Effects of Short-Term Feed Withdrawal on Water Quality in Channel Catfish, *Ictalurus punctatus*, Ponds

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ABSTRACT. The efficacy of short-term feed withdrawal as a method of reducing ammonia concentrations in catfish production ponds was investigated. Channel catfish, *Ictalurus punctatus*, fingerlings averaging 35 g were stocked at 9,880 fish/ha into six 0.04-ha ponds and fed twice daily to satiation for 131 days. For a 9-day period immediately prior to harvest (days 132-140), feeding of fish in three ponds was terminated, while feeding of fish in three other ponds was continued. Total ammonia-nitrogen concentrations were not significantly reduced ($P > 0.05$) in unfed ponds until 9 days after feeding was terminated. However, after 7 days without feed, un-ionized ammonia concentrations were significantly higher ($P < 0.05$) in ponds where fish were not fed, due to significantly higher ($P < 0.05$) pH levels. Short-term (<9 days) feed withdrawal had little effect on lowering total ammonia and actually increased concentrations of toxic un-ionized ammonia in ponds.

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INTRODUCTION

Ammonia is the major end product of protein catabolism in catfish and is excreted primarily as un-ionized ammonia from the gills (Tucker and Boyd 1985). Ammonia is also produced during the decomposition of uneaten or undigested feed and fish feces (Tucker and Robinson 1990). Since oxygen demands in catfish production ponds can largely be met by mechanical aeration, the processing of ammonia to less toxic forms becomes the limiting factor on production intensification in ponds (Tucker and Boyd 1985).

Management of ammonia has proven difficult. In small ponds (<1 ha), concentrations of total ammonia can be maintained at low levels by frequent flushing (Neori et al. 1989). In the larger ponds (>4 ha) that are typically used in commercial channel catfish, *Ictalurus punctatus* culture, the rate of flushing is generally too low to significantly affect total ammonia levels (Tucker and Boyd 1985). The only recommended method for reducing ammonia concentrations in catfish production ponds has been reduction or cessation of feeding (Robinette 1983). However, the efficacy of this approach has not been tested experimentally. The purpose of this study was to test the effect of termination of feeding on total ammonia, un-ionized ammonia and, additionally, on nitrite, dissolved oxygen, temperature, and pH in catfish grow-out ponds.

MATERIALS AND METHODS

Four hundred channel catfish (mean individual weight ± SD = 35.0 ± 1.0 g) were randomly stocked into each of six 0.04-ha ponds at the Aquaculture Research Center, Kentucky State University on May 2, 1990. All fish were fed a commercially prepared floating diet (Purina Catfish Chow, 32% crude protein and 4% crude fat) for 131 days. Fish were offered as much feed as they would consume in 20 minutes twice daily (0830 and 1530). Floating feeding rings, 3.0 m in diameter, were used in all ponds to prevent feed from drifting ashore and to allow recovery of uneaten feed. Rings were made from 2.0-cm diameter plastic pipe and had a 4.0-cm plastic mesh shirt extending 20 cm below the water surface. Ponds were randomly assigned one of two treatments for the 9-day period (days 132-140) immediately preceding harvest: in one treatment, the fish continued to be fed to satiation twice daily; in the other, the fish were not fed. There were three replicate ponds per treatment. Fish were harvested September 20, 1990.

Dissolved oxygen and temperature were monitored twice daily (0800 and 1500) using a YSI[1] Model 57 oxygen meter. When the dissolved oxygen level of any pond was predicted (by graph) to decline below 4.0 mg/L, emergency aeration was provided. On days 1, 3, 7, and 9 of the treatment period, ammonia and nitrite were measured (at 1300) using a DREL/5 spectrophotometer (Hach Co., Loveland, Colorado), and pH was measured with an electronic pH meter (Accumet 900; Fisher Scientific, Cincinnati, Ohio). Un-ionized ammonia was calculated, based on afternoon pH and temperature, using tabular values from Boyd (1979).

