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Effect of different salinity levels on growth, digestibility and evacuation time of *Coptodon zillii* fingerlings

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Abstract

An open cultivation experiment performed on *Coptodon. zillii* fingerlings in mean of weight 21.39 ± 0.66 to recognize the effect of direct transmission from the control salinity 15psu which nearby to the sample station salinity in Shatt Albasrah Cannel to different salinity levels (1.5, 7.5, 15, 30 psu) on Growth Rate GR, Relative Growth Rate RGR, Specific Growth Rate SGR; Satiation level; evacuation time and apparent digestibility coefficient at the end period of 56 days. The salinity 7.5 psu had the highest GR, RGR and SGR. This salinity is considered to be the best salinity of lowering energy cost. However, the other salinities (1.5, 7.5, 15psu) had no statistical differences in GR, RGR and SGR which meant fishes can grow efficiently at these salinities. Satiation level decreased with salinity increase. The present study recorded an increase of evacuation time for *C. zillii* fingerlings with salinity increase accompanied with decrease in total apparent digestibility coefficient TADC% and nutrient apparent digestibility coefficient NADC% for protein, fat and carbohydrate. *C. zillii* fingerlings had a general replace with specific one protein and fat NADC at salt concentrations (1.5, 7.5, 15 psu). Results showed that the salinity 7.5 psu is the best salinity for growth performance in fingerlings of *C. zillii*.

Key words: salinity, growth, digestibility, satiation level, evacuation time.

Introduction

Salinity is an intrinsic factor affects fish development, growth and survival [1; 2] it play essential role in regulation of growth performance of fish [3]. The optimum salinity concentration for best growth performance in fish seems to be species-specific [4]. Imbalance in osmoregulation ordinarily lead to general stress changes in fish, including a decreased in growth performance [4, 5, 6]. Growth of marine and freshwater species affected by salinity changes [7; 5]; few species its growth not affected by salinity change like *Pomatomus saltatrix* [8]. Number of indicators related to growth modified by Salinity effect including metabolic rate, total food intake, food conversion efficiency and hormones involved in metabolism [9; 10, 4; 5]. Iso-osmotic environments reduced the energetic cost for homeostasis leading to save energy requirements to growth [5]. [4] "attributed the growth enhancement at iso-osmotic milieus in stenohaline and euryhaline fish species to many reasons like reduction of energetic costs for osmoregulation, increased food intake and food conversion ratio and stimulation of hormones related to growth".

Salinity have an effect on satiation level (food intake), digestibility and evacuation time (food movement in intestine) [11]. In a study by [12], they found an effect of salinity increase on satiation level in Gilthead seabream and European seabass. [13] found negative effect of salinity increase on trout fish appetite because of the stress from osmoregulation in sudden transfer to high salinities which causes upset digestibility and loss of appetite.

Digestibility is one of the most important physiological measurements that estimate the range of fish advantage to given diet and conduct its nutritional value [14]. There are many factors affecting food digestibility in teleost like temperature, salinity, photoperiod, fish size, physiological status, type and amount of diet and feeding rate [15; 16; 17; 18; 19]. [20] observed a decrease of digestibility and an increase of food movement in the intestine of Milk fish *Chanos chanos* which reduced the time of nutrient absorption with the salinity increase in. Also [21] found a decrease in food digestibility of Rainbow trout fish transfer from freshwater to seawater and given diets with different ratio of sodium chloride.

Coptodon zillii is native tilapia fish in Africa and Middle East [22]. A euryhaline species extended to wide salinity range habitats [23]. [24] "pointed that the three species: *Coptodon zillii; Oreochromis mosambicus* and *O.aureus* are the most salinity-tolerant tilapia species". *C. zilli* is an economic fish in North Africa like in Egypt, Morocco and Libya [25].

The deficiency in freshwater and increasing need for agriculture irrigation and other urban activities increased the necessity to develop aquaculture in brackish and seawater, therefore, tilapia including *C. zillii* fish can be a suitable species for aquaculture in brackish and saline water [24].

The study is aim to estimate which salinity is sutable for culturing *C. zillii* fish in order to satisfy the decrease of fish aquaculture in southern of Iraq because of the salinity increase in Shatt Al-Arab river.

Materials and Methods

Diet composition

The feed ingredients used in preparing an artificial diet were: fish meal (prepared by the researcher), soybean meal, corn meal, barely meal, wheat bran, starch, vitamins and minerals, which were provided from local markets. Diet preparation followed considerations proposed by [26].

