Report for 2001CO882B: Distribution, Habitat, and Life History of Brassy Minnor (Hybognathus hankinsoni) in Eastern Colorado Streams

- Articles in Refereed Scientific Journals:
    - Fausch, Kurt, Christian E. Torgersen, Colden V. Baxter, and Hiram W. Li, 2002, Landscapes to Riverscapes: Bridging the Gap Between Research and Conservation of Stream Fishes, in Bioscience, Vol. 52, No. 6, June 2002, pp. 1-16.
- Other Publications:
    - Scheurer, Julie A. and Kurt D. Fausch, June 2001, Habitat Requirements and Systematics of Brassy Minnow in Intermittent Plains Streams in Eastern Colorado, Project Annual Report to Colorado Water Resources Research Institute and Colorado Division of Wildlife, Aquatic Non-game and Endangered Wildlife Program, Colorado Water Resources Research Institute, Colorado State University, Fort Collins, CO, 84 pp.
    - Scheurer, Julie A. and Kurt D. Fausch, January 2002, Brassy Minnow in Colorado Plains Streams: Identification, Historical Distribution, and Habitat Requirements at Multiple Scales, Final Progress Report, Colorado Water Resources Research Institute and Colorado Division of Wildlife, Aquatic Non-game and Endangered Wildlife Program, Colorado Water Resources Research Institute, Colorado State University, Fort Collins, CO, 148 pp.

Report Follows:

DISTRIBUTION, HABITAT, AND LIFE HISTORY OF BRASSY MINNOW (HYBOGNATHUS HANKINSONI) IN EASTERN COLORADO STREAMS

In Colorado, six of 38 native plains fish species are known to have been lost since the first fish collections were made in the late 1800s. An additional 13 species are listed by the state as endangered, threatened, or of special concern – therefore, half of the native fish have either declined or been lost. The brassy minnow (Hybognathus hankinsoni) is one of three plains fish species listed as threatened or endangered by the State of Colorado in 1998, due to an apparent decline in distribution and abundance in Colorado since the 1970s. To help fishery managers locate suitable habitat and potentially restore the species to more of its native range and preclude the need for further listing, this research project sought to determine the historic distribution and critical habitat requirements of the brassy minnow.

Understanding the native range of brassy minnow is complicated, because it is difficult to distinguish the brassy minnow (Hybognathus hankinsoni) from a closely related species that also occurs in the region, the plains minnow (H. placitus). In addition, both species were originally classified as a different species in the same genus (Mississippi silvery minnow, H. nuchalis) before they were first described in 1929 (brassy minnow) and l962 (plains minnow). As a result, many early collections from Colorado and adjacent counties in neighboring states were classified as Mississippi silvery minnow, even though this species does not occur in Colorado, and many later collections were misclassified as the wrong species due to their similarity. Research investigators developed a method to distinguish the species identity of collections from Colorado and adjacent counties using eye diameter, standard body length, and eye position. This method correctly predicted species identity for 98 percent of the individual fish and 100 percent of the museum collections.

In general, brassy minnow have larger eyes with centers even with the tip of the snout, whereas plains minnow have smaller eyes centered above the tip of the snout (Fig. 1). Reference collections of these species are housed at the CSU Larval Fish Laboratory.

