

The Phalen Enigma: Rainbow Darters in a Lake?

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Lake Phalen (Ramsey County, MN)

The Rainbow Darter (*Etheostoma caeruleum*) is a colorful species of the darter tribe, Etheostomatini which belongs to the perch family, Percidae. The species is widely distributed and quite variable in appearance, this despite an extensive range that includes larger streams, where convergence between populations is possible. This differs somewhat from the often conspecific Orangethroat Darter complex (*E. spectabile*), which frequently inhabits stream headwaters, where isolation can occur frequently and speciation events are more probable (Ceas and Page 1997; Ceas and Burr 2002). Nevertheless, it has been long recognized that Rainbow Darters do vary and this includes northern populations. Such populations would seem less likely to evolve into new species because, in part, glaciation events have been geologically quite recent. But it begs the question: Is it possible for a species to evolve in 10,000 years, which

is the approximate length of time since the last glaciers retreated? One such example of rapid evolution is the pupfish (*Cyprinodontidae*) in southwestern North America. The Amargosa Pupfish (*Cyprinodon nevadensis*) has apparently evolved into several subspecies in as little as 400 to 4000 years (Mehring and Warren 1976).

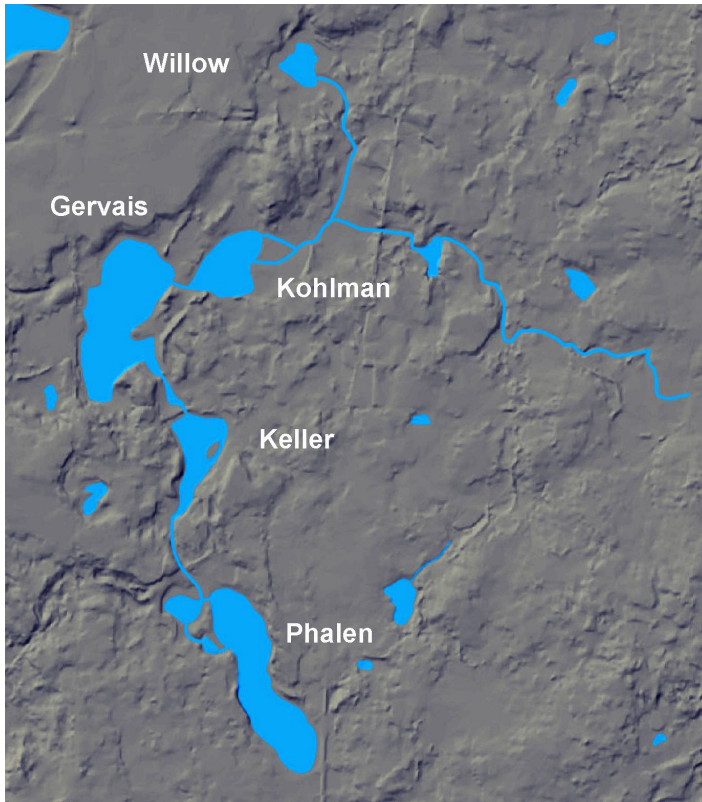
I have collected and observed Rainbow Darters from several populations across the species' range and it is apparent that different forms exist. One of the more interesting of the divergent forms is found in Lake Phalen, Ramsey County, Minnesota. The DNA from this population has been sequenced confirming they belong to the Rainbow Darter complex (Ray et al. 2006). An examination of mitochondrial DNA could reveal how much they may have diverged from other Minnesota populations. Could the Lake Phalen Rainbow Darter population be evolving into a new species? In this article, I will describe some morphological characteristics and social behaviors I have observed in Lake Phalen Rainbow Darters, which may be unique among Rainbow Darter populations.

The Lake Phalen Rainbow Darter population (see page 14) was first discovered in 1996 by Minnesota Department of Natural Resources (MDNR) Fisheries Research Biologist, Melissa Drake. I was first informed of this find by Konrad Schmidt (formerly, MDNR Nongame Fish Specialist), but I dismissed the observation as a misidentification. However, as it became apparent that the observation was correct, I began to ponder possibilities how a typically stream obligate species could turn up in a lake. 1) Perhaps they were found at the mouth of a creek entering or draining the lake. 2) Lake Phalen was possibly a large lake where constant wave action created current that mimicked Rainbow Darter habitats present in streams (i.e., pools or riffles of flowing streams). Or 3) This occurrence is a result of a bait-bucket introduction; however, the cool water temperatures coupled with high water quality and dissolved oxygen parameters required of the species cast significant doubt as this being a feasible explanation.

