

GEER 08 01 2008

Peggy VanArman: Thank you all for attending this last presentation before the wrap-up at 10:30, I wanted to remind you. The GEER organizers have done a wonderful job of integrating top down speakers in food web speak, Federal and State officials and policy makers and bottom up speakers, those dedicated to research in the field and lab investigations, and everyone in between, which includes modelers and others that are trying to tie all this stuff together. We all want the same thing, a healthy and, uh, sustainable Everglades ecosystem. But remember, large things and small are part of the picture.

Moving on, this research was done in, uh, as part of my doctoral dissertation and I'd like to acknowledge a few people, Nova Southeastern University, Dr. Bart Bacca, Dr. Frank Jordan, Palm Beach Atlantic which furnished some financial help, and also the library, which, uh, was very invaluable. Also, I had a host of statisticians, biologists, uh, managers of natural areas that helped facilitate collecting, and especially my family and friends, especially my husband. These are two-thirds of the micro invertebrate decapods from the Everglades, *Procambarus alleni*, the Everglades crayfish, and *Procambarus fallax*, the slough crayfish. The other third, of course, would be Paleo (inaudible), a shrimp. They are very important and are often overlooked. In most aquatic ecosystems in which they are found they're considered to be keystone species, and I would say they are also in the Everglades. They play critical ecological roles and on top of all of their feeding activities they make burrows that serve as refugia for a host of other animals during the dry season. They are indicators for hydrology and pollution, but they're mostly neglected, especially in the United States, except when they're used in aquaculture to feed off.

We have developed this concept model, and you'll notice in the top left, in the top left corner; yeah, oh, yeah, the big part, sorry; in the top left corner over there, uh, we see crayfish as prey. Well, we're gonna start in the middle. This follows Ogden's rule for the Everglades model that he, uh, conceptual model, that he developed in 2005. And we'll see at the top, these are crayfish as prey. And you'll notice that there's a host of invertebrates that eat crayfish as well as a host of vertebrates. There are over 40 documented vertebrates that eat crayfish in, uh, the Everglades, including a lot of birds that are threatened, endangered and of special concern, fish, alligators, etc.

When we look at the crayfish's predators we see this list of invertebrates. There's not a lot known about the invertebrates in the Everglades. David Ceilley has finally gotten a list of these, uh, smaller arthropods that I haven't seen before. Many of these actually live in the burrows during the dry season and they probably form food for the baby crayfish. Notice also

that vertebrates that crayfish eat include fish, which could be at least secondary consumers. So crayfish actually eat fish, fish fry and eggs.

And lastly, crayfish are mostly noted for herbivorous activity where they are known as primary consumers. They eat macrophytes, they eat periphyton, mostly the algal type. They don't like the calcarius stuff. And bacteria lure crayfish to these pieces of vegetation that they have macerated. Bacteria put out enzymes that entice the crayfish to break up little pieces of vegetation and that in turn enhances greatly nutrient recycling in the Everglades.

There's not a lot of previous research known about these crayfish; direct research. A lot of what we really know now comes from Hobbs 1942, and in the year 2000 Hendrix and Loftus put out several papers that gave us what we currently base a lot of our, uh, research on. They're known as secondary burrowers. That means they do burrow, but they live above ground most of the year. They mate and carry eggs in borrows where the young hatch off. And most importantly, notice the hydroperiod. They like short hydroperiods, temporary habitats. Their range, according to Hobbs, was south to Florida Bay, north to Levy, Orange and St. John's, and they were also, they're also found on Big Pine Key, one of the keys in Sanibel. In fact, until the year 2000 when Hendrix and Loftus did their work, we didn't even, uh, consider in Everglades researching that there was another species. Most of the earlier papers always include Everglades crayfish but they never mention slough crayfish, even though Hobbs mentioned them in his 1942 paper.

Slough crayfish are tertiary burrowers. They rarely burrow; uh, it is known that they make horizontal and vertical burrows. I have found these, and Dale Gawlik, working with his students, I think Sam (inaudible) is the one that tracked them into the horizontal burrows down in the, uh, arm locks. They probably mate and release young in vegetation, and notice the hydroperiod; different. They like long hydroperiod permanent habitats. Their range was in; uh, noted by Hobbs in 1942 to Water Conservation Area 1, but, Hendrix and Loftus noticed that they were in the southern Everglades and they actually replace each other seasonally. We also found this species on Sanibel. Their northern range goes up to Georgia.

