J. Black Sea/Mediterranean Environment
Vol. 17(3): 254-259 (2011)

RESEARCH ARTICLE

Fluctuating asymmetry in the otolith length and width of adult Indian mackerel *Rastrelliger kanagurta* (Cuvier, 1817) collected from Muscat waters at the Sea of Oman

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Abstract
Fluctuating asymmetry was calculated for the otolith width and length of adult teleost *Rastrelliger kanagurta*. The results showed that the level of asymmetry of the otolith length was the highest among the two asymmetry values obtained for the otolith of *R. kanagurta*. The results also showed that the level of asymmetry in the two characters studied at its highest and lowest values in fish ranging in length between 311-320 and mm and 261-270 mm, respectively. The value of asymmetry was zero in the fish length ranging from 221-260 mm for both characters. The possible cause of the asymmetry in this species has been discussed in relation to different pollutants and their presence in the area. A trend of increase in the asymmetry values with the fish length was noticed for the otolith length and width.

Keywords*:* asymmetry, otolith width, otolith length, *Rastrelliger kanagurta*, Oman Sea

Introduction

The differential development of a bilateral character between the sides of an organism is known as asymmetry (Van Valeen 1962, Palmer and Strobeck 1986, Leary and Allendrof 1989). Fluctuation asymmetry which is a random deviation from perfect bilateral system can reflect developmental instability (Palmer 1994, Fey and Hare 2008). The inability of an organism to compensate for disturbances during development is known as developmental instability (Zakharov 1992), and can be affected by stress related to environmental or genetic conditions. Taking into consideration environmental stress causes developmental instabilities; high fluctuating asymmetry could indicate the lower condition of larvae that were experiencing unfavourable environments. Thus, the method could show the specific environmental effects on the condition of the organism.

The relationship between fish condition and fluctuating asymmetry has been studied for adult fishes, and a number of measurements have been analysed, including the number of gill rakers, pectoral fin rays, fish body proportions, eye spot area, or otolith size and shape (Al-Hassan *et al*. 1990, Al-Hassan and Hassan 1994, Escós *et al*. 1995, Somarakis *et al*. 1997a, b, Jawad 2001, Øxnevad *et al*. 2002, Gçonalves *et al*. 2002, Jawad 2003, 2004).

Fluctuating asymmetry studies were never performed on the otolith width or length of the species in question, that of the same species from other localities in Omani waters or even that from previous years. Therefore, the present study is considered the first in its kind for Omani waters. The present work studied fluctuating asymmetry in the otolith width and length of the teleost fish *Rastrelliger kanagurta* collected from the vicinity of Muscat City at Oman Sea.

Materials and Methods

Specimens of *R. kanagurta* were collected from Muscat waters at Oman Sea. Otolith width and length were used to study the asymmetry.

The statistical analysis included calculating the squared coefficient of asymmetry variation (CV^2_a) for otolith width and length according to Valentine and Soule (1973):

$$CV^2_a = (S_{r\text{-}l} \text{ X } 100/X_{r+l})^2$$

Where $S_{r\text{-}l}$ is the standard deviation of signed differences and X_{r+l} is the mean of the character, which is calculated by adding the absolute scores for both sides and dividing by the sample size.

Results

The results of asymmetry data analysis of the otolith width and length of *R. kanagurta* collected from waters around Muscat City at Oman Sea are shown in Table 1. The results showed that the level of asymmetry of the otolith length was the highest among the two asymmetry values obtained for the otolith of *R. kanagurta*. For the two otolith characters studied in the present work, the results showed that the level of asymmetry at its lowest and highest values in fish ranging in length between 261-270 mm and 311-320 mm, respectively. The asymmetry value was zero in fish ranging from 221-260 mm for both otolith characters studied.

The percentage of the individuals showing asymmetry in the otolith length was the highest among the percentages obtained for the two otolith characters (Table 1). Individuals of *R. kanagurta* were grouped into length classes (Table 2). A trend of increase in the asymmetry values was noticed in the length and width of the otolith. In both otolith characters and from zero value in length groups 221-260, the asymmetry value showed an increase with the increase of the fish length.

