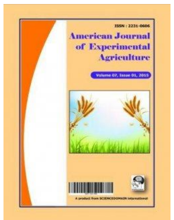

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Effect of Stocking Density and Partitioning of Rearing Period on Growth, Feed Utilization and Production of Common Carp *Cyprinus carpio* Raised in Floating Cages

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Authors' contributions

This work was carried out in collaboration between all authors. All authors read and approved the final manuscript.

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ABSTRACT

The effect of stocking density and partitioning of raising period on growth and economic feasibility for common carp *Cyprinus carpio* was investigated using four wooden floating cages (16 m3 per cage) at Tigris river, Southern Bagdad, Iraq during April to November 2013. Initial weight of fish ranged from 63.7 to 70.9 g. Four different stocking densities (25, 35, 50 and 70 fish/cage) were tried for two raising periods (4 and 8 months). The final weight of 1317.5 gm was obtained by fishes of the lowest density (25 fish/m^3). The same group sowed the heights values for food conversion ratio (FCR) of 2.63, food conversion efficiency (FCE) of 0.38, survival rate 94.5%, daily weight gain of 4.99 gm/day and specific growth of 3.57% day^{-1}. Fish production in the lowest density reached the highest annual return of 54.80% and the best rate of 1.54% among the benefits and costs competition with all other densities.

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Keywords: Common carp; stocking density; partitioning; floating cages; economic feasibility.

1. INTRODUCTION

Fish is considered as a rich source of protein (20%) with excellent amino acids profile and high contents of calcium and phosphorus. For such nutritive value, fish resources worth protecting and developing as renewable resources [1,2]. Fish farming represents the main activities to increase fish production through practicing non-conventional methods with high stocking densities [3]. Fish farming in cages is one of the intensive methods that has been used recently for this purpose [4]. Raising fish at high stocking rate in cages is considered as an economically feasible approach using neglected water bodies to increase productivity in the unit area [5-7]. Recent advances in fish culture in Iraq have been developed via spreading cage culture practices among farmers and researchers as recommended by [8]. This practice allows consumers to have high quality fish protein for better health. The aim of the present study is to evaluate the effect of stocking density and of culture period on growth and production of common carp raised in floating cages.

2. MATERIALS AND METHODS

2.1 Study Area

Twelve floating cages (2 x 3 x 3 m) (16 m^3 each) were constructed and located in Tigris River (1 km before Kut Barrage, Fig. 1). The study area is located between latitudes 32° 30' N and longitudes 45° 49' E. Site selection criteria were maintained to provide acceptable conditions for cage protecting and maintain wellbeing of fish. Water current velocity ranged between 25-45 cm/sec. Vertical transaction of depth at the site was 8 m. The bottom was sandy clay with certain amount of gravel. Scattered aquatic plants such as *Ceratophyllum demersum* and *Phragmites* sp., *Vallisneria* sp. and *Nymphaya* sp. were recorded in the cage location [9]. Small-sized fish of several species (Common carp, Shilig *Aspius vprax*, and Gerri *Silurus* sp.) and freshwater shrimp are also noticed there [10]. Continuous movement of water which was accompanied with variations in water levels was affected by the passing boats.

2.2 Experimental Fish

Common carp fish (initial size 63 - 70 g) from the same race were purchased from local hatchery and transported by special track to the cage site. They were acclimated in floating cages and fed until used for the experiment.

2.3 Experimental Design

The study includes two experiments (Fig. 2). The partitioning experiment includes two raising periods (4 months each). From April 1st to July 31st and from August 1st to November 30th, 2013 by raising half the rate of the control cages, as follows:

C1: 50 fish/m^3 used as control as recommended by [11]. C2: 70 fish/ m^3, T1a: 25 fish/ m^3, T1b: 35 fish/ m^3.

Fig. 1. Iraq map showing study area and location of the floating cages

The continuous experiment aimed at determining the best stocking rate for one rearing period (8 months) from April 1st to November 30th, 2013. It consists of four treatments as follows:

C1: 50 fish/ m^3, C2: 70 fish/ m^3, T2a: 25 fish/ m^3, T2b: 35 fish/ m^3.