Table (1) shows the chemical composition of feed ingredients used in preparation artificial diet for the *C. zillii*, and Table (2) explains the theoretical calculations of the feed ingredients percentages in the *C. zillii's* artificial diet preparation.

Table(1): Chemical composition of feed ingredients (%) used in preparation of *C. zillii* artificial diet (Mean ± S.D.).

Feed ingredients	Moisture	Protein	Fat	Ash	Carbohydrate
Fish meal	2.90±0.03	61.98±0.55	20.96±0.51	12.23±0.23	1.92±0.11
Soybean meal	4.24±0.03	46.17±0.13	1.87±022	8.78±0.17	38.93±0.37
Corn meal	8.81±0.13	11.28±0.`12	4.48±0.21	3.09±0.06	72.33±0.42

Barley meal	8.08±0.08	10.27±0.06	1.43±0.21	4.45±0.20	75.78±0.12
Wheat bran	10.22±0.20	13.47±0.22	4.05±0.06	6.43±0.39	65.83±0.69

Table (2): Theoretical calculations of feed ingredients percentage in *C. zillii* artificial diet preparation.

Feed ingredients	% of ingredients i diet	Moisture %	Protein %	Fat %	Ash %	Carbohydrate %
Fish meal	32	0.94	19.84	6.70	3.91	0.62
Soybean meal	32	1.37	14.77	0.60	2.81	12.46
Corn meal	10	0.89	1.13	0.45	0.31	7.53
Barley meal	10	0.82	1.03	0.15	0.45	7.60
Wheat bran	11	0.14	1.48	0.45	0.71	7.24
Vitamins and Minerals	3	___	___	___	___	___
Starch	2	___	___	___	___	5.6
Sum	100	4.16	38.25	8.35	8.19	41.05
		*Sum of fed ingredients %= (4.16+38.25+8.35+8.19+41.05)=100				

Growth Experiment

Eight aluminum containers with a volume of 200 L were used in an open cultivation system for *C. zillii* fingerlings using the salt concentrations of (1.5, 7.5, 15, 30 psu) in duplicate for each treatment, Aerators used for oxygen supply, mesh cover for preventing fish jumping. Containers salinities were corrected using sea salt from the Aquamedic company (Bissendrof, Germany) contain the essential elements Na^{+}, Mg^{+2}, Ca^{+2}, K^{+}, Cl^{-}, $SO_4^{=}$, HCO_3^{-}, Sr^{+} in concentration of 11000, 1200, 420, 350, 19700, 2200, 180, 16 mg/L respectively. One third of water was discharged and replaced with new stored water daily for each salinity. Cultivation experiments began on the 28th June/ 2011 and prolonged for 8 weeks. *C. zillii* fishes were transferred from acclimation aquaria in the MSC aquaculture station/ Basrah University their original source is Shatt Al-Basrah river on the 28th of June /2011 to the containers in laboratory and 30 fish were distributed for each one. Four salt concentrations (1.5. 7.5. 15, 30 psu) were used in the cultivation experiment. One week was the period for fishes acclimation to laboratory conditions. After that fish were fed artificial diet with a protein concentration 37 % on the 3rd of July /2011. Two times of feeding for one hour in daily rate of 3% divided on two meals of body weight were depend, this percentage corrected every two weeks after body weight measurement. The feeding process prolonged for 56 days. Not eaten diet and feces were removed by a siphon. One third of water in each containers were replaces daily to preservation of water quality. Four environmental factors (temperature, salinity, dissolved oxygen, pH) were measured daily using YSI device model (556 MPS). Fish weight measured every two weeks. Growth rate (GR), relative growth rate (RGR) and specific growth rate (SGR) estimated according to [27] equations:

$GR\ (g/day) = W_2 - W_1 / T_2 - T_1$

$RGR\ (\%) = [(W_2 - W_1)/ W_1] \times 100$

$SGR\ (\%\ g/day) = (\ln W_2 - \ln W_1) / (T_2 - T_1) \times 100$

Whereas:

W_1= initial weight (g)

W_2= final weight (g)

$T_2 - T_1$= days of experiment (day).

Satiation level

An experiment conducted according to principles projected from [28] , [29] and [30]. Fishes were fed one meal until satiation for two hours, then uneaten food were taken, drifted by siphon, filtered by plankton net and dried by air, then dried weight was measured and subtracted from given food weight to calculate eaten food weight every day. The experiment prolonged for seven days within the growth experiment period. The satiation level was estimated according to the equation:

Satiation Level (%) = [Eaten Food (dry weight) / fish body weight] ×100

[14].

