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Evolution & Behavior

Are burrowing snakes digging their own evolutionary grave?

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ABSTRACT

: Does specializing on particular resources restrict an organism's ability to adapt to changing environments and increase its chances of extinction? Species adapted to living underground (fossoriality) tend to be highly specialized to their fossorial environment at multiple levels, and such specialization could potentially limit their ability to adapt to new or changing environments. A recent analysis of lizards and snakes found that fossorial snakes have greater chances of going extinct compared to non-fossorial snakes.

Uropeltis maculata, a member of the fossorial snake family Uropeltidae. Image credits: Vivek Philip Cyriac ©

Why is there variation in the number of species between different groups of animals and plants? Why do some groups seem to be more 'evolutionarily successful' with a higher number of species than other? For instance, there are over 10,000 species of birds but just one species of tuatara (a lizard-like reptile from New Zealand) even though both groups originated around the same time. Differences in diversification rates — the overall rate at which new species accumulate (speciation rate) and disappear (extinction rate) — often explain such huge variations in the number of species in different groups. Variations in diversification rates across lineages are generally associated with the colonization of new geographic areas or the evolution of some trait or key innovation that allows some species to diversify rapidly.

Some traits also hinder diversification by increasing extinction rates, and these are termed evolutionary dead-ends. Ecological specializations are often considered evolutionary dead-ends. When a species

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is a specialist, it can use specific resources and survive better in a specific environment than a so-called generalist species. But such specializations can become problematic when new environmental challenges emerge. In such cases, specialists can have a higher chance of going extinct than generalists. However, there appears to be mixed support for this hypothesis: some studies suggest that specialization increases diversification or that it has no effect. These apparently contradictory results could be because species can be specialists in one aspect, while being a generalist in another aspect. But if a trait results in specialization at many levels, could it increase the chances of extinction? Adapting to life underground (fossoriality) imposes specialization along multiple axes. Burrowing reptiles tend to be very small, and have highly specialized skulls for burrowing into the soil. A skull built for digging must remain within certain limits of shape and size, and these limitations also restrict the prey of fossorial reptiles to soft-bodied prey. Being specialized at different levels, fossorial reptiles could potentially be limited in their ability to adapt to environmental changes.

To know if fossorial reptiles are digging themselves into an evolutionary dead-end, we checked 2078 species of living squamate reptiles (lizards and snakes), and tested whether being fossorial or not made them more likely to go extinct. To do so, we mapped species as being fossorial or non-fossorial on a dated phylogeny, which is like a genealogical tree that shows the evolutionary relationships between species, and the time when they originated. We then used recently developed mathematical models that allow us to estimate the speciation and extinction rates between fossorial and non-fossorial taxa in the phylogenetic tree.

Our results indicate that fossorial snake species emerge less often and go extinct more often than non-fossorial snakes. We also found that it is easier for a non-fossorial snake lineage to become fossorial than a fossorial one becoming non-fossorial. Interestingly we did not find these patterns in lizards. Unlike fossorial snakes, fossorial lizards did not have higher extinction rates. Both fossorial and non-fossorial lizards had similar diversification rates, and the transition from fossoriality to non-fossoriality was easier.

But why do we find different patterns in lizards and snakes? After all, snakes are, evolutionarily speaking, ‘legless lizards’. In general, snakes seem to be more specialized than lizards in several key aspects. The most obvious is in their overall appearance. Snakes have an elongated cylindrical body while body form in lizards is highly varied. Some lizards are dorso-ventrally flattened like many geckos; some are laterally compressed like most Chameleons, while some lizards like the slow worm and worm lizards are elongate, cylindrical and limbless, and look just like snakes. Apart from body form, snakes are specialist sniffers, and rely on their ability to smell for navigating their environment, while most lizards use combinations of vision, smell, and hearing. Overall, the degree of specialization varies between snakes and lizards. Fossorial snakes being highly specialized among snakes may represent an extreme on this specialization spectrum, making them more vulnerable to environmental change and more prone to extinctions.

Studies like ours not only provide insights into why different groups have different species richness, but also give us a glimpse into how different groups of animals have coped with environmental change in the past. Such understanding is also crucial in evaluating the ability of species to adapt to the current rapid changes in the environment.