

TRANSCRIPT**INTERVIEWEE:** Tony Echelle**INTERVIEWER:** David Todd**DATE:** June 18, 2021**LOCATION:** Argentina, by phone**TRANSCRIBER:** Trint, David Todd**SOURCE MEDIA:** MP3 audio file**REEL:** 4058**FILE:**

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David Todd [00:00:01] All right, well, I think that we're recording now and I wanted to just sort of lay out the, the program here, the agenda and what our thoughts were. And the idea is that, with your approval, Dr. Echelle, we plan on recording this interview for research and educational work on behalf of a nonprofit group, the Conservation History Association of Texas, and for a book and a website that are underway for Texas A&M University Press, and finally, for preservation and cataloging at an archive at the Briscoe Center for American History at the University of Texas at Austin. And of course, this recording is for you. And you have all rights to use the recording as you see fit. And I just want to make sure that was agreeable with you.

Tony Echelle [00:01:02] Sounds great.

David Todd [00:01:03] OK, well, let me just lay out when and where and what we're doing here. It is June 18th, 2021. And my name is David Todd. I'm representing a nonprofit group called the Conservation History Association of Texas. And I am in Austin, Texas. We're conducting an interview with Dr. Tony Echelle, who has been a professor at Oklahoma State University, as well as teaching at University of Oklahoma, Cameron State and Baylor. And he's had a lot of experience in the zoology department at Oklahoma State and has worked there since 1980. And during his career, he studied a variety of rare desert fish, including the Leon Springs pupfish. And we're hoping to talk a little bit about his, his life and work and his particular interest in this pupfish. He is currently in Argentina. And so this interview is being done remotely.

David Todd [00:02:18] So we usually start these interviews by just a question about your childhood and if there might have been people - parents, family, friends - who were of big interest in your interest, influence in your interest in working with animals and, and pupfish in particular, or desert fish in particular.

Tony Echelle [00:02:41] Oh. Yes, well, I was raised in southeastern Oklahoma on a farm outside a rural community, Kiowa, Oklahoma. I spent, as a child, lots of time doing what country kids do. I wandered around the hills behind our house a lot. I did quite a bit of hunting, mainly rabbits and squirrels, and I did some fishing in local farm ponds. But my interest in biology probably stems from just having been around animals in my childhood.

Tony Echelle [00:03:21] But I actually didn't, wasn't aware of the field of biology until I became, I was a junior in college. The little high school I attended, the only science course they had was general science, and that lasted for half a year. And I don't think biology was even mentioned. But when I was a junior in college, I was looking for a major. My advisor saw that I had an interest in science. I'd taken some chemistry and physics courses, and he suggested a

degree in natural sciences, which meant I had to take some biology. So my second semester of junior year, I enrolled in freshman biology. It was taught by Luther Hornwith, a wonderful person who and he was in his teaching. He was extremely funny, but at the same time deadly serious when it came to testing. And I made an F on the first test, a D on the second test, and then I actually learned how to study for the first time. So I wound up making a B in the course, but I loved the course and it captured my imagination and kind of gave me direction for the, for my career.

David Todd [00:04:44] Isn't that interesting, that something that you're not aware of until you're close to 20 years old, captures your interest, as you said, and leads you down a track that, you know, lasts for decades. That's, that's wonderful.

David Todd [00:05:02] Were there other teachers or fellow students in college who might have been supportive or encouraging for you?

Tony Echelle [00:05:14] Yes. In college, I had a course in general ecology with a professor who, at the end of the course, he suggested that (this was when I was an undergraduate), he suggested that I might think about going to the Oklahoma, University of Oklahoma, biological station for a, to take, for summer classes. That station was on Lake Texoma on the border between Texas and Oklahoma. But after graduating with my natural science degree, I actually taught at a junior high in Albuquerque, New Mexico.

Tony Echelle [00:05:56] And then one summer I, just sort of on a whim, applied to, for a teaching assistantship at the OU biological station. And the man, the director at the time, was Carl Riggs. And he gave me my first job as a graduate, as a graduate student. So I was a teaching assistant for the summer. But I then enrolled at OU as a graduate student. Carl Riggs was my major adviser. He gave me a fellowship to study the life history of gars in Lake Texoma.

Tony Echelle [00:06:39] And then the second person that I would think of is Lauren Hill. He was the advisor for my, my advisor for the Ph.D. and he was, succeeded Carl Riggs as director of the biological station. And when I finished with the Ph.D., he gave me my first post doctorate, post graduate job, which was as a research biologist at the biological station.

Tony Echelle [00:07:12] And by that time, Alice and I, my wife, we were married. We lived at the biological station for six years. We were basically the only people there except during the summertime. But that probably was the most productive period of our research career. Alice and I were married in 1969 and we have been partners in research for the past 52 years. In fact, on our honeymoon we left the day after we were married for a field trip to western Oklahoma to study pupfish.

Tony Echelle [00:07:54] During my ... Lauren Hill, the, my major adviser for the Ph.D., actually introduced me to pupfish. One time he made a field trip to western Oklahoma. He collected Red River pupfish and brought them back alive to OU. And then one day in the hallway, he said, "Tony, you need to go look at those pupfish, they are really neat." So I went down in the basement of Richards Hall at OU and, and he had them in an aquarium that was about head-high and the aquarium had sand in the bottom. And when I walked up to the aquarium, there were about 20 fish and about half of them dived into the sand. And pupfish do this regularly when they're disturbed. But what they did is they kind of swim into the sand and then turn upward and expose only one eye so they can see what's going on outside.

Tony Echelle [00:08:55] Well, this, I'd never seen anything like this before. And I was looking for a dissertation and I said, you know what? I'm just going to study Red River pupfish for my Ph.D. So Alice and I, on our honeymoon, we spent the time collecting pupfish in western Oklahoma and Texas and then spent that summer at the OU biological station and did a lot of field trips and basically finished off my, my dissertation research that summer. And the dissertation research was on the factors affecting the distribution of Red River pupfish and the behavior of Red River pupfish.

