

Original Research Article

OTOLITH SHAPE INDICES OF JAPANESE THREADFIN BREAM (*Nemipterus japonicus*, Bloch 1791) FROM THE MAKASSAR STRAIT, INDONESIA

ABSTRACT

Japanese threadfin bream (*Nemipterus japonicus*) is a demersal fish that plays a very important role in maintaining ecosystem stability related to webs and food chains. This fish often becomes prey for predatory fish. In efforts to reveal the relationship between predators and prey in food webs and food chains, there is still limited information due to the difficulty of identifying digested food. In connection with this, this study aims to identify the morphology shape index value otolith of Japanese threadfin bream. Sampling was carried out at the Labuang Maros Fish Landing Site with ~~a total sample of 150 samples~~ Japanese threadfin bream and ~~t~~ The morphometric data were collected from 150 pairs of otoliths of Japanese threadfin bream in April and May 2023. The calculation of the shape index uses ~~s~~ six descriptors, which include form factor (FF), roundness (RO), circularity or compactness (C), rectangularity (Rt), ellipticity (E), and aspect ratio (AR). The results showed that there was no significant difference in the otolith morphometry of the right and left otoliths ($P > 0.05$). Based on the shape index value obtained, it explains that the morphometric shape of the otolith of Japanese threadfin bream tends to be oval, elongated, and has an irregular surface.

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Keywords : Japanese threadfin bream; otolith shape; sagittae; Makassar strait

1. INTRODUCTION

Makassar Strait waters are part of the Republic of Indonesia Fisheries Management Area (WPP-RI) 713 which has high potential fish resources with an estimated potential of 374.5 tons or 11.38% of Indonesia's demersal fisheries potential of 3,290.8 tons / year or equivalent to 33.16% of the demersal fisheries potential in WPPRI 713 of 1.129.2 tons / year [1]. The utilization rate, which has only reached 0.3, indicates that it is still possible to exploit it until it reaches the maximum sustainable catch. Japanese threadfin bream is one of the demersal fish with a habit of living in groups, found in coastal waters with sandy and muddy bottom waters. Japanese threadfin bream live in the area around the reef at a depth of 10-50m. This fish has economic value with distribution areas throughout Indonesian waters including waters around Ambon, Sumatra, Java, Nusa Tenggara, Sulawesi, Maluku and Papua [2].

Otoliths are calcium-containing structures found in the inner ear located in the vestibular apparatus. Otoliths are organs that function in maintaining balance. Otoliths are able to provide very important information related to the age and life cycle of fish, able to describe the condition of the waters where fish live and when fish migrate [3].

The use of otoliths as a tool for determining the age of fish is based on the presence of growth rings that form along with the growth of fish [4]. The information recorded on otoliths can provide very accurate and valid data so that it can be a reference source in estimating stocks for both solitary and migratory fish and fish that do not migrate. Otoliths are very helpful in identifying aspects of biology, reproduction and the environment where fish live so that appropriate policies can be determined in their management [5]. Osman et al. [6] examined the use of otoliths as a medium to identify and distinguish three species of fish with the otolith method through measuring otolith length, analyzing the relationship between fish length and other otolith variables.

In an effort to identify the contents of the digestive system, researchers often find types of food in the form of fish that have been destroyed by the digestive process. This has resulted in reduced information on the types of fish they prey on, especially Japanese threadfin bream, which are prey for other large fish. In fact, otoliths can be found in quite large quantities in the digestive organs of predatory fish [16] because otoliths have resistance to the digestive process [17]. This research aims to determine the morphology of Japanese threadfin bream otoliths using shape index values which are still limited through form factor, roundness, circularity or compactness, rectangularity, ellipticity, and aspect ratio. It is hoped that the results of this research can complete basic data related to the identification of fish species, especially fish that are prey and have been digested, to obtain better information regarding predator-prey relationships in networks and food chains in marine ecosystems.

