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The Effects of Feeding Level and Stocking Density on the Growth and Feed Efficiency of Himri Barbel Fry, *Barbus luteus* (Heckel, 1843)

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Abstract: Two stocking densities (20 and 40 fry/80-l tank) with 4 feeding rates (2.5%, 5.0%, 7.5%, and 10.0% body weight/day) were used to determine the optimum feeding level for himri barbel fry during a 60-day culture period. Water quality parameters (temperature, dissolved oxygen, pH, and total ammonia nitrogen) were monitored during the experiment. Final body weight and specific growth rate (SGR) was significantly lower with the 2.5% feeding rate than with the others, at both stocking densities; however, no significant differences were observed between the other feeding rates and between stocking densities. The best feed conversion ratio (FCR) of 1.37 was achieved with the 2.5% feeding rate and stocking density of 40 fry/80 l; yet, in terms of total yield and survival the optimal FCR of 1.50 was obtained with the 5.0% feeding rate and 40 fry/80 l. At the 10.0% feeding rate survival rates were significantly lower. Both feeding ratio and stocking density also affected water quality parameters.

Key Words: Himri barbel, feeding levels, stocking density, growth performance, feed conversion, survival rate

Yemleme Seviyesi ve Stoklama Yoğunluğunun Sarıbenli Balığı, *Barbus luteus*, Yavrularının Gelişimi ve Yem Değerlendirmesi Üzerine Etkileri

Özet: Sarıbenli balığı yavrularının optimum besleme seviyesinin belirlenmesi amacıyla üç tekerrürlü iki stoklama yoğunluğu (20 ve 40 fry/80-l tank) ile 4 yemleme seviyesi (% 2,5, % 5,0, % 7,5, % 10,0)'den oluşan 60 günlük bir deneme kurulmuştur. Deneme boyunca su kalitesi parametrelerinden sıcaklık, çözünmüş oksijen, pH, toplam amonyak azotu izlenmiştir. Deneme sonu vücut ağırlığı ve spesifik büyüme oranı her iki stoklama yoğunluğunda da % 2,5 yemleme oranında belirgin olarak daha düşük bulunmuştur. Bununla beraber, diğer yemleme seviyeleri ve stoklama yoğunluklarında belirgin farklılıklar gözlenmemiştir. En iyi yem değerlendirme oranı (YDO) 1,37 ile % 2,5'luk yemleme oranı ve 40 fry/80 l'lik grupta elde edilmiştir. Ancak toplam ürün miktarı ve yaşam oranı dikkate alındığında, optimum YDO olan 1,5, % 5,0'lik yemleme seviyesi ve 40 fry/80 l'lik grupta sağlanmıştır. % 10,0'luk yemleme oranında yaşam oranı belirgin olarak düşmüştür. Su kalitesi parametreleri de günlük yemleme oranı ve stoklama yoğunluğu tarafından etkilenmiştir.

Anahtar Sözcükler: Sarıbenli, yemleme seviyesi, stoklama yoğunluğu, büyüme performansı, yem değerlendirme, yaşama oranı

Introduction

Fish farmers desire alternative fish species suitable for aquaculture. They target species of high market value that are easy to domesticate and rear. Himri barbel is an indigenous cyprinid in the Mesopotamia Basin and is a valuable food source in the region. It is an omnivorous species that feeds mainly on detritus (1). Its adaptation to earthen ponds was observed when it was accidentally pumped into carp fishponds located near the Euphrates River (2); therefore, himri barbel could be considered a

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potential new species for the region's aquaculture (3). On the other hand, over-exploitation of natural stocks and the deterioration of environmental conditions have resulted in a marked decline in wild populations of himri barbel (3,4). Recent studies have attempted to propagate this species artificially for conservation and aquaculture purposes (3-6); however, most of the zootechnical aspects of the species that are important for successful commercial aquaculture have not been evaluated. The aim of the present study was to determine the optimum feeding level of himri barbel fry under culture conditions at 2 different stocking densities.

Materials and Methods

Himri barbel fry were produced from local broodstock in captivity in the aquaculture department of Mustafa Kemal University, Antakya, Hatay, Turkey. Poultry manure (3 kg/100 m^2) was used to fertilize the nursery pond biweekly. The fish were weaned during a 45-day period by substituting plankton with a commercial trout diet ground and sieved to 250 µm. After nursing, the fry were transferred to the research unit and held for a 2-week acclimatization period before the study began.

A commercial trout diet was used during the experiment. The proximate composition of the diet was analyzed in our laboratory, according to Official Methods of Analysis (7). The diet contained 12% moisture, 12% crude lipid (CL), 45% crude protein (CP), 3% crude cellulose (CC), 13% crude ash (CA), and 3573.8 kcal/kg of digestible energy.