David Todd [00:09:38] Now, the Red River pupfish, would you characterize that as a desert fish, or it sounds like this is quite far East? Wet climes...

Tony Echelle [00:09:50] It is, it's not in the desert, but it's in the short grass prairie of western Oklahoma. The water out there in the Red River is highly saline. So, Alice and I collected the Red River pupfish at salinities as high as, oh, one hundred and fifty parts per thousand, which is about five times the salinity in the ocean. But it's a, the Red River is a shallow stream of the Great Plains, the southern Great Plains.

David Todd [00:10:25] So I guess, akin to the desert pupfish that maybe, the Leon Springs pupfish would fall within, it's a very hardy fish that's adapted to some pretty extreme conditions.

Tony Echelle [00:10:41] Yes, pupfishes as a group are probably the hardiest, maybe the hardiest animals on Earth. A person who did field studies on the Texas Gulf Coast one time described the pupfish there, *Cyprinodon variegatus*, which we'll come back to later, but he described that fish as the toughest aquatic animal on Earth, based on his collection. They, they hold the records for salinity, tolerance of high salinities. Like I said, pupfish can occur at 150 parts per thousand salinity. They also hold the record for the highest temperature tolerances of any fish known. They can occur, long-term, in waters of around 115 degrees Fahrenheit, which would be the same thing as if you and I had had a fever of 115 degrees for our entire lives.

Tony Echelle [00:11:44] And at the same time, they're tolerant of extremely low salinities and extremely low temperatures, subzero temperatures. And finally, pupfishes as a group are tolerant of low oxygen conditions. The Red River pupfish in the laboratory can survive at salinities, I mean, at oxygen concentrations so low that you can't detect any oxygen with the regular standard oxygen meter. So they're extremely hardy animals. And this partly explains why they do so well in the desert.

David Todd [00:12:21] Well...

Tony Echelle [00:12:21] Even in the desert, though. The conditions that they occur in often are not all that harsh, so many, many pupfish occur in constant temperature springs, you know, with moderate or low salinities and so on.

David Todd [00:12:38] I see. Well, you know, I'd be curious to hear if you could maybe give us some understanding of how pupfish, and particularly Leon Springs pupfish, might have evolved. I mean, I understand that that the Leon Springs pupfish has been found out in West Texas for about twenty five thousand years, if I'm not mistaken, but that it may, its forebears may go back over a million years in that area. So it must have had a really fascinating and long history of adaptation to that area.

Tony Echelle [00:13:20] Yeah, actually, Leon Springs pupfishes probably have been in place for somewhere around 500,000 years.

David Todd [00:13:31] Oh boy.

Tony Echelle [00:13:31] And its closest relative is the Pecos pupfish, that occurs in the Pecos River, which is about, oh, 30 miles away from, downstream from where Leon Springs pupfish is. But the Pecos pupfish today, ranges from Roswell, New Mexico, to south, well past, in the Pecos River, well past the Leon Spring, where the Leon Springs pupfish is. But the closest relative of Leon Springs pupfish is the Pecos pupfish. The idea is that, based on genetics and geological and the evolution of rivers, the idea is that the common ancestor of these two species was something like the Red River pupfish. And somewhere around five million years ago, the Pecos River was developing and it captured a stream from the Red River, according to our hypothesis, and then this transferred a form much like the Red River pupfish into the developing Pecos River. This was around five million years ago.

Tony Echelle [00:14:48] Then, sometime around 500,000 years ago, or maybe somewhat less than that, the Leon Springs pupfish began to diverge from the Pecos pupfish. And since Leon Springs pupfish is known only from Diamond Y Spring and Diamond Y Draw, that's likely where the ancestral form was. The question is that since the Diamond Y Draw is only about, oh, 30 miles from, the water in Diamond Y Draw is only about 30 miles from the Pecos River, the question is how did to Pecos pupfish and Leon Springs pupfish, how did they diverge from each other?

Tony Echelle [00:15:35] You would think that gene flow during periods of high water would have kept them from diverging from each other. But, it's, one, and so that's a very difficult question. But one possibility is that in the past, the Pecos River was much more fresher than it is now. Now, the Pecos River is a pitiful remnant of what it was in the 1800s. In the 1800s, the Pecos River was a wide, fast-flowing river that was difficult for travelers to cross. And today is just the trickle that's muddy-bottomed and, and highly saline. So the idea, and this salinity, this is a result of human activity. Humans have degraded the Pecos River in Texas to the point where it doesn't resemble anything like it did in the past.

Tony Echelle [00:16:35] Well, I'm getting around to this kind of slowly, but the idea is that in the past, the pupfishes in the Pecos River basin occurred maybe in the area around Roswell, New Mexico, where the water's highly saline. And then they sometimes got south in the Pecos River to the area of Diamond Y Draw and might have invaded Diamond Y Draw. Well, Diamond Y Draw, the water in that system is is more saline than in most springs in West Texas. So it might be that, in the past, there was very little connection between Diamond Y Draw, or of pupfish in Diamond Y Draw and pupfish in the Pecos River because the Pecos River was at that time, fresh water and not good pupfish habitat. It had a lot of species and pupfish just don't do well when, when there's a lot of other species present. They are generalists in feeding and so on. And so they basically compete with whatever species happens to be in the water. And so, but since they're generalists, they're not, they're sort of like Jacks-of-all-trades and masters of none. And so they get out-competed by other species for food and so on.

Tony Echelle [00:17:55] So my point is that, ancestrally, pupfish in the Pecos River might have occurred primarily in two places, Roswell and Diamond Y Draw. So because they were isolated, this allowed them to diverge. And with, and now we have what we have. We have Leon Springs pupfish in Diamond Y Draw, Pecos pupfish in the Pecos River.

