ARIZONA COOPERATIVE FISH AND WILDLIFE RESEARCH UNIT - SEPTEMBER 2004

Selected Aspects of the Natural History of Gila Chub

2002-2004 Progress Report

Andrew A. Schultz and Scott A. Bonar

Fisheries Research Report 04-04

Funding Provided by:

SELECTED ASPECTS OF THE NATURAL HISTORY OF GILA CHUB

2002-2004 PROGRESS REPORT

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FISHERIES RESEARCH REPORT 04-04

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SELECTED ASPECTS OF THE NATURAL HISTORY OF GILA CHUB

PROJECT JUSTIFICATION

Gila chub (*Gila intermedia*) is a species of fish endemic to the Gila River basin of central and southeast Arizona, southwest New Mexico, and northern Sonora, Mexico (Rinne 1976; Minckley and Demarais 2000). Populations of Gila chub have been reduced or extirpated throughout its range due to loss and modification of aquatic habitats (Hendrickson and Minckley 1984; Vives 1990a; Weedman et al. 1996) and the introduction of nonnative species (Minckley et al. 1977; Dudley and Matter 2000). This species is currently limited to 24 isolated streams, cienegas, and springs; only one of which contains a population that is considered stable and secure by Weedman et al. (1996). The species is considered extirpated in New Mexico (Sublette et al. 1990). Gila chub is a candidate for listing under the United States Endangered Species Act (USFWS 1999).

The natural-history strategies and requirements of this species are poorly understood (Weedman et al. 1996). The limited natural-history knowledge of Gila chub is a deterrent to the recovery of this species (Vives 1990a).

Current knowledge of habitat use by Gila chub is limited and largely qualitative in nature. Gila chub are thought to be a highly secretive species, preferring calm deep water, or remaining close to various cover types (Rinne and Minckley 1991). Adults are often found in deep pools and eddies below areas with swift current. Small young of year inhabit shallow water among plants or debris, while older juveniles are often found in higher velocity areas (Minckley 1973; Minckley and Deacon 1991). In Sabino Creek, Arizona, Dudley (1995) found Gila chub to be highly reclusive in winter, occupying interstitial spaces, with activity increasing as water temperature increased.

Spawning habitat and behavior has yet to be defined. Outside of constant temperature springs, spawning is thought to occur from late spring into summer (Minckley 1973; Griffith and Tiersch 1989; Nelson 1993). Minckley (1973) believes spawning most likely occurs over beds of submerged aquatic vegetation or root wads, with large females being followed by several smaller males. Gila chub may reach sexual maturity by the end of their first year but most mature in their second or third year of life (Griffith and Tiersch 1989).

The benefits obtained from an accurate knowledge of the habitat requirements of Gila chub are as follows: (1) Areas critical to the continued survival of the species can be quantitatively defined in terms of functional importance. (2) In the event that it becomes necessary or desirable for The Nature Conservancy (TNC) or Bureau of Land Management (BLM) to renovate degraded areas, or create additional habitat, these activities can be undertaken with knowledge of how it should affect this species. (3) Over time, changes in the habitat can be evaluated to determine whether current management activities are benefiting or impacting this species. (4) Critical needs can be identified for the species and use patterns designed to avoid conflicts during limiting periods (e.g. spawning).

We are unaware of any quantitative data on the movement patterns of Gila chub. Closure of potential immigration routes to preclude invasion of nonnative fishes is recognized as a current management option for populations of Gila chub (Weedman et al. 1996) and other species of fishes native to the Southwest. The construction of barriers to prevent nonnative fishes from invading upstream areas inhabited by native fishes has been proposed for numerous streams throughout Arizona, including Redfield Canyon. The data we acquire on the movement of various life stages of Gila chub will be used to assess the impacts of stream barriers on various life stages of Gila chub.

