*Asian Fisheries Science* **24** (2011):426-431

ISSN 0116-6514
E-ISSN: 2073-3720
https://doi.org/10.33997/j.afs.2011.24.4.007

Asian Fisheries Science
The Journal of the Asian Fisheries Society

# Otolith Mass Asymmetry in the Adult Indian Mackerel *Rastrelliger kanagurta* (Cuvier, 1816), Collected from the Sea of Oman

**AISHA AMBUALI[1], LAITH A. JAWAD[2*] and JUMA AL-MAMRY[2]**

[1]Department of Marince Science and Fisheries, Sultan Qaboos University,
P.O. Box 34 Al-Khud, Sultanate of Oman.
[2]Marine Science and Fisheries Centre, Ministry of Agriculture and Fisheries Wealth,
P.O. Box 427, Postal Code 100, Muscat, Sultanate of Oman.

## Abstract

The otolith mass asymmetry, *x*, was calculated as the difference between the mass of the right and left paired otoliths divided by average otolith mass. Saccular otolith mass asymmetry was studied in the pelagic water teleost *Rastrelliger kanagurt*a. As in the case of other symmetrical fish species, the absolute value of *x* in *R. kanagurt*a does not depend on fish length and otolith growth rate, although the absolute value of otolith mass difference is increased with the fish length. The value of *x* was between -0.2 and +0.2.

## Introduction

It is suggested that both space illusionary sensations and space motion sickness in human subjects and adverse behavior when fishes are introduced to weightlessness during space flight are due to otolith mass asymmetry (Egorov and Samarin, 1970; Hoffman, 1977; Von Baungarten et al. 1982; De Jong et al. 1996; Hilbig et al. 2002; Rahman and Anken, 2002; Takabayashi, 2003; Lychakov and Rebane, 2004). Acoustic functionality of a fish can be altered by otolith asymmetry due to incompatibility and incongruity of the right and left otolith movement (Lychakov and Rebane, 2005; Lychakov et al. 2006). Such facts show 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).

Because of the nature of the fish otolith being compacted, they were considered suitable as biological model for assessing quantitatively the physiological role of otolith mass asymmetry. In order to study the direct acoustic and space experiments on fishes, it is recommended (Lychakov et al. 2006) before hand to quantify the natural patterns of otolith mass asymmetry. Previous studies on otolith mass asymmetry showed that 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, 2003). In addition, the previous authors concluded that there is no relationship between the magnitude of otolith

*Corresponding author. E-mail address: laith_jawad@hotmail.com

mass asymmetry and length or mass of the fish. Such results could be attributed to the otolith mass fluctuation (Lychakov and Rebane, 2004, 2005). Moreover, researches on the otolith mass asymmetry in most symmetric fish species have shown that it is well below critical values, so they do not experience functional impairment (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 is known as mass asymmetry of otolith, could be one of the important factors that affect the quality of the reception of fish acoustic environment.

The aim of the present study is two fold, first, to quantify and compare the value of the otolith mass asymmetry range and second, to assess the variability of this asymmetry during fish growth.

## Materials and Methods

Data used in the present study were collected from 32 specimens of *Rastrelliger kanagurt*a (Cuvier, 1816), collected from Oman Sea at the coasts of Muscat City during the period 2007- 2008. Standard length was measured following the procedure of Lychakov et al. (2006) prior to 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, and then weighed on a Sartorius TE 313S analytical balance to accuracy of 0.0001g.

The otolith mass asymmetry *(x)* was calculated from $x = (m_r - m_l)\ m^{-1}$, where $m_r$ and $m_l$ 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 ($m_r - m_l$), whereas $x = -2$ or $x = 2$ represents 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. To evaluate otolith growth rate the relationship between otolith mass and fish total length, $m = a\ l + b$, 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 *m* is $m_{mean} = 0.005 \pm 0.002$ ($n = 52$, total length = 227-315 mm). The relationship between otolith mass and fish total length is $m = a\ l + b$, ($n = 52$, total length = 227-315 mm. (b = 0.0017, a = -0.4888) (Fig. 1).

