Isotopes May Control Trade

Horn and Ivory

Story by Nikolaas J. van der Merwe

THE PROCEDURE FOR PINpointing the geographic origin of a tusk or a horn is very similar to that used by archaeologists for pinpointing the marble quarries from which the Greeks and Romans of antiquity obtained the raw material for their statues and monuments. The same is true if one wants to know where a diamond was mined. The details differ from one material to another, but the bases of the various techniques are the same: they involve stable isotope ratio measurements. To this procedure may be added the chemical determination of trace elements in materials.

'It is possible to characterise ivory from individual parks'

In 1990 two groups of scientists published in *Nature* the results of pilot projects aimed at showing how African elephant ivory can be traced to its source by means of isotopic analyses. One group (van der Merwe *et al*, 1990) used the stable isotopes of carbon, nitrogen and strontium in tusks from ten African countries, including 24 different localities or wildlife refuges, and spanning the continent from Sapo forest in Liberia to Addo Park at the most southern tip.

The second group (Vogel, Eglington and Auret, 1990) confined their analyses to southern Africa, but added the isotopes of lead for finer definition. The results of both pilot studies made it clear that it would be possible to trace any piece of ivory to its source, provided that a database is constructed on ivory samples from all the locations where elephants live. At the same time, the results from southern Africa made it clear that it is already possible to characterise the ivory from individual southern African parks and to distinguish them from ivory from elsewhere.

How isotopes work in elephants

Van der Merwe's group chose three isotope ratios, because they had access to the necessary equipment and the costs could be kept low. The three isotope pairs proved to be distributed in elephants as follows:

Carbon (13C/12C). African savanna grasses are high in carbon-13, while bushes and trees are low. Elephants prefer to browse the foliage of bushes and trees (if available), filling in their diet with grass as needed. Consequently, the ratios of carbon-13 to carbon-12 in the bone or tusk protein (collagen) of elephants vary with the density of browse in their habitat. The results for bone and tusk are the same. In well-forested regions (eg; Shimba Hills, Kenya), the 13C/12C ratio is low; in grasslands (eg; Tsavo, Kenya) it is high. In addition, elephants from rain forests (eg; Sapo, Liberia) can be distinguished from all others on the basis of carbon isotope ratios, because their 13C/12C ratios are exceptionally low.

Nitrogen (15N/14N). Nitrogen isotope ratios in elephant tusk or bone collagen vary primarily with rainfall. The lower the rainfall, the higher the nitrogen-15 content. A high 15N/14N ratio identifies an elephant from an arid region (eg; northern Namibia); a low ratio identifies an elephant from an area with adequate rainfall.

Strontium (87Sr/86Sr). Strontium isotope ratios vary with local geology. Strontium-87 is the product of the radioactive decay of rubidium-87, so the amount of strontium-87 in rocks (and thus in the local soil and plants) depends on the amount of rubidium in the same rocks and on their age. In old rocks, most of the rubidium-87 has already decayed to strontium-87, (resulting in high ratios of strontium-87,which increases with age, to strontium-86, which stays the same). Elephants from areas of recent volcanic origin (eg; the Rift Valley of East Africa) have low ratios of 87Sr/86Sr, while those from areas with old rocks (eg;

the Archaean granites of Kruger Park in South Africa) have high ratios.

A combination of these isotope ratios is sufficient to distinguish the 24 localities from which we analysed elephant tusk or bone (the results are the same) in our pilot project. It is possible, of course, that a complete database of African and Asian elephants will reveal two or more localities with identical ratios of carbon, nitrogen and strontium isotopes. If so, it would be necessary (and sufficient) to measure also the isotope ratios of such elements as lead and neodymium in difficult cases only. This we have already done in a pilot study of African rhinoceros horn (Hall-Martin *et al*, 1993) and it works very well. Elephants and rhinoceroses in a given locality have the same ratios of heavy stable isotopes (ie;strontium, lead, neodymium).

Carbon isotope ratios in African rhinoceros horns are not useful for source tracing since African rhinoceroses do not eat mixtures of browse and grass. The black rhinoceros browses the foliage of bushes and trees and has a low 13C/12C ratio; the white or broad-lipped rhinoceros eats grass and has a high 13C/12C ratio. The two species have completely different carbon isotope ratios and can be distinguished on this basis alone. Additional isotope ratios (nitrogen, strontium, lead, neodymium) serve to characterise the localities where rhinoceroses live.

Tracing rhinoceros horn to source is easier than tracing elephant ivory, because:

- they live in far fewer habitats, mostly in Southern Africa;
- the rhinoceroses of East Africa have isotope ratios of strontium, lead and neodymium that are characteristic of young volcanic geology; and
- the rhino of Asia are forest browsers (Java and Sumatra) or mixed feeders (India). Both of these categories can be identified on the basis of carbon isotope ratios and can be distinguished from African black rhinos (not found in dense forest) and white rhinos (grazers).

What is required to do isotopic analyses of ivory and rhinoceros horn?
The sample requirement is less than 1 gramme.

Is it possible to identify the source of a piece of ivory bought in a curio shop?
Maybe. If it comes from one of the wildlife refuges for which we have isotopic data it can be identified. Otherwise not.

Is it possible to identify ivory of a known locality like Kruger National Park?
Positively, yes. It is actually possible to divide Kruger into six identifiable regions, because its plant cover and rainfall vary from north to south, while two major geological provinces divide the park into an eastern and western region. In addition the Lebombo mountains along the eastern boundary of the park form yet a third geological province.

Is it possible to slip a poached tusk 'from somewhere else' in with a shipment of Kruger tusks and escape isotopic detection?
Don't know. If it is not in the database we cannot guess what its isotopic characteristics might be. It is possible that somewhere, out there, exists a locality with isotopic characteristics identical to that of one from the localities in Kruger Park. The chances of rolling five pairs in a row with two dice are about the same.

What about rhinoceros horn. Can it be traced to a particular source?
Very likely, although the database is not quite complete. The rhinoceroses of East Africa (Ngorongoro, Kenya) can be identified, because of their Rift Valley heavy stable isotope ratios. The refuges of southern Africa have been well-studied and can be pinpointed. Asian rhinoceros horns have not been analysed, but on theoretical grounds they should be readily identifiable on the basis of light stable isotope ratios.

Can a horn of a white rhino be distinguished from all other horns, be they those of the African black, Indian, Javan or Sumatran rhinos?
Absolutely categorically, yes. Only a carbon isotope analyses is required.

How much do these analyses cost?
A canvass of commercial laboratories in the USA revealed the following prices, on average:

carbon and nitrogen isotopes (both)	$75
strontium isotopes	$150
lead, neodymium isotopes (each)	$200-250

Our research (in subsidised university laboratories) cost less.

Is it possible to deploy a system for tracing an unknown piece of ivory or horn to its exact source using isotopes?
Not immediately. The database for rhino horn is far along, but not complete. The database for ivory still needs a lot of work.

What will it take to deploy such a system?
Time and money: two to three years of dedicated work by a research team and about $0.5 million in field collecting and laboratory costs.

To sum up: it is certainly possible to identify white rhinoceros horn, but I suspect that the information provided here will not bring happiness to either side in the argument about delisting South African elephants. The answer is 'yes', it is possible to deploy a system for source tracing ivory, or indeed any wildlife product, but 'no', it cannot be done without additional work. The latter will take time and money. ●

References

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