Mesop. environ. j. 2022, Vol.6, No.1 :pp (xx-xx)

Mesopotamia Environmental Journal

ISSN: 2410-2598

Journal Home Page: ***https://mej.uobabylon.edu.iq/index.php/mej/index***

DOI: http://dx.doi.org/10.31759/mej.2022.6.1.0000

Oxygen consumption in Tilapia fingerlings *Coptodon zillii* after direct transfer to different salinities

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To cite this article:

Alkatrani, L.M.A.A.; , Yesses, A.T.; AlAdub, A.Y. Effect of different salinity levels on growth, digestibility and evacuation time of *Coptodon zillii* fingerlings. *Mesop. environ. j.*, 2022, Vol. x, No.x, pp. xx-x x .

Received Date:15 / 1 /2022, **Accepted Date**:25 / 4 /2022, **Publishing Date**: 6/5/2022

Abstract

The study aimed to estimate the oxygen consumption rate of *Coptodon zillii* fingerlings transferred directly to different salinities. Intermittent-flow oxygen consumption meter was used for oxygen consumption measurements, a standard modified method depending upon the amount of oxygen decrease in water, using the water flow rate into the chamber containing the experimental fish *Coptodon zillii* which transferred directly to the salinities (1.5, 7.5, 15, 30psu). (practical salinity unit). The results showed the minimal rates of oxygen consumption were at salt concentrations asymptotic to that recorded in the natural habitat of the studied fish which were (7.5, 15psu). While it increased significantly at higher 30psu and low 1.5psu salinities.

The study concluded that oxygen consumption rates in *C. zillii* fingerlings became at lower range in the isosmotic milieu and increased at hyper and hypo-osmotic environments.

Key words: *Coptodon zillii*, Intermittent flow system, Oxygen consumption, Salinity.

Introduction

Commonly the metabolism in fish is indirectly measured by the mean of oxygen consumption, and it is employed in many fish species at different salinities to estimate the bioenergetics consumed for osmoregulation [1; 2; 3; 4; 5]. The physiological response to salinity changes differs broadly among fish species in oxygen consumption rates. Low oxygen consumption rates were occurs at the isosmotic milieu, while an increment is obtained in hypo or hyper osmotic milieus as in *Sparus sarba* [6], *Oreochromis mykiss*, and *Oncorhynchus tshawytscha* [7]. A study by [8] showed that the fish *O. mossambicus* had a significantly lower oxygen consumption rates in seawater compared to those reared in freshwater. [9] found that *Liza carinata* acclimated to salinity (1.5, 30) psu. consumed more O_2 (15.5%, 20.4%) respectively in contrast with 15psu. [10] said that *Liza abu* had an increase in oxygen consumption rate when transferred from freshwater to (7, 15psu).

Different designs of oxygen consumption meters have been used to measure the respiration rate “which mentions the rate of dissolved oxygen (DO) taken up from the water by biomass” [11]. Traditional designs of oxygen consumption meters required a long time of measure to estimate the activity of respiration of observed fish. Oxygen consumption meters are designed to match research topics and various sizes and species of fish, considering their behavior and lifestyle of them. Therefore, researchers formed their oxygen consumption meter Based on the study theory, the measurement accuracy and the construction cost [12, 13]. In a closed oxygen consumption system measuring the change in water dissolved oxygen over time in a closed chamber containing fish experiment [14].While an open oxygen consumption system measures the variance in O2 content between the inlet and outlet and the flow rate of water through a chamber [13]. An intermittent flow oxygen consumption system operates such as the closed system with the possibility of re-measurement during the time of the experiment [12]. As a result of water decomposition due to the metabolic processes of microorganisms present in the water in closed systems, a decrease in dissolved oxygen and accumulation of metabolites occurred. Bacterial oxygen consumption, accumulation of carbon dioxide and other metabolites in addition to nitrogenous by-products may give wrong results of oxygen consumption in the closed systems [14; 15; 16]. While the complexity of formation and operation, difficulty calibrating the device, and operating difficulty in an open oxygen consumption system are fundamental problems that limit experimental duration [17; 18].

