Effects of stocking density on growth performance of common carp (*Cyprinus carpio*) juveniles reared in earthen ponds

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Abstract

Current experiment was conducted in nine earthen ponds (900 m3) filled with water at 1/8/2023 and fertilized with 250 kg of buffalo wastes. A total of 600 juveniles of common carp were released in ponds 1-3 at average weight of 2.3 g (T1). A total of 1200 juveniles of common carp were released in ponds 4-6 at average weight of 1.3 g (T2). A total of 2400 juveniles of common carp were released in ponds 6-9 at average weight of 1.3 g (T3). All juveniles were released on August 9, 2023 and fed on sinking diet at feeding ratio of 6% of total fish weight. The feeding ratio was reduced to 4% on September 25, 2003. The results of current experiment revealed significant differences ($P \leq 0.05$) in growth criteria for the three treatments, where the best results were observed in low stocking density. Growth pattern was fishes exhibited positive allometric growth of the three treatments, where b values were 3.2902, 3.5958 and 3.8619 for T1, T2 and T3 respectively. Statistical analysis of the results for feed conversion rate showed that there were significant differences ($P \leq 0.05$) betweenT1 and T3, while there were no significant differences ($P > 0.05$) between T2 with T1 and T3.

Keywords: Fish density, Feed conversion, Growth rates, Condition factor.

Introduction

It is well known that the common carp (*Cyprinus carpio*) is the most prevalent species, contributing a major share to inland freshwater fish production for this reason it was introduced to many inland waters such as lakes, dam lakes, rivers and streams in different regions around the world. Khan *et al.* (2016) stated that this species was introduced into many countries in Europe and also in Australia and North America, FAO (2024). Hassan and Mahmoud (2011) pointed out that the density of cultivated fishes is a key factor in determining the management of fish pond and also the production, while Roy *et al.* (2018) stated that fish culture productivity depends mostly on stocking density. Recognized that the competition for feed increased with increasing stocking density and the optimum

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densities for different species should be determined, so the economic profitability for fish performance should be improved.

Musa *et al.* (2010) pointed out that the values of optimum stocking densities for Common carp are highly variable. Mehta *et al.* (2016) referred that the proper stocking density for common carp was 3fish/m3. It is well known that Iraqi culturist used lower stocking densities for common carp cultivated in earthen ponds comparing with other countries around the world for this reason the production per hectare in Iraq is much lower than other countries (Hassan and Mahmoud, 2011). The last fact may be related to the high prices of fish feeds and also to the absence of correct understanding of scientific fish culture and management practices.

At designing an intensive aquaculture system, the most important criterion for designing is determining the optimum stocking density for cultivated fish (Summer felt and Vinci, 2008). Abdel-Tawwab *et al.* (2014) stated that higher stocking densities can affect digestion and food absorption. These densities also affect other factors such as growth performance, the variation in fish weight, fish health and mortality (Ruane *et al.*, 2002; Pouey *et al.*, 2011). It is well known also that higher fish densities caused deterioration of water quality due to increasing metabolic excretion, leading to increased fish stress. Firas *et al.* (2020) pointed out that fish reared at higher stocking densities spent more time feeding and swimming, and less time for resting, So fish growth will be affected .at the same time lower stocking densities may reduce the fish production and causing economic losses by resulting in reduced profits (Apu *et al.*, 2012).The present study aims to evaluate the growth of the common carp juveniles cultivated in earthen ponds at different stocking densities.

