

## Tracing the origins of coat patterns: Charles Darwin, genetics, and the Bengal cat

by Chris Kaelin, Ph.D.

Last October, I escaped reality for a weeklong hiatus to the Galapagos Islands. It was a dream vacation for a nature-loving geneticist. My wife and I traversed expansive lava fields under the equatorial sun, watched long-lived

giant tortoises hike their ancient trails to sparse freshwater ponds, and snorkeled in the undisturbed bay where Charles Darwin first anchored as a young naturalist aboard the S.S. Beagle. I was there on my honeymoon, so there was also time to relax along the beach and return to a book I started early in graduate school – Darwin's *On the Origin of Species*.

I was familiar with the premise, of course; variation among individuals provides the opportunity for natural selection and ultimately speciation. However, I was surprised that Darwin's thesis relied heavily on

examples from domestic species. There is scarce mention of the Galapagos, but plenty about pigeons. Darwin happened to be an avid pigeon fancier. He and his fellow fanciers in 19<sup>th</sup> century London

seized upon small differences in size, shape, color, and behavior to generate varieties of pigeons that were strikingly different from each other. This was

*Chris Kaelin is a scientist at Stanford University conducting a study to identify Asian leopard cat genes that influence coat patterns in Bengals. With the help of Bengal aficionados Anthony Hutcherson and Karen Sausman, he is recruiting feline volunteers willing to contribute a picture and a DNA sample.*

*Contact information is provided at the end of the article. This article compliments a previous one written by Anthony Hutcherson, published in the last edition of the Bengal Bulletin.*

not maintaining a standard; this was selective breeding to create new forms!

There on the Galapagos beach, Darwin and his fancy pigeons gave me a fresh perspective for the passionate goals of Bengal breeders. Like pigeon fanciers of Darwin's era (and today), the Bengal

community is breeding towards unreached goals. It is equal parts art, science, and feline affection, but with a unique twist. Instead of waiting for small trait variations to occur in breeding stocks, Bengal breeders have introduced an entire genome of diversity by breeding the domestic cat with

the Asian leopard cat (ALC), to incorporate appealing wildcat traits into a domestic cat breed.

Such interspecies animal hybrids are uncommon because strong reproductive barriers exist to prevent it from happening. Offspring of individuals from different species are almost always infertile. However, if hybridization barriers can be overcome, the reward is a fresh canvas for mixing and matching genetic components from each species to create distinctive new varieties. A surprising testament to the genetic diversity of Bengals is the recent

development of new cat breeds with striking resemblances to unrelated wildcat species, like the Serengeti (serval) and the Toyger (tiger).

Perhaps now is a good time to mention why, a little less than a year ago, I became fascinated with

Bengals. I had cultivated a scientific interest in the mechanisms for that generate exquisite coat



**Darwin's pigeons** - the rock pigeon (right) has been transformed by selective breeding into different varieties, including a Nuremberg Lark (left). Photographs by Changhua Coast Conservation Action and Jim Gifford, respectively.



**Bengal pattern genetics** - the study aims to identify the gene(s) responsible for pattern differences by comparing Bengal cats with different coat patterns, such as the predominantly spotted (left) and rosetted (right) cats above.

patterns. That interest led me directly to wildcats. The 37 living wildcat species, closely related yet distinctively patterned, are supreme examples of this coat pattern diversity.

Around the same time, a consortium of dedicated scientists had recently developed tools for applying sophisticated genetic approaches in domestic cats. The effort included sequencing and assembling the cat genome and led to the identification of genes responsible for several characteristic traits and genetic diseases. The same approaches are not yet possible in other cat species, but conveniently in the case of Bengals, interesting wildcat traits have been introduced into the domestic cat.

My favorite among these traits are rosettes, characteristic modifications of tabby spotting in which the darker outline of the spot is broken and the center replaced with a lighter color. Rosetted patterns are not found in any other domestic cat breeds, which is a good indication that they are inherited from the ALC.

A strategy to identify the gene(s) responsible for rosetted patterning in Bengals relies on the differences between ALCs and domestic cats. From an evolutionary perspective, domestic cats are as related to ALCs as humans are to chimpanzees! More than six million years have passed since their ancestors took separate paths on the tree of life, long enough for distinctive genetic changes to occur but not so long as to prevent hybridization. ALCs and domestic cats share a common set of genes, but due

to the accumulated genetic changes they work differently in some cases.

A stud book tradition (SBT) Bengal is a domestic cat with a relatively small ALC genetic contribution, ranging from about 2000 to 5000 genes. If you could color code cat chromosomes, with blue domestic cat segments and red ALC segments, then SBT Bengal chromosomes would look like long blue threads interrupted by small red patches, each patch harboring a number of ALC genes.

Of course, chromosomes are not color-coded, and there is no way to visually distinguish segments inherited from different species. In fact, 99% of the basic elements of DNA will be identical between the domestic cat and the ALC, but the 1% that differs is quite useful to a geneticist. Those distinctive genetic changes serve as unique signposts of a species. In Bengals, they offer a way to determine the ancestral origin of different chromosome regions, a molecular 'color-coding' system, if you will.

This type of ancestry information is quite handy for locating the genes responsible for ALC-derived traits like rosettes. Every rosetted cat inherits the 'rosette gene' from the ALC, whereas spotted cats will inherit the complimentary gene from the domestic cat. Determining the ancestry of different genome regions in Bengals with spots and rosettes will help pinpoint the 'rosette gene' location in one of those regions we've painted red for ALC ancestry.

Once the 'rosette gene' is identified, the fun starts. We can begin to ask all sorts of interesting

questions. What does the gene do? How does it interact with the other soon-to-be discovered Tabby patterning genes? What genetic alterations are responsible for different varieties of rosette patterns in ALCs and Bengal cats? And, is the same gene responsible for the rosette patterns in other wildcat species, like jaguars, leopards, and margays?

Of course, the project is not possible without the enthusiastic participation of Bengal owners and it is therefore reasonable to ask how the study will benefit the Bengal community, a breeding program, or a pet. There is a near-sighted and far-sighted answer to this question. In the next few months, genome-wide ancestry information for participating cats will be collected and communicated back to owners in a meaningful way. The information will provide specific insight about the genetic makeup of each Bengal cat, and could help guide breeding strategies to manage the inheritance of ALC genes in future pedigree generations. In the long term, the study aims to provide a better understanding of coat patterning genetics in Bengals. All findings and genetic information about individual Bengal participants will be made available to owners and published in a scientific journal.

We are currently recruiting Bengal volunteers with spots, rosettes, and marble patterns. If you would like to participate, please contact either Anthony Hutcherson ([jungletraxcats@aol.com](mailto:jungletraxcats@aol.com)) or Chris Kaelin ([kaelin@stanford.edu](mailto:kaelin@stanford.edu)) for more details.



**Wild cat patterns** - The Jaguar (left) and the Margay (right) are wild cats with characteristic rosetted patterns. Photographs by Hafiz Issadeen and Tom Jeanne, respectively.