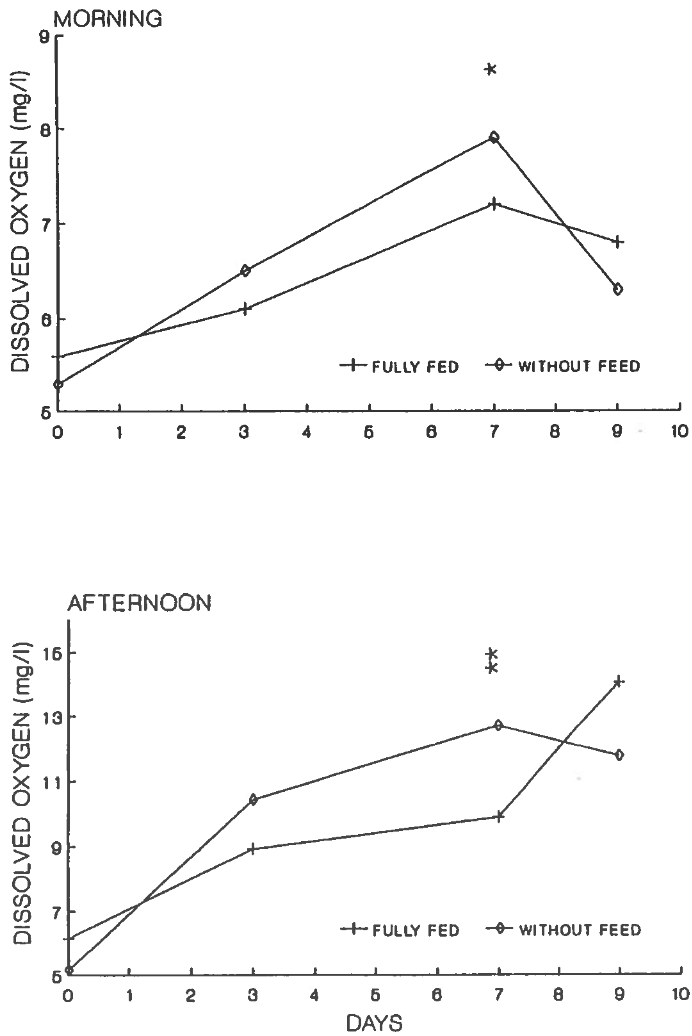
Student's *t*-tests ($P = 0.05$) were used to compare treatment means at each sample period (Dowdy and Wearden 1983), using Microstat procedures for pooled estimate of variance (Microstat 1984).

RESULTS AND DISCUSSION

Morning water temperature was significantly higher ($P < 0.01$) on days 7 and 9 in ponds where fish were not fed (Figure 1). There were no significant differences ($P > 0.05$) between treatments in afternoon water temperatures. Morning and afternoon dissolved oxygen concentrations were significantly higher on day 7 of the treatment period ($P < 0.05$ and $P < 0.01$, respectively) in ponds where fish were not fed. On days 7 and 9, pH was significantly higher ($P < 0.01$ and $P < 0.05$, respectively) in ponds where fish were not fed (Figure 2). Increases in pH and dissolved oxygen may indicate increased phytoplankton populations, shifts in the composition of phytoplankton communities, decreased rates of decomposition and respiration, or combinations of these factors. Fish are known to be able to reduce their metabolic rate as an adaptive response to periods of starvation (Weatherly and Gill 1987). A

1. Use of trade or manufacturer names does not imply endorsement.

FIGURE 1. Average morning and afternoon dissolved oxygen concentrations (mg/L) and morning and afternoon water temperatures (°C) in ponds where for a 9-day period the fish were either not fed or were fed to satiation twice daily. A single asterisk indicates a significant difference between treatments at $P < 0.05$; two asterisks indicate a significant difference at $P < 0.01$.