David Todd [00:18:21] Well, and so I'm curious about the connection between the pupfish in the Roswell area and those in Diamond Y. I mean, these are, as I understand it, Diamond Y is a pretty isolated spring. Was there some sort of overland flow or how would the fish have gotten from, you know, such a distant spot?

Tony Echelle [00:18:45] Yeah, well, in wetter times, the Diamond Y Draw, especially during flood events, there are connections between Diamond Y Draw and the Pecos River. These days, these days it hardly ever happens.

David Todd [00:19:00] I see.

Tony Echelle [00:19:01] Because Diamond Y Draw, it's just not as wet as it used to be. So it hardly ever happens. But during flood conditions of the past, there would have been connections with the Pecos River. The ancestral form would have had access to the springs of the Diamond Y Draw. And so it somehow got there.

David Todd [00:19:23] OK, well, that's fascinating. Thanks for walking us through the evolution. And I'm curious if you can maybe give us an idea of how these pupfish might have adapted to these extreme conditions of salinity and temperature. Did they have particular features that really made them such a hardy creature?

Tony Echelle [00:19:55] Well, for salinity, marine fish, fish that are tolerant of salinity, they have chloride, chloride cells. I mean, well, actually, all fish have, have what are called chloride cells in the gills. And these chloride cells help to balance the salt content of the body. And so it turns out that pupfish have unusually large and numerous chloride cells, compared to other fishes. And so this might, this is one way. What happens is they're exposed to highly saline conditions, individuals that can transport salts out of the body efficiently because they have, you know, more or larger chloride cells, they have an advantage over those that can't do this. And so what happens is you end up with a form that's very effective, efficient at removing salt from the body tissues.

David Todd [00:21:03] Oh, OK.

Tony Echelle [00:21:06] And then, for instance, for temperature, it's just that, for whatever reason, pupfish have evolved the tolerance of high temperatures. And this is characteristic of almost all pupfish. They can tolerate really high temperatures.

David Todd [00:21:24] And that?

Tony Echelle [00:21:24] I should say that at the other end of the, in terms of salinity, pupfish can tolerate extremely fresh water as well. So they don't have to have high salinity to, to, to survive. They can tolerate extremely fresh water. And, but the point I was making earlier is that they don't do well in fresh water situation, in many freshwater situations, because there are so many other species present that out-compete them.

David Todd [00:21:57] I see. OK. OK. So I guess, when they're in a very highly saline environment, they just don't have the, the competition and so they can thrive where others might not.

Tony Echelle [00:22:16] That's right.

David Todd [00:22:16] OK.

Tony Echelle [00:22:17] So, in the, in the, for example, in the Upper Red River, the salinity there, often, is greater than 20 parts per thousand, which is like almost two-thirds seawater - 20 parts per thousand, about two-thirds seawater. Well, at that, in those conditions, you get basically two species of fish. You get the Red River pupfish and another highly tolerant species, the plains killifish. But other fishes are just not there in any abundance at all.

David Todd [00:22:53] Gosh, I bet for biologists, these pupfish must be just a fascinating creature to study because they are so highly adapted and they must be a wonderful sort of vehicle to understand evolution and survival. That's, that's fascinating. Well, can you talk a little bit about the life history of the Leon Springs pupfish?

Tony Echelle [00:23:18] Yeah, it, almost all, it looks like most pupfish. It's a kind of a chubby fish, looks somewhat like a minnow, but fatter, deeper bodied and rounder. They are primarily bottom-dwellers. They feed primarily on the bottom. But at the same time, they can feed at any level in the water consistent. They tend to school on the bottom. They, they are, they're about a maximum of somewhere around two inches in body length. They have teeth in the jaws, unlike, for example, most minnows which don't have teeth in the jaws. But they are omnivores and they can survive on both animal, animal items and they can survive on vegetable material as well. This has been demonstrated for the Gulf Coast species, like *Cyprinodon variegatus*, that you can put them on a diet of dead spartina, which is a kind of a marshy reed, and then they survive just fine. So they eat basically anything.

Tony Echelle [00:24:30] They live, they, they live about two years. Most of them are, survive, don't survive past two years. They, the pupfish, in part because they are generalists in almost every way, they breed nearly year-round. So Red River pupfish - Alive and I have seen them spawning or breeding in all months of the year. But most pupfish can do this. And they, a species like Leon Springs pupfish, which live in springs, which are constant temperature, they often, the most, they can breed year-round. The peak spawning period is in the warm months of the year. What else can I say? I guess that's about it.

David Todd [00:25:27] Well, I'm curious about their, their diet. You know, it seems surprising that they would have the ability to have a reliable food source in some of these really isolated springs. Is that fair to say?

Tony Echelle [00:25:47] Yeah, well, they are, like I said, they're omnivores. So whatever's there, they will eat. If you look at the gut content. They have a high percentage of it is filamentous algae and just sand from the bottom. And that sand contains microscopic organisms - bacteria, also diatoms and so on. But they, they eat almost anything that that they can get their mouth around.

David Todd [00:26:25] Gosh, just another example of what a hardy, tough creature you've, you've studied. Well, you know, it's, it'd be interesting to hear your thoughts about its, its recent history because it seems like it has had a lot of challenges, to say the least, and has survived nevertheless. And I was hoping you might be able to talk to us a little bit about what the last 150 years or so has meant to the Leon Springs pupfish since it's I guess it was first discovered in the 1850s.

