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A Comparative Study on Filtration Area of Gill Rakers in Two Fish Species: Redbelly Tilapia, *Coptodon zillii* and Torpedo Scad, *Megalaspis cordyla* in Basrah, Iraq

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Abstract: The present study is based on a comparison of gill rakers filtration area in two fish species, the red belly tilapia, *Coptodon zillii* (Gervais, 1848) and the torpedo scad, *Megalaspis cordyla* (L., 1758). The fish lengths of tilapia were ranged between 160-320 mm and torpedo scad between 162-328 mm. Samples were collected from Basrah fish market during December-2016 and January-2017. The results showed significant differences ($P>0.05$) in the components of the filtration area for gill rakers between studied species in both gill arch and gill rakers lengths, while no significant differences ($P>0.05$) were found in the number of gill rakers. *M. cordyla* exhibited higher filtration gap rates ranging between 1.76-2.27 mm compared to 0.79-0.92 mm in *C. zillii*. The filtration area of gill rakers was varied between 45.55 and 116.76 mm² in *C. zillii* and between 107.59 and 273.35 mm² in *M. cordyla* indicating significant differences ($P<0.05$) between the studied species.

Keywords: Filtration area, gill rakers, red belly tilapia, torpedo scad, Basrah.

Introduction

The redbelly tilapia *Coptodon zillii* (Gervais, 1848) has a wide spread distribution in tropical and subtropical regions of Africa and Eurasia. It feeds on aquatic plants, epiphyton and some invertebrates (Riede, 2004; Al-Okailee et al., 2017). The *Megalspis cordyla* (L., 1758) is a marine, brackish, reef-associated fish which feeds mainly on fishes (Fischer et al., 1990). These two fish species are considered as commercial species characterized by relatively marketable in local fish markets in Basrah. Measurements of fish gills in teleosts have become of increasing importance in fish growth studies (Pauly, 1981). The gills are related to many important functions in ichthyofauna. The first function is considering them as main respiratory sites of gas exchange (Kumari et al., 2009), while the secondary function is related to feeding habits where the specification of gill filaments and rakers are reflected in the feeding habits of fish species (Narcisco Fernandes, 1996; Kumari et al.,

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2009). The specification of gill rakers plays an important role in controlling the size of food particles consumed. Fish species characterized with many long rakers is categorized as filter feeders, whereas species with few short rakers are classified as omnivores and carnivores (Moodei, 1985). Each gill consists of three parts; gill rakers, gill arch and gill filaments (Yasutake & Wales, 1983; Wilson & Laurent, 2002). The gill rakers in most fishes are cartilaginous or of bony structures that project to the inside of the pharyngeal cavity. The structures are developed following to shifting based on food and feeding habits in relation to the size of the food particles consumed (Almeida et al., 2013). Detritivorous and Planktivorous fishes have numerous and elongated gill rakers with narrow space between each other, however species with few short rakers are mainly carnivorous (Salman et al., 1993; Mansour, 2005; Ouda, 2015). The number and function of gill rakers vary through the growing stages. Gill rakers have dual function of protecting the delicate gill filaments and preventing the escape of captured prey organism through the opercular cavity (Gibson, 1988). Few local studies carried out on filtration efficiency of gill rakers included those of Salman et al. (1993), Mansour (2005) and Ouda (2015). The present study aimed to explain the differences between the components of the filtration gap and filtration area of gill rakers of two commercial fish species in Basrah, southern Iraq. Such studies provide data to compare with other common local fish species to find out differences on physiological properties of gill specifications which determine the feeding habits.

Materials and Methods

Sampling

Fish samples were consisted of 30 specimen of *C. zillii* and 30 specimen of *M. cordyla* which were collected from Al-Basrah fish market between December 2016 and January 2017. Samples selected were stored in a cool box, transported to the laboratory for further preparation including measurement for nearest total length (mm) and dissection to remove gill arches of the left side of each specimen.

Estimation of Filtration Gap and Filtration Area

All gill rakers were dissected out from the investigated species. Each gill arch was removed from the left side of each specimen. The following measurements were conducted using a binocular microscope supplied with an ocular micrometer (Gibson, 1988):

Gill arch length (L).

Number of gill rakers on each arch (N).

Average length of five gill rakers representing all parts on the arch.

Average thickness at the base of three gill rakers (T) on different sites of each arch.

Average space (gap) between gill rakers (G) was calculated following Gibson (1988):

$$G = L-[\{(N-1) \times T\}/(N-1)]$$

Filtering area (F) representing the space between gill rakers through which water can flow was calculated according to Gibson (1988):

$$F = (\sum L - L_{max}) \times G$$

Where: $\sum L$ is the summation of total lengths of all rakers on arch or on all arches and L max is the length of the longest raker on the arch.

Statistical Analysis

Pearson correlation was calculated for the relationships between the average of total length and the components of the filtration gap and filtration area of gill rakers. One-way analysis of variance was performed for statistical comparisons between the studied characteristics in both fish species using SPSS16.

