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Fluctuating asymmetry in otolith morphology of sabre squirrelfish, *Sargocentron spiniferum* (Forsskål, 1775) from the red sea, Egypt

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Abstract
Fluctuating asymmetry in otolith dimensions reflect the stress from environmental conditions such as temperature stress, nutritional stress and pollution. Sagittal otolith characters such as length, width, area and perimeter of *Sargocentron spiniferum* (sabre squirrelfish) from Shalateen fishing area were investigated. *S. spiniferum* samples were divided into four-total length groups. All length groups were examined for asymmetry values in the four otolith characteristic, the level of asymmetry of otolith width was higher than of other otolith characters and the highest asymmetry values were found in the group II (240-309 mm). The lowest asymmetry values in area and perimeter otolith characters were found in the first length group (170-239 mm) and the third one (310-379 mm). The asymmetry in these otolith characters may be a result of the stress from environmental conditions in Shalateen, Red Sea coast of Egypt.

Keywords: Fluctuating asymmetry, *Sargocentron spiniferum*, sabre squirrelfish, otolith, red sea

1. Introduction
Sargocentron spiniferum (sabre squirrelfish) is belonging to the family Holocentridae which is distributed throughout the tropical Indo-Pacific, from the Red Sea and Indian Ocean up to Hawaii, Japan and southern Australia. The species is one of the most commercially important fish species in the Red Sea, Egypt.
Otolith morphology is the most roles for fisheries biology because it allows studies for determination of population stock, fish classification and phylogenetic relationship in many years for [1]. The level of instability among populations and individuals is most commonly expressed by their fluctuating asymmetry levels and it is usually characterized by small, random deviations from perfectly bilaterally symmetry [2]. The fluctuating asymmetry can use as indicator for specific environmental effects in the case of the organism. In fish, otolith asymmetry has been used as a bio-indicator to test the condition between different stocks [3]. Fluctuating asymmetry has been suggested by varied studies as a sensitive indicator for detecting environmental disturbance and pollution [4, 5]. In Egyptian Red Sea, little studies were conducted on otolith asymmetry in different fish species such as [6]. The aim of the present work was using fluctuating Asymmetry as an indicator of environmental stress in the Red Sea, Egypt.

2. Materials and Methods
2.1 Description of sampling area
Shalateen fishing area lies at the southern part of the Red Sea between latitude 23° 09' N and longitudes 35° 36' E (Fig. 1). It is located on the western coast of the Red Sea, 520 km southern of Hurghada.

2.2 Sample collection
Specimens of *Sargocentron spiniferum* were obtained during the period from March 2018 to February 2019 from the commercial landings in Shalateen fishing area. Both left and right sagittal otolith were removed through a cut in the cranium and then cleaned and stored dry in glass vials.

Sagittae specimens were collected from 185 specimens (170-460 mm TL) of *S. spiniferum*. Each sagittal were systematically placed with the sulcus acusticus oriented towards the observer and the length was determined using ordinary light microscope (stereomicroscope V20). The maximum length (OL) and the maximum height (OH) were measured to an accuracy of 0.01 mm, recording the greatest distance from the anterior tip to the posterior edge (OL) and the greatest distance between the otolith dorsal and ventral margins (OH), according to [7, 8]. Also the otolith perimeter and area were used in the present study to evaluate the environmental condition on the fish.

Fig 1: Map of the Red Sea showing the study area at Shalateen, Red Sea coast of Egypt.

2.3 Statistical analysis

The statistical analysis was based on the squared coefficient of asymmetry variation (CV^2_a) for the three otolith dimensions according to [9]:

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

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.

3. Results

The results of asymmetry data analysis of otolith characters of *S. spiniferum* collected from Shalateen, Red Sea coast of Egypt are shown in Table 1. The results showed that the level of asymmetry of otolith width was higher (4.59) than other otolith characters. The lower values of asymmetry were recorded in the otolith area and otolith perimeter (0.016 and 0.03, respectively).

