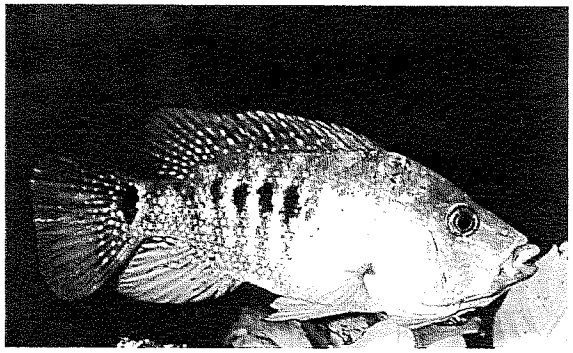
NOTES ON THE NATURAL HISTORY OF THE CUATRO CIENEGAS CICHLID, *CICHLASOMA MINCKLEYI*

By Matt Stephens

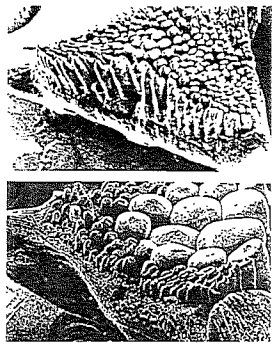
Walking among the cacti and desert shrubs, one would hardly have guessed that he was in the native habitat of any fish, much less that of a cichlid. However, that is exactly the situation I found myself in in the Cuatro Cienegas basin. Located in Coahuila in northern Mexico, the basin is home to many endemic plant and animal species, including *Cichlasoma minckleyi*, a cichlid noteworthy for its curious patterns of dental morphology. The species is named after Dr. W. L. Minckley of Arizona State University who began exploring the fauna of this unique region in the 1960's. The earliest research on the cichlids of the basin recognized several undescribed species separable by pharyngeal dentition and body shape. Studies that followed resulted in the formal description of a single "polymorphic" species, *C. minckleyi*, that manifests three physically-distinct feeding types: a detritivore with smaller, relatively weak (papilliform) pharyngeal teeth; a molluscivore with hypertrophied molariform pharyngeal teeth; and a (rare) piscivore with an elongate, slender head and body (and either papilliform or molariform pharyngeal teeth). The detritivore is further characterized by having a longer intestine than the molluscivore, which is essential to digesting plant matter present in detritus.

What are pharyngeal dentitions, you ask? A defining characteristic of the family Cichlidae is the presence of pharyngeal "jaws," a modification of the posterior gill arches to form two tooth-bearing surfaces (upper and lower) that help to process food items. Two basic types of teeth are found on the pharyngeal plates in *C. minckleyi*. The molluscivore is specialized for eating snails and has large, heavy molariform pharyngeal teeth used for crushing shells. The detritivore's morphology possesses smaller, more slender, needle-like teeth with less development of the surrounding bone and musculature. They use the smaller teeth to shred small prey items found in detritus. A third feeding type can be found as well: the "piscivore" morph is more slender-bodied than the other forms and is suspected to feed on the endemic pupfish (genus *Cyprinodon*) and other small fishes found in the basin. The piscivore can have either papilliform or molariform pharyngeal teeth; interestingly, very few individuals with "intermediate" dentitions have been evidenced.

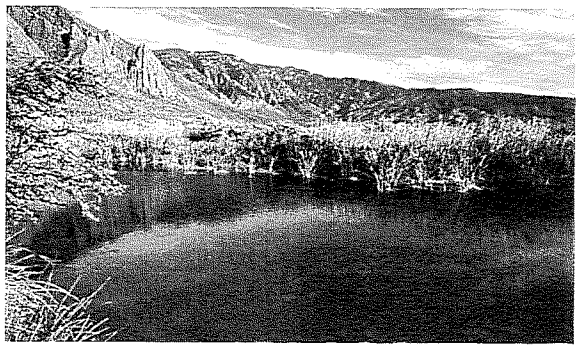


An adult *Cichlasoma minckleyi* in the aquarium. Photo by A. Konings.

