Correlation of otolith morphometrics with total length and weight of shortfin scad (*Decapterus macrosoma* Bleeker, 1851) in the Special Region of Yogyakarta

Farah F. Athaa, Djumanto, Suwarman Partosuwiryo, Namastra Probosunu

Laboratory of Aquatic Resources Management, Department of Fisheries, Faculty of Agriculture, Gadjah Mada University, Bulaksumur Yogyakarta, Indonesia.
Corresponding author: Djumanto, lely4192@yahoo.com

Abstract. Small pelagic fish called shortfin scad (*Decapterus macrosoma* Bleeker, 1851) are primarily caught in the waters southern of the Special Region of Yogyakarta and are highly valuable economically. In this study, the morphological characteristics of the otoliths and the relationship between morphometrics of the otoliths and fish length and weight in the shortfin scad were examined. The shortfin scad samples were taken randomly as much as 35 kg with a total of 119 individuals caught by fishermen operating purse seines in October 2022. A total of 112 pairs of intact otoliths were collected, consisting of 59 pairs of males and 53 pairs of female otoliths. Each otolith's morphometrics were measured, including length, width, area, perimeter, and mass. The shape of the otolith was determined by calculating the six index indicators which include roundness (RO), form factor (FF), rectangularity (Rt), circularity (C), aspect ratio (AR), and ellipticity (E). T-tests were performed on the left and right otoliths, also between the male and female otoliths. The otolith sagitta of shortfin scad was typically oval-shaped, elongated, and had an irregular surface. The left and right otoliths were similar in size and shape and frequently symmetrical. The linear regression equation y = ax + b can be used to describe the relationship between otoliths length and total length. There is an isometric relationship between the otolith morphometrics of sex and position. The lengthening of the otoliths may indicate a significant rise in fish size.
Key Words: *Decapterus macrosoma*, length, morphometric, otolith, symmetric.

Introduction. The Republic of Indonesia Fisheries Management Area (WPPNRI) 573, which covers the Indian Ocean to the south of Java to the south of Nusa Tenggara, the Sawu Sea, and the western part of the Timor Sea, has the potential to capture fisheries resources of 1,267,540 tons per year (Decree of the Minister of Maritime Affairs and Fisheries No. 50 of 2017). The waters of the Special Region of Yogyakarta province have a capture fishery potential of around 32,000 tons year^{-1} which can be caught by fishing vessels of various sizes using various fishing gear (Decree of the Head of the DIY Marine and Fisheries Service Number 188 of 2018). The Special Region of Yogyakarta province has a coastline of about 135 km and a coastal fishing port in Sadeng (PPP Sadeng) to land fish caught by fishermen. The purse seine net is a form of fishing gear used in the coastal waters of Special Region of Yogyakarta, and the catch is landed at the Sadeng Beach Fishing Port. The types of fish caught by PPP Sadeng fishermen between 2017 and 2021 consist of 11 orders, 21 families, and 28 species (Nabil et al 2018).

Fishing vessels with a cargo capacity of 5-30 gross tons (GT) catch small pelagic, large pelagic, and demersal fish in coastal waters as far as 12 miles from the coastline of the Special Region of Yogyakarta province (Jamal et al 2021). The composition of fish caught was dominated by small pelagic fish, then large pelagic fish and the least was demersal fish. Several small pelagic fish mostly caught consist of *Decapterus* sp., *Rastrelliger kanagurta*, *Elagatis bipinnulata*, and *Caranx ignobilis*. *Decapterus* sp. is one of the small pelagic fish commodities most hunted by fishermen using purse seine-type fishing gear, surface gillnet nets, and fishing vessels of various sizes. *Decapterus* sp.

dominated monthly fish production at PPP Sadeng in 2017-2021, and high production occurs almost annually. The cumulative catch of *Decapterus* sp. in 2021 reached 226.548 tons with a total production value of $234,360 US (Jamal et al 2021).

Shortfin scad (*Decapterus macrosoma*) has a wide distribution in Indonesian waters covering the waters west of Sumatra to the Bali Strait, including the waters south of Java, Ambon Sea, and the South Sea of Sulawesi to Makassar. Shortfin scad is a small pelagic fish whose population is relatively abundant in the coastal waters of Special Region of Yogyakarta. Shortfin scad in the coastal waters of Special Region of Yogyakarta can be caught almost every month, but the amount of catch fluctuates (Hendiarti et al 2005). Shortfin scad catches tend to decrease due to the increasing number of operating fishing gear. The decline in the shortfin scad population needs to be anticipated by carrying out appropriate management. Shortfin scad resource management requires basic biological information such as population parameters, reproductive biology, length-weight relationship, degree of plumpness, and growth in length or weight. Fish growth can be determined in various ways, one of which is from the morphometric characteristics of the otolith (Megalofonou 2006).

Otoliths or ear stones in fish are biomineral structures resulting from biomineralization in the fish's body. Every teleost fish's inner ear cavity contains the otolith, an organ of balance, and a hearing aid. Fish's taxon, age, and size have all previously been determined using their otoliths (Cahyadi & Windarti 2016). Currently, otoliths are used in several scientific fields, such as age and growth estimation, fish hearing and balance, fish larvae ecology, species identification, stock identification, and environmental reconstruction of fish habitats (Rodriguez Mendoza 2006). In addition, the growth in fish otolith length is proportional to the fish’s growth in length or weight, so the length or weight of otoliths can be used to estimate fish body length and vice versa (Yilmaz et al 2014). The relationship between otolith and fish length can provide valuable information in assessing fish growth patterns and managing fish resources and conservation (Djumanto 2020). Studies on the morphometry of fish otoliths in Indonesia still need to be made, especially on shortfin scad otoliths, whose population is very abundant in the coastal waters of the Special Region of Yogyakarta. Studying the relationship between the otolith and the length and weight of the shortfin scad is essential for managing shortfin scad resources. The results of this study are one of the primary data to determine fish resource management policies, especially the shortfin scad population in the southern waters of Yogyakarta province, which is included in WPPNRI 573.

