USGS
science for a changing world

Zooplankton diet of bighead carp (*Hypophthalmichthys nobilis*) and silver carp (*H. molitrix*) in the lower Missouri River and one of its tributaries

Bruce M. Davis[1], Patrick L. Hudson[1], Duane C. Chapman[2]-- [1]Great Lakes Science Center, Ann Arbor, MI; [2]Columbia River Environmental Research Center, Columbia, MO

INTRODUCTION

Bighead carp (BHC) and Silver carp (SVC) were imported from China into the U.S. in 1973. Since escaping from aquaculture ponds in the 1980's they have spread throughout much of the Mississippi-Missouri River system and are now encroaching upon the Great Lakes. As recent history has shown, with any exotic species it is important to gather information about its potential impacts on native species. This study was begun to investigate the various impacts of these Asian carp on the lower Missouri River.

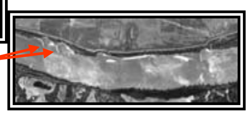
Determination of fish diets is an essential part of this knowledge. In their native environment, both species eat large amounts of zooplankton when young, which is supplemented with phytoplankton as they mature.

The objectives of our portion of the study was to determine the preferred diets of adult BHC and SVC as well as the seasonal distribution and abundance of zooplankton in two Missouri River habitats frequented by bighead and silver carp. This data was then compared with limited historical zooplankton data. Areas downstream of the Fort Calhoun Station (FCS) and Cooper Nuclear Station (CNS) were sampled for zooplankton from 1973-77 with a high-speed Miller sampler with 153 μ mesh.

Sample Sites

Lamine River

Wing dikes



Missouri River

METHODS

•Collections were made in fall, winter, spring and summer of 2003-04, two sampling events per season

•Sampled Asian carp, phytoplankton, and zooplankton behind wing dikes in the Missouri R. and in the channel of the Lamine R. (Booneville, MO).
- •Vertical zooplankton tows were taken using 64 and 100 μ nets (0.5 m off bottom); depths ranged from 3-6 m
- •3 BHC and 3 SVC were sampled from trammel nets each river trip
  - BHC length – 690-975 mm, weight 3.0-11.25 kg
  - SVC length – 729-961 mm, weight 3.8-7.5 kg

•**Zooplankton**
- •Entire sample processed at 20 and 40x, large and rare crustaceans were tallied
- •Sample volume adjusted (50-200ml) dependent on abundance of major taxa; 2 reps of 4ml processed in counting wheel (40x)

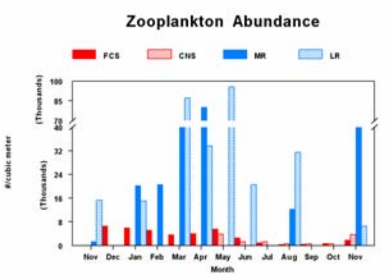
•**Stomachs**
- •Foreguts of carp were dissected out and contents split into portions for zooplankton and phytoplankton analysis
- •Entire sample processed at 20 and 40x
- •Sample volume adjusted (50-200ml) and processed similarly to zooplankton
- •From same sample volume, two 1 ml reps were processed in a Sedgewick-Rafter cell where rotifers and other small items were counted at 126 and 320x

Both with fine-mesh gill rakers
BHC raker sieve size ~85 μ
SVC raker sieve size 12-40μ

BHC

SVC

RESULTS AND DISCUSSION



•Zooplankton abundance followed the same pattern as seen in the samples from the 1970's. The highest densities were seen in April-May, followed by a summertime decline before increasing again in the late fall.

•Zooplankton productivity results between this study and the historical data are not comparable. The effects of using different size meshes are illustrated in the table. Copepoda dominated, while their nauplii were rare, in the 1970s data; nauplii are the major copepod component in the present study. They also did not numerically account for non-crustacean taxa (rotifers, aquatic insect larvae, worms, etc.).

Major Zooplankton Taxa (%)

Taxa	Missouri	Lamine	FCS	CNS
Rotifera	81.9	82.6	NA	NA
Nauplii	10.9	11.5	3	3
Copepoda	2.4	1.7	88	79
Cladocera	.6	.7	9	18
Miscellany	4.2	3.5	NA	NA

•Densities in the Lamine R. were slightly higher and appeared to peak later than in the Missouri R., which suggests a more productive system. However, since samples were not always taken in both rivers on each sampling trip, we don't have a complete picture. Although the densities were higher in the Lamine R., the proportional representation of the major taxa is essentially the same.

•Biomass was substantially higher in the Missouri R. and peaked in February (133.1 mg/m^3) and March (87.9 mg/m^3), whereas the Lamine R. peaked in April (57.2 mg/m^3) and June (51.0 mg/m^3) . The Missouri R. peaks were associated not with rotifers but instead with copepods and aquatic insect larvae. The Lamine R. peaks were mainly associated with aquatic insect larvae.

