991. Manual for otolith removal and preparation for microstructural examination. Technical Publication No. 1991-01, Belle W. Baruch Institute for Marine Biology and Coastal Research, pp: 84.
14. Yilmaz, S., O. Yazicioglu, R. Yazici and N. Polat, 2015. Relationships between fish length and otolith size for five cyprinid species from Lake Ladik, Samsun, Turkey. Turk. J. Zool., 39: 438-446.
15. Waessle, J.A., C.A. Lasta and M. Favero, 2003. Otolith morphology and body size relationships for juvenile Sciaenidae in the Rio de la Plata estuary (35-36° S). Scientia Marina, 6: 233-240.
16. Battaglia, P., D. Malara, G. Ammendolia, T. Romeo and F. Andaloro, 2015. Relationships between otolith size and fish length in some mesopelagic teleosts (Myctophidae, Paralepididae, Phosichthyidae and Stomiidae). J. Fish. Biol., 87: 774-782.
17. Pawson, M.G., 1990. Using otolith weight to age fish. J. Fish. Biol., 36: 521-531.
18. Fitch, J.E. and R.L. Brownell Jr., 1968. Fish otoliths in cetacean stomachs and their importance in interpreting feeding habits. J. Fish. Res. Board Can., 25: 2561-2574.
19. Ainley, D.G., D.W. Anderson and P.R. Kelly, 1981. Feeding ecology of marine cormorants in Southwestern North America. Condor, 83: 120-131.
20. Brown, R.F. and B.R. Mate, 1983. Abundance, movements and feeding habits of harbor seals, *Phoca vitulina*, at Netarts and Tillamook Bays, Oregon. Fish. Bull., 81: 291-301.
21. Jobling, M. and A. Breiby, 1986. The use and abuse of fish otoliths in studies of feeding habits of marine piscivores. Sarsia, 71: 265-274.
22. Williams, R. and B.C. Bedford, 1974. The Use of Otolithd for Age Determination. In: The Ageing of Fish, Bagenal, T.B. (Ed.). Unwin Brothers, Ltd., England, pp: 114-124.