MARSH BULLETIN

Effects of fish density on growth and condition factor of grass carp, *Ctenopharyngodon idella* cultivated in earthen ponds

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Abstract

The current experiment was conducted in Al- Hartha District, about 16 km northeastern Basrah Governorate, during the period 28th February to 26th June 2020. earthen ponds of the Agricultural Research Station, referring to Aquaculture Unit- Agriculture College- Basrah University, were used to investigate the effects of fish density on growth criteria and condition factor for grass carp, *Ctenopharyngodon idella*. The fish were cultivated in six earthen ponds (600 m^2 for each one) using three different stocking densities (T1-250 fish in ponds 1 and 2; T2- 500 fish in ponds 3 and 4 and T3- 750 fish in ponds 5 and 6). The range of fish weight at the beginning of the experiment was 19-203 g, while the range of total length was 12.8-27.0 cm. Fish were fed daily using commercial pellets manufactured by Agricultural Consultant Office belonging to Agriculture College (fishmeal 20%, soybean meal 20%, wheat flour 35%, wheat bran 23%, and vitamin-minerals premix 2%). Results of the current experiment revealed that the best growth and lowest feed conversion rate achieved by fish reared in T1. The length-weight relationship proved a negative allometric growth pattern for grass carp cultivated in all stocking densities (b=2.9702, 2.8140, and 2.7414 for T1, T2, and T3, respectively). The results showed that the increase of modified condition factor (Kb= 1.15-2.72) with increasing stocking densities, while there was no difference in the range of relative condition factor (Kn= 1.00-1.02) and Fulton's condition factor (K= 1.06-1.20).

Keywords: Length-weight relationship, Weight increment, Daily growth rate, Condition factor.

Introduction

Grass carp, *Ctenopharyngodon idella* is a native fish to the large rivers of eastern Asia and has been introduced since 1945 to other regions (Asia and North America and virtually all of Europe) mainly for rearing and aquatic vegetation control (Mitzner, 1978; Pfeiffer and Lovell, 1990; Kırkağaç and Demir, 2006). Cudmore and Mandrak (2004) stated that grass carp is a native fish to southeastern Russia and northwestern China, and it has been deliberately introduced into many countries for vegetation control. This fish is usually used in warm water ponds to consume unwanted aquatic vegetation and filamentous algae (Durborow *et al*., 2007). Grass carp feed almost exclusively on aquatic plants and eat 2–3 times their weight each day and may reach a weight of 2–4 kg in one year (Bozkurt *et al*., 2017).

Grass carp is herbivorous fish that naturally feeds on certain aquatic weeds, while at early life (fry and juveniles) feed on zooplankton. In agricultural conditions, grass carp can well accept artificial feed. Lopinot (1972) pointed out that grass carp feeds on anything when vegetated food is scarce, including small fishes, worms, and insects, but they seem to prefer pelleted feed in pond culture. Grass carp consume fingerlings insect larvae, other invertebrates, and even small numbers of fish fry, but only when desirable vegetation is unavailable, and hatcheries juveniles also feed on commercial fish pelleted diets and continue to older stages, so fish culturists often complain that these fish consume fish feed rather than aquatic plants (Masser, 2002).

Grass carp is now considered as belonging to the family Xenocypridinae instead of Cyprinidae, according to recent phylogenetic studies (Tan & Armbruster, 2018). Grass carp was the most widely cultivated and commercially important freshwater fish species in the world that comprising 11% of the total world fish culture production, while silver carp, *Hypophthalmichthys molitrix* was the second that comprising 10%, and common carp was the third that comprising 8% (FAO, 2018).

Most Iraqi studies on grass carp were focused on laboratory experiments (Al-Dubakel *et al.*, 2011; Jaafar and Ahmed, 2011; Al-Shkakrchy & Ahemed, 2013; Tala, 2013; Al-Maliky, 2017; Taher, 2017; Sayed-Laf *et al.*, 2018). At the same time, limited field studies were conducted (Al- Seyab, 1996; Saleh *et al*., 2008). Al-Dubakel *et al*. (2011) studied the growth parameters, and implication of grass carp larvae reared in a recirculation system. Taher (2017) conducted four laboratory experiments on grass carp. Al-Dubakel *et al*. (2020) pointed out the results of partial replacement of fish meal by *Azolla filiculoides* meal in grass carp feed. The current study investigates the effects of various fish density on grass carp's growth and condition factor cultivated in earthen ponds.

