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The Effect of Stocking Density on Yield, Growth, and Feed Efficiency of Himri Barbel (*Barbus luteus*) Nursed in Cages

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Abstract

Himri barbel (*Barbus luteus* Heckel, 1843) fingerlings (mean wt 15.73 g) were stocked at 40, 60, 80, or 100 fish per cage in 1-m^3 cages suspended in a reservoir lake to determine total yield, growth rate, and feed efficiency after seven months. Total yields increased as the stocking density increased and were 3.59, 4.80, 6.32, and 7.91 kg per cage, respectively. The highest mean fish weight was obtained in the lowest stocking density. Neither the food conversion ratio nor the mortality rate was affected by stocking density.

Introduction

Fish farmers are seeking alternative species for intensive aquaculture, targeting high market value species that are easy to domesticate and rear. The himri barbel, an indigenous cyprinid in the Mesopotamian basin, is a highly valuable food fish in the region. Since it is omnivorous and a detritus feeder (Epler et al., 2001), it may be possible to adapt it to aquaculture in polyculture ponds. Barbel specimens have adapted to earthen ponds stocked with common carp (*Cyprinus carpio*) and other cyprinids after accidentally entering the ponds with water inflow from the nearby Euphrates River. Therefore, this fish could become a new aquaculture species (Al-Hazza and Hussein, 2003a).

The biology of the species in Iraq, Syria, and Turkey has been studied (Epler et al., 1996, 2001; Szypula et al., 2001; Al-Hazza, 2005), but there is little information on its culture (Al-Hazza and Hussein, 2003ab). Overexploitation of natural stocks and deteriorated environmental conditions have caused a marked decline of the wild himri barbel population. Recent research has attempted to propagate the species artificially for conservation and aquaculture purposes. Determining the optimum stocking density is critical in designing cage culture systems. The aim of this study was to determine the optimum stocking density of himri barbel fingerlings in floating net cages under culture conditions.

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Materials and Methods

Fingerlings. Himri barbel (*Barbus luteus* Heckel, 1843) fingerlings were produced from a broodstock kept in captivity in the aquaculture unit of Mustafa Kemal University, Antakya Hatay, Turkey. The larvae were nursed in a pond fertilized with poultry manure before the experiment and gradually weaned to a commercial trout diet (Camli Yem A.S., Izmir, Turkey) that was ground and pressed through a 250-µm sieve. After initial nursing, the fingerlings were kept in cages for an adaptation period of three weeks, during which they were fed pellets.

Experimental facilities and stocking. The experiment was a completely randomized design in which four stocking densities were applied in triplicate. The experiment was conducted in a reservoir lake (mean depth 7 m) at the Department of Aquaculture, Faculty of Fisheries, Mustafa Kemal University, Turkey. Twelve cages (1 x 1 x 1.25 m) were made of 5-mm mesh polyethylene netting and wooden frames. The submerged volume of each cage was 1 m^3. Plastic receptacles (50-l) were attached to the four sides of each cage as floats. The cages were stocked in April 2005 with a total of 840 fish (avg wt 15.73 g) at one of four densities (40, 60, 80, or 100 fish/m^3) and harvested 210 days later in October 2005. The fingerlings were treated with a formalin solution (200 ppm) for 3-5 min before being stocked into the experimental cages.

Diet and feeding. A commercial carp diet (Camli Yem A.S., Izmir, Turkey) was used during the experiment. The diet contained cereal grains, fish products, oil seed products, land animal oils, fats, and minerals. The proximate composition of the diet, analyzed according to AOAC (1990), was 12% moisture,12% crude lipid, 28% crude protein, 3% crude cellulose, 13% crude ash, and 280.38 kcal/kg digestible energy. The daily amount of feed was determined according to fish appetite and delivered to the fish by hand twice a day (at 08:30 and 18:30).

