Asymmetry study in *Siganus rivulatus* Forsskal, 1775 (Family: Siganidae) collected from the Arabian Sea coasts of Oman.

Juma Al-Mamry[1], Laith Jawad[1*], Haithem Al-Busaidi[1], Ahmed Al-Alawi[2], Sami Al-Gharabi[2], Luqman Al-Hasani[2], Sultan Al-Marzouqi[2], Issa Al-Ruwahi[2], Jamal Al-Yarubi[2], Abdulrahim Al-Zahli[2], Mohamed Al-Marzouqi[1], Saoud Al-Nabsi[3]

SUMMARY: Asymmetry analyses have been carried out for some bilateral characters of Siganus rivulatus *Forsskal, 1775 collected from the Arabian Sea coasts of Oman. The results showed that the level of asymmetry of the characters pectoral fin ray count and postorbital length was the highest among those asymmetry values obtained for the remaining characters studied. The lowest value was that for head length. An increasing trend in the asymmetry value with fish length is also obtained for preorbital length, head length and pectoral fin ray count. The possible cause of the asymmetry in this species is herein discussed in relation to different pollutants and their presence in the area.*
***Keywords**: asymmetry, Siganus, Arabian Sea, Oman*

RIASSUNTO: Sono state svolte analisi sulla asimmetria di alcuni caratteri bilaterali di *Siganus rivulatus* Forsskal, 1775 provenienti dalle coste dell'Oman sul Mare Arabico. I risultati mostrano che il livello di asimmetria del numero dei raggi delle pinne pettorali e quello della lunghezza dell'osso postorbitale sono i più elevati tra caratteri studiati. Il valore più basso è stato quello relativo alla lunghezza della testa. I livelli di asimmetria della lunghezza dell'osso preorbitale, della lunghezza della testa e del numero dei raggi della pinna pettorale hanno mostrato la tendenza ad aumentare con le dimensioni del pesce. La possibile causa delle asimmetrie in questa specie è stata anche messa in relazione con differenti sostanze inquinanti e con la loro presenza nell'area.
Parole chiave: asimmetria, Siganus, Mare Arabico, Oman

Introduction

Members of the family Siganidae are among the important demersal fishes in the Arabian Sea coasts of Oman. Several species have been observed in the area and along the coasts of Oman (Randall, 1995).

The effect of the environmental factors on meristic and morphometric characters show a significant defect once those characters became exposed to (Fowler, 1970). Environmental stress is the total environmental influences that affect the structure and function of an organism in such a way that their Neo-Darwinian fitness is reduced (Calow, 1989).

Asymmetry is the differential development of a bilateral character between the sides of an organism (Van Vallen, 1962; Palmer, Strobeck 1986; Leary, Allendorf, 1989). On the other hand, fluctuating asymmetry results from the inability of individuals to undergo identical development of a trait on both sides of the body. It is also suggested that fluctuating asymmetry represents a measure of the sensitivity of development

1. Marine Science and Fisheries Centre, Ministry of Fisheries Wealth, Sultanate of Oman, P.O. Box 427, Postal Code 100 Muscat.
2. Department of Marine Science and Fisheries, Sultan Qaboos University, P. O. Box 34, Al-khud 123, Sultanate of Oman.
* Corresponding author: laith_jawad@hotmail.com

to environmental stress (Moller, Pomiankows, 1993). Asymmetry usually increased under environmental stresses, due to the failure of homeostatic regulatory mechanism. Such developmental effects might occur before the concentration of toxicant in water or food reaches level high enough to produce morbidity (Bengtsson, Hindberg, 1985).

This work studied the bilateral asymmetry phenomenon in selected morphological characters of the siganid species, *Siganus rivulatus* collected from the Arabian Sea coasts of Oman.

Material and methods

Specimens of *S. rivulatus* were collected from the Arabian Sea coast of Oman on the 3rd January 2008. This siganid species is dmersal and it is found on sand and muddy bottoms and it is common on the Omani coasts of the Arabian Sea. The five bilateral characters used to compare asymmetry were as follows: (1) Length of the pre-orbital distance (mm): measured from mouth to the anterior edge of the orbit. (2) Length of the post-orbital distance (mm): measured from the posterior edge of the eye to the posterior edge of the operculum. (3) Eye diameter (mm): measured from the anterior to the posterior edges of the eye. (4) Head length (mm): measured from mouth to the posterior edge of operculum. Meristic characters: (5) Number of pectoral fin rays: a count of the total number of pectoral fin ray, including the most upper ray.