Materials and methods

The current experiment was conducted in Al- Hartha District about 16 km northeastern of Basrah Governorate (30^{o}65\`64.6"N, 47$^{o}$ 74\`79.5"E), using ponds of the Agricultural Research Station belonging to Aquaculture Unit- Agriculture College–Basrah University. The fish farm is consisted of four large ponds (One large pond of donam = 2500 m^2) and 14 small ponds of 600 m^2 each. Water is supplied from one of Shatt Al-Arab branches by an electrical pump, while the outlet is made by gravity. Six small ponds were used to conduct the current study to investigate the effect of three grass carp stocking densities (250 fish in pond 1 and 2; 500 fish in pond 3 and 4 and 750 fish in pond 5 and 6). The range of fish weights at the beginning of the experiment was 19-203 g, while the range of total lengths was 12.8-27.0 cm. Fish were fed daily using commercial pellets manufactured by Agricultural Consultant Office related to Agriculture College (Fishmeal 20%, soybean meal 20%, wheat flour 35%, wheat bran 23%, and vitamins-minerals premix 2%). The total length of all fish were recorded at the beginning and the end of the study period. Fish were weighed periodically and fish feed quantity changed after each weighing. Feeding ratio 3% of the fish weight was used, then increased to 4% and 5% due to increased water temperature. Daily food divided to portions for feeding three times a day, the first given at early morning, the second at mid-day, and the third given at afternoon.

From each pond, temperature, pH, and salinity of the water were recorded during each sampling period. Throughout this period, six fish samples 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

FCR = Food consumed/Fish weight increment

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

Length-weight relationship and condition factor were calculated for fish at the beginning of the experiment and at the end for each stocking density. The length-weight relationship was calculated by using following equation: $W= aL^b$ (Pauly, 1983).

Where W= weight of fish in gram, 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 factor (K) of the grass carp was estimated using these 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

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

Results

Table (1) showed the average fish weight measurements and standard deviation during the study period with the environmental parameters in the six experimental ponds. Water temperature ranged between 17-29 ^oC, pH ranged between 7.7-8.0 and salinity ranged between 1.3-2.6 ppt. There were no fish mortalities during the experiment in the six experimental ponds. Fish recorded highest final average weight (255.3 g) reared in pond 2, while lowest final average weight (124.9 g) was recorded by fish reared in pond 4.

Table (2) indicates growth criteria of different treatments in the experiment. The highest average weight increment (142.7 g) was achieved in T1, and lowest average weight increment (76.8 g) was achieved in T2. Statistical analysis of WI showed significant differences ($P \leq 0.05$) between T1 and T3 with T2, while there were no significant differences ($P>0.05$) between T1 and T3. Highest average daily growth rate (1.24 g/day) was recorded in T1 and the lowest (0.67 g/day) noted in T2. Statistical analysis for DGR showed significant differences ($P \leq 0.05$) between T1 and T3 compared with T2, while there aren't significant differences ($P>0.05$) between T1 and T3. The fish's highest average specific growth rate was 1% recorded in T1, while the lowest was 0.78% in T2. Statistical analysis for SGR showed significant differences ($P \leq 0.05$) between T1 and T3 compared with T2, while there were no significant differences ($P>0.05$) between T1 and T3. The best feed conversion value was 3.91 obtained in T1, while the lowest was 5.06 in T2. Statistical analysis for FCR showed significant differences ($P \leq 0.05$) between T1 compared with T2 and T3, while there were no significant differences ($P>0.05$) between T2 and T3.

