Dwarfs of Devil's Hole

by K.L. Boynton

Desert living would seem to be out of the question for any member of the finny brotherhood. Yet, Death Valley, one of the hottest and driest of all the deserts in the world, is home for an astonishing tribe of little fellows known as pupfish. True enough, these minnow-like fish are small, the largest reaching only about an inch-and-a-half in length, but they are making a big splash in the world today.

The tale of the pupfish is part of the age-old story of the Remaking of the Face of the Earth that has been going on for billions of years as the mighty forces of time, mountain upheaval, erosion work and climates change accordingly. The pupfish's part of it goes like this: Parched and heat-ridden today, the Death Valley region of Nevada and California once was a land of lakes and rivers, for when the ice sheets covered much of North America during the early part of the glacial period, the Southwest was cool and moist. The Valley itself formed the sump for a vast drainage system. A body of water some 100 miles long and 600 feet deep, known to geologists as Lake Manly, covered much of it, fed by the overflow from the Owens River and by waters from the Amargosa and Mohave. Other lakes, some small, some large, were in the vicinity as well as streams and rivers and, dwelling throughout this connected water system, were the ancestors of today's pupfish.

As time wore on, the glaciers receded. Waters from the Owens River no longer reached Death Valley and the flow from the Mohave and Amargosa rivers greatly diminished. The lakes and streams began to go and Lake Manly itself disappeared. The climate became hotter and hotter. The land became drier and drier until all that is left now of the great river and lake system that once was are a few small spring and intermittent water courses spotted here and there in a vast and desolate desert. But pupfish are still around, descendants of the old ones who formerly ranged throughout the ancient river and lake system.

Now many of these springs and streams that became separated from each other when the water courses dried up remained isolated. This meant that the inhabitants of each one, being fish and unable to strike out across the dry desert to seek their fortunes elsewhere, were stuck in their particular watery homesite. Nor could their descendants change residence.

The pupfish evolved with time, and they differed from the ancestral type as could be expected. But more went on. Out of contact with other pupfish, the populations in the various isolated places evolved along different lines until today, some five distinct species and several subspecies exist.

Scientists view this situation with delight. Here in the desert - before their very eyes - evolution is taking place. These relict pupfish, with their great ability to adapt to exceedingly hostile environmental conditions, show the changes that have occured and are still going on due to the scarcity of water and isolation. In a way, each population of pupfish is a kind of natural experiment of evolution. As such, each offers a chance for brand new information in genetics, physiology and behavior. Pupfish are, in short, a scientific treasure.

Charmers, too, these mini-fish. True, most of the Death Valley region pupfish ladies dress rather plainly in brownish tones with dark vertical bars. But the gentlemen, in their courting attire, are something to behold in irridescent blues, purples with golden touches and perhaps dark fin edgings. The clan's small size and rather delicate appearance are foolers, for pupfish are really very tough little characters imbued with great vitality and a strong

survival instinct. In fact, some species have lived for thousands of years in pools so small and poor in resources that they could only support a few hundred individuals.

Take the dwarfs of Devil's Hole, for example. Eclept Cyprinodon diabolis, this inch-long species of pupfish resides in a freshwater spring located in a craggy hole high on the side of a limestone mountain in the Ash Meadows vicinity. Fed by water drawn up from deep underground limestone caverns, the spring has no surface outlet. It is a thermal spring with an almost constant temperature of 92 degrees F., and while the main part is deep, there is a rocky shelf located at the hole's entrance which is covered with water. It is this shelf that has provided the two basic things that have kept these fish in business here so long: a shallow sunlit place for algae to grow which is their only source of food; and the only suitable place for spawning available.

Key to the whole thing is sufficient water on the shelf, and this depends entirely on what happens to the water level in the source caverns far below. Anything that causes the water level down there to drop immediately subtracts water from the vital shelf upstairs which, of course, is bad news for the fish. Under the very best of conditions, home sweet home in Devil's Hole has been a touch-and-go situation, for in winter, due to the rocky overhang, there is no direct sunlight on the shelf, the result being just enough food production to support some 200-500 fish.

Yet, the C. diabolis population has been in residence here for a long, long time. In fact, pupfish probably moved into this spring back in the good old wet days when a lake covered Ash Meadows and flooded this hole, and they were left behind when the waters receded. Geologists think this all happened some 30,000 to 100,000 years ago which, while recent geologically speaking, isn't yesterday by any means. Completely isolated and cut off from connections with other populations of Death Valley pupfish for so long, C. diabolis is today the most highly evolved of them all.

While the food supply has been limited, and reproduction facilities cramped, the pupfish of Devil's Hole have one energy saver: the constant temperature of the spring's water. But what about other pupfish who dwell where conditions are anything but stable?

Cottonball Marsh, located below sea level on the floor of Death Valley, is a fine example of instability. (Unless being a godforsaken spot the year around can be considered some form of stability.) Anyhow, fed by underground water seepage, the marsh is actually a barren crust of salt and gypsum with a few permanent pools. During the fall, winter and spring - the time of the most water- the crusty surface cracks open into narrow channels and the water spreads into additional shallow pools. Summertimes, most of these dry up, those left being dotted here and there on the baked surface. Salt-encrusting algae grows at their edges, eventually practically roofing them over. So rugged are conditions here that only a few scattered clumps of pickleweed and salt grass can make it high on the alluvial fan where the water first seeps out. The lower fan is a lifeless place, the high salt content of the soil making it impossible for anything at all to grow. But here in the saline pools and channels of this desolate marsh - one of the most extreme fish habitats yet discovered - dwells a species of pupfish known as Cyprinodon milleri.

