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SHORT COMMUNICATION

Asymmetry in some morphological characters of *Leiognathus equulus* (Forsskål) (Leiognathidae) collected from the Sea of Oman

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Abstract. Asymmetry analysis was conducted on four morphometric bilateral characters and one meristic character of *Leiognathus equulus* (Forsskål) collected from the Sea of Oman at the city of Muscat. The results showed that the level of asymmetry of the characters of preorbital distance and head length is higher than that of the rest of the characters studied. Increasing asymmetry values with fish length were noted in preorbital and postorbital distances and head length. This might be the result of incomplete development. The possible cause of asymmetry in this species is discussed in relation to different pollutants and their presence in the area.

Keywords: bilateral asymmetry, bioindicator, Leiognathidae, common ponyfish

The differential development of a bilateral character between the sides of an organism is known as asymmetry (Van Valen 1962, Palmer and Strobeck 1986, Leary and Allendrof 1989). Fluctuating asymmetry results when a character present on both sides of the body does not undergo identical development. It is also known that fluctuating asymmetry represents the degree of developmental sensitivity to environmental stress (Moller and Pomiankowski 1993, Jawad 2001, 2003, 2004, Jawad et al. 2010). Asymmetry usually increases under environmental stresses because of the failure of the homeostatic regulatory mechanism. These developmental effects can occur before the concentration of toxicants in the water or food reaches levels high enough to cause morbidity (Bengtsson and Hindberg 1985). To date, the only published study on fluctuating asymmetry in Omani fish species is that of Jawad et al. (2010); therefore, the present study is a quantitative and qualitative addition to previous studies on Omani fish fauna. The present work focuses on the fluctuating asymmetry of selected morphological characters of the teleost fish *Leognathus equulus* (Forsskål) collected from Muscat coastal areas in the central region of the Sea of Oman.

Specimens of *L. equulus* were collected from the Muscat coastal areas of the Sea of Oman. The five bilateral characters used to compare asymmetry were the pre-orbital distance (mm) measured from the mouth to the anterior edge of the orbit, the post-orbital distance (mm) measured from the posterior edge of the eye to the posterior edge of the operculum, the eye diameter (mm) measured from the anterior to the posterior edges of the eye, head length (mm) measured from the mouth to the posterior edge of the operculum, and the number of

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pectoral fin rays counting the total number of pectoral fin rays including the upper-most ray. Most of the characters were measured or counted under a binocular microscope. A magnifying glass was used for specimens too large to fit under the microscope.

Statistical analyses included calculating the squared coefficient of asymmetry variation (CV^2_a) for meristic and morphometric characters according to Valentine et al (1973):

$$CV^2_a = (SD \times 100/X_{r+l})^2$$

where SD 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 right (r) and left (l) sides and dividing this by the sample size. To obviate scaling problems associated with growth in morphometric characters, each measurement was divided by suitable general size measurements, e.g. head length was used as the standardizing measurement. Each of the morphometric characters was treated as such before obtaining the signed differences.

The results of asymmetry data analyses of *L. equulus* collected from the Sea of Oman are presented in Table 1. The highest value was recorded for the preorbital distance and the lowest value for the pectoral fin ray count while there was no asymmetry in eye diameter. The percentage of individuals exhibiting postorbital distance asymmetry was the highest among those recorded for the five characters (74.1% of the total fish studied), and the lowest percentage was for individuals with asymmetrical numbers of pectoral fin rays (11.1% of the total fish studied). No individuals exhibited asymmetrical eye diameter because all the fish specimens used in the study had symmetrical eye diameters on both sides of the head. The *L. equulus* individuals were grouped into length classes (Table 2). Increasing asymmetry values with fish length were noted for preorbital and postorbital distance and head length.

There was some variation in asymmetry values among the six morphological characters studied in *L. equulus*. It is currently impossible to evaluate the degree of asymmetry of these characters and to determine if they are higher or lower than the average because there is a lack of data regarding natural asymmetry in this part of the world. However, characters like preorbital distance and head length showed higher asymmetry values than those of the remaining characters. High asymmetry values for both preorbital distance and head length were also recorded in several freshwater and marine fish species (Al-Hassan et al. 1990, Al-Hassan and Hassan 1994, Jawad 2001, 2003, Jawad et. al. 2010). Such agreements in asymmetry results might indicate the vulnerability of these two characters to immediate changes in the environment. It is not possible at this stage to confirm such an effect since correlations between the degree and the type of 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 the coastal areas of the Sea of Oman. On the other hand, the low asymmetry values displayed by the two characters of postorbital distance and pectoral fin ray count and the absence of asymmetry in eye diameter might be explained by the fact that these characters