Materials And Methods

The research was conducted at the Agricultural Research Station at Al-Hartha (College of Agriculture, University of Basrah), which is located in Al-Hartha district. Inlet water is supplied with electrical pump, while outlets are made by gravity. The water source was from one branch of Shatt Al-Arab River. Nine earthen ponds (600 m^2) were used in current experiment. All ponds were filled with water at 1/8/2023 and fertilized with 250 kg of buffalo wastes. A total of 600 juveniles of common carp were released in ponds 1-3 at average weight of 2.3 g, that means stocking density of 1 fish per square meter (T1).A total of 1200 juveniles of common carp were released in ponds 4-6 at average weight of 1.3 g, that means stocking density of 2 fish per square meter (T2). A total of 2400 juveniles of common carp were released in ponds 6-9 at average weight of 1.3 g, that means stocking density of 4 fish per square meter (T3). All these juveniles released at 9/8/2023 and fed on sinking diet at feeding ratio of 6% of total fish weight. Feeding ratio reduced to 4% at 25/9/2023. The sinking diet was manufactured by food factory related to Agricultural Consultant Office belonging to Agriculture College using different ingredients (Fishmeal 35%, wheat flour 28%, wheat bran 20%, barley 15% and vitamins-minerals premix 2%). At the end of experiment total lengths and weights were measured, while during the experiment period that lasted 91 days, five sampling data were used to calculate the following equations:

WI= FW - IW

DGR= (FW – IW)/days

SGR= 100 * [(ln FW) - (ln IW)]/ days,

Where: WI was weight increment, DGR was daily growth rate, SGR was specific growth rate, FW was final fish weight and IW was initial fish weight.

Length-weight relationship and condition factors were calculated for fishes at the end of the experiment for each treatment using the following equation of Pauly (1983):

$W= aL^b$, where W was weight of fish in g, L was length of fish in cm, a was describes the rate of change in weight with length (intercept) and b is the slope of the length-weight relationship

The condition factors (K) of common carp were estimated by using the following three equations:

Fulton's condition factor K_3= 100 W/L^3 (Froese, 2006)

Modified condition factor K_b= 100 W/L^b (Gomiero and Braga, 2005).

Relative condition factor K_n=W/w^ (Sheikh *et al.*, 2017)

Where W= the actual total weight of the fish in g and w^= the expected weight from length-weight equation formula.

The results of current experiment were conducted with a completely randomized design, and the differences between the means were tested by analysis of variance (ANOVA) and the significant differences were tested by LSD test at 0.05 probability level by SPSS program Ver. 26.

Results

Table (1) illustrated the average fish weight for nine earthen ponds during the experiment in addition to some environmental parameters of the water. Initial average weight of T1 was 2.3 g, while initial average weight of T2 and T3 was 1.3 g. Range of water temperature during experiment was 18-29 ^oC, range of pH was 7.18-7.75 and range of salinity was 1.4-2.8 PSU.

Table (2) showed growth criteria of different ponds and their average for the three treatments. Highest final average weight (72.5 g) reached by T1, followed by 53.0 g reached by T2 and 40.7 g reached by T3. Statistical analysis of the result for final weights proved that there were significant differences ($P \leq 0.05$) in the values of final weights of the three treatments. Weight increments reached by fishes were (70.2, 51.5 and 39.4) g for T1, T2 and T3 respectively. Statistical analysis of weight increments results showed significant differences ($P \leq 0.05$) between the three treatments. Daily growth rate of T1 was 0.7714 g/day, of T2 was 0.6571 g/day and of T3 was 0.4333 g/day. Statistical analysis of daily growth rate results appeared that there were significant differences ($P \leq 0.05$) between the three treatments.

Specific growth rates were (3.79, 4.07 and 3.78%)/day for T1, T2 and T3 respectively. Statistical analysis of the results for specific growth rate showed that there were significant differences (P≤0.05) betweenT2 with T1 and T3, while there were no significant differences (P>0.05) between T1 and T3. Better feed conversion rate (1.64) achieved by fishes in T3, followed by fishes in T2 (1.82), then fishes in T1 (1.92). Statistical analysis of the results for feed conversion rate showed that there were significant differences (P≤0.05) betweenT1 and T3, while there were no significant differences (P>0.05) between T2 with T1 and T3.