Material and Method

Description of the study sites. The Yogyakarta Special Region's waters are the fishing grounds of shortfin scad (Figure 1) which can take place throughout the year. Shortfin scad populations were caught using purse seine nets with a 1-inch mesh size. Fishing for shortfin scad took place from October to November 2022. The fish caught were landed at the PPP Sadeng. Furthermore, samples of shortfin scad fish were randomly selected once every week, as much as about 5 kg. Hence, the total weight reached approximately 35 kilograms, and the total number was about 199 individuals. After that, the fish samples were transferred to the laboratory to collect otolith morphometry data and for measurements of length, weight, and sex determination.

Otolith data collection. Each fish sample was measured for total length using a ruler with an accuracy of 0.1 cm and for weight using a scale to the nearest 0.1 g, then the abdomen was dissected to determine the fish’s sex. Bony fishes contain three pairs of otoliths on both sides of the brain, namely lapillus, asteriscus, and sagitta, which are housed in otolith organs, which are membranous vesicles, with the name’s utricle, lagena, and saccule (Sánchez & Martínez 2017). The otoliths taken were the sagitta, the largest compared to the asteriscus and lapilli otoliths. The otoliths in the head cavity were removed by making a flat set over the eye, from front to back, so that the brain was exposed. Then, the brain tissue was removed so that the sacculus sac, which contains the otolith sagitta, was visible. The sagitta was removed by opening the sacculus on the right and left sides. Next, the otoliths were taken using tweezers, washed using tap water, and cleaned of any attached membranes or dirt. The otoliths were air-dried and stored in a labeled plastic bottle.

Each otolith was weighed to obtain otolith mass (O_M) data using a digital analytical balance to the nearest 1 mg. Then the otolith was photographed in a photo box to get the best contrast image, and each otolith shot was marked with a ruler to determine the length scale when taking morphometric data. Furthermore, each photo was analyzed using the ImageJ application, which included otolith length (O_L), otolith width (O_W), otolith area (O_A), and otolith circumference (O_P) (Figure 2). The explanation of each parameter is as follows; the length of the otolith (O_L) is the farthest distance from the anterior to the posterior part. Furthermore, the width of the otolith (O_W) is the farthest length from the dorsal to the ventral side, a line perpendicular to its length. The area of the otolith (O_A) is a measure of the total surface area of the otolith. The circumference of the otolith perimeter (O_P) is a measure of the length of the outer perimeter of the otolith.

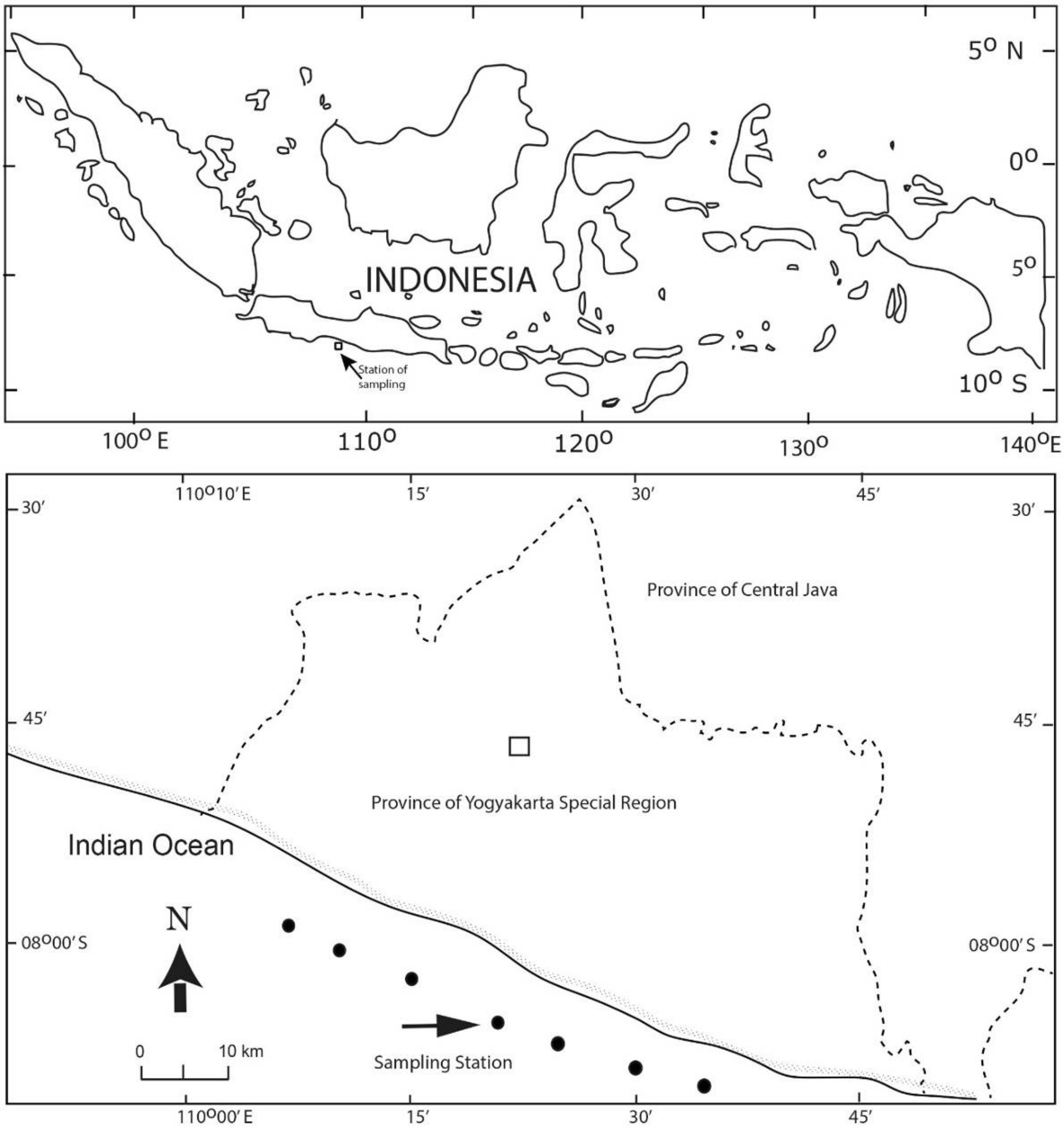

Figure 1. Map showing shortfin scad fishing ground located in the coastal waters of the Special Region of Yogyakarta.