Digestibility

Chromium oxide (Cr_2O_3) was added in a percentage of 1 % to the artificial diet as an indicator for measuring digestibility in *C. zillii* fingerlings. The experiment was done within the growth experiment period. The indirect method explained by [31] estimated digestibility by feeding fishes until satiation on the artificial diet containing chromium oxide, and two hours later uneaten food was drifted by siphon. Feces collected and filtered by a plankton net with a pore volume of 50 µm and washed with distil water and left to dry in laboratory temperature. Feces collection prolonged for two weeks in order to get an enough amount of feces for chemical analysis which done on diet and feces, chromium oxide measured by use digestion method in concentrated nitric and perchloric acids [32].

Total Apparent Digestibility Coefficient (TADC) and Nutrient Apparent Digestibility Coefficient (NADC) were estimated according to [31] by equations:

TADC %= 100 – [100 × (% marker in food) / (% marker in feces)]

$$\text{NADC\%} = 100 - \left[100 \times \frac{\%\ \text{indicator in food}}{\%\ \text{indicator in feces}} \times \frac{\%\ \text{nutrient in feces}}{\%\ \text{nutrient in food}}\right]$$

The Micro kjeldahl method was used for estimating protein in feces and food; fats were measured by being extracted in soxhlet by using the organic solvent chloroform and diethyl ether in the ratio 1:1; ash was measured by burning food and feces in furnace device at 525 °C and moisture measured by oven drying at 105 °C [33; 34].

Evacuation Time

An experiment was done at the end of the growth experiment using an artificial diet containing carmine pigment for fish feeding. The intestinal food movement rate was estimated by measuring total length of the intestine containing food during respective intervals according to [20]. Fishes were killed after (0, 15, 30, 60, 120, 180, 240, 300, 315, 330) minutes of feeding. The intestine became 100% full off when food reached to the anus. The Rate of Food Movement (RFM) and Intestinal Passage Time (IPT) were estimated according to the equations:

RFM (mm/mint) = D / T

IPT (min) = (L × T) / D

Whereas:

D: Length of intestine containing food (mm)

L: Intestine total length (mm)

T: Period of time after feeding (minutes).

Data analysis

Data were analyzed statistically using SPSS software (version 18). For compare the variances between fish in growth experiment at different salinities, one-way analysis of variance (ANOVA) and Revised Least Significant Difference (RLSD) were used in a significance level ($P \leq 0.05$) [35].

Results

Growth

Table (3) showed some environmental factors of water in the growth experiment. Range of temperature was (27.46 - 31.12) °c, salinity (1.56 - 31.08) psu according to salinity concentrations designed for the experiment. D.O ranged from (5.56 - 7.93) $mg.L^{-1}$, and pH ranged from (7.32 - 8.25).

Table (3): Some environmental factors of water during growth experiment in different salinities (Mean ± S.E.).

Environmental Factor	1.5psu	7.5psu	15psu	30psu
Temp. °c	27.9 ±1.17	29.61±0.50	29.37 ±0.50	29.80 ±0.50
Salinity psu	1.67 ±0.02	7.52 ±0.04	14.90±0.07	30.11 ±0.05
D.O. mg/L	7.05 ±0.27	6.55 ±0.30	6.86 ±0.25	6.68 ±0.28
pH	7.91 ±0.06	7.81 ±0.06	7.79 ±0.08	7.74 ±0.08

Table (4) showed the initial and final weight of *C. zillii* fingerlings in growth experiment at salt concentrations (1.5, 7.5, 15, 30 psu). Results showed that highest weight increase was in the salinity 7.5 psu, 2.2 gm, followed by the salinity 1.5 psu, 1.43 gm after 56 days of transfer. The lowest weight increase was in the control salinity 15psu, 0.66gm while the salinity 30psu showed a decrease in weight reaching to - 3.41gm at the end of growth experiment. Data analysis showed a significant ($P \leq 0.05$) increase in weight after 56 days of transfer between the salinities (1.5, 7.5psu) and the control salinity 15psu. While the salt concentration 30psu showed a significant decrease ($P \leq 0.05$) from the control salinity 15psu in weight after 56 days of transfer. There were no statistical differences ($P > 0.05$) between the salinities 1.5psu and 7.5psu in weight gain at the end of growth experiment.

Table (4): Total fish weight (g) to *C. zillii* in growth experiment at different salinities (Mean ± S.E.).