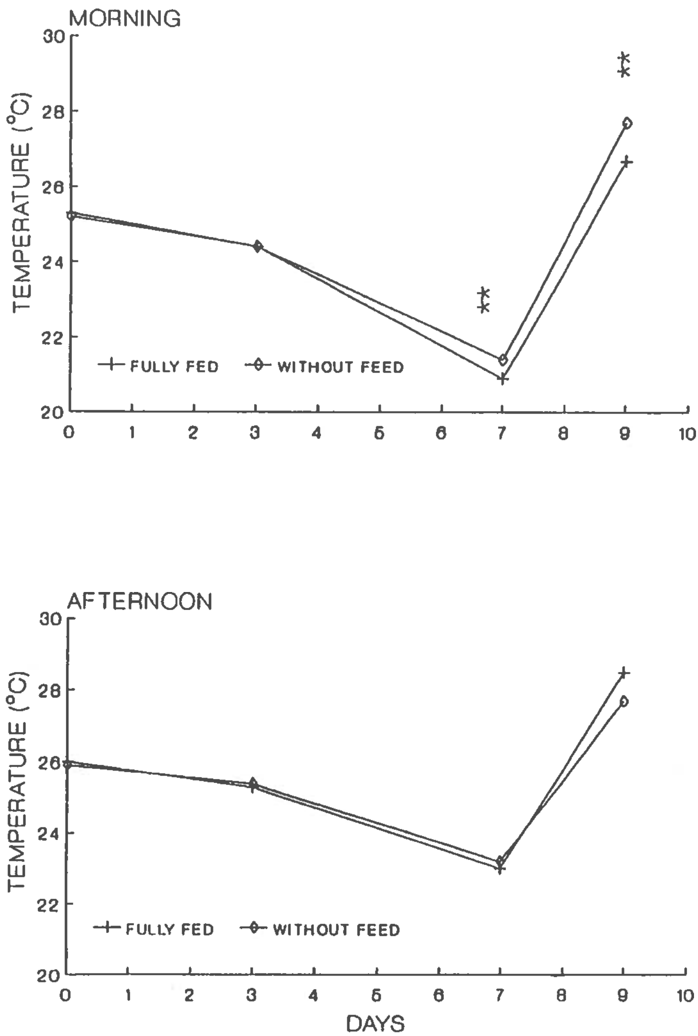
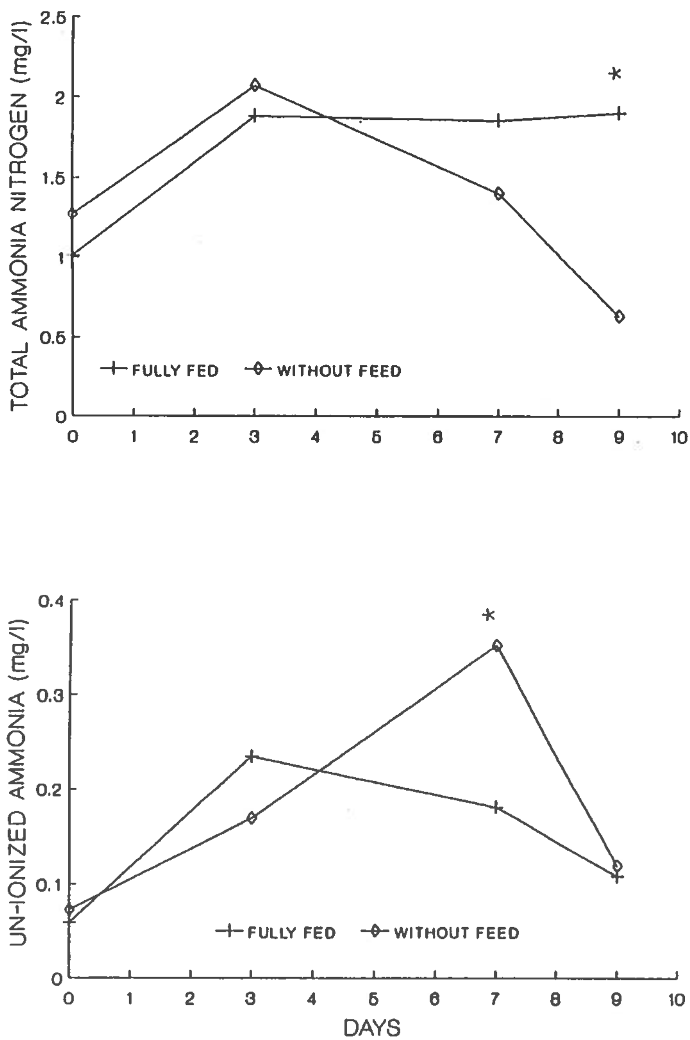