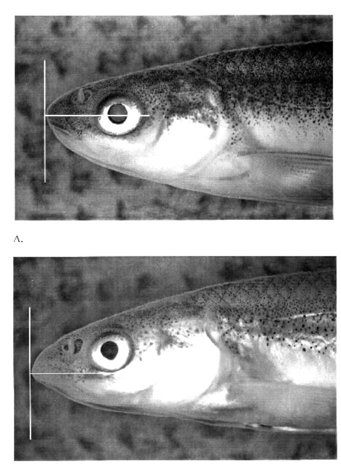


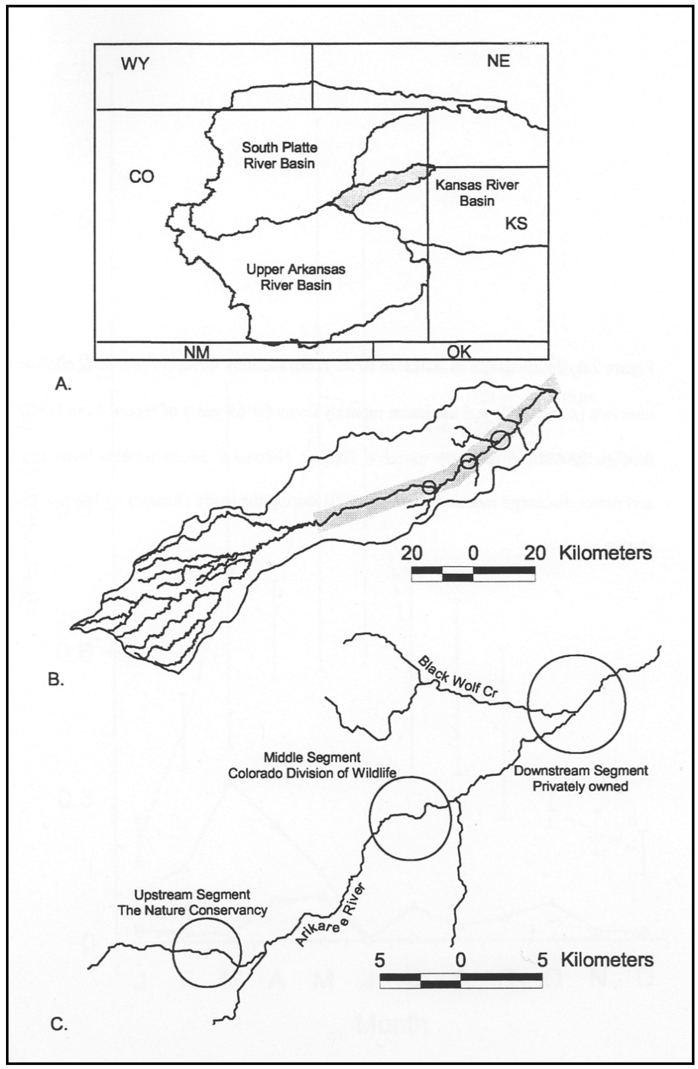
Fig. 1. Eye position characteristics for brassy minnow (top) and plains minnow (bottom). Photos by R.E. Zuellig.

In 1999, the first year of this study, researchers sampled locations throughout eastern Colorado where brassy minnow had most recently been collected. The Arikaree River (Fig. 2) was selected to determine the ecological requirements of the brassy minnow, because it presented a unique opportunity to study population dynamics at three spatial scales (habitat unit, segment, basin) across a gradient of stream intermittency (i.e., drying). This allowed investigators to determine the brassy minnow's thresholds of tolerance and assess how much perennial water is necessary to sustain populations.

Ninety-nine habitat units (pools, backwater pools, and runs) in three 4-mile segments ranging from perennial to seasonally dry were sampled during five surveys in 2000 and 2001, the two driest summers on record. For each survey, participants measured habitat variables in each unit, mapped flow connections between habitat units, and sampled each unit using two-pass depletion seining to determine the presence or absence of brassy minnow. Basin-scale flow connectivity was also mapped three times by aerial flights along the 66-mile mainstem of Colorado's Arikaree River.

At the basin scale, total habitat for brassy minnow was restricted to about 47 miles of the mainstem Arikaree River upstream from the confluence, but during early summer 2001 only a 16-mile stretch that contained the researchers' selected upstream segment had continuous flow. At the segment scale (upper, middle, downstream), drying occurred in all segments each summer, but was most pronounced in the downstream segment. The middle segment was intermediate in its degree of drying and the upstream segment had the most perennial habitat.

The amount of available habitat, number of habitat units occupied by brassy minnow, persistence of brassy minnow through summer drying, and extent of recolonization after the channel rewetted were highest in the upstream segment and lowest in the downstream segment, corresponding to the gradient of flow intermittency.



Right: Fig. 2. Location of the basin and study segments

Of the 86 pools sampled across the three segments in 2000, brassy minnow were present in 65 during at least one survey. They persisted through summer 2000 in about half of the pools where they were present, were extirpated from 17 pools by stream drying, and emigrated to adjacent habitat units or were not present in the 18 pools that remained wet. The researchers first identified factors that predicted brassy minnow persistence in pools that remained wet through the summer drought, and then predicted which pools would persist through summer drying.

Models of brassy minnow persistence through August 2000 were developed using variables measured at both the pool and segment scales. Then, because drying was the dominant mechanism affecting brassy minnow persistence, models of pool persistence through August 2000 were developed based on variables measured in June.

> Logistic regression showed that brassy minnow were more likely to persist through the summer in deeper pools connected to other habitats, and more likely to persist in pools in the upstream segment. The main cause of elimination was by pool drying, which logistic regression showed was more likely in pools with shallower June depths.