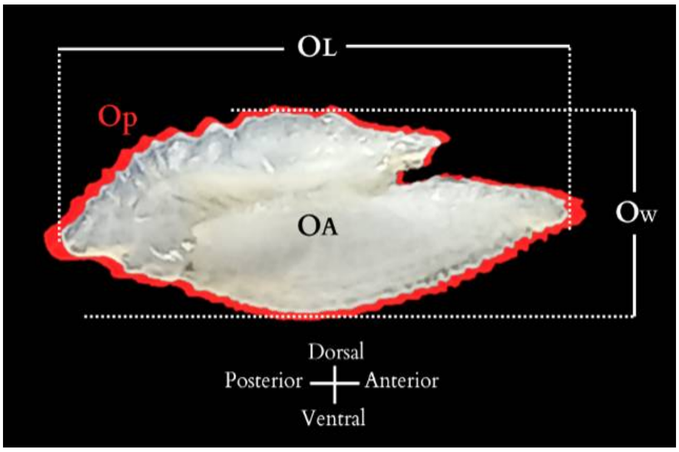

Figure 2. Morphometric measurements of otoliths of shortfin scad.

Data analysis. Analyses of differences in otolith morphometric between right and left side and between female and male sexes were carried out by t-test with a confidence level of 95%. The test results were then compared with the standard t-table. If t count < t table, then (Ho) it is stated that there is no significant difference between the right and left otoliths and between the female and male sexes. Conversely, if t table > t count (H1), it is stated that there is a difference between the right and left otoliths, or there is a difference between the otoliths in the female and the male fish. Then a correlation analysis was performed, which included the relationship between the total length and weight of the fish and the size of the otolith morphometrics, namely O_L, O_W, O_A, Op, and O_M, using statistical correlation analysis and linear regression y = ax + b, with a significance level of 95% (de Santana et al 2018), where y is the length or width of the otolith, and x is the total length.

The otolith morphometric data obtained was then used to calculate the otolith shape index, which consisted of six descriptors. The otolith shape index consists of roundness (R_O), form factor (F_F), rectangularity (R_t), compactness or circularity (C), aspect ratio (A_R), and ellipticity (E). The six descriptor formulas were calculated using Microsoft Excel. Calculations of the equation of each otolith shape index descriptor and its explanation are presented in Table 1. Then a two-way paired t-test was performed on the right and left otolith morphometry and between female and male otoliths, and regression analysis of otolith morphometrics on fish length and weight.

Table 1

Measurement of otolith morphometrics and calculation of the otolith shape index

Shape index	*Formula*	*Explanation*
R_O	$4O_A/\pi O_L^2$	Comparison of otolith shape with full circle shape (R_O = 1 means full circle otolith shape).
F_F	$4\pi O_A/O_P^2$	Determining the regularity of the otolith surface. F_F = 1 means that the otolith surface is regular, like a circle, $F_F \neq 1$ means that the otolith surface is irregular.
R_t	$O_A/O_L\text{-}O_W$	Shows the variation of length and width concerning otolith area. R_t = 1 indicates a perfectly rectangular otolith.
C	O_P^2/O_A	Shows a comparison of otoliths with a full circle shape.
A_R	$O_L - O_W$	Provides information on the shape of otoliths. A value of A_R > 1 means that the otolith has a shape that tends to be elongated.
E	$\frac{O_L - O_W}{O_L + O_W}$	Shows a proportional change in the axis.

Results. The number of shortfin scads measured for length and body weight was 199 individuals. The total length of female fish ranged from 14.4 to 30.5 cm with an average length of 24.9 cm, and for male fish, between 18.0 and 29.3 cm with an average length of 25.4 cm. While the weight of the female ranged from 32.5 to 231.3 g with an average weight of 135.7 g, and the weight of the male fish ranged from 51.7 to 223.9 g with an average weight of 143.7 g. The number of otoliths collected was 199 pairs comprised of 111 males and 86 females. Some of the collected otoliths were damaged during the collection process, such as broken or chipped, so there were 112 pairs of otoliths left, consisting of 59 pairs of males and 53 pairs of females. Based on the morphometric measurements of the otoliths, the means and standard deviations (mean±SD) were as follows: O_L 4.9±0.36 mm, O_W 2.1±0.12 mm, O_A 6.5±0.7 mm^2, O_P 13.81±0.75 (mm), and O_M 0.0042±0.0007 g.

Otolith shape index. The average otolith shape index is presented in Table 2. The otolith shape index on the shortfin scad shows that the otolith sagitta has a round elongated, or oval shape, tends to be convex internally, and is relatively thin. In the center of the otolith there is a concave sulcus acousticus channel extending from anterior to posterior margin of the otolith. The surface of the otolith is irregular, as indicated by the form factor value of 0.425 ($F_F < 1$). A roundness index value of 0.108 ($R_O > 0$) and a circularity value of C = 29.646 indicates that the otolith tends to be oval or the length is greater than the width. The rectangularity index value is 0.227 ($R_t \neq 1$), the aspect ratio is 2.854 ($A_R > 1$), and the ellipticity is E = 0.406, indicating that the otolith of the shortfin scad tends to be elongated.

