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Effect of Sinking and Floating Diets on Common Carp Growth Performance in Earthen Ponds

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Abstract: The current experiment was conducted in earthen ponds at Agricultural Research Station belonging to the Aquaculture Unit, College of Agriculture, University of Basrah at Al-Hartha District. Six small earthen ponds (600 m^2) were used to investigate the effect of sinking (T1) and floating diets (T3) and also the use of as demand feeders (T2) in sinking diet on the growth criteria of common carp. Total length and weight of fishes were measured at the beginning and at the end of the experiment, while subsamples of fishes were weighed periodically, and daily feed changed after each weighing. Temperature, pH and salinity of the pond water were measured at each sampling period. Statistical analysis for the results proved that there were no significant differences ($P>0.05$) between the growth criteria (final weights, weights increments, daily growth rate, specific growth rate and feed conversion rate) of the three treatments. Results of the current experiment proved also that there were wide weight ranges (457-3470 g) in T2 comparing with T1 (1025-2300 g) and T3 (1000-2800 g).

Keywords: Demand feeders, Growth rate, Sinking diet, Feed conversion

Introduction

The effects and importance of aquaculture that has been practiced for centuries were expanded dramatically over the last few decades due to the fact that the amount of fishes caught by traditional capture fisheries stagnated, while the demand increased (FAO, 2001). Hasan et al. (2007) stated that fish ponds characteristics make them very suitable to produce cultivated fishes in an integrated way according to the recent country reviews of FAO. It is well known that common carp, *Cyprinus carpio* was one of the most common species that generates an important part of the fish production in inland freshwater rearing systems. For this reason, it was introduced to inland waters in different regions around the world. Common carp has an excellent growth rate and omnivorous feeding habits, so it is very much favored for cultivation in ponds alone or in combination with other species. According to FAO reports, common carp was the fourth most important freshwater cultivated species in the world, in 2020, that

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consists 8.6% of all world fish production (FAO, 2022). The main aquaculture rearing systems in Iraq were earthen ponds and floating cages, and common carp was nearly the only commercially cultivated fish. So, many field and laboratory studies were done on this species.

Bolorunduro (2002) pointed out that artificial fish feed added to earthen ponds supplements the natural food which provides the fish feeding requirements. Many factors are affecting the supplementary feeding including fish species and size, in addition to the amount and type of natural food available. This will have an effect on the important feed conversion rate (Woynarovich et al., 2010). The most important factors affecting fish growth and production are stocking densities and available natural food (Hassan & Mahmoud, 2011; Roy et al., 2018).

The primary aim of fish culturists is to produce tasty marketable fishes at lower prices. The most important management practice done each day in fish culture is feeding, so bad feeds or feedings practices can adversely affect the culture practice. The choice of feed type, feeding strategies and feeding systems is one of the main operational issues that enhance technical and financial success, especially because the feed amount comprises large percentage of the operating budget (Cardia & Lovatelli, 2015). Lazur (2000) stated that special attention would be paid to proper nutrition and feeding practices required in cultivation systems without natural food in order to minimize fish stress and maximize fish growth. Bolorunduro (2002) referred that natural food in earthen fish ponds provides all feeding requirements for fishes, so at the absent of natural food, it is necessary to use feed that contains all fish feeding requirements.

Jobling et al. (2001) stated that floating pellets had high prices and also high losses of some vitamins during processing due to the high temperature and pressure used, but they had superior water stability properties, more easily digested and can incorporate higher levels of oil. It has been stated that feed quality and the manner of using it are significant tools to determine the profitability of fish culture projects (Beveridge, 2004). In addition to fulfilling nutritional requirements, feeds must also meet other criteria such as reducing pollution in the environment.

There were some studies in Iraq dealing with the culture of common carp (Abdul-Hakim, 2005; Thjeel, 2011; Taher et al., 2014; Al-Dubakel et al., 2018; Albahadly, 2019; Taher, 2020), but all these studies were neither dealing with feeding strategies nor with the evaluation of imported floating fish feeds. The aim of the current experiment is to determine the effect of floating and sinking diets on the growth criteria of common carp cultivated in earthen ponds, and also to investigate the effects of their use as demand feeders.

