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Short communication

FLUCTUATING ASYMMETRY IN THE OTOLITH WIDTH OF *Carangoides caeruleopinnatus* (CARANGIDAE) COLLECTED FROM MUSCAT CITY COAST ON THE SEA OF OMAN

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Summary

The fluctuating asymmetry in two otolith dimensions, the length and width of adult teleost *Carangoides caeruleopinnatus* were calculated. The highest asymmetry value was observed in the otolith width. The fish length groups 201-210 and 281-290 mm showed the lowest and the highest value of asymmetry respectively. In addition, few fish length groups have shown zero value for otolith size asymmetry. Different pollutants and their presence in the area appeared to be one of the reasons that cause the asymmetry in this species. A trend of increase in the asymmetry values with the fish length was noticed for the otolith length and width.

Key words: bilateral asymmetry, otolith, Carangidae, ecological indicator, *Carangoides caeruleopinnatus*

INTRODUCTION

The differential development of a bilateral character between the sides of an organism is called fluctuating asymmetry (Van Valeen, 1962; Palmer and Strobeck, 1986; Leary and Allendrof, 1989). Developmental instability, which is the inability of an organism to compensate for disturbances during development (Zakharov, 1992) can lead to this asymmetry (Palmer, 1994; Fey and Hare, 2008). The fluctuating asymmetry can be affected by stress related to environmental or genetic conditions (REF). Thus, to determine whether fish larvae face unfavourable conditions within the pelagic, we can examine whether there is fluctuating asymmetry within several morphological characters.

Several authors have studied the relationship between fish condition and fluctuating asymmetry of adult fishes, and a number of measurements have been proposed to examine asymmetry, including the number of gill rakers, pectoral fin rays, fish body proportions,

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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, 2003, 2004; Øxnevad et al., 2002; Gonçalves et al., 2002; A l – Busaidi et al., 2010; Al – Mamry et al., 2011a,b; Sadigzadeh et al., 2011). The effect of otolith asymmetry on fishes was determined and reviewed by Gagliano and McCormick (2004) and Gagliano et al. (2008). These authors showed that the survival of young individuals, in particular successful settlement, may be affected by asymmetry in otolith development.

Waters around the vicinity of Muscat City represent one of the main fishing grounds for *C. caeruleopinnatus* and we can predict that settlement of larval *C. caeruleopinnatus* may be important in contributing to this regional fishing population. The present work studied fluctuating asymmetry in the otolith length and width of the teleost fish *Carangoides caeruleopinnatus* collected from the Sea of Oman near Muscat City. It aims to provide information related to the detection of suitable settlement habitats by the larvae of *C. caeruleopinnatus*.

The only scientific work performed on the fluctuating asymmetry of the otolith dimensions of the Omani fishes is that of Al – Busaidi et al. (2010). In the near-by area, the Arabian Gulf, Sadigzadeh et al. (2011) studied the mugilid fish, *Liza kluzingeri* (Sadigzadeh et al., 2011).

MATERIALS AND METHODS

Study area

Fish specimens of *Carangoides caeruleopinnatus* (530) were collected from the coast of Muscat City, Sultanate of Oman. One of the environmental characteristics of the Sultanate of Oman is its geographical location, as it lies on the coasts of three seas: the Arabian Gulf, the Sea of Oman and the Arabian Sea. This country has an extensive coastline of 3,165 km, which includes the Gulf of Oman in the North and the Arabian Sea in the South. Muscat is located in northeast Oman, at 24°00’N 57°00’E 24°N 57°E where the Sea of Oman forms the northern and western periphery of the city.

The climate generally is very hot, with temperatures reaching 54°C (129.2 °F) in the hot season, from May to September. Annual rainfall within Muscat averages 100 mm, falling predominantly in January. The water along the coast of Muscat runs deep (125 m), forming two natural harbors (Muttrah and Muscat). The coastal region of Muscat City is characterized by several inshore islands, rocks and mangrove forest. In addition, the coast can be one of the following: alluvial plains, delta, raised gravel terraces, coastal cliffs, sandy and Sabkha (Thangaraja, 1995).

