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ABSTRACT

Morphological characteristics of Indian oil sardine *Sardinella longiceps* of sagittal otolith were investigated in the Sea of Oman at Muscat area during the period of one year from October 2008 to September 2009. A total of 152 otolith specimens were used for otolith morphometric analysis purposes. The sagittal otolith measurements including length, width and weight of otolith were obtained to assess whether there were differences between left and right otoliths of the fish and to examine otolith-fish size relationships of the species. The value of coefficient of determination $R^2$ of 0.9 showed strong correlation between right and left otolith measurements (length, width and weight), suggesting there was no significance variation in otolith for both sides and this may influence the growth rate of the species. Otolith morphometric observation including length, width and weight were correlated with total length of the fish representing $R^2$ ranged from 0.902 to 0.986 indicating that dimensions of otolith in the species grow in proportion to the total length and weight of fish.

Key words: Sagittal otolith, otolith measurements, oil sardine, Muscat.

INTRODUCTION

The Indian oil sardine *Sardinella longiceps* is a commercially important small pelagic resource in the Indo-Pacific region. It is widely distributed along the coast of Omani waters. Though, this species forms a considerable proportion in the fish catches of Oman, no detailed studies on the biological characteristics of this fish have been attempted. Hence, a study was carried out to investigate the age and growth based on otolith microstructure.

Recent studies on otolith helped to provide a reliable estimate of age information with accurate and precision of clear growth pattern in life stages. There are only few of studies on age based on otolith microstructure of *Sardinella* species in tropical waters (Dayaratne and Gjosaeter, 1986, Brother, 1995). In contrast, a number of growth studies have been carried out on *Sardinella* from the Indian Ocean based on length frequency distribution. Not many fishes of *S. longiceps* species in the Sultanate of Oman and the Arabian Gulf region have been investigated for aging suggested by otolith microstructure. Aging with the help of otolith is the most preferred and accurate technique till date. In addition, otolith is the first organ in fish that records daily events in the life stages of fish (Geffen, 1992). The relationship between otolith dimension (length, width and weight) and fish length was widely used to predict the relative changes in size and shape of the otolith that would influence the growth rate of fish. Further, it was probably used to identify whether there is an extreme variation between the two sides of rostrum, width and weight of the otolith. Schwamborn et al. (2002) suggested there was no significant difference between the right and left side of the otolith of the dusky damselfish, *Stegastes fuscus* in Brazil in terms of weight ($n = 170$, $R^2 = 0.94$). They found that otolith weight increased with fish length at the exponential function of $OW = 0.05 \times FL \text{ (cm)}^{2.35}$ ($n = 88$, $R^2 = 0.97$), where $OW$ is the otolith weight. Laith Jawad et al. (2011) showed that length, width and weight observations were appeared to be correlated with the total and fork length of Indian mackerel, *Rastrelliger kanagurta* in Sea of Oman. The purpose of this study is to investigate the sagittal otolith measurements such as length, width and weight were taken to understand whether there is significant variation between left and right otoliths of the fish and to establish otolith-fish size relationships of different measurements of sagittal otolith of *S. longiceps* in Muscat, Sultanate of Oman.
METHODOLOGY

1. Sample collection

Samples of *S. longiceps* were collected at random twice a month from artisanal catches mainly by beach seine of 47 mm stretched mesh size along the Muscat coast (Figure. 1) for a period of one year from October 2008 to September 2009. About 20 otoliths were collected every month between January and September 2009 from various size ranges of fish. The overall size range of fish varied between 47 mm and 220 mm. The total number of otolith collected was about 186 samples. A total of 152 otolith samples were used for otolith morphometric analysis.

2. Otolith Extraction and Preparation

There are a number of techniques for otolith removal from the fish. A frontal head cut at the level of the top of the eye was established for the removal of sagittal otolith (Brothers, 1987). However, the otolith removal of small sized specimens was carried out under a binocular microscope through the gill cavity, due to their small otolith. Then, the otoliths were cleaned in the water container under a binocular microscope. Each dried otolith was stored in a plastic capsule. The date and identification number were labeled on the plastic capsule. Photomicrographs were taken from optical and SEM (Scanning Electron microscope) instruments.

3. Otolith Measurement

The sagittal otolith measurements such as length, width and weight were taken to understand whether there was differences between left and right otoliths of the fish (Schwamborn *et al.*, 2002) and to examine otolith-fish size relationships of the species (Araya *et al.*, 2001). The morphometric characteristics including otolith length and otolith width were made to the nearest 1mm under a binocular microscope at 20x magnification and then each otolith was weighed to the nearest 1mg using a micro balance.

