COMMERCIAL POLYCULTURE OF BIGMOUTH BUFFALO AND CHANNEL CATFISH IN OKLAHOMA

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Abstract: Bigmouth buffalo (*Ictiobus cyprinellus*) in 1.6-ha commercial channel catfish ponds fed entirely on zooplankton did not use demand feeders. Catfish ponds with buffalo stocked at 14 to 125 fish/ha had an average zooplankton density of 14 ml/m^3, as compared to 57 ml/m^3 in catfish monoculture ponds. At a stocking rate of 500 buffalo/ha, 681 kg/ha of buffalo were produced in addition to the catfish crop.

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The commercial culture of bigmouth buffalo began in the south central states in the 1950's, as both a legal means of avoiding acreage restrictions on the terrestrial crops and for use in rice/fish rotation (Bardach et al. 1972). Within a decade, bigmouth buffalo were supplanted by channel catfish (*Ictalurus punctatus*) as the primary culture fish; thereafter, economic considerations have strongly favored the monoculture of channel catfish.

Studies in natural systems indicate that bigmouth buffalo are facultative filter-feeders capable of consuming all sizes of zooplankton (McCormish 1967, Starostka and Applegate 1970), as well as organic detritus (Tafanelli et al. 1970). It's thought that buffalo, stocked as a secondary species in catfish ponds, will likewise feed primarily on plankton, resulting in improved water quality, increased total production, and greater profits. Thus, in recent years, with the escalating costs of catfish feed, energy and larbor, there has been renewed interest in the culture of bigmouth buffalo.

Experimental studies of buffalo/catfish polyculture ponds have produced conflicting results. Jarman (1968) observed competition between catfish and buffalo only in ponds that received supplemental feed, while Perry and Avault (1975) saw competition in ponds receiving no supplemental feed. In spite of these conflicting results, the addition of bigmouth buffalo to experimental catfish ponds has resulted in additional production of 170 to 740 kg/ha (Hastings and Simco 1973, Hastings 1974, Perry and Avault 1975).

In 1975, Sooner Fish Farm began commercial polyculture of bigmouth buffalo and channel catfish. The behavior, food habits, and growth of bigmouth buffalo were studied on this farm to determine its value as a polyculture species in large commercial ponds.

METHODS

Study Area

This study was conducted at Sooner Fish Farm, located 9.6 km (6mi) south of Norman, Oklahoma, on the South Canadian River flood plain. The farm consisted of 8 rectangular ponds with average surface areas of 1.6 ha. The long axes of the ponds were aligned in a north-south direction, with ponds having individual inlets and drains. Water depth averaged 0.6 m, with gradients of 0.3 to 1.0 m.

The primary species cultured was the channel catfish, with fathead minnows (*Pimephales promelas*), and green sunfish (*Lepomis cyanellus*) also occurring in the ponds. The farm utilized a mixed-size culture with continuous harvest for the production of channel catfish. Each pond was routinely seined once a month, and the food-size fish were removed and sold. Fingerlings were periodically restocked and the ponds were rarely completely harvested. The standing crop of catfish was normally maintained at 1700 - 2300 kg/ha.

In May 1975, 410 kg of bigmouth buffalo averaging 1.4 kg were purchased from a farm in central Arkansas. These fish were stocked into 4 of the 8 ponds at rates of 23, 40, 50, and 200 fish per pond (14 to 125 fish/ha).

Fish Behavior

Bigmouth buffalo were marked for visual observation with coded ping-ping balls attached to a 1.0-m length of piano wire, using the method of Randolph and Clemens (1976). During the 1975 season, 30 bigmouth buffalo were marked and over 130 hours were spent observing fish movements within the ponds.

Fish movements were observed and recorded by 2 methods: 1) location in the pond at 5 min intervals to determine general movement patterns, and 2) measurements of time spent swimming or stationary, and distance travelled, during selected observation periods.

Zooplankton

Total zooplankton density in each of the 8 ponds was measured on 3 dates in October, 1975. On each date, 20 3.8 l subsamples were collected and pooled from a transect of each pond, concentrated through a 153μ mesh size plankton net, and fixed with 70% isopropyl alcohol. The samples were allowed to remain undisturbed for 24 hours and zooplankton settled volumes were calculated and expressed as ml zooplankton/m^3 of water.