Tony Echelle [00:27:05] Yeah, yeah. It was discovered in 1851 as part of the United States / Mexico boundary survey. This survey was commissioned by Congress after the, the, the, the, the US / Mexican War, which ended in 1848. But this boundary survey consisted of engineers, military escort and then some people who were just, who were naturalists, who collected plants, animals and fossils and sent them back to the Smithsonian Institution, the National Museum. And lots of these things were previously unknown to science. And one of them was the Leon Springs pupfish, what was discovered in 1851. By 1918, or so, the Leon Springs, which occur north of, I mean, southwest of Diamond Y Springs, the Leon Springs had, by the early 1900s, had been dammed for irrigation purposes. This diverted flow into the fields and basically there must have been a huge loss of habitat at that time for the Leon Springs pupfish.

Tony Echelle [00:28:39] These species went totally ignored for more than one hundred years after its discovery and description. It was described in 1853 by people at the U.S. National Museum, but it was ignored until 1938 when Carl Hubbs and his family, including Clark Hubbs, who was a child at the time and wound up being a famous professor of ichthyology at the University of Texas. But they visited the Leon Springs in 1938 and failed to collect the pupfish. Then in 1950, Carl Hubbs' son-in-law made a trip to (who was at the University of Michigan), he made a [excuse me], made a trip to Leon Springs and he also failed to collect the pupfish. And he heard from local people at the time that the Springs had been rotenoned to kill carp. And so it's probably the rotenone, sometime in the early 1900s, that eliminated the fish from Leon Springs. Then the species was considered extinct by the 1960s.

Tony Echelle [00:29:59] But then in 1965, W.L. Minckley, a professor at Arizona State University, he and a student, William Barber, returning from a field trip to Mexico and they stopped in Fort Stockton and asked about springs of the area. This was in 1950. Well, a local person told them of what was called Willbank Springs, north of town, about seven miles. So, Minckley and Barber went there and they collected pupfish. And so they, I think, undoubtedly suspected that it was the Leon Springs pupfish. But in a paper published in 1969, Minckley referred to it as a form from Willbanks Spring, north of Fort Stockton. That paper was on the feeding behavior of puppies.

Tony Echelle [00:31:00] Well, I, having an interest in pupfish, I read that paper and then in 1971, a, a student at OU and I, Michael Stephenson [excuse me, my voice is about to go, but], we visited, we went to Fort Stockton and found Minckley's Willbanks Springs. It turns out that Willbanks Springs on the maps is actually Diamond Y Springs, where the pupfish occurs today?

Tony Echelle [00:31:31] So we made our collection, large collection, from Willbanks, from Diamond Y Spring. And then I, having an interest in pupfish, I, I made some counts and measurements on the fish and contacted Robert R. Miller, who again was Carl Hubbs' son-in-law. But he was at the University of Michigan and he was considered, or is considered, the god of pupfish biology. But it turns out that he had examined some of the original specimens of Leon Springs pupfish that were collected during the U.S. / Mexican boundary survey and were used in the description of Leon Springs pupfish - so-called "type specimens". There were only five specimens around by that time, but he made counts and measurements on them.

Tony Echelle [00:32:23] So, those counts and measurements conformed with what I found for the present population in Diamond Y Spring. So we published the paper that re-described the species and announced the rediscovery of the pupfish. Like I said, Minckley probably already realized that it was Leon Springs pupfish. But, so that's sort of the early history.

Tony Echelle [00:32:55] But then, oh, by then, by 1958, the springs were dry. And this was because of some people, including a rich legislator from Texas, had for, were trying to establish a pecan farm, pecan orchards, in the aquifer and they installed electric pumps. These electric pumps pump water; these trees require a lot of water. And these pumps were installed somewhere in the late 1940s, early 1950s. And in less than 10 years, they had pumped the aquifer to the point where the water table fell below the level that could support the springs. And Leon Springs went dry.

Tony Echelle [00:33:52] This is, this occurred alongside the similar thing that happened to Comanche Springs, an even larger spring that was also in Fort Stockton. Comanche Springs, produced at the time, oh, produced about, before it went dry, was producing about 30 million gallons of water a day. And Leon Springs was producing about 10 million gallons of water a day. But because of these, these pumps, they were now drying for the first time. They went dry for the first time in probably tens of, tens of thousands of years, if not millions of years.

Tony Echelle [00:34:40] The, let's see, so anyway, that that brings us up to the 1950s. Then after the rediscovery, shortly after the rediscovery of Leon Springs pupfish, a man by the name of Royal Suttkus at Tulane University, passed through the area and found, at the Highway 18 Bridge, which runs north of Fort Stockton and crosses Diamond Y Draw, he found *Cyprinodon variegatus*, which was not supposed to be there. It's a species that occurs in Texas on the Gulf Coast.

Tony Echelle [00:35:26] Then Alice and I returned the next year and we collected in the area and we found that the lower water course of Diamond Y Draw was, contained, had, had hybrids between Leon Springs pupfish and *Cyprinodon variegatus*. This led, in 1976, to an effort that was actually led by Clark Hubbs at the University of Texas. He, and I and our students, and Alice and all, we gathered at Leon Creek, on, it was, we call it "Black Friday". It was Friday the 13th in 1976. And we went in there and poisoned the lower water course and did a lot of seining and eliminated the hybrids from the lower watercourse.

Tony Echelle [00:36:19] At that time, because we were concerned about the pupfish in the upper water course being contaminated by *variegatus*, we took a sample of, I think it was, 80 fish from the upper watercourse. We took them to Dexter National Fish Hatchery, where they have been ever since, just to protect them against future things that, future genetic contamination by *Cyprinodon variegatus*.

Tony Echelle [00:36:52] Well, this turned out to be extremely fortuitous. Because in the late 1980s, Alice and I found that the population in Diamond Y Spring was a hybrid population, with genes from *Cyprinodon variegatus*, representing about 10 percent of the genome. And then this led to another eradication effort and we eliminated the hybrids from the upper watercourse. Um, with, with a chemical called Antimycin-A. Antimycin-A kills eggs and adult pupfish.

