DNA and the Ivory Trade: How Genetics can help Conserve Elephants

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At the recent CITES convention in Lausanne, member countries resolved to list African elephants as endangered and to outlaw commerce in elephant products, in particular ivory. However, provision was made for the resumption of an ivory trade in the future, but only by countries which could demonstrate healthy and well-protected elephant populations. Indeed, several countries with surplus elephants have already declared their intention to continue trading independently of the CITES agreement. The point is that some ivory trading will persist, and so will the problem of limiting the trade **to** legally exploited populations. If the trade is not to threaten the survival of African elephants, as it has in the past, effective methods of regulation are essential and a prerequisite for efficient control is the ability to discriminate between tusks from legally and illegally exploited populations.

Two scientific techniques have been proposed to reveal the true geographic origin of ivory regardless of what is stated on the trade permit. The first, based on region-specific variation in microchemical composition of tusks looks promising but expensive.[1] The main objective of the pilot study reported here was to test the feasibility of the second method. This would use genetic markers obtained from DNA attached to tusks to identify the parent population. The first tasks were to test whether DNA can be obtained from elephant tusks and whether genetic distinctions exist between elephant populations in different regions. Both these objectives were achieved.

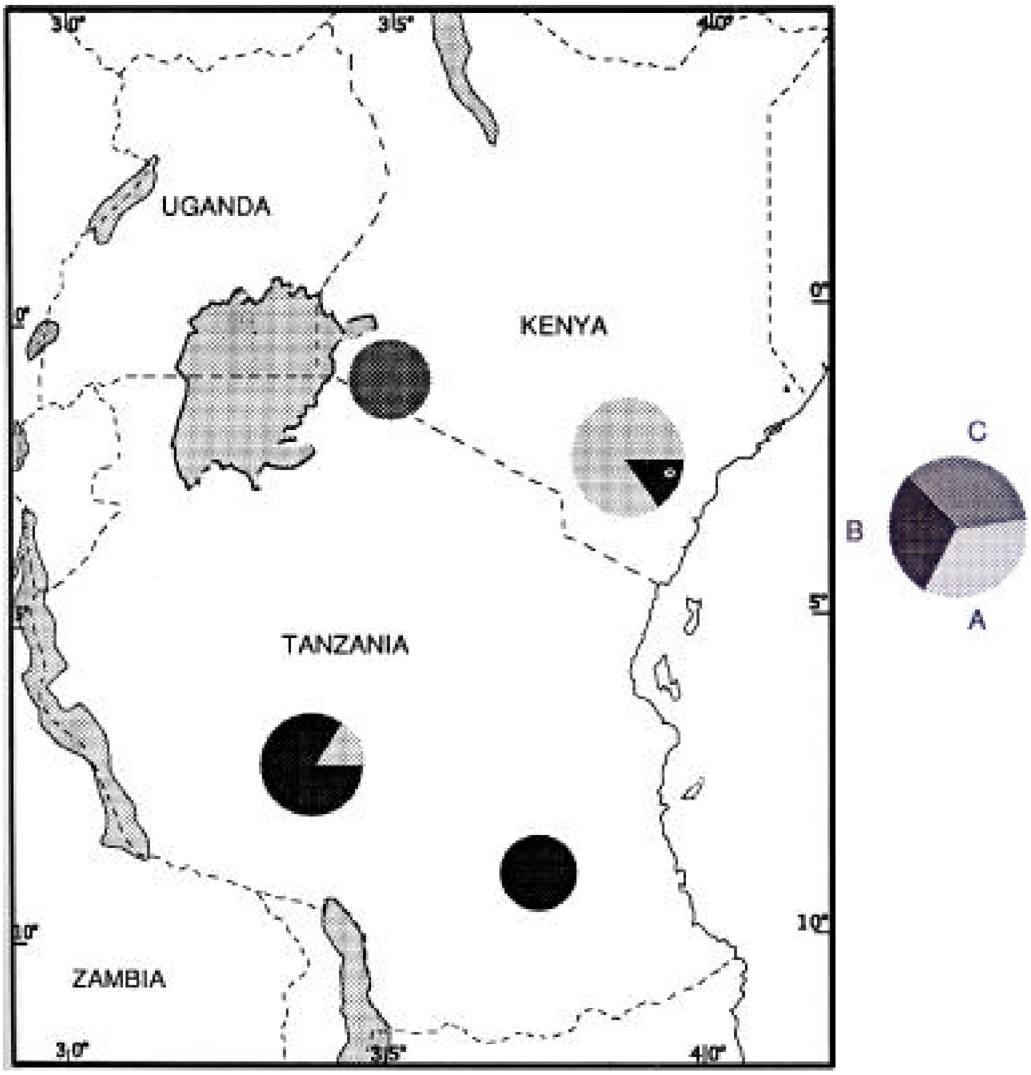

Figure. Evidence for genetic differentiation between elephant populations. Pie diagrams depict frequencies of three mtDNA types in populations around eastern Africa.

