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Effects of initial weight on growth criteria of grass carp, *Ctenopharyngodon idella* cultivated in earthen ponds

M.M. Taher*, S.J. Muhammed, A.Y. Al-Dubakel and A.M. Mojer
Aquaculture Unit, College of Agriculture, University of Basrah, Iraq
**e-mail: maj61ae@yahoo.co*

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Abstract - The current experiment was conducted in the Agricultural Research Station-Aquaculture Unit, College of Agriculture, University of Basrah from 27th June to 10th Nov 2020 in Al-Hartha District about 16 km northern-east of Basrah Governorate (30°65`64.6"N, 47° 74`79.5"E). Six earthen ponds (600 m^3) were used to investigate the effect of three different initial weights of grass carp, *Ctenopharyngodon idella* [220.1-276.8 g (T1); 146.5-169.3 g (T2); 81.5-82.7 g (T3)]. Fishes were fed 3% daily using commercial pellets manufactured by Agricultural Consultant Office. The results of the current study indicated that T1 had better growth criteria (WI= 296.8 g, DGR= 2.53 g/day, SGR= 0.59%/day and FCR 5.23) compared with the other two treatments. There was a negative allometric pattern of growth (b less than 3) in the three treatments before and after the experiment. Statistical analysis of the results proved that there were significant differences ($P \leq 0.05$) in the modified condition factor (Kb) between the three treatments at the end of the experiment, while there were no significant differences ($P > 0.05$) in the relative condition factor (Kn) and Fulton's condition factor (K). It was concluded from the current experiment that the initial average weight of the grass carp must not be less than 250 g to achieved good results for fish culturist.

Keywords: Grass carp, Daily growth, Weight increment, Condition factor.

Introduction

Grass carp, *Ctenopharyngodon idella* is belonging to the family Xenocypridinae instead of Cyprinidae according to the recent phylogenetic studies (Tan and Armbruster, 2018). Grass carp in 2018 was the most widely cultivated and commercially important freshwater fish species in the world that consisted 10.5% of the world production, while silver carp, *Hypophthalmichthys molitrix* was the second that formed 8.8%, Nile tilapia, *Oreochromis niloticus* was the third that consisted 8.3% and common carp, *Cyprinus carpio* occupied the fourth place (7.7%) of the total world production (FAO, 2020).

Grass carp is a native to the large river of eastern Asia and has been introduced since 1945 to other regions (Asia, North America, and virtually all of Europe) mainly for culture and aquatic vegetation control (Mitzner, 1978; Pfeiffer and Lovell, 1990; Kırkağaç and Demir, 2006). Grass carp is a native fish to northwestern China and southeastern Russia, and it has been introduced into many countries to control vegetation (Cudmore and Mandrak, 2004). Durborow *et al.* (2007) pointed out that grass carp is normally used in water ponds to consume unwanted aquatic vegetation and filamentous algae.

Grass carp is a herbivorous fish that naturally feeds on certain aquatic plants, while (as most fishes) in early life it feed on zooplankton, but under culture conditions, can accept artificial pelleted feed. Masser (2002) stated that fingerling of grass carp consume insect larvae and other invertebrates and even small numbers of fish fry, when desirable vegetation is unavailable, but juveniles in hatcheries fed on commercial pelleted diets and continue to consume pelleted diets throughout their lives. This fish feed exclusively on aquatic vegetation and consume daily 2-3 times their weight and may reach weights of 2-4 kg in one year (Bozkurt *et al.*, 2017).

Limited field studies were conducted (Al-Seyab, 1996; Saleh *et al.*, 2008) in Iraq on grass carp, while most studies were focused on laboratory experiments (Al-Dubakel *et al.*, 2011; Jaafar and Ahmed, 2011; Al-Shkakrchy and Ahemed, 2013; Talal, 2013; Al-Maliky, 2017; Taher, 2017; Sayed-Lafi *et al.,* 2018). Al-Dubakel *et al.* (2020) pointed out that partial replacement of fish meal by *Azolla filiculoides* meal could be used in the diet of grass carp cultivated in the laboratory. Abdullah *et al.* (2020) studied in the laboratory the feeding preferences of grass carp on three species of Iraqi aquatic plants. Taher (2020) studied the effects of fish density on the growth and condition factor of grass carp cultivated in earthen ponds. The current experiment aimed to investigate the effects of fish initial weight on growth criteria of grass carp cultivated in earthen ponds using pelleted diets.

