Effect of Over-Wintering on Three Cyprinid Fish Raised in Earthen Ponds in Basra Province, Southern Iraq

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Abstract

This study aimed to evaluate the effect of winter conditions and restricted feeding on the growth performance of three cyprinid species, common carp (*Cyprinus carpio*), grass carp (*Ctenopharyngodon idella*), and silver carp (*Hypophthalmichthys molitrix*) reared in earthen ponds in Basra Province, southern Iraq. The trial was conducted during the winters of 2015, 2016, and 2017 in two ponds at the Marine Science Center, each stocked at a density of 5000 fish/ha with a species composition of 50% common carp, 30% grass carp, and 20% silver carp. Fish were fed only on natural food with no supplementary feeding. Water temperatures ranged from 9.2°C to 18.1°C across the studied winters. Growth performance, evaluated through weight gain and specific growth rate (SGR), varied among species and years. The highest SGRs for common carp, grass carp, and silver carp were recorded in 2016 at 0.719, 1.195, and 2.355% g/day, respectively. Gross production peaked in 2017, reaching 705 kg/ha/90 days for common carp and 265 kg/ha/90 days for silver carp. The findings suggest that winter rearing under restricted feeding may result in acceptable growth rates, particularly for silver carp, and can reduce operational costs. Implementing such feeding strategies may optimize fish production by lowering labor and feeding input during colder months.

Keywords: Common carp, Grass carp, Silver carp, Winter growth, Specific growth rate, Restricted feeding, Earthen ponds.

Introduction

Optimizing feeding strategies during the winter months is a critical challenge in aquaculture, particularly in regions with suboptimal temperatures for fish growth. Feed constitutes a major operational cost, and the use of restricted or natural feeding during colder seasons has been proposed to improve production efficiency. Previous studies have demonstrated that fish subjected to compensatory growth in subsequent seasons may recover from reduced feeding during winter, thereby justifying the exploration of

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restricted feeding regimes (Kim and Lovell, 1995; Sealey *et al.*, 1998; Small *et al.*, 2016). Water temperature is widely recognized as a key abiotic factor influencing the physiological performance of fish, including metabolism, growth, reproduction, and survival (Pankhurst and King, 2010; Shahjahan *et al.*, 2017). Since fish are ectothermic organisms, their biological functions are directly regulated by ambient water temperatures, which affect feeding behavior and conversion efficiency (Volkoff and Rønnestad, 2020). Common carp (*Cyprinus carpio*), grass carp (*Ctenopharyngodon idella*), and silver carp (*Hypophthalmichthys molitrix*) are known to exhibit temperature-dependent growth patterns, with optimal development occurring between 23°C and 30°C (FAO, 2009).

Iraq's climatic conditions, characterized by hot summers and relatively mild winters, present unique challenges for aquaculture. During the winter months in Basra, water temperatures often drop below the optimal range for carp species, reducing metabolic activity and feeding rates (Al-Shamma *et al.*, 1996; Hussein, 2010). Nonetheless, limited research has been conducted on the overwintering performance of carp species in southern Iraq, particularly under restricted feeding conditions and in semi-natural environments such as earthen ponds.

The present study addresses this knowledge gap by evaluating the growth performance, specific growth rate (SGR), and gross production of three cyprinid species during the winters of 2015, 2016, and 2017 in earthen ponds in Basra Province. The study specifically investigates the potential of overwintering with natural feeding as a cost-effective approach to maintain fish condition and reduce operational expenses. The findings aim to contribute to the development of adaptive aquaculture strategies suitable for subtropical climates.

Materials and Methods

The study was conducted at the Marine Science Center, University of Basrah, Iraq, during the winter months (January to March) of three consecutive years: 2015, 2016, and 2017. Two earthen ponds, each with a surface area of approximately 0.25 hectares, were used to evaluate the overwintering growth performance of three cyprinid fish species under natural feeding conditions. Each pond was stocked at a density of 5000 fish/ha with a species composition of 50% common carp (*Cyprinus carpio*), 30% grass carp (*Ctenopharyngodon idella*), and 20% silver carp (*Hypophthalmichthys molitrix*). Fish were not provided with any artificial feed; instead, they relied solely on natural pond productivity. Organic manure was applied at a rate of 1.5 kg/100m² one week prior to stocking, following the protocol outlined by Taher and Al-Dubakel (2020), to enhance natural food availability.