Materials and Methods

The current experiment was conducted in earthen ponds at the Agricultural Research Station belonging to the Aquaculture Unit, College of Agriculture, University of Basrah at Al-Hartha District, about 16 km north-east of Basrah City (30^{o}39`20.264''N, 47$^{o}$ 44`51.533''E) from June 17th to October 9th 2021. Six small earthen ponds (600 m^2) were used for the current experiment to investigate the effect of floating and sinking diets on the growth criteria of common carp cultivated in earthen ponds, and also to investigate the effects of using them by demand feeders. Sinking diet were used in T1 and it was offered three times a day by hands, while in T2 it was placed in as demand feeders. Floating diet was used in T3 and offered one time daily. The average fish weight for T1 was 552.8 g, for T2 was 549.0 g and for T3 was 560.5 g.

Sinking fish pellets manufactured by Agricultural Consultant Office of the College of Agriculture (fishmeal 25%, wheat flour 28%, wheat bran 25%, barley 15%, soybean meal 5% and vitamins-minerals premix 2%). Gharb Daneh floating pellets, imported from the Islamic Republic of Iran, were manufactured by using fishmeal, poultry products, soybean meal, wheat flour, corn, corn gluten, wheat bran, soybean oil, premix, concentrate growth promoter, immune stimulant and antioxidant.

Total length and weight of fishes were measured at the beginning and at the end of the experiment, while subsamples of fishes were weighed periodically and daily food was changed after each weighing. Temperature, pH and salinity of the pond water were measured at each sampling period. Throughout this period, six sampling data were collected to calculate the following equations:

Weight increment (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) and IW= initial fish weight (g).

Length-weight relationship and condition factors were calculated for fishes at the beginning and at 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= describes the rate of change in weight with length (intercept) and b= weight at unit length (slope).

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

Fulton’s condition factor, the value of K was calculated according to Froese (2006): $K3 = 100\ w/L^3$.

Modified condition factor (Ricker, 1975) was estimated by following Gomiero & Braga (2005): $Kb = 100\ w/L^b$.

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 and ^w= the expected weight from length-weight equation formula.

The results of current experiment was 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 0.5% probability level by SPSS program Ver. 26.

Results

Table 1 shows the measurement of average fish weight with stranded deviation during the experiment for the three treatments, in addition to some environmental factors. Initial fish weights ranged between 490-631 g. Water temperature ranged from 25 ^{0}C during October to 30 ^{0}C during August, pH ranged between 7.7-8.0 and salinity between 3.01-4.14 Practical Salinity Unit (PSU).

Table 2 displays the growth criteria of the three treatments in the experiment. The highest average final weight (1743.5 g) was achieved by common carp in T2, while the lowest (1641.8 g) was achieved by common carp in T3. Statistical analysis for final FW showed no significant differences (P>0.05) between the three treatments. The highest average weight increment (1194.5 g) was achieved by common carp in T2, followed with 1188.0 g achieved by common carp in T1, while the lowest average weight increment (1081.3) was achieved by common carp in T3. Statistical analysis for WI showed no significant differences (P>0.05) between the three treatments. Common carp in T1 and T2 recorded the highest average daily growth rate (10.45 g/day) while the lowest (9.50 g/day) was recorded in T3. Statistical analysis for DGR showed no significant differences (P>0.05) between the three treatments. The highest average specific growth rate (0.805%/day) was recorded by common carp in T2, while the lowest (0.750%/day) was recorded in T3. Statistical analysis for SGR showed no significant differences (P>0.05) between the three treatments. Average feed conversion rates recorded were 2.375, 2.380 and 2.580 for T1, T2 and T3, respectively. Statistical analysis for FCR showed no significant differences (P>0.05) between common carp in the three treatments.

Table 3 shows data on length and weight of common carp before and after the experiment. Average length increased recorded were 13.4, 13.2 and 13.1 cm for T1, T2 and T3, respectively. Maximum length (47.1 cm) were reached by T1 and maximum weight (1743.5 g) were reached by T2. Weight ranges at the end of experiment were 1025-2300, 457-3470 and 1000-2800 g for T1, T2 and T3, respectively. Table 4 illustrates the ratio of weight groups for common carp at the end of experiment. Dominant weight groups were 2200-2299, 1700-1799 and 1500-1599 g for T1, T2 and T3, respectively.