Table (3) shows the ranges and means of total length and weight of fishes for three treatments. Maximum total length (27.2 cm) and weight (265 g) reached by fishes in T1. Table (4) and figure (1) shows the parameters of length-weight relationship equation for common carp in different treatments after the experiment, where growth pattern was positive allometric in fishes of the three treatments. Table (5) appeared the three kinds of condition factors for fishes after the experiment. Depending on the results of these condition factors it appeared that better condition factors achieved by fishes of T1 and T2, while the worthiest achieved by fishes in T3. The statistical analysis of condition factors values appeared significant differences (P≤0.05) between T1 and T2 with T3, while there were no significant differences (P>0.05) between T1 and T2.

Table (1) Measurements of average fish weight during the experiment with environmental parameters.

Date	Average Fish Weight (g)									Temp.	pH	Sal.
	T1P1	T1P2	T1P3	T2P4	T2P5	T2P6	T3P7	T3P8	T3P9			
9/8	2.3	2.3	2.3	1.3	1.3	1.3	1.3	1.3	1.3	29	7.3	2.8
30/8	29.8 ±5.7	30.1 ±5.9	31.1 ±6.1	19.2 ±4.8	22.3 ±5.7	25 ±4.9	11.6 ±2.9	15 ±3.5	12.7 ±2.9	27	7.8	2.2
25/9	55.7 ±10.9	41.2 ±11.7	48.4 ±14.5	30.8 ±8.5	32.9 ±9.2	34.2 ±10.7	23 ±8.8	22.6 ±9.6	24.2 ±10.1	25	7.6	1.8
10/16	60 ±24.3	49.6 ±18.2	50 ±19.8	37.1 ±12.1	39.7 ±14.4	36.1 ±16.7	27.2 ±14.7	26.6 ±12.8	30.6 ±14.1	23	7.2	1.4
8/11	75.8 ±32.1	62.4 ±30.1	79.3 ±29.8	48 ±19.1	57 ±22.1	54.1 ±20.9	40.3 ±17.9	40.3 ±20.8	41.6 ±19.5	18	7.3	1.4

Table (2): Growth criteria of different treatments in the experiment.

Growth Criteria	T1			T2			T3		
	P1	P2	P3	P4	P5	P6	P7	P8	P9
FW (g)	75.8	62.4	79.3	48.0	57.0	54.1	40.3	40.3	41.6
Average	72.5 a			53.0 b			40.7 c		
WI (g)	73.5	60.1	77.0	46.7	55.7	52.8	39.0	39.0	40.3

Average	70.2 a			51.7 b			39.4 c		
DGR (g/day)	0.8077	0.6604	0.8461	0.5132	0.6121	0.5802	0.4286	0.4286	0.4428
Average	0.7714 a			0.6571 b			0.4333 c		
SGR (%/day)	3.84	3.63	3.89	3.96	4.15	4.10	3.77	3.77	3.81
Average	3.79 b			4.07 a			3.78 b		
FCR	1.97	2.07	1.72	1.88	1.73	1.86	1.57	1.68	1.66
Average	1.92 a			1.82 ab			1.64 b		

*Different letters in one row are significantly different ($P \leq 0.05$).

Table (3): Data of length and weight of common carp after the experiment.

Treatments	Length range (cm)	Weight range (g)	Mean length (cm)	Mean Weight (g)
T1	17.0-27.2	50-265	19.2	72.5
T2	12.6-22.2	11-116	17.0	53.0
T3	14.0-21.2	18-120	16.2	40.7

Table (4): Equation parameters of length-weight for common carp after the experiment.

Treatments	a	b	R^2	tvalue (calculated)	Significance of t
T1	0.0041	3.2902	0.8109	0.3511	0.3632
T2	0.0017	3.5958	0.8946	1.3180	0.0959
T3	0.0008	3.8619	0.9074	1.8337	0.0354*

Table (5): Condition factors of common carp after the experiment.