Results

The morphological measurements of the gill rakers showed that *C. zillii* possessed short and acute gill rakers along gill arches whereas *M. cordyla* had elongated and thin gill rakers in first gill arch but with short gill rakers on the other arches. Moreover, the results indicated differences in lengths of the gill arch in the studied species, indicating small gill arch (17.8-30.2 mm) in *C. zillii* in comparison with 34.4-48.2 mm in *M. cordyla* (Table 1). A positive correlation between fish length and gill arch length was observed (0.994 and 0.997 in *C. zillii* and *M. cordyla*, respectively) as indicated in Table (2). The statistical analysis indicated significant differences ($P<0.05$) in gill arch lengths between the studied species (Table 3).

The results showed an approximation in averages of number of gill rakers in both species, which ranged between 20.6-38.4 to 16.12-28.18 in *C. zillii* and *M. cordyla*, respectively (Table 1). The observations revealed a positive correlation between fish length and number of gill rakers, where found to be 0.994 and 0.984 in *C. zillii* and *M. cordyla* respectively (Table 2). The statistical test showed no significant differences ($P>0.05$) in number of gill rakers (Table 3).

Wide variation in lengths of gill rakers were noticed in both species. *C. zillii* possessed gill raker with length ranged between 2.6 and 4.0 mm whereas the longest gill rakers were ranged between 2.8-4.2 mm. However, the lengths of gill rakers in *M. cordyla* was varied between 3.2 and 5.8 mm and the longest gill rakers were ranged between 3.8 and 6.2 mm (Table 1). Additionally, positive correlations were obtained between fish length and both gill raker length (0.988) and longest gill raker (0.994) in *C. zillii*, while these correlation in *M. cordyla* were 0.998 between fish length and gill raker length and 0.986 between fish length and longest gill raker (Table 2). The statistical analysis results indicated significant differences (P<0.05) in lengths of gill rakers between the studied species (Table 3).

The results on gill raker thickness (base of gill raker) revealed that gill raker thickness was ranged between 0.016-0.024 cm in *C. zillii* and 0.018-0.022 cm in *M. cordyla* (Table 1). The relationship between fish length and gill raker thickness were equal to 0.938 for *C. zillii* and 0.947 for *M. cordyla* (Table 2). Due to similar range obtained of gill raker thickness in the two investigated species, no significant differences have been indicated (P>0.05) as presented in Table (3). The filtration gap was ranged between 0.79-0.92 and 1.76-2.27 mm in *C. zillii* and *M. cordyla*, respectively (Table 1). The results showed negative correlation between fish length and filtration gap where r was found to be -0.961 and -0.926 in *C. zillii* and *M. cordyla*, respectively (Table 2). The statistical analysis indicated significant differences (P<0.05) between the studied species in this respect (Table 3).

The results presented in Table (1) showed a wide variation in filtration area in both species where the values indicated that *M. cordyla* possessed large filtration area with a range between 107.59 and 273.35 mm² in comparison with 45.26 and 116.76 mm² for *C. zillii*. The correlation coefficient results showed positive correlation between fish length and filtration area where r equal to 0.986 for *C. zillii* and 0.998 for *M. cordyla* (Table 2). As a result of noticeable variation in filtration area between the investigated species, the statistical analysis revealed significant differences (P>0.05) between the studies fishes in this respect (Table 3).

Table (1): Gill specification in relation to total length of *C. zillii* (upper row) and *M. cordyla* (lower row).

Fish length (mm)	No. of fish examined	Gill arch length (mm)	No. of gill rakers	Length of longest raker (mm)	Gill raker longer (mm)	Gill raker Thickness (base) (mm)	Filtration gap (mm) (G)	Filtration Area (mm²) (F)
160.20 ± 10.15	6	17.8 ± 2.14	20.6 ± 1.14	2.6 ± 0.08	2.8 ± 0.16	0.016 ± 0.008	0.92 ± 0.024	45.26 ± 3.97
162.80 ± 20.18	6	34.4 ± 2.24	16.12 ± 0.70	3.2 ± 0.17	3.8 ± 0.12	0.018 ± 0.006	2.27 ± 0.012	107.59 ± 7.13
200.18 ± 15.25	6	20.5 ± 1.15	24.16 ± 1.16	2.8 ± 0.45	3.0 ± 0.12	0.018 ± 0.006	0.87 ± 0.02	55.85 ± 3.48
204.62 ± 15.34	6	38.2 ± 2.46	18.16 ± 0.75	3.8 ± 0.16	4.2 ± 0.44	0.018 ± 0.004	2.23 ± 0.022	143.16 ± 9.62
240.28 ± 22.14	6	22.8 ± 1.08	28.4 ± 1.29	3.2 ± 0.18	3.4 ± 0.20	0.018 ± 0.008	0.82 ± 0.009	70.68 ± 6.12
248.4 6 ± 18.22	6	42.4 ± 1.66	20.33 ± 1.36	4.4 ± 0.21	4.8 ± 0.34	0.020 ± 0.002	2.21 ± 0.016	183.87 ± 10.44
280.23 ± 12.26	6	26.10 ± 2.20	32.12 ± 1.14	3.6 ± 0.24	3.8 ± 0.42	0.020 ± 0.012	0.81 ± 0.008	91.34 ± 8.32
286.82 ± 16.44	6	44.6 ± 1.85	24.80 ± 1.32	5.2 ± 0.22	5.8 ± 0.18	0.020 ± 0.008	1.92 ± 0.018	228.48 ± 23.24
320.38 ± 20.16	6	30.20 ± 2.16	38.4 ± 1.16	4.0 ± 0.15	4.2 ± 0.36	0.024 ± 0.014	0.79 ± 0.022	116.76 ± 6.23
328.64 ± 24.46	6	44.6 ± 1.85	28.18 ± 0.89	5.8 ± 0.18	6.2 ± 0.21	0.022 ± 0.008	1.76 ± 0.020	273.35 ± 14.67