Materials and Methods

The current experiment was conducted in six earthen ponds (600 m^3) at the Agricultural Research Station, Aquaculture Unit, Agriculture College at University of Basrah, Al-Hartha District about 16 km northern-east of Basrah Governorate (30°65`64.6"N, 47° 74`79.5"E) from 27th June to 10th Nov 2020.

The ponds were supplied by water from a branch of Shatt Al-Arab River by electric pump, while outlet was by gravity. The six small ponds (600 m^3) were used for the current experiment to investigate the effect of three initial weights of grass carp [220.1-276.8 g in pond 2 and 1 (T1); 146.5-169.3 g in pond 4 and 3 (T2); 81.5-82.7 g in pond 5 and 6 (T3)].

Fishes were fed daily 3% of fish weight on commercial pellets manufactured by Agricultural Consultant Office belonging to College of Agriculture using different ingredients (Fishmeal 20%, soybean meal 20%, wheat flour 35%, wheat bran 23%, and vitamins-minerals premix 2%). Total length and weight of fishes were measured at the beginning and the end of the experiment, while fishes were weighed periodically and daily food changed after each weighing. Daily feed was divided into three meals, the first was given early on the morning, the second at mid-day and the third given in afternoon.

Temperature, pH and salinity of the water of the ponds were measured at each sampling period. Throughout this period, seven sampling data were collected to calculate the following equations:

Weight increments (WI, g) = FW - IW

Daily growth rate (DGR, g/day) = FW - IW / days

Specific growth rate (SGR, %/day) = 100 * [(Ln FW) - (Ln IW)] / days

Where: FW = Final fish weight (g); IW = Initial fish weight (g)

Length-weight relationship and condition factor were calculated for fishes at the beginning and the end of the experiment for each treatment. The following equation was used to calculate the length-weight relationship:

$W= aL^b$ (Pauly, 1983).

Where W= weight of fish in g, L= Length of fish in cm, a= describe the rate of change in weight with length (intercept), and b = weight at unit length (slope).

The condition factors (K) of the grass carp were estimated using the following equations:

1. Fulton’s condition factor, the value of K was calculated according to Froese (2006): $K3 = 100\ w/L^3$
2. Modified condition factor (Ricker, 1975) was estimated following Gomiero and Braga (2005): $Kb = 100\ w/L^b$
3. Relative condition factor ‘Kn’ (Le Cren, 1951) was estimated following Sheikh *et al.* (2017): Kn = W/ ^w

Where W= the actual total weight of the fish in g, ^w= the expected weight from length-weight equation formula. Statistical software SPSS IBM (23) and Excel 2013 were used for analyzing the data.

Results

Table (1) showed the average fish weight during the study period with some of the important environmental parameters prevailed on the cultivated grass carp in the six experimental ponds.

Water temperature ranged from 22 to 29 °C, pH ranged between 7.7 and 8.2, and salinity ranged between 1.9 and 3.0 ppt. The final average weight (620.5 g) was recorded by fish reared in pond 1, while the lowest final average weight (152.0 g) was recorded by fish reared in pond 5.

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

Date	Average Fish Weight (g) ±SD						Temp. (°C)	pH	Sal. (ppt)
	T1P1	T1P2	T2P3	T2P4	T3P5	T3P6			
27-6-2020	276.8 ±136.8	220.1 ±112.7	169.3 ±24.9	146.5 ±23.0	82.7 ±20.5	81.5 ±20.9	29	8.0	2.8
17-7	316.4 ±144.3	239.2 ±115.7	182.1 ±23.7	163.2 ±19.8	86.5 ±20.5	83.2 ±19.9	30	8.2	3.0
14-8	393.4 ±250.9	294.5 ±130.9	224.5 ±87.9	201.4 ±33.6	105.1 ±33.3	110.8 ±33.3	29	7.9	2.8
4-9	450.0 ±266.7	322.4 ±180.7	260.0 ±123.7	226.9 ±33.3	116.1 ±55.9	119.7 ±32.7	28	8.0	2.6
28-9	520.3 ±330.9	377.5 ±199.4	280.3 ±180.7	256.4 ±53.7	128.7 ±54.7	144.5 ±55.9	27	7.9	2.4
18-10	588.6 ±410.7	420.7 ±210.4	300.6 ±194.2	268.1 ±70.9	146.0 ±66.6	150.0 ±64.5	24	7.7	1.9
10-11	620.5 ±480.4	470.0 ±213.8	330.8 ±258.2	280.5 ±82.4	152.0 ±71.8	152.4 ±67.7	22	7.7	1.9