Genes from Tusks

While not extractable from pure ivory, DNA in varying degrees of degradation was secured from about 90% of minute tissue samples taken from 88 tusks of known origin in the ivory rooms of Nairobi and Dar es Salaam. Surprisingly, the DNA in most samples was sufficiently intact to yield genetic fingerprints, and these revealed considerable disparity between samples. Unfortunately, genetic variations between animals in a single population were as marked as the distinctions between individuals from different populations. Thus, the fingerprinting technique proved unsuitable for revealing population-specific markers. However, be-cause each elephant had a unique genetic fingerprint, we were able to identify matched pairs of samples that had unwittingly been collected from the left and right tusks of the same individual.

Next we tried a new and elegant technique, called the Polymerase Chain Reaction (PCR), which soon gave us the population-specific markers we were seeking. In a cocktail containing the building blocks of DNA and an enzyme that strings them together, many copies of a short but specific sequence of DNA can be made from as few as a single template. For each individual animal, a unique segment of up to 3000 base pairs, chosen from more than a billion, can be ‘amplified’ millions of times in a reaction lasting a few hours. With so many copies to work with, genetic differences between individuals can be conveniently sought within the segment using a variety of techniques. For our purpose, the main advantage of PCR is that even highly degraded DNA from minute tissue samples of a few cells will work, and this permits us to apply the method to minuscule DNA samples taken from tusks.

We focused our attention on DNA in a cellular body, known as the mitochondrion, that is discrete from the nucleus yet contains its own DNA. Mitochondrial DNA (or mtDNA) is unique in the way it is passed from one generation to the next: most sexually reproducing animals inherit all their mtDNA only through the mother. The father contributes no mtDNA to offspring although he does, of course, contribute half of the offspring’s nuclear DNA. Thus, in a species such as the elephant where females tend not to migrate far from the region in which they were born, genetic markers that characterize a given population are most likely to accumulate in mtDNA. This is exactly what we found. Although sample sizes are small, segments of mtDNA in tusks from populations in the Masai Mara (western Kenya), Tsavo (eastern Kenya) and southern Tanzania were sufficiently distinct to suggest that regulating an ivory trade using DNA markers is technically and biologically feasible (Figure).

Imptications for Elephant Biology and Conservation

For other than technical reasons, we still are far from applying this method to regulating the ivory trade. However, the biological implications of this study are as important to elephant conservation as they are to the trade. For example, results suggest that elephant populations that are separated by more than 250 km constitute distinct gene pools, at least in eastern Africa. Does the same apply to populations separated by distances that are more easily traversable by elephants? That is, are genetic neighbourhoods of interbreeding individuals smaller than is suggested by the long distances that elephants are capable of travelling? An understanding of genetic patterns and processes in elephant populations has the potential to answer this and many other questions that are pertinent to effective conservation such as:

1. To what extent will effective population sizes be modified in the future by human development?

2. To what extent are the major remaining populations genetically differentiated, which of them are the most genetically divergent and why? What proportion of the total genetic variation that currently exists is likely to persist under various future conservation strategies?

3. In the past, how much gene flow was due to migration between adjacent populations and, in the future, to what extent will effective migration be interrupted by human development?

4. What were the evolutionary patterns within elephants on the African continent? When did savanna *(L. a. africana)* and forest *(L. s. cyclotis)* elephants diverge, and to what extent do they hybridize today?

5. Is social structuring in elephant populations based on genetic relatedness among individuals? Has excessive exploitation disrupted natural population genetic patterns?

The Next Step

To provide answers to these and other questions, we propose a second phase of research on a continental scale into the genetic patterns and processes of African elephant populations. Because both the trade and the biological aspects of this research are based on the same genetic information, progress can be made on both simultaneously. However, initial development will be limited by the need to collect enough samples from each of the various populations throughout Africa. What constitutes a sample? So far we have collected dried bits of tissue and bone attached to tusks, and these have worked very well. Additionally, we have sampled live animals from the Amboseli population in southern Kenya, using an ingenious new technique for collecting skin biopsies that does not require immobilization of the donor. The technique was developed by Dr Bill Karesh, a field veterinarian now at the New York Zoo, who substituted a biopsy probe for the hypodermic needle on a standard (0.5” cal) immobilization dart. Fired by a small charge, the dart bounces out of the target animal with a sample of skin sufficient for genetic analysis. While this technique does not harm the donor it most certainly does not guarantee the health of the collector! We can therefore use anything from fresh, frozen skin to dried flesh, skin or bone to obtain the genetic information we need.

Can You Help?

For future collection of samples, we need your help. If you know how we can obtain bits of dried tissue or bone, no matter how small, from elephants OF KNOWN ORIGIN, please write to Dr Nick Georgiadis, WCI, Bronx Zoo, NY, 10460. We stress that the samples must be of known origin, since without that information we would just be ‘chasing our tails’. If you yourself can collect specimens, we will be most grateful. Dried samples are easily dealt with: simply place in an envelope, mark with the date, sex, tissue type, collector’s name and address, and information regarding the area where the elephant lived (if you don’t know exactly, indicate how inexactly). By all means keep the sample dry, and <u>try and handle it as little as possible</u>. We will be happy to pay for postage.

Acknowledgements

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Reference

1. R.H.V. Bell, J.P. Kelsall, M. Rawluk and D.H. Avery, “Tracing Ivory to its origin: microchemical evidence”, *Pachyderm, No* 12, (1989), pp 29-31.