Table 1

Otolith shape index of shortfin scads

Otolith shape index	*Male n = 59*		*Female n = 53*		*Max*	*Min*	*Average*
	Left	*Right*	*Left*	*Right*			
Ro	0.107	0.108	0.109	0.107	0.131	0.094	0.108±0.007
F_F	0.428	0.423	0.428	0.421	0.492	0.372	0.425±0.023
R_t	2.273	2.283	2.266	2.250	0.257	0.197	0.227±0.133
C	29.494	29.746	29.481	29.907	33.724	25.533	29.65±0.1554
A_R	2.882	2.829	2.809	2.892	3.500	1.900	2.854±0.263
E	0.407	0.402	0.405	0.411	0.83	0.703	0.406±0.129

Differences between right and left otoliths. A total of 112 pairs of sagittal otoliths were obtained from 199 samples of shortfin scad. Each pair of sagittal otoliths obtained had variations in length, width, area, perimeter, and weight. The right otolith has an average O_L = 4.9±0.33 mm, O_W = 2.1±0.12 mm, O_A = 6.47±0.65 mm^2, O_P = 13.83±0.7 mm, and O_M = 0.0042±0.0006 g. Meanwhile, the left otolith has an average O_L = 4.9±0.38 mm, O_W = 2.1±0.12 mm, O_A = 6.46±0.73 mm^2, O_P = 13.92±0.8 mm, and O_M = 0.0042±0.0007 g.

Statistical analysis was performed on O_L, O_W, O_A, O_P, and O_M, which resulted in a morphometrics comparison of the right and left otoliths with no significant difference ($p < 0.05$). A comparison of right and left meristic otoliths in shortfin scad fish, as illustrated by the boxplot diagram, is presented in Figure 3.

Differences between male and female otolith. The morphometric size of the sagitta otoliths from male and female samples differs. The morphometric size of the female otoliths averaged O_L 4.9±0.4 mm, O_W 2.1±0.13 mm, O_A 6.43±0.76 mm^2, O_P 13.92±0.8 mm, and O_M 0.0042±0.0007 g. Male otoliths have an average size of O_L 4.9±0.32 mm, O_W 2.1±0.12 mm, O_A 6.49±0.63 mm^2, O_P 13.83±0.7 mm, and O_M 0.0042±0.0006 g.

Statistical analysis of the length, width, area, circumference, and weight of the otoliths (OL, OW, OA, OP, and OM) revealed no significant differences between the morphometry otoliths of male and female shortfin scads. Figure 4 shows a boxplot of differences between female and male shortfin scads of otolith morphometric size.

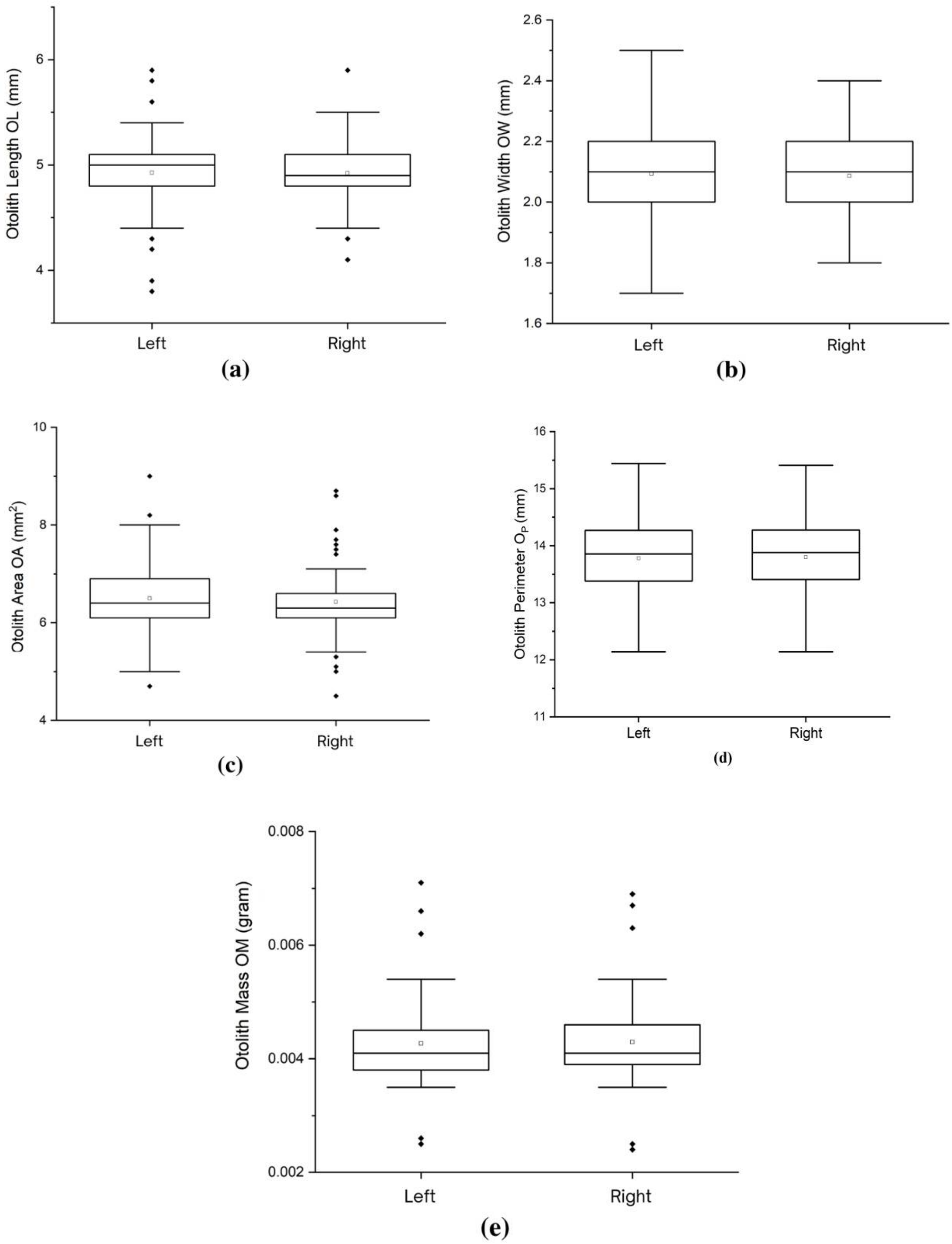

Figure 3. Morphometrics comparison of right and left otoliths of shortfin scad (a) otolith length, (b) otolith width, (c) otolith area, (d) otolith perimeter, and (e) otolith weight.

