University of Benghazi
Faculty of Education Almarj

جامعة بنغازي
كلية التربية – المرج
ISSN 2518-5845

العدد السبعون / ديسمبر /2023

Gill morphometrics of freshwater *Tilapia zillii* as an indicator of fish welfare

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Abstract

Tilapia zillii was used to examine the effect of environment on gill morphometric therefore to discover the probability of using gill morphometrics to measure welfare in wild fish. Thirty mature *Tilapia zillii* was collected from Lagoon of Ain-Ziyana in eastern of Benghazi city and the sizes of their gills were estimated. The gill respiratory surface area of *Tilapia zillii* reached from 851.31 mm^2 to 1929.32 mm^2/ g of body weight. The connection among gill respiratory surface area and fish body weight was found to be highly significant (P= 0.001). The gill respiratory surface area of *Tilapia zillii* rise as the fish grows this may be since the gill filaments number, the secondary lamellae number and the surface area of secondary lamellae increases. Great gill surface area might support survival of Tilapia fish in oxygen-stressed. This recommends that the measure developed here could be possibly used as an guide of welfare in wild fish.

Key words: gills, morphometric, welfare, *Tilapia zillii*.

مورفولوجيا خياشيم البلطي الزيللي: الاستخدام المحتمل للخياشيم كمؤشر للرفاهية في الأسماك في بيئتاه الطبيعية.

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الملخص :

تم استخدام البلطي الزيللي في اختبار تأثير البيئة على القياسات الظاهرية للخياشيم كذلك لاكتشاف امكانية استخدام القياسات الظاهرية لقياس الرفاهية في الاسماك في بيئتها الطبيعية. ثلاثين سمكة بلطي زيللي جمعت من بحيرة عين الزيانة في شرق مدينة بنغازي و قد تم قياس خياشيمها. السعة التنفسية لخياشيم للبلطي الزللي بلغت من 851.31 ملم^2 /جم الى 1929.32 ملم^2/جم من وزن الجسم. الارتباط ما بين السعة التنفسية لخياشيم سمكة البطلي الزيللي وجدت عالية جدا (P=0.00) . السعة التنفسية لخياشيم البلطي الزيللي تزداد مع نمو السمكة و هذا ربما بسبب الزيادات في عدد الخيوط الخيشومية، وعدد الصفائح الثانوية و المساحة السطحية للصفائح الثانوية. المساحة الكبيرة للخياشيم ربما تدعم بقاء سمكة البلطي اثناء اجهاد الاكسجين. و هنا يمكن ان يوصى بقياس نمو الخياشيم كدليل على رفاهية الاسماك في بيئتها الطبيعية.

الكلمات الدالة: الخياشيم ، المورفومترية ، الرفاهية ، Tilapia zillii .

Introduction

Several studies have discovered the connection among gill morphometrics (for instance, the length and number of the gill filaments and the length, length and spacing of the gill secondary lamellae) and the behaviours, life style and habitation of fish concerned [1, 2, 3]. Growth of the gill respiratory surface regularly estimated geometrically, based on the creation of the mean estimated part of the separate gill fish secondary lamellae and their estimated the total number of secondary lamellae in the whole gill system.

The life challenge in water results in a leading role for structures such as gills, not just in relations of respiration, but concluded osmoregulation, through which the gill plays an essential role in the physiological responses to ecological changes. The large surface area of the gill is a main route through which numerous biotic or abiotic complexes enter the fish body [4, 5]. Since fish gills make a number of important functions and have a great surface area in interaction through the external environment, they are very sensitive to ecological variations, then, the main goal structure in fish for several environmental variations [6, 2]. For instance, the effects of low oxygen levels on fish gill morphology have been studied in numerous fish species, for example, in ruffe (*Gymnocephalusc ernuus*) by [7] and common carp (*Cyprinus carpio*) by [7]. The degree of the gill changes notes depends on the fish species sensitivity and to the extent of the stressor. Effects of the environment on the morphometric and microstructure of the gill, include changes in size of gill surface area and pavement cells (the most abundant cell type, which covers much of the lamellar and filament surfaces of the gill), mucous cell, chloride cells and gill epithelia [2, 8].