Oddly, Rainbow Darters have not been found in the chain-of-lakes draining into Lake Phalen. However, none of these lakes share the exceptional water quality and clarity of Lake Phalen where transparency was recorded at 17 feet in June 2009.

The lake is small by Minnesota standards at 198 acres, which typically cannot produce the fetch required for large wave action associated with the Great Lakes or oceans. Lake Phalen has a maximum depth of 91 feet (MDNR 2012a), but 80 acres (41% of the surface area) is classified as littoral (less than 15 feet deep and where aquatic plants can grow). Also peculiar is that Lake Phalen is located in the metropolitan area of St. Paul, Minnesota, where lakes and streams generally do not fare well and sensitive species

are either rare or extirpated. Historically, Phalen Creek drained the lake to the Mississippi River, but most of the stream was buried a century ago and routed through storm sewers.



Phalen Chain of Lakes

The first time I kept Phalen Rainbow Darters (PRBD) in an aquarium, I immediately noticed subtle morphological differences from the other populations I had kept. I found it odd that the dorsal color patterns on the body varied greatly from male to male, and I later discovered this trait is passed down to their offspring. Perhaps this is a result of the population's long isolation and adapting from a riverine to a lake environment. Other PRBD differences include more vertical bands and an iridescent gold background on non-breeding males and females. Larry Page (formerly, Illinois Natural History Survey) was the first ichthyologist to examine a collection of PRBD. He likewise found the specimens unusual (Flier 2000), quoting:

"The Rainbows possessed bands in the dorsal fin that were unlike those of most populations, but the most interesting trait was the variation in the banding exhibited in this single collection. However, until someone looks at the geographic variation over the range of the species, we won't know how odd they really are."

In 2000-2001, Kimberly Strand (formerly, University of Minnesota) studied Rainbow Darter morphology of preserved specimens in the James Ford Bell Museum of Natural History fish collection. She submitted the following summary of her results for inclusion in this article, quoting:

"Rainbow Darters (Etheostoma caeruleum) are found in eight major drainages in the state of Minnesota, all are river populations

except for one population, the Lake Phalen population. The body morphometrics of the Lake Phalen population of Rainbow Darters show unique characteristics, including: higher, on average, number of unpored scales on the lateral line; lower, on average, number of scales above the lateral line; lower, on average, number of scales above and below the lateral line; lower number of scales around the caudal peduncle; decreased nape scalation; and about half of the specimens lacked a complete supratemporal canal, unlike all of the other sampled populations."

In the spring 1998, I had an opportunity to collect this enigmatic Rainbow with Konrad Schmidt and Jay Hatch (University of Minnesota). We collected ripe females in one portion of the lake where the water was slightly deeper and boulder strewn. We moved to an area with a sand beach, but the substrate did contain some rubble. Here we caught male Rainbows along with a fair number of Iowa Darters (*Etheostoma exile*). Professor Hatch jokingly remarked, "We have a problem here. The males and females are separated so how are they going to perpetuate the species?"

We collected specimens using dip nets with everyone standing side by side, kicking and lifting. After a morning's work, we had about 30 specimens and Konrad and Jay offered them to me to keep and possibly reproduce. I took the three-hour drive home hoping the specimens would survive the ride. I was also concerned that spring lake temperatures in this northern climate were still cold and the Rainbows may not acclimate to the warmer water temperatures in my aquarium.



Rainbow Darter spawning habitat: flooded in spring - dry in fall

The high anxiety I put myself through was all for naught. The fish survived and adapted to life in captivity very well; however, I had no idea the PRBD were about to show me some very odd behaviors. The first was a very a distinct aversion to any type of current created from the wash of aquarium powerheads and filters. This trait was much more typical of Iowa Darters that inhabit lakes and sluggish streams. PRBD quickly adapted to the standard aquarium fare. Frozen brine shrimp and bloodworms, and also live glass and white worms were accepted with gusto. However, they exhibited a very peculiar feeding habit. When feeding frozen foods, PRBDs would swim around the food clumps rapidly in a

tight circle, stirring up the food particles. Having kept and cultured a large number of darter species over the years, including several populations of Rainbow Darters, this was a behavior I had never observed before. I can only speculate that in the wild this feeding method is utilized to stir up bloodworms (chironomids) or other food items from the substrate. Konrad Schmidt observed a similar behavior in Lake Phalen. On 14 June 1997, a congregation of several hundred adults and juveniles of both sexes appeared to be loosely schooling like minnows in about 6 to 12 inches of water covering a large sand-gravel flat free of boulders and cobble. Within the giant mass, several smaller mobs rotated in generally circular directions, which created a mesmerizing mosaic in motion (K. Schmidt, pers comm.).

