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Otolith mass asymmetry in *Rhynchorhamphus georgi* (Valenciennes, 1846)(Family: Hemiramphidae) collected from the Sea of Oman

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Abstract

Saccular otolith mass asymmetry was studied in the teleost *Rhynchorhamphus georgi* collected from the Sea of Oman. It was calculated as the difference between the mass of the right and left paired otoliths divided by average otolith mass. the absolute value of x in *R. georgi* does not depend on fish length and otolith growth rate as the case of other symmetrical fish species. On the other hand, the absolute value of otolith mass difference is increased with the fish length. The value of *x* falls between -0.2 and +0.2.

Key words: Otolith, mass asymmetry, *Rhynchorhamphus*, the Sea of Oman, Sultanate of Oman

Introduction

Among the effects of the otolith mass asymmetry is the adverse behaviour when fishes are introduced to weightlessness during space flight (Egorov and Samarin 1970; Hoffman 1977; Von Baungarten *et al*.

1982; De Jong *et al*. 1996; Hilbig *et al*. 2002; Rehman and Anken 2002; Takabayashi and Ohmura-Iwasaki 2003; Lychakov and Rebane 2004). Such phenomenon can alter acoustic functionality of a fish. This happened when otolith mass asymmetry affect directly the incompatibility and incongruity of the right and left otolith movement (Lychakov and Rebane 2005; Lychakov 2006). In doing so, it is clear that otolith mass asymmetry can have severe effects on vestibular and auditory functions, but the exact quantitative morphological and physiological bases of otolith asymmetry are still unclear (Lychakov *et al*. 2006).

The compact shape of the otolith is always the preferred shape to play as biological model through which the physiological role of the otolith mass asymmetry can be assessed quantitatively. The natural patterns of otolith mass asymmetry should be quantified before hand (Lychakov *et al*. 2006).

As it has been shown in the previous studies on otolith mass asymmetry, the majority of the fish species studied have this asymmetry within the range of $-0.2 < x < +0.2$ or $< 20\%$ (Lychakov 1992; Lychakov *et al*. 1988; Lychakov and Rebane 2004, 2005; Takabayashi and Ohmura-Iwasaki 2003). Furthermore, the previous authors concluded that there is no relationship between the magnitude of otolith mass asymmetry and length or mass of the fish. Otolith mass fluctuation might consider to be the reason behind such effect (Lychakov and Rebane 2004, 2005). Moreover, functional impairment does not happen to most symmetric fish species when otolith mass asymmetry falls well below critical values (Lychakov and Rebane 2005; Lychakov *et al*. 2006). Taking into account that the mass of right and left paired otoliths are generally not equal (Egorov and Samarin 1970; Lychakov 1992; Samarin 1992; Lychakov 2002; Scherer 2001), it is clear that the otolith mass differences, or what known as mass asymmetry of otolith, could be one of the important factors that affect the quality of reception acoustic environment by fish.

The only work on Omani fishes that dealt with otolith mass asymmetry was Jawad *et al*. (2010). Thus, the present work is considered as additional information in this field for Omani fish fauna. The aim of the study at hand is two folds, firstly, to quantify and compare the value of the otolith mass asymmetry range, and secondly, to asses the variability of this asymmetry during fish growth.

Materials and Methods

Data used in the present study were collected from 124 specimens of *R. georgi* collected on the coasts of Muscat City, the Sea of Oman, in 2009-2010. Total length was measured following the procedure of Lychakov *et al.* (2006) prior to the removal of otoliths. After the dissection of the auditory capsules, otoliths were removed from each side, rinsed in distilled water, air-dried at room temperature for a few days, then weighed on a Sartorius TE 313S analytical balance to an accuracy of 0.0001g (Figure 1).