2.4 Experimental Procedures

After stocking the cages with the pre-determined number of fish per cubic meter (Fig. 2), fish were fed floating pellets (6 mm) using mechanical demand feeders. Weight of feed was calculated as (5%) of the biomass for each cage, and the exact amount is stored in the feeder tank, as recommended by [12]. Samples of fish for the measurements of growth parameters are taken as 20-30 % of the stocked number monthly. They were weighed and measured to calculate the growth parameters as described by [13] as follows: Weight gain (WG in g) = Average final weight (W_f) – Average Initial weight (W_i), Daily weight gain (g/day) = Wf – Wi / Experimental period (days) Biomass Increment (BI in kg) = Final biomass (B_f) – Initial biomass (B_i), Relative growth rate (% RGR) = Wf – Wi / Wi, Condition factor (CF) = W x 100 / L^3 , Specific growth rate (SGR % day^{-1}) = (Ln Wf – Ln Wi) x 100/ Experimental period (days), Feed conversion ratio (FCR) = Amount of feed offered (g) / Weight gain (g), Feed conversion efficiency (FCE) = Weight gain(g) / Amount of feed (g) x 100, Survival rate (SR) = Number of fish at harvest / Initial number x 100

2.5 Economic Feasibility

The project economic feasibility was calculated using the following parameters: 1. Final harvested yield as fish weight gain as a biomass (kg), 2. Permanent invested capital including land, water, cages, machines and furniture, 3. Changeable invested capital which include prices of fish, feeds, workers and guards.

Considering five years as the functioning age for the cages, the cost of each cage was recalculated as:

350000 / 5 = 70000 ID/cage/year

Feasibility was then calculated according to [14] as follows:

1- Net value = Total revenue – Total costs. Positive net value means a feasible project,
2- Average annual revenue for the invested capital: Average annual revenue = Net revenue / costs x 100, 3- Ratio of revenue to costs: Revenue/ Costs If the result is > 1, the project is feasible. if ≤ 1, the project is not feasible.

2.6 Statistical Analysis

The experiment was conducted using the (CRD) design and general linear models (GLM) procedure of XLSTAT. Pro. 7.5 One way (ANOVA) analysis was adopted to test significance as pointed out by [15].

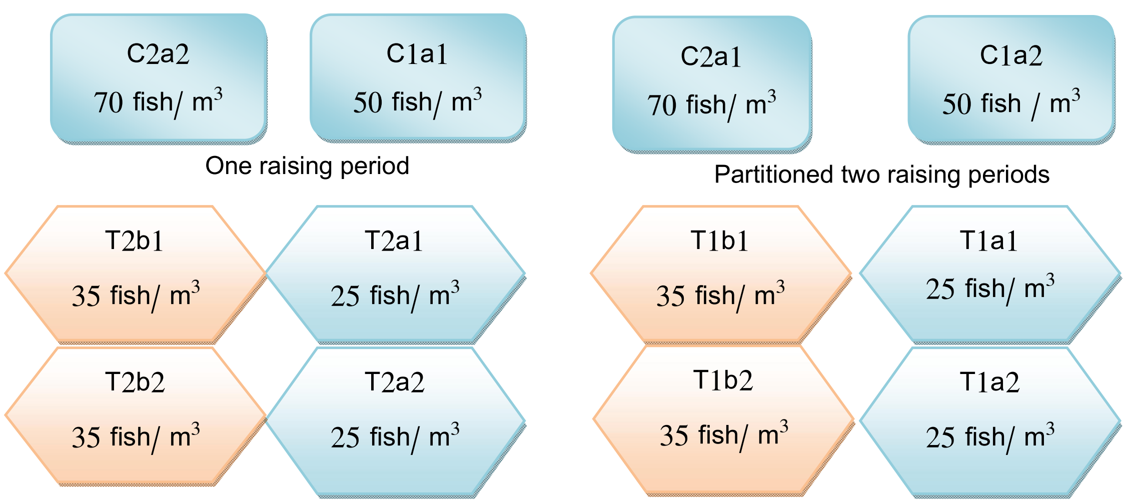

Fig. 2. The design of experimental treatments

3. RESULTS AND DISCUSSION

3.1 Growth, Feed Utilization and Survival

Fish in the lowest stocking rate ($25/m^3$) partitioning treatment (T1a) showed the best growth rate. As seen in Table 1, fish weight increased during the first rearing period (April – July) from 70 g to 595 g in T1a and 500 g in T1b, compared with control group (C1) which reached 408 g in four months. Differences are significant ($P<0.05$). Similarly, weight increment in the lowest stocking treatment ($25/m^3$) of the second experiment (T2a) reached 586 g for the same period, which is not significantly different ($p>0.05$) from (T1a). However, diffrences with other treatments are significant ($p<0.05$).

At the end of the second rearing period (Aug. – Nov.), the partitioning treatments T1a and T1b recorded an average final weight of 722.5 g and 562.5 g respectively. Accordingly, the accumulated harvest weights of fish in the partitioning experiment for the two periods reached 1317.5 and 1062.9 for T1a and T1b respectively.

