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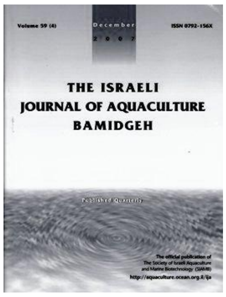

Nibbling Frequency of Carps in Periphyton-Based Aquaculture Systems with and without Supplemental Feed

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Abstract

The nibbling frequency of five carp species (rohu *Labeo rohita*, mrigal *Cirrhinus mrigala*, catla *Catla catla*, common carp *Cyprinus carpio*, silver carp *Hypophthalmichthys molitrix*) on bamboo lateral sticks (kanchi) colonized by periphyton was examined in fed and unfed systems. There were three treatments: (a) no carp and no supplemental feed (control), (b) carp without supplemental feeding (unfed treatment), and (c) carp with supplemental feeding (fed treatment). For 12 h (07:30-19:30) during six days, nibbling behavior was observed in real time via a digital video camera and recorded on a camcorder for later viewing. Rohu, catla, and common carp nibbled on the kanchi, while mrigal and silver carp did not. In rohu and catla, the nibbling frequency was significantly higher in the unfed treatment than in the fed treatment ($p<0.05$); supplemental feeding reduced nibbling frequency by 81% and 91%, respectively. Hence, in periphyton-based aquaculture systems, there is no need for a high density of substrates in ponds that receive supplemental feed. Alternatively, the amount of supplied feed can be reduced to force these species to consume more periphyton.

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Introduction

Few fish species are grown in periphyton-based aquaculture systems, and 80% of them are carps. Not all carp species are capable of using periphyton. Rohu (*Labeo rohita)*, kalbaush (*Labeo calbasu*), and gonia (*Labeo gonia*) graze on periphyton in aquaria (Rahmatullah et al., 2001). Other herbivore and omnivore species including hybrid tilapia (*Oreochromis niloticus* x *O. aureus*; Milstein et al., 2005, 2008) catla (*Catla catla*), common carp (*Cyprinus carpio*), and mrigal (*Cirrhinus mrigala*) do not directly feed on periphyton, but periphyton-based systems are suitable for them (Azim et al., 2002a).

Information on grazing by fish can be obtained by observation (number of bites during a defined time period) or measuring the difference in biomass on artificial substrates before and after grazing (Van Dam et al., 2002). Knowing the food preferences of carps will help to select species and prepare culture packages for periphyton-based aquaculture systems. In the present experiment, we determined the nibbling frequency of rohu, catla, mrigal, common carp, and silver carp (*Hypophthalmichthys molitrix*) on bamboo sticks with and without supplemental feeding.

Materials and Methods

The experiment was conducted in glass aquaria (1.21 x 0.51 x 0.52 m) from 27 August to 1 September 2007 in the laboratory of the Asian Institute of Technology, Thailand. The experiment included three treatments: (a) no fish and no supplemental feeding (control); (b) fish but no supplemental feeding (unfed treatment), and (c) fish with supplemental feeding (fed treatment). The experiment was carried out in a completely randomized block design with three time blocks (07:30-11:30, 11:30-15:30, 15:30-19:30) and three replicates.

Periphyton were allowed to grow on bamboo sticks for one month in a pond fertilized with urea and trisodium phosphate (TSP) at 28 kg N and 7 kg P/ha/week, respectively. Each day of the 6-day experiment, two aquaria were filled with pond water and tap water (1:16) to a depth of 45 cm. One aquarium was used for the control and the other for either the fed or the unfed treatment. Two bamboo sticks were collected from the periphyton-colonization pond on the same day and fixed in the aquaria, one in each aquarium.

The fed or unfed aquaria were stocked with five fish from each carp species: rohu (20.1±0.6 g), catla (22.2±2.3 g), mrigal (14.2±0.7 g), common carp (22.2±1.3 g), and silver carp (16.9±1.1 g). Prior to the experiment, the fish were graded, fasted for 48 h, and acclimatized in the aquaria for one day. In the fed treatment, fish were given ground feed (25% crude protein) at 09:00 and 16:00 at 5% of their body weight per day.

