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ECOLOGY OF FISHES IN REDFIELD CANYON, ARIZONA, WITH EMPHASIS ON *GILA ROBUSTA INTERMEDIA*

Few perennial streams exist in the Southwest that are free of the impacts of human activities. Redfield Canyon in southern Arizona is one such stream. It has been subjected to only light grazing by domestic livestock, and no non-native fishes have as yet become established. Redfield Canyon also supports a population of Gila chub. This cyprinid, felt by some (i.e., Rinne, 1976) to warrant designation as *Gila intermedia,* is now recognized by the American Fisheries Society as a subspecies of *Gila robusta,* the roundtail chub (Robins et al., 1980). The fish was considered for federal listing as threatened (Williams and Sada, 1985), and, although listing never occurred, the Gila chub is considered as threatened by the state of Arizona. It is included in the "special concern" category by the American Fisheries Society (Deacon et al., 1979).

As part of a field ecology project, students from Idaho State University investigated fish populations of Redfield Canyon in May 1983. Objectives were to: 1) assess species composition and abundance in typical habitat, 2) examine habitat selection by each species, with emphasis on *Gila*, 3) assess the age and growth of the *Gila* population, and 4) describe the diet of *Gila* over a 24-h period.

Redfield Canyon drained the southeastern slope of the Galiuro Mountains in Graham Co., Arizona. Perennial flow terminated at the upper edge of the San Pedro River valley. Our study area was that portion of Redfield Canyon acquired by The Nature Conservancy in 1982. It was in the middle portion of the canyon (T11S, R20E) at 1,265 m elevation where a natural barrier in the form of a 5-m-high waterfall prevented fishes from dispersing above a point 0.7 km below the mouth of Sycamore Canyon. Below the falls, streamflow at time of sampling was approximately 0.3 m^3/s, and channel width was 2.5 to 3.0 m, with pools up to 1.1 m deep. Water temperature varied from 16.7 to 19.0°C during daylight hours. Shading was a riparian canopy dominated by Arizona alder (*Alnus oblongifolia*). Aquatic macrophytes were uncommon, but algae, especially *Cladophora* and *Spirogyra,* were abundant.

Upper and lower study sites (300 and 600 m below the falls, respectively) were sampled on 19 through 22 May 1983. Population estimates of fish were conducted on one riffle at each site. Upper and lower pools were 39 and 19 m long, and the upper and lower riffles were 26 and 36 m long, respectively.

Fishes were sampled with a backpack electroshocker at or below 100 volts DC. Population estimates were conducted by placing blocking seines at each end of a study section and removing fishes in three passes. All fishes were released alive after total lengths (TL) were recorded. Population estimates and 95% confidence intervals were calculated using the maximum likelihood procedure. Qualitative electroshocking was conducted in pools between the upper and lower study sites. For 20 pools, maximum depth was measured and compared with length of largest *Gila* present.

Scales were removed from all *Gila* from the side of the body above the lateral line immediately below the insertion of the dorsal fin. Scales were examined on a microprojector at a magnification of 84×. Since checks were most evident on lateral fields, scale measurements were made from the focus to the edge of the larger of the two lobes separating the anterior and lateral fields. Fish lengths were back-calculated from a nomograph prepared from the body-scale relationship.

Diet of *Gila* was assessed by analysis of contents of gastrointestinal tracts collected at three times during a 24-h period on 21 and 22 May. Fish were collected in darkness (no moon) at 0100 h, at 1000 h, and at 1900 h (dusk) by electroshocking in several pools immediately downstream from the upper study site. Abdomens were slit to facilitate preservation of gut contents immediately after capture. In the laboratory, fish were weighed, and gastrointestinal tracts were removed. Contents of esophagus to first flexure of the intestine, first flexure to second flexure, and second flexure to the vent were examined separately. Contents were identified, where possible, and their total weight recorded after drying for 24 h at 65°C.

Four indigenous taxa were captured. Three were cyprinids: *Gila robusta intermedia, Rhinichthys osculus, Agosia chrysogaster.* The fourth was a catostomid which was tentatively identified as *Catostomus insignis*, although *Catostomus clarki* may also have been present.

TABLE 1—Population estimates (fish/100 m²) of fishes in Redfield Canyon, Arizona. Numbers in parentheses indicate 95% confidence intervals.

Species	Upper site		Lower site		Total
	Pool	Riffle	Pool	Riffle	
Gila	41	41	11	2	95
	(40–45)	(33–61)	(11–15)	(2–3)	
Agosia	19	14	48	33	114
	(15–31)	(14–16)	(38–78)	(32–37)	
Rhinichthys	61	128	65	100	354
	(55–71)	(117–144)	(50–99)	(97–104)	
Catostomus	27	31	25	3	86
	(27–28)	(31–34)	(23–36)	(3–5)	
Total/100 m²	148	214	149	138	
Area, m²	101.4	70.2	47.5	104.4	

Rhinichthys osculus was the most abundant species in both riffles and pools, often comprising about half of the total number of specimens. Numbers of the other three species were relatively equivalent, and density of all species combined was generally similar in pools as compared with riffles (Table 1).

Habitat utilization by the four species was similar to that in other Arizona streams such as Aravaipa Creek (Barber and Minckley, 1966; Rinne, 1985). *Rhinichthys osculus,* normally a riffle species, was abundant in Redfield Canyon riffles but was also present in high densities along the margin of pools. *Agosia chrysogaster* was common in both pools and riffles. Larger *Catostomus* were found exclusively in pools, with smaller individuals being abundant in the upper riffle site but uncommon in the lower riffle. *Gila robusta intermedia* were equally abundant in the upper pool and upper riffle but were more abundant in the lower pool than in the lower riffle. There was a strong linear relationship ($r^2 = 0.95$) between pool depth (range of 40 to 112 cm) and total length of the largest of *Gila* present in that pool (range of 51 to 222 cm). The relationship is described by the equation $Y = 2.42X - 43.82$ where X is pool depth in centimeters and Y is total length in millimeters.