Time	1.5 psu	7.5 psu	15 psu	30 psu
Initial weight	19.77 ± 0.25 c	22.81 ± 0.29 a	20.93 ± 0.49 bc	22.04 ± 0.58 ab
14 day	19.80 ± 0.24 c	22.85 ± 0.27 a	20.95 ± 0.01 bc	21.52 ± 0.51 b
28 day	20.25 ± 0.13 b	23.33 ± 0.47 a	21.02 ± 0.06 b	20.14 ± 0.02 b
42 day	20.93 ± 0.25 b	24.35 ± 0.39 a	21.51 ± 0.35 b	19.12 ± 0.50 c

Final Weight 56 day	21.2 ± 0.08 b	25.01 ± 0.58 a	21.59 ± 0.37 b	18.64 ± 0.02 c
Weight increase	1.43 ± 0.17 a	2.2 ± 0.29 a	0.66 ± 0.39 b	-3.41 ± 0.60 c

* Different letters in one row are significantly different (P≤0.05).

Table (5) showed GR (g/day), RGR (%) and SGR (% g/day) of *C. zillii* in growth experiment at salt concentrations (1.5, 7.5, 15, 30 psu). The highest GR , RGR and SGR were in the salinity 7.5psu in the values of 0.039 g/day, 9.63 % and 0.165 % g/day respectively, followed by the salinity 1.5psu which have the GR , RGR and SGR values of 0.026 g/day, 7.25 % and 0.125 % g/day, respectively, after going 56 days. The control salinity had the lowest values in GR , RGR and SGR which were 0.013 g/day, 3.16% and 0.06 % g/day respectively while the salinity 30psu showed a decrease in GR, RGR and SGR values (-0.06 g/day, -15.39 % and -0.3 %g/day) respectively.

Statistics clarify no significant differences (P > 0.05) between the salt concentrations (1.5, 7.5, 15psu) in GR , RGR and SGR after 56 days of growth experiment, but a significant decrease (P < 0.05) in GR , RGR and SGR between the salt concentration 30psu and the control salinity 15psu observes after passing 56 day of experiment.

Satiation level and survival rate

Table (5) showed satiation level (%) and survival rate (%) of *C. zillii* in growth experiment at salt concentrations (1.5, 7.5, 15, 30psu). Results showed highest value in satiation level was in the salinity 1.5psu which was 2.23 %, followed by the salinity 7.5psu in a value of 2.17 % and then the control salinity 15psu 1.71 % after 56 days of experiment, the salinity 30psu gave the lowest value in satiation level which was 0.48 %. Data analysis showed a significant increase (P < 0.05)in satiation level in the salinities (1.5, 7.5psu) from the control salinity 15psu after 56 days, and a significant decrease (P < 0.05) in satiation level in the salinity 30psu from the control salinity 15psu. There were no statistical differences (P > 0.05) between the salinities 1.5 and 7.5psu in the satiation level.

Highest value in survival rate recorded in the salinity 7.5psu was 100% followed by the salinity 1.5psu 93.33% and then the control salinity 15psu (88.34%), the salinity 30psu gave the lowest survival rate value 5%. Statistics showed significant differences (P < 0.05) between all salinities in survival rate.

Table (5): Growth rate (g/day), relative growth rate (%), specific growth rate (% g/day), satiation level (%) and survival rate (%) of *C. zillii* fingerlings in growth experiment at different salinities (Mean ± S.E.).

Parameters	1.5psu	7.5psu	15psu	30psu
GR g/day	0.026±0.003 a	0.039±0.005 a	0.013±0.007 a	-0.06±0.001 b
RGR %	7.25±0.95 a	9.63±1.15 a	3.16±1.87 a	-15.39±2.34 b
SGR % g/day	0.125±0.01 a	0.165±0.01 a	0.06±0.03 a	- 0.3±0.05 b
Satiation level %	2.23±0.00 a	2.17±0.02 a	1.71±0.007 b	0.48±0.14 c

Survival rate %	93.33±0.00 b	100±0.00 a	88.34±1.66 c	5.00±1.67 d

*similar letters means there were no statistical differences between measurements.

Digestibility

Table (6) showed the chemical composition (moisture, protein, fat, ash, chromium oxide and carbohydrate)% of diet and feces for the growth experiment in salt concentration (1.5, 7.5, 15, 30psu). Protein concentration in artificial diet was 38.01%, and the fat was 7.52%, while the chromium oxide was 1.27% in artificial diet composition. Feces in the four salt concentrations (1.5, 7.5, 15, 30psu) have significant decrease ($P \leq 0.05$) from artificial diet composition in protein and fat percentage, while feces in the four salt concentrations (1.5, 7.5, 15, 30psu) had significant increase ($P \leq 0.05$) in ash and chromium oxide percentage from the diet composition, only feces of the salinity 30psu had no significant differences ($P > 0.05$) with a diet composition in chromium oxide percentage. The artificial diet had no significant differences ($P > 0.05$) with feces at the salinities (1.5, 15psu) in carbohydrate percentage, while feces in the salinity 7.5psu had a significant increase ($P \leq 0.05$) and feces of the salinity 30psu had a significant decrease ($P \leq 0.05$) from diet composition of carbohydrate.