Nibbling on the bamboo sticks was observed for 12 h (07:30-19:30). A digital video camera (D-Link Corporation, Taiwan) connected to a monitor was placed on one side of the aquarium. The monitor was placed in another room, far from the digital camera and aquarium, to make sure that the presence of the observer did not influence the behavior of the fish. The number of bites was recorded by the observer as they occurred. Simultaneously, a camcorder (JVC Everio GZMG130) was placed in front of the aquarium, at a right angle to the digital camera, so that the front, back, and sides of the aquarium could be viewed. Fish nibbling recorded by the camcorder was viewed later, after the experiment.

Periphyton samples were collected every night after the experiment from the water surface (0-15 cm), middle (15-30 cm), and bottom (30-45 cm) of the aquaria and placed on aluminum foil. Periphyton biomass was analyzed following Azim et al. (2002a) and consumed periphyton was estimated by subtracting the biomass on the bamboo stick in the fed or unfed treatment from the biomass on the bamboo stick in the control.

Nibbling data were analyzed by two-way analysis of variance (ANOVA) followed by Student's t test with treatment (fed or unfed) and time (morning, afternoon, evening) as factors, using SPSS (version 12.0) statistical software (SPSS, Chicago, IL, USA). Periphyton biomass data were analyzed by Student's t test. Differences were considered significant at a level of 0.05.

Results

Only rohu, catla, and common carp were observed nibbling on the bamboo stick in both the fed and unfed treatments (Table 1). The mean nibbling frequency of rohu and catla was significantly higher in the unfed treatment than in the fed treatment. The nibbling frequency of rohu was significantly affected by time in the unfed treatment, with a higher rate in the afternoon than in the morning or evening. The consumed periphyton biomass, in terms of dry matter and ash-free dry matter remaining on the bamboo sticks at night, was significantly higher in the unfed treatment than in the fed treatment (Table 2). In terms of ash content, there was no significant difference.

Table 1. Nibbling frequency (no. bites) of carps on periphyton-colonized bamboo sticks during morning (07:30-11:30), afternoon (11:30-15:30), and evening (15:30-19:30) in aquaria that did or did not receive supplemental feed (fed and unfed treatments, respectively).

	Species									
	Rohu		*Catla*		*Mrigal*		*Common carp*		*Silver carp*	
	Unfed	*Fed*	*Unfed*	*Fed*	*Unfed*	*Fed*	*Unfed*	*Fed*	*Unfed*	*Fed*
Morning	6.7 ± 0.9^{ay}	1.7 ± 0.3^{bx}	1.0 ± 0.0^{ax}	1.0 ± 0.6^{ax}	0	0	0.7 ± 0.7^{ax}	0.7 ± 0.7^{ax}	0	0
Afternoon	18.3 ± 1.7^{ax}	2.7 ± 0.7^{bx}	11.7 ± 4.8^{ax}	0^{ax}	0	0	5.0 ± 2.5^{ax}	0^{ax}	0	0
Evening	2.3 ± 1.9^{ay}	0.7 ± 0.3^{ax}	0.7 ± 0.7^{ax}	0.3 ± 0.3^{ax}	0	0	0.3 ± 0.3^{ax}	0^{ax}	0	0
Mean±SE	9.1 ± 4.3^{a}	1.7 ± 0.6^{b}	4.4 ± 4.0^{a}	0.4 ± 0.4^{b}	0	0	2.0 ± 1.8^{a}	0.2 ± 0.4^{a}	0	0

Values with the same superscript do not significantly differ ($p>0.05$).
Notations a and b refer to horizontal comparisons between treatments; notations x and y refer to vertical comparisons between time periods; both within the same species.

Table 2. Periphyton biomass (means±SE) consumed by carps in aquaria that did or did not receive supplemental feed (fed and unfed treatments, respectively).

