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How do glassfrogs become transparent?

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Abstract

Glassfrogs earned their name not because they are fragile, but because they are see-through! These tropical frogs have transparent skin and muscles. When sleeping on green leaves, their bodies are almost impossible to see. This form of camouflage is rare. Most animals have colorful red blood cells that would be visible under transparent skin and give them away to predators. We used a special scanner to figure out how glassfrogs overcome this challenge. We discovered that these frogs are more transparent when they sleep than when they are active. They do this by hiding most of their red blood cells in their livers during sleep! This makes them nearly transparent to predators. Our results help explain how glassfrogs can manage this unusual kind of camouflage. This finding may also help doctors treat medical conditions in humans.

Introduction

What would you do if you had an invisibility cloak? For humans, invisibility cloaks are just make-believe. But one group of frogs has mastered the art of disappearing in plain sight.

Glassfrogs live in the rainforests of Central and South America. They spend their days sleeping on the undersides of leaves (Fig. 1). This leaves them vulnerable to predators. These small frogs are on the menu for snakes, birds, lizards, mammals, and even large spiders!

But glassfrogs can do a biological magic trick. They use an unusual form of **camouflage** to hide from predators. The skin on their backs is green to match the surrounding leaves. But the skin on their bellies is **transparent**. Viewed from above, the frogs are almost invisible!

Very few **vertebrates** that live on land are transparent. That's because their blood contains **red blood cells** that are – you guessed it – red. These cells are necessary to deliver oxygen around the body. But their color makes them highly visible under transparent skin.

We wondered how glassfrogs got around this challenge. Then we noticed that glassfrogs seemed more transparent when they were sleeping. When they were awake, it was easier to see their blood moving around their bodies. We wondered: where does the blood go when they sleep?

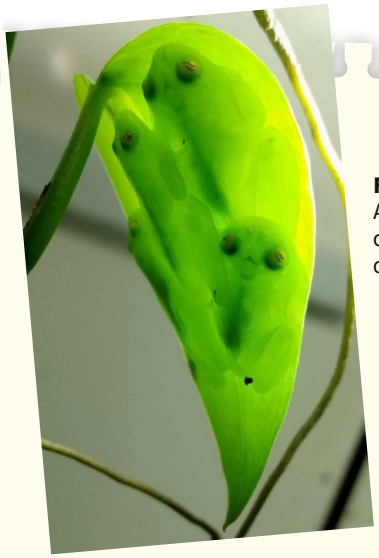


Figure 1:
A few glassfrogs demonstrate their camouflage as they sleep together on the underside of a leaf.

How many glassfrogs can you count?

Methods

We first wanted to be sure that glassfrogs really are more transparent when they sleep. We shone a light through their bodies and took color photographs. We did this while they were active, sleeping, and **anesthetized** (not awake but also not in control of their bodies).

Next, we needed a way to track where the red blood cells were in the frogs' bodies over time. We used a type of scanner called **photoacoustic microscopy**. This technique involves shooting a safe laser beam of light into tissue. It is absorbed by cells and converted into **ultrasonic** sound waves. A sensor then picks up these sound waves to track their location.

For our experiments, we shone a green laser at glassfrogs as they slept upside down in a laboratory dish. This is similar to how they would sleep on a leaf. The red blood cells in the frog's body absorbed the green light and emitted ultrasonic waves. We used these waves to track the locations of red blood cells in the frogs' bodies. Both the green laser and the ultrasonic waves were silent, so that frogs would not wake up.

We also used this technique to track red blood cells in non-transparent frog species for comparison (**control group**).

Results

First, we found that glassfrogs are more transparent when they sleep (Fig. 2) – up to 61% more transparent than when they are active!

Next, we used our scanner to determine where the glassfrogs' red blood cells go during sleep. Surprisingly, we saw that the frogs hide around 90% of their red blood cells in their **livers** when they sleep (Fig. 3). This resulted in their livers growing about 40% larger.

The anesthetized frogs did not store their red blood cells in their livers.

Once the frogs woke up, the red blood cells quickly flowed out of the liver and circulated all around their bodies. Their livers returned to their normal size, and they became redder and less transparent.

Finally, we looked at red blood cells in other non-transparent frog species. We found that the livers of other frogs stay the same size when they sleep. Also, most of their red blood cells continued to move around their bodies. These findings suggest that non-transparent frogs do not store red blood cells in their livers when they sleep.