The oceanography of the region, including water temperature, salinity and pH, is characterised by substantial seasonal variation. Thangaraja (1995) reported 23.39° - 23.90 °C, 20.0 – 23.72 °C, 36.8 – 38.5 ppt and 7.7 – 8.9 for surface water temperature, temperature in the water column, salinity and pH value, respectively. Recently, Al – Shaqsi et al. (2007) gave slightly different values for the above mentioned ecological factors (23.13 – 26.69 °C, 18.04 – 32.74 °C, 35.32 – 41.46 ppt and 7.03 8.98 respectively).

It is evident that monsoons are the main meteorological force affecting the physical–

biological in the coastal ecosystem of the Sea of Oman (Al – Azri et al. 2010). Monsoons manifest themselves as strong, seasonally reversing winds (Wiggert et al., 2000). There are two types of monsoons, the north east monsoon (NEM) and the south west monsoon (SWM). The NEM shows its effect from November–February, during which sea surface winds over the Sea of Oman are mainly northeasterly (Schott et al., 1990). The SWM takes place from June–mid-September when sea surface winds over the region are predominantly from the southwest (Brock and Mc Clain, 1992) and stronger than during the NEM (Burkill et al., 1993). Coastal upwelling persists during SWM along the coast of Oman and mainly impacts the southern part of the coast (known as the Dhofar region) (Savidge et al., 1990). The effects of upwelling on the Omani coasts can be detected up to 750 km offshore of the Sultanate of Oman and can also be observed in the Sea of Oman. These effects are manifested as injection of cool water into the coastal area. Inflow of water from the Arabian Gulf to the Sea of Oman and high air temperature has a strong impact on the intrusion of upwelled water into the Sea of Oman. Such effect leads to strong vertical stratification in the coastal water masses (Quinn and Johnson, 1996).

Sample collection

Fish specimens of *C.caeruleopinnatus* (530) were collected using gill net from only one location on 25 June 2010 from coastal waters of Muscat City, Sea of Oman. Asymmetry level was studied in the otolith length and width of *C.caeruleopinnatus*. In the present study fluctuating asymmetry was not correlated with sex because asymmetry develops in the early stages of the fish life. At this stage larvae are not recognizable sex wise and any compensational growth during the level stage cannot correct it. The anomalies persist and become a source of stress to the individual further in its life.

Statistical analyses

The statistical analysis was based on the squared coefficient of asymmetry variation (CV^2_a) for the two otolith dimensions according to Valentine et al. (1973):

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

Where S_{r-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 length and width of *C. caeruleopinnatus* collected from coastal waters of Muscat City, Sea of Oman are shown in Table 1.

The asymmetry level of the otolith width was the highest among the two asymmetry values obtained for the otolith of *C. caeruleopinnatus*. Table 2 shows the correlation between the level of asymmetry and fish length, marking its lowest and highest values in fish, ranging in length between 201-210 and 281-290 mm respectively.

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

Tablica 1. Koeficijent varijabilnosti asimetrije (CV^2_a) i srednja vrijednost parametara (X_{r+l}) za Carangoides caeruleopinnatus.

Character / Parametar	CV^2_a	N	Character mean / Srednja vrijednost	% of individuals with asymmetry / % jedinki s asimetrijom
Otolith length/ Dužina otolita	28.429	530	5.49	98
Otolith width/ Širina otolita	54.053	530	2.7	100

The percentage of the individuals showing asymmetry in the otolith width character was the highest among the percentages obtained for the two otolith characters (Table 1).

DISCUSSION

In vast number of animal taxa, asymmetry in morphological characters is usually negatively correlated with animal fitness (e.g. Møller and Nielson, 1997; Martin and Lopez, 2001; Bergstrom and Reimchen, 2003). However, there is still little information on the effect of asymmetry on dispersal and recruitment of individuals (Matess, 1997; Breuker et al., 2007). There are two main effects of bilateral asymmetry in fish otolith mass, these are the abnormal swimming activity (Helling et al., 2003) and interference with correct sound localization resulting in inability of individuals to integrate with the habitat they live in (Lychakov and Rebane, 2005). In this study, the two otolith dimensions demonstrated bilateral asymmetry. This asymmetry in the morphological characters of the larvae of *C. caeruleopinnatus* might cause a deviation in their settlement due to the damage in the mechanism that leads them to their natural niches.

