

THE MOST ENDANGERED PUPFISH

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There is a hole in the middle of the southern Nevada desert. This hole, once called the Miner's Bathtub, has been known for many years now as Devil's Hole. The hardrock miner who once slaked his thirst at this remote desert site is long gone but the small Devil's Hole pupfish (*Cyprinodon diabolis*) who has inhabited this breach in the desert for over 20,000 years is still here.

To understand the Devil's Hole pupfish it is necessary to understand its unique habitat. Devil's Hole is located in a range of rugged, low hills at an elevation of 732 meters above mean sea level in Ash Meadows. Ash Meadows, which straddles the Nevada-California state line, is only a few kilometers east of Death Valley, California, but about 1000 meters higher.

The word "meadows" brings to mind well-watered valleys full of green grasses surrounded by lofty pines. The only thing well-watered in Ash Meadows are the checkerboard fields of alfalfa planted by hopeful agribusiness concerns. With these exceptions, Ash Meadows is a vast, arid area. There is water in Ash Meadows. In fact, a surprising number of springs, seeps, and pools host many species and subspecies of pupfish. Devil's Hole is one of these small but extremely important aquatic habitats.

Devil's Hole is a rock-bound pool about seven by three meters which lies 15 meters deep inside the unnamed hill it occupies. Although the pool is small, it is only a surface manifestation of a deep and only partially explored subterranean reservoir.

The Amargosa Desert Ground Water Basin, of which Ash Meadows and Devil's Hole are a part, receives its water from the Nevada Test Site (where the nuclear weapons of Armageddon are tested). Water from the Site flows underground until it is forced to the surface by what geologists refer to as a hydraulic barrier. This is a very slow process. In fact, water which fell in the Test Site area about 10,000 years ago is just now reaching Devil's Hole. The hydraulic barrier which forces water to the surface is a geological fault which extends from Big Springs in Ash Meadows northwest towards the dusty desert crossroads at Lathrop Wells, Nevada.

Over the millennia, the massive Sierra Nevada Mountain range to the west of the California-Nevada desert thrust higher and higher into the western skies in response to movements of immense plates under

the earth's surface. The growing mountain range blocked the moisture-laden clouds which roll in from the Pacific Ocean. Precipitation which once reached across western North America was caught by the granite fangs of the Sierras. Denied moisture, the inland waters began to evaporate. Although it took many thousands of years, the land eventually assumed its present arid form. Ferns gave way to pickleweed and saltgrass. Many life forms vanished while a few hardy species, including pupfish, evolved in and around springs, pools and marshes.

The Devil's Hole pupfish played a small but significant role in this process of desertification. In fact, if the deserts hadn't developed neither would have the Devil's Hole pupfish. Isolation of the Devil's Hole pupfish through geological changes could have led to extinction but the strong genetic variability of the fish contributed to its survival. Speciation may have occurred with many other organisms in much the same way as it did with the Devil's Hole pupfish -- that is isolation of a small population due to environmental conditions followed by population expansion when conditions improve. Conditions, however, never really improved for this isolated species and its situation remained essentially unchanged for many thousands of years.

The Devil's Hole pupfish first came to the attention of science in the 1890's when it was classified as *Cyprinodon nevadensis*, the Nevada pupfish, and slightly later as *Cyprinodon macularius*, the present name of the desert pupfish. It wasn't until 1930, when Joseph Wales published his biometrical studies of the pupfish of the Death Valley region, that the unique nature of this fish was recognized and it was assigned its present designation as *Cyprinodon diabolis*.

According to Dr. Robert Rush Miller of the University of Michigan at Ann Arbor, the Devil's Hole pupfish is one of the oldest evolved forms of the Death Valley pupfishes having become separated from the ancestral type earlier than any of the other pupfishes presently existing. David Soltz and Robert Naiman, in their book on Death Valley pupfishes, refer to this species as extremely divergent, both morphologically and behaviorally due to its long isolation in the limestone cavern at Devil's Hole.

The Devil's Hole pupfish is the smallest of the desert cyprinodont fishes rarely reaching 25mm total length with a majority of individuals much smaller. This unique species also lacks pelvic fins as well as the distinctive vertical barring so common among other pupfish and has a large head in proportion to its body. What do these diminutive fish look like? The female is colored yellowish-brown along the back. There is a dark edge on the dorsal fin and a vague dark bar through the area just in front of the tail fin. As with all pupfish, the sexes of this species are differently colored. The sides of the breeding male are blue and iridescent, the back is brownish to silver, and the gill covers are violet. Young fish resemble the females.