Tony Echelle [00:37:40] We chose not to poison the lower water course, even though it was, had a low degree of contamination with genes from *Cyprinodon variegatus*, but we chose not to poison them out because, even though they were partial hybrids, they still had genes from the original Leon Springs pupfish. So they were primarily the Leon Springs pupfish with the, and so adapted to the local situation.

Tony Echelle [00:38:14] Anyway, we went, Alice and I went back the following year. I think this was when we did the poisoning in the upper watercourse, I think that was 1996, I think.

And in the following year we went back and we found that we had, indeed it was successful. There was nothing present in Diamond Y Spring except you know, I mean as far as pupfish went, except Leon Springs pupfish. There were no hybrids.

David Todd [00:38:44] Can you go through that one more time? I'm a little bit confused. So the, there were hybrids in both the upper and the lower sections of the, of the spring and the watercourse below it. But those below, you decided were worth keeping. And I'm not sure why that was the case.

Tony Echelle [00:39:10] And just, just because .. what happened, well, we, when we poisoned out the fish from the upper, from the upper watercourse, we, we then replaced them with fish from the National Fish Hatchery...

David Todd [00:39:26] From Dexter?

Tony Echelle [00:39:26] That we had exported to the hatchery in 1976. And then, if you keep fish in captivity like that, this would have been for, this would have been for, what's 1976 - nearly 40 years, or so. That, that, that's for a pupfish that's 80 or 100 generations because they can produce more than one generation per year. They start breeding when they're about, oh, two or three months old and within four or five, within another ... so, so you can get in a single breeding season, you can get two or three generations of pupfish.

Tony Echelle [00:40:05] So the pupfish in Dexter in captivity had been there for probably 100 generations. Well, when you keep animals in captivity like this, you, they, they tend to lose genetic diversity. So we were concerned about the genetic quality of the fish at the National Fish Hatchery in Dexter, New Mexico. And for this reason, we wanted to retain some of the original diversity of Leon Springs pupfish. And so we didn't poison them out of the lower water course, even though they had a low frequency of genes of *Cyprinodon variegatus*.

David Todd [00:40:46] OK, I think I understand. So you, you were, I guess, tussling with, with two problems at the same time. On the one hand, you wanted to have the, the purest strain of, of Leon Springs pupfish, but same time you wanted to have some, I guess, robustness and genetic diversity in that group of pupfish in the Springs. Is that fair to say?

Tony Echelle [00:41:13] Yeah. Yes. Genetic diversity is important for long-term adaptation and the health of the population, but also not just diversity, but some of the genetic makeup of the Leon Springs pupfish likely is adapted to the local conditions. And some of that diversity probably had been lost in the captive population at Dexter. And we wanted to maintain what little, what, what might have been remaining in the, in the natural habitat.

David Todd [00:41:52] I see. OK. Well..

Tony Echelle [00:41:56] I'm sorry. I should mention that a study that we did 10 years after the original transport of fish to the National Fish Hatchery, we found that they actually had lost some of their genetic diversity and that after only 10 years. And so that's, by the time we did the second renovation of Diamond Y Draw, they would have lost, probably lost more diversity.

David Todd [00:42:27] OK, well, you've mentioned the effort to try to protect these Leon Springs pupfish from hybridization. I understood that, that two other problems facing the fish

had been bulrush encroachment and then also a competition with *Gambusia nobilis*. Is that, is that true? How did you address that?

Tony Echelle [00:42:56] Well, the the bulrush thing is, is a problem for lots of spring fishes these days. But what happens is: bulrush grow on the sides of the water. And then, with time, as sediments build, they encroach into the open water of the spring. And pupfish do best in open water, shallow open water situations. This is where they spawn and they occur there most abundantly. So, with the encroachment of bulrush, this reduces the population size, or the spawning habitat, for the pupfish. And it just, the water supports fewer fishes. So and this is, this is kind of a general phenomenon for, for spring fishes when you.

Tony Echelle [00:43:48] And so what happens with, with this, in this situation: what started out, what was done for the purpose of protecting the pupfish was to remove cattle. Once the, this property was, was, it now belongs to the, to the Texas Nature Conservancy. They bought it, I think, back in the, in the 1990s. But they, as part of their program, removed cattle. Well, cattle previously would cross Diamond Y Draw. And when they would cross Diamond Y Draw, they trampled the bulrushes. And this created open spaces. And these were the places where the pupfish were most abundant. So what started what was done to protect the fish actually might have been somewhat harmful. Alice and I actually think, and have recommended, (but nobody listens to us) that they might want to release a, have a managed herd of American bison in, on the Diamond Y preserve, because the bison would do the same thing that cattle did, creating open water habitat for the the pupfish.

David Todd [00:45:07] That is so fascinating. I guess cattle are often thought as a sort of an aggressive species that have changed a lot of ecosystems, but in this case, it sounds like, through trampling the bulrushes, they might have actually opened the water up, if I'm following you, and created more spawnable habitat for those, those rare desert fish. Is that fair?

Tony Echelle [00:45:36] Right. I'm one thing people have done, Alice and I have participated in this, and Murray Itzkowitz at Lehigh University, has studied this situation for a long time. But, but with so and John Karges was, formerly worked for the Texas Nature Conservancy, and he was much involved in the restoration of Diamond Y. But we would go in there and just pull up bulrush by hand and clear out spaces. This is a, kind of, a futile thing because this bulrush grows back so fast that it's almost not worth doing. Murray Itzkowitz's students, they, they tried pulling bulrush and putting in little tiles that served as spawning places for pupfish. And this seemed to have an effect, though I'm not sure if it's well documented, but it seems to have had an effect on improving the habitat for the pupfish.

David Todd [00:46:38] So if, if I'm following you, you're saying that Dr. Itzkowitz's students came in and they pulled up the bulrushes and then they laid down tile that I guess would close the soil so bulrushes couldn't grow back? Is that what was going on?

