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RESEARCH ARTICLE

BASELINE OF THE IMPLICATION OF ENVIRONMENTAL DISTURBANCE ON THE MORPHOMETRIC PARAMETERS IN TWO FISH SPECIES: SARDINELLA AURITA AND MUGIL CEPHALUS

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ABSTRACT

Environmental perturbation such as pollution is one of the most disturbing aspects of environmental degradation. The Gulf of Gabes is presently facing severe environmental issues due mainly to intense fishing activity and improper industrialization (metal pollution). We have proposed in the present study, to assess the impact of environmental pollution on two fish species: *Sardinella (S.) aurita* and *Mugil (M.) cephalus*. To attend our objective, an exploration of morphological and asymmetry parameters was undertaken. The comparative analysis of the obtained data showed for *S. aurita* and *M. cephalus*, the existence of a significant difference between both male and female sexes, the total length (the standard length, the length to the fork and the predorsal length and the morphological variables total length, standard length, length into the fork, the caudal length of the peduncle, the height of fishes, dorsal fin length and anal fin length respectively for the two species. The study of asymmetry parameters revealed some asymmetries affecting the length of the head and the diameter of the eye, respectively for *M. cephalus* and *S. aurita*.

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INTRODUCTION

The pollution constitutes one of the most disturbing aspects of the degradation of the natural environment. Understanding the biological impacts of pollution is crucial for predicting the future status of biological systems at the levels of organisms, populations, and communities, as well as for anticipating their reactions to environmental changes. The environmental stress can affect the structure and the function of a body (Calow, 1989). During these last years, the metallic pollution of the aquatic systems became one of the most fascinating domains of the scientific research. Many research works revealed that Because of their sensitivity to environmental factors, fish are thought to be excellent environmental indicators (Seixas *et al.,* 2013, 2016). Asymmetry is the term used to describe the uneven development of a body's bilateral feature (Leary and Allendorf, 1989). Random deviation from perfect symmetry in populations of organisms are known as fluctuating asymmetry (FA) (Palmer and Strobeck, 1992). It is a metric for developmental noise, which expresses the average level of adaptation and coadaptation in a population.(Graham *et al.,* 2010). The species under research should be locally resident, live under a wide gradient of pollution, and ideally feed on bottom fauna to allow direct access to sediment contamination in order for FA to monitor the effects of pollution in the marine environment. Two biological models represented by two species of fishes widely distributed on the Tunisian coast and presenting an important economic interest: *S.aurita* and *M. cephalus* was the object of the present study. These two species were taken from Gulf of Gabes, south western coast of Tunisia.

To discern possible morphological variations to both natural populations of *S. aurita* and *M. cephalus*, a morphological study on the scale of the body was made. This study concerned as well physical measurements as characters which can reflect a state of asymmetry affecting certain parts of the body (sides right/left). Besides these moderate morphological parameters, certain characters meristic were explored. This study aimed to investigate the impacts of water pollution from the Gulf of Gabes on two fish species, *Mugil cephalus* and *Sardinella aurita*, which are considered sentinel species for biomonitoring aquatic ecosystems. Morphological biomarkers were used, employing fish anatomy (FA) methodologies, with the ultimate goal of evaluating their potential as predictors of environmental pollution status in fish. We examined changes in the mean values of morphological traits used in this study to provide context for understanding FA asymmetry patterns.

MATERIAL AND METHODS

The samples were collected from Gulf of Gabes (Figure 1). In total, 80 specimens were analysed. All individuals were sexed; weight and total length was measured. The morphological study concerned 39 samples of *S. aurita* (total length averages = 18.19±0.73cm and Weight = 49.25±6.34 g) and 41 samples of Mullet *M. cephalus* (TL averages = 23.2±2.56 cm and Weight = 100.13±32.8 g). Thirteen morphological parameters for the *S. aurita*specimens were determined (Figure 2); while seventeen measures were noted for *M. cephalus* (Figure 3). These parameters recover as well standard morphological parameters and parameters of asymmetry measured on both sides of the body. For the measure of the total length (TL), the length into the fork (FL) and the standard length (SL) of every sample, we used a ruler and a caliper "ACEM" (Digital Caliper; 0-150 mm). The study of the characters meristic was made by counting the number of the rays of the dorsal, pectoral (right / left), pelvic (right / left) and anal fins. To reduce the potential impact of methodological artifacts on asymmetry results, the same single researcher examined the right (R) and left (L) sides of bilateral body components using the same binocular stereomicroscope and digital caliper for morphometric measurements.

Statistic Analysis

Values for morphological analysis are expressed as mean± SE. Prior to analyses, data were checked for normality (Shapiro-Wilks test). Univariate analysis for each morphological parameters and a GLM analysis procedure on the relationship between sexes and species was performed.

