# It's in the genes...

We are frequently told that inbreeding is bad - full stop. But is this necessarily the case? What are the real implications behind pairings of this type, and are there possible advantages to inbreeding? Andy Tedder investigates.

**The first thing to do is to define what we actually mean by the term 'inbreeding'. It is mating between close relatives, such as littermates. So what is potentially wrong with this? Well, statistically speaking, these 'full siblings' will share 50 per cent of their genes (or more accurately, the alleles which are present at each loci on their chromosomes).**

This can potentially have both positive and negative effects, particularly if the same allele is present at the same position on both chromosomes, creating what is known as a homozygous individual. Inbreeding is particularly significant as far as colour variants are concerned, because many such colour changes are the result of recessive mutations that can only be expressed in a visual sense in the homozygous state.

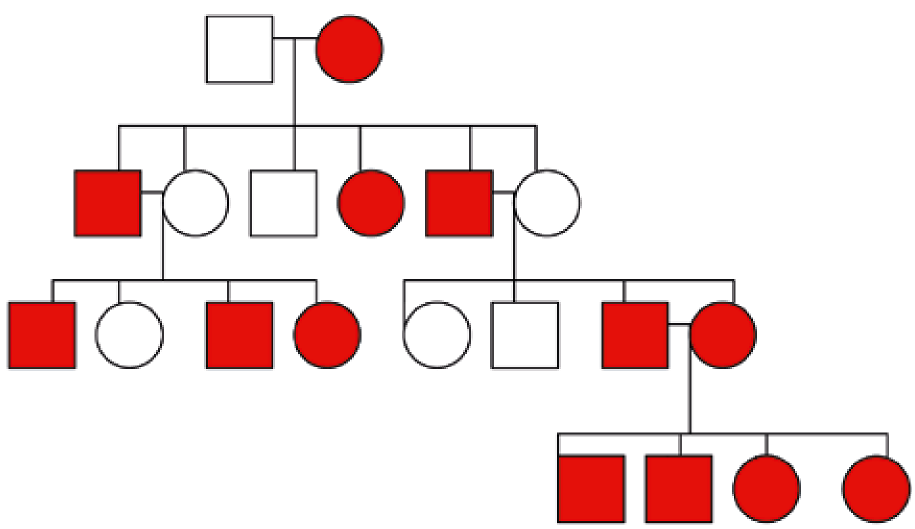
If all of the individuals in a population (or captive group) share the same alleles for a particular gene, then this gene can be said to be fixed. This means that if this allele corresponds to a negative (or positive) mutation, all offspring from the group will carry it.

Genetic fixation, which reflects how genes spread in a population, hinges on the following assumptions:

1. Population size – generally speaking, this must be small, or inbreeding will not be prevalent because of the wide choice of mates, based on the law of averages.
2. Selection – forces of nature mean that in general, positive traits will overcome negative ones. In instances where a mutation is harmful, it will tend to disappear from the population.

If you can't select for a negative trait, then how does it arise? Well, a trait such as colouration that is not under selection in a specific niche (habitat) can show negative characteristics in a different environment. Imagine introducing a black lizard into a bare chalk landscape. It then stands out and will be more vulnerable to predators. The effects of the negative trait may also not emerge until after breeding has taken place. As an example, it might change colour late in life.

Genetic fixation



## Pairings

With the aid of the simplified tree left, I will attempt to explain how an inbred homozygous trait can become fixed in the population. First off, the squares represent the males, and the circles are females. Red is the negative trait. In small populations, as reflected here by just a single pair, a number of offspring are produced, each with a 50 per cent chance of receiving the negative red trait.

When these offspring breed together, they are likely to mate randomly, providing the negative trait has not prevented them from doing so. As you can see here, random male – female pairings will rapidly lead to all red (negative trait) pairings within just three generations, resulting in all the offspring carrying this trait. Through genetic ▶

drift, this allele can reach 100 per cent in the population and become fixed. This then means that each subsequent generation will be afflicted by this allele, as by that stage, it is the only one possible at that loci on the chromosome.

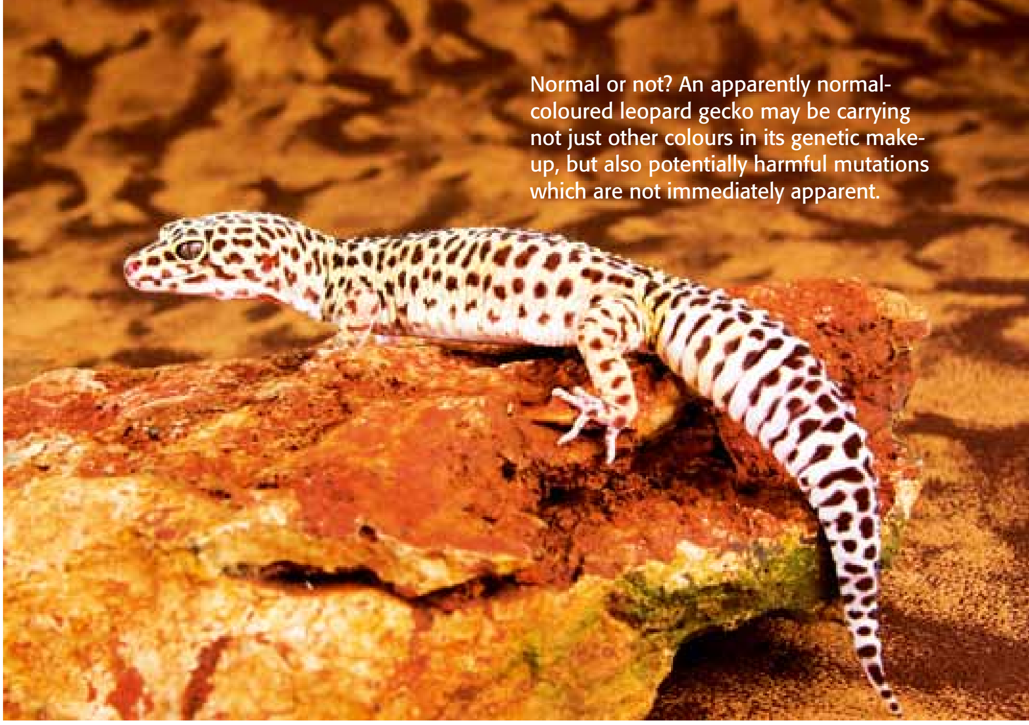
So when does this become a problem? Well, in truth, it never has to be a bad thing, in the given niche in which it arose. A problem can occur when the species (or individual) changes its environment though, as mentioned previously, and the gene is then under selection pressure.