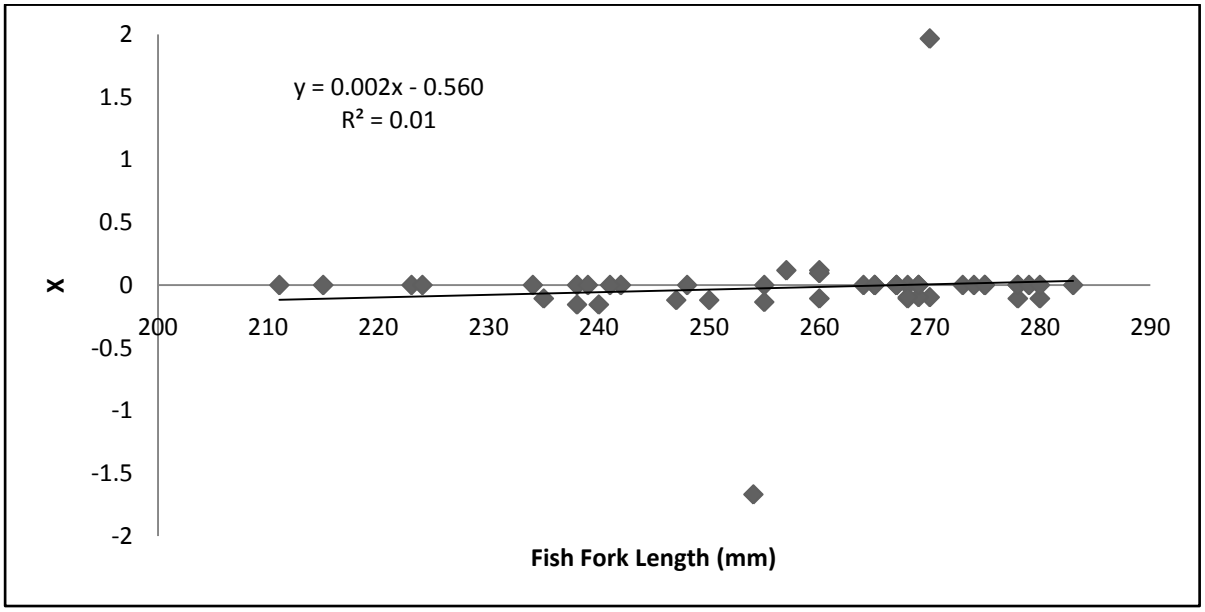


**Fig. 1.** Saccular otolith mass asymmetry x in *R. kanagurta* as a function of fish length.

According to the regression analysis there was no relationship between fish length and both $x$ (Fig. 1) and $|x|$ (Fig. 2). However, the absolute value of otolith mass difference $|m_r - m_l|$ is slightly increased with the fish length (Fig. 3).