Treatments	Condition factors		
	Modified condition factor $K_b = 100\ W/L^b$	Relative condition factor $K_n = W/W^\wedge$	Fulton's condition factor $K_3 = 100\ W/L^3$
T1	0.4170 a ±0.0661	1.0170 a ±0.1612	0.9756 a ±0.1568
T2	0.4195 a ±0.0623	1.0233 a ±0.1520	0.9756 a ±0.1453
T3	0.3902 b ±0.0632	0.9517 b ±0.1541	0.8603 b ±0.1474

*Different letters in one column are significantly different ($P \leq 0.05$).

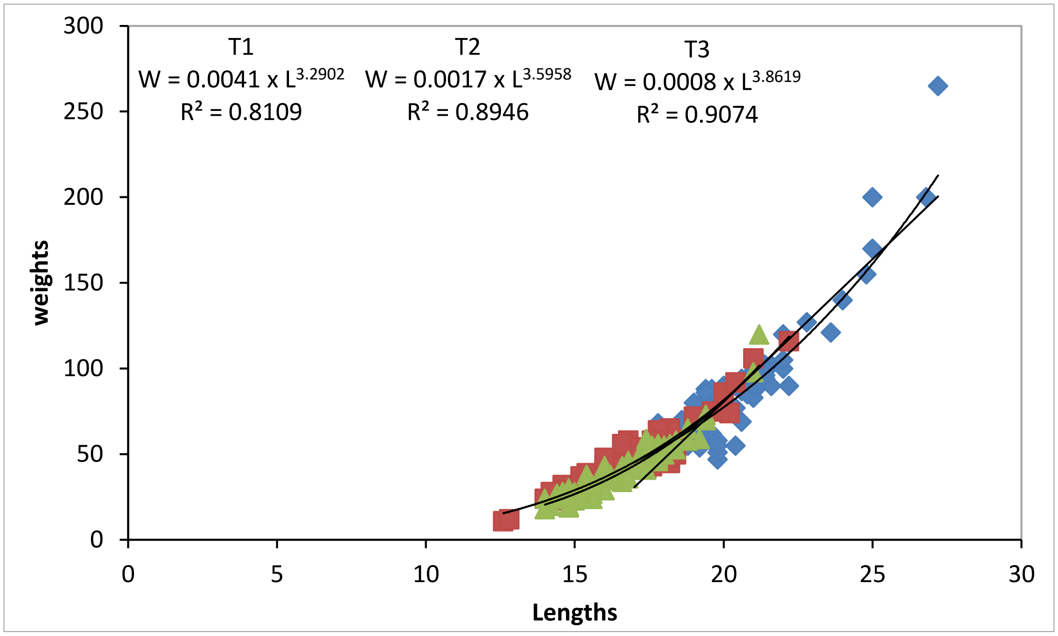

Figure (1) Length-weight relationships for all treatments of common carp at end of the experiment.

Discussion:

It is well known that water quality greatly affects aquaculture activities. At current experiment water temperature during August-October was at optimum for common carp growth. According to previous studies (Bhatnagar and Devi, 2013; Mocanu *et al*., 2015; Oprea *et al*., 2015) it has been reported that in earthen ponds, the desirable water temperature for carp culture should be from 20 to 30°C which was more or less similar to the present study. However, in 2015 a high mortality rate of common carp recorded during acute increasing of water temperature in the same area (Al-Dubakel *et al*., 2018). Salinity in the present study is considered suitable for common carp culture. However, at high salinities common carp may be able to survive, but the growth is extremely affected. Mangat and Hundal (2014) mentioned that these fish showed high appetite for feeding between 0 to 6 PSU salinities.

It is well known that the natural food available in earthen ponds is very important for growth and production of fishes, as well as this natural food affected too much by stocking densities and size of cultivated fishes. The results of current experiment appeared good correlation between stocking densities and growth rate of common carp, so growth rate decreased with increasing stocking densities. Many previous studies recorded that fishes reared in lower stocking exhibited higher growth rates (Musa *et al*., 2010; Hossain *et al*., 2014; Rumpa *et al*., 2016; Taher and Al-Dubakel, 2020).