Table (2) showed the growth criteria of the three treatments in the experiment. The highest average weight increment (296.8 g) was achieved by T1, followed by 147.7 g achieved by T2 and the lowest average weight increment (70.1 g) was achieved by T3. Statistical analysis for WI showed significant differences ($P \leq 0.05$) between T1 with T2 and T3, while there were no significant differences ($P > 0.05$) between T2 and T3. Fishes in T1 exhibited the highest average daily growth rate (2.18 g/day) followed by T2 (1.09 g/day), while the lowest (0.52 g/day) was recorded by T3. Statistical analysis for DGR showed no significant differences ($P > 0.05$) between the three studied treatments. The average specific growth rates recorded were 0.58, 0.48 and 0.46 %/day for T1, T2 and T3, respectively.

Statistical analysis for SGR showed significant differences ($P \leq 0.05$) between T1 with T2 and T3, while there were no significant differences ($P > 0.05$) between T2 and T3. Average food conversion rates recorded were 5.23, 6.88 and 12.60 for T1, T2 and T3, respectively. Statistical analysis of FCR showed significant differences ($P \leq 0.05$) between T1 with T2 and T3, while there were no significant differences ($P > 0.05$) between T2 and T3.

Table 2. Growth criteria of different treatments of grass carp in the experiment.

Growth Criteria	Treatments					
	T1		T2		T3	
	P1	P2	P3	P4	P5	P6
WI (g)	343.7	249.9	161.5	134.0	69.3	70.9
Average	296.8 a*		147.7 b		70.1 b	
DGR (g/day)	2.53	1.84	1.18	0.98	0.51	0.52
Average	2.18 a		1.09 a		0.52 a	
SGR (%/day)	0.59	0.56	0.49	0.48	0.45	0.46
Average	0.58 a		0.48 b		0.46 b	
FCR	5.36	5.11	6.19	7.58	8.55	16.66
Average	5.23 a		6.88 b		12.60 b	

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

Table (3) showed that the ranges of the total lengths and weights of the experimental fish before starting the experiment and at the end of the experiment. In all the treatments there were an increase in total length and weight. The highest increase (5.1 cm) in total length was achieved by T2, followed by T1 (3.6 cm) and T3 (3.2 cm). Figure (1) pointed out the length-weight relationship for fishes before the experiment. There was a negative allometric pattern of growth (b less than 3) in the three treatments as b values were 2.7161, 2.8156 and 2.4313 for T1, T2 and T3, respectively. Figure (2) pointed out that the length-weight relationship for the three treatments at the end of the experiment had negative allometric pattern of growth (b=2.6066, 2.8534 and 2.6712 for T1, T2 and T3, respectively).

Table (4) indicated that the parameters of the length weight-relationship for the grass carp before the experiment and after the experiment. Statistical analysis showed that there were no significant differences ($P>0.05$) between values of b with value 3 (Isometric pattern of growth) of grass carp at the end of the experiment for the three treatments.

Table (5) revealed three models of condition factors for grass carp at the beginning and the end of the experiment. Statistical analysis proved that there were significant differences ($P \leq 0.05$) in modified condition factor (Kb) between the three treatments at the end of the experiment, while there were no significant differences ($P>0.05$) in relative condition factor (Kn) and Fulton's condition factor (K).

Table 3. Data on length and weight of grass carp before and after the experiment.