Figure 1 points out the length-weight relationship of common carp before the experiment. There was a negative allometric pattern of growth (b= 2.9395) for the common carp before experiment. Figure 2 points out the length-weight relationship for the treatments after the end of the experiment with a negative allometric pattern of growth (b= 2.6214) for the common carp in T1 and positive allometric pattern of growth (b= 3.2090 and 3.2137) for T2 and T3, respectively.

Table 5 illustrates the parameters of the length weight-relationship for common carp before and after the experiment. Statistical analysis showed that there were no significant differences (P>0.05) between values of b with the value 3 (isometric pattern of growth) of common carp before and after the experiment and also between the three treatments.

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

Date	Average Fish Weight (g) ±SD						Temp. (ºC)	pH	Sal. (PSU)
	T1P1	T1P2	T2P3	T2P4	T3P5	T3P6			
17-6-2021	558.0±171.3	547.6±181.3	598.0±161.6	500.0±171.9	631.0±166.3	490.0±151.5	28	8.0	3.69
10-7	713.3±190.8	861.1±200.7	700.0±191.3	612.0±181.3	754.8±200.5	690.0±210.3	29	7.8	4.01
31-7	850.7±210.8	910.6±199.8	804.6±231.3	722.5±233.3	886.5±222.2	788.7±271.3	29	7.9	4.14
23-8	921.0±245.8	1113.0±271.3	1055.0±322.8	1250.0±399.8	984.0±288.8	1045.0±279.8	30	7.7	3.34
13-9	1240.6±300.8	1320.4±314.3	1205.8±399.0	1430.6±513.8	1120.9±315.9	1212.7±278.3	29	7.8	3.01
9-10	1842.2±322.7	1637.3±344.9	1707.2±466.2	1779.7±625.4	1654.1±399.9	1629.5±359.3	25	7.9	3.23

Table 2: Growth criteria of fishes reared on three different diet regimes.

Growth criteria	T1 (Sinking Diet)		T2 (Demand Feeder)		T3 (Floating Diet)	
	P1	P2	P3	P4	P5	P6
FW	1842.2	1637.3	1707.2	1779.7	1654.1	1629.5
Average	1739.8[a]		1743.5[a]		1641.8[a]	
WI (g)	1286.2	1089.7	1109.2	1279.7	1023.1	1139.5
Average	1188.0[a]		1194.5[a]		1081.3[a]	
DGR (g/day)	11.3	9.6	9.7	11.2	9.0	10
Average	10.45[a]		10.45[a]		9.50[a]	
SGR (%/day)	0.83	0.76	0.73	0.88	0.67	0.83
Average	0.795[a]		0.805[a]		0.750[a]	
FCR	1.93	2.82	2.54	2.22	2.76	2.40
Average	2.375[a]		2.380[a]		2.580[a]	

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

Table 3: Length-weight data of common carp before and after the experiment.

Treatments	Length range (cm)	Weight range (g)	Mean length (cm)	Mean weight (g)
Before experiment	27.4-42.2	300-1040	33.7	554.1
After experiment				
T1 (SD)	41.4-52.7	1025-2300	47.1	1739.8
T2 (DF)	30.7-56.2	457-3470	46.9	1743.5
T3 (FD)	40.1-54.0	1000-2800	46.8	1641.8

Table 6 shows three models of condition factors for common carp before and after the experiment. The values of Kb were 1.6637 before the experiment and 10.4340, 0.7182 and 0.6961 for T1, T2 and T3, respectively after the experiment. The values of Kn were 1.0083 before the experiment and 1.4759, 1.0115 and 1.0088 for T1, T2 and T3, respectively after the experiment. Statistical analysis of Kb and Kn proved that there were significant differences ($P \leq 0.05$) between the values before the experiment with values of T1 after the experiment and between T1 and the other two treatments, while there were no significant differences ($P>0.05$) between T2 and T3. The values of K3 were 1.3404 before the experiment and 1.6535, 1.6038 and 1.5826 for T1, T2 and T3, respectively after the experiment. Statistical analysis of K3 proved that there were no significant differences (P>0.05) between before and after the experiment, while there were significant differences (P≤0.05) between the values of T1 and T3 after experiment.

Table 4: Weight groups of common carp after experiment.