The significant differences in weight gain between first growth period (9/8 to 30/8) may be related to much available natural food in the beginning of experiment. Taher (2020) stated that the highest growth performance was achieved by grass carp cultivated in low density (about 2.4 fish per cubic meter) compared with medium and high densities.

The low availability of food resources in earthen ponds affected the growth and the final average weight specially at high stocking densities (Célestin *et al.,* 2011), while Shafiullah *et al*. (2019) mentioned that significantly higher ($p<0.05$) production can be reached in higher stocking densities. Cordeli *et al*. (2021) stated that better growth performance achieved by common carp reared in recirculated system at density of 0.9 kg/m^3 compared with (1.8, 2.6 and 3.5)kg/m^3.Hayat *et al*. (2018) recorded similar weight gain and SGR in Majalaya common carp reared at stocking densities of 50 to 100 fish/m^3, but at stocking density of 125 fish/m^{3}the weight increment and SGR were reduced, while feed conversion ratio and survival of Majalaya common carp were not affected by the three stocking densities. Rahman *et al*. (2023) found in poly culture of (rohu *Labeo rohita*, catla *Catla catla*, mrigal *Cirrhinus cirrhosus*, and silver carp *Hypophthalmicthys molitrix*) that both weight gain and length gain were lowest for all species in higher stocking densities (120 fish/decimal) compared with medium (80 fish/decimal) and lower (40 fish/decimal) stocking densities.

Conclusions

The results of the present study have a significant importance to know the effect of stocking density for common carps in earthen ponds. It had been concluded from the results of current study that better growth criteria achieved by fishes reared in stocking density of one fish/m^{2}compared with two or four fish.

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تأثير الكثافات على أداء النمو في صغار اسماك الكارب الشائع (*Cyprinus carpio*) المرباة في الاحواض الترابية

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المستخلص

إجريت الدراسة الحالية في تسع احواض ترابية (900م^3) مملوءة بالماء بتاريخ 2023/8/1 ومسمدة بـ 250 كغم من السماد العضوي تم إطلاق ما مجموعه 600 من صغار أسماك الكارب الشائع في الأحواض من 1 إلى 3 بمتوسط وزن 2.3 غرام (T1) كما تم إطلاق ما مجموعه 1200 من صغار أسماك الكارب الشائع في الأحواض من 4 إلى 6 بمتوسط وزن 1.3 غرام (T2) أُطلق ما مجموعه 1200 من صغار أسماك الكارب الشائع في الأحواض من 4 إلى 6 بمتوسط وزن 1.3 غرام (T2) كما أُطلق ما مجموعه 2400 من صغار أسماك الكارب الشائع في الأحواض من 6 إلى 9 بمتوسط وزن 1.3 غرام (T3) أُطلقت جميع الأسماك الصغيرة في 9 أغسطس/آب 2023، وتم تغذيتها على عليقة غاطسة بنسبة تغذية 6% من إجمالي وزن الأسماك. ثم خُفِّضت هذه النسبة إلى 4% في 25 سبتمبر/أيلول 2003. أظهرت نتائج التجربة الحالية فروقًا معنوية (P≤0.05) في معايير النمو للمعاملات الثلاث، حيث سُجِّلت أفضل النتائج عند كثافة تخزين منخفضة. أظهر نمط النمو نموًا غير متماثل إيجابيً للأسماك في المعاملات الثلاث، اذ بلغت قيم b 3.2902 و3.5958 و3.8619 للمعاملات T1 و T2و T3على التوالي. أظهر التحليل الإحصائي لنتائج معدل التحويل الغذائي وجود فروق معنوية (P≤0.05) بين T1 وT3، بينما لم تكن هناك فروق معنوية (P>0.05) بين T2 و T1 وT3.

الكلمات المفتاحية: كثافة الأسماك، التحويل الغذائي، معدلات النمو، معامل الحالة.