	Unfed experiment			*Fed experiment*		
	Control	*Unfed treatment*	*Consumed by fish*	*Control*	*Fed treatment*	*Consumed by fish*
Dry matter (mg/cm)	1.78±0.22	1.34±0.19	0.44 ± 0.04^{a}	2.08±0.46	1.87±0.48	0.22 ± 0.04^{b}
Ash-free dry matter (mg/cm)	1.57±0.22	1.28±0.21	0.29 ± 0.05^{a}	1.78±0.41	1.65±0.40	0.13 ± 0.01^{b}
Ash (%)	14.9±1.0	13.6±1.4	1.3±0.91	16.3±2.1	15.3±2.5	1.05±0.48

Discussion

Only rohu, catla, and common carp nibbled the bamboo stick. Nibbling frequency was highest in rohu, then in catla and in common carp. Rohu is a periphyton feeder (Wahab et al., 1999; Azim et al., 2002b); its subterminal transverse mouth and thick fringed lips might be advantageous for grazing on periphyton (Chakrabarty, 1998). Catla and common carp grazed on the periphyton, which consisted of an assemblage of algae and zooplankton that are part of the natural diet of these species (Azim et al., 2002b; Saikia and Das, 2009). In contrast, catla did not graze on periphyton growing on bamboo substrates in ponds (Azim et al., 2002a). However, the present experiment proves that catla are able to graze on periphyton, at least when there is no other available food. The difference in results might be explained by the fact that the findings of Azim et al. (2002a) were based on the ratio of nitrogen to carbon isotopes in the fish body, while results in our experiment were based on observation.

The mrigal and silver carp showed a negative preference for the periphyton by not grazing on the bamboo stick. They most likely fed on phytoplankton, as the aquaria contained 6% pond water. Silver carp do not consume feed in ponds, preferring phytoplankton (Cremer and Smitheran, 1980).

The supplied feed had a significant effect on the nibbling frequency of the rohu and catla, but not on that of the common carp. The mean nibbling frequencies of rohu and catla were higher in the unfed treatment than in the fed treatment, resulting in a significantly higher reduction of periphyton biomass in the unfed treatment. Supplemental feed reduced the nibbling frequency of rohu and catla by 81% and 91%, respectively, showing that both species preferred the supplemental feed over periphyton. Since the fish were starved for 48 h prior to the experiment, the hungry fish seemed to have preferred the readily-available supplemental feed over the natural food. Therefore, there is no need to use high substrate density in periphyton-based aquaculture ponds that receive supplemental feed. Alternatively, the amount of supplied feed can be reduced, forcing these species to consume more periphyton.

In the unfed treatment, the nibbling frequency of rohu varied with time and was higher in the afternoon than in the morning and evening, similar to findings of Rahman (2006). The higher nibbling frequency of rohu in the afternoon can be attributed to the higher light intensity that enables fish to better detect food (Houlihan et al., 2002) or to the higher temperature that increases periphyton intake (Brett, 1979). In the fed treatment, rohu, catla, and common carp nibbled the bamboo stick independently of time, perhaps due to endogenous control: the feeding rhythm in fish depends on gastric emptying and feeding commences when the amount of food in the stomach falls below a certain threshold (Houlihan et al., 2002). When supplemental feed is supplied, the nibbling frequency of rohu, catla, and common carp might be regulated by gastric emptying rather than external cues.

Nibbling on the bamboo stick by rohu, catla, and common carp showed niche overlapping for periphyton. Although the catla nibbled periphyton less than the rohu, catla are needed in periphyton-based polyculture systems because they filter planktonic organisms, allowing more light to penetrate into the water column for periphyton growth (Azim et al., 2002b). Mrigal and silver carp did not utilize the periphyton at all but are necessary in appropriate combinations in periphyton-based aquaculture ponds to utilize detritus and plankton. Although no intense interspecific interactions were observed among the fish, the effects of such interactions on feeding behavior cannot be ignored.

This experiment was carried out for short time periods and should be complemented by further research during longer periods for more reliable results.

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