Table (2): Correlation coefficients between fish length and gill specification of *C. zillii* and *M. cordyla*.

Characteristic	*C. zillii*	*M. cordyla*
Gill arch length (mm)	0.994	0.997
Numbers of gill rakers	0.994	0.984
Gill rakers length (mm)	0.988	0.998
Length of longest raker (mm)	0.994	0.986
Gill raker thickness (base) (mm)	0.938	0.947
Filtration gap (G) (mm)	-0.961	-0.926
Filtration area (F) (mm^2)	0.986	0.998

Table (3): Statistical analysis of gill specification between *C. zillii* and *M. cordyla*.

Characteristic	F-value	Significant level	Difference
Gill arch length (mm)	31.099	0.001	Significant
Numbers of gill rakers	3.600	0.094	Non-significant
Gill rakers length (mm)	5.414	0.048	Significant
Length of longest raker (mm)	8.395	0.020	Significant
Gill raker thickness (base) (mm)	0.067	0.803	Non-significant
Filtration gap (G) (mm)	142.314	0.000	Significant
Filtration area (F) (mm^2)	11.977	0.009	Significant

Discussion

Fishes generally vary in the structure, shape, number and length of the gill rakers. These variations are mostly related to the feeding habits (Khalaf-Allah et al., 2016). The previous studies on food habits of *C. zillii* carried out by Eccles (1992) and on *M. cordyla* conducted by Fischer et al. (1990), indicated that the former is omnivorous and the latter is carnivorous. However, the present study showed no real differences in the shape and structure of gill rakers in the gill arches between the two species except for the first gill arch in *M. cordyla*.

The gill arches are composed of one part in *C. zillii* and two parts in *M. cordyla*. This variation is reflected on significant differences observed in the lengths of the gill arches between the two species (Almeida et al., 2013) during a study undertaken on six fish species found that the length of the gill rakers were highest in the first gill arch with no differences among the other gill arches. Similarly, the present study indicated a difference in gill rakers specifications only the first gill arch in *M. cordyla* in comparison with other gill arches for both species.

The results showed that the number of gill rakers in the investigated species ranged between 16 and 38, explaining that the distribution of gill rakers is not equal along the gill arches which reflects on the associations between feeding habit and gill raker number, although there is a positive relationship between number of gill rakers and fish length. Such finding are in agreement with other relevant studies (Amundsen et al., 2004; Salman et al., 2005; Almeida et al., 2013; Abumandour & Gewaily, 2016). The length of the gill rakers is an important character to determine the efficiency of filtration area in relation to the gill rakers (Gibson, 1988; Mansour, 2005). The significant differences in the gill raker lengths noticed in the present study in both fish species is attributed to differences in feeding habits and fish length as well. The difference in the large rates of longer gill rakers between the two species explains the important role of the gill rakers located in the middle of the gill arch in retention of the food particles as also indicated in several studies (Gibson, 1988; Amundsen et al., 2004; Mansour, 2005; Salman et al., 2005; Ouda, 2015; Don & Shaikh, 2016). Thickness of the gill raker is an important character to estimate the average of space of gill raker and filtration area (Gibson, 1988). The present study elucidated less differences in rates of thickness of the gill rakers, indicated by significant differences between the studied species. Salman et al. (2005) studied the filtration gap for gill rakers of eight teleost species in the Red Sea coasts of Yemen. The results showed that the lowest filtration gap rate was 0.135 mm in *Pomadasys maculates* in comparison with 3.210 mm in *Carangiodes malabaricus* and some carnivores need to increase the filtration gap as the fish grew bigger to be able to consume larger preys. In the present study, the results indicated differences in the filtration gap between the studied species with higher rates of filtration gap in *M. cordyla* in comparison with *C. zillii*. These differences could be related to the feeding habits and behavior of fishes as concluded by Gibson (1988), Amundsen et al. (2004), Mansour (2005) and Salman et al. (2005). The filtration, as a feeding mechanism used by different fish species, which need to increase the efficiency of food filtration to attain metabolic rate required by increasing the filtration area for gill rakers (Mansour, 2005). As a result, the increase in the filtration area was confirmed by high positive correlation coefficient with increasing of the fish length in both studied species. Hence, the significant differences in lengths of the gill arches and length and number of gill rakers affect the average of the filtration area of the gill rakers in the two investigated species.

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