When we look at these ranges, we can see the; oh, shoot. Sorry. When we look at these ranges, we can see that in the middle of the state the ranges overlap, slough crayfish go further north, and we don't really have a lot of information about southwest Florida. However, some of the papers, uh, this paper has presented, uh, information that shows us that Everglades crayfish is found around, uh, at least Picayune Strand, and some of the other people have been telling me that they found them in other places over here.

The research I'm presenting today is part of my doctoral dissertation work done in 2002-2003. It was based on problems of the Everglades noted by Davis and Ogden in 1994. And we've heard about these problems at every single talk we've had all, uh, during this entire week. So we have reduction of geographic extent, alterations of physical driving forces, these cause biological changes. So while water management policies, uh, created impoundments, levies and pumping stations and so forth, the hydroperiod changes that resulted have unintended consequences probably on crayfish distribution and abundance. Unfortunately, we don't have a lot of that information. There is very little information on crayfish distribution and abundance except what, uh, Dick France did, I think it was in the early 90's.

So my question was we know from historical data written in Hobbs and we know from geographic location of these crayfish that alleni or Everglades crayfish probably came to Florida and settled first. They're found further south. They're found in, uh, Big Pine Key, 30, uh, mile marker 30 in the keys, and therefore I was wondering do slough crayfish out-compete when they're in the same places? So I'm thinking, okay, is the range extending south and west? Uh, implications of changes, alterations to the environment and the effects of those changes in crayfish distribution may give slough crayfish a competitive advantage and that would change crayfish distribution and availability and food webs. We would also have a loss and reduction of crayfish burrows as refugia if Everglades crayfish were out-competed. So we might be able to use distribution and abundance of both species as a basis to determine restoration success. We need a lot more of updated research. When we went back and looked at those ranges, we don't know if those crayfish really weren't there or whether people just didn't find them. So my question was are there differences in growth and development between these two species? Beginning with a null hypothesis, I looked at survival, size, growth rate and development determined by the presence of gonopods.

I went out in the field and collected buried females. Those are the females that have eggs or I brought crayfish into the lab and mated them. These are all laboratory studies. The uniqueness of this research is that this is baseline data. I used crayfish hatchlings that were about 24 hours old. So we now have crayfish that are exactly the same age. My collecting areas were part of the historical Everglades, the Corbett area, Grassy Waters, DuPuis. Notice that they all drain down here into Conservation Area 1 historically.

When I collected at Grassy Waters and at the Corbett area, Grassy Waters and Corbett area, I collected slough crayfish and they were collected in permanent bodies of water, long hydroperiods obviously, but

when I collected at, uh, a little further east of the entrance at the, uh, Corbett area, I found both crayfish in syntopic distribution. That means they live in the same habitat, in the same geographic location. And I was very surprised to find both of them in my traps at the same time.

This is typical measuring, uh, standard protocol for measuring crayfish. And we'd start from the tip of the rostrum to the tip of the uropod to get total length. We measure across the carapace for total width. And the gonopods are structures on the bottom of the crayfish, central side of the crayfish. If you look at their abdominal segments, the first two pleopods or appendages turn into these sperm transmittal structures called gonopods. Gonopod 1 develops first and then gonopod 2 develops. So I looked for their presence and I measured the gonopods as they came in.

Uh, this is a little hard to see, but the gonopods are right here and when the crayfish turns from, transitions from juvenile to adult, this gonopod (inaudible) and then they can carry the sperm and they place it in a packet on the female, that I'll show you in a minute. This top left slide shows you right in this area there are two things called headlights that Hendrix and Loftus found, that's how you can identify alleni or Everglades crayfish in the field. Slough crayfish do not have them, although it's hard to see on this picture.

The two bottom pictures show you females and you see where it's noted ventricular anuli; that's where the sperm packets are placed. And right above that is something called a ventral shield, and those ventral shields can also be used to tell gender, uh, and species. So the gonopods and the ventricular anuli are used; they're species specific.

