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Relationship between fish length and otolith length and width in the lutjanid fish, *Lutjanus bengalensis* (Lutjanidae) collected from Muscat City coast on the Sea of Oman

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Abstract

Otoliths are usually used to identify fish species, to estimate their age and their size. This information is useful for studies like population management, feeding habits and archaeology. The relationship between the length of a fish and the length of its otoliths is lacking for the species living in the Omani waters (Sea of Oman and the Arabian Sea coasts of Oman). Therefore, the regressions between otolith size (length and width) and fish length in the lutjanid fish, *Lutjanus bengalensis* from the coast of Muscat are provided. ANCOVA test showed no difference in length and width of the right and left otolith of fish. Similarly, no significant difference was observed between regressions of length and width of otolith over fish size, so a single linear regression was plotted against total length (TL) for otolith length (OL) and otolith width (OW). Analysing the morphometric relationships, we concluded that otolith length and width are good indicators of fish total length in the species studied.

Key words: otolith length, otolith width, fish length, relationship, *Lutjanus*, Muscat City, Sea of Oman

Introduction

Fishes of the family Lutjanidae, popularly known as snappers is a large family of the order Perciformes and it is important in both tropical and subtropical waters. The snappers are medium to large in size and strong swimming open-water fishes (Randall 1995). The family is represented by 13 genera and 103 species (Allen 1985). In Oman, this family is composed of 26 species belonging to 5 genera (Randall 1995) which are considered as most important commercial commodity.

In bony fishes, the otolith sagittae are the largest pair among the three pairs of otoliths that the fishes have in their inner ear (Harvey *et al*. 2000). Fishery biologists have used sagittae in different aspects of biological studies due to their large size and distinct growth rings (Boehlert 1985, Sumerfelt and Hall 1987). On the other hand, paleontologists, oceanographers and marine biologists have used the species specific distinctive morphology of the sagittae and their dense structure that can resist certain degree of disintegration to determine the identity of fish species found in sediments and stomach contents of marine birds and mammals (Fitch 1964, 1969, Tripple and Beamish 1987, Ainley *et al*. 1981, Treacy and Crawford 1981).

The use of the relationship between otolith size and fish size did not become a common practice until the early second half of the twentieth century till Trout (1954) and Templemann and Squires (1956) demonstrated their usage in retrieving the fish size from the size of their otolith (Echeveria 1987, Aydin *et al*. 2004).

In Omani waters, the relationship between fish size and otolith length and width has not been investigated. The aim of the present study was to find out the relationship between fish length and otolith length and width in the lutjanid *Lutjanus bengalensis*. These data may be useful for future researchers studying archaeology and food habits of piscivores to determine the size of fishes from the length of recovered otoliths.

Materials and Methods

Specimens were collected in March-May 2010 from the coastal waters of Muscat City at the Sea of Oman using long lines. The total length (TL; most anterior point to the posterior tip of the caudal fin) was measured to the nearest millimeter. Sagittae were (total of 76 individuals, *i.e.*, 152 otolith) removed through a cut in the cranium to expose them and then cleaned and stored dry in glass vials. The left and right otoliths were considered separately. Specimens with obvious evidence of calcite crystallization (Strong *et al*. 1986) or other aberrant formations were rejected. Each sagitta placed with the sulcus acusticus oriented through the observer and its length was determined using hand-held vernier callipers and defined as the longest dimension between the rostrum and postrostrum axis (nomenclature of Smale *et al*. 1995) and width as the dimensions from the dorsal to ventral edge taken at right angles to the length through the focus of the otolith. The relationships between otolith size (length, width) and fish size (TL) were determined using least square linear regression for the following parameters: otolith length (OL)-fish length (TL) and otolith width (OW)-fish length (TL). These equations were first calculated for both left and right otoliths and ANCOVA test (Fowler and Cohen 1992) was used to check any differences between regressions. Similarly, the sex-linked changes in fish length and otolith length were examined statistically with the ANCOVA test. The regression coefficients were compared and when significant differences ($P<0.05$) were not found, the H_0 hypothesis ($b_{right} = b_{left}$) was accepted. When the equations did not differ statistically, a single linear regression was reported for each parameter (OL, OW).

Results

The linear regressions of otolith length and width against fish length for male, female and combined sexes were calculated and are given in Figures 1 and 2.

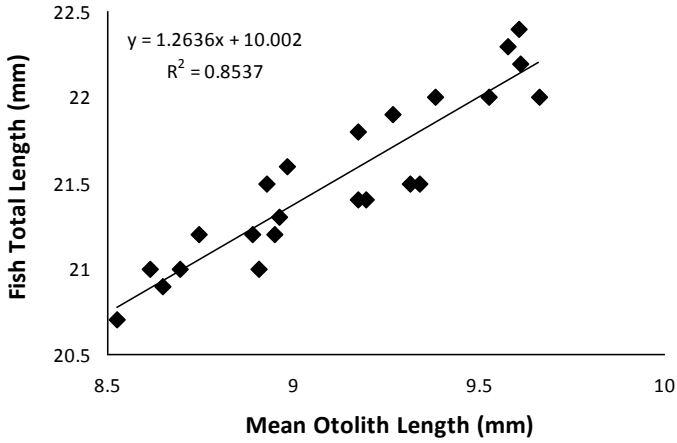

Figure 1. Total length-mean otolith length relationship.