Tony Echelle [00:46:58] Yes, I think so. And also, pupfish males like to spawn, like they defend territories over these tiles. They like a hard spot for their, for their territories. And so it not only helped eliminate the bulrush, but it also provided a good surface for spawning activity.

David Todd [00:47:20] That is so interesting. Thanks for explaining that.

David Todd [00:47:24] I think one of the other issues that has been a factor in the pupfish's decline, and that I guess you all have worked on, is this competition with the *Gambusia nobilis*. And I thought that was so interesting, because from what little I understand, that's also a very rare fish. And I was wondering how you balance protecting both at the same time.

Tony Echelle [00:47:46] Yeah, this is also, this is mainly Murray Itzkowitz's work with his students, especially, well, Jenny Dunn and Andrew Black and others, but they, Jenny, noticed that, when she was a graduate student, she, she took photos of spawning behavior in these pupfish and, and she noticed that when, what happens is a male is defending a territory, which is about a foot square or so in size, and female, a female who's receptive comes into the territory, and they pair up and they spawn on the bottom. And when they spawn, they, they stir up the sediments and so on. But, but they, at each spawning act, the female deposits a single egg. And then she noticed, though, that when they would spawn, during each spawning act, the *Gambusia* would flock around the pair and there would be 20 or 30 *Gambusia* associated with this pair, clustering around it. And so they suggested that what was happening is these *Gambusia* were eating the eggs as fast as they were spawned and that this would, was depressing the abundance of the pupfish in Diamond Y spring.

Tony Echelle [00:49:19] This, this is a hypothesis and they're still working on it. There's some conflicting, they've done some work that has produced conflicting results. I don't think it's perfectly clear that the *Gambusia* are eating the egg because, again, the eggs are only about one millimeter in diameter. They're only deposited one at a time.

Tony Echelle [00:49:47] And what I think might be happening is that, well, yeah, they might eat some eggs, but they also are, the *Gambusia* are, eating invertebrates that are stirred up by the spawning activity of, of the pair. So Murray, Murray and his students, I think they're going to be going back out there this summer and they're going to do some work trying to document this effect of egg predation on the fish. But right now, I think it's sort of a question.

David Todd [00:50:18] I see. Well that is so interesting, you know, that it's, it's a work in progress. And you've, you've got, I guess, hypotheses that you're working with. And there's, there's this sort of a fog of lack of clarity. But, you know, meanwhile, this very rare fish is under threat. So it's wonderful that you are all continuing to work with it.

David Todd [00:50:49] So I think we've, we've talked a little bit about the pupfish, of course, and some of the other creatures there. But I was wondering if you could talk a little bit about the spring itself and the land surrounding it - Diamond Y.

Tony Echelle [00:51:09] OK, yeah. If you, if you go to Google Earth and look at Diamond Y Spring, the, the square mile around there probably has somewhere around 100 or more oil pumpjacks that are pumping oil into pipelines that then get pumped over to a refinery. Well, Diamond Y Spring, it starts out with a head pool that's about 20 meters across, or 20 yards across, and that head pool is about, oh, maybe no more than 100 meters from the refinery, from the refinery. And there are pump jacks within 50 meters of the, of the Diamond Y head pool. Well, but if you look at it with Google Earth, there's, I think, there's probably 100 within a square mile, 100 pumpjacks within a square mile, and several pipelines that cross the Diamond Y Draw. So that's kind of it. Otherwise, it's basically Chihuahuan Desert with creosote bush and sand and what have you.

David Todd [00:52:24] And so I guess there's a, there's a concern that these, these wells, or the pipeline, or the refinery might have a spill. I think that at one point a dam was built to try to protect the spring. Is that correct?

Tony Echelle [00:52:43] Yeah, well, actually, there was a spill back in, I think it was in the late '70s or early '80s. There was a spill in, just upstream from Diamond Y, where Diamond Y empties into Diamond Y Draw. Just upstream from that is Leon Creek, that empties into Diamond Y Draw. But there was a spill, a break in a pipeline, that, and a spill of oil into the watercourse. And not much was done to determine what the total effect was, but it did kill all the fish that were present in that short segment of water.

Tony Echelle [00:53:25] Well, the oil company then came in and they built an earthen berm around that oil spill that pretty much contained it. Then that caused, created concern for a Diamond Y head spring, which, like I said, is within 50 yards of a pumpjack and pipelines and things like that.

Tony Echelle [00:53:44] So what happened was the, the Soil Conservation Service built a earthen berm around the head pool to protect it from oil spills upslope. That, that construction was, I think, funded by the Northern Natural Gas Company, who owned, who, they operated the, the, the oil operation. But, yeah, the whole idea is to keep an oil spill from dumping into Diamond Y Spring, which would be a major disaster.

David Todd [00:54:25] Yeah, well, something else I guess I've been following, and I'm sure you're aware of, is that a lot of the production out in, in the Permian Basin, which I guess is, is in that area...

Tony Echelle [00:54:40] Yeah.

David Todd [00:54:40] ... involves fracking now and a good deal of water is needed to, to pressurize those, those systems. And I was curious if, if that, those water withdrawals, have been local enough to impact the springs there or if that's not an immediate problem.

David Todd [00:55:06] Well. About 50 miles west of Diamond Y Spring, or west of Fort Stockton, is the town of Balmorhea. And the town of, in that area, there's one of the largest springs in Texas. It was, it's as big as the, it's another spring that used to produce, in the early 1900s, it was producing 30 million gallons a day of water. And now it's down to about 15 million gallons a day.

Tony Echelle [00:55:38] Several other springs in that area have already gone dry. And this is well before the oil field development. And it was a result of, again, the same thing that happened in Fort Stockton: farmers sinking wells and pumping, causing the water table to drop. So the Springs failed.