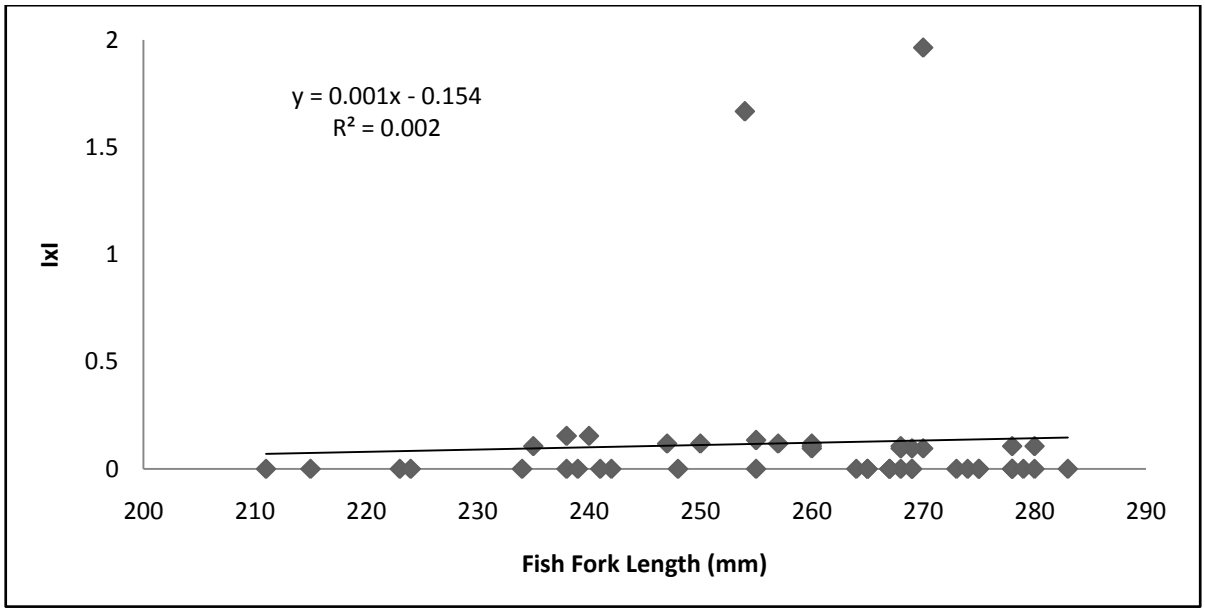


**Fig. 2.** Absolute otolith mass asymmetry as function of fish length.

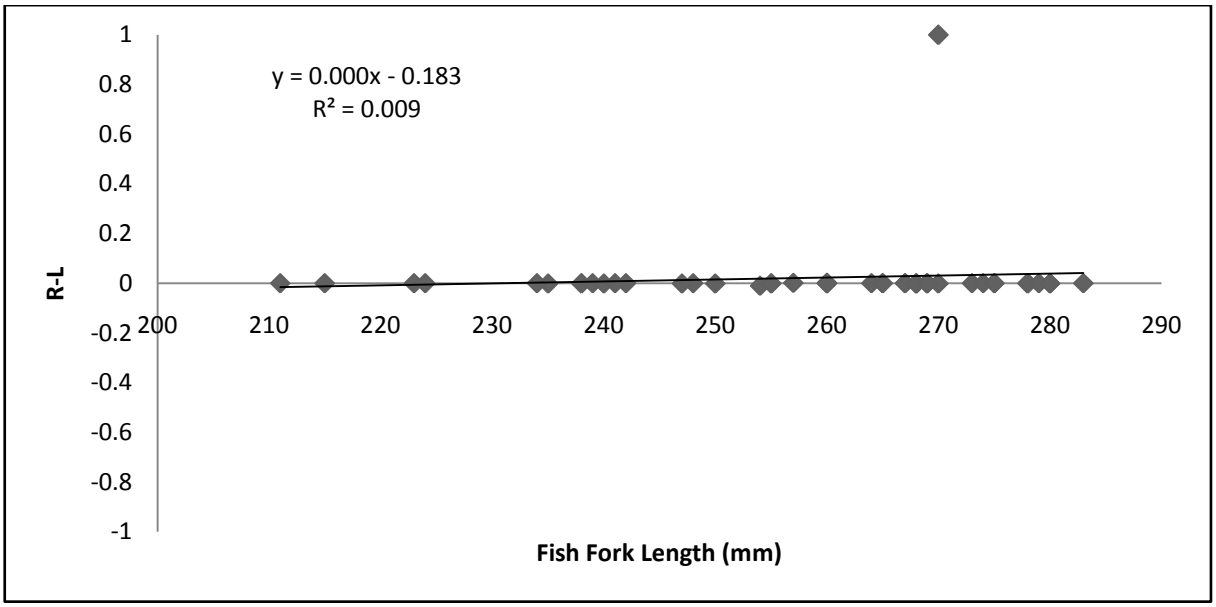


**Fig. 3.** Saccular otolith mass difference in *R. kanagurta* as a function of fish length.

## 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 a large number of marine species (Lychakov et al. 2006) and did not depend on otolith growth rate. The saccular otolith mass difference increases with the fish length and this is a characteristic of the littoral and bottom fishes and not the pelagic fishes (Lychakov and Rebane, 2004).

Lychakov and Rebane (2004, 2005) have shown through mathematical modeling 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 ($|x| < 0.5$), 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 $|x| > 0.2$ 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 on saccular otolith mass asymmetry show it does not depend on fish size. This agrees with the results obtained by other workers on several marine and freshwater fish species (Lychakov and Rebane, 2004, 2005; Lychakov et al. 2006, Jawad et al. 2010). However, the relationship between otolith mass difference and fish length is more complex. In the present work, there is 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 that the absence of relationship might be due to the small sample used in the study and when the specimens do not differ markedly in size. Both suggestions are evident in the data of the species in question as only 52 specimens ranging in standard length between 227-315 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.

## Conclusion

Saccular otolith mass asymmetry was evident in the pelagic water teleost *R. kanagurt*a. The otolith mass asymmetry in *R. kanagurt*a does not depend on fish length and otolith growth rate, although the absolute value of otolith mass difference is increased with the fish length. The value of $x$ was between -0.2 and +0.2.