Gill morphometrics can consequently be used as an indicator of the welfare status of fish [9]. Gill morphometrics of fish furthermore differs on a longer, evolutionary time scale, in relation to activity and habitat of the fish. Consequently, active fishes with high metabolic needs or those inhabiting hypoxic environments usually have gill specializations simplifying gas transport [2, 5, 10]. These specialisations contain the gill arches size, the gill filaments length and the number and bilateral surface area of secondary lamellae, wholly of which respond to selection for increased uptake of oxygen from the water environment.As present, there are no reliable data on gill respiratory surface area in *Tilapia zillii* in the literature. The welfare of fish has been studied for years to improve the living conditions of fish [11]. Latest study has found that welfare of fish is powerfully correlated to fish physiology, for example, gills function and structure [2]. In general, fish have mechanisms of homeostatic that tolerate characters to acclimate to their water environment, by physiological changes of gills and other organs [12 and 13]. The aim of this study was to examine exactly the gill morphometrics of freshwater *Tilapia zillii* relation to welfare.

Material and Methods

Subjects:

Thirteen *Tilapia zillii* were obtained from Ain-Ziyana lagoon in eastern of Benghazi city and transported directly to the Marine research laboratory at Zoology department, Benghazi University. The fish were maintained in holding tanks of water at a temperature 18.8 ±0.2 ºC and allowed for two weeks of acclimatisation.Fish were killed by a blow to the head and their gill structure examined.

General Morphometrics:

The body weight (g), total length (to the nearest mm), and head length (to the nearest mm) of all fish were measured according to [2 and 5].

Gill morphometrics:

All four gill arches from right sides of each fish were dissected out and placed in 10% normal saline. The gill arches were separated and in each gill arch, every fifth gill filament from all gill arch was counted for the number of gill filament, and their lengths were measured. Then in every fifth gill filament the average number of gill secondary lamellae per mm of gill filament length from the tip, middle and base was counted and average bilateral area of gill secondary lamellae were estimated. The basic methods of treatment of the gill material for measurements of gill lamellae surface area were essentially the same as used by [13].The measurements taken for the right side of each gill arch using a binocular microscope at a magnification of 3X with an eyepiece micrometre.

Estimated Gill surface area:

Gill respiratory surface area (GRSA) were estimated using methods established by [14] and calculated by the equation:

GRSA= *l. n. bl*

Where GRSA is the total gill respiratory surface area, *l* is the total length of the gill filament, *n* is the mean number of gill secondary lamellae per mm on every fifth gill filament on two sides of gill filament and *bl* is the bilateral surface area of gill secondary lamellae.

Statistical analysis:

Statistical analyses were carried out, using the MINITAB statistical package, series 16. First of all, the data were checked for normality. Initial scrutiny of the data was carried out using means. Regression analysis was then used to explore the relationship between all variables and body weight.

Results

Increase in body weight was gone together with by an increase in the total gill filament number from (334 – 669) (Table 1). Concurrently, the total gill filament length increased (from 2050.76 – 5218.20) (Table 1). Moreover the average number of gill secondary lamellae increased with the body weight from 44 to 75 (Table 1).The total gill surface area in the smallest fish specimen was *ca* 857. 31 mm^2/g of body weight and *ca* 1930 mm^2/g of body weight in the largest fish specimen.

Table 1: Summarized results of gill morphometrics in *Tilapia zillii*.