Weight groups (g)	T1 (Sinking Diet)		T2 (Demand Feeder)		T3 (Floating Diet)	
	Fish No.	Ratio (%)	Fish No.	Ratio (%)	Fish No.	Ratio (%)
400-490	-	-	1	0.80	-	-
500-590	-	-	2	1.60	-	-
700-790	-	-	1	0.80	-	-
800-890	-	-	1	0.80	-	-
1000-1099	1	1.82	6	4.80	6	7.89
1100-1199	3	5.45	5	4.00	1	1.31
1200-1299	4	7.27	6	4.80	8	10.53
1300-1399	3	5.45	10	8.00	4	5.26
1400-1499	4	7.27	9	7.20	8	10.53
1500-1599	4	7.27	10	8.00	12	15.79
1600-1699	6	10.91	9	7.20	9	11.84
1700-1799	2	3.64	14	11.20	3	3.95
1800-1899	3	5.45	11	8.80	4	5.26
1900-1999	8	14.54	8	6.40	5	6.58
2000-2099	9	16.36	5	4.00	4	5.26
2100-2199	2	3.64	10	8.00	4	5.26
2200-2299	5	9.09	2	1.60	4	5.26
2300-2399	1	1.82	2	1.60	2	2.63
2400-2499	-	-	1	0.80	1	1.31
2500-2599	-	-	6	4.80	1	1.31
2600-2699	-	-	1	0.80	-	-
2700-2799	-	-	1	0.80	-	-
2800-2899	-	-	1	0.80	1	1.31
3100-3199	-	-	1	0.80	-	-
3200-3299	-	-	1	0.80	-	-
3400-3499	-	-	1	0.80	-	-
Total	55	100	125	100	76	100

Table 5: Equation parameters of length-weight relationship for common carp before and after the experiment.

Treatments	a	b	R^2	t value (calculated)	Significance of t
Before experiment	0.0165	2.9395	0.8597	-0.0205	0.4936
After experiment					
T1 (SD)	0.0707	2.6214	0.8165	-0.0157	0.4952
T2 (DF)	0.0071	3.2090	0.8730	0.0406	0.4871
T3 (FD)	0.0069	3.2137	0.7737	0.0216	0.4931

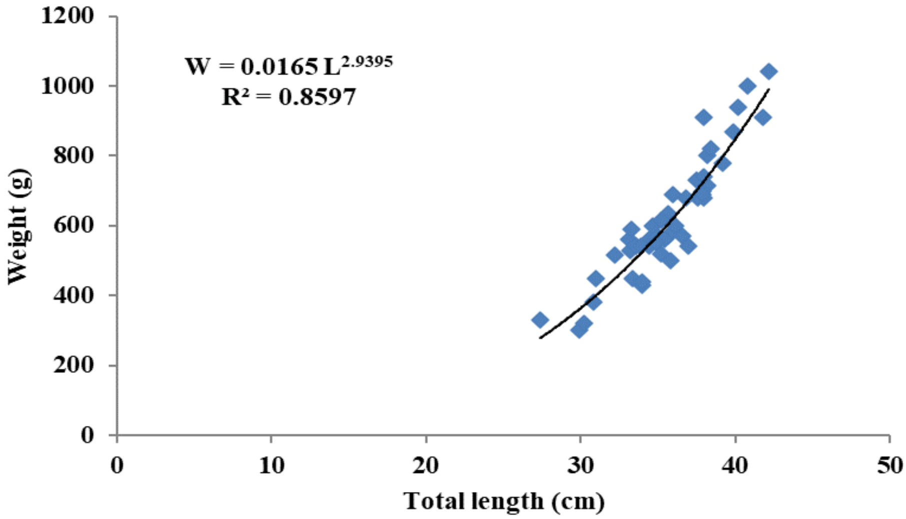

Figure 1: Length-weight relationship for common carp at the beginning of the experiment.