RESULTS AND DISCUSSION

The morphological study concerned as well morphological variables as variables of asymmetry. Indeed, for *S. aurita*, the analysis of 8 morphological variables showed the existence of a significant difference between both male sexes and female in certain studied lines. Indeed, the total length, the standard length, the length to the fork and the predorsal length show a significant difference between both sexes(Table1). However, we did not note statistically significant difference between both sexes for dorsal fin length, anal fin length as well as height of the fish (Table 1). Also, males and females of *S. aurita* do not present significant differences for the total weight as well as for both variables moderate meristic: number of the rays of the dorsal fin (F=0.001; p=0.972) and counts rays of the anal fin (F=1.749; p=0.194) (Table 1).

Fig. 1. Studied sites

For *M. cephalus*, we noted that males and females present significant differences concerning the morphological variables total length, standard length, length into the fork, the caudal length of the peduncle, the height of fishes, dorsal fin length and anal fin length (Table 2). However, we did not note difference for the predorsal length as well as for both parameters meristic (number of the rays of the anal and dorsal fin) between males and females at *M. cephalus* (Table 2). Also, we noted that the total weight of females presents a statistical significant difference with the individuals of male sex (Table 2).

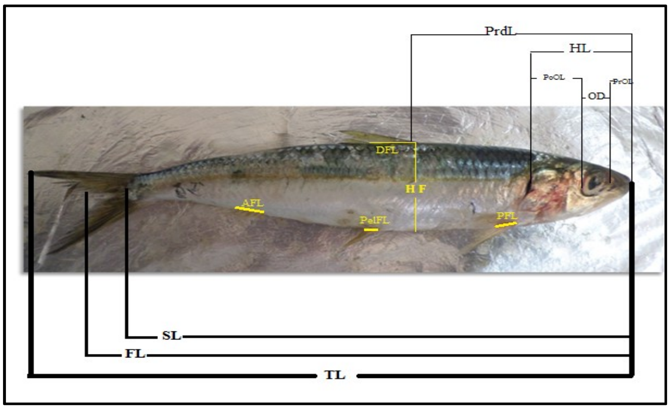
Table 1. Statistical analysis of the various morphological traits for *Sardinella aurita*

Parameters	Sex	Mean ±ES	F	*p*
TL	Male (M) Female (F)	17.64±0.165 18.575±0.107	24.691	0.001
SL	M F	14.919±0.133 15.503±0.086	14.798	0.0005
FL	M F	15.709±0.142 16.265±0.093	11.755	0.001
PrdL	M F	6.406±0.082 6.724±0.047	12.764	0.001
DFL	M F	1.778±0.026 1.849±0.035	2.284	0.139
AFL	M F	1.921±0.04 1.971±0.03	1.023	3.185
HF	M F	3.167±0.039 3.279±0.05	2.735	0.106
Total Weight	M F	47.649±1.634 50.371±1.274	1.77	0.191

Table 2. Statistical analysis of the various morphological traits for *Mugil cephalus*

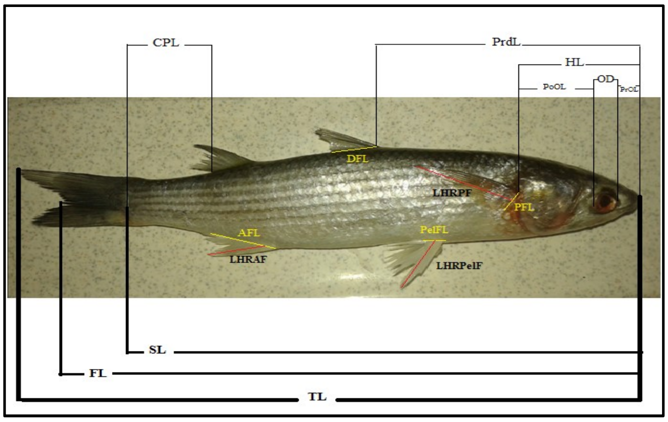
Parameters	Sex	Mean ±ES	F	*p*
TL	Male (M) Female (F)	21.357±0.492 24.07±0.463	13.609	0.007
SL	M F	17.443±0.454 19.4±0.287	14.415	0.005
FL	M F	19.457±0.463 21.603±0.363	12.608	0.001
PrdL	M F	14.312±5.664 9.483±0.155	4.732	0.238
CPL	M F	2.691±0.08 3.003±0.048	12.671	0.001
DFL	M F	1.31±0.062 1.553±0.062	6.154	0.0175
AFL	M F	1.893±0.048 1.727±0.045	5.029	0.03
HF	M F	3.637±0.107 4.008±0.074	8.728	0.006
Total Weight	M F	80.939±6.562 112.166±6.125	10.26	0.0027

In our study, analysis of asymmetry parameters to both species showed that in *Sardinella* the diameter of the eye is the only character showing a statistical significant difference between the right and leftside of fishes (Table 3) however to the *M. cephalus* it is the length of the head that presents a difference between both sides of the individual (Table 4). In several other studies relationship between FA and contamination was not found or was found for only some characters (Kenney and von Hippel, 2013; Lajus *et al.,* 2014). In general, in fish FA is now routinely used for assessment of stress and fitness (Allenbach, 2011). The statistical analysis of the bilateral variables of asymmetry revealed the absence of difference between the male sexes and female (F=0; p=0.69) as well as between both species *M. cephalus* and *S. aurita* (F=2.52; p = 0.11).The analysis of the various parameters of asymmetry to both species showed that the length of the head to the *M. cephalus* and the diameter of the eye to the *S. aurita* represent the parameters affected by the asymmetry. The effects of environmental disturbance especially, pollution, on fish stress, resulting in increased asymmetry, has been shown in many researches *Leuresthestenius* affected by industrial pollution (Valentine *et al.,* 1973); *Gasterosteus aculeatus* from industrially polluted waters (Zakharov, 1981); *Carassius auratus* from with different level of industrial pollution (Romanov and Kovalev, 2004). The meristic and morphometric characters are very sensitive to the environmental factors and show a significant variation further to exposure in the disturbances of the environment (Fowler, 1970).