Sixty-day-old fry were sorted to select similarly sized individuals that were randomly distributed into 80-l tanks. Aeration was provided by an air compressor and water temperature was maintained at a constant 26 °C. Feces and waste feed were siphoned from the tanks every 3 days until day 15, every 2 days until day 45, and every day for the remainder of the study.

A 4 × 2 factorial design was used for the 4 feeding rates (2.5%, 5.0%, 7.5%, and 10.0% body weight (BW)/day) and 2 stocking densities (20 and 40 fry/80-l tank.) All treatments were performed in triplicate, meaning that there were 24 tanks in use (4 × 2 × 3 = 24). Himri fry with an average weight of 0.71 ± 0.22 g were stocked into the tanks and fed the commercial diet 3 times/day (08:30, 12:30, and 16:30) for 60 days, according to our previous study (6). Fish in each tank were weighed (± 0.01 g) collectively every 15 days and their average weights were recorded.

Water quality parameters were monitored weekly as follows: dissolved oxygen (DO) with a YSI-52 model O_2-meter, pH with a Hanna pH-meter, and total ammonia nitrogen (TAN) with a spectrophotometer. Un-ionized ammonia nitrogen (UIA-N) concentrations were calculated from TAN measurements using pH and temperature values.

The specific growth rate (SGR) and feed conversion ratio (FCR) were calculated using the following equations:

Specific Growth Rate (%) = 100 (ln final weight – ln initial weight)/time(days);

Feed Conversion Ratio = dry feed intake (g)/wet weight gain (g).

One-way analysis of variance (ANOVA) was used to compare growth rate, feed conversion ratio, and survival rate between treatments. All data were analyzed using the SPSS computer program (8). Tukey's test was used to determine the differences between treatment means when F-values from ANOVA were significant. For all statistical analyses, $P \leq 0.05$ was considered significant.

Results

Results of the experiment show that feeding level and stocking density significantly affected fry growth performance, FCR, and survival rates (Table 1). The maximum weight gain was achieved in fish fed 7.5% BW/day and stocked at 20 fry/80 l, but no significant differences in growth performance were observed between the 5.0%, 7.5%, and 10.0% BW/day feeding groups at both stocking densities (Figure 1). Growth performance was extremely poor in fish fed 2.5% BW/day. SGR was lowest at the 2.5% BW/day feeding rate at both stocking densities, and was highest at the 10.0% BW/day feeding rate at the 20 fry/80-l density, and at the 7.5% BW/day at the 40 fry/80 l-density ($P < 0.05$) (Table 1). FCR was also significantly affected by the feeding rate. In contrast to growth performance, FCR was better at the 2.5% and 5.0% feeding rates than at the other rates (Figure 2).

The survival rate ranged between 88% (10% BW/day treatment) and 100% ($P < 0.05$).

Mean (± SD) water quality parameters are presented in Table 2. Water quality parameters, excluding temperature, varied significantly among the treatments. Dissolved oxygen decreased as feeding level at the same stocking

Table 1. Growth performance, FCR, and survival rates of himri barbel fry during the experiment. Values in the same line followed by the same superscript are not significantly different (P > 0.05).

	20 fry				40 fry			
Parameters	2.5%	5.0%	7.5%	10.0%	2.5%	5.0%	7.5%	10.0%
Initial body weight	0.72 ± 0.04	0.71 ± 0.41	0.70 ± 0.93	0.71 ± 0.23	0.71 ± 0.24	0.72 ± 0.01	0.71 ± 0.15	0.72 ± 0.07
Final body weight	1.71 ± 0.01^{a}	3.25 ± 0.29^{b}	3.37 ± 0.57^{b}	3.25 ± 0.40^{b}	1.73 ± 0.11^{a}	3.19 ± 0.20^{b}	3.23 ± 0.01^{b}	3.04 ± 0.11^{b}
SGR	1.39 ± 0.01^{a}	2.52 ± 0.12^{bc}	2.51 ± 0.24^{bc}	2.60 ± 0.03^{c}	1.48 ± 0.10^{a}	2.47 ± 0.08^{bc}	2.48 ± 0.05^{bc}	2.35 ± 0.48^{b}
FCR	1.41 ± 0.02^{a}	1.43 ± 0.15^{a}	2.48 ± 0.45^{b}	3.20 ± 0.01^{c}	1.37 ± 0.13^{a}	1.50 ± 0.17^{a}	2.42 ± 0.14^{b}	3.61 ± 0.14^{d}
Survival (%)	97^{a}	100^{a}	95^{a}	88^{b}	100^{a}	99^{a}	97^{a}	90^{b}