Size of the 113 *G. r. intermedia* collected ranged from 45 to 222 mm. A length-frequency distribution indicated considerable overlap between age groups, with an indication of modes at approximately 95, 145 to 155, and 205 mm.

Less than 5% of the scales examined were regenerated, with most regeneration noted in scales of larger fish. Checks were normally apparent as changes in circuli spacing, although some crossing-over of circuli was observed in scales of older fish. Although checks that appeared to be annuli were consistently present, our results are based on a single sample and should be viewed as tentative. Annulus formation appeared to result from reduction in, or cessation of, growth during the winter period.

TABLE 2—Back-calculated lengths and annual growth increments in millimeters of *Gila robusta intermedia* collected in Redfield Canyon, Arizona, in May 1983. Annual increments (mm) for each growth season were 89.6, 45.3, 25.2, and 23.3, respectively.

Age group	Number	Calculated length at end of growth season, mm			
		1	2	3	4
I	85	88.1			
II	18	95.6	137.3		
III	7	86.0	129.5	159.9	
IV	3	102.6	132.6	160.3	183.4
Weighted average	113	89.6	134.9	160.1	183.4

TABLE 3—Frequency of occurrence and total weight of food items in guts of *Gila robusta intermedia* from Redfield Canyon, Arizona. Nine fish from each sampling period (0100 h, 1000 h, and 1900 h) were examined on 21 and 22 May 1983.

	Gastrointestinal tract portion								
	Eosphagus to first flexure			First flexure to second			Second flexure to vent		
Taxon	0100	1000	1900	0100	1000	1900	0100	1000	1900
Fish	1[1]	0	0	1[2]	0	1[3]	1	0	2[3]
Unidentified insects	0	2	0	1	3	0	0	6	1
Terrestrial insects	7	7	1	7	4	2	8	2	1
Aquatic insects	1	0	2	1	2	2	0	0	0
Terrestrial plant materials	5	1	1	1	4	0	2	4	2
Algae	3	5	1	2	8	0	3	6	3
Diatoms	7	7	1	8	8	0	8	9	3
Gravel[4]	0	4	1	2	3	1	2	3	2
Empty	0	0	7	0	0	5	0	0	4
Total dry weight, g	0.35	0.12	0.08	0.32	0.23	0.19	0.37	0.40	0.31
Dry weight excluding fish remains	0.20	0.12	0.08	0.22	0.23	0.14	0.19	0.40	0.25

[1] One speckled dace, 41 mm.
[2] One speckled dace, 73 mm.
[3] One speckled dace, 66 mm, and unidentifiable fish remains.
[4] Not weighed.

Seasonal water temperatures are not available for Redfield Canyon, but, at a similar elevation on Aravaipa Creek, they dropped to 8°C in December (Barber and Minckley, 1966). Scale erosion probably resulting from resorption of scale margins during spawning was also present on scales from larger *Gila* and from some of the yearlings.

Fish were resuming or rapidly accelerating growth. Scales of 51% of yearling *G. r. intermedia* showed new growth, with from one to three (average 1.9) new circuli evident at the margin. No older fish showed new growth. During the first year, fish laid down an average of 14.8 circuli (range of 9 to 23). The body-scale relationship was described by the equation $Y = 2.31X + 25.19$ ($r^2 = 0.78$) where Y is fish length in millimeters and X is 84 times the scale radius in millimeters. Scale analysis indicated that four age groups were present in the population rather than the three suggested by the length-frequency distribution. Back calculation indicated average lengths of about 90, 135, 160, and 183 mm at the end of the first, second, third, and fourth years of life, respectively (Table 2). Annual growth increments declined rapidly after the first year, with growth in the second and third years being about half that of the preceding year in each case. Some *Gila* of both sexes were reaching sexual maturity at the end of their first year of life in Redfield Canyon. The smallest ripe males and ripe females that we handled were 90 to 95 mm in length.

Age and growth analysis is complicated by the likelihood that spawning occurs over an extended period of time. In constant temperature springs in the Sonoita Creek basin, *G. r. intermedia* may spawn throughout the year (W. L. Minckley, in litt.). Judging from the size range (45 to 111 mm) of fish that were apparently 1 year old or less in May in Redfield Canyon, spawning does continue over several months. Age and growth analysis may also be complicated by the sexual dimorphism typical for *Gila* (females growing larger than males; Minckley, 1973), although we did not systematically record sex of the fish we collected.

Specimens of *Gila* we dissected were omnivorous, with both plant and animal material being ingested (Table 3). The ratio of the gastrointestinal tract length to fish body length is 1.0. No true stomach is present. Fishes were eaten by four of the 27 *Gila* examined. The three prey that could be identified were *R. osculus*. Aquatic insects were rarely found. One dobsonfly nymph (order Megaloptera) was found. Terrestrial insects provided a major source of food, with ants (30 or more in some cases), caterpillars, and beetles occurring in some individual fish. Diatoms appeared to be the most common food item by volume and could be a major dietary component. The presence of small particles of gravel in guts of several fish suggested the occurrence of benthic feeding. Based on the weight of the contents of gut sections (Table 3), *Gila* appeared to be feeding mainly at night, capitalizing on ants. At dusk (1900 h), the anterior third of the guts of seven of nine fish was empty (total dry weight = 0.08 g). Six hours later at 0100 h, all fish showed full anterior guts (total weight = 0.35 g).

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