Given the current status (i.e., candidate for listing) of the Gila chub, the lack of quantitative information on the species' natural-history requirements needs immediate remedy. The proposed research will allow for proactive planning and management before the species is listed. Additionally, the information acquired from this study will enable the United States Fish and Wildlife Service to make well-informed decisions about upcoming conservation plans for the species and allow for more accurate critical-habitat designation, an improved recovery plan, and section-seven consultations. Furthermore, native fishes are conservation targets in TNC's and BLM’s ecosystem management plan for the Muleshoe Ranch Cooperative Management Area, BLM's Empire-Cienega Resource Conservation Area (Jeff Simms, BLM, personal communication), and TNC's upcoming Apache Highlands Ecoregion Plan (Dave Gori, TNC, personal communication). Work is scheduled to begin on the Apache Highlands Ecoregion Plan in the spring of 2001. Due to the extremely limited distribution of most species of native fishes, all sites with native fishes will be included in the ecoregion portfolio, as they were in the Sonoran Desert Ecoregion Plan.

PRIMARY OBJECTIVES

(1) Quantify macrohabitat preferences of Gila chub.

(2) Quantify spawning habitat, temporal range and behavior of Gila chub.

(3) Quantify movement patterns of Gila chub.

STUDY AREAS

Cienega Creek is a third order tributary of the Santa Cruz River (Pima and Santa Cruz County, Arizona) flowing north through a valley bottom lying between the Santa Rita and

Empire Mountains on the west and the Whetstone Mountains on the east, joining Pantano Wash near Vail, Arizona.

Approximately 13.6 km of Cienega Creek (including Mattie Canyon) is inhabited by Gila chub (Jeff Simms, BLM, personal communication). The BLM manages the Empire-Cienega Resource Conservation Area (EC-RCA) which encompasses all of the perennial section of Cienega Creek in which Gila chub occur. The EC-RCA is managed to preserve aquatic, riparian, and associated wildlife values. Cienega Creek is the only stream within the Gila chub's range that was listed as stable and secure by Weedman et al. (1996). Nonnative fishes have not been recorded from Cienega Creek and the threat of nonnative fish contamination from migration or surreptitious introduction from local sources is low (Weedman et al. 1996).

Bonita Creek is a first order tributary (Graham County) of the Gila River. The stream flows south and east from the Nantac Rim and between the Gila Mountains before joining the Gila River east of Safford, Arizona. Perennial flow in Bonita Creek begins on the San Carlos Apache Indian Reservation and continues from the reservation boundary about 17 km downstream before going underground then resurfacing about 6 km from the Gila River. This ephemeral reach of stream appears to be an effective barrier to upstream dispersal of nonnative fishes from lower Bonita Creek and the Gila River, as nonnative fishes have not been recorded above this reach (Jeff Simms, BLM, personal communication). The BLM owns and manages most of the land buffering perennial Bonita Creek. Much of Bonita Creek is within the Gila Box Riparian National Conservation Area.

Gila chub inhabit most of perennial Bonita Creek, but are considered rare from the confluence with the Gila River upstream to the aforementioned ephemeral reach. In contrast, nonnative fishes are abundant below, yet absent above, this reach (Weedman et al. 1996; Jeff Simms, BLM, personal communication).

Due to the presence of a natural fish community, flow regime, and channel character, Cienega Creek and Bonita Creek provide ideal settings to study the essential aspects of the biology of Gila chub in distinctly different habitat conditions (i.e., an interior marshland stream versus a canyon-bound stream).

METHODS

QUANTIFICATION OF MACROHABITAT PREFERENCES

We used a random stratified design (Brown and Austen 1996) to select stream reaches in which to sample Gila chub from 3-29-04 to 8-6-04. Both streams were stratified by upper and lower sections based on susceptibility to desiccation and road access and were further divided within these sections into 100-m stream reaches (N = 83 Cienega Creek; N = 40 Bonita Creek). Chosen reaches were divided according to macrohabitat type using criteria in McMahon et al. (1996) and the addition of marsh habitat types. Prior to instream activity we visually quantified stream cover, substrate, canopy cover, bank stability, water clarity, and cattle use for each macrohabitat type. We defined stream cover as physical features of stream relief (i.e., woody, algal, vegetative, rock/boulder) occurring instream or closely overhanging (< 0.5 m) the stream surface and recorded as a percent area of each macrohabitat type. We classified substrate according to a modified Wentworth scale (boulder >256 mm, cobble 64-256 mm, pebble 32-64 mm, gravel 8-32 mm, sand/gravel 0.5-8 mm, fines <0.5 mm, bedrock, and algae/detritus/vegetation) and recorded as a percent area of each macrohabitat type. We categorized canopy cover as none, sparse (about 0-25% direct above water coverage), moderate