2. MATERIALS AND METHODS

2.1 Data collection and sample handling

Otolith samples totaling 150 pairs were obtained from fishermen's catches using gill net fishing gear in the Makassar Strait. Otolith extraction is was done by cutting or splitting the head of the fish, then taking the sagitta type otolith using tweezers with a sharp tip. Handling Otoliths were cleaned by cleaning using distilled water to clean otoliths from the remaining membranes and mucus, then dried and then put in an eppendorf bottle before otoliths are measured.

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2.2 Morphometric observation of otoliths

Otolith Morphometric measurements were carried out on otoliths that were still intact and not damaged. The length and width of the otolith were measured with a digital caliper and each left and right otolith were weighed using a micro balance (OHAUS adventurer AX223) with a sensitivity of 0.0001 g to obtain otolith weight data in g units. To identify the shape of the otolith, take a photo was taken using the zoom feature of a cellphone camera with a dark

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background with a capacity of 13 mega pixels and 4 times magnification assisted by light in the form of a ringlight so that the object can be seen more clearly.

Measurement of otolith length started ~~eds~~ from the left end (posterior) which ~~is was~~ based on the *sulcus acusticus* (center point) to the right (anterior) on the rostrum. The width of the otolith ~~is was~~ measured from the dorsal to the ventral part with the midpoint measuring the *sulcus acusticus*. The measured parts included ~~d~~ otolith length (OL, mm), otolith width (OW, mm), otolith area (OA, mm²), and otolith perimeter (OP, mm) (Figure 1). The radius was measured from the *sulcus acusticus* posteriorly, anteriorly, dorsally and ventrally for both the right and left otoliths. The number of otoliths required for morphometric purposes is 150 pairs of right and left otoliths.

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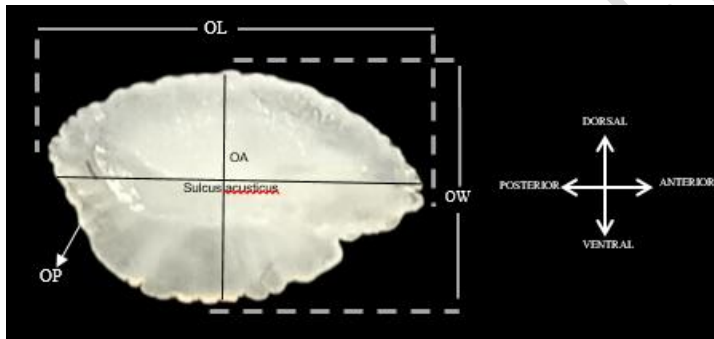


Fig 1. Otolith morphometric measurement axis. *Otolith length* (OL), *otolith width* (OW), *otolith parameter* (OP), *otolith area* (OA).

2.3 Data Analysis

The morphometric data of the right and left otoliths were tested for normality and homogeneity using the Kolmogorov-Smirnov test, to determine the significance of differences in the morphometric data of the right and left otoliths. Determination of otolith shape index can be done with six descriptors consisting of form factor (FF), roundness (RO), circularity (C), rectangularity (R), ellipticity (E), aspect ratio (AR) [7], [18], [19] [20], [21], [22], as shown in Table 1.

Table 1. Calculation of otolith shape index using morphometric measurements.

Shape index	Formula	Usability
FF	$4 \pi OA / Op^2$	Estimates the regularity of the otolith surface, where FF=1 indicates a regular surface like a circle. FF<1 means surface is irregular, while FF=1 means the surface is regular.
RO	$4 OA / \pi L^2$	Comparing the otolith shape against the full circle shape, where RO=1 indicates a full circle shape.
C	(OP^2 / OA)	Comparing otolith shape to full circle shape
RT	$OA / (OL \cdot OW)$	Describes the variation of otolith length and width with respect to area, where Rt = 1 represents a perfectly square otolith.
E	$(OL - OW) / (OL + OW)$	Indicates a proportional change in axis
AR	OL / OW	Indicates the shape of otolith, where an AR value >1 indicates an otolith shape which to be elongated.