Table 1: Squared coefficient of asymmetry (CV^2_a) value and character means (Xr+1) of *S. spiniferum.*

Characters	No.	Cv^2_a	Mean	% of individuals with asymmetry
Otolith Length	185	2.34	11.89	85.40
Otolith width		4.59	7.56	90.27
Otolith area		0.016	66.90	22.73
Otolith Perimeter		0.03	32.28	7.57

The results of asymmetry data analysis of otolith characters according to length groups are shown in Table 2. The lowest value of asymmetry in the area and perimeter otolith characters were found in the fish total length group I (170-239 mm) and group III (310-379), while the highest value in width otolith character was found in the fish total length group II (240-309 mm). Also, the results showed that asymmetry was correlated with fish length.

Table 2: Squared coefficient of asymmetry (Cv^2_a) and character means by size of *S. spiniferum.*

Characters	Length groups (mm)	N	Cv^2_a	Mean	% of individuals with asymmetry
Otolith length	Group I: 170-239	9	0.52	10.07	66.67
	Group II: 240-309	90	2.98	11.30	83.33
	Group III: 310-379	64	1.77	12.54	100
	Group IV: 380-460	22	1.42	13.18	81.82
Otolith width	Group I: 170-239	9	1.27	6.41	100
	Group II: 240-309	90	5.07	7.05	91.11
	Group III: 310-379	64	4.64	7.95	92.19
	Group IV: 380-460	22	2.20	8.97	77.27
Otolith area	Group I: 170-239	9	0.62	52.42	44.44
	Group II: 240-309	90	0.18	60.71	10.00
	Group III: 310-379	64	0.00	71.38	0.00
	Group IV: 380-460	22	0.01	85.07	22.73

Perimeter	Group I: 170-239	9	0.00	26.83	0.00
	Group II: 240-309	90	0.05	30.94	12.22
	Group III: 310-379	64	0.00	32.27	0.00
	Group IV: 380-460	22	0.01	37.09	13.64

4. Discussion

Direct or indirect effects of environmental stress on the animals affect the symmetry of bilateral characters of the animals and their developmental instability. Sea water pollution and sediments by agricultural and livestock wastes, soil erosion, chemical pollution, biological and physiological contaminants, atmospheric pollution, industrial wastes, heavy metals, mining activities, insecticides and pesticides are considered the main cause of environmental stress [10]. Animals are sensitive to environmental effects in morphometric characters, especially in the meridian characters and show a significant fitness disorder when they became exposed to environmental stress [11-13].

Environmental condition cause developmental instability; which lead to the high fluctuating asymmetry, and bilaterally symmetrical deviations in the bilateral characters of the living being [14, 15]. Increased levels of fluctuating asymmetry have been linked to various forms of stress (*e.g.* temperature stress, nutritional stress and pollution), and reduced performance in fitness-related variables like growth, fecundity or survival [15, 16]. Several authors stated that both environmental and genetic factors had positive effects on otolith asymmetry such as [6, 10, 17, 18].

In the current study, some variation in fluctuating asymmetry values was observed among otolith characters of *S. spiniferum*. The pollution-induced stress can be affected the otoliths of fish to gain an asymmetric characters. Moreover, the asymmetry of morphological characters is negatively correlated with fitness of several animal taxa [19, 20]. Based on the previous studies in this field, it is possible to suggest an environmental stress due to pollution and asymmetry in the morphology of this species, such as [21, 22].

In the present work, the results showed that fluctuating asymmetry in otolith characters does not depend on fish size and this agree with the results obtained for various organisms of the aquatic fish [23, 24].

In the present study, the fluctuating asymmetry value of otolith width was higher than the otolith length and this result is similar to others studies. Such as, [25] reported that in *Sardinella sindensis, Sillago sihama* and *Lutjanus bengalensis*. In other studies, it has been reported that otolith length has a higher fluctuating asymmetry value than otolith width. For instance, [26] reported that in *Rastrelliger kanagurta*. Similarly, [7] noted that in *Chlorurus sordidus* and *Hipposcarus harid*.

These differences among studies may be due to the size of the sample, the species of fish, pelagic or demersal, habitat differences, and even genetic predisposition Some authors have shown that there is a positive correlation between asymmetry coefficient and the total fish length [27, 28].

5. Conclusion

Fluctuating asymmetry in otolith characters could be used as an indicator method to determine the environmental stress in aquatic ecosystems. The Fluctuating asymmetry in otolith characters of *S. spiniferum* fishes was indicator for temperature stress, nutritional stress and pollution in the Shalateen, Red Sea coast of Egypt. The fluctuating asymmetry in otolith characters in *S. spiniferum* fishes do not depend on fish size.

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