This study is important in understanding the ecology of *C.caeruleopinnatus* in order to estimate its stock in the area, as this species is designated with high commercial importance. The lack of data regarding natural asymmetry in Oman represents the main obstacle to evaluating the level of asymmetry of the two morphological characters of the otolith of *C. caeruleopinnatus*, especially to determine if they are higher or lower than the average.

Due to the unavailability of data, it is impossible to have a precise indication on the significance of the correlation between asymmetry in the morphology of the fish species in question and different environmental pollutions along a pollution gradient, or from fish taken from polluted and unpolluted sites. However, on the basis of previous studies in this field, it is possible to correlate between environmental stress due to pollution and asymmetry in the morphology of this species.

Pollution factors are present in Sea of Oman waters in general and the Omani coasts of the Sea of Oman in particular (De Mora et al., 2004; De Mora et al., 2005; Al – Darwish et al., 2005; Tolosa et al., 2005; Abdul Gawad and Lothy, 2008; Khan, 2008).

Table 2. Squared coefficient of asymmetry and character means by size class of Carangoides caeruleopinnatus

Tablica 2. Koeficijent varijabilnosti asimetrije i srednja vrijednost parametara po dužinskoj grupi za Carangoides caeruleopinnatus

Character/ Parametar	CV^2_a	N	character mean/ Srednja vrijednost X_{r+1}	% of individuals with asymmetry/% jedinki s asimetrijom
Otolith length/ Dužina otolita				
201-210	5.629	30	4.885	100
211-220	8.534	80	5.104	100
221-230	30.119	70	5.339	100
231-240	42.493	120	5.360	92
241-250	43.650	80	5.446	100
251-260	47.980	60	5.868	100
261-270	54.980	20	6.158	100
271-280	62.430	20	5.855	100
281-290	64.127	30	6.262	100
301-310	0	10	5.865	100
311-320	0	10	6.335	100
Total/Ukupno		530		
Otolith width/ Širina otolita				
201-210	24.423	30	4.885	100
211-220	18.962	80	5.104	100
221-230	19.640	70	5.339	100
231-240	91.008	120	5.360	92
241-250	95.230	80	5.446	100
251-260	99.874	60	5.868	100
261-270	120.650	20	6.158	100
271-280	123.650	20	5.855	100
281-290	257.127	30	6.262	100
301-310	0	10	5.865	100
311-320	0	10	6.335	100
Total/Ukupno		530		

Several natural events can be listed as environmental causes and nutritional deficiencies can be caused by many factors such as various pathogens and various population phenomena (Bengtsson and Hindberg, 1985). It is highly possible that these factors may be in action in the Oman Sea as they seem to be common in the aquatic environment.

Fish length and asymmetry in morphological characters have shown to be correlated as indicated by several authors (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 results also show a trend of increase of otolith length and width asymmetry value with fish length.

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Sažetak

FLUKTUACIJA ASIMETRIJE ŠIRINE OTOLITA KOD *Carangoides caeruleopinnatus* (CARANGIDAE) ULOVLJENIH NA OBALI MUSCATA U OMANSKOM MORU

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Mjerena je fluktuacija asimetrije dvaju veličina otolita, dužine i širine adultnih koštunjača vrste *Carangoides caeruleopinnatus*. Najveća asimetrijska vrijednost je zabilježena u širini otolita. Dužinske grupe riba od 201-210 i 281-290 mm pokazale su najnižu, odnosno najvišu asimetrijsku vrijednost. Povrh toga, malo dužinskih grupa analiziranih jedinki je pokazalo nultu vrijednost za asimetriju veličine otolita. Čini se da su različiti onečišćivaći i njihovo prisustvo na istraživanom području jedan od razloga koji uzrokuju asimetriju kod ove vrste. Uočen je trend rasta asimetrijskih vrijednosti dužine i širine otolita s porastom dužine ribe.

Ključne riječi: bilateralna asimetrija, otolit, Carangidae, ekološki indikator, *Carangoides caeruleopinnatus*

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