Most characters were counted and measured under a binocular dissecting microscope. For specimens too large to fit under a microscope, a magnifying glass was used. In the statistical analysis, the square coefficient of asymmetry variation (CV^2_a) for meristic and a morphometric character was calculated according to Valentine *et al*. (1973) as:

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

Where S_{r+l} is the standard deviation of the signed difference, 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.

To eliminate scaling problems associated with growth in morphometric characters (non discrete, measurable), each measurements was divided by a conventional standardizing measurement (e.g. head length was used in the present study). Every morphometric measurement was treated in a similar squared coefficient of asymmetry was determined as before.

Charcter	CV^2_a	N	Character mean	% of individuals with asymmetry
Preorbital length	24.62	2	14.75	36.00
Postorbital length	71.96	94	13.78	64.83
Eye diameter	47.08	94	11.58	49.36
N. Pectoral Fin ray	80.75	94	14.73	69.64
Head length	8.84	94	42.67	44.89

Tab. 1. Squared coefficient asymmetry (CV^2_a) values and character means (X r+l) of *Siganus rivulatus*.
Tab. 1. Quadrato del coefficiente di asimmetria (CV^2_a) valori e caratteri medi di Siganus rivulatus.

Results

The results of asymmetry data analysis of the previously listed characters of *S. rivulatus* collected Arabian Sea coasts of Oman are shown in Table 1. The highest value was recorded for pectoral fin ray count and postorbital length.

The percentage of the individuals showing asymmetry in the postorbital character was the highest among the percentages recorded for the five characters (64.83% of the total fish studied) and the lowest percentage was for the individuals with asymmetry in the character head length (44.89 % of the total fish studied). Individuals of *S. rivulatus* were grouped into length classes (Tab. 2). An increasing trend in the asymmetry value with fish length is also obtained for preorbital length, head length and number of pectoral fin ray.

Discussion

There is some variation in the asymmetry values among the five morphological characters studied in *S. rivulatus*. At the present time it is impossible to evaluate the level of asymmetry of those characters and to determine if they are higher or lower than average due to the lack of data regarding natural asymmetry in this part of the world. However, characters like pectoral fin ray count and postorbital length showed hi-

Size Class	n	CV^2_a	character mean X_{r+1}	% of individuals with asymmetry
Preorbital length				
16.1-17.0	2	24.62	14.25	50.00
17.1-18.0	2	78.13	16.00	100.00
18.1-19.0	7	79.17	16.14	28.57
19.1-20.0	13	85.62	16.54	69.23
20.1-21.0	18	98.40	17.39	88.89
21.1-22.0	25	99.31	18.51	80.00
22.1-23.0	15	102.03	19.20	80.00
23.1-24.0	5	108.85	20.16	80.00
24.1-25.0	3	110.77	20.88	100.00
25.1-26.0	1	115.00	22.00	0
26.1-27.0	2	117.27	23.00	100
27.1-28.0	1	119.34	23.60	0
Total	94			
Postorbital length				
16.1-17.0	2	43.27	10.75	50.00
17.1-18.0	2	0	12.00	10.00
18.1-19.0	7	109.43	13.36	100.00
19.1-20.0	13	45.84	12.85	61.54
20.1-21.0	18	118.07	13.19	72.22
21.1-22.0	25	60.48	13.86	48.00
22.1-23.0	15	51.68	14.37	60.00
23.1-24.0	5	74.56	15.10	80.00
24.1-25.0	3	3.72	15.50	33.33
25.1-26.0	1	0	14.50	100.00
26.1-27.0	2	69.20	17.00	50.00
27.1-28.0	1	0	19.50	10.00
Total	94			
Eye lens diameter				
16.1-17.0	2	0	9.50	0
17.1-18.0	2	0	10.00	0
18.1-19.0	7	36.92	11.36	42.86
19.1-20.0	13	27.55	11.00	30.77
20.1-21.0	18	71.65	11.64	50.00
21.1-22.0	25	61.84	11.60	52.00
22.1-23.0	15	54.54	11.97	33.33
23.1-24.0	5	15.12	11.50	20.00
24.1-25.0	3	20.24	12.83	33.33
25.1-26.0	1	0	13.00	0
26.1-27.0	2	30.76	12.75	50.00
27.1-28.0	1	0	14.00	0
Total	94			
Head length				
16.1-17.0	2	0	35.00	0
17.1-18.0	2	33.33	38.75	50.00
18.1-19.0	7	34.44	39.79	57.14
19.1-20.0	13	42.94	40.31	53.85
20.1-21.0	18	45.45	41.56	72.22
21.1-22.0	25	54.49	43.27	60.00
22.1-23.0	15	59.14	44.07	80.00
23.1-24.0	5	60.97	45.40	100.00
24.1-25.0	3	69.93	46.00	100.00
25.1-26.0	1	70.90	46.50	100.00
26.1-27.0	2	80.76	51.00	100.00
27.1-28.0	1	85.78	56.50	100.00
Total	94			
Number of pectoral fin ray				
16.1-17.0	2	80.50	14.50	50.00
17.1-18.0	2	85.12	14.50	10.00
18.1-19.0	7	89.12	14.50	71.43
19.1-20.0	13	98.77	14.85	61.54
20.1-21.0	18	96.42	14.96	55.56
21.1-22.0	25	98.56	15.54	64.00
22.1-23.0	15	105.51	15.93	60.00
23.1-24.0	5	106.09	16.10	40.00
24.1-25.0	3	107.04	16.50	33.33
25.1-26.0	1	109.98	16.80	0
26.1-27.0	2	118.89	17.00	100.00
27.1-28.0	1	120.76	17.30	100.00
Total	94			