Table (7) shows the total apparent digestibility coefficient (TADC)% and nutrient apparent digestibility coefficient (NADC)% for protein, fat and carbohydrate of *C. zillii* in growth experiment at salt concentrations (1.5, 7.5, 15psu). Results showed that highest values of TADC in the salinity 1.5psu, which was 82.68%; followed by the salinity 7.5psu which has a TADC value of 67.65% and then the control salinity 15psu 59.54%; the salt concentration 30psu gave the lowest value in TADC which was (29.79)%. Statistical analysis showed a significant increase ($P \leq 0.05$) in the salinity 1.5psu from the control salinity 15psu, but there were no significant differences ($P > 0.05$) between the salinity 7.5psu and the control salinity 15psu in the TADC after 56 days of growth experiment. The salinity 30psu had a significant decrease ($P \leq 0.05$) from the control salinity 15psu in TADC, the two salinities 1.5psu and 7.5psu had no significant differences ($P > 0.05$) in TADC.

Similarly, apparent coefficient digestibility of fat showed there was a significant increase ($P \leq 0.05$) in salt concentration 1.5psu from the control salinity 15psu but there were no significant differences ($P > 0.05$) between the salt concentration 7.5psu and the control salinity 15psu in the NADC of fat. The salt concentration 30psu had a significant decrease ($P \leq 0.05$) from the control salinity 15psu in NADC of fat, the two salinities 1.5psu and 7.5psu had no significant differences ($P > 0.05$) in NADC of fat. The highest value of fat NADC was 96.68% in the salinity 1.5psu, followed by the salinity 7.5psu which had fat NADC values of 87.02% and the control salinity 15psu 76.06%, the salinity 30psu gave the lowest values in fat NADC which was 43.84%.

The highest value of protein NADC was 95.01% in salt concentration 1.5psu, followed by 7.5psu which has the protein NADC values of 94.22% and then the control salinity 15psu 87.17%. The salt concentration 30psu gave the lowest values in protein NADC which was 50.14%. Data analysis showed no significant differences ($P > 0.05$) between the three salt concentrations (1.5, 7.5, 15psu) in protein NADC but there was a significant decrease ($P < 0.05$) at salt concentration 30psu from the control salinity 15psu in protein NADC.

Carbohydrate apparent digestibility coefficient results showed no statistical differences ($P > 0.05$) between the control salinity 15psu and salt concentrations (7.5, 30psu), which had carbohydrate NADC values (61.33, 61.79, 60 75)% respectively, while significant differences ($P < 0.05$) observed between the salinity 1.5psu and other salinities in carbohydrate NADC value and was (83.41)%.

Table (6): Chemical composition of diet and feces (Mean ± S.E.)

Feed Stuff	Moisture %	Protein %	Fat %	Ash %	Cr_2O_3 %	Carbohydrate %
Artificial diet	3.33±0.84 b	38.01±0.29 a	7.52±0.04 a	9.03±0.10 c	1.27±0.09 c	40.84±0.8 b

Feces 1.5 psu	5.14±0.17 a	10.98±0.3 c	1.51±0.55 e	36.13±1.73 a	7.35±0.00 a	38.89±2.68 b
Feces 7.5 psu	5.28±0.16 a	7.25±1.27 d	3.05±0.19 d	32.32±0.96 b	4.22±0.73 b	47.88±2.68 a
Feces 15 psu	4.26±0.32 ab	12.01±0.70 c	4.52±0.74 c	37.13±0.50 a	3.16±0.22 b	38.92±0.43 b
Feces 30 psu	3.93±0.26 ab	26.90±0.55 b	5.60±0.19 b	38.42±0.12 a	1.83±0.14 c	22.93±0.66 c

*similar letters means there were no significant differences in chemical composition.

Table (7): Total apparent digestibility coefficient (TADC) and nutrient apparent digestibility coefficient (NADC) of artificial diet of *C. zillii* in growth experiment in different salinities (mean ± S.E.).