Carp Diet Taxa (%)

Taxa	BHC Missouri	BHC Lamine	SVC Missouri	SVC Lamine
Rotifera	95.7	90	97.7	72.5
Copepoda	3.3	.6	0	2.7
Cladocera	.2	1.4	0	.3
Miscellany	.8	8	2.3	24.5
#/fish	**13,512**	**2929**	**404**	**918**

Carp Diet Taxa Biomass (%)

Taxa	BHC Missouri	BHC Lamine	SVC Missouri	SVC Lamine
Rotifera	64.5	49.8	97.9	69.5
Copepoda	8.4	1.2	0	4.6
Cladocera	.9	10.4	0	1.8
Miscellany	26.2	38.6	2.1	24.1
mg/fish	**8.1**	**1.8**	**.15**	**.19**

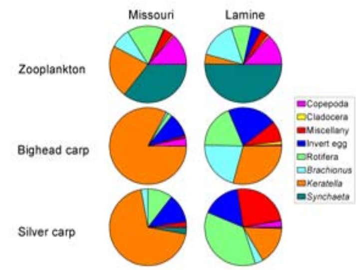
•Zooplankton diet of carp largely reflected the proportion of taxa in both rivers. Rotifers dominated the diets of both species, particularly in the Missouri R.; these numbers also include the vast amount of invertebrate eggs which appeared to be from rotifers. The higher percentage of miscellany in the SVC in the Lamine R. is mainly from an abundance of *Difflugia*, a rhizopod protozoan, in June.

•BHC ate substantially more zooplankton than SVC. This is true for both rivers, though much more so for the Missouri, with the majority of this being from fish sampled in April (≈ 71,000/fish). This may be a function of having a larger gape and the ability to ingest more while foraging, or it could be due to where the fish species reside in the water column. SVC have usually been observed closer to the surface (they are the species making the spectacular jumps) and the higher densities of zooplankton may occur deeper. However, both species have been observed feeding on the surface.

•The biomass table illustrates the importance of the larger taxa to the fish diets. Although the rotifers simply because of their numbers still dominate, miscellaneous items (aquatic insect larvae, worms, etc.) make a substantial contribution to the biomass. This is more true for BHC than SVC who's proportions are the same for numbers and biomass and for both rivers. This shows that the BHC are eating larger zooplankton on average. It would be expected that SVC can retain smaller prey (phytoplankton) than BHC because of the smaller raker sieve size*, but that should not limit their eating of larger prey. Though particulate feeding could explain the difference, these both appear to be obligate filter-feeders. Again it may be possible that the larger zooplankton occur deeper in the water column.

•The amount of zooplankton prey eaten seasonally reflected the amount present in the rivers, with similar peak times. Both species opportunistically ate the most food in the spring; Missouri R. fish peaked earlier in abundance and biomass than Lamine R. fish. The peak abundance of zooplankton in Missouri R. BHC stomachs is attributable to a glut of ***Keratella*** spp. However, as with the zooplankton, the biomass peaks in April (32.8 mg/fish) and March (10.1 mg/fish) are attributable to copepods and aquatic insect larvae.

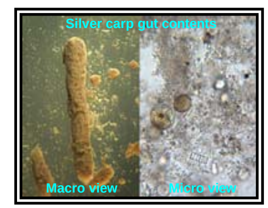
*Their gill rakers are also longer and fused into a sponge-like apparatus.



•Comparing the overall proportions of zooplankton in the rivers versus those found in the stomachs gives some indication of selectivity. Both rivers are numerically dominated by rotifers (bottom 5 categories), in particular ***Synchaeta*** spp. Instead of ***Keratella*** spp., as in the Missouri R., ***Brachionus*** spp. rank second proportionately in the Lamine R., which may indicate a somewhat more eutrophic environment.

•The diet of both species are dominated by ***Keratella*** in the Missouri R., whereas prey taxa are more evenly distributed in the Lamine R. diets. This may indicate diet flexibility but still shows preference for the smallest prey taxa.

•The most notable taxa differences between diet and environment is the lack of ***Synchaeta*** in the diets of both species. We believe this is due to differential digestion. ***Synchaeta*** are highly contractile soft-bodied rotifers whose presence sometimes could only be determined by identification of their mouthparts (trophi). ***Keratella*** and ***Brachionus*** are loricate rotifers whose soft parts are enclosed in a hard exoskeleton. Inclusion of ***Synchaeta*** could potentially double the numbers of zooplankton prey in the diets.



•Much of the material in the stomachs came tightly clumped and it was necessary to tease these apart. Fine Particulate Organic Matter **(FPOM)** was discovered to be a large proportion of the material in both species stomachs. Overall visual estimation showed approximate proportions of: **85% FPOM, 9% algae, 4% zooplankton, and 3% sand** for BHC, and **92% FPOM, 7% algae, 0.5% zooplankton, 0.5% sand** for SVC.

•Stable isotopes methods for carbon, sulfur, or nitrogen would have added greatly to this study as they might have been able to determine the initial source and makeup of this FPOM.

SUMMARY

•Both species can feed throughout the water column, but SVC were probably feeding at a higher position in the water

•Bighead carp eat a larger fraction of zooplankton including larger individuals

•Silver carp probably eat a larger fraction of phytoplankton; raker sieve size 2-7 times finer

•Both species consume large fractions of FPOM, greater than 80% of volume

•Source and makeup of FPOM should be studied with use of stable isotopes of carbon, sulfur, nitrogen