Dr. Kodric-Brown of the University of Arizona, Tucson, reports that Devil's Hole pupfish uses a consort-pair breeding system. In this system, one male will follow closely behind an egg-bearing female. The two will stay paired for up to an hour with aperiodic descents to the algae covered bottom for spawning. The Devil's Hole pupfish can spawn throughout the year, but concentrates most of its reproductive effort in April and May. Year-round spawning is made possible by the relatively constant 32.0 degrees C. water temperature of the spring pool.

Growth of this species is closely related to the availability of food. The small 2x4 meter limestone shelf on which the fish spawns also provides a majority of the algae and much of the diatoms on which the fish feed. A 1975 study of the food habits of the Devil's Hole pupfish determined that diatoms were the most important food in fall and summer. Also included among the pupfish food is amphipod *Hyaella*, an unidentified ostracod, and protozoans. A beetle, *stenelmis*, a tubellarian, *Dugesia*, and a hydrobiid snail, *Tryonia* are much less commonly used as food.

The Devil's Hole pupfish might have remained one of those obscure species known only to a handful of scientists and resource managers if it had not been for the rapid development of agriculture in the Ash Meadows area. Agriculture means water and in the arid southwest the competition for water can mean serious trouble, especially for wildlife. In the later 1960's the trouble centered around the tiny Devil's Hole pupfish.

In 1967, this fish was declared an endangered species. At about the same time, increasing demands were being made on the water resources of Ash Meadows by land developers. The water level in Devil's Hole began to drop. Under the best of conditions only a little water covers the limestone shelf where this pupfish breeds and where much of its food is grown. Without this shelf, and with a lifespan of less than one year, it would not have taken much to push the Devil's Hole pupfish over the edge and into oblivion of extinction.

In 1969, the Desert Fishes Council was formed in response to the plight of the small fish. The battle was fierce. During this period, bumper stickers boldly proclaiming "Kill The Pupfish" could be seen on cars throughout Nevada, as could others appealing to "Save The Pupfish." In 1972, mostly through the efforts of the Council, the people of the United States brought suit against the land developers and the State of Nevada. The legal battle continued for almost four years and centered around the question of water rights. In June 1976, the United States Supreme Court ruled in favor of the fish. The Court, upholding a lower court order established a minimum water level in Devil's Hole which would insure the continued existence of the pupfish.

The battle to save this diminutive fish took place in the field as well as in the courts. Researchers and resource managers installed artificial lights over the shallow spawning shelf to stimulate diatom and algae growth thus providing more food in the hope that the pupfish population would respond by increasing. Routine census taking was instituted by both SCUBA diving teams and surface counting teams. In the early spring of 1973, it appeared that even nature was conspiring against the pupfish. A flash flood carried large amounts of debris into Devil's Hole scouring away much of the food on which the fish feed and the algae in which they spawn -- the pupfish population declined. In 1978 natural forces struck again. An earthquake with its epicenter in distant Mexico caused such violent water disturbance in Devil's Hole that algae was again scoured from the shallow rock shelf.

Although court orders and careful management have subsequently led to population stability at about 400 fish population, the circumstances of the Devil's Hole pupfish remains precarious. In 1952, Devil's Hole and a surrounding forty acres was incorporated as a disjunct part of Death Valley National Monument --providing another small measure of protection. In 1972, a small number of fish were removed from Devil's Hole to a concrete tank near Hoover Dam; and in 1981, a few more fish were removed and placed in another concrete tank about a mile distant from Devil's Hole. The management philosophy behind this distribution is that spreading the fish out will minimize the possibility of losing this species due to natural or man-caused disaster.

The United States Department of the Interior, Fish and Wildlife Service, charged with the primary responsibility of administering the Endangered Species Act, formed a Recovery Team for Devil's Hole in 1976. The Team published its recommendations in 1980. Among its other objectives, the Team hopes to promote the acquisition of lands in Ash Meadows. Senator Alan Cranston (Democrat-Calif.) has also proposed the establishment of a Desert Pupfish National Wildlife Refuge (SB-41). This bill also calls for the acquisition of land and water rights and may, in the final analysis be the only sure way to insure the continued existence of the Devil's Hole pupfish and the more than 30 other unique fishes, plants, and invertebrates of Ash Meadows.

While the water war in southwestern Nevada grinds on, research continues at the University of Nevada,

Las Vegas, under the direction of the authors. This research is focusing on the social behavior and reproductive biology of the Devil's Hole pupfish and the vexing problem of the aquaculture of this somewhat enigmatic species. It is hoped that techniques can be developed that will allow artificial propagation of the Devil's Hole pupfish in aquaria providing one more safeguard for this endangered species. The accompanying series of photos record an event which has never before been photographed for publication --- the spawning sequence of the rare and endangered Devil's Hole pupfish, *Cyprinodon diabolis* Wales. The photographs were taken as part of a study of the social behavior and embryological and larval development of this attractive, elusive species.