(25-50%), dense (50-75%), or very dense (> 75%). We categorized bank stability as poor (pervasive and active bank erosion with little vegetative cover), fair (some erosion and moderate vegetative cover), or good (little erosion evident and strong vegetative cover). We recorded water clarity as clear, stained, or turbid. Cattle use was defined as the presence or absence of recent activity by cattle at sample sites (i.e., tracks or fecal material). We captured fish within designated macrohabitats using a backpack electrofisher set at a frequency of 60-Hz pulsed DC and a 6-ms pulse width. Voltage was usually set at 300 V. Mid-day water temperature, dissolved oxygen, pH, and conductivity were measured within each macrohabitat. Following electrofishing we used a point transect method to quantify depth and velocity of each macrohabitat. Transects were spaced every 2 meters if the macrohabitat length was < 20 meters and every 5 meters if the length was > 20 meters. Macrohabitats 5 meters or less were bisected. We recorded stream depth at three equidistant points along each transect (sensu Platts et al. 1983). Average velocity was taken at each depth measurement using a Global Flow Probe. We calculated surface area for each macrohabitat type by summing the area of planes formed by width measurements.

QUANTIFICATION OF SPAWNING HABITAT, TEMPORAL RANGE AND BEHAVIOR

We used direct observation to witness spawning and associated behavior (Vives 1990b). We removed gonads from sacrificed Gila chub taken periodically throughout the year. Gonad weight will be divided by total fish weight minus the gastrointestinal tract and gonad weight to determine the Gonadosomatic Index (GSI). We will plot the GSI (for mature individuals only) against collection date to determine the temporal range of the spawning season (Vives 1987a, 1987b). We estimated fecundity by counting eggs from spawns in the laboratory and subsamples of ova from sacrificed female Gila chub. To estimate the relationship between fecundity and fish size, fecundity will be plotted against total fish weight. Ova diameters were measured with an ocular micrometer and an average diameter was determined from a subsample of ova per fish (Vives 1987a, 1987b). We described secondary sex characteristics, such as tubercles and coloration patterns, for all captured Gila chub. We described differences in secondary sex characteristics between sexes by examining those Gila chub sacrificed for GSI and those Gila chub that were sexed without autopsy (e.g., ripe Gila chub expelling gametes).

QUANTIFICATION OF MOVEMENT PATTERNS

We estimated movement patterns of adult Gila chub through the recapture of tagged fish using electrofishing and baited hoop-nets. We injected sterilized Passive Integrated Transponder (PIT) tags into the post-dorsal musculature of adult Gila chub and sealed the wound with an antibacterial ointment. We determined movement patterns of larval Gila chub using drift nets (Kelso and Rutherford 1996). We set drift nets in Cienega Creek from early to late June during the day and night in a stream reach directly upstream and about 400 meters upstream of a natural stream barrier.

RESULTS / DISCUSSION

QUANTIFICATION OF MACROHABITAT PREFERENCES

A total of 488 Gila chub were captured. A total of 16,115 m^2 of habitat was sampled. Density of Gila chub was four times greater in Bonita Creek (0.048 fish per m^2) than Cienega Creek (0.014 fish per m^2), and markedly so for adult chub. Gila chub were captured in all six macrohabitats (i.e., pool, run, riffle, chute, cascade, marsh) and nearly all of the meso-habitats.

Pools accounted for 45.2% of the habitat sampled, runs 30.8%, marshes 13.8%, riffles 6.7%, chutes 3.3%, and cascades < 1%. Gila chub used cascades and chutes more than predicted from their availability (Table 1). Gila chub used runs slightly more than predicted from their availability. Gila chub used pools in about the same proportion as their availability. Gila chub used riffles less than their availability. Gila chub rarely used marsh habitat. When further dividing pools and runs into various meso-habitats (Table 2) it is apparent that catch data largely followed macrohabitat trends. The exception was Gila chub used pool-marsh and run-marsh less than predicted which lies contrary to the macrohabitat data for pools and runs but coincides with data for marshes.