My setup was 57 5.7 liter bins, 10 crayfish per bin. I used 319 Everglades crayfish hatchlings, 250 slough crayfish hatchlings over a 12 week period. The results in survival, at the top for the Everglades crayfish, at the bottom for the slough crayfish, the first column shows the hatch numbers, the second column, uh, shows the number of crayfish that were alive at 12 weeks, the third column shows us the, uh, the; oh, I'm sorry, this is the original number that I started with, this is the number alive at 12 weeks, and the fourth column shows percent survival at 12 weeks.

For slough crayfish the weighted mean was; uh, the weighted mean of survival was 62%, and for fallax the weighted mean for survival was 83%. That was at the 95% confidence interval.

When we looked at growth, we looked at the mean weight at 12 weeks in grams, the mean total length in centimeters, and then we looked at the growth rate per week over the 12 week period. We found that Everglades crayfish had, uh, were .47 grams at 12 weeks versus slough crayfish .26

grams. Everglades crayfish were 2.49 centimeters versus 2.26 centimeters for the slough crayfish. And growth per week, uh, was .04 versus .025 grams. These are all significant figures.

Another test that we did was to plot the log weight, and this is the log weight against the length in centimeters over, uh, over the time period. And we see with the regression lines for Everglades crayfish, this is the one for slough crayfish, when we look at the slope numbers we see .775 for the slough crayfish, .731 for the Everglades crayfish. This indicated that at, at a given length the slough crayfish were actually heavier than the Everglades crayfish.

My conclusions are that the Everglades crayfish might have a competitive advantage in the short hydroperiod ephemeral bodies of water in that they are larger sized, they have faster growth rates, they have what we call a size structured population, and that means that in every container where we had an Everglades crayfish we'd have one really huge crayfish, one really tiny one and then the rest of them were intermediate.

Slough crayfish, on the other hand, might have an advantage in long hydroperiod permanent bodies of water because they had higher survival, they matured at a smaller size and earlier age, they were heavier at a given length and they had more of the same sized population. So every container we had that had, uh, slough crayfish in it, at a given age these crayfish was, were, uh, had a very small, uh, range of sizes. When we're looking at the slough crayfish and the Everglades crayfish, that would make sense because the Everglades crayfish change seasonally. They move in those short hydroperiods. They migrate. They burrow. They have to be ready to, uh, look for a different variety of foods and mechanisms for survival, whereas slough crayfish are living in longer hydroperiods, more permanent bodies of water, they probably have food in the form of vegetation and small organisms available to them year round.

The, uh, one of the things that we do as biologists, we go into the field, we bring the crayfish in, we're doing studies in the lab or on mesocosms and we're trying to see how mature are they, how old are they. You can't tell that by picking them up. When we looked at our early development, you could go in the field, pick up a very small slough crayfish and that might be sexually mature, but you could pick up a very large Everglades crayfish and it might not be sexually mature. So we have to watch for things like that.

Implications for Everglades restoration, we now have some baseline data. I did two other experiments on these hatchlings. I did an ecology and behavioral experiment. And the key here is that they're same age, so they'll be really good for the models. And those are the models that make

up, uh, help managers make decisions on management of the quality, timing, flow and delivery of water. We want to conserve both populations of crayfish. We don't know a lot about the specific predator prey interactions. There are people doing work now. Dale Gawlik's group is doing some bird prey. Some people are doing some, uh, fish studies. I think, uh, Shawn Liston did some; uh, she's been doing some bird studies for Audubon. So we want to conserve both species because we don't know where they fit into those Everglades food webs.

Hydroperiod influences on distribution are critical because at an early age changing hydroperiod, even on these, uh, on these very tiny crayfish can have an effect on a whole year class, which could affect their availability as food. Future research is wide open. Life history is not known. Predator prey interactions are not known. Water quality parameters, microhabitat differences when they live in syntopic distributions, don't know a lot about that. It's very important for us to coordinate laboratory experiments with field work and models. Those three factors have got to be entered into everything that we're doing. And, uh, monitoring and the effects of hydrology is another really critical part in Everglades restoration.

Most of the current research, at what little there is at this point on crayfish is focused on hydrology. So if you're looking at, uh, Joel Trexler, Bill Loftus, uh, Nathan Doran, Laura, uh, Laura, oh, I can't remember the last name, from the Fish and Wildlife, they're all looking at hydrology, which is what we've heard about all week. So if you take nothing else away from this talk, please try and think of how totally important and critical crayfish are in all of their roles in the Everglades. Thank you. Are there any questions?