The intermittent-flow oxygen consumption system keeps of the easiness and low-cost construction of the closed system, Also it can control the duration of a measurement time by changing water as soon as oxygen levels drop too low [19] and maintaining suitable levels of dissolved oxygen concentration for the species tested by frequently refreshing the chamber with oxygen saturated water and frequent measurements can be directed on the same sample during the experiment [20]. The accumulation of waste products can be reduced by freshens the chamber with new water at defined times in intermittent flow systems. More of that fish can swim easily in the chamber without any trouble in intermittent flow systems [12]. Water volume should be minimized in oxygen consumption studies when tested fish is small or has low metabolic rates [21]. Therefore, fish size should be equal and suitable to the oxygen consumption system to make measurements in short time intervals [14]. Water flow rate in the intermittent flow system should be preserved at a low level to get permanent exchange of the water without fish disturbance [22].

The energetic cost of osmoregulation characterized by the oxygen consumption play an important role in fish growth rates [23, 24]. Many studies considered an improvement of growth rate with reduced oxygen consumption at osmoregulatory period [25; 6; 26].

Study aims to estimate the energetic cost represented by the oxygen consumption rate of *Coptodon zillii* fingerlings transferred directly to different salinities using an intermittent flow oxygen consumption meter.

Materials and methods

A standard modified method by [13] depends upon the amount of oxygen decrease in water, using the water flow rate into the chamber containing the experimental fishes, (figure 3).

1: Design of Oxygen consumption meter

Two intermittent-flow chambers were used to quantify oxygen consumption of *C. zillii* fingerlings, the water flow through two chambers in an open model. Each chamber was an 8-L glass tank container. The first chamber was the oxygen saturated which was provided with an aerator with a constant level of oxygen saturated water, its size was (20×20×20)cm. The second is the measurement chamber which has a tight cover to prevent the entrance of external O_2, its size was (20×20×60)cm. The water level at this chamber reached 20 cm in height and with a lid size of height = 6 mm, length and width = 20 cm. The measurement chamber was placed on a magnetic stirrer device (Fig. 3). The magnetic stirrer created a current inside the measurement chamber to make certain an equal supply of dissolved oxygen. The current speed is organized by the stirrer and kept the same over time of measurements. The inflow and outflow tubes were fitted by clamps which facilitated the water flow rate regulation in the chambers. The water flow rate out from the two chambers estimated by measuring the volume of exchanged outflow water in a graduated cylinder (1000) ml from the measurement chamber for 15 minutes, the average water flow rate in the two chambers was (1L/15 min), i.e. (4L/hr) (Fig. 2). Levels of dissolved oxygen in each chamber were measured by a dissolved oxygen meter model (ExStik DO600). The oxygen meter probe entered into the lid of the measuring chamber via a rubber stopper which is glued upon the lid to ensure an airtight fitness. After fish introducing to the measuring chamber and during the closed model of the system, the lid of the measuring chamber is wrapped with adhesive tape [13].

2: The experiment

C. zillii fishes brought from the acclimation ponds in the MSC aquaculture station, the salinity of which was 5.45 psu then fishes were acclimated in a laboratory condition for one week at an aquaria of (60 × 30 × 30) cm, with a salinity of was 15 psu; this aquaria salinity of 15 psu was considered as a control salinity. An oxygen consumption experiment was established at (21-22/1/2013). Six (6) fishes for each salinity (1.5, 7.5, 15, 30) psu were transferred to the measurement chamber of the oxygen consumption system in a water volume of 8L and a flow rate of (4L/hr) and left for 3 hours to reach stable status in the chamber; then dissolved oxygen was recorded every half an hour for 2.5 hours. Table (1) shows total length and weight of fishes in the experiment. The temperature mean was 15.22 ± 0.45, length and weight mean of the fish experiment were (10.3 ± 0.48) cm, (23.41 ± 3.15)g respectively.

3: Oxygen consumption calculation

Oxygen consumption rate (mg/g/hr) was calculated according to the following equation [27]:

$$O_2 \text{ consumption} = \frac{\Delta mg\ O_2 \times V}{W \times T} \quad (mgO_2/g\ /hr)$$

Whereas:

ΔmgO_2 = Differences of oxygen concentration between saturated and measurement chambers (mg/l).

V = volume of water in the chamber (l).