Table (3) showed that the total lengths and weights range before starting the experiment and three treatments after the experiment. There was an increase in total length and weight in all treatments, with the highest average total length (26.6 cm) and the highest average weight (205.7) achieved by T1. Figure (1) pointed out that the length-weight relationship for fishes before experiment with a negative allometric pattern of growth (b less than 3, b=2.9710), while Figure (2) pointed length-weight relationship for three treatments after the experiment with a negative allometric pattern of growth (b=2.9702, 2.8140 and 2.7414 for T1, T2 and T3 respectively). Table (4) indicates the parameters of length-weight relationship for grass carp before the experiment and three treatments after experiment. Statistical analysis showed that there were no significant differences (P>0.05) between values of b with number 3 (Isometric pattern of growth) for grass carp before the experiment and after the experiment for the three treatments.

Table (5) revealed three types of condition factors for grass carp at the beginning and the experiment. Statistical analysis proved significant differences (P≤0.05) in modified condition factor (Kb) between fish at the beginning and at the end of the experiment and between fish reared in different stocking densities. Statistical analysis indicates that there were no significant differences (P>0.05) in relative condition factor (Kn) between reared fish at the beginning and the end of the experiment and also between fish reared in different stocking densities. Statistical analysis showed that there were significant differences (P≤0.05) in Fulton's condition factor (K) between reared fish at the beginning and the end of the experiment. At the same time, there were no significant differences (P>0.05) among fishes reared in different stocking densities.

Table (1) Average reared fish weight and environmental conditions during the study period.

Date	Average Fish Weight (g) ±SD						Temp. (^oC)	pH	Salinity (ppt)
	T1P1	T1P2	T2P3	T2P4	T3P5	T3P6			
28-2-2020	61.1 ±33.3	65.0 ±32.5	58.6 ±28.9	46.8 ±30.8	50.0 ±27.4	71.5 ±37.8	17	7.7	1.3
27-3	88.4 ±38.9	106.4 ±60.5	77.6 ±35.6	78.5 ±28.7	76.8 ±34.8	88.2 ±35.9	21	7.8	1.7
17-4	93.3 ±55.9	112.1 ±71.0	83.1 ±33.8	90.9 ±44.8	76.9 ±55.9	113.3 ±67.9	23	7.8	1.6
7-5	130.3 ±77.6	137.6 ±93.6	90.2 ±60.9	99.5 ±64.7	81.2 ±55.8	132.7 ±106.8	26	7.8	2.0
2-6	141.5 ±80.7	166.8 ±98.7	113.0 ±88.3	110.8 ±67.9	113.6 ±66.9	185.3 ±155.9	28	8.0	2.3
26-6	156.2 ±84.9	255.3 ±128.2	134.1 ±117.0	124.9 ±82.9	137.5 ±84.8	200.5 ±185.2	29	8.0	2.6

Table (2) Growth criteria of the reared fishes at the end experiment.

Growth Criteria	Treatments					
	T1		T2		T3	
	P1	P2	P3	P4	P5	P6
WI (g)	95.1	190.3	75.5	78.1	87.5	129.0
Average	142.7a		76.8b		108.25a	
DGR (g/day)	0.83	1.65	0.66	0.68	0.76	1.12
Average	1.24a		0.67b		0.94a	
SGR (%/day)	0.82	1.19	0.72	0.85	0.88	0.90
Average	1.00a		0.78b		0.89a	
FCR	4.98	2.85	5.09	5.04	4.14	4.24
Average	3.91a		5.06b		4.19b	

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

Table (3) Data of length and weight for grass carp at the beginning at the end of the experiment.

Treatments	Length range (cm)	Weight range (g)	Mean length (cm)	Mean weight (g)
At the beginning of experiment	12.8-27.0	19.0-203.0	$17.5_{\pm 2.8}$	$61.5_{\pm 34.8}$
T1	14.5-36.0	32.0-622.0	$26.6_{\pm 4.5}$	$205.7_{\pm 115.9}$
T2	17.1-37.8	58.0-630.0	$22.3_{\pm 4.1}$	$129.5_{\pm 108.4}$
T3	16.6-39.0	58.0-702.0	$23.9_{\pm 5.5}$	$169.0_{\pm 132.7}$

Table (4) Length-weight equation parameters of the reared grass carp at the beginning and the end of the study period.