3. RESULT AND DISCUSSION

The measurement results of otolith morphometric samples vary in size for the right and left otoliths of Japanese threadfin bream. The right otolith has a length ranging from 3.8-6.9 mm (5.506 ± 0.871 mm) with a width ranging from 2.2-4.6 mm (3.261 ± 0.756 mm), a minimum radius of 1.861 ± 0.368 mm and a maximum of 2.828 ± 0.550 mm. While the left otolith has a length ranging from 3.8-6.7 mm (5.478 ± 0.854 mm) with a width ranging from 2.3-4.2 mm (3.294 ± 0.604 mm), with a minimum radius of 1.894 ± 0.392 mm and a maximum of 2.789 ± 0.594 mm. The results of the morphometric measurements of the right and left otoliths provide information that the morphometric otoliths with an average length value are greater than the average width with the radius of the core towards the length also greater than the width.

The otolith shape index was calculated by referring to the six descriptions proposed by Aviglian [8]. The six descriptions of otolith shape obtained in this study are shown in Table 2. The data in Table 1 after statistical testing using the t test obtained no difference between the shape index of the right and left otolith of Japanese threadfin bream ($P > 0.05$).

Table 2. Shape index of the right and left otolith of Japanese threadfin bream obtained during the study.

Variable	Otolith shape index		Indication of calculation result
	Right	Left	
F _F	0.891	0.886	FF value < 1 indicates irregular otolith
R _O	0.619	0.531	RO value ≠ 1 indicates that the circle is not full

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C	14.723	14.706	Irregular otolith shape with not full circle condition
R _t	0.820	0.815	R _t value < 1 depicts square but imperfect otoliths
E	0.256	0.249	Indicates the occurrence of proportional axis change
A _R	1.688	1.663	A _R value > 1 indicates an otolith shape that tends to elongate

Description: F_F = *Form factor*, R_O = *Roundness*, C = *Circularity* atau *compactness*, R_t = *Rectangularity*, E = *Ellipticity*, dan A_R = *Aspect ratio*

Referring to the otolith shape index as shown in Table 2, it is obtained that the surface of the otolith of Japanese threadfin bream both on the right and left side is obtained with irregular appearance, the shape of the circle is not full, the otolith shape is irregular with the condition of the circle is not full, the otolith is square but not perfect, there is a proportional change in the axis and the otolith shape tends to be elongated. The condition of the otolith shape index obtained in this study is thought to be due to the otolith dimensions, namely length, width, area and radius, which are the basic data in calculating the otolith shape index.

Each fish species has a certain morphometric size (length and weight) and characteristics (shape), where otolith morphometrics have been studied to identify growth and environment and life history [9]. When the fish undergoes a change in length, the circle on the otolith also increases until it reaches an asymptote (saturated growth), the shape of the dark and light growth circles on the otolith is far from the core and close to the core of the otolith. This is related to the recording of fish events during their lifetime [10]. However, [Bani et al.](#) [11], revealed that the thickness and level of roundness formed in the otolith of pelagic fish with the habit of being an active swimmer so that it has a thin and elongated otolith sagittale shape, while demersal fish have a thick otolith shape due to limitations in swimming.

Fish otolith shape index can be influenced by abiotic factors (temperature), environmental parameters (food availability) and biotic factors, namely individual genotypes [12]. Otolith growth is highly dependent on fish growth and otolith shape varies with fish diet in nature [13]. Otolith shape can differ systematically between right and left otoliths and can vary geographically due to environmental conditions [14].

Changes in the shape index of fish otoliths can be caused by global warming [5]. [Kelig et al.](#) [15], explained that global warming contributes to the decline in the production of polyunsaturated fatty acids such as (eicosapentaenoic acid₂(EPA) and docosahexaenoic acid₂(DHA) in phytoplankton in the food web, especially in fish that live in the sea. EPA and DHA are nutrients for most fish species in the form of omega-3, so if there is a decrease in production, it can affect aspects of fish physiology, especially otolith morphogenesis. Global warming also causes temperature fluctuations and changes. ~~Temperature has~~ which have an impact on the speed and trajectory of otolith morphogenesis. Changes in otolith shape occur when the width/length ratio decreases with the distance between the rostrum and antirostrum.