Mean depths of 10-20 cm accounted for the most area sampled (over 28%). Gila chub used macrohabitats with mean depths < 20 cm much less than in proportion to availability (Table 3). With a few exceptions Gila chub used macrohabitats with mean depths 20-110 cm equal or greater than was available. Gila chub were not captured in habitats with mean depths greater than 110 cm. This may reflect the sparseness of such habitats, or more likely the difficulties in sampling deep habitats. Analysis of the relationship between maximum depth of a habitat and use by Gila chub was inconsistent and showed no definitive patterns (Table 4).

Gila chub used macrohabitats with 20-70% total cover more than predicted from availability (Table 5). Gila chub appeared to use areas with little cover and large amounts of cover less than predicted from availability. Gila chub decreased activity in the winter months often holding close to cover. This coincides with that found by Dudley (1995).

Mean velocities from 0-10 cm/s accounted for the most area sampled (over 56%). Gila chub used macrohabitats with slower mean velocity less than predicted from availability (Table 6). Gila chub used the highest velocity category in about the same proportion as availability.

The highest mean velocity category accounted for over 10% of the area sampled. Gila chub used most other mean velocities in about the same proportion or slightly more than predicted from availability of other velocity categories.

The length of captured Gila chub ranged from 22-222 mm TL. The average of the mean length of Gila chub was greatest for chutes and riffles, and least for marshes (Table 7). Sampling efforts that produced no fish were not included in the above average.

The results of habitat use versus availability hint at Gila chub being habitat generalists. This would coincide with that observed for other fishes native to the Southwest. Gila chub, especially adults, have often been regarded as a relatively calm-water pool-loving species. While there is no doubt that large Gila chub are often conspicuous in deep pools, our data and experiences thus far have shown that large Gila chub will also often use shallow water with swift current. Some of these individuals were in spawning or pre-spawn condition and thus the use of such habitats by adults may be seasonally linked to reproduction. Further sampling this spring, when spawning is at its peak, will help define this relationship. Gila chub have often been associated with cienega type habitats (i.e., marshes) (Hendrickson and Minckley 1984). However, our data thus far show Gila chub using marsh macrohabitat and meso-habitats less or much less than predicted from availability. It should be noted that marsh habitats were often some of the most difficult to sample.

Difficulties – Electrofishing efficiency was greatly decreased in deep water. We observed most Gila chub to be only slightly affected by the electrical field in deep water. Some habitats were too deep for backpack electrofishing and restricted sampling to primarily near shore areas. Marsh habitats were often difficult to access, traverse, and sample. Velocity data needs more scrutiny, as an updated version of the Global Flow Probe may be more sensitive to slow water velocities than the version used through much of the study.

QUANTIFICATION OF SPAWNING HABITAT, TEMPORAL RANGE AND BEHAVIOR

In the laboratory I observed and recorded spawning of Gila chub on several occasions. One to multiple presumably male Gila chub would chase and come along the posterior side of presumably a female. A slight upward turn of one or more of the group was often noticed with sudden quick vibratory movements. These actions were often vigorous in nature. This behavior was repeated several times, however, it is unknown if more than one female was spawning but is not suspected. Apparent egg predation often followed each spawning pulse and Gila chub enthusiastically tried to reach eggs under the protective grate. Spawning colors varied from none to moderate. Eggs were demersal, adhesive, ovoid, and translucent with about the inner 90% of the egg a light yellow cream color and the remaining 10% colorless. Eggs less than a day old measured 2 mm or less (mean = 1.93 mm; N = 5) and hatch after 4-5 d at about 22 °C. Fecundity appears to range from roughly 300-3000 for Gila chub about 110-170 mm TL. Newborn Gila chub are about 7 mm TL and swim up appears to occur within the first 36 hours.