Given such broad plasticity in trophic structures, it is easy to understand why the different "morphs" were first thought to be separate species. After all, African rift lake cichlids with such divergent morphologies are typically placed in different genera! Such a pattern of variability is especially interesting to evolutionary biologists, because *C. minckleyi* has managed to occupy several different ecological niches without speciating, in contrast to many African forms which have undergone impressive speciation with little niche specialization. Several lines of evidence support the conspecificity of the multiple morphs in *C. minckleyi*. Kornfield *et al.* (1982) surveyed trophic morphologies in breeding pairs in the wild and found 57% of the pairs to be mixed with respect to pharyngeal dentition, which is inconsistent with an hypothesis that each morph is a reproductively-isolated "species." Another study by Liem and Kaufman (1984) looked into the nerve impulses of jaw musculature involved with food manipulation in both the molluscivore and detritivore morphs and found insufficient differences to delineate two distinct species. Polymorphism also could not be ruled out by allozyme studies (Kornfield *et al.*, 1982).



Comparison of papilliform (above) and molariform (below) pharyngeal dentitions in *Cichlasoma minckleyi*.

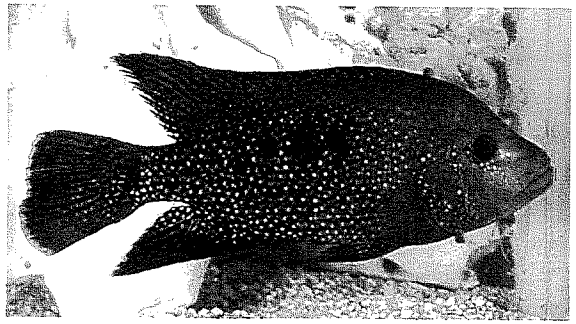


One of the many springs at Cuatro Cienegas in northern Mexico that are the home of the endemic *C. minckleyi*. Photo by A. Konings.

How these different feeding morphologies evolved without speciation within the confines of a small isolated valley is a question of major concern to evolutionary biologists. Several explanations exist to date. Sage and Selander (1975) proposed that a *Herichthys cyanoguttatus*-like ancestor invaded the basin and gave rise to the molariform morph in response to the abundant snail populations already there. Another theory is similar, except the ancestral stock is thought to be related to *Nandopsis labridens* (Kornfield and Taylor, 1983). Still another theory proposes that both ancestral types were present in the basin at some point and hybridized in isolated habitats, resulting in the expression of different pharyngeal tooth types (Liem and Kaufman, 1984). This is an interesting possibility in that many populations of *C. (N.) labridens* have large stout molariform pharyngeals, while most populations of *C. (H.) cyanoguttatum* have papilliform teeth (LaBounty, 1974). It is also noteworthy to mention that members of the *C. (N.) labridens* species-complex are very prominent components of the cichlid fauna throughout the Rio Panuco (the next major drainage basin south of the Rio Grande) where aquatic snails are often very abundant.

Like *C. minckleyi*, many of the snails of the Cuatro Cienegas basin are unique to the area. Shell strength tests conducted during studies of feeding ecology revealed that snails of the basin tested stronger than most other freshwater snails analyzed and were indeed closer in strength to some marine species. It is quite likely that *C. minckleyi* and at least three snail species have evolved together for some time in the Cuatro Cienegas basin. It has been hypothesized that the molariform morph might actually "track" snail abundance over time. If this is the case, it could explain the selective pressures exerted on snails to evolve stronger shells. In any event the whole system offers a wonderful opportunity to teach us how organisms interact and evolve in their natural environment.

Cuatro Cienegas offers a seemingly endless array of aquatic habitats for study. One of the most prominent sites is La Becerra (home of the notorious "Golden *Minckleyi*;" Konings, 1994), an area frequently used for swimming by both tourists and locals. Now only a third its original size, La Becerra is being drained by a connection to a canal system that spans a large part of the basin. Still, large shoals of pupfish, Mexican tetras (*Astyanax fasciatus*), and cichlids inhabit the site, which consists of two deep pools connected by a small, swift-moving channel. I observed many dark-green to black cichlids foraging (for snails?) by diving into the gray-brown detrital layer. At least some of the larger individuals exhibited a broad head with protruding opercula, suggesting the appearance of a formidable snail-crusher. Many other cichlids were observed foraging throughout the vegetation of the pools and the channel, while other just swam about lazily in loose



An adult male *C. minckleyi*. Photo by M. Stephens.

schools. Around the edges of the pools, aquatic plants and roots and debris of terrestrial species combine to provide a refuge and forage area for juvenile fishes, including cichlids. Observing these smaller fishes led me to wonder how many would fall prey to the elusive piscivore that I was so hoping to see. After a lengthy period of snorkelling aimlessly, I finally came upon my objective. There right in front of me, heading for cover among lily pads on the far side of the pool was a large, elongate, big-mouthed cichlid; I thought this must surely be the piscivorous morph of *C. minckleyi*. I followed it eagerly hoping to see it in action, but it eventually eluded me among the vegetation. Soon after I came upon another exciting sight: a snow-colored female guarding her brood of fry underneath a limestone ledge.