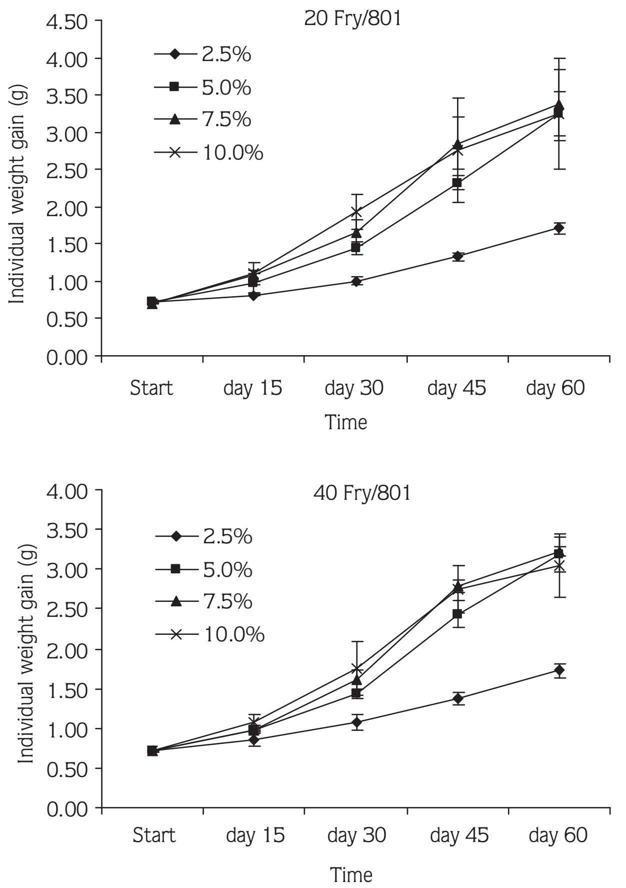

Figure 1. Mean weight gain (g) of himri fry at different feeding rates and stocking densities.

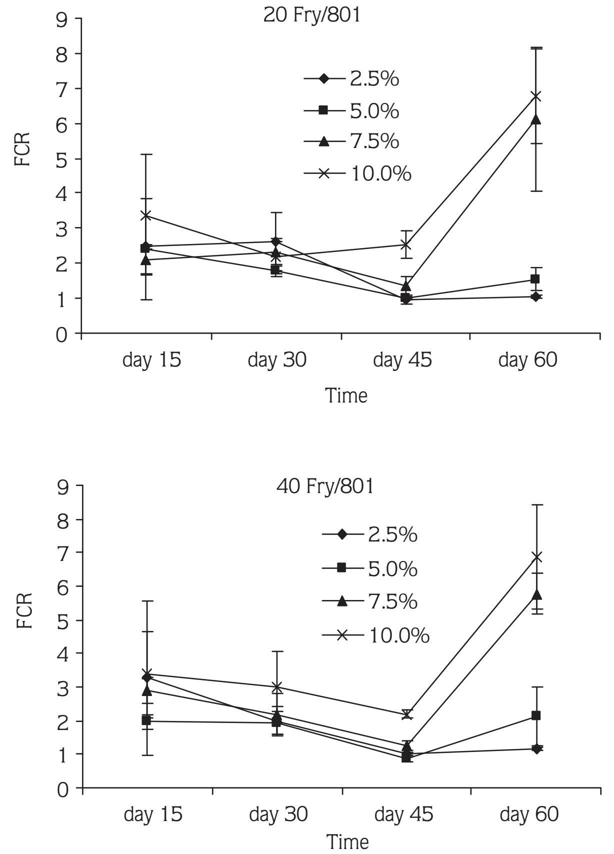

Figure 2. FCR of himri fry at different feeding rates.

Table 2. Water quality parameters of himri barbel fry during the experiment. Values in the same line followed by the same superscript are not significantly different (P > 0.05).

	20 fry				40 fry			
Parameters	2.5%	5.0%	7.5%	10.0%	2.5%	5.0%	7.5%	10.0%
Temp. (°C)	26.2 ± 0.75	26.3 ± 0.74	26.4 ± 0.70	26.4 ± 0.12	26.4 ± 0.93	26.3 ± 0.76	26.1 ± 1.00	26.3 ± 0.15
DO (mg l^{-1})	7.75 ± 0.61^{e}	6.89 ± 0.53^{d}	6.75 ± 0.13^{d}	6.01 ± 0.11^{a}	7.65 ± 0.22^{e}	6.42 ± 0.12^{c}	6.22 ± 0.21^{b}	5.89 ± 0.73^{a}
pH	7.71 ± 0.22^{a}	7.79 ± 0.13^{a}	8.13 ± 0.24^{b}	8.45 ± 0.51^{d}	7.99 ± 0.11^{ab}	8.01 ± 0.79^{b}	8.25 ± 0.89^{c}	8.88 ± 0.12^{e}
TAN	0.097 ± 0.001^{a}	0.192 ± 0.019^{b}	0.231 ± 0.011^{c}	0.239 ± 0.034^{c}	0.189 ± 0.002^{b}	0.322 ± 0.007^{d}	0.378 ± 0.046^{e}	0.422 ± 0.091^{f}
UIA-N (mg NH_3-N l^{-1})	0.0022 ± 0.0009^{a}	0.0069 ± 0.0013^{ab}	0.0166 ± 0.0003^{c}	0.0315 ± 0.0022^{d}	0.0108 ± 0.0017^{b}	0.0183 ± 0.0009^{c}	0.0359 ± 0.0016^{d}	0.1165 ± 0.0002^{e}

