The Leopard Gecko Debate

the need for sustainable breeding practices

In last month's issue, John Courteney-Smith highlighted problems facing breeders of leopard geckos ('Back to basics with leopard geckos – the move to create new natural strains'). Here geneticist Dr. Andy Tedder argues that it is very important to make the correct choices for sustainable breeding programmes, and these must be based on sound scientific guidelines, with the aid of actual data.


Back to basics with
leopard geckos
The move to create
new natural strains
Most neutral observers would concede that strains of leopard geckos today are not as vigorous as used to be the case, before the creation of colour morphs started to predominate. John Courteney-Smith recently made an unexpected discovery though, which could be the way forward.

Fitness, inbreeding depression, and the current state of the captive 'gene pool'

John's article discussed the perceived weaknesses in leopard geckos, particularly relating to their adult size, their hatching size, their disease susceptibility and average lifespan. These are genuinely measures that can be used to assess the 'fitness' of an individual (to varying degrees), but it is very important that we have data in place so it is possible to determine what constitutes average 'fitness', before we can define what constitutes reduced 'fitness'.

Without this data, we can simply compare individuals, but make no judgement on which is more or less 'fit' - after all, larger does not always mean better. John made specific reference to the size upon hatching of F1 (first) generation individuals – those which have been bred from wild stock. He stated that "…weight and size-wise, these normal leopard geckos are at the same stage when they hatch as a captive morph which is four weeks old". While I will freely admit that natural genetic variation, selection, and environmental provisioning can cause this trait to be highly variable, I would suggest that this statement is a little misleading.

Group	Year	Hatching weight (mean)	Range	Number of animals	Source
F1 individuals	1993	3.5 g	2.9 - 4.8 g	24	UK 'hobbyist' breeder
Captive bred	2008	3.6 g	2.7 - 5.3 g	118	Mean of seven UK 'hobbyist' breeders
	2009	3.6 g	2.9 - 5.1 g	73	
	2010	3.8 g	2.7 - 5.1 g	85	

Table 1 – Comparison of weight on hatching in leopard geckos *(Eublepharis macularius)*. 'Captive bred' individuals in this comparison represent individuals whose lineage is from captive lines for at least three preceding generations.

As you can see from Table 1, there is no apparent difference in the mean weight of individuals at hatching between groups or between years. Some variation is clearly seen within the range of both groups, and this likely reflects differences in the adult females. It is worth pointing out, of course, that sample size is much lower for the F1 group, and increasing it could impact on the mean (which is the average figure), but this difference is unlikely to be statistically significant.

Differences in growth rate, which is another common measure of 'fitness' and a trait linked with natural survival, may perhaps go some way to explaining the differences that John has reported between captive animals and their F1 captive counterparts.

Table 2 shows the growth rate of the same individuals seen in Table 1 over a period of 3 months. During this time period, F1 individuals do not grow faster than their relatively more line-bred cousins; in fact the 'captive bred' stock (representing individuals from captive origins for at least three preceding generations) show a statistically significant increase in growth rate compared with the F1 individuals. Again, I will stress that this trait, while influenced by genetic characters, is also heavily influenced by environmental factors, and so may not be the most reliable estimate of 'fitness'.

Inbreeding depression (the negative effects of becoming homozygous – carrying corresponding genes - for deleterious recessive mutations) can and will affect the genetic and physical fitness of both individuals and the captive population, if correct breeding practices are not followed. The problem, of course, is identifying reduced fitness traits in the population, and as we can see from the data provided above, this may not be straightforward.

So, what, if anything, can we conclude about the current 'fitness' of the captive 'gene pool' of leopard geckos? The answer, unfortunately, is not very much. It is clear that there is evidence of inbreeding depression at the individual level (although this is anecdotal and not quantitative), and that this could be perpetuated if animals exhibiting reduced 'fitness' (relative to other individuals) are maintained as 'breeding stock'.