Digestibility coefficient	1.5psu	7.5psu	15psu	30psu
TADC	82.68 ± 1.14 a	67.65 ± 6.32 ab	59.54 ± 2.85 b	29.79 ±6.03 c
NADC (Protein)	95.01 ± 0.27 a	94.22 ± 0.65 a	87.17 ± 1.39 a	50.14 ± 5.32 b
NADC (Fat)	96.68 ± 1.01 a	87.02 ± 2.42 ab	76.06 ± 2.67 b	43.84 ± 5.94 c
NADC (carbohydrate)	83.41 ± 1.99 a	61.79 ± 8.16 b	61.33 ± 3.26 b	60.75 ± 2.19 b

*similar letters means there were no significant differences in digestibility coefficients.

Evacuation Time

The effect of salt concentrations (1.5, 7.5, 15psu) in intestinal food movement (RFM) and intestinal passage time (IPT) are explained in table (8) and figures (1) and (2), the salinity 30psu excluded because it seem to be out of the fish physiological tolerance. Results showed that the intestinal food movement (RFM) rate have a direct proportion with salinity increase, the highest value of RFM was in the control salinity 15psu which was (1.89) mm/min followed by the salinity 7.5psu which has an RFM value (1.74) mm/min. The lowest value of RFM was in the salinity 1.5psu which was (1.49) mm/min. Statistics showed significant differences ($P < 0.05$) between the three salt concentrations in RFM values.

Intestinal passage time (IPT) results show there were a reverse proportion with the salinity increase which means that food moves faster in shorter times when the salinity increases. The highest value of IPT was in the salinity 1.5 psu, which was (260.89) min; followed by the salinity 7.5 psu which has an IPT value (230.21) min. The lowest value of IPT obtained in the control salinity 15 psu and was (206.95) min. Data analysis showed significant differences ($P < 0.05$) between the three salinities in the IPT values.

Table(8): Rate of Food Movement (RFM, mm/min) and Intestinal Passage Time (IPT, min) of *C. zillii* intestine in growth experiment at different salinities (Mean ± S.D.).

Time (min.)	1.5psu		7.5psu		15psu	
	RFM	IPT	RFM	IPT	RFM	IPT
15	4.13±0.4	80.88±4.92	4.26±0.12	72.91±2.19	4.67±0.48	56.94±2.35
30	1.86±0.12	147.01±5.79	2.9±0.15	101.12±2.42	2.83±0.2	105.7±11.87
60	1.25±0.06	230.66±8.92	1.49±0.1	201.05±5.59	1.31±0.13	184.42±2.3
120	1.00±0.07	300.87±17.59	1.14±0.05	261.01±3.25	1.31±0.05	245.99±6.4
180	1.04±0.02	307.97±4.56	1.08±0.07	292.2±2.1	1.12±0.15	278.93±27.33
240	1.13±0.07	299.35±6.47	1.06±0.14	285.81±17.67	1.12±0.14	276.69±10.9
300	0.98±0.005	328.6±3.51	1.03±0.03	312.52±9.12	0.89±0.06	300±0.00
315	1.04±0.02	322.64±2.41	0.95±0.04	315±0.00	___	___
330	0.94±0.02	330±0.00	___	___	___	___
Mean ± S.E.	1.49±0.02 C	260.89±0.39 a	1.74±0.02 B	230.21±1.61 b	1.89±0.03 A	206.95±1.77 c

*Capital letters indicated significant differences between salt concentrations in RFM.

