

Evolution & Behaviour

It's clear: the glass frog's transparent belly has a special advantage

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doi.org/10.25250/thescbr.brk455

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This Break was edited by Akira Ohkubo, Scientific Editor - TheScienceBreaker

Glass frogs are well known for their transparent belly skin that gives them a unique translucent appearance. We asked how being translucent, rather than completely transparent, may act as camouflage. We found that translucency creates targeted camouflage that helps the frogs better blend into their surroundings, hide from predators, and survive another day.



Image credits: Geoff Gallice

Imagine you are a small frog, only one or two centimeters long, sitting on a leaf high up in the canopy of Ecuador's tropical rainforest. This is one of the most biodiverse places in the world with thousands of species living around you, many of which would be quite happy to call you lunch. Your best bet for survival is to avoid being spotted, blend into your surroundings, and become invisible.

To [camouflage](#) is to 'hide in plain sight'. Many species go to extraordinary lengths with colors, patterns, and protuberant appendages that match their backgrounds or transform their bodies into replica leaves, sticks, rocks, or bird poop. A few species go one step further and modify their body tissues to become almost completely transparent. Being transparent has a noticeable advantage — unlike a

single camouflage pattern that can only fit a few niche areas, transparency enables you to change instantaneously to perfectly match any background.

Back in the canopy of Ecuador's rainforests, glass frogs appear to have evolved in exactly this direction with transparent belly skin, which has made them a common feature of nature documentaries and online listicles. These frogs are often depicted with captivating images that showcase how their beating hearts and squirming intestines can be clearly seen through their skin. However, glass frogs are not completely transparent and have green pigments in their backs and legs that give them more of a translucent appearance. This begs a question: if predators cannot look straight through the frogs,

why have they evolved transparent skin? Can being translucent still provide camouflage?

A hallmark of transparent camouflage is that it will appear to change depending on the background. If glass frogs are doing something similar, we should be able to detect this change and we would expect it make the frogs a closer match to their immediate surroundings. To study this hypothesis, we photographed the frogs on two backgrounds: bright white paper and dark green leaves. We then tested how easily the frogs' predators (birds, snakes, and mammals) as well as humans would be able to visually distinguish between the frogs' colors on the different backgrounds. We found that all observers could see a change in the frogs' appearance, but rather than changing in color, they changed in brightness. This brightness change was most pronounced on their legs.

We next tested whether this change in brightness was strong enough to drive effective camouflage with two further experiments. First, to assess detectability, we created a 'find the frog' computer game with frog-shaped targets, that were either translucent or opaque. We asked a group of human participants to find and click on the frogs as quickly as possible, and found that it took them longer to find the translucent frogs than the opaque frogs. Second, to assess whether translucency was

effective against natural predators, we prepared edible model frogs, again either translucent or opaque, and stuck them to green leaves within glass frog habitat. We then monitored how quickly these models were eaten by wild birds. Over the course of one week, the translucent models survived at nearly twice the rate of the opaque frogs, suggesting that they were harder for the birds to find. Thus, we could demonstrate the effectiveness of the glass frogs' unique form of camouflage.

Here, we aimed to answer a long-standing mystery as to why glass frogs have evolved imperfect transparency. We found that the frogs' transparent belly makes them translucent and improves their camouflage. The glass frogs always appear green due to pigments that are similar in color to the leaves on which they spend their lives. Translucency then allows this generic camouflage to shift in brightness to better match their immediate surroundings, making the frogs harder to find and more likely to survive than if they were opaque. What's more, since the frogs sit with their legs tucked to the sides of their bodies when resting, the legs' greater translucency creates a gradient from leaf color to body color rather than a high contrast edge that would more easily catch a predator's eye. When hiding in plain sight, a transparent belly may be a route towards more effective camouflage and a greater chance of surviving another day.