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Who lives in Texas groundwater?

Authors:
Tom Devitt and colleagues
Associate Editors:
Preethila Zaman and Erin Conlisk

Abstract

Did you know that some salamander species in Texas live in water underground and never see the light of day? Unfortunately, overuse of groundwater, pollution, and habitat loss threaten them with extinction. Before we can decide how best to protect these animals, we need to know more about them. For example, how many species are there? Where do they live? What do they need to survive?

To learn more, we collected DNA from salamanders living in the springs and caves of the Edwards-Trinity aquifer system in Texas. Differences in DNA showed that the individual salamanders we collected fall into 14 different species. Three of those species were new discoveries! Then, we investigated how the different species were related, providing clues to how they evolved over millions of years.

Introduction

The Edwards-Trinity *aquifer system* provides water for more than two million people in Texas. It is also home to dozens of *species* found nowhere else in the world! These include blind catfish, aquatic beetles, crustaceans, and many salamander species.

? for the curious

Unlike many amphibians, Edwards-Trinity salamanders are aquatic from the beginning of their lives to adulthood (they breathe through gills).

Why are there so many salamander species there? Mainly because of natural barriers that separate species. Different combinations of species live in different *watersheds*. A watershed is an area of land where water falls as rain (and collects underground) and drains into a river. Although the salamanders are aquatic, they usually "go with the flow" and don't move far outside of their watershed.

Scientists are racing to learn more about these salamanders. The *groundwater* that they need for survival is being used faster than it's being replaced through rainfall. If the groundwater disappears, their *habitat* will vanish and these species will go *extinct*.

To learn more about these amazing amphibians, we asked:

1. How many salamander species are there in the Edwards-Trinity aquifer system?
2. How and when did they evolve?
3. What does it mean for conservation – of salamanders and groundwater – in Texas?

It can be impossible to identify a salamander's species with the naked eye. These two animals are actually the same species - *Eurycea latitans*. The top one was caught above ground and the bottom, in a cave. **Photo:** Tom Devitt

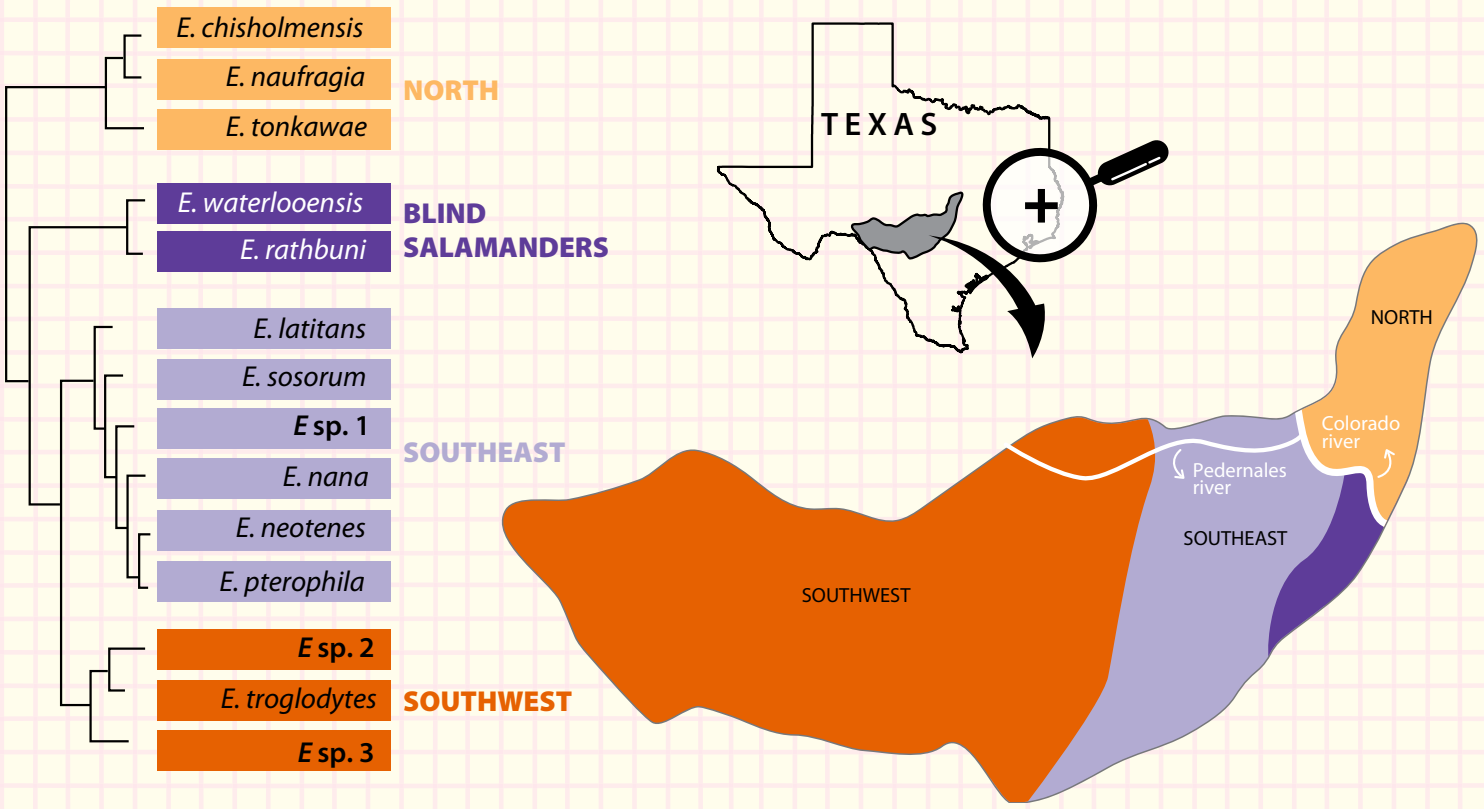
Salamanders' Adaptations
Salamanders are *amphibians*. Depending on the species and their life stage (larva or adult), amphibians may breathe through some combination of gills, lungs, and skin. Some salamanders have no lungs and rely primarily on their skin for gathering oxygen. Some have external gills. Species that have *adapted* to living underground have even lost their eyes like the Texas blind salamander (*E. rathbuni*). Who needs eyes when you never see the light of day?