** Small letters indicated significant differences between salt concentrations in IPT.

***L.S.D. for RFM = 0.1567, L.S.D. for IPT = 23.26.

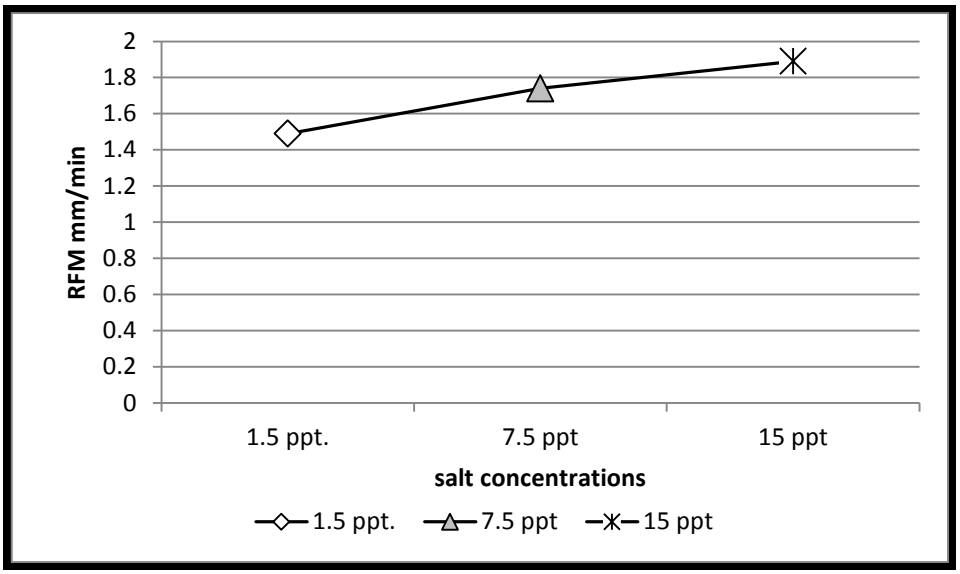

Figure (1): Rate of Food Movement (RFM, mm/min) of *C. zillii* intestine in growth experiment at different salinities.

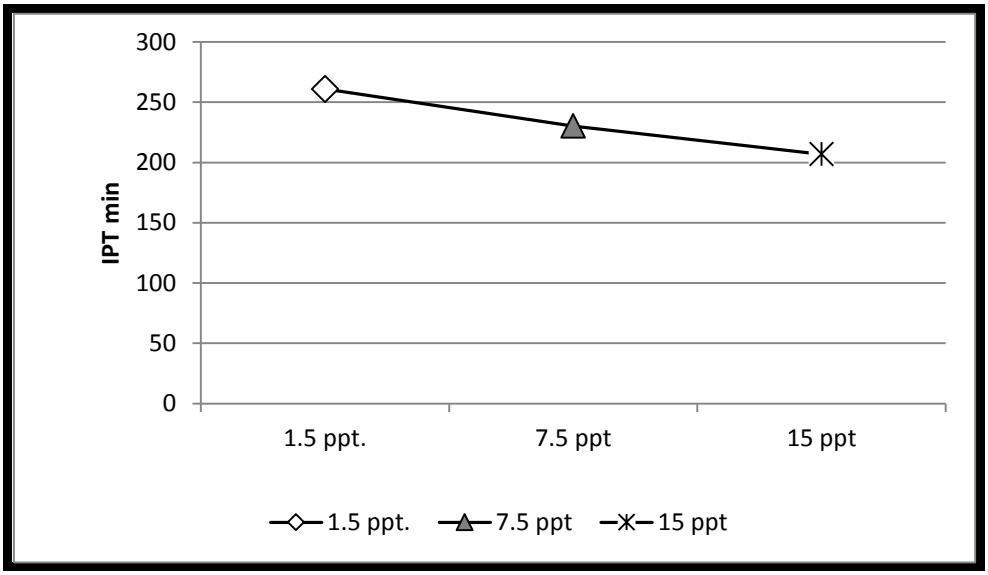

Figure (2): Rate of Intestinal Passage Time (IPT, min) of *C. zillii* intestine in growth experiment at different salinities.

Discussion

growth

Study showed that growth rates of *C. zillii* fingerlings are clearly affected by salinity changes. However, it appears that growing at the salinity 1.5psu is not the best for this fish. Thus, GR, RGR and SGR were lower in this salinity compared with the salinity 7.5psu. While the higher salinity 15psu gave the lowest GR, RGR and SGR, the highest salinity 30psu showed a decrease in GR, RGR and SGR. The results indicated that growth rates in *C. zillii* fingerlings affected negatively in the high salinity 30psu, while the three salt concentrations (1.5, 7.5, 15psu) had no significant differences in GR, RGR and SGR which meant fishes can grow efficiently at these salinities. This study showed optimum growth performance for the *C. zillii* fingerlings have been reported in the salinity 7.5psu, we considered this salinity the best for *C. zillii* growth. [36] found the best salinity for growth in *Sparus aurata* was 12psu, [5] recorded 15psu was the best salinity for growth of *Scopthalmus maximus* and [37] mentioned that 15psu was the best salinity for *Dicentrarhus labrax*. In contrast [6] found that *Umbrina cirrosa* did not affected by transfer from seawater to iso osmotic salinity while in hypo osmotic water fish exhibit low growth performance. Every fish species has its own optimum salinity associated with optimum temperature for growth, *Scophthalmus maximus* grew well at 18.5psu and 21.8°C [5]. *Anguilla australis* had optimum salinity 17.5psu and temperature 26.5°C [38].

