# COMMUNICATING IN COLOUR

BY DEVI STUART-FOX

**Rather than merely blending into the background, dwarf chameleons change colour to stand out from the crowd and attract mates and intimidate their rivals.**

Chameleons are odd creatures. With independently moving, bulging eyes, fingers and toes fused into opposable pads, and lightning-fast suction cap- tipped tongues stretching more than the length of their own bodies, they seem like the stuff of science fiction.

But perhaps their most remarkable feature is their ability to change colour, an ability rivalled only by cuttlefish and octopi in the animal kingdom. By switching from bright, showy colours to the exact colour of a twig within seconds, chameleons are able to use colour for both communication and camouflage.

Chameleons show an extraordinary range of colours, from nearly black to bright blues, oranges, pinks and greens in a matter of seconds, even showing different colours on the two sides of their bodies. This ability to change colour was first described in 350 BC by Aristotle, who thought that it only occurred when chameleons were inflated with air. We now know that he was wrong.

Colour change in chameleons occurs through the movement of pigments within specialised cells in the skin called chromatophores. There are several types of chromatophore that contain different types of pigment or light-reflecting crystalline structures. Some chromatophores have many arms, like a starfish, extending towards or away from the skin surface. Pigments can be moved into and out of these arms to conceal or reveal other chromatophores, resulting in colour change.

**Game on! Two male Jackson's chameleons put on their brightest fighting colours and lock horns.**

A popular misconception is that chameleons can match whatever background they are placed on, whether a chequered red and yellow shirt or a smartie box. But each species has a characteristic set of chromatophores distributed over their bodies in a specific pattern, which determines the range of colours and patterns they can show. To the great disappointment of many children, placing a chameleon on a smartie box generally results in a stressed, confused, dark grey or mottled chameleon.

Although we now understand the mechanism of colour change, in more than 2000 years since Aristotle's day we have learnt remarkably little about chameleons. When and why do they change colours? To what extent is this ability controlled by the brain and to what extent is it controlled by hormones? How and why did this ability evolve?

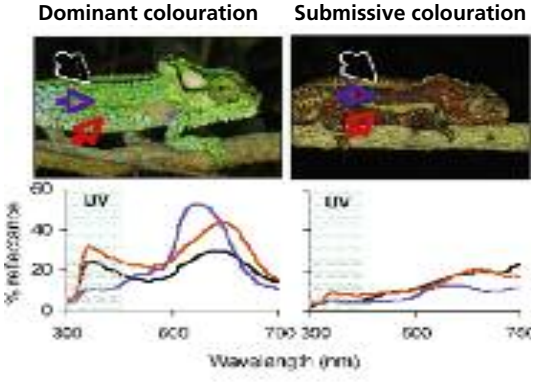
One reason we still know so little is that most are nearly impossible to find during the day, which is when they go about the important business of feeding,

**Game over! The male Knysna dwarf chameleon on the right concedes defeat by switching to submissive colouration.**

fighting, courting, mating and looking out for predators. Chameleons are known as masters of camouflage with good reason. Researchers must generally find chameleons at night when they are asleep and become very pale, standing out against the dark vegetation in torchlight. I spent 4 years in South Africa doing just this to discover why colour change evolved.

Chameleons are a diverse group of lizards, with more than 150 species in the family and new species being described every year. More than half of the recognised species are found in Africa with all of the rest but two found in Madagascar and nearby islands. Of the two remaining species, one occurs in the Mediterranean and the other in India.

They come in a wide array of shapes and sizes. Some are among the smallest vertebrates known, sitting comfortably on the end of a matchstick, while others are longer than your forearm. They occur in almost every type of habitat from barren desert, grasslands and coastal heaths to dense rainforest. Some have up to four horns, some have giant casques that would put a cassowary to shame, and others have an array of knobs and flaps. But most importantly, chameleons vary in their ability to change colour: some have surprisingly limited capacity for colour change while others show a range of brilliant hues.




**Measurements of chameleon colours revealed that several species, like the Knysna dwarf chameleon picured here, use display colours with a UV component (peaks in the blue shaded region). Line colours correspond to the coloured arrows indicating the body regions measured.**

In South Africa, one group has diversified and dominates the chameleon fauna: the dwarf chameleons. There are currently 15 recognised species, with several other recently discovered genetically and morphologically distinct populations currently being described.