Group	Year	Growth rate (per day)	Standard deviation	Number of animals	Source
F1 individuals	1993	0.16g	±0.02 g	24	UK 'hobbyist' breeder
Captive bred	2008	0.25g	±0.04 g	118	Mean of seven UK 'hobbyist' breeders
	2009	0.21g	±0.02 g	73	
	2010	0.27g	±0.05 g	85	

Table 2 – Growth rate (grams per day) of juvenile leopard geckos over a 84 day period from hatching.

Standing out from the crowd can have negative consequences in the 'wild' but in captivity, pattern morphology carries no negative health risks.

However we have no baseline 'fitness' criteria, and no estimates of 'fitness' from 'wild' individuals. Therefore, to make sweeping statements (as tempting as it may be) about the total captive population is quite dangerous, especially for a species that is now so widely-kept and bred in many countries worldwide.

Selection, hybrid vigour, and sustainable population management

The suggestion advocating an influx of new genotypes (via importation of wild-caught animals) to increase genetic diversity is not a bad idea. In fact, on the surface, it appears to be a very good one. Hybrid vigour (meaning increased fitness in the resultant offspring as a result of increasing overall heterozygosity) resulting from breeding two independent lines, which in this case would be one captive and one wild, will increase 'fitness' in the first generation.

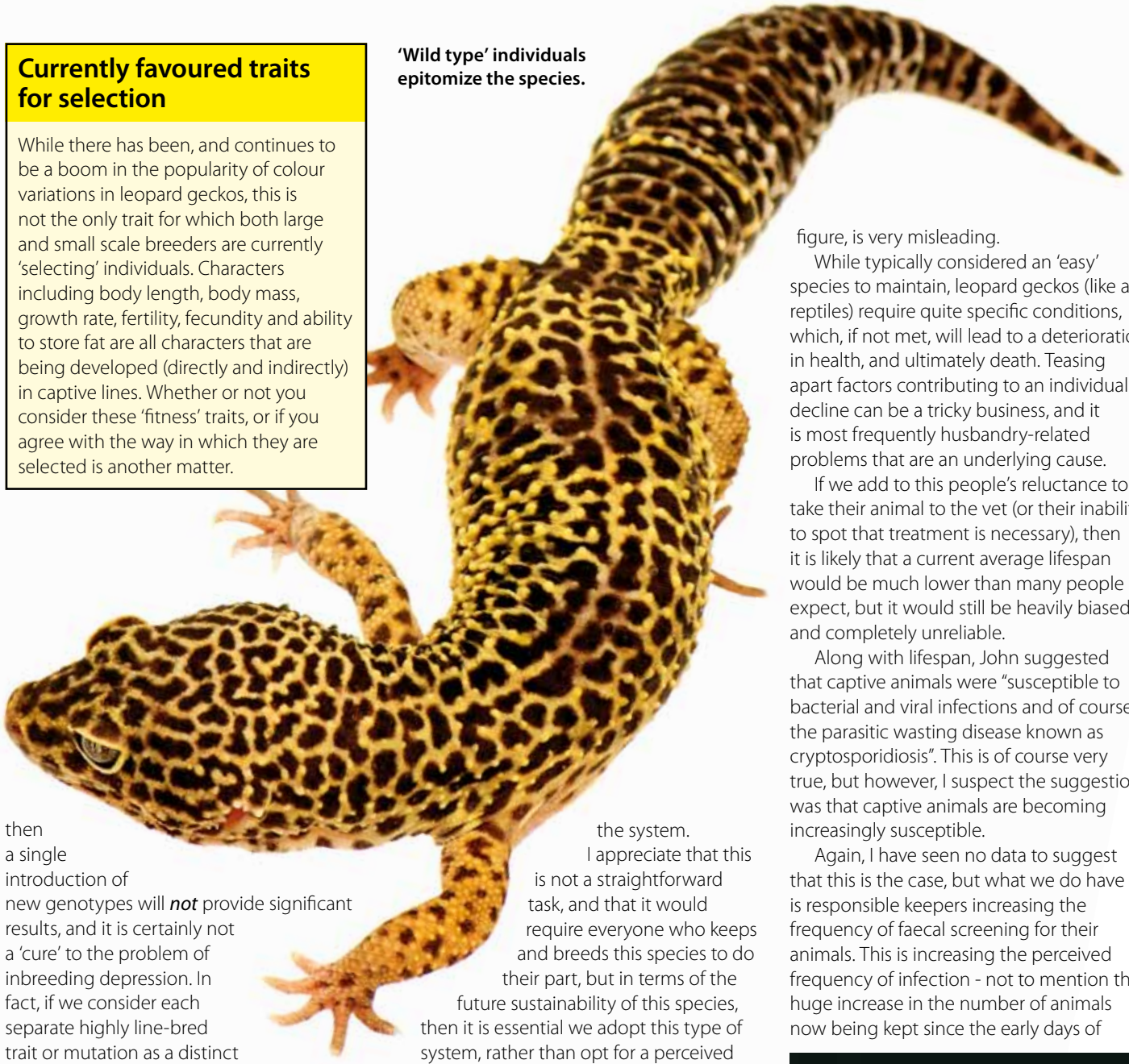
However, subsequent generations will then continue the steady decrease in 'fitness' associated with becoming more and more homozygous, due to breeding within one lineage. In reality it isn't really this simple, as the 'captive gene pool' is not one entity. It is, in fact, several smaller 'pools' that represent large scale breeders.

