Asian Journal of Fisheries and Aquatic Research

Volume 26, Issue 5, Page 90-96, 2024; Article no.AJFAR.117199
ISSN: 2582-3760

Otolith Shape Indices of Japanese Threadfin Bream (*Nemipterus japonicus*, Bloch 1791) from the Makassar Strait, Indonesia

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Authors' contributions

This work was carried out in collaboration among all authors. All authors read and approved the final manuscript.

Article Information

DOI: https://doi.org/10.9734/ajfar/2024/v26i5769

Open Peer Review History:
This journal follows the Advanced Open Peer Review policy. Identity of the Reviewers, Editor(s) and additional Reviewers, peer review comments, different versions of the manuscript, comments of the editors, etc are available here: https://www.sdiarticle5.com/review-history/117199

Original Research Article

Received: 06/03/2024
Accepted: 09/05/2024
Published: 18/05/2024

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 150 samples and morphometric data were collected from 150 pairs of otoliths in April and May 2023. The calculation of the shape index uses 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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***Cite as:** Annisa, S. N., Kantun, W., & Kabangnga, A. (2024). Otolith Shape Indices of Japanese Threadfin Bream (Nemipterus japonicus, Bloch 1791) from the Makassar Strait, Indonesia. Asian Journal of Fisheries and Aquatic Research, 26(5), 90–96. https://doi.org/10.9734/ajfar/2024/v26i5769*

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 10-50 m. 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]. [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 [7] because otoliths have resistance to the digestive process [8]. 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 obtained from fishermen's catches using gill net fishing gear in the Makassar Strait. Otolith extraction is done by cutting or splitting the head of the fish, then taking the sagitta type otolith using tweezers with a sharp tip. Otoliths were cleaned by distilled water from the remaining membranes and mucus, then dried and then put in an eppendorf bottle before otoliths are measured.

2.2 Morphometric Observation of Otoliths

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, a photo using the zoom feature of a cellphone camera with a dark 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 starts from the left end (posterior) which is based on the *sulcus acusticus* (center point) to the right (anterior) on the rostrum. The width of the otolith is measured from the dorsal to the ventral part with the midpoint measuring the *sulcus acusticus*. The measured parts include otolith length (OL, mm), otolith width (OW, mm), otolith area (OA, mm^2),

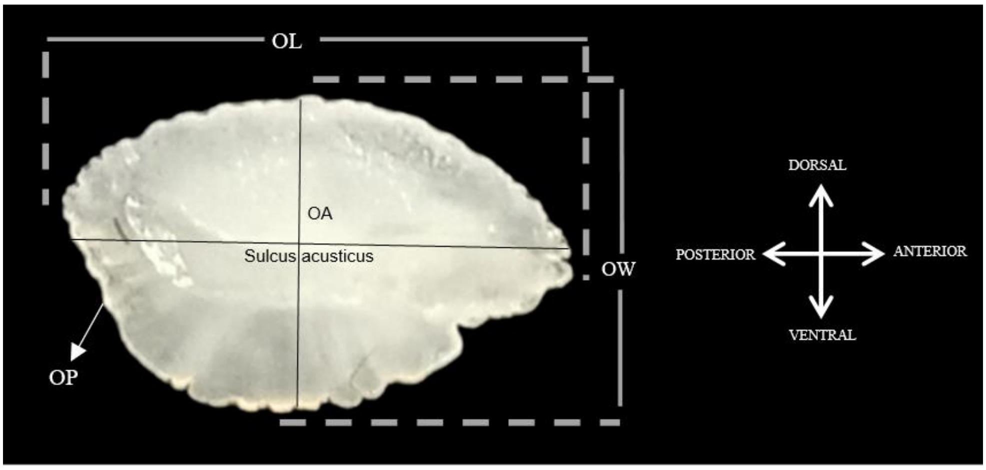

Fig. 1. Otolit morphometric measurement axis. *Otolith lenght* (OL), *otolith widht* (OW), *otolit parameter* (OP), *otolit area* (OA)

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

Shape index	Formula	Usability
FF	4 π OA / Op2	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 / π L2	Comparing the otolith shape against the full circle shape, where RO =1 indicates a full circle shape
C	(OP2 / OA)	Comparing otolith shape to full circle shape
RT	OA / (OL . 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

and otolith perimeter (OP, mm) (Fig. 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.

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) [9], [10], [11] [12], [13], [14], as shown in Table 1.

3. RESULTS 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.

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
C	14.723	14.706	Irregular otolith shape with not full circle condition
R_t	0.820	0.815	Rt 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	AR 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

The otolith shape index was calculated by referring to the six descriptions proposed by Aviglion [15]. The six descriptions of otolith shape obtained in this study are shown in Table 1. 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).

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. The otolith shape index can help identify and determine types of food, especially those that have been destroyed by predators. Identify types of fish, especially fish that are prey and have been digested, so that predator-prey relationships in webs and food chains in marine ecosystems can be detected properly. Wujdi *et al*. [9] also used the otolith shape index to identify types of food in the food chain..

Otolith shape can also be important information relating to ecological aspects between predators and prey [16]. The shape of the otolith is also related to the history of the fish species and feeding habits [17] thus contributing to the development of the shape and microstructure of the otolith. Otolith shape is influenced by abiotic factors (temperature), environmental parameters (food availability) and biotic factors, namely the individual's genotype [18]. Varying otolith shapes are closely related to fish genetics and ecology as well as fish biological behavior [19], ontogenetics, and environmental factors such as temperature, habitat, seasonal variations and food [20]. Otolith growth is highly dependent on fish growth and the shape of the otolith varies with the fish's diet in nature [21]. In this regard, observation and identification of otolith shape indices can also be carried out on other species using the same method provided the otoliths are still intact.

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 [22]. 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 [23]. However, [24], 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 sagittae 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 [25]. Otolith growth is highly dependent on fish growth and otolith shape varies with fish diet in nature [26]. Otolith shape can differ systematically between right and left otoliths and can vary geographically due to environmental conditions [27].

Changes in the shape index of fish otoliths can be caused by global warming [5]. [28], explained that global warming contributes to the decline in the production of polyunsaturated fatty acids (eicosa pentaenoic acid, EPA and docosa hexaenoic acid, 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 which have an impact on the speed and trajectory of otolith morphogenesis. Changes in morphogenesis can characterize fish stocks that are characterized by differences in environmental and genetic conditions. These differences cause variations in otolith growth, resulting in variations in otolith shape and allowing for stock discrimination throughout the species' distribution range [29].

Changes in otolith shape occur when the width/length ratio decreases with the distance between the rostrum and antirostrum. 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 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.

ACKNOWLEDGMENTS

The author would like to thank the help of various parties who have helped from the beginning to the end of the research so that everything can run smoothly.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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