The zooplankton size distribution of both an intestinal and pond sample were made with a Wild's inverted microscope using the same measurements as Brooks and Dodson (1965).

RESULTS

Fish Behavior

Adult bigmouth buffalo in these large culture ponds exhibited movement patterns quite different from channel catfish. Typically, individual bigmouth buffalo

criss-crossed a restricted area of pond for periods of up to 2 hours (Fig. 1), then moved to another area of the pond. During the course of a day, however, individual fish thoroughly covered the entire pond (Fig. 1). One fish swam a total of 1500 m during 8 hours of daylight observation. Fish activity decreased at night, with fish remaining relatively inactive near the shore.

The buffalo in this study exhibited a stop/go movement pattern, rather than continuous swimming. During 8 hours of timed observation, 1 fish averaged 35 sec stationary in the water, followed by 24 sec swimming, travelling and average distance of 3 m. During any given day, the fish spent less time stationary earlier in the day, and more time satationary later in the day.

Each pond was fed a 32% protein, sinking feed with a demand feeder, however, during 130 hours of observation the marked buffalo were never observed near the feeder. On 1 occasion, feed was hand scattered in a transect across the middle of a pond for 3 days in a row to see if buffalo could be induced to feed on the pellets. This had no effect on the fish movements, and none of the fish under observation even hesitated when crossing the trail of feed.

While there were as many as 5 marked buffalo under observation in a single pond (out of a total population of 40), there was no evidence of schooling behavior. All fish appeared to be moving independently of the others.

Food Habits

During the 1975 growing season 6 buffalo were sacrificed and their intestinal contents examined. All fish contained only zooplankton, with no traces of fish feed or bottom detritus. On 23 October 1975, a 1.8 kg buffalo was captured with a cast net, its intestinal contents removed and fixed in 70% alcohol. Size distributions were made of both the intestinal zooplankton exoskeletons and a net sample collected from the same pond 3 days earlier. Bigmouth buffalo captured all sizes of zooplankton, including nauplii, and appeared to be more efficient at capturing the smaller size organisms (Fig. 2). This was probably due to the escape of the large calanoid copepods, as documented by Staroska and Applegate (1970).

Effect on Zooplankton Density

From both the behavioral studies and the analysis of intestinal contents, it was determined that adult bigmouth buffalo fed entirely on zooplankton. In October 1975, samples were collected from all 8 ponds (4 stocked with catfish, 4 stocked with catfish and buffalo) to study the effect of buffalo predation on the zooplankton density.

The 4 ponds stocked with buffalo and catfish had significantly lower zooplankton densities than those without buffalo. While the control ponds averaged 57 ml zooplankton/m^3 (settled volume), those stocked with buffalo averaged only 14 ml/m^3 (t-test, $P < 0.001$).

Only one of the control ponds had a zooplankton volume less than any of the buffalo ponds, and only on the 1st 2 sampling dates (Fig. 3). Pond 4, with the highest buffalo stocking rate (125 fish/ha), had the lowest zooplankton volume on 2 of the 3 sampling dates.