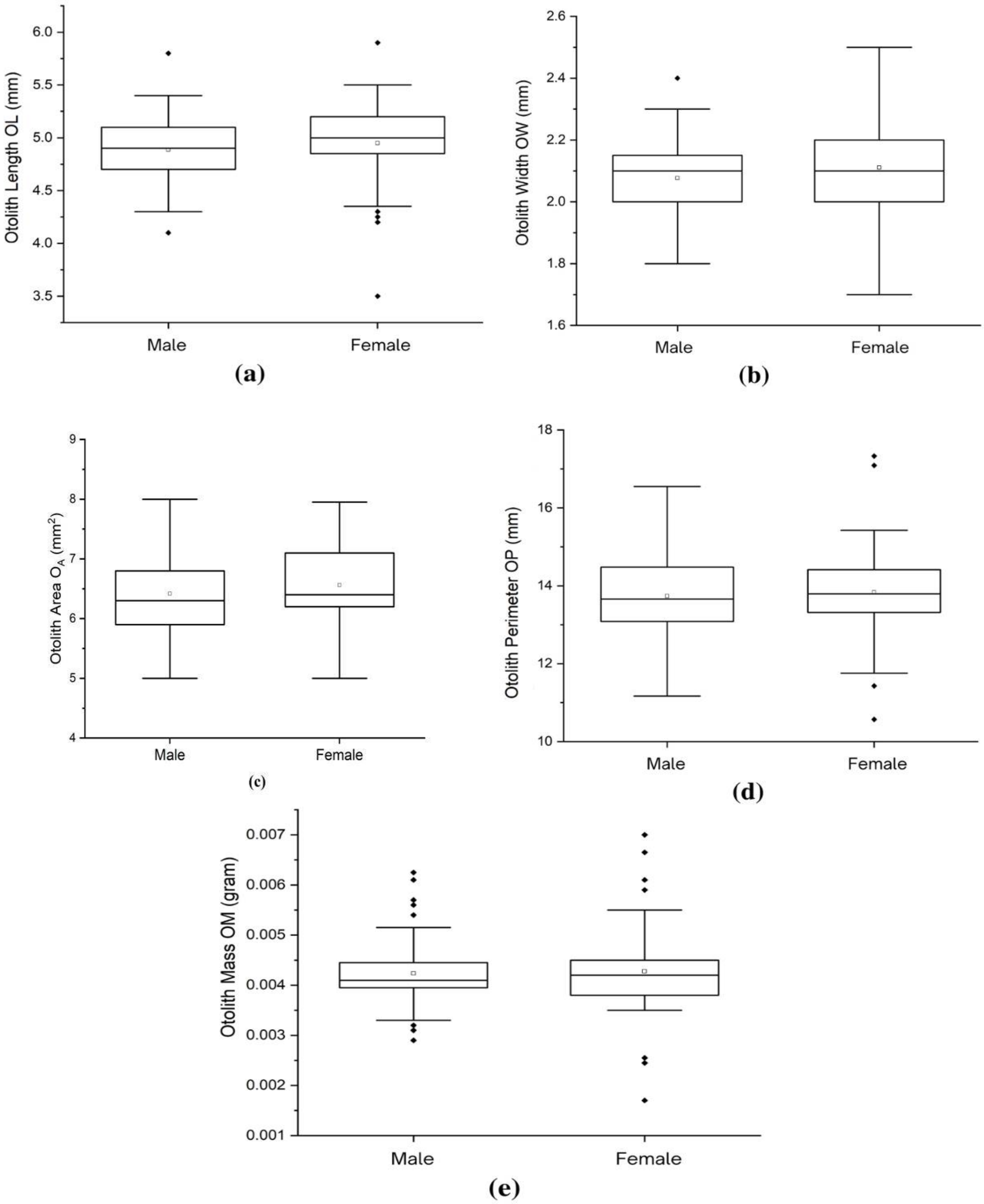

Figure 4. Morphometric comparison between female and male shortfin scad otoliths: (a) otolith length, (b) otolith width, (c) otolith area, (d) otolith circumference, (e) otolith weight.

Relationship of otolith with length and weight. The relationship between the length, width, or surface area of the otolith to the total length gain of shortfin scad fish shows a pattern of linear regression relationship. A proportional increase will follow each increase in the total length of the fish in the length, width or surface area of the otoliths. The findings of the linear regression analysis revealed a pattern of positive and linear relationships between the shortfin scad fish's length (O_L), width (O_W), area (O_A), otolith perimeter (O_P), and otolith weight (O_M). Figure 5 shows the linear regression relationship pattern equation for each parameter.