W = weight of fish (g), T = time (hour)

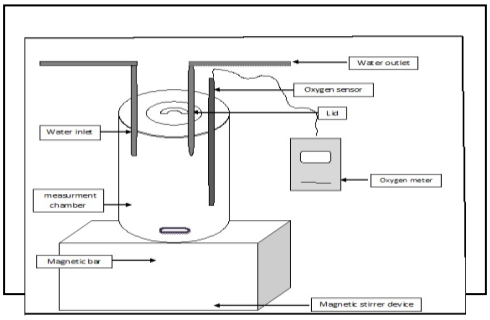

Figure (3): A schematic diagram of the 8-L oxygen consumption system (measuring chamber)

4: Data analysis

Data were analyzed statically using SPSS program (version 18). For compare the variances between fish in oxygen consumption rates at different salinities, one-way analysis of variance (ANOVA) and Revised Least Significant Difference (RLSD) were used in a significance level ($P < 0.05$)[28].

Results

Table 1 showed the total weight (gm) and length (cm) of the *Coptodon zillii* fingerlings used in the experiment. The mean fish weight was (23.41 ± 3.15) gm and the mean fish length was (10.3 ± 0.48) cm. Table (2) and figure (2) showed the oxygen consumption rates (mg/g/hr) for *C. zillii* fingerlings after direct transference to different salt concentrations (1.5, 7.5, 15, 30psu). The lowest value of oxygen consumption rates was (0.084) mg/g/hr for the salinity 7.5 psu, it has no statistical differences ($P > 0.05$) from the control salinity 15 psu which has (0.085) mg/g/hr. The highest value of the oxygen consumption rates was (0.124) mg/g/hr in the salinity 1.5 psu followed by the salinity 30 psu which was (0.106) mg/g/hr. Significant variances ($P < 0.05$) were detected between salinities (1.5, 30psu) with the control salinity 15psu and between each other.

Table (1): Total weight (gm) and length (cm) of *C. zillii* fingerlings in the oxygen consumption experiment at different salinities.

No	1.5 psu		7.5 psu		15 psu		30 psu	
	weight	length	weight	length	weight	length	weight	length
1	17.92	9.6	31.07	11.5	37.37	11.9	15.4	9.2
2	28.26	10.5	28.41	10.8	31.24	11.6	18.66	9.5
3	17.73	9.8	27.97	11.1	30.26	11.5	14.56	9
4	17.85	9.4	37.31	12	17.55	9.1	27.2	10.9
5	14.39	9.1	31.9	11.7	27.29	10.9	17.14	9.5
6	15.31	9.0	22.66	10.9	22.43	10.4	11.85	8.2

Mean ± S.E	18.58 ±2.03 b	9.57 ±0.22 B	29.89 ±1.99 a	11.33 ±0.48 A	27.69 ±2.85 a	10.9 ±0.42 A	17.47 ±2.16 b	9.38 ±0.36 B

Similar small letters mean that there were no significant variances in fish weight.

Similar capital letters mean that there were no significant variances in fish length.

Table (2): Oxygen consumption (mg/g/hr) for *C. zillii* fingerlings in the oxygen consumption experiment at different salinities. (Mean ± S.E.)

Salinity	O_2 consumption (mg/g/hr)
1.5 psu	0.124 ± 0.003 a
7.5 psu	0084 ± 0.004 c
15 psu	0.085 ± 0.001 c
30 psu	0.106 ± 0.001 b

Similar letters mean that there were no significant variances in oxygen consumption rates.

Different letters mean that there were significant variances in oxygen consumption rates.