Tony Echelle [00:56:01] One spring, that Phantom Lake Spring, which is upslope from the San Solomon's Spring, which is the biggest spring in the area. But Phantom Spring, I think, went dry, it went dry in 19., somewhere in the 1990s. And now it's only maintained by, artificially, by a electric pump that pumps water from the cave opening of, for the spring - pumps water out of the aquifer into what once was a spring and it now still supports pupfish.

Tony Echelle [00:56:34] But what happened in the last five years, I think, or so, is the discovery, or maybe at least I think five years or so, the discovery of what's called the "High

Plains" oil deposit. And this created a tremendous amount of excitement in, for the, I think it was the Apache Oil company. They thought this was going to produce, would be one of the most productive oil fields on earth, actually. And so they went in there and there was, there were oil wells dug, as you said, fracking. And fracking takes tons of water. A single well can take 30 million gallons of water, just to do the fracking. And so the plans were to to make, to produce oil wells all over the place. And they did some of this. What I saw recently, though, is that, that, that turned out to be pretty disappointing from the standpoint of oil production, because it was mostly natural gas. And if I understand correctly, the Apache gas company has now decided not to drill any more wells. So at least for the time being, and that, of course, is good for the water aquifer.

David Todd [00:58:00] And I guess the other pressure on, on the water systems to support the Leon Springs and Phantom Springs, and Balmorhea, and so on is, I guess, not just irrigation, and oil and gas production, but also municipal water use. I think I've read that there's been interest from cities as far away as Midland and Odessa, and even San Angelo and Abilene, to use some of these waters, groundwaters from the Trans-Pecos. Is that, is that so? Or what's your knowledge about that?

Tony Echelle [00:58:38] Yeah, yes. All those cities have grown hugely in the 50 years since Alice and I started going out there. Odessa, Midland, Abilene, all those towns, are massive compared to then. And so that's, that's a major concern as well - municipal use of water. You know, the whole area of Trans-Pecos Texas is so different from what it was in the early 1900s, or 1800s, for sure. We had the massive growth of humans, human population, and then associated with that, massive demand for water for irrigation and municipalities. So, so the Rio Grande and the Pecos, both, and the Pecos River, both, in Texas, are just trickles of what they were 100 years ago. And so it's a very different environment.

Tony Echelle [00:59:42] And do you think that the change in the hydrology out there is, is because of groundwater pumpage for irrigation, or is it more, you know, overgrazing in, in years past?

Tony Echelle [01:00:00] Well, I think groundwater pumping is the major thing that has caused springs to fail. But there, in other, I don't know how, how important this has been in that, in the Trans-Pecos area, but in other parts of the Southwest, overgrazing has led to spring failures as well. What happens is that cattle graze off the vegetation, the soil holds less water, and also with the removal of the vegetation, the arroyos get cut deeper and deeper, and this eventually cuts down to a point where it's below the level of, well, I can't remember the exact process, but it causes springs to fail as well.

David Todd [01:00:50] I see. Gosh, it's, it's interesting. It is truly the canary in the coal mine, I guess, these pupfish. They are a real indicator for the health of that big system out there.

David Todd [01:01:06] Well, you know, we've talked mostly about the Leon Springs pupfish, but I was wondering if you could sort of give us the larger context of, of the issues facing other rare desert fish. I think that there's the Devil's River minnow, the Comanche Springs pupfish, the Pecos Gambusia, the Big Bend Gambusia. Are they seeing similar impacts, suffering in similar ways to the Leon Springs pupfish?

Tony Echelle [01:01:36] Yeah. The Leon Springs pupfish situation reflects what's going on all over, has gone on all over the Southwest, in, in the southwestern United States and northern Mexico. There's been, I think, and for pupfish, there have been nine different, nine extinctions

of pupfish in the last, oh, 80 or 90 years. And most of this is the result of the pumping of groundwater, the dropping of the water table, and the failure of springs. In northern Mexico, in one small area, six species of pupfish have gone extinct because of overpumping of groundwater.

Tony Echelle [01:02:28] Recently, I think only about five years ago, another system of springs over in Chihuahua has gone dry. And what happened there is there was a pupfish, a minnow, and a crayfish that were threatened with extinction. What happened there is that people went in and took the animals out of the springs before they went completely dry, transported them to another spring about 10 miles away that had no fish in it. And now they have an artificial population that's, that's in, it's in a natural, more or less natural environment, but the native environment. And this also is a result of overpumping of groundwater.

Tony Echelle [01:03:19] So then if, but if you talk about, say, the Rio Grande Gambusia, *Gambusia gaigei*, its primary problem seems to be competition with Western mosquitofish, *Gambusia affinis*. The spring flows seem, seem to be OK. But the *gaigei* occurs only in one small spring, spring-fed system, at Big Bend National Park. And that, I think is, is, I'm not sure exactly what the, what the, if the springs were threatened by the same thing, by, by overpumping of groundwater or not? There's not much crop. There's not much agriculture down there and not much of a municipal situation. So the biggest problem there seems to be competition with *Gambusia affinis*.

Tony Echelle [01:04:18] And then *Gambusia nobilis* occurs in Diamond Y Spring and then only over 50 miles away in the Balmorhea area, in those springs. So it's, it's, it's got the same problems that the Leon Springs pupfish has.

Tony Echelle [01:04:37] The, the Devil's River minnow, it's kind of an interesting story. It probably was once much more abundant than it is now, but because its habitat was flooded by Amistad Reservoir. But it is flourishing in a creek down, down, down river from Amistad Reservoir, which is called, in Del Rio, San Felipe Spring. But that spring actually has been kind of rejuvenated by the, by the presence of the reservoir. The water pressure that the reservoir creates has actually increased the flow, or at least maintains, the flow in San Felipe Spring. But, so the Devil's River minnow, of course, is, is, is restricted in area and is highly threatened.

David Todd [01:05:41] Hmm, I guess the circumstances of each of these fish are similar, but distinct since their, their springs are often disconnected and isolated. But I guess these aquifers are all connected and under the same kind of pressures. What a, what a complicated situation.