Chasing behavior similar to that observed in the laboratory was noted in Bonita Creek on 4-13-02 during daylight hours but further activity was not witnessed. Strong spawning colors appeared from February through August but were most intense in April and May. Tuberculation also coincided with strong spawning colors. Slight to moderate spawning colors were noted year-round. We captured small Gila chub (< 40 mm TL) throughout the year indicating spawning may also occur outside spring and early summer. One priority of sampling this fall is to acquire more data on the reproductive patterns of Gila chub outside of spring and early summer via increased drift netting, GSI sampling, and direct observation.

Difficulties – Sampling efforts have shown that large adults are uncommon in Cienega Creek, which increases the difficulty of finding suitable Gila chub for reproductive analysis. We lack a practical method to identify gender of non-ripe individuals in the field. Hopefully our ongoing examination of sacrificed Gila chub will allow for the development of a method to differentiate the sexes for future studies.

QUANTIFICATION OF MOVEMENT PATTERNS

Field work, data entry, and analysis for marked / tagged fish is currently ongoing. Over 100 adult Gila chub have been PIT-tagged with roughly 6 recaptures having occurred. Only a single larval fish was captured at night using drift nets (6-4-04). We believe this low number reflects the timing of reproduction and drift nets will be set out this fall and earlier next spring.

Difficulties – As previously alluded to, adult Gila chub of a size suitable for tagging are often uncommon in Cienega Creek. Both streams cover a relatively large longitudinal area and the rate of returns may likely reflect this.

ACKNOWLEDGMENTS

We must first thank Gina Schultz for her enduring technical support. We thank Jeff Simms of Bureau of Land Management for his tireless support on numerous levels. We thank Bureau of Land Management for funding this study and BLM employee Janell Reifel for her administrative assistance. We thank Andrew Schultz's PhD committee Dr. Scott Bonar (major advisor), Dr. Courtney Conway, Dr. Kevin Fitzsimmons, Dr. Peter Reinthal, and Dr. Cecil

Schwalbe. We thank the professionals at the Bureau of Land Management in Safford, Arizona for their support, especially Heidi Blasius. We thank all staff and faculty at the University of Arizona that assisted in any respect during this study, especially Carol Yde and Cecily Westphal. Thanks to John Sottilare, Shawna Collins, Sheldon Caldwell-Meeks, Daniel Arevalo, David Ward, Corissa Carveth, Stan Culling, Erics Sontz, Greg Stoehr, Michelle Riley, Michelle Martin, Devin Beck, Andrea Francis, Sachiko Aso, Dan Koepke, and Abe Randolph, for their assistance in the field and laboratory. Thanks to all the other technicians and volunteers not mentioned here.

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Table 1. - Comparison of percent catch of Gila chub per macrohabitat type and area sampled per macrohabitat type from 3-29-02 to 8-6-04 in Cienega Creek, Arizona (Pima County) and Bonita Creek, Arizona (Graham County).

MACROHABITAT	% AREA PER MACROHABITAT TYPE	% CHUB PER MACROHABITAT TYPE
Cascade	0.25%	0.61%
Chute	3.30%	6.35%
Marsh	13.76%	0.20%
Pool	45.22%	48.77%
Riffle	6.70%	3.89%
Run	30.76%	40.16%

Table 2. - Comparison of percent catch of Gila chub per meso-habitat type and area sampled per meso-habitat type from 3-29-02 to 8-6-04 in Cienega Creek, Arizona (Pima County) and Bonita Creek, Arizona (Graham County).

MACROHABITAT	MESO-HABITAT	% AREA PER MESO-HABITAT TYPE	% CHUB PER MESO-HABITAT TYPE
CASCADE		0.25%	0.61%
CHUTE		3.30%	6.35%
MARSH		13.76%	0.20%
POOL	debris	8.06%	9.63%
POOL	deflection	0.10%	0.00%
POOL	marsh	4.53%	0.82%
POOL	plunge	0.12%	0.20%
POOL	trench	0.91%	0.20%
POOL	variable	31.49%	37.91%
RIFFLE		6.70%	3.89%
RUN	fast	1.69%	3.89%
RUN	marsh	1.16%	0.41%
RUN	slow	2.41%	2.66%
RUN	variable	25.50%	33.20%

Table 3. - Comparison of percent catch of Gila chub per mean depth category and area sampled per mean depth category from 3-29-02 to 8-6-04 in Cienega Creek, Arizona (Pima County) and Bonita Creek, Arizona (Graham County).