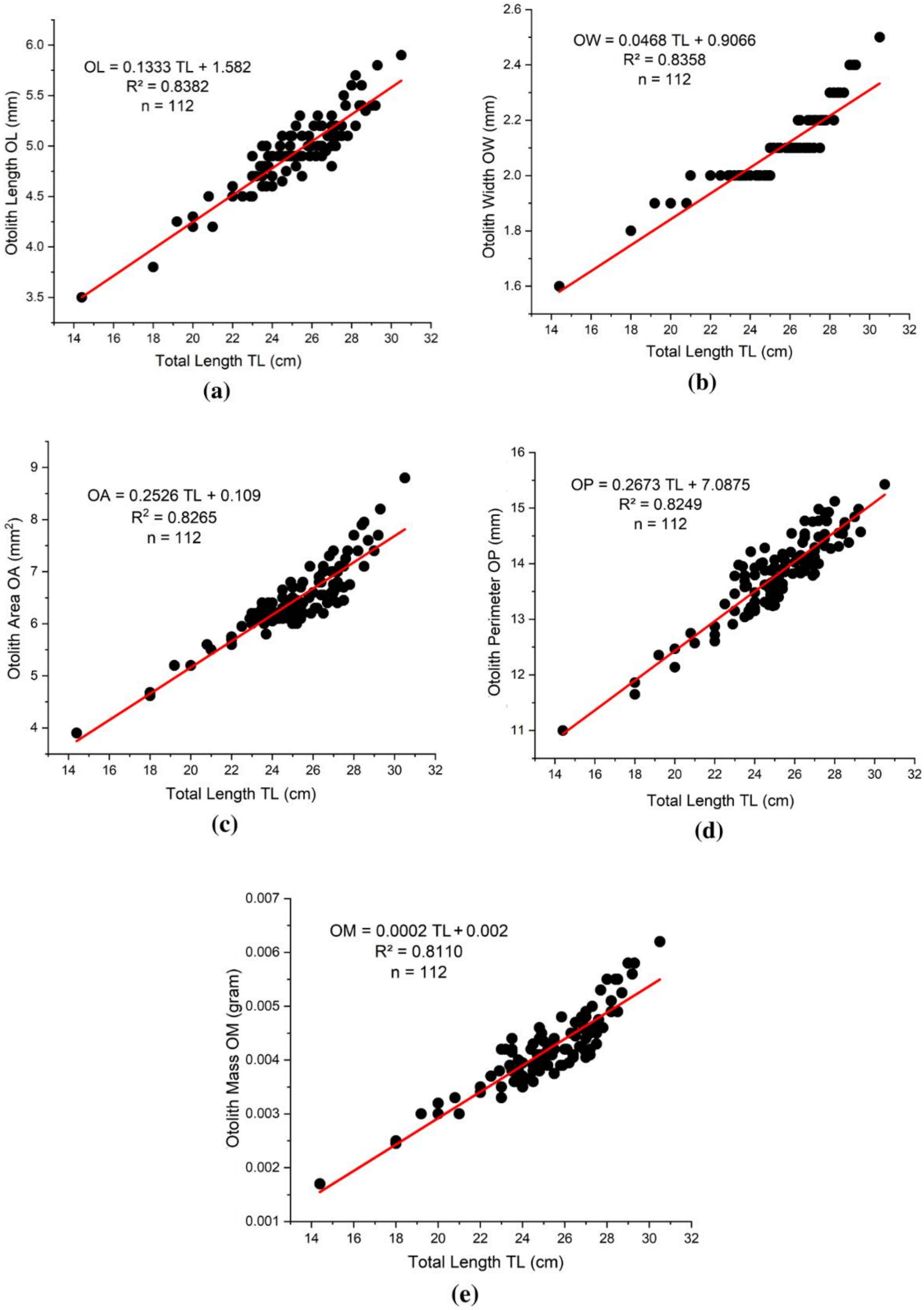

Figure 5. Linear regression relationship between total length (TL) and otolith morphometrics: (a) otolith length, (b) otolith width, (c) otolith area, (d) otolith perimeter, and (e) otolith weight.

Growth in total length (TL) of the shortfin scad with otolith length (O_L) and otolith width (O_W) has the form of a linear regression relationship with the equation O_L = 0.133 TL + 1.582 and O_W = 0.047 TL + 0.907 with a coefficient of determination of 0.84 each. Every 1 cm growth in length will be followed by growth in length and width of the otolith, respectively 0.13 mm and 0.047 mm. The relationship between total length (TL) and otolith area (O_A), and otolith circumference (O_P) has a linear regression relationship with the equations O_A = 0.253 TL + 0.109 and O_P = 0.267 TL + 7.087 with a coefficient of determination of 0.83 each. Every 1 cm growth in length will be followed by an increase in the area and circumference of the otolith by 0.25 mm^2 and 0.27 mm, respectively. While the relationship between total length (TL) and otolith weight (O_M) has a linear regression pattern forming the equation O_M = 0.0002 TL + 0.002 with a coefficient of determination of 0.81. For every 1 cm length growth in the shortfin scad, the otolith weight increases by 0.0002 g. The average growth of the total length of fish successively affects the growth of the length and width of the otolith by 84%, the growth of the area and circumference of the otolith by 83%, and the growth of the otolith weight by 81%.

Figure 6 shows the relationship between the length, width, area, circumference, and weight of the otolith with the body weight of the shortfin scad, which forms a linear regression line.

