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Abstract—Bonytail, *Gila elegans,* in Cibola High Levee Pond, an isolated lower Colorado River backwater, fed more during evening and after dark than during daylight. Fish were omnivorous, and contents of stomachs ($n = 72$) included amorphous organic matter (materials digested beyond visual identification), aquatic macrophytes, invertebrates (micro-crustaceans, insects, and crayfish), bullfrog, and fish. Proportion of plants decreased while that of invertebrates increased with increased size of fish. Remains of fish were found only in the largest specimens. Asian tapeworm, *Bothriocephalus acheilognathi,* was in 11% of the sample and represents the first report for this parasite from open waters of the lower Colorado River system.

Resumen—La carpa elegante, *Gila elegans,* en Cibola High Levee Pond, un remanso aislado en la parte baja del río Colorado, se alimentó más durante la noche que durante el día. Los peces fueron omnívoros, y el contenido de estómagos ($n = 72$) incluyó materia orgánica amorfa (materiales digeridos más allá de la identificación visual), macrófitas acuáticas, invertebrados (micro-crustáceos, insectos y cangrejos de río), rana toro, y peces. La proporción de plantas disminuyó mientras que la de invertebrados aumentó al incrementarse el tamaño del pez. Restos de peces se encontraron sólo en los especímenes más grandes. El gusano plano *Bothriocephalus acheilognathi* se encontró en el 11% de la muestra, y representa el primer registro de este parásito en las aguas abiertas de la parte baja del sistema del río Colorado.

Cibola High Levee Pond is a small (ca. 2 ha) remnant of the lower Colorado River channel located between the river and inland (high) levees on United States Fish and Wildlife Service Cibola National Wildlife Refuge in La Paz County, Arizona, and Imperial County, California. The pond was reclaimed to eliminate nonnative fishes and stocked with native endangered bonytail (*Gila elegans*) and razorback sucker (*Xyrauchen texanus*) beginning in 1993. Since then, the site has served roles in management and research (M. LaBarbara and C. O. Minckley, in litt.; G. A. Mueller et al., in litt.). At the time of our study, the pond contained only these two species, each represented by multiple generations including stocked and naturally produced individuals. Sporadic individuals of other species (threadfin shad, *Dorosoma petenense*; bluegill, *Lepomis macrochirus*; largemouth bass, *Micropterus salmoides*; western mosquitofish, *Gambusia affinis*; an undetermined ictalurid catfish, either channel catfish, *Ictalurus punctatus*, or flathead catfish, *Pylodictis olivaris*) have been encountered over the years and removed; none were known to be present during the time of our study.

Sites like Cibola High Levee Pond play a central role in the strategy for management of endangered fishes of the Colorado River (Minckley et al., 2003; United States Fish and Wildlife Service, in litt.), and they are critical to the life-history needs of native fishes. The purposes of this investigation were to document foods utilized by bonytail in springtime, examine utilization of food as a function of size of fish, and investigate temporal aspects of feeding habitats and utilization of food by bonytail inhabiting Cibola High Levee Pond. These goals were accomplished by nonlethally acquiring samples from stomachs of fish from evening and nighttime collections of bonytail representing relatively larger and relatively smaller fish across 2 years. Although not comprehensive, this information provides a better understanding of foods utilized and may be important to management because it can guide the design of new backwaters and modification of existing ones that play a key role in plans for conservation of the species (Minckley et al., 2003; United States Fish and Wildlife Service, in litt.), for example, by providing habitats that foster development of important resources of food.

A combined sample of 72 bonytail was acquired from collections made with trammel nets on 7 May 2003 and 4–5 May 2004. Acquisition of larger sample sizes was precluded by limitations of permits and the critically imperiled status of the species. Telemetric studies at Cibola High Levee Pond indicated that adult bonytail are active during nighttime and spend the daylight hours dormant and under cover (Marsh et al., 2013), so nets were deployed to sample two feeding times, evening (1800–2400 h) and night (0100–0545 h). A distinct size class was sampled each year. Target total length for 2003 was >375 mm ($n = 28$) and for 2004 was <375 mm ($n = 44$), but some individuals exceeded the latter limit. Fish were held in a floating holding-net for a brief time after capture, then measured (total length to nearest millimeter) and weighed (nearest 2 g). Contents of stomachs and intestines (gastrointestinal tract) were removed by flushing material from the gastrointestinal tract through the vent by using a special apparatus inserted into the esophagus (Wasowicz and Valdez, 1994) that was an effective method to avoid sacrifice of fish. The apparatus consisted of a one-way, rubber squeeze bulb and tygon tubing of varying sizes (6.5, 8.0, 9.5, and 11.0 mm in outside diameter), with tubing size matched appropriately to size of gape of fish. Gastrointestinal tracts were flushed with clear water (from the site of collection of fish) through a sieve and into a container for the sample. Fish with empty tracts were noted. Samples were fixed in 10% formalin and later rinsed in fresh water and transferred to 70% ethanol for later examination at 10–40X with a compound dissecting microscope.