Total length (TL), Length to fork (FL), Standard length (SL), Predorsal length (PrdL), Head length (HL)(Right/Left),The pre-orbital distance length (mm)(PrOL) (Right/Left), The post-orbital distance length (PoOL) (mm) (Right/Left), Orbital diameter (mm) (OD) (Right/Left), Dorsal fin length (DFL),Pectoral fin length (PFL) (Right/Left), Pelvic fin length (PelFL) (Right/Left), Anal fin length (AFL), Height BODY Fish (HF).

Fig. 2. Morphological parameters of *Sardinella aurita*.



Total length (TL), Length to fork (FL), Standard length (SL), Caudal peduncle length (CPL), Predorsal length (PrdL), Head length (HL) (Right/Left), The pre-orbital distance length (mm) (PrOL) (Right/Left), The post-orbital distance length (PoOL) (mm)(Right/Left), Orbital diameter (mm)(OD) (Right/Left), Dorsal fin length (DFL),Pectoral fin length (PFL) (Right/Left), Higher rays of pectoral fin length (LHRPF) (Right/Left), Pelvic fin length (PelFL) (Right/Left), Higher rays of pelvic fin length (LHRPelF) (Right/Left), Anal fin length (AFL), Higher rays of anal fin length (LHRAF), Height Body Fish (HF).

Fig. 3. Morphological parameters of *Mugil cephalus*

Table 3. Statistical analysis of the asymmetry parameters for *Sardinella aurita*

Variable	*t* de Student	*W* Shapiro-Wilk	Difference ±ES
D HL	0.01	0.0003	0.01±0.006
DPrOL	0.18	0.5	-0.01±0.05
DPoOL	0.002	0.0001	-0.05±0.01
DD OD	0.03	0.75	0.01±0.006
D PFL	0.001	0.18	0.04±0.01
DPelFL	0.02	0.39	0.02±0.01
DNbRPF	0.88	0.0004	-0.02±0.19

Additionally, it is recognized that the varying asymmetry signifies a single level of sensitivity to environmental stress (Moller and Pomiankowski, 1993; Jawad, 2003; Jawad *et al.,*2010). He was demonstrated that the asymmetry usually increases under environmental requirements because of the failure of the mechanism which checks the homeostasis. These effects on the development can occur before the concentration of toxic matter in the environment reaches levels enough raised to pull the mortality of the individuals. It was shown that under environmental requirements, asymmetry typically rises due to the breakdown of the system that maintains homeostasis.

Table 4. Statistical analysis of the asymmetry parameters for *Mugil cephalus*

Variable	*t* de Student	*W* Shapiro-Wilk	Difference±ES
D HL	0.01	0.6	0.03±0.01
DPrOL	0.36	0.4913	0.01±0.01
DPoOL	0.38	0.0001	-0.023±0.02
DD OD	0.17	0.06	0.01±0.01
D LHRPF	0.24	0.0001	-0.06±0.05
D PFL	0.01	0.11	0.04±0.01
DPelFL	0.12	0.23	0.03±0.02
DLHRPelF	0.004	0.5031	-0.05± 0.01
DNbRPF	0.001	0.0001	-1.48±0.42

These developmental impacts may manifest prior to the environmental concentration of hazardous materials reaching a threshold that would otherwise result in individual death.It is feasible to draw the conclusion that there is a direct relationship between environmental stressors like pollution and asymmetry by basing this conclusion on earlier research. According to reports, the species under investigation must live in a region with a large gradient of pollution, feed on bottom fauna to allow direct access to sediment pollution, and be locally resident in order for FA to monitor the effects of pollution in the marine environment. Furthermore, according to Allenbach (2011), it must possess an adequate quantity of useful morphological structures to enable precise FA analysis. Although contaminants already documented for the Gulf of Gabes function as potential stressors generating asymmetry, our data do not show the influence of pollutants accumulation on FA (Annabi *et al.,* 2009; 2012; 2018). According to Jones *et al.* (2001), an individual's general poor growth, resilience to sickness, ability to reproduce, and ability to withstand and generate hardship in their environment can all be negatively impacted by asymmetry. On the other hand, it has also been noted that the FA found for certain natural populations of *O. ruber* may be influenced by the availability of food resources, exposure to other pollutants and harmful agents (organic pollutants, metallic trace elements, algal toxicity), as well as environmental and oceanographic factors (Seixas *et al.,* 2012).

Ethical Statement: No live specimens were used in the present investigation.

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