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An Experimental Evaluation of the Short-Term Phytoplankton Impacts of Silver and Bighead Carps and their Hybrids

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Abstract

Both hybrids of silver and bighead carps and the parent species were evaluated for their effectiveness in reducing by filtering off-flavor cyanobacteria (blue-green algae) and for impacts on phytoplankton in general. While silver carp eliminated these algae in the 48 h study, the hybrids were intermediate between the parent carps. Of the 10 planktivores evaluated in the mesocosm study at University of Arkansas at Pine Bluff Aquaculture Research Station, silver carp and Nile tilapia were the most effective, and exhibited good control. Chinese carps, however, are currently more injurious in the US and invasive. In addition, silver carp cannot easily be confined in pond polyculture and will consume pellets if allowed. Nile tilapia have been raised without feeding in cages in ponds successfully.

Keywords: Phytoplankton; Aquaculture; Planktivores; Polyculture; Ictalurus punctatus; Zooplankton

Introduction

Chinese carps, mainly silver *Hypophthalmichthys molitrix,* bighead *H. nobilis,* and grass carp *Ctenopharyngodon idella* lead the world in aquaculture production statistics. They are primarily cultured in native China. Traditionally, they, and five or so other cyprinids, formed the most efficient extensive (without addition of complete feeds) polyculture system known due to their differing abilities to utilize almost all naturally-occurring pond food sources. Silver and bighead carp are able to filter plankton, and were imported to the U.S. to investigate their ability to control nuisance algal blooms and improve water quality, and in the case of bighead carp utilize zooplankton in channel catfish *Ictalurus punctatus* ponds while adding to overall production. Grass carp are useful in higher aquatic vegetation control with gill arches modified into grinding "teeth." They are currently required to be sterile triploids. However, fertile diploid grass carp are spawning in the central US rivers from earlier escapes. They do not pose as severe a risk to ecosystems as silver and bighead carps however. A fourth Chinese carp, black carp *Mylopharyngodon piceus*, is also present in the central U.S. rivers. It is perhaps of most concern as it feeds on molluscs and attains the largest sizes, over 40 kg. Many native molluscs are endangered and fortunately the black carp is not yet abundant.

The silver and bighead carp that escaped in Arkansas in the 60s and 70s are rapidly colonizing the larger rivers in central U.S. The diets of phytoplankton and zooplankton by silver and bighead carps, respectively, overlap the diet of important native forage species, such as threadfin shad (*Dorosoma petenense*), and of the early stages of many native aquatic organisms. Thus much research and effort into impacts and control have been and are being conducted. Hybrids between the two have been found in central U.S. rivers [1], although research into hybrid impacts on plankton are lacking and needed. An early polyculture study in Israel compared gut composition and pond composition of plankton [2].

As part of a study [3] on the ability of 10 planktivore species to control of off-flavor cyanobacteria, also known as (blue-green algae, impacts of the two hybrids (*H. nobilis* female X *H. molitrix* male and the reciprocal cross) were evaluated and compared with the parents and other planktivores in outdoor 500-l mesocosms at the University of Arkansas at Pine Bluff (UAPB) Aquaculture Research Station. Zooplankton impacts were also examined for several of the planktivores.

Methods

Planktivore juvenile fishes were stocked (Table 1) into 500-l tank outdoor mesocosms freshly filled with adjacent eutrophic pond water, ranging from 69-256 ug/l chlorophyll *a,* and dominated by cyanobacteria. Interest was focused on their ability to remove odor-causing cyanobacteria, and pond water was chosen with high levels of the following species producing HABs (harmful algal blooms). *Oscillatoria chalybea* is a primary problem organism in production of MIB or musty flavor and *Anabaena circinalis and A. sphaerica* are major sources of geosmin or earthy flavors. In addition to the carps, an important forage fish and native planktivore threadfin shad was tested.

After 48 h (96 h for bighead carp), water column samples were taken and compared with controls from triplicate mesocosms. Phytoplankton were counted, and chlorophyll *a* (corrected for phaeophytin *a*) were determined following APHA (1995), with the exception of using 90% ethanol for extraction. Appreciation is expressed to Dr. Ron Phelps of Auburn University for making and providing the hybrid carps.

Species	Stocking size (g)	Stocking density (g/l)	Study Duration (h)
Silver carp	100	1	48
Bighead carp	650	3	96
Silver X bighead	25	0.1	48
Bighead X silver	25	0.1	48
Threadfin shad	15	1	48

Table 1: Stocking sizes, densities, and exposure times for 5 planktivores in the UAPB mesocosm study.

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Silver carp and threadfin shad impacts on zooplankton were also compared. Water column samples were filtered with a Wisconsin plankton net and the concentrate preserved with dilute formalin. Counts of major zooplankton groups and nauplii were made in a 1 ml Sedgwick rafter cell as with phytoplankton.

Results and Conclusions

Results are presented in Table 2. Silver carp was most effective in reducing *Anabaena,* as well as *O. chalybea*. Chl. *a* was also reduced. The increase in phaeophytin *a* perhaps indicated silver carp was utilizing the algae, as well as filtering them out. Bighead carp was less effective, and only the largest cyanobacteria species, *O. chalybea,* was significantly reduced. It should be noted that larger bighead carp were stocked, at higher densities, and for a longer time in their trials (Table 1). This may have increased the accumulation of phaeophytin and either decreased or increased other parameters slightly.