For the second stage, fish from the same strain (initial weight 101 g) were cultivated at half stocking rate of control treatments (25 and 35 fish/m^3) for a contineous rearing period of 8 months. Average fish weight at harvest for the two treatments (T2a & T2b) are 1027.5 g and 922.5 g respectively (Table 1). Differences were significan ($p< 0.05$) between the two treatments and compared with the control treatment C1 (50 fish/m3) in which fish attained an average weight of 845 g for the same period. The other control treatment C2 (70 fish/m3), however, recorded the lowest harvest weight with only 292.5 g on average. Differences in harvest weight clearly revealed the negative effect of increased stocking density above 50 fish/m3 on growth of common carp in floating cages. The optimum density in the present study ranged between 25-35 fish/m3 which is on controry with [16] who stated that 50 fish/m3 was the optimum.

Findings of the present investigation are not in aggreement with results of [17] who cultivated 100-180 g common carp to attained only 800 g as individual weight of fish at harvest. Maximum average weight at harvest of the low stocking rate treatments (25 and 35 fish/m3) ranged between 1062.9 g and 1317.5 g in the partitioning trial and 922.5 g and 1027 g for the contineous trial respectively.

Maximum daily weight gain was recorded in T1a, approaching 4.99 g/day. This agreed with [18] who found that the daily gain of Nile Tilapia *Oreochromis niloticus* reared in floating cages increased in the lower stocking density. Cultivation of fish in lower density allow for more space and better feeding and relative growth [19]. Maximum total and net biomass was found in the control group C1 approaching 155.4 kg and 141.8 kg respectively (Table 2). They differ significantly ($p<0.05$) from other treatments. Contradictory to the present results of [20] who found that the lower stocking rate gave the best biomass. The best specific growth and relative growth rates were recorded in T1a also reaching 13.55 and 3.57% respectively. They differ significantly ($p<0.05$) from other treatments.

Values of SGR recorded in this study for control and T2 treatments (Table 3) are comparable with [21] who recorded SGR value of 1.69% per day for common carp in floating cages in Maninjau Lake in Sumatra. Control group, however, showed the lowest values for these parameters compared with T1. This may be due to dufferences in stocking rates. The present findings are different from those pointed out by [16] who stated that 50 fish/m^3 gave the best weight increment.

Table 1. Average values ± SE of initial and final weight of common carp in all treatments

Treatments	Initial weight (g)	Final weight 1st period (g)	Initial weight 2nd period (g)	Final weight 2nd period (g)	Total final weight (g)
C1	67.85±0.15a	407.78±2.78c	-	-	845.00±5.00 d
C2	68.70±1.10a	257.50±2.50d	-	-	492.50±2.50 e
T1a	70.00±3.60a	595.00±5.00a	102.40	722.50±2.54a	1317.50±6.22 a
T1b	63.70±4.20a	500.40±4.80b	99.70	562.50±2.50b	1062.90±4.13 b
T2 a	70.90±2.10a	586.20±1.80a	-		1027.50±4.50 b
T2b	68.65±2.85a	500.60±0.20b	-	-	922.50±3.50 c

Average values with different letters in the same column are significantly differenr (p<0.05)

Table 2. Average values ± SE of growth and feed utilization parameters for common carp reared in floating cages for all treatments

Treatments	Daily weight gain (g)	Total biomass (kg)	Net biomass (kg)	Amount of feed used (kg)	Feed conversion efficiency FCE (%)	Feed conversion ratio (FCR)
C1	3.39±0.02 e	155.43±2.97 a	141.86±3.00a	432.29±3.39 b	32±0.50 b	3.04±0.04 b
C2	1.84±0.01 f	122.44±0.45 d	103.20±0.77c	622.29±15.11 a	16±0.51 d	6.02±0.19 d
T1a	4.99±0.04 a	129.88±1.03 c	116.17±1.91b	305.67±3.63 d	38±1.50a	2.63±0.07 a
T1b	3.92±0.01c	143.18±0.77 b	120.30±0.81b	380.98±1.75 c	31±0.01cb	3.16±0.01 cb
T2a	4.17±0.02 b	96.54±0.45 e	89.45±0.66d	276.63±1.30 e	32±0.41 b	3.09±0.04 cb
T2b	3.72±0.01d	188.23±2.13 d	108.62±2.53c	369.76±0.46 c	29±1.00 c	3.40±0.08 c

Average values with different letters in the same column are significantly differenr (p<0.05)

Table 3. Average values ± SE of growth, survival and production of common carp reared in floating cages in Tigris River

Treatments	Production (kg/m^3)	Specific growth (% per day)	Relative growth rate (%)	Survival rate (%)
C1	38.85±0.74 a	1.11±0.01 c	11.45±1.01 a	91.50±0.75 dc
C2	30.60±0.11 d	0.87±0.01 d	6.16±1.51 b	88.03±0.50 d
T1a	32.46±0.26 c	3.57±0.12 a	13.55±5.74 a	94.50±1.00 a
T1b	35.79±0.64 b	3.35±0.01 b	11.49 ±1.84a	94.28±0.75 ba
T2a	24.13±0.12 e	1.18±0.01 c	13.49±4.64 a	92.00±1.00 bc
T2b	29.55±0.54 d	1.19±0.02 c	12.43±5.22 a	89.64±0.40 dc

Average values with different letters in the same column are significantly differenr (p<0.05)

The best feed conversion ratio (FCR) and feed conversion efficiency (FCE) were seen in T1a approaching 2.63 and 38% respectively (Table, 2). They differ significantly (p<0.05) from other treatments. Values of feed conversion ratio (1.23 – 1.48) recorded by [22] in floating cages are lower than those recorded by this study.

