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SHORT COMMUNICATION

OTOLITH MASS ASYMMETRY IN *CARANGOIDES CAERULEPINNATUS* (RÜPPELL, 1830) (FAMILY: CARANGIDAE) COLLECTED FROM THE SEA OF OMAN

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ABSTRACT

The sagittae mass asymmetry was studied in the teleost *Carangoides caeruleopinnatus*. The value of the asymmetry was calculated as the difference between the mass of the right and left paired otoliths, divided by average otolith mass. The results show that the absolute value of *X* in *C. caeruleopinnatus* does not depend on fish length and otolith growth rate, as it does in other symmetrical fish species. However, the absolute value of otolith mass difference increases with the fish length. The value of *x* falls between -0.2 and +0.2.

INTRODUCTION

Usually, when fish experience weightlessness or if there are mass asymmetries in their otoliths, they show significant changes in their behaviour (Egorov and Samarin, 1970; Hoffman, 1977; Von Baungarten et al., 1982; De Jong et al., 1996; Hilbig et al., 2002; Rehman and Anken, 2002; Lychakov and Rebane, 2004). As a result of such a phenomenon, dramatic changes happen to the acoustic functionality of fish. When otolith mass asymmetry occurs, the incompatibility and incongruity of the right and left otolith movement get affected directly as a result of such changes (Lychakov and Rebane, 2005; Lychakov et al., 2006). Furthermore, a significant impairment to the vestibular and auditory functions becomes evident, but the exact quantitative, morphological and physiological basis of otolith asymmetry is still unclear (Lychakov et al., 2006).

Usually, the symmetrical fish species have a range value for the otolith mass asymmetry of $-0.2 < x < +0.2$ or $< 20\%$ (Lychakov, 1992; Lychakov et al., 1988; Lychakov and Rebane, 2004, 2005; Takabayashi, 2003). In addition, previous studies did not find a relationship between the magnitude of otolith mass asymmetry and length or weight of the fish. Hence, otolith mass fluctuation might be considered the reason behind such an effect (Lychakov and Rebane, 2004, 2005). Moreover, in symmetrical fish species, when otolith mass asymmetry falls well below critical values, the functional impairment does not occur (Lychakov and Rebane, 2005; Lychakov et al., 2006). Egorov and Samarin (1970), Lychakov (1992), Samarin (1992), Lychakov (2002) and Scherer (2001) have stated that the mass of right and left paired otoliths were not generally equal and the otolith mass differences, or what is known as mass asymmetry of the otoliths, could be one of the important factors that affect the quality of acoustic reception in fishes.

Jawad et al. (2010, 2011) are the only two studies on the fishes of Oman investigating otolith mass asymmetry. Thus, the present work will add information to the field of fish research in Oman. The aim of this current study is to quantify and compare the otolith mass asymmetry range and to assess the variability of otolith asymmetry during growth of *Carangoides caeruleopinnatus*.

MATERIALS AND METHODS

Specimens of *C. caeruleopinnatus* (150 individuals, 300 otoliths) were collected from the coasts of Muscat City in the Sea of Oman during the period 2009-2010. Total length was measured following the procedure given in Jawad et al. (2010, 2011) prior to removal of otoliths. The auditory capsules were dissected to remove the otoliths which were rinsed in distilled water, air-dried at room temperature for few days and weighed on a Sartorius TE 313S analytical balance to an accuracy of 0.0001 g.

The formula x = (MR – ML) M-1 was used to calculate the otolith mass asymmetry (x), 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.

Absence of asymmetry {Mass of the right otolith (MR) - Mass of the left otolith (ML)} occurs when the value of x varies between -2 and 2, and x = 0, whereas x = -2 or x = 2 represent the maximal asymmetry (absence of one otolith). A larger otolith on the right side gives positive value of x 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 was 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 total 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 0.0632+ 2.4105, n = 150 (Fig. 1) and the absolute value of the otolith mass asymmetry IXI is 0.0886 + 0.2418, n = 150 (Fig. 2).