Gastrointestinal samples were individually washed through a sieve with a 500-micron mesh, and solids were weighed wet to the nearest 0.001 g. Contents of each sample were visually examined, and the percentage of the total quantity was estimated for each of the following six categories: amorphous organic matter; inorganic matter; plant; fish; invertebrate; other. When possible, items were identified to family or a more specific taxonomic level. Samples were then placed in 70% ethanol for storage.

Bonytail examined from 2003 ($n = 28$) were 376–510 mm in total length (mean = 447) and ranged in weight from 305–1,136 g (mean = 565). Fish from 2004 ($n = 44$) were smaller, 271–509 mm in total length (mean = 325) and 129–710 g (mean = 222). Weight-length relationships represented a continuum from smaller to larger fish, and there was more variation among larger individuals.

Empty gastrointestinal tracts represented 18% (13) of 72 fish sampled in both years. Frequency of empty tracts was more than four times higher for evening (33%) than for night (7%) samples (Yates corrected chi squared homogeneity, $\chi^2 = 6.44$, $df = 1$, $P < 0.05$), but the gross composition of gastrointestinal contents was similar between the two feeding times (Fig. 1).

Bonytail were omnivorous and consumed a wide variety of materials. Amorphous organic matter consisted predominantly of nondescript, brownish material that might have included lining of the stomach, mucous, or ingested materials in advanced stages of digestion and beyond visual identification. Inorganic material consisted of pebbles, sand grains, and larval cases of insects that incorporated sand grains and pebbles (e.g., trichopterans including Hydroptilidae). Plants consisted of various aquatic macrophytes including *Najas*, *Potamogeton*, and *Chara*. Fish consisted of any whole part or pieces including scales, bones, and flesh; only bonytail and razorback suckers were available for consumption but the two were not differentiated in gastrointestinal samples. Invertebrates consisted of a variety of groups including micro-crustaceans (copepods, ostracods, and *Daphnia*), red swamp crayfish (*Procambarus clarki*), Corbiculidae (*Corbicula fluminea*), tapeworms, dipteran larvae and adults, Notonectidae, and odonate nymphs and adults. Other matter included identifiable (bullfrog, *Lithobates catesbeianus*) and unidentifiable remains of vertebrates.

Asian tapeworm (*Bothriocephalus acheilognathi*) was positively identified in one specimen. Proglottids of tapeworms, presumably Asian tapeworm, were found in 8 of 72 (11%) samples representing all available sizes of bonytail, but scolexes could not be located in these fish so identification could only be presumptive.

For invertebrates, fish, and plants, proportions in gastrointestinal tracts varied by size (total length) of fish; plants decreased while invertebrates and fish increased with increased size of fish (Fig. 2). Parts of fish were observed in 8% of gastrointestinal samples (6 of 72) and were restricted to fish longer than 425 mm. Weights of gastrointestinal samples showed little linear relationship to body weight or total length of fish. Mean wet-weight of samples from stomachs was 1.54 g (nonzero range of 0.06–13.97 g; $SE = 0.35$).