Species	*Anabaena sphaerica*+A. circinalis (filaments/ml)	*Oscillatoria chalybea (filaments/ml)*	Chlorophyll *aug/l)*	Phaeophytin *a Ug/l)*
Silver carp	0.0 (-100.0*)	24.0 (-89.5*)	89.0 (-53.5*)	7.0 (+1000.0*)
Bighead carp	98.6 (+124.8)	0.3 (-92.5*)	558.0 (+318.0)	115.6 (+545.3)
Silver X bighead	0.3 (-92.5)	-	220.3 (-14.0)	42.3 (+100.0)
Bighead X silver	0.0 (-100.0)	-	201.5 (-21.5)	41.8 (+197.2)
Threadfin shad	75.3 (-88.0*)	0.0 (-100.0)	288.4 (+419.0*)	0.0 (0.0)

Table 2: Concentrations and (%) removal/stimulation of selected phytoplankton parameters after 48 h (bighead carp 96-h means). Hybrids were not presented with *Oscillatoria chalybea.* Significant differences (0.1 level) from controls indicated by *.

Hybrids did not significantly change the parameters, and were in between silver and bighead parents in impacts. However, pond water did not contain *O. chalybea* in their trials. The local planktivore, threadfin shad, also significantly eliminated some cyanobacteria (*Anabaena*), however variation in control levels of the other tested cyanobacteria made significance testing not possible, but stimulated the overall phytoplankton to a greater degree than bighead carp. Threadfin shad may not have utilized the filtered algae however, as phaeophytin *a* (a chlorophyll *a* breakdown product) did not increase.

Silver carp and threadfin shad reduced cladocerans (by 95% and 77%), copepods (by 92% and 93%) and rotifers (by 75% and 77%) compared to controls. Nauplii were stimulated by silver carp (388%), but reduced by shad (96%). Bighead carp and the hybrids were not evaluated for zooplankton impacts, but would be expected to exceed that of silver carp as zooplankton is their major food item by long, thin filtering gill rakers.

The intermediate effectiveness of the hybrids compared to the parents undoubtedly reflects the impaired gill rakers, as also observe by Spataru et al. [2]. The hybrids have been shown to have incomplete fused gill raker nets of silver carp or clubbed long gill rakers of bighead carp [1]. While this may reduce the hybrids condition [4] as well as impacts on phytoplankton and zooplankton in one study greater biomass of hybrids than parents have resulted in pond studies and was attributed to a wider diet of the hybrids. The altered gill rakers may also be one of the easiest ways to detect hybrids. Hybrids are numerous in aquaculture due to the differential availability of brood fish for artificial stripped spawning [1].

Of the remaining 5 planktivores that can be grown in ponds that were evaluated -native gizzard shad (*Dorosoma cepedianum*), lilliput clam (*Toxolasma* spp.) and giant floater clam (*Anadontis grandis*), and exotics Nile tilapia (*Oreochromis niloticus*) and blue tilapia (*Oreochromis aureus*), Nile tilapia were similar in effectiveness of phytoplankton and off-flavor algae control to silver carp [3]. Blue tilapia were slightly less effective in lowering Chl. *a.* However, blue tilapia reduced copeopds to a greater degree than silver carp and Nile tilapia (96% vs. 92/93%) and reduced rotifers to a similar degree to Nile tilapia but greater than silver carp (85% compared to 86% and 75%). Blue tilapia resulted in an increase in nauplii similar to silver carp and more than by Nile tilapia [3]. As indicated, zooplankton impacts were not evaluated for bighead carp, which is the major food item for this species, and were not evaluated for the carp hybrids. The other species tested did not impact the phytoplankton measurably, and were not evaluated for zooplankton impacts.

Another native planktivore species of great value for caviar is the paddlefish *Polyodon spathula*. Difficulty in acquiring fingerlings and the large size attained precluded their evaluation in this study. In addition, studies at UAPB by the author and Dr. Bart Green of the USDA ARS of paddlefish co-cultured with channel catfish resulted in low survival of paddlefish with predation by channel catfish indicated by gnawed fins of the paddlefish. An earlier study by the author in the mesocosm tanks found paddlefish lowered problem cyanobacteria HAB blooms [5]. They primarily consume zooplankton with gill rakers similar to bighead carp, but also consume large phytoplankton. While not in all likehood able to benefit from this, the algae were observed to be damaged from passage through the spiral valve gut.

Tilapias have been shown to be useful in co-culture (as a secondary species in polyculture) with penaeid shrimp, freshwater prawns, and freshwater fish species [6]. Control of HABs, altering bacterial communities away from disease-causing gram negative bacteria, improvement in water quality and consequent reduction in disease and mortality, and valuable additional production are the more important benefits. And, as mentioned, when used in polyculture in native regions the Chinese carps are very successful. However, they will consume and compete for food pellets if not confined, as will bighead carp. As large, fast-swimming fishes, they do not lend themselves to cage confinement as well as Nile or blue tilapias [7,8].

Reductions in biomass and size of plankton by the carps and their hybrids are likely in systems they invade and dominate. Hybrid carp may be more damaging than their parents from the results of the study mentioned that found they have a wider diet than the parents and grow faster. Native planktivores and larval stages of most native fish species (which are dependent on zooplankton) are expected to be negatively impacted. And many other aquatic species larval stages also depend on phytoplankton and zooplankton.

In culture, hybrids may be more desirable than parents, with a purported wider diet that led to faster growth. Organoleptic evaluations of hybrids compared to parents would be needed, as bighead carp is preferred.

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