Having successfully transported live fishes back to the lab at the Texas Memorial Museum in Austin, I have found that the aggressive but highly social *C. minckleyi* does best when kept in large aquaria and in groups of at least ten individuals. Isolated specimens tend to sulk and eat less, resulting in poor overall health. Larger groups however develop definite social hierarchies even at early ages, which probably contribute to the large variability in size seen among siblings. Food preferences vary greatly among individuals and over time. At first, wild-caught fish would accept only frozen bloodworms and live foods, but later developed an affinity for brine shrimp and, eventually, flakes. Smaller individuals are less picky from the outset.

Within weeks of the introduction of fourteen adults to a 100-gal tank, two pairs formed and spawned at opposite ends of the aquarium. Non-breeding individuals were removed to avoid injury from the aggressive parents, who continued to fight and badger both mates and the rival pair. Disputes between pairs often resulted in mixing of the two broods. If left together, males usually ended up killing their mates. Therefore once a pair formed, the members were isolated and then kept separated by installing a perforated plexiglass plate between them, which allowed for exchange of both visual and olfactory stimuli, as well as successful fertilization of the eggs. Presence of additional fishes as "dither" seemed to help reinforce the pair bond by redirecting aggression toward the outside "threat" posed by the dither fish.

Breeding behavior in *C. minckleyi* is similar to that of other cichlasomines, including jaw-locking, erect fins, and side-by-side jockeying in either head-to-head or head-to-tail positions. Once they decide not to kill each other (!), courtship can span several hours before spawning occurs with the female making successive passes over the spawning site, followed by the male as he fertilizes the eggs. Both sexes display genital tubes while spawning, though the female's appears first and serves as a dependable cue to the onset of spawning. At one point one of my pairs was laying 150-200 eggs every 3-4 weeks. One problem I frequently experienced was massive fungal infections of the eggs which can be treated with methylene blue. Though first choosing to leave the eggs with the female, I eventually discovered that a higher survival rate was obtained by removing the egg-bearing spawning substrate to a separate incubation tank with light sponge filtration.

In comparison to other cichlids, *C. minckleyi* belongs in the same class, in terms of aggressiveness, as the "big boys" of cichlidom so popular with feeder freaks. I have kept them successfully with several other large Central American species. Because they are prone to indiscriminate outbursts of mayhem, I'm not sure I can recommend them for your basic "start-up" effort. However, for the experienced cichlid-keeper they can be a wonderful treat. Breeding pairs display prominent sexual dichromatism both in the wild and in captivity. Females take on an opaque, snow-white color with hints of blue in the dorsal fin and stark, black markings on the flank. Dominant breeding males can vary (in single individuals over time!) from blue-grey to dark-green to black. At times they somewhat resemble breeding Texas cichlids with the posterior third of the body being very dark. The pale yellowish eggs hatch in about 94 hours at 82° F. Newly-hatched wrigglers adhere to the spawning substrate via filamentous structures protruding from pores on the top of the head. These structures disappear in about a week as the yolk sac is absorbed and the fry become free-swimming.

In closing, it wouldn't be prudent to fail to mention conservation issues currently affecting Cuatro Cienegas and the surrounding region. Like much of Mexico the area is economically depressed; the issue of day-to-day survival is often much more compelling to people of the area than ecology and conservation. Preservation has to date been at least partially a function of chance in that the water from the springs that supply the aquatic systems of the basin is very high in both dissolved minerals and salts, making it virtually useless for agriculture and livestock. Therefore, development has been restricted by what can be done with the land. Fortunately the basin has recently been declared a protected area, resulting in bans on brush fires, fishing, and bathing in certain pools. Major threats, however, remain, including habitat destruction, lowered water levels due to canalization, and competition from introduced exotic species. Hopefully, the people of Cuatro Cienegas can continue to adapt and protect this unique and beautiful environment.

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