To monitor growth, a sample of 15 fish from each species was randomly collected every 15 days. Individual body weight was recorded to the nearest gram using a digital balance. The following parameters were calculated:

Weight gain: WG (g) = final weight (g)-initial weight (g)

Specific growth rate: SGR % g /day = ($LnW_2 - LnW_1/t$) ×100.
Where Ln is the natural log; (W_1) is the initial fish weight, (W_2) is the final fish weight in grams, and (t) is the period of the experiment in days.
Gross fish production: Gross fish production was calculated according to Apu *et al.* (2012)
Gross weight = No. of fishes harvested × average final weight
Gross fish production (kg/ha/90 days) = Gross weight (kg) of fish per ha. per month × 3
Water quality parameters, including temperature (°C), dissolved oxygen (mg/l), and pH, were measured biweekly using portable water quality meters. These parameters were recorded in situ to reflect the natural pond conditions affecting fish growth.

Statistical analysis

Data was subjected to statistical analysis using one-way analysis of variance (ANOVA) to compare differences among years and species, followed by Tukey's HSD post hoc test where applicable. Statistical significance was set at $p < 0.05$. All analyses were performed using SPSS software version 26.

Results

Water Quality Parameters

The water temperature, dissolved oxygen (DO), and pH values recorded during the winter months of 2015, 2016, and 2017 are summarized in Table 1. The average temperatures declined progressively over the three years, ranging from 15.3 ± 2.8°C in 2015 to 11.3 ± 1.8°C in 2016 and 11.55 ± 2.35°C in 2017. Dissolved oxygen levels remained within acceptable ranges for cyprinid culture, varying between 5.2 and 7.4 mg/l. The pH values were slightly alkaline, with seasonal means ranging from 7.05 to 8.05. These conditions, while suboptimal for maximal growth, were within the physiological tolerance of the three species studied.

Table 1. Ranges and mean values ± SD of water quality parameters observed throughout the study period.

Winter season	Water Temperature °C	Dissolve Oxygen mg/l	pH
2015	12.5-18.1 (15.3 ± 2.8)	5.8-7.4 (6.6 ± 0.8)	7.2-8.1 (7.05 ± 0.45)
2016	9.5-13.1 (11.3 ± 1.8)	5.2-6.3 (5.75 ± 0.55)	7.1-8.3 (7.7 ± 0.6)
2017	9.2-13.9 (11.55 ± 2.35)	5.5-6.8 (6.13 ± 0.65)	7.5-8.6 (8.05 ± 0.55)

Weight Changes Over Time

The weight changes patterns of common carp, grass carp, and silver carp throughout the 90-day overwintering period are presented in Table 2. All species exhibited steady

increases in body weight, although the magnitude of growth varied across years and species. Common carp gained the most weight in 2015 (from 125 g to 219 g) and 2017 (from 200 g to 282 g), while growth was more modest in 2016 (from 45 g to 86 g). Grass carp demonstrated consistent growth across the seasons, with final weights reaching 151 g in 2015, 88 g in 2016, and 126 g in 2017. Silver carp showed a significant increase in 2016, growing from 15 g to 125 g, indicating a remarkable growth capacity under colder conditions.

Table 2. Changes in fish weight (g) of common carp, grass carp and silver carp that reared in earthen ponds during the winters of 2015, 2016 and 2017.

