Using engineering plus evolutionary analyses to answer natural selection questions

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Glossophaga soricina, a nectarivorous bat, feeding on the flowers of a banana plant. Nectar feeding bats comprised one of three evolutionary optima for mechanical advantage among New World Leaf-nosed bats. Credit: Beth Clare, Queen Mary University of London

Introducing a new approach that combines evolutionary and engineering analyses to identify the targets of natural selection, researchers report in the current issue of *Evolution* that the new tool opens a way of discovering evidence for selection for biomechanical function in very diverse organisms and of reconstructing skull shapes in long-extinct ancestral species.

Evolutionary biologist Elizabeth Dumont and mechanical engineer Ian Grosse at the University of Massachusetts Amherst, with evolutionary biologist Liliana Dávalos of Stony Brook University and support from the National Science Foundation, studied the evolutionary histories of the adaptive radiation of New World leaf-nosed bats based on their dietary niches.

As the authors point out, adaptive radiations, that is, the explosive evolution of species into new ecological niches, have generated much of the biological diversity seen in the world today. "Natural selection is the driving force behind adaptation to new niches, but it can be difficult to identify which features are the targets of selection. This is especially the case when selection was important in the distant past of a group whose living members now occupy very different niches," they note.

They set out to tackle this by examining almost 200 species of New World leaf-nosed bats that exploit many different food niches: Insects, frogs, lizards, fruit, nectar and even blood. The bats' skulls of today reflect this dietary diversity. Species with long, narrow snouts eat nectar, while short-faced bats have exceptionally short, wide palates for eating hard fruits. Species that eat other foods have snouts shaped somewhere in between.

Dumont explains further, "We knew diet was associated with those things, but there was no evidence that natural selection acted to make those changes in the skull. The engineering model allowed us to identify the biomechanical functions that natural selection worked on. Some form or function helps an animal to perform better in its environment, but it can be hard to demonstrate exactly what that form or function is. We studied the engineering results using the evolutionary tree, which is a very cool new thing about this work."

She and colleagues built an engineering model of a bat skull that can morph into the shape of any species, and used it to create skulls with all possible combinations of snout length and width. Then they ran engineering analyses on all the models to assess their structural strength and mechanical advantage, a measure of how efficiently and how hard bats can bite.

Analyzing the engineering results over hundreds of evolutionary trees of New World leaf-nosed bats revealed three optimal snout shapes favored by natural selection, they report. One was the long, narrow snout of nectar feeders, the second was the extremely short and wide snout of short-faced bats, and the third optimum included all other species. Overall, selection for mechanical advantage was more important in determining the optima than was selection for structural strength, they add.

"Thanks to this new approach," Dumont says, "we were able to answer our original question about natural selection in the evolution of these bats. It favored the highest mechanical advantage in short-faced bats, which gives them the high bite forces needed to pierce through the hardest figs. Nectar feeders have very low mechanical advantage, which is a trade-off for having long, narrow snouts that fit into the flowers in which they find nectar."

More information: onlinelibrary.wiley.com/doi/10 … 1/evo.12358/abstract

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