Treatments	b	a	R2	t value (calculated)	Significance of t-test
At the beginning of experiment	2.9710	0.0113	0.872	0.0191	N.S.
T1	2.9702	0.0128	0.9584	0.0853	N.S.
T2	2.8140	0.0215	0.9575	0.0514	N.S.
T3	2.7414	0.0268	0.9282	0.0638	N.S.

Table (5) Condition factors of reared grass carp at the beginning and the end of the experiment.

Treatments	Condition factors		
	Modified condition factor K= 100 W/ Lb	Modified condition factor K= 100 W/ Lb	Modified condition factor K= 100 W/ Lb
At the beginning of the experiment	1.15± 0.24 a	1.02±0.21 a	1.06± 0.22 a
T1	1.28± 0.14 b	1.00± 0.11 a	1.17± 0.13 b
T2	2.16± 0.23 c	1.01± 0.11 a	1.20± 0.14 b
T3	2.72± 0.46 d	1.01± 0.17 a	1.19± 0.22 b

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

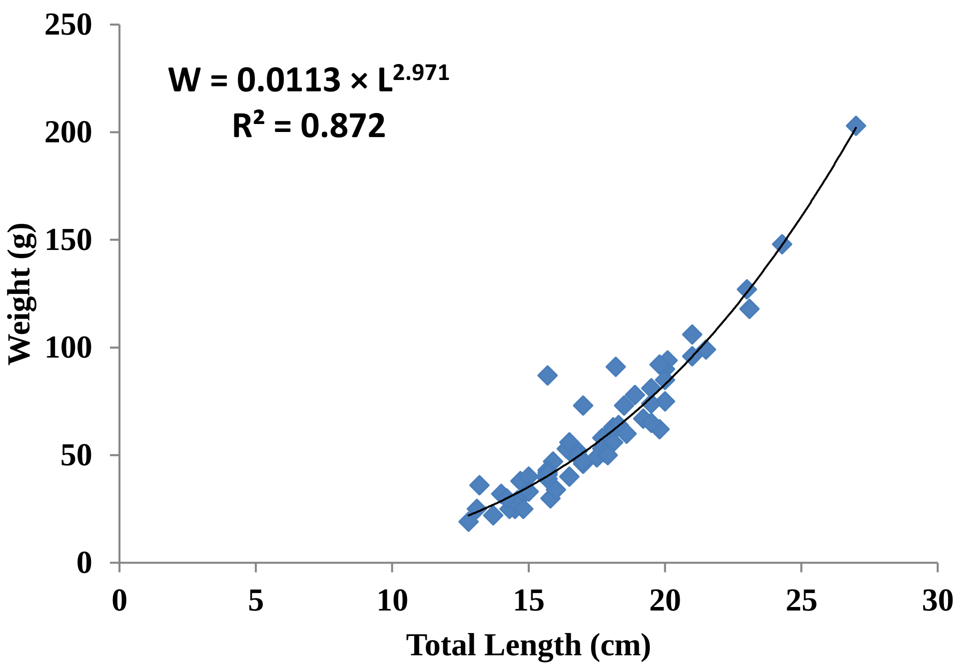

Figure (1) Length weight relationship for grass carp at the beginning of experiment.

