

Evolution & Behaviour

Howler monkeys: living a life in colour helps finding better food

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In terms of their ability to see colours, primates are unique compared to other mammals. Many primates have trichromatic colour vision and can see differences among red, orange, yellow, and green hues. What is particularly fascinating, however, is how much variation there is *among* primates in their ability to see colour. Take humans, for example. Compared to our closest relatives - African and Asian apes and monkeys - a sizeable number of humans are red-green "colour-blind". This trait is far more common among men, because the gene linked to perception of reddish hues is located on the X-chromosome (one of the so-called sex-chromosomes: men possess only one of them, whereas women have two - in the latter case a second spare gene is always available in case one it doesn't function properly).

Interestingly, variation among individuals is even greater among monkeys living in Mexico, Central and South America (Neotropics). Here, almost all of the day-active species possess many (4 - 8 or more) different types of colour vision in a single group of monkeys. All males and some females have a form of red-green colourblindness, while some females can tell apart reds from greens the way most humans can; this is true of all day-active species except for [howler monkeys](#). Due to a unique evolutionary event, all howler monkeys, male and female, possess a similar type of trichromatic vision and can tell apart a red fruit from a green leaf.

Perhaps not surprisingly, fruit eating has been suggested as a principle driver of the evolution of colour vision in primates. Almost all primates eat fruit, and many ripe fruits eaten by primates are yellow, orange or red: hues that

only a trichromat could see against green leaves. Yet, while howler monkeys do eat fruits when they are available, they are famous for eating huge amounts of leaves. The goal of our research was to test an idea proposed several years ago based on the study of African primates - that colour vision could also be good for finding new, immature leaves that are the most nutritious and easy to digest.

We studied which trees howler monkeys ate from in Sector Santa Rosa, in northwestern Costa Rica. The primates at this field site have been studied for years, and the forest is fascinating because of how seasonal the rainfall, fruit production and patterns of leafing are. Using a field-portable equipment, we collected and measured the colour of leaves from the trees howler monkeys ate from. We also analyzed DNA from howler feces to examine the genes linked to colour vision at this site. As expected, we found that all the howler monkeys had trichromatic colour vision, although a few had slight variations from the others. We also found that for about half of the plant species we looked at, the young leaves were indeed reddish in colour. This included several plant species (for example, fig trees) that were seasonally very important in their diet when overall food availability was low. We then predicted how the leaves of different trees would look to the howler monkeys using models of their colour vision. We found that the reddish-coloured young leaves would be far more visible against mature green leaves to howler monkeys with trichromatic colour vision, than they would be to other colourblind monkeys that share the forests with them.

Previous studies have found that trichromatic colour vision is useful to primates

for finding and selecting fruit. We show that additionally it is useful to howler monkeys for finding young leaves. When there is little else to eat, howler monkeys can eat mature leaves; however, they prefer to eat fruits and young leaves when they are available. Therefore, their unique colour vision helps them with two important foraging tasks, which may both contribute to the evolution of their unique form of trichromacy. We also suggest that colourblind howler monkeys may have been weeded out by natural selection. Interestingly, colourblind people and smaller neotropical monkeys are better at breaking camouflage, which seems to help monkey hunt insects; red-green colourblindness may persist in these populations due to some foraging advantages. Unlike their neighboring monkeys, however, howlers do not hunt camouflaged prey to a large extent, so colourblind howlers may be at a strong disadvantage.

In summary, we show that red-green colour vision is found in all howler monkeys, and it likely helps howlers to find preferred young, reddish leaves, which are an important part of their diet. Natural selection for trichromatic colour vision may be stronger for howler monkeys than it is for other primate species living in the same areas.