The best survival (94.5%) was noticed in T1a treatment (Table 3). Survival values recorded in the present study are comparable to those recorded by [22] and [23] that using high biomass for fish production in floating cages may cause high rates of fish mortality. On the other hand, [24] found that survival rates of Tilapia are not significantly affected by stocking density in floating cages.

3.2 Production and Economic Feasibility

The control group C1 showed the highest production value of 38.85 kg/m^3 , followed by the partitioning treatments T1b and T1a with production values of 35.79 and 32.46 kg/m^3 respectively (Table 3). Differences between control group and the other treatments of the two trials are significant (p<0.05). As stated by [25], the total production costs of fish in floating cages depend on several factors such as costs of cultivated fish, feed and cage materials, in addition to length of growing season and climatic conditions. Table 4 showed data related to the economic feasibility calculation.

The highest annual revenue and the ratio between revenue and costs were recorded in the partitioning treatment T1a with an average value of 54.75% and 1.54 respectively. These values are significantly differing from other treatments. The control group C1 (50 fish/m3) came second with values of 46.35% and 1.46 followed by the partitioning treatment T1b (35 fish/m^3) for the two parameters respectively. The lowest annual revenue and ratio was recorded in stocking rate treatment T2a. The second control treatment (70 fish/m^3) has not gained any revenue at the end of the trial.

The production rate of this experiment exceeds that of [21] for common carp in floating cages with low values of only 18 kg/m^3 when stocked at the rate of 3.1 kg/m^3 in Sumatra. The present production rate is also higher than that reported by [26] with values reached 28.5 kg/m^3 for common carp stocked at the rate of 6 kg/m^3 (45 fish/m^3) in floating cages.

These results are contradictory to those reported by [20] who found that the revenue coefficient (ratio of revenue/ costs) increased from 1.01 to 1.15 and 1.40 with increasing the stocking rates from 50, 100 and 200 fish/m^3 respectively.

Table 4. Economic feasibility analysis of cage culture of common carp in Tigris River

Costs and revenue	C1a	C2a	T1a	T1b	T2a	T2b
Fish prices	150000	21000	75000	105000	75000	105000
Feed cost	280992	404488	198686	247640	179814	40347.5
Work cost	61500	61500	61500	61500	61500	61500
Cage price	17500	17500	17500	17500	17500	17500
Deterioration cost	17500	17500	17500	17500	17500	17500
Total costs	527492	710988	370186	449140	351314	441847
Crop weight (g)	153375	1213975	124442.5	140367	94527	115772
Weight of Intruder fish (g)	2055	1050	5157.5	2417.5	1850	2367.5
Price of reared fish per kg	5000	4000	45000	4500	5000	5000
Price of intruder fish per kg)	2500	2500	2500	2500	2500	2500
Total price of reared fish	766875	485590	559991	631653	472745	578862
Total price of intruder fish	5137.5	2625	12893	6043	4625	5918
Total Revenue	772012	488215	572885	637696	477370	.584781
Net Revenue	244520	222773	202699	188556	126056	142933
Average Annual Revenue (%)	46.35±1.82 b	0.0 f	54.75±0.69 a	41.98±0.16 c	35.88±0.14 d	32.34±1.38 e
Ratio of revenue /costs	1.46±0.02 b	0.68±0.01 f	1.54±0.05 a	1.14±0.05 c	1.35±0.05 d	1.31±0.02 e

Average values with different letters in the same column are significantly differenr (p<0.05)
Prices, costs and revenue were calculated by Iraqi Dinar (ID). 1US $ = 1225 ID

The same trend was also reported by [26]. Revenue coefficient for common carp reared in floating cages, as reported by [22], ranged between 0.93 to 1.27 which agreed with values recorded by the present study.

4. CONCLUSIONS

From the present results, fish production in the lowest density reached the highest annual return of 54.80% and the best rate of 1.54% among the benefits and costs competition with all other densities.

5. RECOMMENDATIONS

It is recommended to use the lowest stocking rate of 25 fish per m3 for two raising periods to attain the maximum return.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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