EVOLUTION OF COLOURATION

Fearsome white owls

Analysis of barn owl and prey behaviours reveals the importance of moonlight for the evolution of white plumage.

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An old legend says that thousands of years ago the Moon came down to Earth and became entangled among the branches of a tree. A wolf began to caress the Moon with his nose and, after freeing it from the tree, played with it all night. At dawn the wolf returned to the forest and the Moon returned to heaven after stealing the wolf's shadow to remember him forever. Ever since, the wolf howls at the full Moon to ask him to return it.

Light changes during the lunar cycle, rather than the theft of its shadow, explain the legendary lupine tendency to howl at the full Moon[1], as well as many rhythms, temporal patterns and behaviours of animals[2]. Moonlight alters animal capacities to use visual cues for communication[3], for finding food[4] or avoiding predators[5], and its variability is behind the evolution of many visual displays of nocturnal animals[6]. But so far, these studies have given only a partial view of how moonlight may have shaped the colouring of nocturnal animals as they did not analyse how moonlight variability could influence the fitness of individuals that differ in their colouration. Writing in *Nature Ecology & Evolution*, Roulin and co-workers[7] provide an exciting example of how moonlight variation may affect the adaptive significance of colouration in barn owls (*Tyto alba*), nocturnal hunters whose plumage colour ranges from white to dark red (Fig. 1)[8], and who mostly prey on common voles (*Microtus arvalis*). The authors combine long-term detailed reports of behaviour and performance of owls with control experiments using taxidermized owls and live voles in the lab to analyse prey behaviours. They reveal that light changes during the lunar cycle have differential behavioural effects on plumage colour morphs and ultimately affect fitness. They also provide evidence for a novel mechanism based on rodent aversion towards bright lights that may increase hunting efficiency, explaining the paradox of why some barn owls have bright white plumage. These findings have broad implications for our understanding of how moonlight has shaped animal phenotypes and open up new avenues to discover the function and evolution of plumage colour in birds.

Fig. 1 | Red and white barn owl morphs. Reproduced from ref. [7], Springer Nature Ltd. Credit: Isabelle Henry

Roulin and colleagues made these discoveries by combining the use of infrared cameras in the nests of an owl breeding population over five years with high-resolution GPS tracking of males to quantify owl parental behaviours. They found that owls with the reddest plumage were less successful hunters and provided fewer prey to their offspring on full-Moon nights, when, they argued, well-lit conditions would favour vole detection of brown owls. As expected, analyses of nest records collected over 20 years revealed reduced weight and survival for owlets of the reddest owls on moonlit nights.

Unexpectedly, Roulin and colleagues found that hunting success and fitness of the whitest owls was unaffected by moonlight levels. The reason, they argue, might be that white plumage triggers longer 'freeze' times in their prey, facilitating hunting and outweighing the cost of their conspicuous plumage being detected by prey. To test this novel idea, they assessed how common voles detect and react to red and white owl taxidermy mounts under full and new moonlight conditions in a lab experiment. As hypothesized, they found that voles freeze for longer when confronted with a white mount under full-Moon light conditions and suggest that inducing longer freezing might be adaptive for barn owls in terms of prey capture. The adaptive significance of a prolonged freezing time for the prey remains elusive, however, and should ideally be assessed in natural settings.

Variation in environmental luminosity is a well-known driver of phenotypic colour diversity in birds[9–11], and an aspect that has mostly been addressed by comparative methods. Here Roulin and colleagues show that progress can be

made using long-term, individual-based approaches which allow fitness calculations, generating novel insights into the adaptive value of alternative colour design in nocturnal environments. Their results point to an important role for moonlight variation and pre-existing sensorial bias towards bright lights in the evolution of barn owl plumage. Moonlight variation, however, is likely to influence the behavioural patterns of prey as well, raising the possibility that prey may adapt to moonlight. This means that results on food provisioning and hunting success could have been affected by prey behavioural adaptations. Future research that simultaneously tracks changes in predator and prey behaviours in response to moonlight changes will be necessary to fully understand the adaptive value of owl plumage designs in terms of prey detection in nocturnal scenes. ❐

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