Treatments	Length range (cm)	Weight range (g)	Mean length (cm)	Mean Weight (g)
	Before Experiment			
T1	26.8-39.0	214-702	30.5	248.4
T2	20.2-27.2	123-303	23.6	157.9
T3	14.5-22.5	32-123	19.9	82.1
	After Experiment			
T1	23.1-55.1	200-2120	34.1	545.2
T2	22.0-44.6	150-1132	28.7	305.6
T3	16.8-31.0	77-397	23.1	152.2

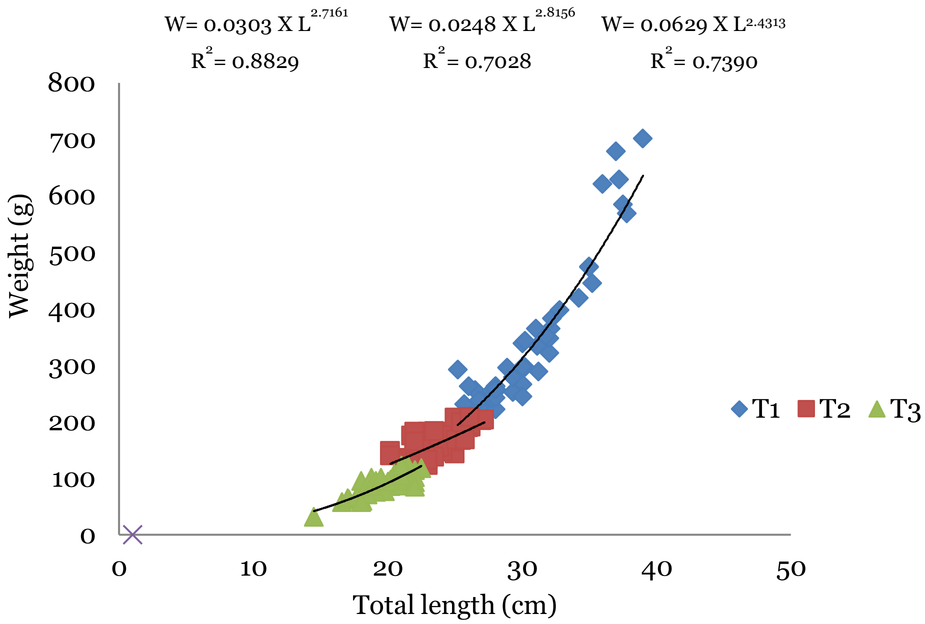

Figure 1. Length-weight relationship for three treatments of grass carp before the experiment.

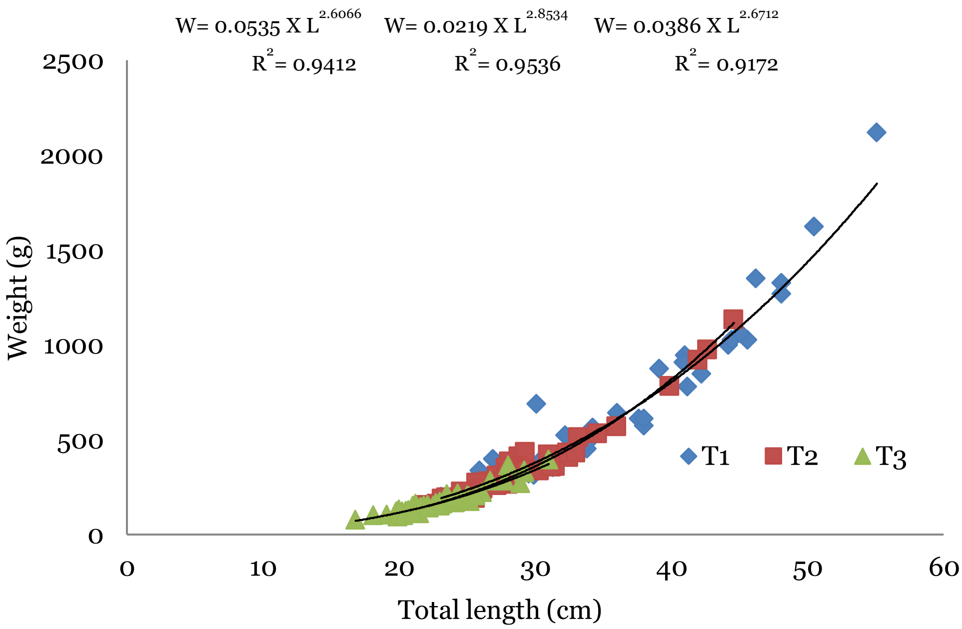

Figure 2. Length-weight relationship for three treatments of grass carp at the end of the experiment.