From this, it becomes clear that inbreeding does not have to be harmful. If the homozygous gene confers a positive benefit, then it will be selected for and the speed of its spread and establishment in the population will increase accordingly. Simple examples of this would be characteristics like camouflage or perhaps limb length.

## Inbreeding in the wild

So, how frequently does inbreeding occur in wild populations, and how important is it? The answer, which is perhaps surprising, is that it takes place very frequently, and actually has a huge evolutionary impact. Development of new species – a process known as 'speciation' – relies heavily on breeding between individuals with a new mutation that confers a positive advantage. Without this, the trait would not be seen in subsequent generations, and species itself would not evolve further.

Traits that have a negative impact, however, will not be selected, as they will affect the population's overall fitness. These can take many forms, with some simple examples being a reduction in fertility, or colouration. Although albinos crop up not infrequently in wild populations of reptiles, they rarely survive through to maturity, largely because they are more conspicuous to predators, and also may have more difficulty catching prey themselves.



Normal or not? An apparently normal-coloured leopard gecko may be carrying not just other colours in its genetic make-up, but also potentially harmful mutations which are not immediately apparent.

Genes combine randomly as a result of mating, but mutations more likely to become evident when the breeding animals are closely-related.

This process of elimination, relating to those mutations which are less likely to survive and reproduce, is described as 'purging'. The unsuitable characteristic (phenotype) and its underlying cause, expressed in the genotype, is removed from the gene pool before the individuals attain sexual maturity. In this example, they fall victim to predators, but it could be they are more susceptible to disease. This is important, as breeding of these individuals would otherwise reduce the overall fitness of the population.

## Consequences for captive-breeding

So how does this apply to captive breeding, and what positives and negatives can it produce? Well, the main concern here is that fitness no longer under selection, or not as we have come to recognise it from "wild" situations. Selection itself is now based on human choice, rather than being moulded by the reptile's environment. As a result, negative traits can easily enter the animal's genetic blueprint or 'genome' without challenge, and unfortunately some, such as poor fertility, may not be immediately apparent.

The positive side is that specific characteristics or 'traits', notably colouration, which is entirely a matter of personal preference in vivarium stock, can be selected and intensified. This has allowed a host of colour mutations to become established. "We don't want weak bloodlines" is a popular argument against inbreeding, but is it that simple? It depends on what is defined as a negative characteristic, and also, how this links to the gene that the breeding programme is aiming to develop.

The fact is that we simply cannot predict which genes are linked, especially if in the heterozygous state, the deleterious effect of the pairing may not be apparent, and that is the problem. Breeding two heterozygote carriers together which do not show symptoms can, however, produce homozygotes that do.

Does this then mean that there must be 'outbreeding' to unrelated stock? Again, the answer is less definitive than you might expect. If the gene that confers the problem is not linked to the gene that is responsible for the desired trait, then unfortunately, outbreeding will be of no use whatsoever under these circumstances. We still know too little about dominance relationships of specific gene families, and how inheritance of characteristics is affected by these groupings, to reach a comprehensive answer. Furthermore, some traits are polygenic, being affected by more than one gene and so do not function with the same simple genetic rules that most hobbyist breeders currently recognise. This added layer of complexity makes breeding outcomes and tracing reduced fitness back through generations very difficult.

## Conclusions

So what is the ultimate answer? Indeed, is there one? Short of genetic testing, what can we do to prevent the spread of potentially harmful alleles? Is outbreeding the answer, or is purging the only suitable strategy? Arguments can be made for both, but in my opinion, purging is the best way to avoid reduced fitness or 'inbreeding depression' arising from negative traits associated with a specific genotype. However, I am certainly not advocating that affected animals should be euthanised, but only they should not be used in a breeding programme. Ultimately, by purging the captive population artificially in this way, this will ensure that the incidence of the harmful trait will be reduced, to the stage that ultimately, it will disappear from the gene pool. ■

**Andy Tedder is an enthusiastic breeder of geckos, and has a particular interest in genetics. You can find his web site at www.glasgowgecko.co.uk*