The few available data from other studies indicate that bonytail feed on benthic and drifting aquatic inverte-

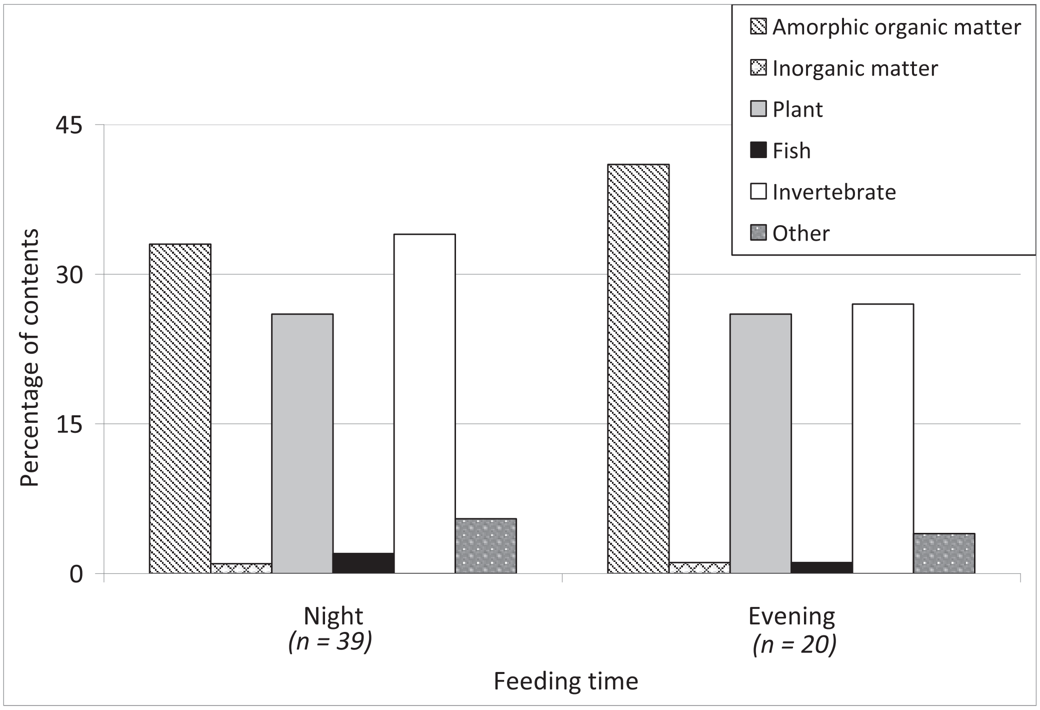

FIG. 1—Proportion of categories of food represented in the gastrointestinal tracts of bonytail (*Gila elegans*) following periods of nighttime and daytime feeding at Cibola High Levee Pond, Arizona-California, 2003–2004. Fish with empty stomachs are excluded.