Table 1. Squared coefficient of asymmetry (CV^2_a) value and character means (X_{r+l}) of *Rastrelliger kanagurta*.

Character	CV^2_a	N	Character mean	% of individuals with asymmetry
Otolith length	88.71	46	5.34	95.65
Otolith width	41.75	46	1.98	98.87

Table 2. Squared coefficient of asymmetry and character means by size class of *Rastrelliger kanagurta*

Character	CV^2_a	N	character mean X_{r+l}	% of individuals with asymmetry
Otolith length				
221-230	0	1	4.42	100
231-240	0	1	4.85	100
241-250	0	1	4.62	100
251-260	0	1	4.66	100
261-270	13.69	8	5.00	87.50
271-280	16.48	6	5.50	83.33
281-290	23.62	6	5.43	98.87
291-300	46.74	16	5.56	100
301-310	61.85	4	5.39	100
311-320	86.43	2	5.52	100
Otolith width		46		
221-230	0	1	1.67	100
231-240	0	1	1.68	100
241-250	0	1	1.71	100
251-260	0	1	1.86	100
261-270	17.54	8	1.84	87.50
271-280	18.56	6	1.95	83.33
281-290	26.32	6	2.07	100
291-300	31.08	16	2.03	100
301-310	33.68	4	2.12	100
311-320	41.32	2	2.17	100
Total		46		

Discussion

There is some variation in the asymmetry values among the two morphological characters of the otolith of *R. kanagurta*. At present it is impossible to evaluate the level of asymmetry of those characters and to determine if they are higher or lower than the average due to the lack of data regarding natural asymmetry. However, a character like otolith length showed higher asymmetry value than

other otolith characters. The high asymmetry value of the otolith length might indicate the vulnerability of this character to the immediate changes in the environment. It is not possible at this stage to confirm such effect as the correlation between different environmental pollution and the morphology of the fish species in question is not available. However, based on previous studies in this field, it is possible to conclude that there is a direct correlation between environmental stress due to pollution and asymmetry in this species. Such environmental factors are present in the waters of Oman Sea. On the other hand, the low asymmetry value displayed by the otolith width character might be explained on the basis that this character is less vulnerable to environmental stresses.

The origin and cause of asymmetry in fishes can depend on several factors, one of which is genetic factors that might be responsible for the asymmetry in these two characters, but these cannot be discussed at this stage due to the lack of genetic data on the ichthyofauna of Oman. The other possible factor is the environmental stress which leads to an increased level of asymmetry, but might occur at low levels before causing wide spread death (Bengtsson and Hindberg 1985).

Pollution of sea water and sediments by hydrocarbons, heavy metals, pesticides and organic matter are considered the main cause of environmental stress. This state of pollution is not unusual for the Oman Sea environment where different pollutants were reported to affect its water for at least in the last twenty years (De Mora *et al*. 2004; De Mora *et al*. 2005; Al-Darwish *et al*. 2005; Tolosa *et al*. 2005; Abdel Gawad *et al*. 2008; Khan 2008).

The environmental causes might be natural events, and several factors are known to produce nutritional deficiencies such as various pathogens and various population phenomena (Bengtsson and Hindberg 1985), and it is highly possible that these factors may be in action in Oman Sea as they seem to be common in the aquatic environment.

Several authors have shown a relationship between the coefficient of asymmetry and fish length (Al-Hassan *et al*. 1990; Al-Hassan and Hassan 1994; Al-Hassan and Shwafi 1997; Jawad, 2001) where there was a trend of increase in the asymmetry value with the increase in fish length. The otolith morphological characters studied were identical and gave zero value for the asymmetry coefficient in several length groups studied. This is because there is only one fish specimen in these groups. The results also show a trend of increase of otolith length and width asymmetry value with fish length.

Acknowledgements

We would also like to thank the Ministry of Fisheries Wealth, the Agriculture and Fisheries Development 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 organisms in Sultanate of Oman and to provide the appropriate financial support.

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Received: 30.07.2011
Accepted: 20.10.2011