How the horse can help us answer one of evolution's biggest questions

February 13 2017, by Luke Dunning

Credit: AI-generated image (disclaimer)

For 600m years, life has been responding to our changing world. Virtually every conceivable environment in every corner of the planet has been occupied as animals and plants have diversified. Environmental shifts and mass extinctions produce new evolutionary opportunities for organisms to exploit as they compete for survival.

But how do organisms grasp these opportunities? Do they evolve new traits in response to the pressures of new environments, or are they able to move into new habitats because they have already evolved the right adaptations? Much of evolutionary study rests on the the former idea being right. Yet a new study of the development of horses is the latest in a growing body of research that suggests the answer to this chicken-egg situation may be more complicated.

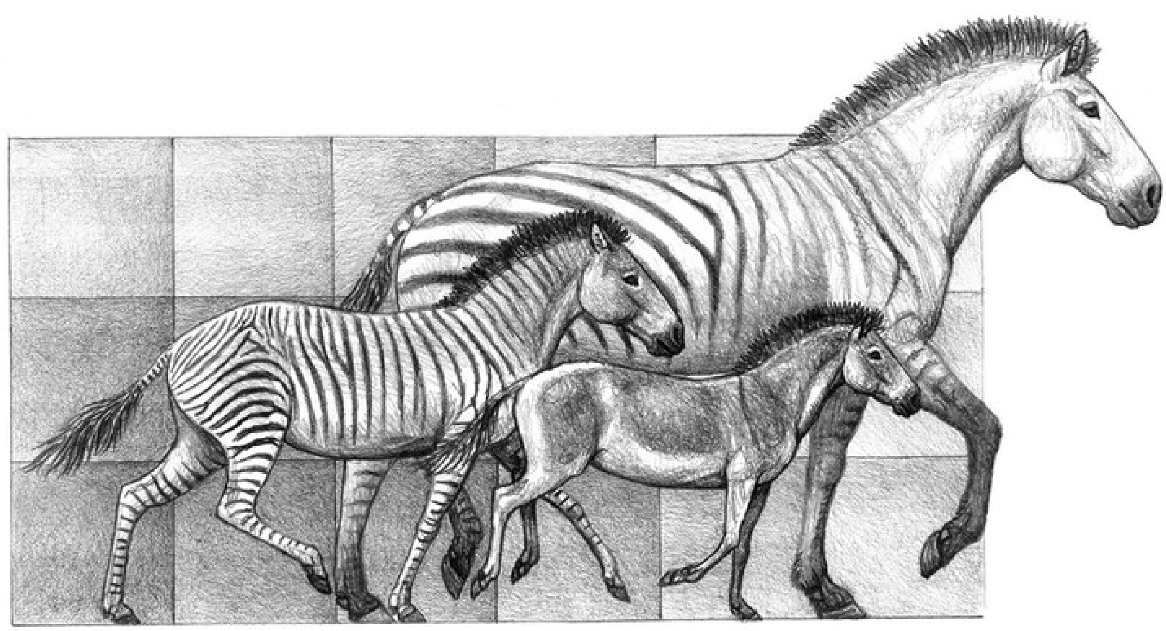
The chances of an organism's survival in a new habitat are governed by the area's biological and environmental conditions and whether these are compatible with the organism's basic requirements (its ecological niche). If they are compatible, the organism may be able to persist, adapt and thrive. The more specialised an organism's ecological niche, the harder it may be to move into a new environment.

For example, the caterpillars of the monarch butterfly feed almost exclusively on milkweed. It's hard to imagine the caterpillars successfully colonising a new habitat that doesn't have this vital food source. Another point to consider is that just because an organism can survive in a new environment doesn't necessarily mean it will be able to get there. For example, it would be practically impossible for polar bears to naturally spread from the North Pole to Antarctica.

Much of our understanding of how organisms evolve new traits to occupy new environments and ecological niches comes from the study of adaptive radiations. An adaptive radiation is the evolutionary process by which organisms rapidly diverge from a common ancestor into multiple different forms. There are numerous charismatic examples documented, including: Darwin's finches on the Galapagos Islands, cichlid fish in the lakes of East Africa, and Anolis lizards on the Caribbean islands.

From this kind of research it has been shown that adaptive radiations are primarily driven by ecological opportunity, the chance for a species to thrive when its environmental circumstances change. Examples of these opportunities include filling a vacant niche after a mass extinction event when it has fewer competitors or predators, or taking advantage of a newly available resource.

As animals and plants exploit these ecological opportunities, we would expect them to go through rapid physical changes as they adapt to their new environments. The pace of change would then slow over time as the opportunities run out. This prediction has formed the basis of much of evolutionary research, although studies are beginning to question the validity of our assumptions.



Just a little horse. Credit: Mauricio Antón

Horse history

The evolution of horses is remarkably well documented in the fossil record and is a textbook example of how evolutionary success is linked to trait evolution. Over the past 50m years, horses have evolved from dog-sized forest dwellers into the modern animals we know.

Along the way they have accumulated numerous environmental advantages, such as teeth adapted for grazing and modified hooves for speed. Although there are only seven species from this adaptive radiation alive today (the horse, donkey, plains zebra, mountain zebra, Grévy's zebra, kiang, and onager), fossils of hundreds of extinct species have been unearthed.

Now a new study published in Science has looked at the last 18m years of horse evolution to ask whether the origin of new horse species was linked with rapid physical changes. As you would expect, horse evolution has seen bursts of diversification when there have been new ecological opportunities. These opportunities included increased food availability, which meant larger and more varied populations of horses could be sustained.

Another ecological opportunity horses exploited was being able to migrate from America to Siberia across the Bering land bridge. From there they were able to colonise Europe, Asia, North Africa and the Middle East.

But the fossil record shows these bursts of horse diversification didn't follow the rapid evolution of new physical traits such as body size and teeth shape. Horses didn't need to change to be able to colonise the Old World, presumably because they were already adapted to similar grassland habitats in America.

The physical features that distinguish modern horse species in different locations evolved later. They are likely to be a result of short-term responses to extreme environmental conditions and shifts in resource availability.

The results of this latest study not only increase our understanding of the evolutionary history of one of the most successful lineages of mammals on earth, but also adds to our broader knowledge of when and why organisms adapt to their environment. When it comes to evolution's "which comes first?" question, the answer is probably both.

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