MEAN DEPTH CATEGORY (CM)	% AREA PER MEAN DEPTH CATEGORY	% CHUB PER MEAN DEPTH CATEGORY
0-10	15.16%	1.84%
10-20	28.12%	13.32%
20-30	13.10%	25.82%
30-40	7.50%	14.75%
40-50	6.54%	7.58%
50-60	9.13%	18.24%
60-70	5.36%	6.56%
70-80	3.82%	3.69%
80-90	3.93%	5.53%
90-100	2.90%	0.41%
100-110	0.53%	2.25%
110-120	1.42%	0.00%
120-130	1.30%	0.00%
130-140	1.10%	0.00%
150+	0.09%	0.00%

Table 4. - Comparison of percent catch of Gila chub per maximum depth category and area sampled per maximum depth category from 3-29-02 to 8-6-04 in Cienega Creek, Arizona (Pima County) and Bonita Creek, Arizona (Graham County).

MAX DEPTH CATEGORY (CM)	% AREA PER MAX DEPTH CATEGORY	% CHUB PER MAX DEPTH CATEGORY
0-10	0.53%	0.00%
10-20	12.28%	1.84%
20-30	9.15%	8.61%
30-40	10.54%	15.37%
40-50	17.70%	13.32%
50-60	7.64%	4.71%
60-70	2.17%	7.79%
70-80	1.99%	1.23%
80-90	3.50%	4.71%
90-100	2.65%	3.89%
100-110	3.70%	9.02%
110-120	3.82%	4.10%
120-130	2.24%	5.94%
130-140	4.22%	4.10%
140-150	2.11%	1.84%
150-160	2.04%	4.71%
160-170	1.41%	0.82%
170-180	1.31%	2.25%
190-200	5.65%	1.23%
200-210	0.90%	0.00%
210-220	1.42%	0.00%
220-230	0.09%	0.00%
230-240	0.00%	0.00%
240-250	2.92%	4.51%

Table 5. - Comparison of percent catch of Gila chub per total cover category and area sampled per total cover category from 3-29-02 to 8-6-04 in Cienega Creek, Arizona (Pima County) and Bonita Creek, Arizona (Graham County).

% TOTAL COVER CATEGORY	**% AREA PER TOTAL COVER CATEGORY**	**% CHUB PER TOTAL COVER CATEGORY**
0-10	16.41%	12.91%
10-20	17.67%	12.91%
20-30	15.70%	26.02%
30-40	8.13%	13.32%
40-50	11.43%	15.57%
50-60	6.97%	9.22%
60-70	2.45%	4.10%
70-80	4.35%	3.28%
80-90	5.77%	2.46%
90-100	11.11%	0.20%

Table 6. - Comparison of percent catch of Gila chub per mean velocity category and area sampled per mean velocity category from 3-29-02 to 8-6-04 in Cienega Creek, Arizona (Pima County) and Bonita Creek, Arizona (Graham County).

MEAN VELOCITY CATEGORY (CM/S)	% AREA PER MEAN VELOCITY CATEGORY	% CHUB PER MEAN VELOCITY CATEGORY
0-10	56.68%	46.11%
10-20	3.77%	8.61%
20-30	10.07%	3.07%
30-40	4.89%	6.35%
40-50	2.63%	6.76%
50-60	1.60%	1.64%
60-70	0.52%	2.87%
70-80	0.86%	2.05%
80-90	0.48%	0.82%
90-100	4.30%	0.20%
100-110	0.82%	4.51%
110-120	2.03%	3.07%
120-130	0.36%	1.64%
130-140	0.22%	0.00%
140-150	0.53%	0.00%
150+	10.76%	10.45%

Table 7. - Comparison of macrohabitat type and the average of mean length of Gila chub per macrohabitat type from 3-29-02 to 8-6-04 in Cienega Creek, Arizona (Pima County) and Bonita Creek, Arizona (Graham County).

MACROHABITAT	AVG. OF MEAN CHUB LENGTH (MM)
Cascade	50.6
Chute	123.1
Marsh	29
Pool	91.5
Riffle	121.7
Run	97.8