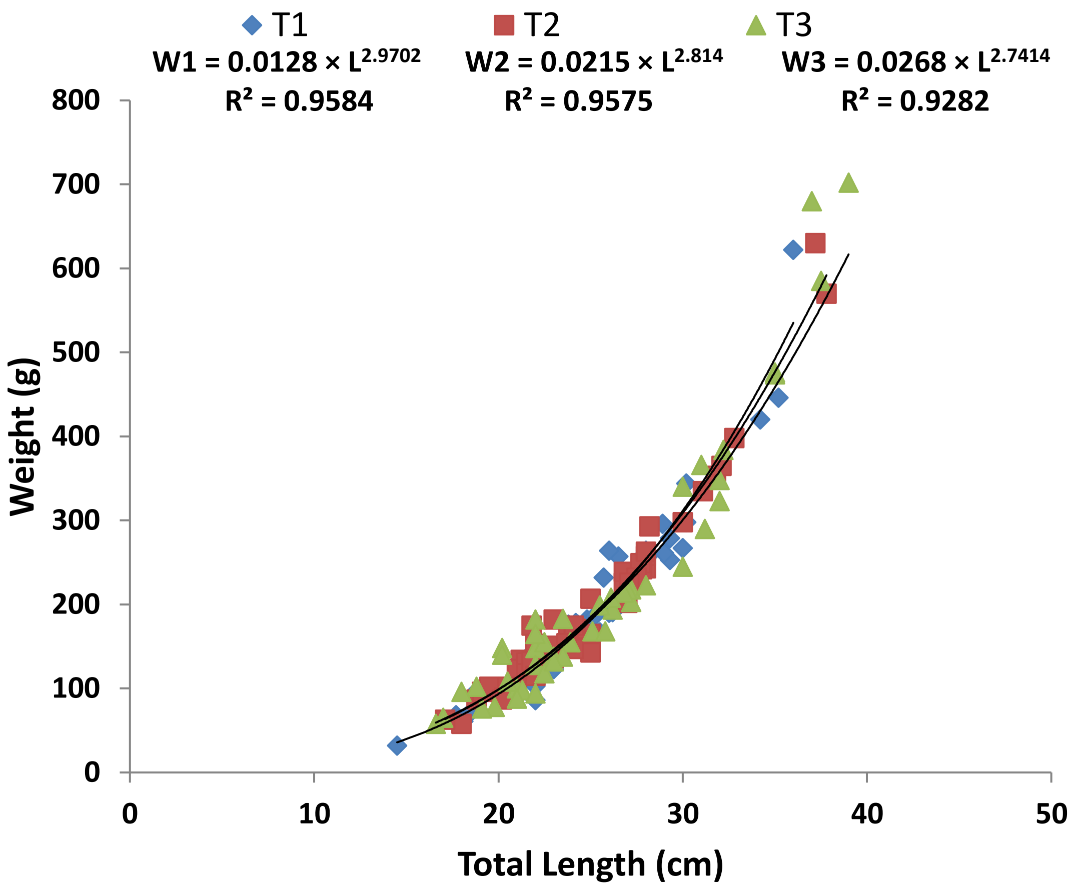

Figure (2) Length-weight relationship of reared grass carp in the three stocking densities at the end of the experiment.

Discussion

Opuszynski and Shireman (1995) pointed out that many factors influence grass carp feeding strategies cultivated in ponds such as fish age and size, water temperature, availability of plant species, size of ponds and fish stocking densities. The growth of cultivated grass carp depends on factors such as quantity and nutritional value of plants, water temperature, salinity, dissolved O_2, fish age and stocking densities (Filizadeh *et al*., 2004). Water temperature of the current experiment could be considered as an optimum level for grass carp growth according to Masser (2002), who stated that grass carp consume vegetation steadily at 10 to 16 ^oC, with optimal consumption at temperatures between 21 and 30 ^oC. Feeding activity of most warm-water fishes such as grass carp decrease when water temperature exceeds 30 ^0C in summer and again when the temperature drops below 26 ^0C during fall (Pfeiffer & Lovell, 1990).

The current experiment results showed that better growth criteria were achieved by grass cultivated in 250 fish stocking density. Cremer *et al*. (2002) recorded better FCR (1.74) than current experiment when cultivated in earthen ponds with silver carp, while recorded lower survival rate (94%) in comparing of the present experiment (100%). Essa *et al*. (2004) found that grass carp cultivated using artificial feed (34.8% crude protein) showed lower daily growth (0.51 g/day) and lower survival rate (96.67%) than the current experiment, while recorded nearly the same FCR (3.83) of T1 in the present experiment. The high grass carp densities used in the pond experiment, and the type of feed used were likely to be responsible for low growth rates (Filizadeh *et al*., 2004). Kırkağaç and Demir (2004) stated that grass carp cultivated in 100 m^2 earthen pond from May to September at low stockings densities (200, 400, and 600 fish per hectare), showed 100% survival rate and highest weight gain of 428 g at the minimum stocking density. Singh *et al*. (2013) found that grass carp cultivated in poultry waste recycled ponds for one year with common and silver carp achieved weight increments range between 428-524 g and survival rate between 48-75%. Guerrero III *et al*. (1988) stated that grass carp production was the highest in the commercial diet-fed pond.