Tab. 2. Squared coefficient of asymmetry and character means (X_{r+1}) by size class of *Siganus rivulatus*.
Tab. 2. Quadrato del coefficiente di asimmetria e media dei caratteri (X_{r+1}) per classi di dimensioni di Siganus rivulatus.

gher asymmetry values than those of the other characters studied. High asymmetry values for pectoral fin ray count and postorbital length have also been recorded in several freshwater and marine fish species (Al-Hassan *et al*., 1990; Al-Hassan, Hassan, 1994; Jawad, 2001; 2003; Jawad *et al*., 2010). Such agreements in results of asymmetry might indicate the vulnerability of those two characters to immediate changes in the environment. It is impossible at this stage to confirm that these levels of asymmetry correlate to various types of environmental pollution, and the morphology of the fish species in question is

not available. However, based on previous studies, 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 the Arabian Sea coasts of Oman. On the other hand, the low asymmetry values displayed by the three other characters, preorbital length, head length and eye diameter, might be explained on the basis that those characters are less vulnerable to environmental stresses. This may be the case when the developmental period of those characters does not coincide with the presence of adverse environmental events (Jawad, 2003; Jawad *et al*., 2010). Other factors, including genetic ones, might be responsible for the asymmetry in these characters, but these can not be discussed at this stage due to the lack of genetic data on the ichthyofauna of Oman.

The origin and cause of asymmetry in fish can depend on several factors, one of which is environmental stress, which leads to an increased level of asymmetry, but might occur at low levels before causing wide spread death (Bengtsson, Hindberg, 1985). Pollution of sea water and sediments by hydrocarbons, heavy metals, pesticides and organic matter are considered the main cause of environmental stress. Pollution is not unusual for the Omani waters, as reports of adverse conditions in this part of the world continue alerting people to local ecological disasters (Ramamurthy, 1991; Badawy, Al-Harthy, 1991, Sen Gupta *et al*., 1993).

The environmental causes might be natural events. Several factors are known to produce nutritional deficiencies such as various pathogens and various population phenomena (Bengtsson, Hindberg, 1985), and it is highly possible that these factors may be in action in Oman Sea, since 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, Hassan, 1994; Al-Hassan, Shwafi, 1997; Jawad *et al*., 2001; Jawad *et al*., 2010) where there was a trend of increase in the asymmetry value with the increase in fish length. The results show a trend of increasing asymmetry with fish length for the preorbital legth, head length and number of pectoral fin ray count. This trend is probably the result of incomplete development; character means are always lowest in smaller size classes (Valentine *et al*., 1973). The same results were obtained by Valentine *et al*. (1973) in selected fish species collected from California, U.S.A. They suggested two possible hypotheses that may account for such a trend; these are the ontogenetic changes which are an increase in asymmetry with size (age) and the possible historical process which is a secular increase in asymmetry.

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