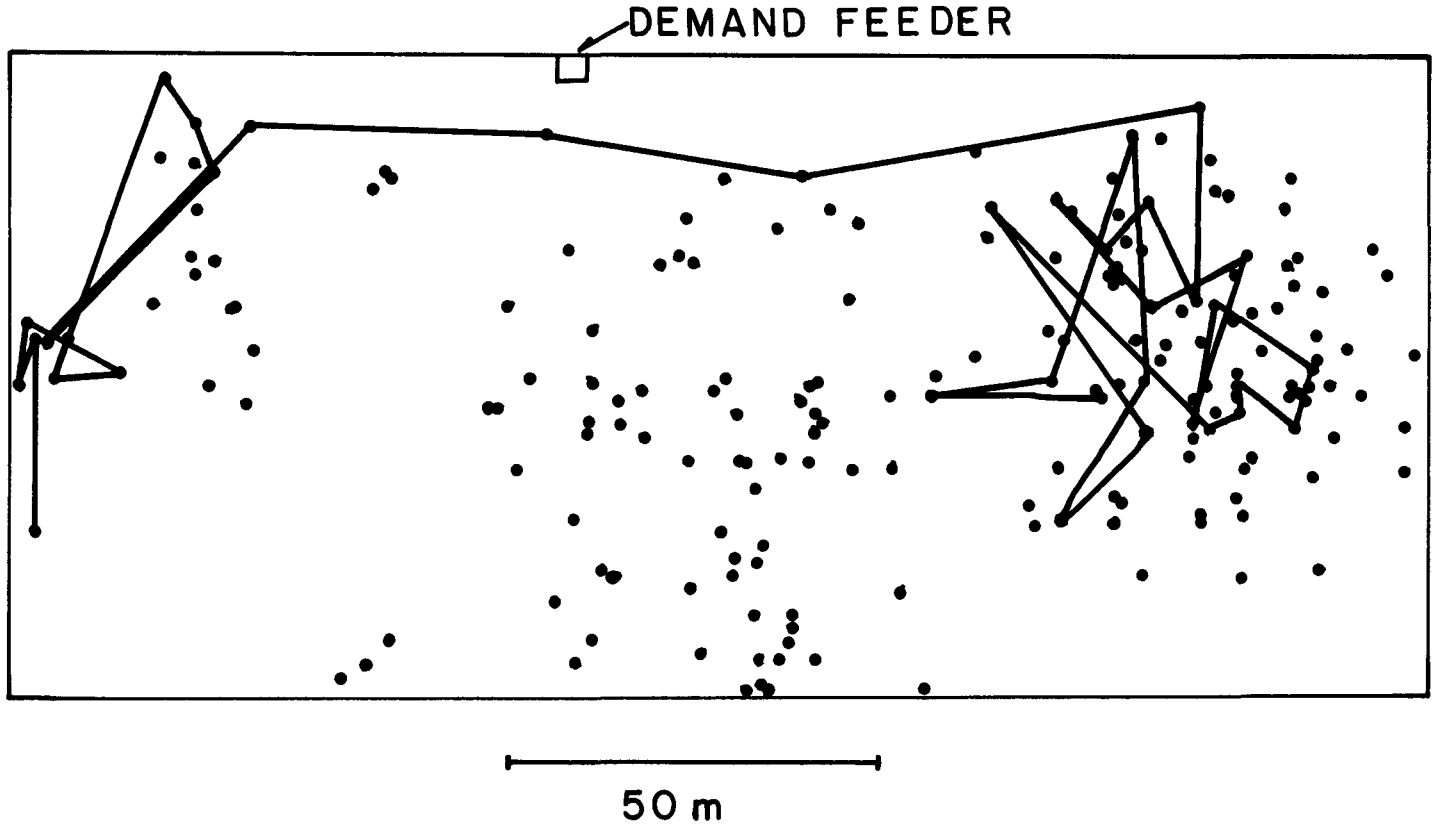

Fig. 1. Movement of a 1.4 kg bigmouth buffalo in a 1.6-ha commercial catfish pond. Dark line traces route travelled during a 3-hour observation period. Dots are locations at 5-min intervals during 8 hours of daylight observation.