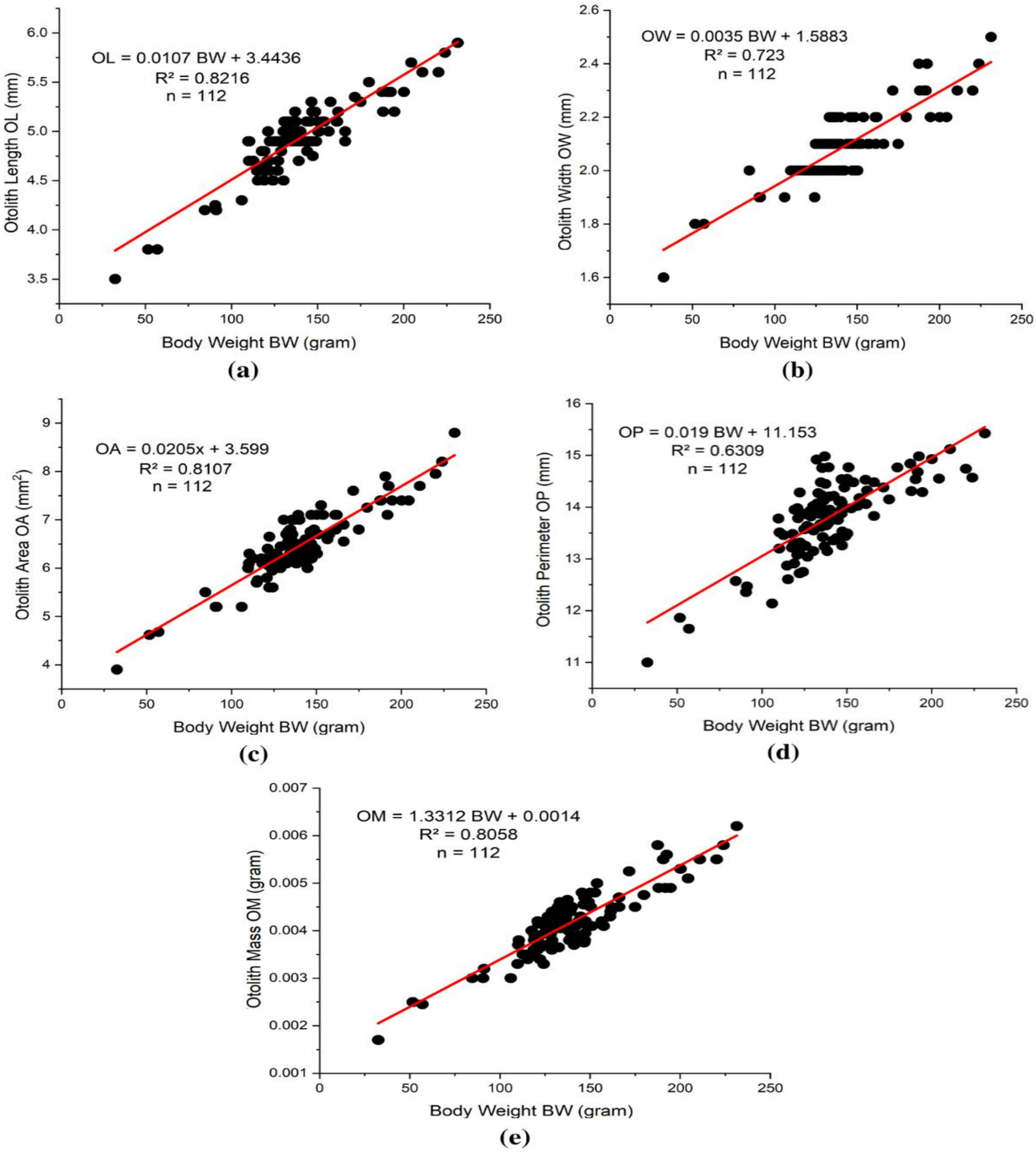

Figure 6. Linear regression relationship between body weight (W) and otolith morphometrics consisting of (a) otolith length, (b) otolith width, (c) otolith area, (d) otolith circumference, and (e) otolith weight.

The strongest relationship between fish body weight and otolith morphometrics is with otolith length, otolith area, and otolith weight. All three have a strong relationship with a coefficient of determination of 0.82, 0.81 and 0.81, respectively. The weight growth for every 1 g in the shortfin scad will affect the otolith's length, area, and weight by 0.011 mm, 0.021 mm^2, and 1.133 g, respectively. The weight growth of fish will affect the growth of otolith length by 82%, as well as the increase in otolith area and fish otolith weight by 81%. The relationship between fish body weight and otolith width and otolith perimeter has a strong linear regression relationship with a coefficient of determination of 0.72 and 0.63, respectively. Each 1 g weight growth in the shortfin scad will be followed by an increase in the width of the otolith by 0.0035 mm and the perimeter of the otolith by 0.019 mm. The average growth of fish weight will affect the growth of the width and perimeter of the otolith by 72% and 63%, respectively.

Discussion. Shortfin scad has an otolith shape index value in the same range as other fish from the genus *Decapterus* such as mackerel scad (*Decapterus macarellus*) with an average index $R_O = 0.351$ ($R_O > 0$), $F_F = 0.464$ ($F_F < 1$), $R_t = 0.659$ ($R_t \neq 1$), C = 27.558, $A_R = 2.370$ ($A_R > 1$), and E = 0.81 (Manginsela et al 2020). In addition, the index value of the otolith shape of shortfin scad also has the same range as the redtail scad (*Decapterus kurroides*) with an average index of $R_O = 0.359$ ($R_O > 0$), $F_F = 0.487$ ($F_F < 1$), $R_t = 0.669$ ($R_t \neq 1$), C = 25.91, $A_R = 2.403$ ($A_R > 1$), and E = 0.409 (Manginsela et al 2020). Fishes from the genus *Decapterus* show the same otolith shape, which is not round or circular and tends to be elongated. The variation in the shape index value of each fish otolith depends on the biomineralization process and the abundance of feed (Manginsela et al 2020).

Based on the shape index value of the shortfin scad otoliths caught in the coastal waters of the Special Region of Yogyakarta, the otoliths on the right and left sides, as well as the females and males, have the same shape. The results of the t-test showed no significant differences between the otoliths morphometry of the right and left, as well as female and male, which included length, width, area, perimetry, and weight. The position of the otolith on the right and the left does not affect the morphometrics. These results are consistent with the morphometrics of the right and left otoliths in *D. kurroides* in the Northern Sulu and Southern Sibuyan Seas (Barnuevo et al 2023). The same results were shown for *Decapterus muroadsi* from the waters of Monado Bay, which yielded no differences in right and left otolith morphometry, including length, width, perimetry, and area (Umar et al 2019). The morphometric size of the right and left redtail scad (*D. kurroides*) otoliths in Kema Bay, North Minahasa district, did not show a significant difference (Manginsela et al 2020). The absence of a significant size difference indicates that the biomineralization process of the right and left otoliths have the same rate (Manginsela et al 2020).

The male and female shortfin scad otoliths were not significantly different in terms of length (O_L), width (O_W), area (O_A), circumference (O_P), and weight (O_M). The shortfin scad male and female have symmetrical otoliths. These findings are corroborated by morphometric analyses of the otoliths of male and female in *D. kurroides* in the Northern Sulu and Southern Sibuyan Seas (Barnuevo et al 2023). The redtail scad (*D. kurroides*), amberstripe scad (*D. muroadsi*), and *Decapterus akaadsi* at Amurang Bay in North Sulawesi all demonstrated the same result (Baweleng et al 2018; Manginsela et al 2020).