Table 4. Equation parameters of length-weight for grass carp before and after the experiment.

Treatments	a	b	R2	t value (calculated)	Significance of t
	Before Experiment				
T1	0.0303	2.7161	0.8829		
T2	0.0248	2.8156	0.7028		
T3	0.0629	2.4313	0.7390		
	After Experiment				
T1	0.0535	2.6066	0.9412	-0.4801	0.3166
T2	0.0219	2.8534	0.9536	-0.2798	0.3904
T3	0.0386	2.6712	0.9172	-1.0488	0.1496

Table 5. Condition factors of grass carp before and after the experiment.

Treatments	Condition factors		
	Modified condition factor Kb= 100 W/ Lb	Relative condition factor Kn= W/ W^	Fulton's condition factor K3= 100 W/ L3
	Before Experiment		
T1	3.05±0.37	1.01±0.12	1.16±0.15
T2	2.51±0.33	1.01±0.13	1.40±0.18
T3	6.34±0.86	1.01±0.14	1.16±0.17
	After Experiment		
T1	5.41±0.88 a*	1.01±0.16 a	1.37±0.26 a
T2	2.21±0.24 b	1.01±0.11 a	1.35±0.15 a
T3	3.88±0.40 c	1.01±0.10 a	1.39±0.15 a

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

Discussion

Filizadeh *et al.* (2005) pointed out many factors affecting the growth of cultivated grass carp such as water temperature, salinity, dissolved O_2, fish age and stocking densities. The water temperature range of the current study is considered as optimum temperature for growth (Masser, 2002), who stated that the optimum temperature for grass carp was 21-30 °C. Pfeiffer and Lovell (1990) indicated that the feeding activity of warm water fishes decreased when water temperature drops below 26 °C or increased by more than 30 °C. Opuszynski and Shireman (1995) pointed out that the feeding strategies of pond grass carp are affected by several factors, such as fish age and size, temperature, availability of plant species, size of the water body and stocking densities.

Results of the current experiment showed that better growth criteria were achieved by grass carp cultivated with higher initial weight (T1). Kırkağaç and Demir (2004) recorded higher weight increment (428 g) than the current experiment for grass carp cultivated in a 100 m^2 earthen pond from May to September.

This result may be due to very low stocking densities (200, 400 and 600 fish per hectare) compared with the current experiment (about 4000 fish per hectare). Grass carp cultivated in poultry waste recycled ponds for one year reached weight increments of 428-524 g (Singh *et al.*, 2013).

Taher (2020) recorded weight increments of 142.7, 76.8 and 108.2 g for grass cultivated in low, medium and high stocking densities, respectively. Essa *et al.* (2004) found that grass carp of initial weight 30.6 g cultivated using artificial feed showed the same daily growth (0.51 g/day) of T3 obtained in the current study, but it was very much lower growth compared with the other two treatments. Taher (2020) stated that the daily growth of grass carp cultivated in earthen ponds at three different densities were 1.24, 0.67 and 0.94 g/day, however, the specific growth rates (0.78-1.00 %/day) were higher than those recorded in the current study. This result may be due to lower initial weights (53-63 g) used by Taher (2020) compared with the initial weights used in the current study.

The value of FCR in the present experiment is too high and not encouraging from an economical point of view. Many researchers recorded better FCR for grass carp such as Cremer *et al.* (2002) who recorded 1.74 and Essa *et al.* (2004) who recorded an FCR of 3.83. Cremer *et al.* (2004) stated that FCR values for grass carp ranged from 1.48 in the first month to 2.46 in the last month with an average of 1.74. Taher (2020) pointed out that FCR for grass carp cultivated in earthen ponds at three stocking densities were 3.91, 5.06 and 4.19.