Fish body weight (g)	Total body length (cm)	Head length (cm)	Total filaments number	Total filament length (mm)	Average number of secondary lamellae per mm of filament length	Surface area of an average secondary lamellae (mm²)	Gill respirator surface area (mm²)/g of body weight
11.70	9.21	2.20	334	4275.4	44	0.12	1929.324
12.00	9.40	2.30	334	4381.8	45	0.12	1793.052
14.63	9.51	2.30	344	3690.6	46	0.13	1508.524
15.22	9.83	2.40	350	405.6	47	0.12	1502.455
15.30	9.80	2.53	352	3648.6	48	0.13	1488.048
15.83	9.90	2.51	363	343.3	49	0.14	1487.268
16.10	10.01	2.50	380	3458.2	49	0.14	1463.471
16.21	10.00	2.50	386	3403.2	49	0.14	1440.289
18.22	10.03	2.52	409	3488.4	49	0.15	1407.238
18.60	10.02	2.51	409	159.6	50	0.16	1358.963
19.00	10.01	2.54	416	9951.4	50	0.16	1321.144
19.21	10.02	2.61	422	3374.1	50	0.15	1317.314
19.44	10.00	2.61	422	3089.6	50	0.16	1271.449
19.62	10.20	2.70	428	3287.5	50	0.15	1256.685
20.00	10.22	2.70	428	3076.1	50	0.16	1230.456
20.32	10.30	2.70	430	3045.5	51	0.16	1223.014
20.30	10.30	2.83	434	2988.0	51	0.16	1201.082
20.60	10.30	2.83	437	2755.4	52	0.16	1112.844
21.30	10.51	2.84	442	3030.9	52	0.15	1109.917
21.60	10.52	2.84	444	2766.3	53	0.16	1086.001
21.71	10.60	2.84	448	2763.4	53	0.16	1079.412

22.00	10.70	2.90	449	3558.1	53	0.17	1060.296
22.21	10.82	2.91	457	2682.9	53	0.16	1024.347
23.44	11.00	2.91	473	2558.1	54	0.17	1001.836
23.84	11.00	2.94	474	2581.9	54	0.17	994.2071
24.21	11.02	2.92	488	2470.7	55	0.17	954.1939
25.92	11.11	2.93	489	2113.9	55	0.21	941.9542
26.31	11.50	3.00	510	2071.4	55	0.21	909.3555
26.61	11.52	3.02	535	1967.4	55	0.22	894.6228
28.60	11.70	3.03	669	1423.8	57	0.30	851.3077

Table 2. Results of regression analyses of body weight (g) against total body length (cm), head length (cm), total gill filament number, total gill filaments length, and respiratory gill surface area per mm²/g of body weight, ** P < 0.01 and ***P < 0.001.

Variable	Regression	R^2%	P- value
Total body length	Y= 7.50 + 0.143 X	93	***
Head length	Y= 1.65 + 0.05 X	90	***
Total filament number	Y= 128 + 15.2 X	23	**
Total gill filament number	Y= 116 + 145 X	80	***
Gill respiratory surface area	Y= 2456 – 60.8	94	***

Discussion

The present study indicates that the broad morphometrics of gills of *Tilapia zillii* is similar to the other teleost fish. The gills morphometry is a conciliation between the metabolic requirements and fish life mode [5]. Gill morphometrics, including the gill filament length, the gill filament number, the secondary lamellae number on the filaments, and area of gill secondary lamellae, are changed by selective reasons to supplement gill respiratory surface area and increase requirements of oxygen [16, 2, 5]. A strong relationships between morphometrics of fish gill and body weight has been reported for bony fish, for example *Piaractus mesoptamicus* [16] and *Gymnocephalus cernuus* [7]. Generally, large gill surface area suggests as an adaptation for an active mode of life and measurements of gill morphometrics have permitted conclusions about fish habit and habitat [2, 5 and 17]. Inability to respiration at low levels of dissolved oxygen in water with small gill surface area, fish could reduce the energy ratio required for growth, respiration and other activities [5 and 17] and this could be effect on fish welfare.

Conclusion

The gill of fish is an unusual adaptation that characterizes the phenomena of natural variety. It's complicated construction and effective function have been permissible fish to succeed in a massive selection of water environments. Gill lamellae make available increased gill surface area for gas altercation, which is mainly very important. This is beneficial as it growths and increase the fish gill area which gases and other materials can be transported into and out of the fish body, for example, through cells diffusion and cells active transport. Increasing gill surface area will product in extra quick growth, good heating and cooling and good feeling, this may make possible improved feature of fish welfare.

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