The shortfin scad otolith has a length (O_L) that is included in the small category because it is in the range of 3-5 mm. The size of the otoliths was grouped into very small (< 3 mm), small (3-5 mm), medium (> 5-8 mm), and large (> 8 mm) (Baweleng et al 2018). Based on the linear regression equation analysis between otolith morphometrics consisting of length, width, area, perimeter, and weight with total length and body weight, the otolith morphometrics has a positive correlation with total length and body weight (Silooy et al 2019). The increase in total length and body weight can be an indicator of fish growth. Shortfin scad otolith growth shows a linear pattern with somatic growth (Triantini et al 2021). This result is in line with several previous studies, including the relationship between otolith morphometrics and the size of *Sardinella lemuru* in the Bali Strait (Wujdi et al 2016), shorfin scad (*D. macrosoma*) in the waters of South Bali

(Mourniaty et al 2020), *D. kurroides* in Kema Bay, North Sulawesi (Manginsela et al 2020); saber squirrelfish (*Sargocentron spiniferum*) in the South Red Sea (Osman et al 2021), brushtooth lizardfish (*Saurida undosquamis*) in Taiwan waters (Chang et al 2022).

The relationship between otolith morphometrics (O_L, O_W, O_A, O_P, and O_M) with total length has almost the same correlation coefficient. It shows that the growth in length will affect the growth of all comparable otolith morphometric parameters. The correlation between otolith length (O_L) with total length and weight has the highest coefficient value compared to other otolith morphometric parameters (Leguá et al 2013). The relationship between the length of the otolith and the total length can describe a stronger correlation than the otolith's width, area, perimeter, and weight. This result is confirmed by the correlation between otolith length and total length of *S. lemuru* in the Bali strait waters (Wujdi et al 2016). The otolith length is the best indicator to describe the growth in length of fish in the shortfin scad and other several small pelagic fish species, for example, in *Engraulis encrasicolus* in the Black and Marmara seas (Zengin et al 2015), in *S. lemuru* in the Bali Strait (Wujdi et al 2016), in *D. akaadsi* in the waters of Amurang Bay (Baweleng et al 2018), and *Decapterus macarellus* in Manado and Kema Bays (Manginsela et al 2020).

Metabolism that results in the growth length and biomineralization of otoliths causes growth in otolith size. Metabolism causes the deposition of calcium carbonate, which lasts throughout the fish's life (Cahyadi & Windarti 2016), so the otolith increases in length as the fish grows. The metabolism rate affects the deposition rate of calcium carbonate minerals on the otolith surface. When fish's metabolism is very high, the rate of deposition of carbon minerals is also high, and vice versa. Fish generally have a high metabolic rate during the day and slow at night, so that differences in the deposition rate cause the formation of growth rings that occur daily (Tzeng & Yu 1992). In addition, differences in metabolic rate and environmental conditions, as well as feed availability, can affect the rate of deposition of calcium carbonate minerals in otoliths so that it can cause different otolith sizes in individuals of the same size (Hoie et al 2008). Fish at a young age have a high metabolic rate, so the rate of deposition of calcium carbonate minerals in otoliths is relatively high when they are young (Long et al 2018).

The aquatic environment's temperature will affect the metabolism rate, which in turn can affect the rate of deposition of protein and calcium carbonate in fish otoliths. An increase in the metabolic rate of fish can increase protein deposition and vice versa. A decrease in the metabolic rate causes the deposition of calcium carbonate to decrease, forming a dark zone. The formation of light and dark zones describes the daily circle structure, which increases daily (Irgens et al 2020). The increase in fish size with otolith morphometrics in the shortfin scad from the southern waters of Yogyakarta is influenced by the environment and metabolism of fish.

In this study, the correlation between body weight and otolith weight was more significant than the correlation between total length and otolith weight. It demonstrates how ingested calcium carbonate and feed protein will precipitate and form otoliths in fish. Fish with the same total length can have different otolith weights and vice versa. Fish with the same total length can have the same otolith weight and be much heavier or lighter. Likewise, the same weight of otoliths can be found in fish of the same total length, much longer or shorter.

Conclusions. The shortfin scad (*Decapterus macrosoma*), whose habitat is in the waters of the Special Region of Yogyakarta, has an otolith sagitta whose shape tends to be oval and elongated with an uneven surface. Left and right otolith morphometrics and male and female otolith morphometrics were not significantly different and tended to be symmetrical in shape. The relationship between otolith morphometrics consisting of length, width, area, perimeter, and weight of the otolith with total length and body weight forms a positive linear regression equation. The otolith length has a more significant coefficient of determination to better describe the increase in fish size compared to the otolith's width, area, perimeter, and weight.

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Conflict of interest. The authors declare that there is no conflict of interest.

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Authors:
Farah Fariha Athaa, Laboratory of Aquatic Resources Management, Department of Fisheries, Faculty of Agriculture, Gadjah Mada University, Flora Street, Building A4, Bulaksumur Yogyakarta, Indonesia, e-mail: farahfariha01@mail.ugm.ac.id
Djumanto, Laboratory of Aquatic Resources Management, Department of Fisheries, Faculty of Agriculture, Gadjah Mada University, Flora Street, Building A4, Bulaksumur Yogyakarta, Indonesia, e-mail: lely4192@yahoo.com
Suwarman Partosuwiryo, Laboratory of Aquatic Resources Management, Department of Fisheries, Faculty of Agriculture, Gadjah Mada University, Flora Street, Building A4, Bulaksumur Yogyakarta, Indonesia, e-mail: suwarman.p@ugm.ac.id
Namastra Probosunu, Laboratory of Aquatic Resources Management, Department of Fisheries, Faculty of Agriculture, Gadjah Mada University, Flora Street, Building A4, Bulaksumur Yogyakarta, Indonesia, e-mail: probosunu@ugm.ac.id

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