The length-weight relationship of the same species may be different in the population because of feeding, reproduction activities, and an important tool for fishery management, giving information about size, structure, age, and fish health. The current experiment results revealed that the growth pattern of grass carp is negative allometric. The slope (b) for the length-weight relationship decreased with increasing stocking density and reached 2.8140 in T3. Chitrakar and Parajuli (2017) recorded negative allometric growth for grass carp in Balkhu live fish Market of Kathmandu, Nepal. Jones *et al*. (2017) calculated 3.0116 as b value for the length weight relationship of grass carp caught in the Great Lakes basin. Khalid and Naeem (2017) stated a very close value (2.97) to ideal slope value (3) for farmed grass carp from Muzaffar Garh, Southern Punjab, Pakistan. Shukla and Mishra (2017) found 4.018 as value of b in Ranitalab pond for grass carp of lengths from 67.02-79.08 cm and weight from 3863-7118 g. Sobirov *et al*. (2019) pointed 2.9205 as b value for grass carp's length weight relationship in Tudakul Reservoir of Uzbekistan. Results of current experiment showed increasing of modified condition factor (Kb= 1.15-2.72) with increasing stocking densities, while there were no much difference in relative condition factor (Kn= 1.00-1.02) and Fulton's condition factor (K= 1.06-1.20). Chitrakar and Parajuli (2017) recorded condition factor (K) for grass carp range between 1.18-1.85 and relative condition factor (Kn) ranged between 1.01-1.08 according to season.

Conclusion

This study indicates that the cultivation of grass carp at stocking densities between 1000-1500 fish gives better results of growth criteria and condition factor and lower feed conversion rate.

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تأثير كثافة الاستزراع على نمو ومعامل الحالة للكارب العشبي *Ctenopharyngodon idella* في الاحواض الترابية

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المستخلص

اجريت الدراسة الحالية في قضاء الهارثة، 16 كم شمال شرق محافظة البصرة باستعمال الاحواض الترابية التابعة لمحطة البحوث الزراعية- وحدة الاستزراع المائي - كلية الزراعة – جامعة البصرة، لمعرفة تأثير كثافة الاستزراع على نمو ومعامل الحالة لأسماك الكارب العشبي *Ctenopharyngodon idella*. استزرعت الاسماك في ستة احواض طينية (600 متر مربع) بثلاث كثافات مختلفة (250 سمكة في حوض 1 و2 (T1) و 500 سمكة في حوض 3 و 4 (T2) و750 سمكة في حوض 5 و6 (T3)). تراوحت مديات اوزان الاسماك في بداية التجربة بين 19-203 غم ومديات الاطوال الكلية بين 12.8-27.0 سم. غذيت هذه الاسماك يوميا باستخدام علف مركز مصنع من قبل المكتب الاستشاري الزراعي لكلية الزراعة (مسحوق سمك 20% ومسحوق فول الصويا 20% وطحين الحنطة 35% ونخالة الحنطة 23% وفيتامينات ومعادن 2%). اظهرت النتائج بان افضل نمو واقل معدل تحول غذائي تمثل في T1. اظهرت علاقة الطول بالوزن وجود نمو نموذج نمو متماثل سلبي للكارب العشبي المستزرع في ثلاث كثافات مختلفة (قيمة انحدار العلاقة هي 2.9702 و2.8140 و2.7414 للمعاملة الاولى والثانية والثالثة على التوالي). بينت نتائج الدراسة الحالية زيادة في معامل الحالة المعدل للأسماك، إذ تراوح بين 1.15-2.72 مع ازدياد كثافة الاستزراع، بينما لم توجد فروقات كبيرة في معامل الحالة النسبي (Kn= 1.00-1.02) ومعامل حالة فولتون (K= 1.06-1.20).

الكلمات المفتاحية: علاقة الطول بالوزن، الزيادة الوزنية، معدل النمو اليومي، معامل الحالة