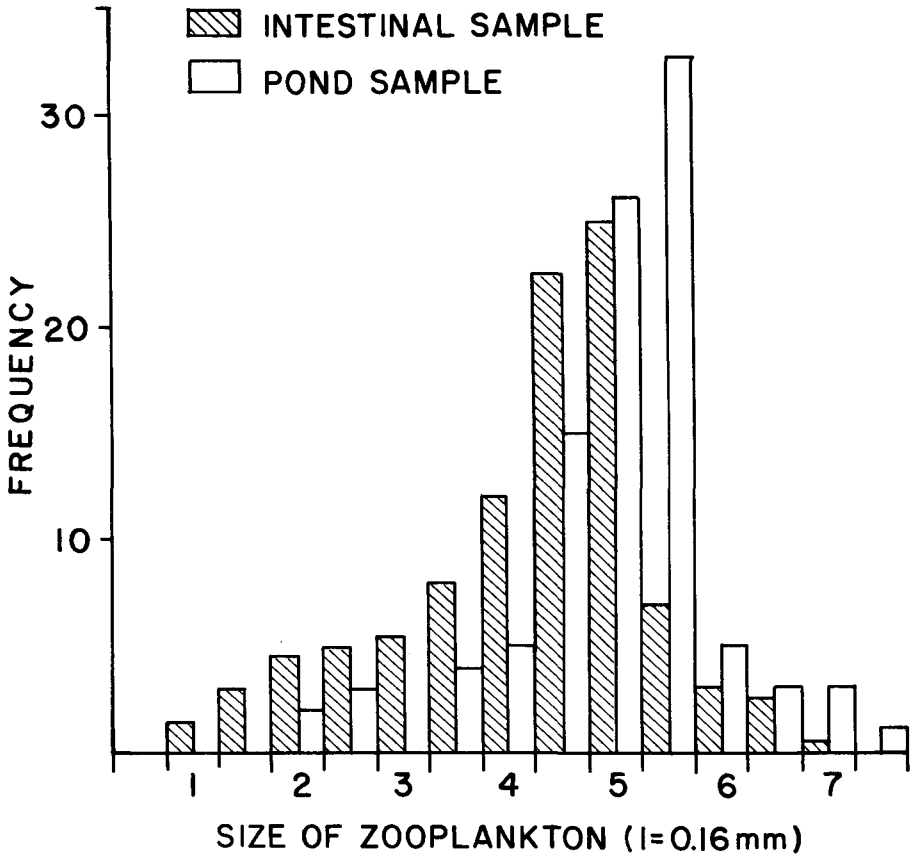

Fig. 2. Length-frequency distribution of zooplankton from a bigmouth buffalo intestinal sample and a pond water sample.

Production

Stocking rates of 14 to 125 buffalo (1.4 kg each)/ha resulted in standing crops of 32 to 284 kg/ha at the end of the 1st (1975) growing season. These fish spawned in all 4 ponds in the spring of 1976, and were then gradually harvested and sold to local fish markets.

Sufficient young-of-the-year, weighing 200 - 300 g, were obtained from pond 4 in the fall of 1976 to stock all 8 ponds at increased rates of from 50 to 500 fish/ha. In the fall of 1977, all 8 ponds were completely harvested and buffalo production ranged from 70 to 681 kg/ha.

Due to the nature of the management at this fish farm, it was not possible to collect precise data on the catfish crop. However, during the course of this 3 season study, bigmouth buffalo had no obvious effects on catfish growth, production or food conversion efficiency. In fact, at the highest buffalo stocking rate (500 fish/ha), the sale of buffalo nearly paid the catfish feed bill for that pond.

