The extreme tactic of self-amputation means survival in the animal kingdom

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Credit: AI-generated image (disclaimer)

Imagine yourself in the grips of a deadly predator. You see your life flash before your eyes: this looks like the end of the road. But wait! With a quick yank, your limb pops off in the predator's mouth and you make a break for freedom. You've escaped certain death through a grisly trade.

If you manage to sit through the survival drama 127 hours —based on the true story of hiker Aron Ralston, who amputates his own arm to free himself from a fallen boulder —then you might have asked yourself: how far would I go to escape a lethal situation?

As it turns out, this extreme tactic of self-amputation is one that has evolved many times across the animal kingdom. Our team of evolutionary ecology researchers studies how diverse and functional traits like this evolve in nature.

Dead weight

Shedding an appendage can help captured animals by distracting predators and allowing the animal to flee. Many lizard species use this tactic, shedding their tails when startled or attacked. You may have seen this happen if you ever owned a pet gecko and accidentally spooked it. In some species of gecko, their tail can even keep twitching for up to 30 minutes after being dropped, keeping potential predators distracted.

Many crabs, insects and spiders can break off a limb at a precise weak spot on their limb. Leaf-footed cactus bugs self-amputate not only to escape predators, but to shed injured appendages that might otherwise hinder their movement.

Self-amputation is also not limited to limbs. African spiny mice can shed up to 80 percent of their skin when gripped by a predator, sort of like peeling a sausage.

Although it can help with escaping a fatal encounter, shedding appendages can come at a high cost. The animal is now down a limb, making it slower or weaker. To make matters worse, the site of amputation is at risk of infection. Even if it can regrow the appendage, this process can be a big strain for the animal, using up precious

resources. Since losing limbs is costly, there is some mystery behind which species opt for self-amputation, and why.

These unique self-amputation behaviours have inspired engineers. Lots of safety features in our modern lives protect people by failing on purpose during extreme events like a car crash. Sign and light posts along roads pose considerable risks to a driver who loses control. Some posts are engineered to purposely break at special joints when hit by a car, resulting in less damage to the occupants. Likewise, many elements of the car are also designed to fail in ways that better protect the passenger.

Multiple defence strategies

What if self-amputation is an effective strategy against some predators but not others? An animal shouldn't drop a limb when there is no real danger.

Credit: ROMAN ODINTSOV from Pexels

Some North American damselflies —the slender delicate cousin of dragonflies —have developed different strategies to avoid being preyed upon. The larval stage of damselflies can sometimes find themselves in ponds, with either fish or larger insects like dragonflies as predators. The hunting strategies of these predators are different, so different defensive strategies are needed.

Our research team was curious about whether damselflies might tailor their defence tactics to different types of predators.

For damselflies trying to escape grasping predators like a dragonfly, shedding an appendage is a valuable defence. Dragonflies often target the feathery tail appendages of fleeing damselflies, called lamellae. Damselflies can self-amputate these appendages during escape, leaving the would-be predator in the lurch. This is a risky move, since this appendage is also important for swimming and breathing underwater.

In some cases, self-amputation is a useless defence tactic for damselflies. Not all predators grasp at their prey; bigger predators like fish will swallow damselflies whole. With fish predators, there should be no reason to try self-amputation, and so damselflies are more likely to survive by stealth and camouflage.

Planning for predators

We observed that larvae from dragonfly ponds shed their lamellae appendages more easily than those from fish ponds. But how exactly do they know to grow more sturdy appendages that won't shed accidentally, or more delicate appendages that can be amputated at a moment's notice?

Kathryn Black, an undergraduate student at the time and a member of our research team, was interested in this question.

To figure it out, she collected damselfly larvae from ponds near Guelph in southern Ontario and raised them in the laboratory. She exposed some damselfly larvae to a dragonfly predator placed in their enclosure behind a mesh barrier and then observed what happened to the joints that connect the lamellae to the abdomen as the damselfly larvae developed.

To assess the strength of the joint, we precisely measured the force needed to break off a lamella. Since larval damselflies are so small (usually only a couple of centimetres long), we needed a specialized

instrument that could detect a change in force smaller than one milligram of pressure per millimetre. This was quite a delicate task, but our patience paid off in the end: we found that damselflies growing up in the presence of dragonflies developed a weaker lamellae joint.

When we examined the structure of the lamellae more closely, we noticed that the diameter of the joint attachment was smaller in the damseflies with weaker joints. This self-induced weak point allowed them to amputate the lamellae more easily when attacked by a hungry dragonfly.

This means that damselfly larvae can change how they develop depending on the cues in their environment. Such an ability is crucial for survival, as they can't know which predators they will have to face at their local pond.

And when you're going as far as amputating your own limb to avoid being someone's dinner, it's awfully important that it works.

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