Table 1
Squared coefficient asymmetry (CV^2_a) values and character means (X_{r+l}) of *Leiognathus equulus*

Character	N	CV^2_a	Mean	% of individuals with asymmetry
Preorbital distance	27	25.76	1.93	51.85
Postorbital distance	27	7.53	3.72	74.07
Eye diameter	27	0	1.76	0
Head length	27	17.03	5.48	48.15
Pectoral fin ray	27	3.25	18.39	11.11

Table 2
Characteristic of squared coefficient of asymmetry and character means (X_{r+l}) by size class of *Leiognathus equulus*

Size class (cm)	N	CV^2_a	Mean	% of individuals with asymmetry
Preorbital distance				
19.1-20.0	1	0	1.75	100
20.1-21.0	12	11.39	1.89	41.67
21.1-22.0	9	16.13	1.84	66.67
22.1-23.0	3	19.59	2.03	66.67
23.1-24.0	2	20.23	2.45	69.89
Postorbital distance				
19.1-20.0	1	0	3.60	100
20.1-21.0	12	3.03	3.68	58.33
21.1-22.0	9	6.84	3.57	66.89
22.1-23.0	3	9.80	3.98	88.67
23.1-24.0	2	11.07	4.3	98.54
Eye diameter				
19.1-20.0	1	0	1.60	0
20.1-21.0	12	0	1.72	0
21.1-22.0	9	0	1.80	0
22.1-23.0	3	0	1.77	0
23.1-24.0	2	0	1.85	0
Head length				
19.1-20.0	1	0	5.05	100
20.1-21.0	12	1.49	5.33	55.55
21.1-22.0	9	12.49	5.46	69.55
22.1-23.0	3	14.03	5.77	66.66
23.1-24.0	2	26.27	6.23	73.33
Pectoral fin ray				
19.1-20.0	1	0	18.00	0
20.1-21.0	12	2.28	18.29	8.33
21.1-22.0	9	2.88	18.50	11.11
22.1-23.0	3	6.73	18.16	33.33
23.1-24.0	2	0	19.00	0

are less vulnerable to environmental stress. This might be the case when the developmental period of the postorbital distance, the pectoral fin ray count and eye diameter do not coincide with adverse environmental events (Jawad 2003, Jawad et al. 2010). Other factors, including genetic ones, might be responsible for asymmetry in these characters, but these cannot be discussed at this stage due to the lack of genetic data on the ichthyofauna of Oman.

Asymmetry in some characters can increase under certain kinds of environmental stress (Bengtsson and Hindberg 1985). Developmental effects might occur before the concentration of toxic substances reaches levels high enough to cause mortality. The pollution of sea water and sediments by hydrocarbons, heavy metals, pesticides, and organic matter are considered the main causes of environmental stress. This state of pollution is not unusual for the coastal environment of the Sea of Oman where various

pollutants have been recorded for the last twenty years at least (De Mora et al. 2004, 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 can occur in the Sea of Oman waters as they are common in aquatic environments.

Several authors have identified 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 et al. 2001, Jawad et al. 2010) and an increasing trend in asymmetry values with increasing fish length. This trend is probably the result of incomplete development; character means are always the lowest in smaller size classes (Valentine et al. 1973). The same results were obtained by Valentine et al. (1973) in selected fish species collected in California, and by Jawad et al. (2010) in the carangid fish species *Decapterus russelli* (Ruppel), from the northern coastal region of the Sea of Oman. They hypothesized that ontogenetic changes that increase in asymmetry with size (age) are specifically responsible for this trend.

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Streszczenie

Asymetria niektórych parametrów morfologicznych u *Leiognathus equulus* (Forsskål) (Leiognathidae) z Zatoki Omańskiej

Cechy mierzalne oprócz znaczenia przy identyfikacji ryb wykorzystywane są do oceny zmienności kształtu ciała W pracy przeprowadzono analizę asymetrii wybranych cech morfometrycznych i merystycznych u *Leiognathus equulus* (Forsskål) złowionych w Zatoce Omańskiej w pobliżu Maskatu. *L. equulus* zasiedla wody przybrzeżne Oceanu Indyjskiego i zachodniego Pacyfiku. Największym poziomem asymetrii wyróżniały się odległość przedoczna oraz długość głowy. Wraz ze wzrostem długości wzrastał poziom asymetrii odległości przedocznej, odległości zaocznej oraz długości głowy. Jako przyczynę obserwowanej asymetrii rozważane były zanieczyszczenia wód morskich.