Table 1. Total length and mass of the otolith of *Carangoides caeruleopinnatus*

Total length (mm)	Mass of the otolith (g)	
	Left side	Right side
202	0.0068	0.0067
209	0.0086	0.0079
210	0.0078	0.0075
213	0.0111	0.0113
213	0.0088	0.0088
215	0.0218	0.0109
215	0.0074	0.0072
217	0.0094	0.0090
218	0.0115	0.0114
218	0.0097	0.0085

Table 1. Continued

Total length (mm)	Mass of the otolith (g)	
	Left side	Right side
220	0.0096	0.0091
223	0.0099	0.0097
225	0.0100	0.0100
226	0.0118	0.0118
227	0.0096	0.0100
228	0.0097	0.0098
230	0.0097	0.0100
230	0.0115	0.0111
232	0.0082	0.0085
236	0.0093	0.0105
238	0.0193	0.0185
238	0.0990	0.0106
238	0.0102	0.0108
239	0.0107	0.0103
239	0.0090	0.0092
240	0.0172	0.0170
240	0.0106	0.0100
240	0.0106	0.0100
240	0.0130	0.0123
240	0.0105	0.0106
240	0.0097	0.0101
242	0.0125	0.0127
242	0.0105	0.0109
243	0.0100	0.0102
245	0.0151	0.0142
245	0.0106	0.0108
245	0.0099	0.0094
250	0.0105	0.0103
250	0.0106	0.0103
253	0.0132	0.0138
253	0.0140	0.0140
256	0.0235	0.0222
256	0.0139	0.0133
258	0.0117	0.0113
260	0.0178	0.0172
262	0.0221	0.0216
265	0.0198	0.01094
274	0.0146	0.0152
280	0.0201	0.0211
286	0.0194	0.0197
286	0.0189	0.0174
288	0.0266	0.0260

According to the regression analysis there was no relationship between fish length and both IXI (y = 0.0166x - 0.313) ($P > 0.05$, $R2 = 0.0272$) and x (y= -0.0168x + 0.3444) ($P > 0.05$, $R2 = 0.0263$). The relation between otolith mass difference (MR – ML) and fish length was more complex than the relation between x and fish length (n = 150, total length = 202-313 mm, $P > 0.05$, y = -0.0002x + 0.0027, $R2 = 0.0016$) (Fig. 3).

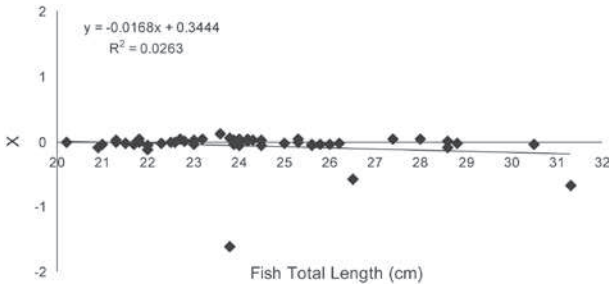

Figure 1. Saccular otolith mass asymmetry (x) in *Carangoides caeruleopinnatus* as a function of fish length

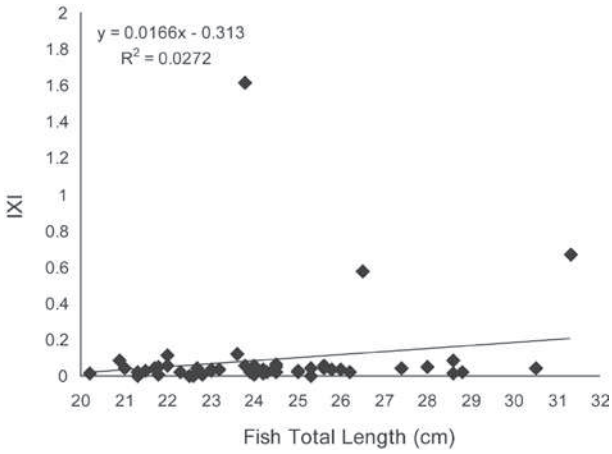

Figure 2. Absolute otolith mass asymmetry(IXI) as function of fish total length

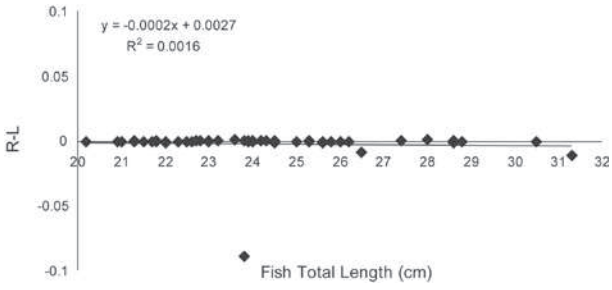

Figure 3. Saccular otolith mass difference in *Carangoides caeruleopinnatus* as a function of fish length. R & L= right and left side otolith mass