## Acknowledgements

Our sincere thank goes to the Ministry of Agriculture and Fisheries Wealth, the directorate of Agriculture and Fisheries Developmental Fund and the Marine Science and Fisheries Centre for giving us the opportunity to work on the fish samples within the qualitative and quantitative distribution of marine organism's project in Sultanate of Oman and to provide the appropriate financial support.

## References

De Jong, H.A.A., N.P.M. Songad, A. Kuipers and W.J. Oosterveld. 1996. Swimming behaviour of fish during short periods of weightlessness. Aviation Space Environment Medicine 67: 463-466.

Egorov, A. D. and G.I. Samarin. 1970. Possible change in the paired operation of the vestibular apparatus during weightlessness. Kosmicheskaya biologiya I Aviakosmicheskaya Meditsina 4:85-86 (in Russian).

Hilbig, R., R. H. Anken, A. A. Bäuerle and H. Rahman. 2002. Susceptibility to motion sickness in fish: a parabolic aircraft flight study. Journal of Gravitational Physiology 9:29-30.

Hoffman, R. B., G. A. Salinas and A.A. Baky. 1977. Behavioural analyses of killifish exposed to weightlessness in the Apollo-Soyus Test Project. Aviation Space Environment Medicine 48:712-717.

Jawad, L. A., J. M. Al-Mamry and H. K. Al-Busaidi. 2010. Otolith mass asymmetry in the teleost *Beryx splendens* Lowe, 1834 (Family: Bercidae) collected from the Arabian Sea coasts of Sultanate of Oman. Thalassas 26:43-47.

Lychakov, D.V. 1992. Morphometric studies of fish otoliths in relation to vestibular function. Zhurnal evoliutsionnoi biokhimii i fiziologii.28:531-539 (in Russian).

Lychakov, D.V. 2002. Otolithic membrane: structural and functional organization, evolution, ecomorphological plasticity and tolerance to extreme conditions (Doctorskaya Dissertaziya), Vol 1. Sechenov Institute, St.-Petersberg (text, tables), pp. 266 pp, Vol. 2 (illustrations), pp. 107 pp (in Russian).

Lychakov, D.V. and Y.T. Rebane. 2004. Otolith mass asymmetry in 18 species of fish and pigeon. Journal of Gravitational Physiology11:17-34.

Lychakov, D.V. and Y.T. Rebane. 2005. Fish otolith mass asymmetry: morphometry and influence on acoustic functionality. Hearing Research 201:55-69.

Lychakov, D.V., A. Boyadzhieva- Mikhailova, I. Christov, A.N. Paschinin, I.I. Evdokimov and A.A. Matkov. 1988. Changes in the otolith apparatus of rat and fish after prolonged exposure to acceleration. Kosmicheskaya Biologiya I Aviakosmicheskaya Meditsina 22: 27-33 (in Russian).

Lychakov, D.V., Y.T. Rebane, A. Lombate, L.A. Fuiman and A. Takayabayashi. 2006. Fish otolith asymmetry: morphometry and modelling. Hearing Research 219:1-11.

Lychakov, D.V., T.Y. Rebane, A. Lombarte, M. Demestre and L. Fuiman. 2008. Saccular otolith mass asymmetry in adult flatfishes. Journal of Fish Biology 72:2579-2594.

Rahman, H. and R.H. Anken. 2002. Gravitational biology using fish as model systems for understanding motion sickness susceptibility. Journal of Gravitational Physiology 9:19-20.

Samarin, G. I. 1992. Study of the labyrinth asymmetry and its possible role in the motion sickness genesis (Tezisy Kandidatskoi Dissertazii). Institute for Biomedical Problems, Moscow. 33 pp (in Russian).

Scherer, H., K. Helling, A.H. Clarke and S. Hausmann. 2001. Motion sickness and otolith asymmetry. Biological Sciences of Space 15:401-404.

Takabayashi, A. 2003. Functional asymmetry estimated bymeasurements of otolith in fish. Biological Science of Space17:293-297.

Von Baumgarten, R.J., J. Wetzig, H. Vogel and J.R. Kass. 1982. Static and dynamic mechanisms of space vestibularmalaise. Physiologist 25 (Suppl. 6):33-36.

*Received 29/08/2011; Accepted 15/11/2011(MS11-70)*