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This suggests that otolith shape is highly sensitive to changes in ambient temperature, making it an effective parameter for identifying fish stocks.

4. CONCLUSION

~~The morphological characteristics of the otolith of Japanese threadfin bream of the sagitta species based on the otolith shape index obtained the surface of the otolith of Japanese threadfin bream both on the right and left side obtained results with an irregular appearance, the shape of the circle is not full, the shape of the otolith is irregular with the condition of the circle is not full, the otolith is square but not perfect, there is a proportional change in the axis and the otolith shape tends to be elongated.~~

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The morphological characteristics of the otolith on both right and left sides of Japanese sea bream of the species sagitta showed an irregular appearance, an irregular square shape, an empty circle, and an axis tending towards an elongated shape.

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REFERENCES

1. Decree of the Minister of Marine Affairs and Fisheries of the Republic of Indonesia Number 19 Year 2022. Regarding the Estimation of Fish Resource Potential, Allowable Catch, and Utilization Rate of Fish Resources in the State Fisheries Management Area of the Republic of Indonesia. [Indonesian]. 2022.p7. <https://ppid.riau.go.id/download/30/1670571648kepmen-kp-no.pdf>
2. Oktaviani S, Boer M, Yonviter. Biological aspects of Japanese threadfin bream (*Nemipterus japonicus*) in Banten bay waters [Indonesian]. Bawal Widya Journal of Capture Fisheries Research. 2016;8(1):2502-6410. <https://dx.doi.org/10.155578/bawal.8.1.2016.21-28>
3. Adiansyah V. Training in making observations and analyzing fish otoliths: reading the age and life cycle of fish with otoliths [Indonesian]. Faculty of Biology, Gadjah Mada University. 2018.
4. Habibie SA, Djumanto, Rustadi. Use of otoliths to determine age and spawning time of red devil fish, *Amphilophuslabiatus* [Gunther, 1864] in Sermo Reservoir, Yogyakarta [Indonesian]. Journal of Indonesian Ichthyology. 2015;15(2):87-98. <https://jurnal-iktiologi.org/index.php/jii/article/view/63>.
5. Kantun W. and Budimawan. Application of otolithometry in fisheries [Indonesian]. IPB Press. 2023. p188.
6. Osman AGM, Farrag MM, Mahenna SF, Osman YA. Use of Otolithic Morphometrics and Ultrastructure for Comparing Between Three Goatfish Species (Family: mullidae) From the northern Red Sea, hurghada, Egypt. Iranian Journal if Fisheries Sciences. 2020;19(2):814-832. [https://DOI: 10.22092/ijfs.2018.120044](https://doi.org/10.22092/ijfs.2018.120044).
7. Wujdi A, Maya A, Jatmiko I. Otolith shape of skipjack, *Katsuwonus pelamis* (Linnaeus, 1758) from the Indian Ocean. Journal of Indonesian Ichthyology. 2018;18(2):151-163. <https://doi.org/10.32491/jii.v18i2.312>