DISCUSSION

The value of *x* obtained for the species in question falls between -0.2 and +0.2 as in other marine fish species (Lychakov et al., 2008). The value of mass asymmetry of the saccular otolith obtained for large number of marine species is usually less than 0.05 (Lychakov et al., 2006). This value coincides with the value of mass asymmetry obtained for *C. caeruleopinnatus* in the present work 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).

Unlike for the littoral and bottom fish species, saccular otolith mass difference for pelagic fish species does not increase with the fish length (Lychakov and Rebane, 2004). Otolith mass asymmetry is considered as one of the causes of reduced acoustic and vestibular functionality of fish's ear. This fact was determined by Lychakov and Rebane (2004, 2005) through the mathematical modelling they wrote. The value of IXI is shown to be low (<0.5), irrespective of fish length, in the majority of fishes studied (Lychakov et al., 2006), which is also true for the species at hand. When asymmetry appears in the utricular and lagenar otolith organs of symmetric fish species, it happens infrequently. In theory, only fishes with largest otolith and with IXI >0.5 will experience difficulty in sound reception due to incompatibility and incongruity of the movement of the two otoliths (Lychakov and Rebane, 2005). Thus, with otolith mass asymmetry below critical value, most fish species can avoid functional disability.

One of the results obtained in the present work is that the saccular otolith mass asymmetry does not depend on fish size. This is consistent with the results of other studies on marine and freshwater fish species (Lychakov and Rebane, 2004, 2005; Lychakov et al., 2006, Jawad et al., 2010, 2011). The mathematical model of Lychakov et al. (2006) has shown that the value of *x* might be stable during the life of fish, however, it is unknown how fish manage to keep the value of their otolith asymmetry at a low level (Lychakov et al., 2006). Rahmman and Anken (2002) proposed that a monitoring agent acts on the growth of the otolith via negative feedback loop between the brain and the inner ear. Weight of the otolith on the sensory epithelium is found to be this monitoring agent. But other evidence disagrees with this hypothesis, and otolith weight seems not to be involved in the regulation of its growth (Luchakov, 2002).

In the present work, there is no relationship between fish length and otolith mass difference, as this relationship is more complex. This is in agreement with the results obtained by Lychakov and Rebane (2004, 2005) and Jawad et al. (2010, 2011) on several fish species. Lychakov et al. (2006) suggested three reasons for the absence of relationship: (1) small sample size plays a vital role in this study; (2) narrow range of variation in the specimen size; and (3) feasible genetic factors. These suggestions are evident in the data of the species in question as

only 150 specimens ranging in total length between 202-313 mm were used in this work.

For the future studies, it is advisable to use large number of specimens and wide range of body size to further investigate the relationship between the otolith mass difference and the fish length.

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Sažetak

ASIMETRIJA MASE OTOLITA KOD *CARANGOIDES CAERULEPINNATUS* (RÜPPELL, 1830) (FAMILY: CARANGIDAE) IZ OMANSKOG MORA

Proučavana je asimetrija mase sagite kod vrste *Carangoides caeruleopinnatus*. Vrijednost asimetrije je računata kao razlika između mase desne i lijeve strane otolita dijeljena sa srednjom masom. Rezultati pokazuju da apsolutna vrijednost za X kod *C. caeruleopinnatus* ne ovisi o dužini ribe i rastu otolita, kao što je to slučaj kod drugih simetričnih ribljih vrsta. Međutim, apsolutna vrijednost razlike mase otolita se povećava s dužinom ribe. Vrijednost *x* iznosi od -0,2 i +0,2.

Ključne riječi: otoliti, asimetrija mase, *Carangoides caeruleopinnatus*, Sultanat Oman

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