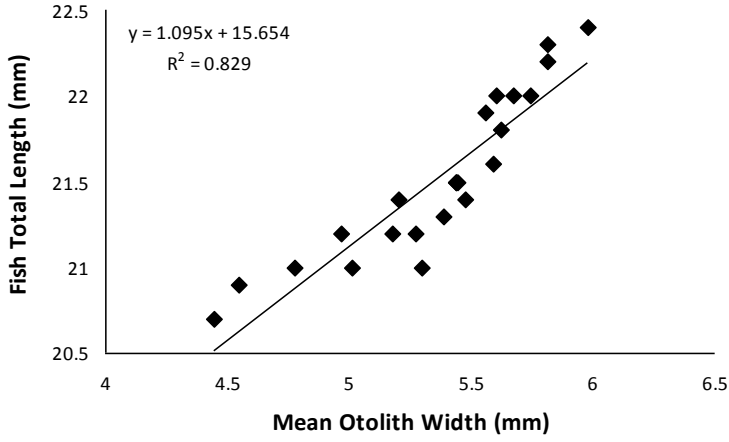

Figure 2. Total length-mean otolith width relationship.

The statistical analyses revealed no significant differences (P>0.05) between; (1) the regressions of the left and right otolith on the fish length; (2) the regressions of the otolith length and width of two sexes; (3) the combined (male and female) regression of the left and right otolith length on fish length.

Discussion

Among the characteristics of fish otolith, its shape has high inter-specific variability. This trait is used in fish identification (Battaglia *et al*. 2010). As a result, several reference works on and the morphology of the fish otolith are in use specially in the field of identification of fish preys, to identify fish species depending on the shape of their otolith (Smale *et al*. 1995; Campana 2004; Lombarte *et al*. 2006; Tuset *et al*. 2003). However, only certain geographical areas are covered and the access to reference materials remains requisite (Santos *et al*. 2001). Thus, it is essential to estimate specific equations which are useful to calculate the size of the preys.

The results of the present paper address to this need, providing TL-OL and TL-OW relationships for the lutjanid fish *L. bengalensis*. In spite of the high commercial importance of the species, its biology and ecology has not been investigated from Oman.

Biomass reconstruction of the prey using the otolith size might be limited as several authors have shown this fact. Individuals of the same fish species inhabiting different areas or individuals of different stocks of the same species have different growth rate. Such difference in the growth rate will affect the morphology of the otolith (Campana and Casselman 1993; Reichenbacher *et al*. 2009). The increased or reduced otolith growth rates most often are the result of changes in water temperature, water depth and diet (e.g., Lombarte and Lleonart 1993, Tuset *et al*. 2003, Katayama and Isshiki 2007, Mérigot *et al*. 2007). Elongated otolith are usually produced during increased growth rates, while more rounded otolith contours occur if growth is reduced

(Reichenbacher *et al*. 2009). Such situation is not observed in the results of the present study.

The factors that might cause in the underestimation of the otolith size are the effect of chemicals and mechanical abrasion in the digestive track of the predators on the morphology of the otolith (Jobling and Breiby 1986, Granadeiro and Silva 2000). Such effects have been observed in some otoliths of the species in question retrieved from the stomach of fishes collected from Sea of Oman. In these otolith, the ornaments usually found on the mesial side of the otolith have been severely abrassed and the anterior and posterior edges of the otolith have been deteriorated and the size of the otolith looks much smaller than that of the otolith recovered directly from the fish body of the same species (Sulaiman *et al*. 2001, Saad 2005, Khalid 2007).

Previous studies usually focused on the relationship between fish size and only one sagitta sizes (Wyllie 1987, Gamboa 1991, Granadeiro and Silva 2000, Harvey *et al*. 2000, Waessle *et al*. 2003, Battaglia *et al*. 2010). This paper on the other hand, supplies additional information by considering both the otolith length (OL) and otolith width (OW). It is more reliable to calculate more than one equation (TL-OL and TL-OW) since the tip of the otolith rostrum or the dorsal or ventral edges of the otolith may be damaged, making it impossible to measure the OL or OW.

In agreement with Battaglia *et al*. (2010) and in contrast with the findings of Harvey *et al*. (2000) and Waessle *et al*. (2003), the otoliths of *L. bengalensis* did not show significant differences in sizes between left and right sagittae.

In spite of data fitted well with the linear regressions obtained in the present study, it is advisable to use these equations within the fish size range limit reported for this species in the results section. Authors who studied wide range of fish length and include larvae in their sample, have supplied two different TL- OL regressions, one for the small sized fish and another for the adult specimens (Nishimura and

Yamanda 1988, Linkowski 1991). Such situation is not applicable to the results obtained in the present study as no larvae were considered. As the individuals of *L. bengalensis* collected in the present study belonged to the size range of 195- 230 mm TL, the regressions TL-OL and TL- OW calculated are ideal for the above size group of fish.

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