Species	Winter season	Dateof measurement						
		1st Jan	15th Jan	30th Jan	15th Feb	28th Feb	15th Mar	30th Mar
Common carp	2015	125^{a} ±5.49	128 ^{a}±5.05	153^{b} ±8.79	163^{c} ±6.35	201^{d} ± 5.21	205^{d} ± 1.25	219^{e} ± 3.42
	2016	45^{a} ± 1.64	47^{a} ± 0.23	52^{ab} ± 1.06	55^{ab} ± 1.18	60^{b} ± 2.13	77^{c} ± 2.09	86^{c} ± 2.57
	2017	200^{a} ± 4.82	208^{ab} ± 1.23	217^{bc} ± 1.65	227^{cd} ± 1.81	230^{d} ± 0.23	266^{e} ± 2.07	282^{f} ± 2.13
Grass carp	2015	80^{a} ± 7.31	87^{a} ± 2.56	91^{ab} ± 1.69	100^{b} ± 3.27	143^{c} ± 7.76	145^{c} ± 2.01	151^{c} ±2.25
	2016	30^{a} ± 1.45	33^{ab} ± 0.18	34.5^{ab} ± 1.04	37.5^{ab} ± 1.16	43^{b} ± 1.02	61^{c} ± 2.15	88^{d} ± 2.58
	2017	71^{a} ± 2.94	85^{b} ± 1.46	890^{b} ± 0.28	90^{b} ±0.83	91^{b} ± 1.06	111^{c} ± 1.57	126^{d} ± 3.12
Silver carp	2015	60^{a} ± 5.12	63^{a} ± 2.59	74^{a} ± 2.45	85^{a}± 2.24	110^{b} ± 3.12	112^{b} ± 0.28	129^{b} ± 1.36
	2016	15^{a} ±1.07	16^{a} ± 0.97	17^{a} ± 0.88	24^{a} ±0.26	28^{ab}± 0.84	45^{b} ± 2.037	125^{c} ± 4.60
	2017	154^{a} ± 5.06	160^{ab} ± 4.29	173^{abc} ± 2.04	175^{bc} ± 1.55	187^{c} ± 1.69	190^{c} ±1.05	256^{e} ± 2.13

*Means in each raw with different superscripts are significantly different ($P < 0.05$).

Growth Performance Indicators

As shown in Table 3, the specific growth rate (SGR) and weight gain varied substantially: The highest SGR was observed in silver carp during 2016 (2.355% g/day), followed by grass carp (1.195% g/day) in the same year, indicating strong adaptability to cold temperatures. Common carp recorded its highest SGR in 2016 (0.719% g/day), despite lower weight gain compared to 2015. Weight gain was generally highest in 2015 for most species, suggesting more favorable thermal conditions. These results reflect interspecific differences in temperature tolerance and feed utilization during winter months.

Gross Fish Production

Gross production (kg/ha/90 days) was calculated for each species over the study period: Common carp reached the highest production in 2017 (705 kg/ha), despite recording its lowest SGR that year. Grass carp achieved its best yield in 2015 (226 kg/ha), with lower production in subsequent years. Silver carp exhibited a significant increase in production from 125 kg/ha in 2016 to 265 kg/ha in 2017. These findings highlight the role of environmental conditions and species-specific growth responses in determining final yields.

Table 3. Initial body weight, final body weight, weight gain, specific growth rate, and gross production of common carp, grass carp, and silver carp during the winter months of 2015, 2016 and 2017.

Species	Winter season	Initial weight(g)	Final weight (g)	Weight gain(g)	Specific growth rate (% g/day)	Gross production (kg/ ha/90 days)
Common carp	2015	125 ± 5.09	219± 3.42	94±1.67	0.623	547.5
	2016	45 ± 1.06	86 ± 2.57	41±1.51	0.719	215
	2017	200 ± 4.82	282± 2.13	82±2.69	0.381	705
Grass carp	2015	80 ±7.31	151 ±2.25	71±5.06	0.381	226
	2016	30 ±1.45	88 ± 2.58	58±0.8	1.195	132
	2017	71 ± 2.94	126± 3.12	55±0.18	0.234	139
Silver carp	2015	60 ± 5.12	129 ±1.36	69±3.76	0.850	129
	2016	15 ± 1.07	125± 4.60	110±3.53	2.355	125
	2017	154 ± 5.06	256± 2.13	102±2.93	0.603	265

Discussion

The results of the present study demonstrated that the three cyprinid species common carp, grass carp, and silver carp could sustain growth rates during winter in southern Iraq under restricted feeding conditions. This outcome confirms that the natural productivity of fertilized earthen ponds, combined with the thermal tolerance of these species, is sufficient to support overwintering survival and moderate growth.

Water temperature proved to be a determining factor in growth performance. Lower average temperatures in 2016 and 2017 were associated with lower weight gain in common carp and grass carp, yet silver carp displayed superior adaptability, achieving the highest specific growth rate (SGR) in 2016 (2.355% g/day). These findings are consistent with previous studies (Siddik *et al.* ,2014; Shahjahan et al., 2017; Volkoff and Rønnestad, 2020), which reported enhanced cold tolerance and metabolic flexibility in certain carp species. Interestingly, while common carp exhibited lower SGR in 2017, it

achieved the highest gross production, suggesting that other factors such as initial body size and population dynamics may influence final yields.