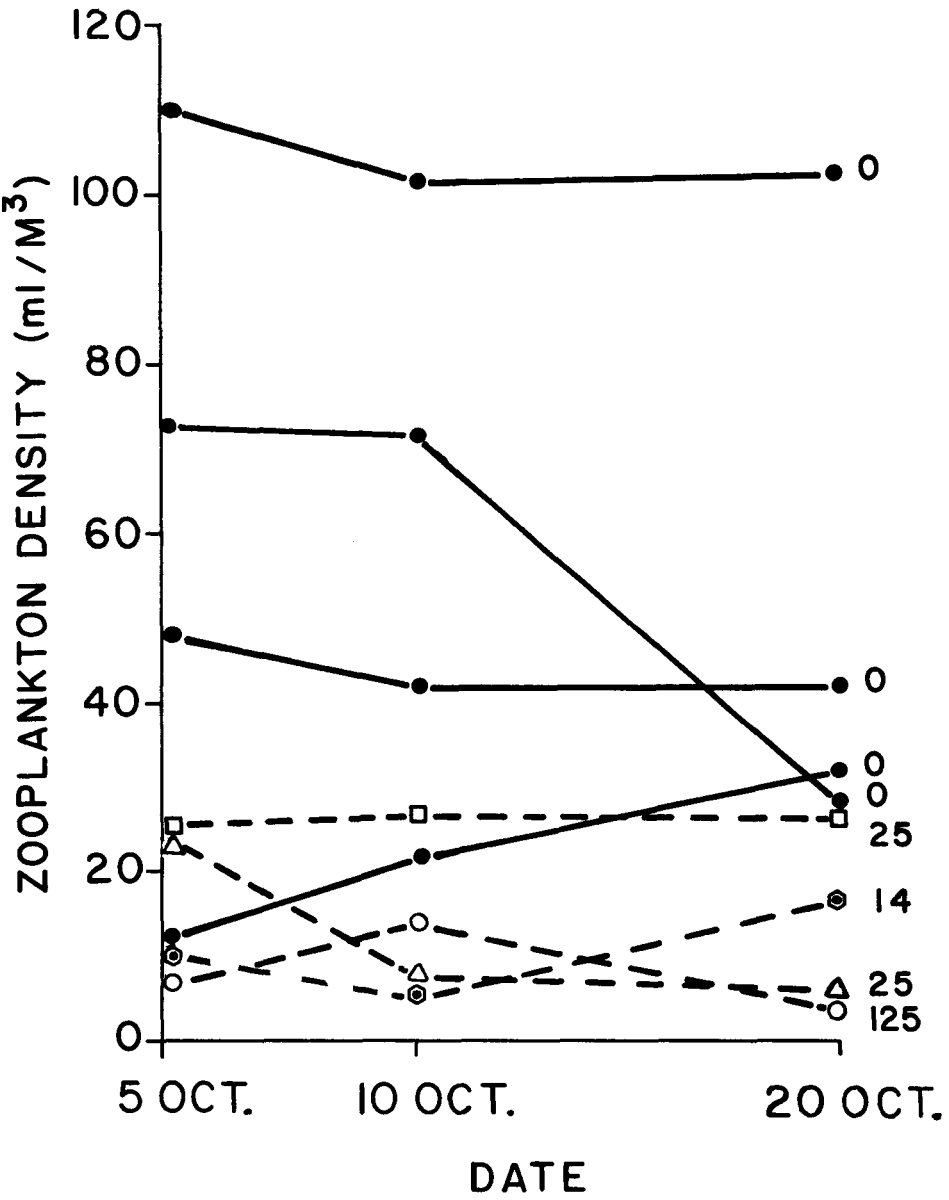

Fig. 3. Zooplankton densities in 8 commercial culture ponds on 3 sampling dates in 1975. Stocking rates of adult buffalo (in fish/ha) are on the right.

DISCUSSION

Bigmouth buffalo are facultative filter-feeders capable of meeting their dietary needs entirely with zooplankton. In the large, old, intensively managed ponds of this study, the zooplankton density was high enough to act as the sole food source for bigmouth buffalo. In lake or river systems, or in culture ponds with reduced nutrient input, the zooplankton density may not be adequate to support buffalo through filter-feeding, and they must turn to other food items (benthic detritus or commercial feed). Even intensively managed experimental ponds may not provide adequate zooplankton, since they are rarely under continuous production and usually have a lower catfish standing crop (and thus, a lower feeding rate) than the ponds in this study. In addition, small experimental ponds may be physically incapable of supporting bigmouth buffalo solely through filter-feeding. If the far-ranging fish movements observed in our study are an integral part of their fitler-feeding mechanism, buffalo may be unable to feed effectively on zooplankton in smaller ponds, and may turn, at least partially, to other food sources.

Commercial polyculture of bigmouth buffalo is now a viable enterprise at least in Oklahoma. We found that 1.5 kg, 2-year-old bigmouth buffalo could be sold for $1.10 - 1.65/kg (live weight) once a constant supply of fish to the market was established. At a stocking rate of 500 fish/ha, 681 kg/ha of bigmouth buffalo were produced and sold in addition to the catfish crop.

Larger commercial farms that utilize mechanized seining and sorting will face the additional problem of hand-sorting the buffalo at each catfish harvest until they reach market size. However, this apparently is not a limiting factor, since there are now over 560 ha of catfish/buffalo polyculture ponds in the state of Arkansas alone (Freeze and Fiegel 1980). Further increases in the use of bigmouth buffalo as a polyculture species in the south will be largely dependent on the development of new markets, and a steady supply of fish to these markets.

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