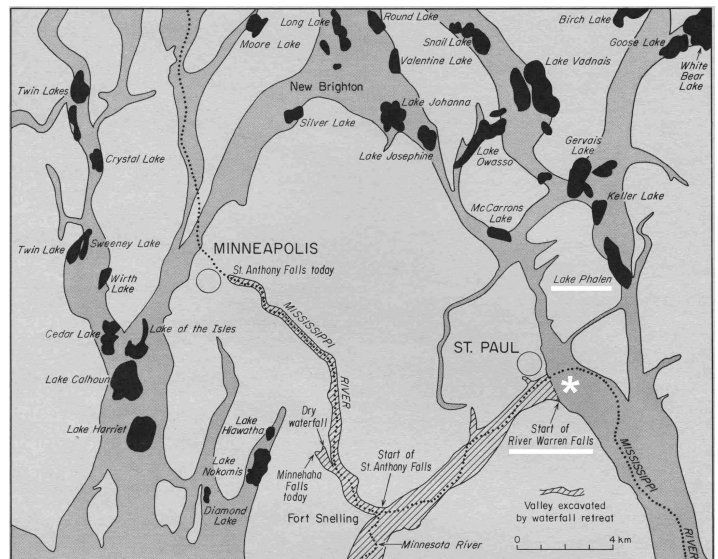
Spawning in aquaria was typical for Rainbow Darters. Ova were deposited in the substrate and I estimated there were about 1,000 fry in this first batch. The ova and fry in comparison to other Rainbow Darter populations were slightly smaller in size and I had concerns whether or not the PRBD fry could consume freshly-hatched *Artemia* versus micro-worms. Through trial and error, I learned preventing major losses of PRBD fry required initially feeding the smaller micro-worms. Fry of all other Rainbow populations I have cultured immediately accepted *Artemia* with minimal mortality. Spawning period of PRBD was yet another aberration. Konrad Schmidt has collected very ripe (i.e., ready to burst) females as early as 25 March within a day or two after ice out and all were spent within a week. This is several weeks ahead of stream populations in Minnesota. In captivity, spawning commences in early to mid-April and winds down by mid-May. Nearby stream populations I have cultured in southwest Wisconsin start in late April and continue through mid-June. While observations of wild PRBD appear to concur with a similar onset of spawning in captivity, I must note these are captive observations and time periods could be skewed due to artificial factors present in an aquarium environment. However, just prior to submitting this article, PRBD I had conditioned through the winter spawned in my aquarium at 47° F on 30 March 2013 (see ova images page 14).

In spring 2005, I had the opportunity to culture four populations of Rainbow Darters while working for John Bondhus at his hatchery facility. These included specimens from the Black River, WI and Zumbro River, Root River, and Lake Phalen, MN. One of my goals was to start the Rainbow fry on dry feed right after yolk-sac absorption. It proved relatively easy weaning three populations, but the PRBD would not accept it and suffered mortality until I switched to micro-worms. If fed properly, the PRBD will spawn after the first year. The other observations I have noted about PRBD are a smaller body size of adults and shorter life spans than other populations. Few PRBD have lived more than two years versus a maximum of four years in Wisconsin populations (Becker 1983). Generally, fish that are well maintained in aquariums live longer than wild populations; however, this could again be a factor of a captive environment. It also could be an indicator of the stable water quality parameters that PRBD may require. A lake environment, particularly such a deep lake as Phalen, should provide much more stable conditions than a riverine environment. Finally, one of my initial assumptions about PRBD was they should be more tolerant and possess an adaptive edge suited to aquarium life, but this has not been my experience.

The population of Rainbow Darters in the lower St. Croix River is the nearest to Lake Phalen. It is quite plausible that the PRBD originated from that population. Compared to other Rainbow populations in Minnesota and Wisconsin, individuals from this population, in my opinion, are very similar to PRBD. Other populations do occur in southeastern Minnesota, but are disjunct and isolated from PRBD.