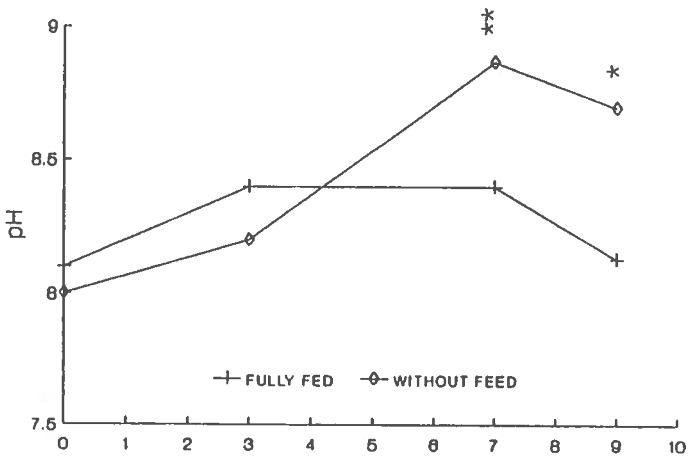
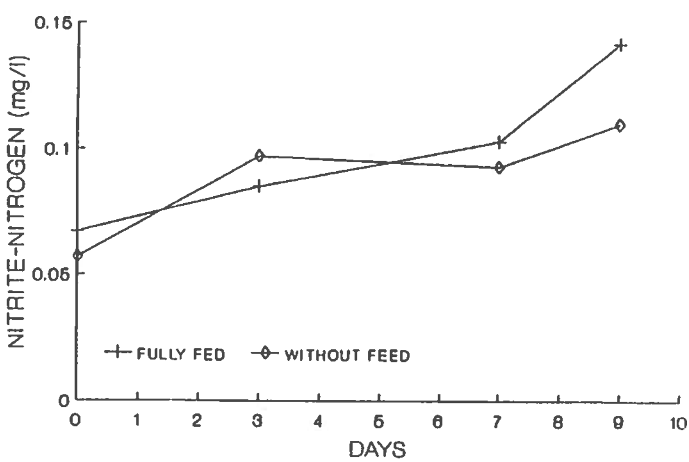