Sampling and measurements. Fish from each cage were collectively weighed at 15-day intervals and average weights were recorded. Once a week, dissolved oxygen was measured with an O_2-meter (YSI-52), pH with a pH-meter (Hanna), and total ammonia nitrogen with a spectrophotometer. Parameters were measured at 05:30. The specific growth rate (SGR) and feed conversion ratio (FCR) were estimated using the following equations: SGR = 100(ln final wt - ln initial wt)/time and FCR = dry feed intake/wet wt gain.

Statistical analyses. One-way analysis of variance (ANOVA) was used to compare growth rates, feed conversion ratios, and survival. All data were analyzed using the SPSS computer program (SPSS System for Windows, Version 10.0). The Duncan test was used to determine differences among treatment means when F-values from the ANOVA were significant (El-Sayed, 2002). Differences were considered significant when $p<0.05$.

Results

The highest individual weight gain was obtained in the lowest stocking density (Table 1; Fig. 1). FCR and survival were similar in all treatments. Water temperature, pH, dissolved oxygen, and total ammonia nitrogen (TAN) are given in Table 2. Although FCR was not affected by stocking density, it was less efficient in July-August due to the higher water temperature (Fig. 2).

Discussion

Stocking density is one of the most important factors affecting growth, yield, and survival of cultured fish (Smith et al., 1978). As fish density increases, competition for food and living space intensifies. Cultures can be either density-dependent or density-independent (Huang and Chiu, 1997). When stocking density negatively affects fish growth, the culture is density-dependent. In this study, the results appear to be density-dependent. The total harvest was clearly enhanced by increasing the stocking density and, even though individual weights were lower, the highest density produced the highest total yield.

Lower growth in higher stocking densities is generally related to poor water quality, competition for food, social interaction, aggressive behavior, or neurohormonal and/or metabo-

Table1. Growth, feed conversion ratio, and survival of himri barbel during 210 days of nursing at different stocking densities.

	Stocking density (fish/m³)			
	40	*60*	*80*	*100*
Mean initial wt/fish (g)	15.70±0.10[a]	15.73±0.15[a]	15.77±0.06[a]	15.73±0.10[a]
Mean final wt/fish (g)	93.70±0.70[a]	88.93±1.54[b]	84.97±0.95[c]	86.17±3.54[bc]
Biomass at harvest (g)	3591.33±27.45[a]	4800.00±1.54[b]	6316.33±73.26[c]	7927.64±324.46[d]
Total net wt gain (g)	2964.00±28.58[a]	3856.82±351.29[b]	5054.73±67.90[c]	6354.64±318.26[d]
SGR (%)	0.827±0.006[a]	0.803±0.006[ab]	0.790±0.010[b]	0.787±0.025[b]
FCR	1.71±0.09[a]	1.74±0.06[a]	1.71±0.08[a]	1.75±0.07[a]
Survival (%)	95.83±1.44[a]	89.97±7.26[a]	92.92±1.44[a]	92.00±6.25[a]

Means with different superscripts significantly differ at $p<0.05$ (one-way ANOVA).

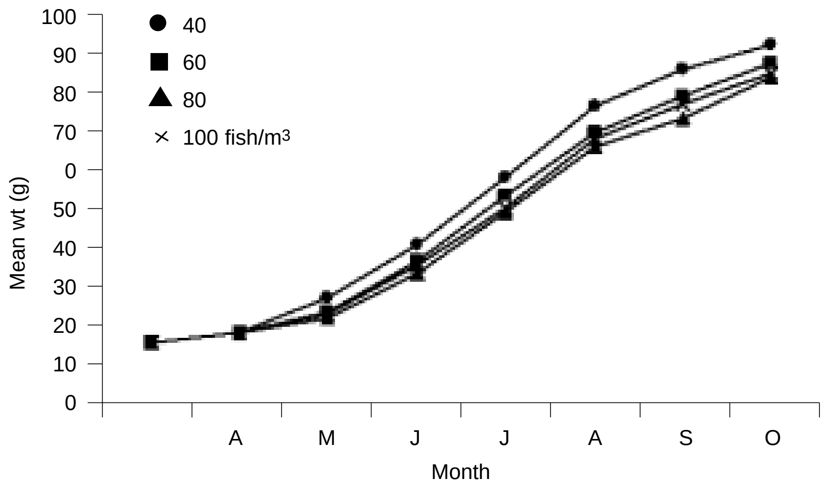

Fig. 1. Mean weight of himri barbel fry stocked at different densities.