If long-term increased 'fitness' is the goal (and I suspect many readers will agree that this should be), ▶

It is important you keep accurate records so that changes in their health across the generations can be picked up easily.

Currently favoured traits for selection

While there has been, and continues to be a boom in the popularity of colour variations in leopard geckos, this is not the only trait for which both large and small scale breeders are currently 'selecting' individuals. Characters including body length, body mass, growth rate, fertility, fecundity and ability to store fat are all characters that are being developed (directly and indirectly) in captive lines. Whether or not you consider these 'fitness' traits, or if you agree with the way in which they are selected is another matter.



'Wild type' individuals epitomize the species.

then a single introduction of new genotypes will ***not*** provide significant results, and it is certainly not a 'cure' to the problem of inbreeding depression. In fact, if we consider each separate highly line-bred trait or mutation as a distinct lineage, which is a reasonable assumption in my view, then simply breeding between two distinct lineages will also produce hybrid vigour in the following generation.

So, if a single introduction (regardless of size) of new genotypes will not alter 'fitness' in the long-term (although it may have limited impact on 1-3 generations relative to current individuals, and depending on what characters are perceived as desirable), and continued large-scale imports are also not deemed desirable, then we need to consider more appropriate ways of maintaining a healthy captive population. And this requires us to fully delimit what constitutes 'fitness', and rigorously maintaining strict breeding practices.

The best method to overcome inbreeding depression in this situation is strong selection. If an individual exhibits reduced 'fitness' then it should be removed from breeding stock, thus effectively purging deleterious mutations. Maintaining a strict system like this will allow the 'fitness' of the captive population to be increased, by fixing neutral and positive genotypes in the system.

I appreciate that this is not a straightforward task, and that it would require everyone who keeps and breeds this species to do their part, but in terms of the future sustainability of this species, then it is essential we adopt this type of system, rather than opt for a perceived 'quick fix' which will only serve as creating a minor delay in a long-term trend of decreasing 'fitness'.

The effects of husbandry on perceived 'gene pool fitness'

Life expectancy (or average lifespan) is another character trait that is occasionally used as an estimator of individual 'fitness'. While John points out that the traditional estimate of lifespan in this species is reported as between 15-20 years, this is not an average, but represents a small sample of individuals from zoological records. It is thus an estimate of what is possible under certain conditions - the equivalent to suggesting that human life expectancy is 100 years, because people occasionally live to this age.

