**Quick guide**

**Colour polymorphism**

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**What is colour polymorphism?**

Colour polymorphism refers to the occurrence of multiple discrete colour phenotypes within populations that result directly from genetic variation. Direct genetic causality distinguishes colour polymorphism from polyphenism, whereby identical genotypes possess the ability to express varied phenotypes depending upon the environment. This definition also excludes ontogenetic and reversible colour change. Colour polymorphism may be limited to the presence of just two discrete morphs (dichromatism). Cases involving multiple morphs are not uncommon, however, and are particularly well documented for colour polymorphism. Dramatic examples include the exuberantly polymorphic happy-face spider (*Theridion grallator*) that exhibits 12 different morphs across four Hawaiian Islands, or poison strawberry frogs (*Oophaga pumilio*) with at least 20 true-breeding morphs across their Central American distribution (Figure 1).

**How does colour polymorphism develop?**

Colour in nature is almost exclusively due to pigments that absorb light or physical structures that reflect it. Both properties may be highly sensitive to genetic variation. In some cases, starkly divergent colour patterns may result from allelic variation in one or a few genes. Cichlid fish of the genus *Amphilophus*, for example, exhibit a dark-versus-gold polymorphism that is entirely due to alleles at a single pigment-controlling locus. Likewise, human eye colour is largely determined by the outcome of dominant and epistatic allelic interactions at two primary loci. In more complex cases, polymorphisms may result from variation across multiple genes that segregate together. This linkage across loci can enable discrete yet highly complex colour phenotypes while precluding less fit intermediates.

**Is colour polymorphism common?**

Colour polymorphism occurs across a breadth of taxa and ecological contexts. Cases are documented for most major metazoan animal groups (Figure 1), across gymnosperm and angiosperm plants, and for species residing in terrestrial and aquatic habitats. Among animals, the incidence of colour polymorphism appears over-represented (if not over-reported) in taxa such as birds, anurans and lepidopterans. Functionally, polymorphism has been documented for colour traits involved in sexual signalling, crypsis, thermoregulation, mutualism, aposematism and in various forms of deceptive signalling including Batesian and Müllerian mimicry.

**How is colour polymorphism maintained?**

Stable polymorphism is thought to require some form of balancing selection to maintain equivalent average fitness among colour morphs. One obvious candidate is negative frequency dependent selection, which arises when rarity confers a selective advantage. This is particular well established in the context of predation, as in the classic case of polymorphic grove snails (Figure 1C,D), and is referred to as ‘apostatic selection’. Visually guided predators, such as birds, often memorize and form ‘search images’ of locally abundant prey. Rare prey morphs therefore benefit from
exists, as in seasonality, phenotypic plasticity is readily favoured as an adaptive regulator of colour variation.

What are the consequences of colour polymorphism? With respect to evolution, one ultimate consequence is the potential for speciation. This could occur via several pathways. First, reproductive isolation in sympatry can arise when disruptive selection acts on a phenotypic trait that also mediates assortative mating. Colour polymorphisms offer excellent candidates for such so-called ‘magic traits’ because visual signaling often plays a key role in mate selection. Although considered rare in nature, putative magic traits have been identified in *Heliconius* butterflies and in fishes such as cichlids and sticklebacks. Second, any geographic basis to polymorphism raises potential to influence allo- and parapatric speciation. Clinal variation in morph frequency typifies many colour polymorphisms, and may result from geographic gradients of selection. Although countered by gene flow, such scenarios may promote reproductive isolation at a level ultimately necessary for speciation. Notably, some 20 % of polymorphic birds exhibit clinal morph variation, and colour polymorphism has been linked to accelerated rates of both phenotypic evolution and speciation in these systems.

Where can I find out more?

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