lism-related changes associated with high stocking density (Vijayan and Leatherland, 1988; Alanara and Brannas, 1996; Montero et al., 1999, 2001). In the present experiment, water quality was not affected by stocking density. The reduction in growth could have been related to the observed reduced food consumption and food efficiency, probably caused by stress. Competition for food or space may have been responsible for the growth differences (Canario et al., 1998; Papoutsoglou et al., 2006).

Table 2. Water quality during nursing of himri barbel fry in cages in a reservoir lake.

	Temperature (°C)	*Dissolved oxygen (mg/l)*	*pH*	*TAN (mg/l)*
Apr	18.09±2.6	7.22±0.12	8.70±0.96	0.637±0.012
May	20.11±3.12	6.95±0.14	8.25±0.95	0.5349±0.009
Jun	24.39±3.36	6.34±1.05	8.47±0.12	0.2657±0.024
Jul	29.11±1.12	5.60±0.96	8.57±0.10	0.2145±0.001
Aug	33.87±0.26	5.20±0.54	8.45±0.12	0.2879±0.002
Sep	26.12±4.23	6.10±0.32	8.55±0.12	0.4461±0.014
Oct	23.79±2.11	6.99±3.10	8.53±0.10	0.6927±0.002

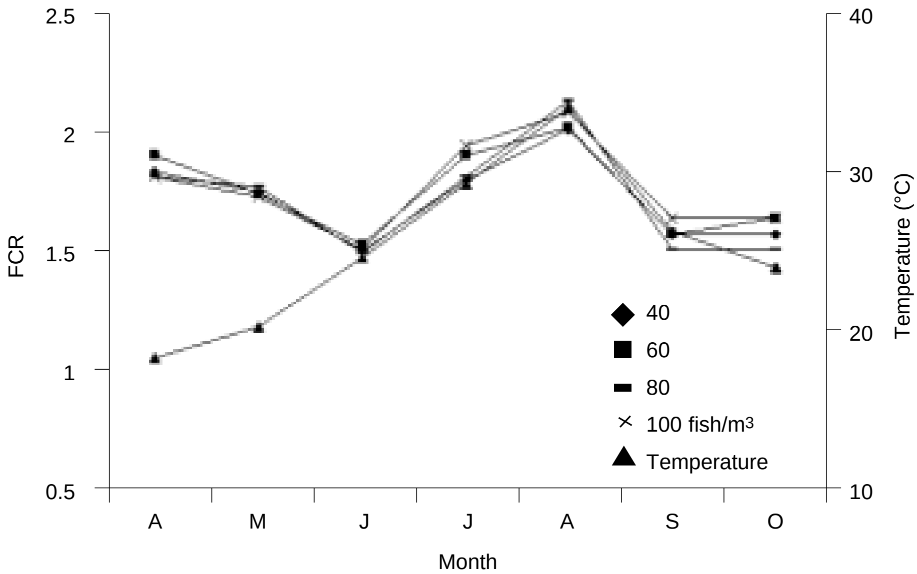

Fig. 2. Feed conversion ratio of himri barbel fry stocked at different densities.

In general, growth performance was low, possibly because of the low protein and energy commercial diet. The nutritional requirements of this species are unknown and himri barbel cultured in cages may require higher levels of protein, energy, vitamins, and minerals for optimal growth. Additional experiments should be conducted to determine these parameters.

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