R.L.S.D. = 0.00892

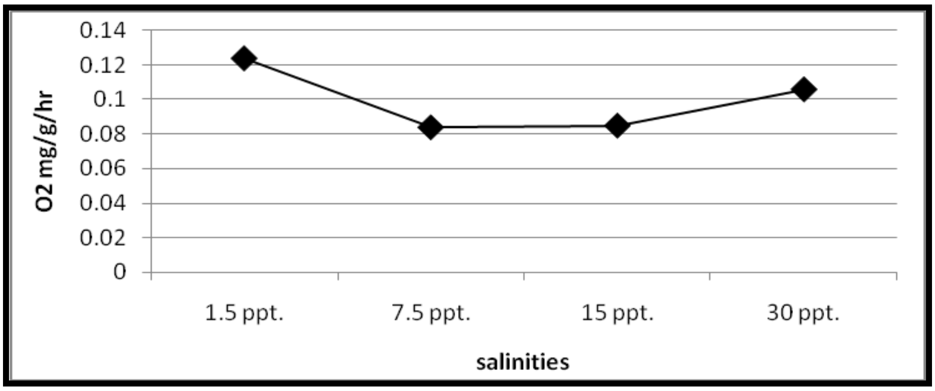

Figure (2): Oxygen consumption (mg/g/hr) for *C. zillii* in the oxygen consumption experiment at different salinities.

Discussion

Fishes of the *C. zillii* used in the study were sampled from the Shatt-Albasrah canal, a brackish water environment in a salinity range (12-18psu). The study showed a minimal oxygen consumption rates at salinities asymptotic to those recorded in the study station of the *C. zillii* fingerlings, this result corresponded with the studies of [29; 30;31]. They found a minimal range of oxygen consumption in the salinities near to the natural habitat for *O. hatcheri* and *O. bonariensis* fishes. The oxygen consumption rate in *C. zillii* fingerlings was minimal in the salinity 7.5psu and the control salinity 15psu, respectively, these salinities approach the salinity recorded in the study station of samples fishes. when fish transfer to high salinity 30 psu and low salinity 1.5 psu, oxygen consumption rates significantly increased in the two salinities, the high values of oxygen consumption rates obtained in the low salinity of 1.5psu, followed by the salinity of 30psu. Abruptly decreased value in the salinity 30psu in comparison with the low salinity 1.5psu might be a result of reduced fish activity at this high salinity, which indicates the severe tolerant by the fish to this salt concentration. The results indicated that oxygen consumption rates became at minimal range in the isosmotic milieu and increased at hyper and hypo-osmotic environments. Many studies in agreement with this result, [32] found that the oxygen consumption rate in *Odontesthes hatcheri* and *Odontesthes bonariensis* at minimal in salinities near to the natural environment where they were distributed in. [33] found oxygen consumption rate in hybrid grouper *Epinephelus fuscoguttatus* × *E. lanceolatus* juveniles was significantly lower at 15 psu but higher at 25 and 30 psu, indicating the high metabolic rate of fish in high salinities. In contrast, many studies showed that the lowest oxygen consumption rates recorded in the hypo osmotic milieus [34; 7], the study of [13] also showed the oxygen consumption rate correlated directly with salinity increase in juvenile *Litohognathus lithognathus.* [32] found low oxygen consumption in larvaes of *Odontesthes hatcheri* and *O. bonariensis* at very high salinities and explain that as a result of the reduced movement, which indicated a severe saline tolerance by fish, this probably explains the lowest oxygen consumption rate in the highest salinity 30psu in present study whereas fish less active than others in the lower salt concentration 1.5 psu.

Oxygen consumption in seawater Atlantic cod, *Gadus morhua* did not affect by salinity changes to 14psu [35]. Silver sea bream, *Sparus sarba* showed the least oxygen consumption rate in isosmotic salinity 15psu in comparison with low and high salt concentrations (7 and 35psu) [6]. “The energetic cost of ion regulation expressed by oxygen consumption is lower in the isosmotic milieus, where the ionic gradients between inside and outside fish are at a minimum level” [7]. The effect of salinity varies on oxygen consumption rates, according to the measurement devices, acclimation period for the milieu environment, species, age, and weight of fish [36, 37, 38]. The measurement of oxygen consumption rate is an indicator of metabolism in fish and one of the most sever stressors affecting fish growth is hypoxia which lead to behavioral and physiological response vary according to fish species [39, 40, 41, 42].

Conclusion

The study concluded that oxygen consumption rates in *C. zillii* fingerlings became at a minimal range in the isosmotic milieu and increased in hyper and hypo-osmotic environments.

Acknowledgment

The researchers would like to extend their thanks and gratitude to all the employees of the Marine Vertebrate Department at the Marine Science Center, where the study was carried out in the nutrition laboratory.

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