If an accurate 'average life expectancy' estimate existed (which it doesn't), then it would undoubtedly be lower than the figure of 15-20 years. The problem with estimating average lifespan is that there are many factors that influence longevity, not least husbandry. Thus to suggest that average lifespan is decreasing, based on this figure, is very misleading.

While typically considered an 'easy' species to maintain, leopard geckos (like all reptiles) require quite specific conditions, which, if not met, will lead to a deterioration in health, and ultimately death. Teasing apart factors contributing to an individual's decline can be a tricky business, and it is most frequently husbandry-related problems that are an underlying cause.

If we add to this people's reluctance to take their animal to the vet (or their inability to spot that treatment is necessary), then it is likely that a current average lifespan would be much lower than many people expect, but it would still be heavily biased and completely unreliable.

Along with lifespan, John suggested that captive animals were "susceptible to bacterial and viral infections and of course, the parasitic wasting disease known as cryptosporidiosis". This is of course very true, but however, I suspect the suggestion was that captive animals are becoming increasingly susceptible.

Again, I have seen no data to suggest that this is the case, but what we do have is responsible keepers increasing the frequency of faecal screening for their animals. This is increasing the perceived frequency of infection - not to mention the huge increase in the number of animals now being kept since the early days of

The physical health of leopard geckos needs monitoring.

importation.

It is important to realize that all animals are susceptible to parasites, and that certain tolerance levels can be developed through selection and to some extent, this is happening in captivity. But to suggest that wild-caught individuals (and subsequent generations bred therefrom) are less susceptible to infection represents a clear misunderstanding. They may be more tolerant of certain parasites, but will certainly be less tolerant to others. Introducing new geckos into captivity also runs the risk of introducing new parasites to which captive animals have no tolerance.

It is the development of colour morphs that has done much to popularise the keeping of leopard geckos.

Behavioural traits, and supplementation regimes

Along with physical traits being altered in captivity, it has been suggested that some behavioural traits are also being affected. John describes a shift from a natural crepuscular (dusk and dawn) orientation to a less defined period of activity. The reason that this is occurring is not related to inbreeding however, but is the result of the relaxation of selection pressure in captivity. This reflects reduced predation plus an abundance of resources, such as readily available food. In truth, this trait is very plastic, and also occurs in long-term captive individuals.

Other behavioural traits, which are linked to morphology, present more of a challenge. For example, John mentions albinism, and the reduced tolerance (which shows a large degree of variation) to UVB and other spectrums of light. While I agree that UVB is essential to all reptiles for adequate calcium metabolism, having morphological constraints like this does not represent reduced 'fitness' in captivity, as it may in the 'wild'.

The reason for this is that keepers are responsible for selection pressure, and so this character becomes neutral (i.e. not negative) if husbandry practices are altered to accommodate it. Increasing the amount of shelter, or modifying the supplementation regime accordingly, are perfectly suitable alternatives in this case.

It is of course important to point out that none of the mutations responsible for variation in morphology in this species are man-made. They are all present in the 'natural' population, and are only brought together due to a reduction in the selection pressure seen in the 'wild'.

It seems like a very poor idea to suggest that all individuals in captivity can be deemed less 'fit' for an environment they do not live in, when compared to the animals that do. We should not judge our captive animals by inappropriate standards. They will never need to survive in the 'wild', and so suggesting they are incapable of doing so (however true this may be) is debatable.

In conclusion

I fully understand the point which John was seeking to make, and it is clear that others share his opinion. However, we must realise that generalisations without data are frequently detrimental to our understanding of current husbandry issues, and without a rigorous and complete method of defining 'fitness' in this species, there is no sensible way to progress.

I suspect no one will deny that there is evidence of inbreeding depression in captive lines of this species, but a 'quick fix' method (as was suggested) is not sustainable, and will not resolve the problem. We as keepers need to be more clear on how to judge individual 'fitness', what characters to base this judgement on, and require clear guidelines as to what constitutes 'acceptable' 'fitness'. With this information, we can design sustainable breeding programmes, which utilise strict selection and do not require large scale, unnecessary collection of wild individuals. ■