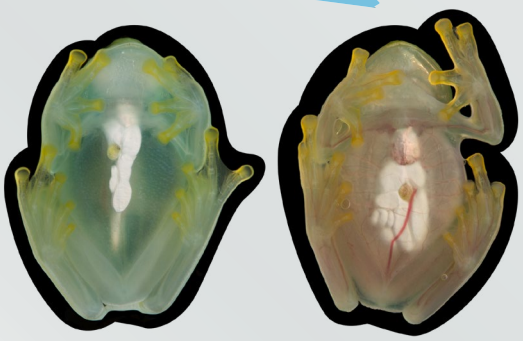
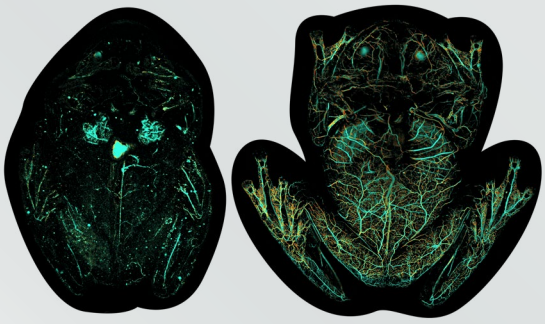


Figure 2:
Flash photography of a glassfrog showing the change in red blood cells when sleeping and active. The glassfrogs' red blood cells are much more visible when active.



Where do glassfrogs' red blood cells go when they sleep?

Figure 3:
Results from the scanner showing the location of red blood cells of the same frog while asleep and under anesthesia.

Discussion

We found that glassfrogs conceal their red blood cells in their livers when sleeping. But why isn't the liver then clearly visible to predators? Glassfrog livers are surrounded by millions of **nanocrystals** that reflect light. This makes the liver act almost like a mirror. That hides the red blood cells within!

We are not sure exactly how glassfrogs store and release their red blood cells on demand like this. However, we think that understanding how they do this could have implications for human medicine.

For most vertebrates, packing red blood cells together in one place results in dangerous blood **clotting**. But glassfrogs don't appear to have any problems with their health from storing blood in their liver. Understanding how the frogs can pool their blood this way may give us clues to some human health conditions involving clotting. These include **deep vein** thrombosis and **stroke**. If we do more research on glassfrogs, it could lead to new medication that stops blood clotting.

Conclusion

We hope that this discovery will help researchers develop new treatments. These could help people with clotting disorders. Deep vein thrombosis and stroke are much more common in adults than in children. Young people are more at risk if they have other medical conditions or if they have to spend a long time in hospital.

Everyone can make choices that reduce the risk of thrombosis and stroke. These include staying active, not sitting still for too long, not smoking, and eating healthy foods.

Check your understanding

1. Glassfrogs have transparent skin and muscles. Why is this helpful to them?
2. How do glassfrogs' livers change when they sleep?
3. How could research on glassfrogs be applied to human health?
4. Can you think of other animals that use camouflage? Provide an example and how it helps the animal.
5. Transparency is rare in animals that live on land but more common in animals that live in the ocean. In small groups, research some transparent ocean animals and how they accomplish transparency.

Glossary of Key Terms

Anesthetic/anesthetized – a substance that makes a person or animal unconscious. People are anesthetized before they have surgery.

Camouflage – a way of hiding or disguising one's presence. Many animals use camouflage to blend into their surroundings and avoid predators noticing them.

Clotting – the process in which blood changes from a liquid to a solid lump. Blood clots form over an injury to prevent further bleeding.

Control group – a group in an experiment that is used as a comparison.

Deep vein thrombosis – a medical condition in which a blood clot forms in a deep vein in the body, usually a leg. When blood cannot flow or clot properly, a deep vein thrombosis may form. Sometimes the blood clot will travel through the bloodstream to the lungs, where it can get stuck.

Liver – an organ located in the abdomen that aids in digestion and cleanses the blood. The glassfrog's liver increases in size when it stores red blood cells.

Nanocrystal – microscopic crystals measured in nanometers. One nanometer is one billionth of a meter. Light reflective nanocrystals make the glassfrog's liver nearly invisible to predators.

Photoacoustic microscopy – a biomedical imaging method using light energy and ultrasound. Researchers used photoacoustic microscopy to look deep within the bodies of glassfrogs.

Red blood cell – a type of cell found in blood that carries oxygen throughout the body. Because of their color, glassfrogs' red blood cells have the potential to give away their location.

Stroke – a medical condition that occurs when blood flow to a part of the brain is blocked. A stroke can lead to long-lasting brain damage and disability or death.

Transparent – allowing light to pass through. Glassfrogs' skin and muscles are so transparent, you can see inside to their organs.

Ultrasonic – too high in frequency for people to hear; sound waves with a frequency above the upper limit of human hearing.

Vertebrates – animals with a backbone.

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