Oreochromis aureus grew better in 12psu [39]. [40] indicated that red tilapia grow better in brackish water and sea water than fresh water. [41] reported that *Tilapia rendalli* had salinity range from 5 to 10psu for growth. Many studies founded fish growth was better in brackish water than fresh and sea water [5; 42; 43; 44; 45; 38; 46; 47; 6]. A study of [48] clarified the good growth performance of *C. zillii* was in nearly isosmotic salinities and they are desirable species for brackish water farming. [49] mentioned that tilapia species are currently farmed in freshwater, brackish-water and even seawater environments because of its wide range of salinity tolerance.

Satiation level

The ability of osmoregulation in different salinities is not necessary to be a good indicator of acclimation successes [50]. From a scientific viewpoint the success acclimation lead fish to show a good status of growth and feeding [51].

Results showed decrease in satiation levels with salinity increase. *C. zillii* fingerlings transferred from the control salinity 15psu to the lower salt concentrations (1.5, 7.5psu) have an increase in satiation level which were in agreement with the study of [12], they founded an increase in satiation level with salinity decrease in Gilthed seabream and European seabass transferred directly to the salinities (8, 18, 28) psu and natural seawater. [50] found a decrease of food intake in *Salmo salar* fishes when transfer from freshwater to saline water. In contrast [11] found that food intake in *Liza carinata* was higher in the salinity 30 psu from other lower salinities and that may be because of the increase in food movement rate. [14] pointed out that the appetite of Rainbow trout fishes acclimated to seawater is better from its appetite in freshwater; [52] pointed the same comments on *Salmo salar* fishes. [53] recorded a transitional decrease in growth and appetite of Rainbow trout (*Salmo gairdineri*) after transfer from freshwater to water salinity 32.5 psu; while [54] recorded a permanent decrease in *Salmo gairdinary* growth and appetite in water salinities more than 10 psu. [55] related this decrease in growth and appetite mainly to the mechanism of redistribution and regulation of blood ions and not to the stress expended in osmoregulation.

Digestibility

There was a reverse concentration of salinity with the total apparent digestibility coefficient (TADC) and nutrient apparent digestibility coefficient (NADC) for protein , fat and carbohydrate in *C. zillii* fingerlings reared in salt concentrations (1.5, 7.5, 15, 30psu), digestibility was decreased with salinity increase; however results for protein NADC showed no significant differences between the three salinities (1.5, 7.5, 15) psu and that meant the *C. zillii* fishes had an acceptable protein NADC at these three salinities. The salinity 30psu had a decrease value in TADC, NACD for protein and fat because of the high osmoregulatory cost at this salinity. This study is in agreement with [56] who found a decrease in digestibility of *Acanthapagrus latus* fishes when transferred from 3psu to the salinities (23, 30psu); while digestibility increased in the salinities (7, 15psu) when compared with fishes in tap water and 3psu. [57] found a decrease in digestibility of the *Salvelinus alpinus* fishes cultured in saline water in a comparison to fishes cultured in freshwater; explaining the reason to the osmoregulatory cost in seawater fishes was due to drinking seawater that causes the digestion to be very complex in these fishes.

Evacuation time

Salinity affected gastric evacuation time by one of two ways: first includes an increase of food movement rate without accompaniment of an increase in digestibility, the second is also an increase of food movement rate but accompanied with a digestibility increase [53]. The present study recorded an increase of food movement rate (RFM) for the *C. zillii* fingerlings with a salinity increase accompanied with a decrease in total apparent digestibility coefficient (TADC)% and nutrient apparent digestibility coefficient (NADC)% for protein, fat and carbohydrate. These results was similar to those of [11] who found that the highest value of TADC in the *Liza carinata* 63.29% was in the salinity 1.5psu accompanied with the lowest value of RFM (7.4) mm/min, and the lowest value of TADC (58.9)% was in the salinity 30 psu accompanied with the highest value of RFM 11.7 mm/min. The study of [14] found a decrease in TADC and NADC for protein and fat in the rainbow trout fishes acclimated to seawater. [20] mentioned salinity affected the digestibility of *Chanos chanos* fishes because of the fast food movement rate which increased with salinity. Studies by [58], [59] and [60] found there was an increase in marine fish requirements to protein because of the decrease of protein digestibility with a salinity increase; and the fish itself increased its requirements to protein in order to face the external milieu with high osmosis.

Conclusion

This study confirms that the salinity 7.5psu had the highest Growth Rate, Relative Growth Rate and Specific Growth Rate and increased satiation level and digestibility coefficients. This salinity is considered to be the best salinity of lowering energy cost and better growth performance for *C. zillii* fingerlings.

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