The length-weight relationship is an important tool for fishery management which gives information about size, structure, age and also fish health, and it may be different for the same species in the population due to many factors such as feeding and reproduction activities. Results of the current experiment revealed that the growth pattern of grass carp is negative allometric and the value of the slope (b) for length-weight relationship don't increased with increasing initial weights. A negative allometric growth of grass carp was also recorded by Chitrakar and Parajuli (2017) in the Balkhu live fish Market of Kathmandu, Nepal, while Jones *et al.* (2017) recorded a (b) value of 3.0116 for the grass carp caught in the basin of Great Lakes. Grass carp cultivated in Muzaffar Garh, Southern Punjab, Pakistan exhibited a very close b value (2.97) to the ideal slope value (3) (Khalid and Naeem, 2017). It has been found that grass carp in Ranitalab pond (lengths from 67.02-79.08 cm and weight from 3863-7118 g) had b value of 4.0180 (Shukla and Mishra, 2017). Sobirov *et al.* (2019) stated that the b value was 2.9205 for the length weight relationship of grass carp in Tudakul Reservoir, Uzbekistan. Taher (2020) recorded b values of grass carp ranged between 2.7414 and 2.9702.

Results of the present experiment showed nearly the same relative condition factor for the three treatments before and after the experiment, while there was no obvious pattern of the other two models of condition factors before and after the experiment. Chitrakar and Parajuli (2017) stated that the values of condition factor (K) for grass carp ranged between 1.18 and 1.85 and relative condition factor (Kn) between 1.01 and 1.08 according to season. Taher (2020) recorded modified condition factor (Kb= 1.28-2.72) for grass carp cultivated at three different stocking densities, relative condition factor (Kn=1.00-1.02) and Fulton's condition factor (Kn= 1.17-1.20).

Conclusion

It seemed from the results of the current experiment that growth criteria improved with increasing of initial weight for grass carp. For this reason it is recommended for fish culturist to consider initial average weight of 250 g or more when cultivated grass carp in their farms.

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تأثير الوزن الابتدائي في معايير نمو اسماك الكارب العشبي *Ctenopharyngodon idella* المستزرعة في الاحواض الارضية

ماجد مكي طاهر، صادق جواد محمد، عادل يعقوب الدبيكل و أحمد محسن موجر
وحدة الاستزراع المائي، كلية الزراعة، جامعة البصرة، العراق

المستخلص - اجريت الدراسة الحالية للفترة من 17 حزيران لغاية 10 تشرين الثاني عام 2020 في قضاء الهارثة حوالي 16 كم شمال محافظة البصرة(30º65`64.6"N, 47º 74`79.5"E) باستعمال احواض محطة البحوث الزراعية التابعة لوحدة الاستزراع المائي في كلية الزراعة جامعة البصرة. ستة احواض صغيرة (600 متر مكعب) استعملت لغرض دراسة تأثير الوزن الاولي (T1) 220.1-276.8 g و (T2) 146.5-169.3 g و (T3) 81.5-82.7 g لأسماك الكارب العشبي *Ctenopharyngodon idella*. غذيت الاسماك يوميا باستعمال حبيبات العلف المركز المصنع في مصنع المكتب الاستشاري الزراعي لكلية الزراعة. اظهرت نتائج الدراسة الحالية ان افضل معايير النمو (زيادة وزنية 296.8غم، معدل نمو يومي 2.53 غم/يوم، معدل نمو نسبي 0.59 % / يوم ومعدل تحول غذائي 5.23) قد تم الحصول عليها في T1 مقارنة بـ T2 و T3. بينت النتائج وجود نمو متماثل سلبي (الانحدار b اقل من 3) في المعاملات الثلاثة قبل وبعد التجربة، كما وبينت نتائج التحليل الاحصائي ايضا وجود فروقات معنوية ($P \leq 0.05$) في معامل الحالة المحور Kb بين المعاملات الثلاث بعد التجربة، في حين لم توجد فروقات معنوية ($P > 0.05$) في معامل الحالة النسبي Kn ومعامل حالة فولتون 3K.

الكلمات المفتاحية: الكارب العشبي، معدل النمو اليومي، الزيادة الوزنية، معامل الحالة.