Methods

Our study included 303 individual salamanders from 11 previously described species. We collected them from about a hundred different springs and caves in the Edwards-Trinity system. We took samples of muscle or liver from each individual. These tissue samples provided us with individuals' *DNA*.

Salamanders of the same species have similar DNA because they breed with each other. Salamanders from different species show more differences because they don't interbreed. By comparing differences in DNA, we can learn how and when species evolved from a common ancestor over millions of years. Like a family tree, we can show this in a branching diagram called an *evolutionary* (or *phylogenetic*) *tree*.

Figure 1:
Fourteen salamander species are found in the Edwards-Trinity region.
Three of them are newly discovered species (in bold) and haven't been named yet.
The **evolutionary (phylogenetic) tree** shows relatedness among individuals and species.
The four colors represent the four main branches in the tree and geographical regions within the aquifer.



Results

It turns out that there are more salamander species than we originally thought. We found three new salamander species! Figure 1 shows the main branches of the evolutionary tree which also correspond to four different geographic regions.

Some interesting results are that:

- The oldest split between groups of species occurs across the Colorado River. This ancient divergence may be anywhere from 10-20 million years old!
- Some populations that were previously thought to be Georgetown salamanders actually turned out to be Salado salamanders (*E. chisholmensis*).
- We found enough similarity between two other species (*E. latitans* and *E. tridentifera*) to combine them into a single species.
- One of the new species is found only in a small area of the Pedernales River basin. The other two new species are found over a larger area in the western part of the aquifer.

Discussion

Natural barriers, such as divides between watersheds and different aquifers, provide additional evidence to help us separate sampled individuals into species. These natural barriers can be even more important than the distance between populations. For example, we found that Berry Creek populations are actually Salado salamanders (*E. chisholmensis*) even though they are found closer to nearby Georgetown salamanders (*E. naufragia*).

Conclusion

Despite being mostly unseen, we should care about groundwater-dependent species because they tell us about the health of the water and the environment. For example, unseen microbes can help purify the water that people drink by breaking down chemicals that pollute it. Unfortunately, in some areas, groundwater levels have declined by hundreds of feet due to overuse.

But there is hope! You can help save these salamanders and conserve groundwater by reducing your personal "water footprint" – the amount of water you use, including how much is used to grow the food you eat. Here are some more ideas:

- Installing efficient toilets, showerheads, and appliances at home
- Using native landscaping instead of lawns that require a lot of water
- Collecting rainwater for irrigation (watering gardens and crops)
- Choosing foods that take less water to grow

REFERENCES

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Gizmodo: There's a Hidden World of Salamanders Living Beneath Texas
https://earther.gizmodo.com/theres-a-hidden-world-of-salamanders-living-beneath-tex-1831733067

The Edwards Aquifer website
https://www.edwardsaquifer.net/intro.html

Glossary of Key Terms

Adapt – when a species becomes better suited to its environment over many generations as a result of natural selection. Individuals with characteristics that give them an advantage in their environment are more likely to survive to reproduce, passing those characteristics onto the next generation. These are called adaptations.

Aquifer system – an aquifer is an underground layer of rock or sand that holds water. An aquifer system is a collection of interconnected aquifers.

DNA – deoxyribonucleic acid is a molecule composed of long chains of nucleotides that carry genetic information; it's the blueprint of life which contains the instructions needed for an organism to grow, develop, survive, and reproduce.

Extinction – the loss of all individuals of a species. Species in danger of going extinct are called "endangered." Species likely to become endangered are called "threatened."

Genus – the rank above species in biological classification; for example, domestic dogs (*C. familiaris*) and wolves (*C. lupus*) are both in the genus *Canis*.

Groundwater – the water present beneath Earth's surface in rocks and soil.

Habitat – a place where an organism or a community of organisms lives, including living and nonliving parts of the surrounding environment.

Evolutionary (phylogenetic) tree – a diagram that depicts the lines of evolutionary descent of different species, organisms, or genes from a common ancestor. Learn more about how to read a phylogenetic tree from Khan Academy.

Species – a group of organisms that can reproduce with one another in nature and produce fertile offspring. Determining what species an organism belongs to is important because they are the units for conservation.

Sustainability – the maintenance of a natural resource so that it can be used by future generations.

Check your understanding

1. Sometimes two species can look identical to the human eye. Scientists call these cryptic species. Some of the salamander species in our study were cryptic. Can you find other examples of cryptic species? How can we distinguish between seemingly similar-looking yet separate species?
2. What is one reason why more species might have evolved in a particular location?
3. What is an evolutionary tree and what do the branches tell us? (Hint: Which of the following species is more closely related to *E. waterlooensis: E. neotenes* or *E. tonkawae*?)
4. What can unseen, indistinguishable salamanders tell us about the health of groundwater ecosystems?

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