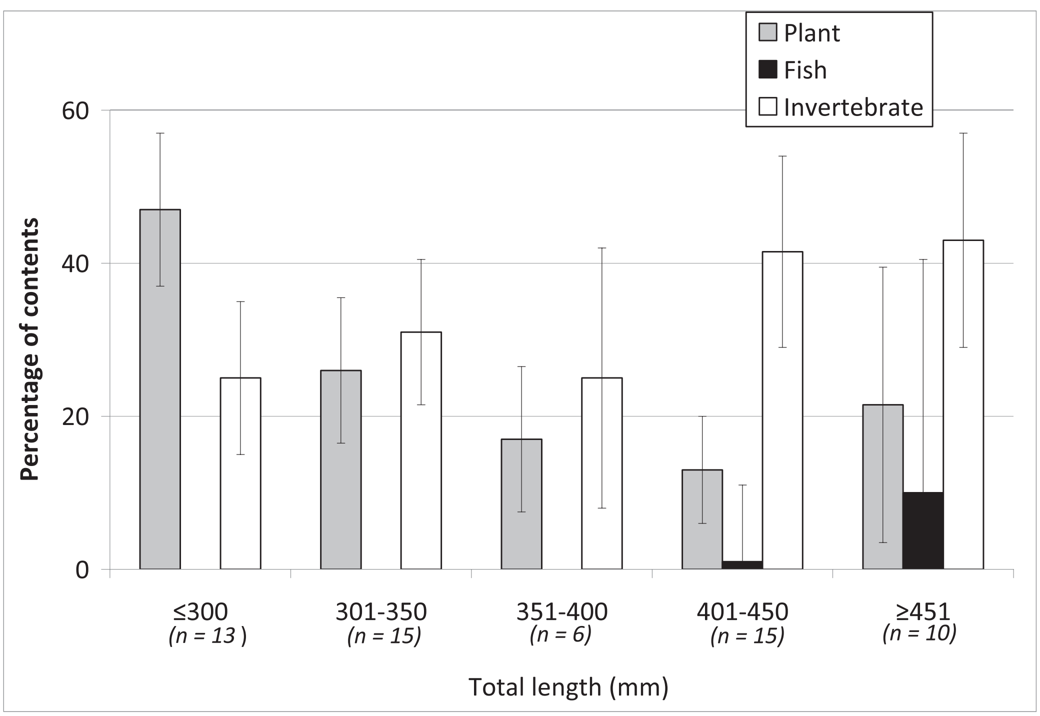

FIG. 2—Proportion of major categories of food represented in the gastrointestinal tracts of bonytail (*Gila elegans*) for each of five 50-mm size classes at Cibola High Levee Pond, Arizona-California, 2003–2004. Fish with empty stomachs are excluded; bars represent ±1 *SE*.

brates and terrestrial insects under natural conditions of streams (Kirsch, 1889). A composite sample of subadult bonytail and roundtail chub (*Gila robusta*) from Green River, Utah, ate mostly chironomid dipteran larvae and nymphs of mayflies (Ephemeroptera) when small, shifting to floating items (e.g., terrestrial insects) as they grew (Vanicek and Kramer, 1969). Adult bonytail in Green River fed mostly on terrestrial insects, presumably taken from the surface, but there was no evidence of piscivory. In contrast, bonytail in Lake Mohave were found to prey on small (64 mm in total length), newly stocked rainbow trout (R. A. Wagner, in litt.). Jonez and Sumner (1954) found plankton, insects, algae, and organic debris in bonytail from Lake Mead, and a few specimens from lakes Mohave and Havasu contained zooplankton (Minckley, 1973). Juvenile bonytail 100–200 mm in total length readily consumed small red swamp crayfish under experimental conditions (Lenon et al., 2002). Our results contribute substantial new detail to our understanding of the feeding ecology of bonytails but add little new qualitative information about their utilization of food.

The volume and composition of contents of stomachs and proportion of empty gastrointestinal tracts indicated the most intense feeding occurred at night. This pattern of behavior is consistent with telemetric studies, which indicated that adult bonytail are active during nighttime and dormant during daylight (Marsh et al., 2013).

No control was used in our study that could evaluate the effectiveness of the gastric flushing versus surgical extraction of contents from the gastrointestinal tract. Studies by others are equivocal. Bio/West (in litt.) and Wasowicz and Valdez (1994) suggest that flushing was nearly 100% effective with roundtail chub and was assumed effective with humpback chub (*Gila cypha*). Bonytail is morphologically similar to these congeners, and we are unaware of any reason flushing of the gastrointestinal tract would be differentially effective among the three species. Stone (2004) compared our method with the Baker-Fraser technique, which flushes the gastrointestinal tract from the vent toward the mouth, on 10 bonytail from a hatchery. He concluded both techniques were selective in favor of smaller, more digestion-resistant items, but this bias should be less with Baker-Fraser lavage. If true, our results could have underestimated use of larger foods including fishes. Asian tapeworm was reported in humpback chub from the Little Colorado River in Grand Canyon (Clarkson et al., 1997), but ours represents the first record of Asian tapeworm in bonytail from natural habitat on the lower Colorado River (see Choudhury et al., 2006) and may signal future occurrences of this parasite in other species and in other places. It is unknown if the tapeworm was introduced into Cibola High Levee Pond accidentally with stocks of bonytail or razorback sucker from the hatchery, or with other species that were stocked without authorization by unknown persons. Researchers, managers, and others should be aware of its potential presence and provide interested parties with incident reports as they occur.

Bonytail, humpback chub, and roundtail chub are omnivorous, but our most significant result may have been detection in bonytail of nonnative bullfrog and crayfish. Bonytail may suppress one or both of these pestiferous animals in habitats off the channel such as Cibola High Levee Pond and, thus, enhance native fishes (e.g., Lenon et al. 2002). Further, bonytail may consume at least nonspiny-rayed, nonnative fishes like western mosquitofish and, thereby, meliorate populations and enhance native fishes in ponds for conservation such as Cibola High Levee Pond, those at United States Fish and Wildlife Service Imperial National Wildlife Refuge, and others. Myriad opportunities for further investigation are obvious.

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