David Todd [01:06:03] Well, I think another question I wanted to ask you is that, what happens, say, you've got these very rare fish in a spring, and an egret or heron comes, and is hungry for some fish. And of course, the egrets or herons are protected. How do you manage a competition between two protected species? Have you run into that kind of situation?

Tony Echelle [01:06:40] Well, one, one problem is the *Gambusia nobilis* / Leon Springs pupfish situation that you mentioned earlier. You have two endangered species and one of them might be affecting the abundance of the other. What do you do about that? So managers have to be, just be aware of the situation and deal with it. I don't think, you know, I don't think herons and so on are that much of a problem for pupfish. They eat them, of course. But pupfish have existed with, you know, these animals for millions of years. And I think they can handle that, more or less.

David Todd [01:07:30] I guess they can hide in the sand, as you were saying, or keep one weather eye out .

Tony Echelle [01:07:41] Yes.

David Todd [01:07:41] Well, you've told us so much. I think maybe we can sort of think about how to wrap up this wide-ranging conversation we've had.

Tony Echelle [01:07:55] You know, to some extent, these, these creatures live or die at the level of people's interest and tolerance and investment. And I'm curious how, how do you make the case to folks who are maybe not really intimately involved in pupfish, or fish, or wildlife in general and, you know, explain to them why it's important to protect these Leon Springs pupfish or their kin species?

Tony Echelle [01:08:31] Yeah, that's the hardest question I think you can ask, because I know some people, I've heard people say cynically that, well, you know, if you don't already know the answer to that question, then nothing I can say is going to change your mind. But that's too cynical, you know. Of course, we need the public on board for conservation efforts. They vote and that influences politicians to do the right thing for the environment. Also, local landowners are crucial in conservation efforts. So we have to have these people on board.

Tony Echelle [01:09:10] So for me personally, my best answer, I think, is it just seems like the morally correct thing to do to preserve the Leon Springs pupfish. You know, to keep the Leon Springs pupfish in its natural habitat, you have to preserve the spring. And that spring is an ecosystem with a community of organisms that evolved there over millions of years. If you protect the springs you don't only, not just you save, not just the pupfish, but also the other animals that occur in Diamond Y Springs and nowhere else on Earth.

Tony Echelle [01:09:52] So there are at Diamond Y Springs, there's three species of snail that don't occur anywhere else on Earth. There's a species of arthropods that occurs in Diamond Y Spring and nowhere else. The puzzle sunflower occurs in Diamond Y Spring, and then nowhere else on Earth except in a small place in New Mexico. And then, of course, we've mentioned *Gambusia nobilis*, which occurs in Diamond Y Springs and nowhere else except in the Balmorhea area.

Tony Echelle [01:10:25] So it just seems like, it's, you know, Diamond Y Spring where Leon Springs pupfish lives, you know, it's a tiny, tiny remnant of what once was a large system of springs and marshes fed by over, over 40 or 50 million gallons of water a day. And so this was a, you could think of it, it was a, a beautiful oasis in the middle of the Chihuahuan Desert. It was a major feature of the cultural and economic history of the Fort Stockton area. But by preserving Diamond Y Springs, we preserve a tiny, tiny, small portion of that.

Tony Echelle [01:11:13] It seems like, people argue, especially my friend Gary Garrett, who now works for, at the University of Texas. He is a big proponent of informing local people of what they have in their backyard. And if they understand its history and how unique it is, they'll, they'll take pride in that and maybe be more supportive of conservation efforts.

David Todd [01:11:46] Yeah, so I guess a remnant of a really storied past with all sorts of ecological and social and political stories all wrapped up in this, this one spot, and this one creature that you've been studying is such a wonderful example of that.

David Todd [01:12:10] Well, I guess you're so eloquent about explaining that. Is there anything else you might want to talk to us about regarding Leon Springs pupfish, or desert springs fish in general, or just, you know, your work in biology over the years?

Tony Echelle [01:12:28] Oh, I don't have much else to say, except I don't know, I feel very lucky to have been able to do this. Sometimes we're out seining and we pull the seine to shore and we're checking to see what's there. And then I just kind of marvel that somehow somebody found a way to pay me to do this for 50 years.

Tony Echelle [01:12:56] I think most of the people involved in conservation of fishes in the, in the desert southwest, I don't think there are any more dedicated people on Earth than these folks. They work for state and federal agencies. They don't care about the time clock. They care about the resource. And they're, they're, you know, laser-focused on what they can do to convince people that these animals are worth preserving. I just feel lucky to have been part of that.

David Todd [01:13:38] Yeah. You know, one thing that I would like to ask you just towards the end, and I think it's really remarkable not only that you've worked with all these colleagues at universities and, and state and federal agencies, and landowners and so on. But, but that you've had this wonderful partnership with your wife, which seems so distinctive and special. And I was curious if you have any remarks you'd like to share about that.

Tony Echelle [01:14:07] Yeah, you're going to have me in tears here in a minute. But, no, Alice and I, we've been joined at the hip for 52 years. And she has, most people that know us, think that she's done most of the work, so, so I wouldn't trade that for anything. We, we reinforce each other. And I've gotten a few little minor awards for our work over the years, my work over the years, and every one of them, Alice is a co-recipient. So, yeah, we've had a special, special thing going.

David Todd [01:14:52] Well, thank you for, for all you've done, both of you. And I sure appreciate your time today giving us, you know, a short story about, about all that's consumed over 50 years. It's just remarkable what you've done. And it's, it's kind of you to share it.

Tony Echelle [01:15:13] Thank you. Thanks for inviting me.

David Todd [01:15:15] Yes. And if we could just stay on the line for just a moment, it allows our recordings to be uploaded and we want to make sure we get a complete record of what you've told us. But I think, I think we've got it now.