For example, a pool with a maximum depth in June of 0.5 meters would have only a 50 percent probability of persistence in the downstream segment, but a 77 percent probability of persistence in the middle segment and a 95 percent probability in the upstream segment. Thus, shallower pools were more likely to persist in the upstream segment and more likely to dry in the downstream and middle segments.

Because brassy minnow were tolerant of high water temperature (36C=97F) and low dissolved oxygen (as low as 0.01 mg/L), other factors, such as predation by terrestrial vertebrates and pool drying, likely had a greater effect on their persistence. Overall, the patterns of stream drying at the segment scale were more important predictors of brassy minnow population persistence than water chemistry or habitat features measured at the local or pool scale.

In addition to persistence of brassy minnow and their habitat, we compared several measures of brassy minnow population performance among segments, including survival, growth, and reproductive success.

> Brassy minnow survived to older ages and were larger at older ages in the most perennial segment compared to the others. However, despite poor adult survival in the drier segments, brassy minnow larvae were present in all three segments in both years, indicating that they are capable of reproduction and rapid recolonization when water is available.

Brassy minnow spawned from mid-April to mid-May and larvae appeared from mid-May through mid-June. The beginning of larval hatching coincided with the onset of pumping for irrigation and rapid dewatering of the driest segment, which killed most larvae.

For many fish populations living in “patchy” environments, such as streams that are seasonally intermittent, persistence at the regional scale depends on the balance between local extinction and colonization from adjacent patches that serve as refuges. Many seasonally intermittent steams are distinguished by marked wet and dry periods, so extinction and recolonization of fish populations are common. Extinction occurs primarily as streams dry, whereas recolonization is prevalent during the wet season. Understanding the processes that drive populations in such habitats requires examining the distribution of fishes at both local and regional scales and during cycles of wetting and drying. Groups of subpopulations that persist in a network of patches despite local extinctions are termed 'metapopulations.'

Only a few studies have addressed whether stream fish populations are arranged as metapopulations, despite numerous studies of movement, extinction, and colonization patterns. However, several studies provide good evidence that metapopulation processes are at work in stream fish populations. Researchers have found that fish apparently move relatively long distances to recolonize pools where previously fish had been eliminated by drought or freezing.

If any stream fish are likely to show metapopulation processes, fishes of the Great Plains are good candidates. Plains streams are harsh environments that fluctuate drastically in both physical and chemical properties due to flash floods that rearrange habitat, seasonal drying, and winter freezing. The extreme conditions created by these natural processes are often exacerbated by land and water use practices. Understanding the role of metapopulation processes in sustaining rare and declining species is important for managers, because their goal is to achieve regional persistence of these species and their habitats.

Brassy minnow in the Arikaree River showed evidence of metapopulation dynamics because persistence was related to patch size (depth) and isolation, with extinctions more likely in shallow, disconnected pools. Moreover, some suitable habitats were empty, there were asynchronous local dynamics among pools, and the species persisted at the segment (regional) scale despite population turnover. The dynamic nature of plains streams, differences in flow regimes among segments, and the large scales over which brassy minnow fulfill their life history require management at the 'intermediate' segment scale for effective conservation.

This research showed that brassy minnow are very tolerant of harsh conditions, move relatively long distances to recolonize empty habitat, and produce offspring even during the driest years on record. This suggests that the declines observed from 2000 to 2001 could be offset by a series of wet years. However, a prolonged drought could extinguish brassy minnow from most of the basin, and recolonization could take many years once favorable conditions return.

RECOMMENDATIONS

The following measures are recommended to improve habitat conditions in the Arikaree River and enhance brassy minnow populations:

- Increase spring flows to prevent early drying of the downstream segment and improve survival of brassy minnow larvae.

- Maintain riparian and stream processes that create deep pools and provide critical refuges for brassy minnow during summer drying. Intact riparian vegetation binds stream banks and allows deep pools to be carved by periodic floods from summer thunderstorms. In addition, beaver dams often create deep pools that persist through summer.

- Maintain the native fish community and prevent invasion of exotic predators or competitors. Although most nonnative fishes apparently cannot withstand the harsh physicochemical conditions of plains streams, off-channel ponds supplied by groundwater can provide refuges that harbor nonnative predators like largemouth bass. These fishes can emigrate and decimate native fishes in adjacent stream habitats.

- Investigate the effects of irrigation on groundwater hydrology that maintains stream flow and permanent refuge pools. These pools and backwaters are critical for brassy minnow larval and adult survival during periods of summer drying and winter freezing. A better understanding of the linkages between land and water use and plains fish populations at segment scales will be needed for effective conservation of these fishes.