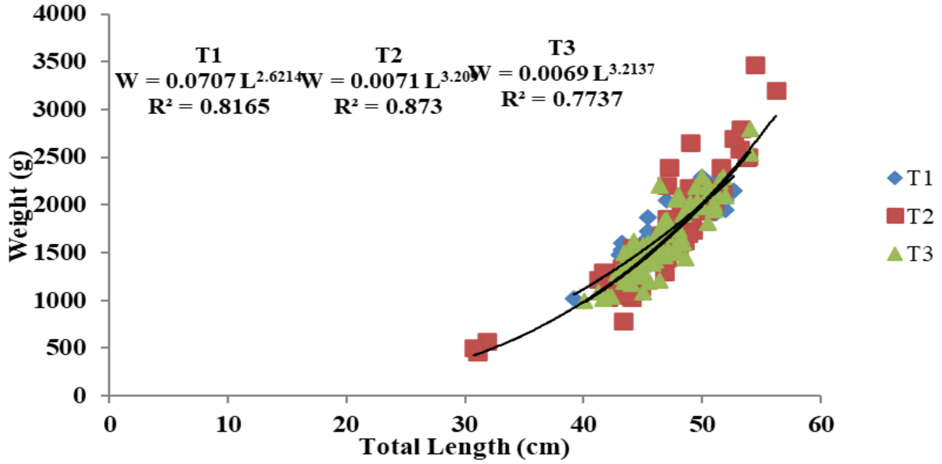

Figure 2: Length-weight relationship for three treatments of common carp at the end of the experiment

Table 6: Condition factors of common carp before and after the experiment.

Treatments	Condition factors		
	Modified condition factor Kb= 100 W/L^b	Relative condition factor Kn= W/W^	Fulton's condition factor K3= 100 W/L^3
Before experiment	1.6637^b ± 0.1719	1.0083^b ± 0.1042	1.3404^{ab} ± 0.1392
After experiment			
T1 (SD)	10.4340^a ± 0.9505	1.4759^a ± 0.1344	1.6535^a ± 0.1580
T2 (DF)	0.7182^b ± 0.0859	1.0115^b ± 0.1210	1.6038^{ab} ± 0.1942
T3 (FD)	0.6961^b ± 0.0767	1.0088^b ± 0.1111	1.5826^b ± 0.1754

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

Discussion

The feeding requirements of any cultivated fishes depend on many factors including fish species and fish size in addition to another environmental criteria such as water temperature, physiological situation and stress (Piska & Naik, 2013). Water temperature, dissolved O_2, salinity, pH and ammonia concentration were most important factors that affected cultivation of fishes (Stickney, 2000; Piska & Naik, 2013). Many researchers stated that the desirable range of water temperature for cultivation of common carp in ponds was 20 to 30 °C (Bhatnagar & Devi, 2013; Mocanu et al., 2015; Oprea et al., 2015). It is well known that optimum water temperature for cultivation of common carp ranged between 25-28 °C in tropical and subtropical regions. In the current experiment, nearly all environmental factors were optimum for the growth of common carp.

Bolorunduro (2002) stated that the major factors affecting fish growth were water temperature, fish density, feed quality, feeding methods and feeding frequency. The results of the current experiment revealed that there were no significant differences ($P>0.05$) between the three treatments in all growth criteria (FW, WI, DGR, SGR and FCR). Weight increment and daily growth rate recorded in the current experiment were too high in comparison of other local studies. Taher et al. (2014) found best results at 5% feeding ratio where DGR was 3.16 g/day comparing with 3 and 7% feeding ratio for common carp cultivated in floating cages. Taher et al. (2018) recorded DGR of 4.87 g/day for common carp reared in semi-closed system. Taher (2020) recorded DGR of 4.07-8.21 g/day when investigated four imported floating pellets fed to common carp reared in floating cages. Taher et al. (2021) pointed out that the values of DGR were 3.72 and 5.92 g/day for common carp reared alone and with grass carp in earthen ponds, respectively. Albahadly et al. (2021) found DGR values ranged between 3.26-4.73 g/day for graded and ungraded common carp reared in floating cages. Taher et al. (2022) recorded low DGR (5.73 and 5.87 g/d) comparing with the current experiment when cultivation of common carp in earthen ponds depended on 2 and 3% feeding ratio, respectively, while they recorded nearly the same DGR (9.55 g/day) of the current experiment when used 4% feeding ratio.

Specific growth rates recorded in the current experiment were 0.795, 0.805 and 0.750%/day for T1, T2 and T3, respectively. Al-Jader & Al-Sulevany (2012) recorded SGR of 0.71, 0.87 and 0.76%/day when fed common carp on 25, 30 and 35% crude protein diets, respectively. Taher et al. (2014) recorded SGR of 1.85%/day for common carp cultivated in floating cages on 5% feeding ratio. Hossain et al. (2014) recorded SGR of 4.95 and 4.80%/day in two densities of mirror carp during 90 days experiment. Taher et al. (2018) recorded SGR of 2.44%/day for common carp reared in semi-closed system for 52 days. Taher et al. (2021) recorded SGR of 1.07 and 0.98%/day for common carp cultivated with grass carp or alone, respectively. Taher et al. (2022) pointed out that the SGR range was 0.88-1.00%/day for common carp cultivated in and outside cages at earthen ponds.