While writing this article, I attempted to understand the complex geology and hydrology of the Lake Phalen area to comprehend how this Rainbow Darter population might have become isolated from other Minnesota/Wisconsin populations. Dr. Carrie Jennings (MDNR Land and Minerals Research Scientist) provided helpful guidance and insight of the last ice age retreat. The following quotes are from emails she provided that very roughly estimated the point of isolation between 9,000 and 13,000 years ago:

“The channel that formerly connected the Mississippi to the Phalen channel was significantly steepened by the retreat of glacial River Warren Falls about 13,000 years ago. Glacial River Warren Falls started in downtown St. Paul where the river abruptly gets wider (by the downtown airport). As that main waterfall retreated, it would have created waterfalls at the mouths of the tributaries. That could have isolated fish that couldn’t navigate the drop into the gorge. It looks like the drop from the Phalen channel would have been in two steps; an initial drop onto the first bedrock terrace and then to a level that is actually below the modern river floor (it has been filling since this occurred).”



Start of River Warren Falls that isolated Lake Phalen population

“After its creation, the tributary falls migrated up that small stream more slowly (proportional to the flow), deepening it and perhaps spreading out into a series of rapids and thereby lessening the steepness of the original fall (north-trending reach). This occurred because it was cutting through glacial sediment, not bedrock and therefore a single step in the gradient was not likely because there was no hard bedrock to hold it up. The less-incised portion (west-trending reach) looks like it occupies a former glacial channel so the falls would have probably been extinguished by this point. The final northward turn into Lake Phalen is still a steep reach. If the river was allowed to

continue adjusting its gradient naturally, the adjustment in gradient would have continued to move up that reach and Lake Phalen would ultimately have a lower level.


“Lake Pepin used to come all the way up to downtown St. Paul. It has been “shrinking” as a delta migrates into it from the sediment carried by the river. The delta also closed off the mouth of the St. Croix, backing it up to form Lake St. Croix. Basal dates on the lake sediment are about 9,000 I believe. So you could have further separated a St. Croix and Minnesota/Mississippi population by filling and narrowing this part of the river.

“I think the fish in the St. Croix likely communicated with the Mississippi River and Phalen prior to and during River Warren time.”

Since this population occurs in a large city, why weren't the PRBD discovered earlier? Fish biologists, who manage gamefish populations, routinely use survey gear that targets only large species. A query of the MDNR lake survey data confirms only large-mesh gill nets and trap nets were used in Phalen from 1951 to 1989 (MDNR 2012b). When gear such as kick nets and chain seines are used, they often reveal the presence of smaller benthic fishes, which would pass undetected through the larger mesh of gill and trap nets.

At the very least, PRBD serve as an environmental indicator to Lake Phalen's health. It also appears PRBD could be en-route to evolving into a new species. Lake Phalen would be an ideal research area to study the process of speciation. However, this population faces many threats. *The Riverview Times* article also reported that the MDNR stocked 20,000 Channel Catfish (*Ictalurus punctatus*) fingerlings in Lake Phalen. Konrad Schmidt informed me the darter population appears to still be doing fine despite the introduction. Channel Catfish are voracious predators, and also are bottom feeders, which are both excellent traits for preying on benthic-dwelling PRBD. Channel Catfish have not been stocked since 2002, but the MDNR has stocked mostly fingerlings and yearlings of Tiger Muskie (*Esox lucius* x *E. masquinongy*) and Walleyes (*Sander vitreus*) through at least 2011 (MDNR 2012a). Despite Phalen's remarkable water quality, an explanation for these conditions remains a puzzle. Phalen is at the bottom of the chain. The next lakes upstream are Keller and Spoon, which are smaller and shallower, and during the summer show their super eutrophic colors of dark green to brown. Phalen also directly receives storm sewer water from a golf course and residential areas of Maplewood and St. Paul. In early July 2012, Konrad Schmidt observed the normally blue gem turn pea green following a very heavy rainfall. The water clarity very slowly improved, but a green tint remained visible well into the fall. Not everything is bad news. Almost all of the riparian area along the lakeshore recently received a face lift. Non-native grasses were removed and replaced with prairie species. Water access was restricted to several small openings in the vegetation scattered around the lake which has greatly reduced soil erosion. Lastly, only electric trolling motors are allowed on Phalen which eliminates the suspension of sediments in the water column and wave action eroding the shoreline from boat wakes. With a little luck plus public awareness and concern, I hope this population will thrive long into the future.

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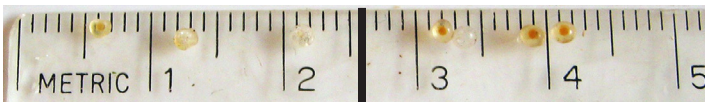


Male Lake Phalen Rainbow Darters



Female Lake Phalen Rainbow Darter

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Rainbow Darter ova (29 April 2013)

Phalen (left) smaller diameter than Root River, MN (right)



Jenny Kruckenberg

Lake Phalen: view from south shore