8. Avigliano E, Domanico A, Sanchez S. &Volpedo AV.Otolit elemental fingerprint and scale and otolith morphometry in *Prochiloduslineatus* provide identification of natal nurseries. *Fisheries Research*. 2017;186:1-10.DOI:10.1016/J.FISHRES.2016.07.026
9. Darmanto H. Fish species recognition based on otolith contours using convolutional neural network [Indonesian].*Journal joined*. 2019.2 (1). <https://doi.org/10.31331/joined.v2i1.487>
10. Aisyah S. Morphometric study and age determination of Lencam fish (*Lethrinuslentjan*) at the Ketapang fish auction (TPI) in Pangkalpinang City [Indonesian]. *Journal of Aquatic Resources*. 2018. <https://journal.ubb.ac.id/akuatik/article/view/692>
11. Bani A, Porsaed S, Tuset VM. Comparative morphology of the sagittal otolith in three species of south Caspian Gobies. *Journal of fish biology*. 2013;82(4):1321-1332.<https://doi.org/10.1111/jfb.1207>
12. Vignon M. & Morat F. Environmental and genetic determinant of otolith shape revealed by a non-indigenous tropical fish. *Marine Ecology Progress Series*. 2010; DOI :10.3354/meps0865. Doi : [10.3354/meps0865](https://doi.org/10.3354/meps0865)
13. Mille T, Mahe K, Cachera M, Villanueva MC, de Pontual H, Ernande B. Diet is correlated with otolith shape in marine fish. *Mar. Ecol. Prog.* 2016; Ser. 555, 167–184.DoI : [10.3354/meps11784](https://doi.org/10.3354/meps11784)
14. Mahe K, Ider D, Massaro A, Hamed O, Jurado-Ruzafa A, Goncalves P, Anastasopoulou A, Jadaud A, Mytilineou C,&Elleboode R.Direction bilateral asymmetry in otolith morphology may affect fish stock discrimination based on otolith shape analysis.2021;13 (6):987. <https://doi.org/10.3390/sym13060987>
15. Kelig MC, Gourtay G, Bled, Defruit C, Chantre H, de Pontual R, Amara G, Claireaux C, Audet JL, Zambonino-Infante. ErnandeB. Do environmental conditions (temperature and food composition) affect otolith shape during fish early-juvenile phase? An experimental approach applied to European Seabass (*Dicentrarchus labrax*). *Journal of Experimental Marine Biology and Ecology*. 2019; Volume 521.<https://doi.org/10.1016/j.jembe>
16. Pascoe PL. Fish otoliths from the stomach of a thresher shark. *Journal of the Marine Biological Association of the United Kingdom*, 1986. 66(2), 315–317. <https://doi.org/10.1017/S0025315400042958>
17. Aydin R, Calta M, Dursun S, Coban MZ. Relationships between fish lengths and otolith length in the population of *Chondrostoma regium* (Heckel, 1843) In habit ingKeban Dam Lake.Pakistan Journal of Biology Science, 2004. 7(9): 1550–1553. <https://doi.org/10.3923/pjbs.2004.1550.1553>
18. Ponton D. Is geometric morphometrics efficient for comparing otolith shape of different fish species?.*Journal of Morphology*, 2006. 267(6): 750–757. <https://doi.org/10.1002/jmor>
19. Aguera A, Brophy D. Use of saggital otolith shape analysis to discriminate North east Atlantic and Western Mediterranean stocks of Atlantic saury, *Scomberesox saurus saurus* (Walbaum). *Fisheries Research*, 2011. 110(3): 465–471. <https://doi.org/10.1016/j.fishres.2011.06.003>
20. Sadighzadeh Z, Tuset VM, Valinassab T, Dadpour MR, Lombarte A. Comparison of different otolith shape descriptors and morphometrics for the identification of closely related species of *Lutjanus* spp. from the Persian Gulf.*Marine Biology Research*, 2012. 8(9): 802–814. <https://doi.org/10.1080/17451000.2012.692163>

21. Zengin M, Saygin S, Polat N. Otolith shape analyses and dimensions of the Anchovy *Engraulis encrasicolus* L in the Black and Marmara Seas. *Sains Malaysiana*, 2015. 44(5), 657–662.
22. Zischke MT, Litherland L, Tilyard BR, Stratford NJ, Jones EL, Wang Y. Otolith morphology of four mackerel species (*Scomberomorus* spp.) in Australia: Species differentiation and prediction fisheries monitoring and assessment. *Fisheries Research*, 2016.176: 39–47. <https://doi.org/10.1016/j.fishres.2015.12.003>

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