Results of the current experiment revealed that FCR recorded were 2.375, 2.380 and 2.580 for T1, T2 and T3, respectively. Taher et al. (2014) recorded the same FCR (2.63) for common carp cultivated in floating cages on 5% feeding ratio. Taher et al. (2018) revealed that FCR of 2.12 was recorded for common carp reared in semi-closed system. Taher et al. (2021) recorded FCR of 2.24 and 2.46 for common carp cultivated with grass carp or alone, respectively. It has been found that FCR range was 2.67-2.77 for common carp cultivated in and outside cages at earthen ponds (Taher et al., 2022).

According to the results of the current experiment for weigh groups ratio and ranges (1025-2300 g for T1, 1000-2800 g for T3 and 457-3470 for T2), wide fish range was found in T2 when using sinking diet in as demand feeders. This finding proved that large fishes in as demand feeders consume more feed and do not give an opportunity to allow smaller fishes to take their adequate feed. This phenomenon was one of the negative characters when using this technique in feeding the fishes. Mohapatra et al. (2009) stated that the demand feeder was found suitable for feed delivery to Indian major carp *Labeo rohita* in outdoor culture systems, and it is reducing the FCR from 4.90 (hand feeding) to 3.62.

The length-weight relationship is an important tool for fisheries and fishery management. Results of the current experiment revealed a negative allometric pattern of growth (b= 2.9395) for the common carp before experiment with a negative allometric pattern of growth (b= 2.6214) for the common carp in T1 and positive allometric pattern of growth (b= 3.2090 and 3.2137) for T2 and T3, respectively. Kumar et al. (2014) recorded a negative allometric growth for common carp cultivated at Mid Hill Region, while Singh et al. (2015) recorded a positive allometric growth pattern in Bengal. Rashid et al. (2018) mentioned a negative allometric growth pattern (b= 2.574) for common carp in Little Zab River, Northern Iraq. Similar results have been found in Gölhisar Lake (Alp & Balık, 2000) and in Lake İznik (Tarkan et al. 2006). Positive allometric growth (b= 3.319) has been recorded in Almus Dam Lake for some populations of common carp (Karataş et al., 2007) and in Ömerli Reservoir recorded by Vilizzi et al. (2013). Taher et al. (2022) pointed out a positive allometric patterns for common carp reared inside and outside cages located in earthen pond. Taher et al. (2022) revealed that there were positive allometric pattern of growth for common carp (b= 3.0333, 3.1573 and 3.5854) fed 2, 3 and 4% feeding ratio, respectively. These variations in growth pattern may be related to different factors such as environmental conditions, feeding practice, fish size, sex and maturity.

Results of the current experiment showed extreme value of Kb (10.4340) for T1 in comparison to the other two treatments. This result may be attributed to the differences in the value of b. Taher et al. (2021) revealed that Kb of 0.31 was recorded for common carp cultivated with grass carp and 0.98 for common carp cultivated alone, while K3 of 1.47 for common carp cultivated with grass carp and 1.35 for common carp cultivated alone. Al-Dubakel et al. (2022) recorded Kb between 0.19-0.79 and Kn from 1.38-1.56 for common carp cultivated in and outside cages located in earthen ponds. It has been found that relative condition factor (Kn) for common carp reared in Bengal varied from 0.95 to 1.19 in females and 0.93 to 1.10 in males (Singh et al., 2015), while in the river Ganga, Allahabad, Das et al. (2019) found Kn more than 1 in both sexes of common carp. Taher et al. (2021) recorded 0.31 as Kb value for common carp cultivated with grass carp and 0.98 when cultivated alone in earthen ponds. Al-Dubakel et al. (2022) compared common carp cultivated in and outside cages at earthen ponds and recorded Kb values ranged from 0.19-0.79, Kn values range 0.99-1.05 and 1.38-1.56 as values range of K3.

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