To a fish, the relation between the salt content of its blood and the salt content of the water outside is a matter of life or death, since it is the key to the proper water balance in its tissues. Fish gills and mouth membranes work like the old physics osmosis test where when a semi-permeable membrane separates two salt solutions of different strength, water passes through it from the weak solution to the strong as if to make the two sides equal. So any fish that lives in water saltier than its blood is in danger of losing too

much body water unless physiological adjustments are made constantly to maintain the proper balance.

The team of biologists James La Bounty and James Deacon, out to see what the Cottonball Marsh pupfish were actually up against in regard to salinity, found that the salt content varied among the channels and pools. Pupfish were in all of them, even in pools where it ran as high as 160 p M- a matter of great surprise.

Now another kind of pupfish, Cyprinodon salinus by name, which lives in the very saline watersof Salt Creek, has long been known for its ability to stand heavy salt concentration. So naturally, La Bounty and Deacon had to put their new marsh dweller up against this champion. Both fish did O.K. at 67.3 p M salinity, but when the test water was increased to 78.5, the Salt Creek entry died, while the Cottonball Marsh dweller was still going strong when the test was ended five days later.

Geologists figure the time that Cottonball Marsh fish have been cut off from other pupfish to be only some 3600 years, or even perhaps as little as 300-400, when there might have been water connections on the floor of Death Valley. Pondering this, La Bounty and Deacon wondered about the differences in form between the Salt Creekers and the Cottonball Marshers that made them two distinct species and different from other pupfish. They concluded that saltiness of the water, of course, was a major factor, but what could be even more important here and, in fact, affect the evolution of other populations of pupfish throughout the Death Valley system, was the actual chemical content of the particular water where each lived. And, too, maybe the variable seasonal temperatures had something to do with it.

Temperature, the three-man team of Robert Naiman, Shelby Gerking and Thomas Ratcliff, were betting had a big effect at Cottonball Marsh, since a summer scorcher at Furnace Creek, only a few miles away, can hit 132.8 degrees F. when it feels like it, and winter days can be below freezing. So they tested the water in the marsh, expecting to find it very hot in the summer. But the water is surprisingly cool, due to the fact that it runs underground for a considerable distance before emerging at the marsh. Evaporation helps in cooling, the salt dome formation over many pools helps with shade. An 89 degree F. registered in summer, for instance, is far below the lethal limit of 109.4 for this fish. So, actually, C. milleri does not suffer high temperature water stress even on hot summer days. But what does happen is that the temperature of the water fluctuates daily, a difference of some three degrees in the channels to as much as 25 degrees in the last shallow pool.

Fluctuation is rough on fishes. Since they are unable to maintain a constant temperature within themselves, their bodies simply adjust passively to that of the water around them. Rapid changes are the hardest to stand, for while there might be a chance for some fishes to handle unusual temperatures, they cannot adjust fast. Heat is picked up or unloaded mainly through the skin and large capillary areas in their gills and this takes time.

Cogitating on all this, Naiman, Gerking and Ratcliff concluded that while there is no big pressure evolutionarily speaking on the Cottonball Marsh to develop tolerance to high heat, there certainly is plenty of pressure for tolerance to wide temperature ranges. Individuals that could not stand fluctuation would be weeded out by natural selection.

C. milleri is a big thing to evolutionists for yet another reason: the population could not have been isolated for more than 3600 years at most, but due to the selective pressures imposed by the marsh, and because the generation turnover is rapid (pupfish breed at an early age), species differentiation took place here in a very, very short time - maybe as little as 300-400 years? - an eyebrow raiser bound to revise some old thinking.

The dwarfs of Devil's Hole had their turn at theory-upset, too. Since this

diabolis bunch had been living in thei[illegible] degree F. spring for 30,000 years, it was fully expected that they would have dropped off any ability to adjust to temperature changes just as cave dwellers have gradually lost their eyes through disuse - elimination by natural selection. So, biologists James Brown and Robert Feldmeth, testing the dwarfs against other pupfish who lived in an artesian well outflow and were accustomed to water temperature variance, were all set to show that diabolis couldn't take it.

They had a big surprise coming. The dwarfs, it seems, had not lost the ability at all, but could still stand a 66 degree range in water temperature as long as the change was not too sudden. Acclimated to 32 degrees cold, they could go to 102 O.K. Starting from a warmer 40 acclimation, they could make it easily to 108. This is a very big deal, evolutionarily speaking again, for it shows that, while eyes and the like might be lost under disuse and disadvantage, the old homeostatic systems basic to the running of the fish machine are highly resistant to evolutionary change. Furthermore, it showed that what an animal might be able to stand is not always so closely correlated only with what it is accustomed to, as was formerly thought.

So, with all these new angles coming to light, and with researchers privately betting more upsets in scientific thinking are bound to come, compliments of pupfish, it is obvious the EACH population of these invaluable little fish is exceedingly important. Not ONE of the strange isolated habitats should be upset.

Hence, the dismay and frantic efforts to preserve the Devil's Hole fish doomed by pumping operations in the vicinity that have lowered the underground water level and all but wrecked their food and spawning shelf. (This, in spite of the fact that the Hole has been a national monument for years.) Other populations are threatened throughout the Death Valley system by land development and its concurrent lowering of the underground water supply. Hence, too, bills before the House and Senate by Congressman Jerome R. Waldie and Senator Alan Cranston to establish a pupfish national wildlife refuge and monument in California and Nevada, are an effort to save these finny treasures before they are lost forever.

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