RESULTS

Morphological Characteristics

A total of 186 fish were used for the analysis of otolith dimension. However, 152 otolith were observed for otolith measurements due to the loss and breaking of one side pair of otolith. The measurements of lengths of otolith, rostrum, anticrostrum and otolith width were shown in Figure 2. Right and left otoliths were observed to understand whether there was a significant variation in the shape and sizes of otoliths (Fig. 3). The relationships between length, width and weight of right and left otoliths for both sexes were shown in Figure 4. The $R^2$ was highly correlated with all the measurements between right and left otoliths.

The relationships of right otolith of both sexes between the length of fish and weight of otolith (Fig. 5. A), length of fish and length of otolith (Fig. 5. B), length of otolith and weight of otolith (Fig. 5. C) and fish weight and otolith length (Fig. 5. D).

The otolith weight increased with fish length as an exponential function. Furthermore, otolith length increased with total length and was expressed by a power function. Otolith weight increased with otolith length exponentially whereas, the otolith length increased linearly with fish weight. In general, the correlation of $R^2$ ranged from 0.902 to 0.986. In fact, these observations indicate that the dimensions of otolith in the species grow in proportion to the length and weight of fish.
Fig. 1: Map showing sampling sites of *Sardinella longiceps* in Muscat area (Matrah, Mina al Fahl and As Seeb). ([http://www.atfp.org.ae/english/countries/oman/oman.htm](http://www.atfp.org.ae/english/countries/oman/oman.htm)).

Fig. 2. Otolith morphology of *S. longiceps* species. The external features of a fish measuring a total length of 210 mm from Oman Sea, Muscat. The sample was viewed under Scanning Electron Microscope (SEM) at 35x magnification (scale bar 500 µm) of the model JEOL (JSM-5600 LV).
Fig. 3. Right and left otoliths of *S. longiceps*. Right and left otoliths were established to predict relative changes in appearance and size that may influence the growth rate of fish. The right and left otoliths viewed under the reflected microscope with 59.0 x (Field: 3.9 mm, scale: 3.28 mm). The otolith had length: 3.28 mm, width: 1.18 mm and anti-rostrum otolith length: 2.54 mm.
Fig. 4. Comparison of measurements between left and right otoliths in *S. longiceps* from Muscat (Otolith length (mm), otolith width (mm) and otolith weight (mg)).
Fig. 5. Regression analysis of otolith dimensions of *S. longiceps* showing different correlation of measurements of right otolith.
DISCUSSION AND CONCLUSION

The study of morphometric measurements is important to identify whether there is any significant difference in shape and size between right and left otoliths (Hunt, 1992; Schwamborn et al. 2002). In addition, the otolith dimension (O-L, O-W and O-WT) would be useful to correlate with total length of the fish (Araya et al. 2001; Jawad et al. 2011). In fact, otolith morphology has been used to identify species and discriminate stock. Further, it is a species-specific that is used to determine a prey from the stomach contents (Compana, 2004). Moreover, the growth rate in fish may affect the morphology of otolith (Reichenbacher, et al. 2009). As a result, otolith elongated is normally formed when the growth rate increased, while more rounded otolith contour is produced during decreased growth rate (Reichenbacher, et al. 2009). This observation agreed with S. longiceps otolith shape in the present study.

There is a lack of studies on otolith dimension of Indian oil sardine in temperate and tropical fisheries. In the present study, otolith dimensions were initiated to provide some information associated with otolith characteristics. The value of coefficient of determination R^2 of 0.9 showed strong correlation between right and left otolith sizes (length, width and weight) and that indicated there was no significance variation in otolith for both sides may influence the growth rate of the species. However, the variation on otolith sizes would occur in both otoliths for some species. In this situation, the smaller pairs were excluded for all samples to avoid possible effect of over or under estimation of growth rate (Hunt, 1992). The regression relationships of (TL-OW, TL-OL, OL-OW and FW-OL) using the value of coefficient of determination R^2 as 0.9 indicated an evidence that otolith weight (OW) and otolith length (OL) were strong indicators of fish total length of the species studied.

Similarly, the otolith weight (OW) and fish weight (FW) potentially appeared as appropriate indicators of otolith length obtained for this species. Jawad (2011) concluded that otolith length and width were indicative of total length of Lutjanus bengalensis in Omani waters. Attempts were made on otolith-fish size relationships to estimate age from some species with the knowledge of growth rate or assumed to be constant (Steward et al. 2009). To conclude, these regressions suggested that dimensions of otolith in the species grow in proportion to the length and weight of fish.

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REFERENCES