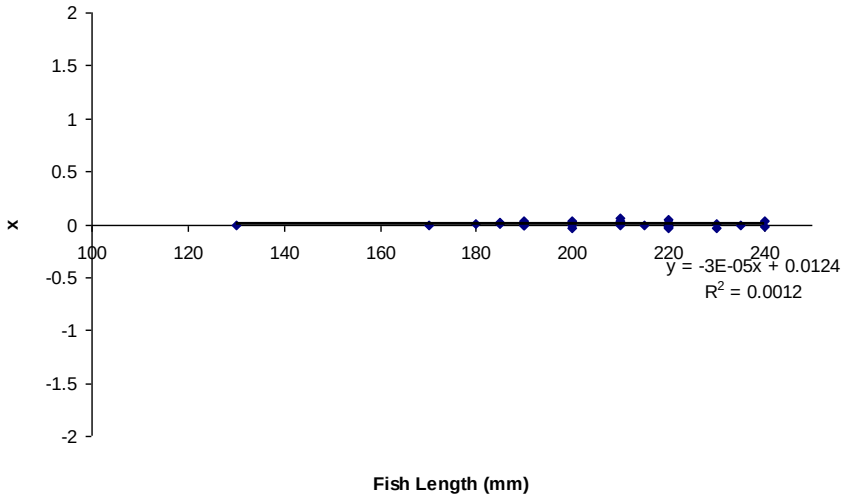

Figure 1. Saccular otolith mass asymmetry x in *Rhynchorhamphus georgi* as a function of fish length.

The otolith mass asymmetry *(x)* was calculated from: $x = (MR - ML) M^{-1}$, where MR and ML are the otolith masses of the right and left paired otoliths and *M* is the mean mass of the right and left paired otoliths.

In theory, *x* value can vary between -2 and 2, and x = 0 represents the absence of mass asymmetry (MR – ML), whereas *x* = -2 or *x* = 2 represent the maximal asymmetry (absence of one otolith). The positive value of x means that the right otolith mass is larger than the left paired otolith mass and a negative sign means the opposite. The relation between species absolute value of *x* and the species otolith growth rate was examined. The absolute value of the species otolith mass asymmetry is calculated as the average individual value. To evaluate otolith growth rate the relationship between otolith mass and fish length, $m = a \times l + b$, was calculated where, *l* is the length of the fish, *"a"* is the coefficient characterizing the growth rate of the otolith, and *"b"* is a constant for the species in question.

Results

The mean value of *x* is 0.2222± 0.00814, *n* = 124 (Figure 1) and the value of IXI is 0.3529 + 0.0081, *n* = 124 (Figure 2). According to the regression analysis there was no relationship between fish length and both IXI ($y = 0.0068x - 0.0768$) ($P > 0.05$, $R^2 = 0.0043$) and *x* ($y = 0.0042x - 0.0958$) ($P > 0.05$, $R^2 = 0.0011$). The relation between otolith mass difference (MR – ML), and fish length was more complex than the relation between *x* and fish length (*n* = 124, total length = 180-220 mm, $P > 0.05$, $y = 4E\text{-}05x - 0.0009$, $R^2 = 0.0013$) (Figure 3).

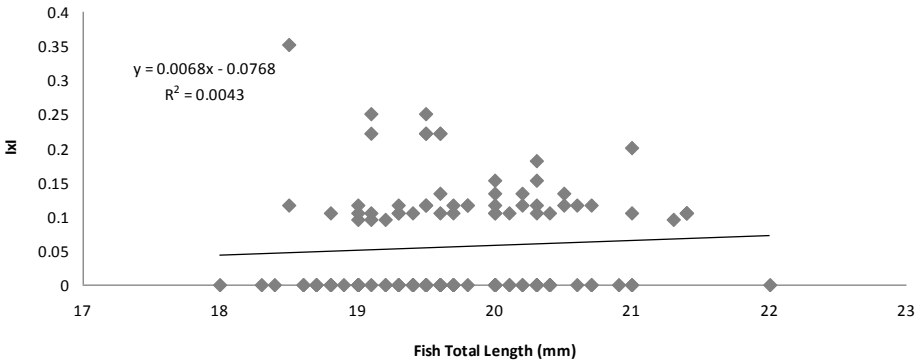

Figure 2. Absolute otolith mass asymmetry as function of fish length.