density increased, and decreased as the stocking density at the same feeding level increased. Mean TAN concentration was significantly higher at the 40 fry/80-l density than at the 20 fry/80-ldensity ($P < 0.05$). Mean pH also increased as the feeding rate at the 20 fry/80-l stocking density increased. Increasing stocking density (40 fry) elevated pH levels. Mean UIA-N concentration increased as pH increased ($P < 0.05$).

Discussion

Stocking density and feed rate are important factors affecting growth, total yield, and survival of cultured fish (9). As fish density increases, competition for food and living space intensifies in the culture system. The effect of stocking density can be divided into 2 categories: density-dependent and density-independent (10). If the stocking density negatively affects the growth of fish, it is considered to be density-dependent, such as reported for Chinook salmon (*Oncorhynchus tshawytscha*) (11), Nile tilapia (*Oreochromis niloticus)* (12), and African catfish (*Clarias gariepinus*) (13). In contrast, growth and survival rates have been reported to be density-independent by many authors, for example for Walleye (*Sitzostedion vitreum*) (14,15), Golden Shiner (*Notemigonus crysoleucas*) (16), and *Oreochromis spilurus* (17). In the present study, himri fry was observed to be density-independent. The higher stocking density did not negatively affect himri barbel fry final body weight; however, survival and SGR rates declined at the higher stocking density, evidence that some competition for food and living space occurred in the present study.

The results of the present study clearly indicate that the feeding rate had a profound effect on fry growth and survival. At the lowest feeding rate (2.5%), FCR and growth rates were significantly lower than at the other feeding rates, at both stocking densities. FCR values started to decrease with the 2.5% and 5% feeding rates after 30 days, and were significantly lower on day 60 (Figure 2).

While the amount of feed offered to fish has a significant bearing on the growth rate, feed can also have a negative effect on growth by contributing to the deterioration of water quality (18). In the present study, oxygen consumption rates were higher at higher feeding rates due to uneaten feed, feces, and fry (Table 2). Furthermore, TAN concentration was higher at the high stocking density (40 fish/80 l) than at the low stocking density (20 fish/80 l), except for the 2.5% BW/day feed rate at the high stocking density. A significant amount of uneaten feed was siphoned by drainage pipes, which might have deteriorated the water quality, leading to stressful conditions. Thus, low dissolved oxygen levels were measured at high feeding rates at both stocking density treatments.

Total ammonia actually exists in water in 2 forms, the ammonium ion (NH_4^+) and un-ionized ammonia (NH_3), with relative concentrations being pH- and temperature-dependent (19). The un-ionized form is the most toxic due the fact that it is uncharged and thus traverses biological membranes more readily than the charged and hydrated NH_4^+ ions. Significantly lower survival rates were recorded at the 10% feeding rate at both stocking densities, possibly due to a high TAN concentration combined with high pH levels at this feeding rate. UIA-N ratios in TAN increased as the feeding rate increased, which also caused pH values to increase. Jingbo et al. (20) reported that the 96-h LC sub(50) values for silver carp, bighead carp, and common carp fingerlings in 15 °C-water were 0.38, 0.30, and 0.66 mg NH_3/l (un-ionized ammonia), respectively. The 96-h LC 50 value for common carp then dropped considerably from 0.66 mg NH_3/l to 0.44 mg NH_3/l when the water temperature increased from 15 to 20 °C. In the present study the highest mean UIA-N concentration was 0.1165 mg NH_3/l at 26 °C, which was measured in the 40 fry/8-l stocking density and 10% feeding rate group.

According to the results of the present study, a diet containing 45% dietary protein fed at the rate of 10% BW/day until the end of the first month, 7.5% BW/day until day 45, and, finally, 5% BW/day until day 60 at the stocking density of 40 fry/80-l tank can be recommended for himri barbel fry. The cultured fish did not significantly increase in weight as the feeding rate increased. Thus, over feeding resulted in a waste of feed.

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