MORNING
30
28
26
24
22
20
TEMPERATURE (°C)
* *
* *
FULLY FED
WITHOUT FEED
0 1 2 3 4 5 6 7 8 9 10
AFTERNOON
30
28
26
24
22
20
TEMPERATURE (°C)
FULLY FED
WITHOUT FEED
0 1 2 3 4 5 6 7 8 9 10
DAYS

FIGURE 2. Average total ammonia-nitrogen concentrations (mg/L), un-ionized ammonia concentrations (mg/L), pH, and nitrite-nitrogen concentrations (mg/L) in ponds where for a 9-day period the fish were either not fed or were fed to satiation twice daily. A single asterisk indicates a significant difference between treatments at $P < 0.05$; two asterisks indicate a significant difference at $P < 0.01$.




9
8.5
8
7.5
pH
FULLY FED
WITHOUT FEED
0
1
2
3
4
5
6
7
8
9
10


0.15
0.1
0.05
0
NITRITE-NITROGEN (mg/l)
FULLY FED
WITHOUT FEED
0
1
2
3
4
5
6
7
8
9
10
DAYS

reduction in oxygen intake and CO_2 production by the unfed fish could possibly account for some of the increased pH and dissolved oxygen concentrations (C. Tucker, Mississippi State University, Stoneville, Mississippi, pers. comm.). Increased phytoplankton densities and photosynthetic rates could also account for these increases but are normally associated with nutrient input, not withdrawal.

Nitrite-nitrogen concentrations increased in both treatments during the treatment period (Figure 2). However, there were no significant differences ($P > 0.05$) between treatments, and nitrite-nitrogen concentrations averaged 0.094 mg/L, overall. These values are in agreement with previous studies at similar densities (L. Tucker et al. 1979; Hollerman and Boyd 1980).

Average total ammonia-nitrogen (TAN) concentrations ranged from 0.63 to 2.07 mg/L during the treatment period. Between days 3 and 7, TAN levels began to decline in ponds where fish were not fed, while remaining essentially static in fully fed control ponds. Only after 9 days were TAN concentrations significantly lower ($P < 0.05$) in ponds where fish were not fed compared to control ponds (0.63 and 1.90 mg/L, respectively).

Total ammonia-nitrogen exists as un-ionized ammonia (NH_3) and ammonium ion (NH_4^+) in a temperature and pH dependent equilibrium (Boyd 1979). The un-ionized form is highly toxic to fish (Robinette 1976). Since pH and temperature fluctuate, un-ionized ammonia levels reflect interactions of changes in TAN, pH, and water temperature.

After 7 days without feed, ponds in the unfed treatment had significantly higher ($P < 0.05$) levels of un-ionized ammonia than control ponds where fish were fully fed (0.35 and 0.18 mg/L, respectively). Total ammonia-nitrogen concentrations did not increase between days 3 and 7, and afternoon temperatures decreased during the period. However, pH increased from 8.2 to 8.9, which increased un-ionized ammonia concentrations in ponds where fish were not fed. As stated previously, the reasons for increased pH in unfed ponds is not completely understood. Between days 7 and 9, un-ionized ammonia concentrations declined in unfed ponds as pH and TAN declined. After 9 days without feed, there was no significant difference ($P > 0.05$) in un-ionized ammonia levels between treatments.

Treatment differences in un-ionized ammonia concentrations could represent levels of practical concern to producers. Growth of channel catfish is reduced linearly with increasing concentrations of un-ionized ammonia between 0.048 and 0.989 mg/L (Colt and Tchobanoglous 1978). Fish exposed to un-ionized ammonia may also develop gill and kidney damage (Robinette 1983).

Highest sustained concentrations of TAN in catfish culture ponds usually occur in late fall and winter (Tucker and Robinson 1990). Extended periods of un-ionized ammonia concentrations greater than 0.20 mg/L are common in catfish ponds during the winter (C.S. Tucker et al. 1984). If fish entering this period were exposed to additional water quality and nutritional stresses, their health could be affected.

Fish that are not fed also do not receive required nutrients. Some important nutrients, such as water soluble vitamins, are not stored and may be rapidly depleted. Two water soluble vitamins (ascorbic acid and folic acid) may be especially critical. Ascorbic acid is important in maintaining immune response (Li and Lovell 1985), and a lack of folic acid has been implicated in the severe idiopathic anemias reported in commercial catfish production (Butterworth et al. 1986). Consequently, a period of nutritional stress in late summer or fall could be especially compromising to the winter health of the fish.

In summary, 9 days without feed were required to reduce total ammonia levels. Feed withdrawal of less than 9 days did not reduce total ammonia and actually increased levels of toxic un-ionized ammonia. This, combined with sacrificed growth and potential nutritional stresses, indicate that short-term (<9 days) feed withdrawal should not be utilized to attempt to decrease ammonia concentrations in catfish production ponds.

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