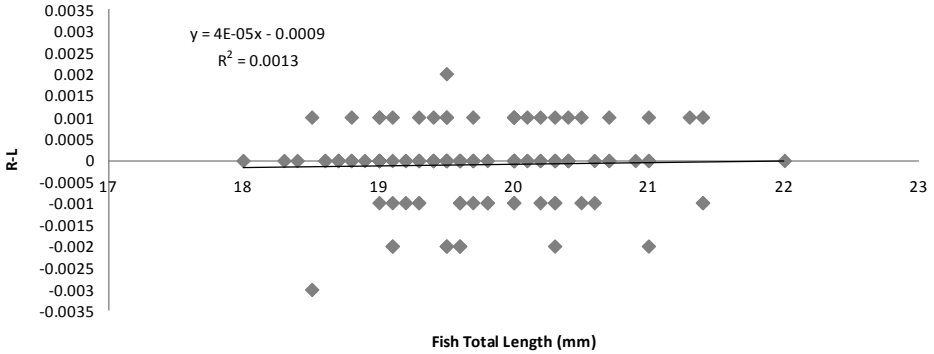

Figure 3. Saccular otolith mass difference in *Rhynchorhamphus georgi* as a function of fish length.

Discussion

As in other marine fish species (Lychakov *et al*. 2008) the value of *x* falls between -0.2 and +0.2. On the other hand the saccular otolith mass asymmetry was less than 0.05 a value that coincided with the value of mass asymmetry obtained for large number of marine species (Lychakov *et al*. 2006) and did not depend on otolith growth rate. In both symmetrical roundfish and asymmetric flatfish species, there are no

apparent differences in *x* between benthic, littoral and pelagic fishes (Lychakov *et al*. 2006).

The saccular otolith mass difference does not increase with the fish length and this is a characteristic of the pelagic fishes and not the littoral and bottom fishes (Lychakov and Rebane 2004). Lychakov and Rebane (2004, 2005) have shown through the mathematical modeling they wrote that acoustic and vestibular functionality of a fish ear can be reduced due to otolith mass asymmetry. However, in the great majority of fishes studied (Lychakov *et al*. 2006), including the species in question, saccular otolith mass asymmetry is very low (IXI < 0.5), irrespective of fish length. This low level of otolith asymmetry is typical for utricular and lagenar otolith organs also in symmetric teleost fishes. On the other hand, Lychakov and Rebane (2005) have shown that only fishes that contain the largest otoliths and IXI > 0.5 could, in theory, have difficulties with sound processing due to incompatibility and incongruity of the movement of the two otoliths on both sides of the head of the fish. Therefore, most fish species can avoid functional disability as they have otolith mass asymmetry below critical value.

The results obtained in the present work show that saccular otolith mass asymmetry show it does not depend on fish size. This agrees with the results obtained on several marine and freshwater fish species (Lychakov and Rebane 2004, 2005; Lychakov *et al*. 2006). According to the mathematical model of Lychakov *et al*. (2006), the value of *x* is probably stable during fish's lifetime. However, it is unknown how the fish maintain the right-left otolith symmetry at stable and low level (Lychakov *et al*. 2006). Rahmman and Anken (2002) suggested a regulating factor that control growth of the otolith via negative feedback loop between the brain and the inner ear. This factor is the weight of the otolith mass on the sensory epithelium. But other evidence argue against this hypothesis, and otolith weight seems not to be involved in the regulation of its growth (Luchakov 2002).

However, the relationship between otolith mass difference and fish length is more complex. In the present work, there was no relationship

between fish length and otolith mass difference. This is in agreement with the results obtained by Lychakov and Rebane (2004, 2005) on several fish species. Lychakov *et al*. (2006) suggested three reasons for the absence of relationship; (1) it might be due to the small sample used in the study; (2) when the specimens having same range of size or do not differ markedly in size; and (3) possible inherent cause. Both suggestions are evident in the data of the species in question as only 124 specimens ranging in total length between 180-220 mm were used in this work.

Further studies with large number of specimens and wide range of body size are required to investigate the relationship between the otolith mass difference and the fish length.

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