My research, done in collaboration with Adnan Moussalli from Museum Victoria, looked at colour change in 21 different populations of dwarf chameleon, which included all described species and six other distinctive lineages. When the chameleons' colour responses were measured in different situations – such as in the presence of other chameleons or model predators, the maximum range of colour change occurred during contests between males.

Chameleons are visual animals with excellent eyesight, and they communicate with colour. When two male dwarf chameleons encounter each other, each shows its brightest colours. They puff out their throats and present themselves side-on with their bodies flattened to appear as large as possible and to show off their colours. This enables them to assess each other from a distance.

If one is clearly superior, the other quickly changes to submissive colouration, which is usually a dull combination of greys or browns. If the opponents are closely matched and both maintain their bright colours, the contest can escalate to physical fighting and jaw-locking, each trying to push each other along the branch in a contest of strength. Eventually, the loser will signal his defeat with submissive colouration.

Females also have aggressive displays used to repel male attempts at courtship. When courting a female, males display the same bright colours that they use during contests. Most of the time, females are unreceptive and aggressively reject males by displaying a contrasting light and dark colour pattern, gaping and swaying rapidly from side to side. If the male is undeterred, females often chase and bite the males until they retreat. But the range of colour change during female displays, although impressive, is not as great as that shown by males.

Male display colour patterns are specific to each species. In some species, colours are limited to shades of light and dark greys and browns, whereas others show impressive blues, oranges, greens and even ultraviolet colours. By meas-

uring chameleon colouration with a spectroradiometer, which measures reflected wavelengths from the ultraviolet to infrared, my study revealed that many chameleons use UV display colours that are invisible to the human eye.

Unlike humans, both chameleons and their predators can see in the ultraviolet. To humans, green and UV-green look the same but to a chameleon they are two different colours, just like red and purple are to us. This is because humans have only three types of cone in their retina, whereas chameleons have four, one of which is ultraviolet-sensitive.

Why do some species have greater colour change abilities than others? Answering this question can give us clues about why colour change evolved. Many people assume that colour change evolved to enable chameleons to match a greater variety of backgrounds in their environment. If this was the case, then the ability of chameleons to change colour should be associated with the range of background colours in the chameleon's habitat. For example, forest habitats might have a greater range of brown and green background colours than grasslands, so forest-dwelling species might be expected to have greater powers of colour change. But there was no evidence for such a pattern.

Instead, males of species that showed the greatest colour change had display colours that were the most eye-catching. Their displays were composed of colours that contrasted highly with each other as well as with the background vegetation. This suggests that the species that evolved the most impressive capacities for colour change did so to enable them to intimidate rivals or attract mates rather than to facilitate camouflage.

How do we know that chameleon display colours are eye-catching to another chameleon – or, for that matter, to a predatory bird? Measuring the colour of the chameleons and their backgrounds is only the first step. Getting a view from the perspective of chameleons or their bird predators requires information on the chameleon's or bird's visual system and an understanding of how their brains might process visual information. This is because the perceived colour of an object depends as much on the brain's wiring as on the physical properties of the object itself. Luckily, recent scientific advances have made it possible to obtain such measurements in the field, and information on visual systems of a variety of animals is becoming increasingly available.

**Showing off to girls. A male Transvaal dwarf chameleon puffs out his throat and presents his best side to a female**

When the male display colours for the 21 populations were analysed through the eyes of chameleon and bird visual systems, dominant males were highly conspicuous – both to other chameleons and their predators. The most conspicuous species were also those with the greatest capacity to change colour.

This suggests that selection for conspicuous social signals led to the evolution of an increased capacity for colour change. In other words, chameleons evolved colour change to attract attention, quite the opposite of camouflage.

Because chameleons are slow-moving creatures that rely on camouflage to avoid being eaten by predators, they can't afford to attract too much attention. The ability to rapidly change colour allows them to perform the essential tasks of attracting a potential mate or intimidating a rival with bright colours while remaining camouflaged at other times. Although conspicuous colours might also attract the attention of a predator, the colours are displayed only briefly, thereby minimising the risk.

This strategy is similar to that of lizards with strikingly coloured throat fans that they can fold away, or birds with brilliant iridescent plumage patches revealed only during elaborate courtship displays. These animals hide their most conspicuous ornaments from predators, revealing them only when necessary.

The spectacular diversity of colours and ornaments in nature has inspired biologists for centuries. But if we want to understand the function and evolution of animal colour patterns, we need to know how those colours are perceived by the animals themselves – or their predators. After all, camouflage and conspicuousness are in the eye of the beholder.

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