The observed variation in growth among years and species may also be attributed to fluctuations in dissolved oxygen and pH levels. Although all recorded values were within the tolerance range for cyprinids (Michael, 1969; Likongwe *et al.*, 1996; Nasir *et al.* 2019), indirect interannual differences could have influenced feeding behavior and energy conversion efficiency. Additionally, the absence of artificial feeding could have favored species with greater filter-feeding efficiency or better utilization of natural pond resources, such as silver carp.

Compared to earlier regional studies (Al-Shamma *et al.*, 1996; Taher, 1986), which reported limited or negative growth of common carp during winter, the current findings suggest that even under natural feeding regimes, fish can attain measurable growth. The application of organic fertilization prior to stocking may have enhanced plankton availability and contributed to this outcome (Vromant *et al.*, 2002; Hussein, 2012).

While growth rates were lower than those typically reported during warmer seasons (Handeland *et al.*, 2008; Pang *et al.*, 2016), the data demonstrate that winter culture can be a viable component of year-round production strategies. The adoption of restricted feeding in winter may reduce operational costs, particularly feed and labor, without severely compromising fish health or future growth potential. However, further research incorporating controlled feeding trials and economic analysis would be necessary to optimize these strategies. The study contributes novel data on the overwintering performance of cyprinids in subtropical earthen pond systems, a topic that remains underrepresented in aquaculture literature. By documenting species-specific responses to winter conditions over three successive years, the findings provide a foundation for developing climate-adapted aquaculture models in regions with similar environmental constraints.

Conclusions

This study showed that overwintering in earthen ponds allowed all three cyprinid species—common carp, grass carp, and silver carp—to maintain or gain weight without supplementary feeding. While silver carp exhibited the highest growth rates, common carp achieved the greatest production output. Grass carp showed lower performance in later years. Overall, winter rearing with natural food and restricted feeding can be effective for maintaining fish condition and reducing costs.

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تأثير التشتية على ثلاثة أسماك من نوع الشبوطيات المرباة في أحواض ترابية في محافظة البصرة، جنوب العراق

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المستخلص

هدفت هذه الدراسة الحالية إلى تقييم تأثير ظروف الشتاء والتغذية المقيدة على أداء نمو ثلاثة أنواع من أسماك الكارب، وهي الكارب الشائع (*Cyprinus carpio*)، والكارب العشبي (*Ctenopharyngodon idella*)، والكارب الفضي (*Hypophthalmichthys molitrix*)، المُرباة في أحواض ترابية في محافظة البصرة، جنوب العراق. أُجريت التجربة خلال فصول شتاء 2015 و2016 و2017 في حوضين في مركز علوم البحار، حيث زُوّدت كل منهما بكثافة 5000 سمكة/هكتار، بتركيبة أنواع تتكون من 50% من الكارب الشائع، و30% من الكارب العشبي، و20% من الكارب الفضي. غذّيت الأسماك على الغذاء الطبيعي فقط دون أي تغذية تكميلية. تراوحت حرارة الماء بين 9.2-18.1 °م خلال فصول الشتاء المدروسة. تباين أداء النمو، الذي يُقيَّم من خلال زيادة الوزن ومعدل النمو النوعي (SGR)، بين الأنواع والسنوات. سُجِّلت أعلى معدلات نمو لأسماك الكارب الشائع، الكارب العشبي، الكارب الفضي في عام 2016، إذ بلغت 0.719٪، و1.195٪، و2.355٪ غم/يوم، على التوالي. وبلغ الإنتاج الإجمالي ذروته في عام 2017، حيث بلغ 705 كغم/هكتار/90 يوماً للكارب الشائع، و265 كغم/هكتار/90 يوماً للكارب الفضي. وتشير النتائج إلى أن التربية الشتوية مع التغذية المقيَّدة قد تُؤدي إلى معدلات نمو مقبولة، وخاصةً للكارب الفضي، ويمكن أن تُخفِّض تكاليف التشغيل. تنفيذ مثل هذه الاستراتيجيات التغذوية قد يُحسّن إنتاج الأسماك من خلال تقليل العمالة ومدخلات التغذية خلال الأشهر الباردة.

الكلمات المفتاحية: الكارب الشائع، الكارب العشبي، الكارب الفضي، النمو خلال الشتاء، معدل النمو النوعي، التغذية المقيدة، الأحواض الترابية.