Forensic techniques for wildlife crime

- Lady Monet Buchanan

Evaluate the use of current forensic and analytical techniques in the investigation and control of crimes against animals, wildlife and the environment

Introduction

Wildlife crime has in recent years become a major problem. Many wildlife/animals are being illegally killed, traded and smuggled every day. Illegal smuggling of animals and plants are typically smuggled for medicine, food and antiques. Wildlife trade is predominately done with items such as skin, ivory, horn, eggs, meat, and feathers (Singh *et al* ., 2006). Examples of crimes against wildlife are poaching and illegal hunting of bears, tigers, rhino's and elephant's. Whilst all wildlife trade is not illegal, there are still trades such as buying and selling African elephant ivory pre-1947 (Wwf. org. uk, 2009) that are illegal and still despite the laws, are still being traded throughout the world. Items can be smuggled across many different borders and through many different trade routes (Wasser *et al* ., 2007). The convention on international trade in endangered species of wild fauna and flora (CITES) in 1989, ban the international trade of elephant ivory (Singh *et al* ., 2006), however it is still a major problem today. This essay will focus on three important forensic analytical techniques; radiocarbon dating, stable isotope analysis and X-ray fluorescence analysis, which all aid in distinguishing whether ivory traded is legal or illegal and where the ivory may have come from. Case study's using these techniques to help combat the illegal trade in elephant ivory will also be discussed and evaluated.

Background about elephant ivory and analytical techniques used

African elephant ivory trading was ban by CITES in 1989 (Singh *et al* ., 2006) due to the serious threat of global elephant population (Wozney and Wilson, 2012). Although the ban has been put into place, there is still an increase with the amount of elephant ivory being traded. There are many cases where officers around the world have seized tons of ivory and with the help of analytical techniques, have been able to identify they have originated from illegal sources. In 2011 the 13 th largest seizure was made involving 23 metric tons of illegal elephant ivory (Worldwildlife. org, 2015). Analytical techniques can be used to detect the type ivory and what specie it may have came from, the geographical identification of ivory and whether the ivory was obtained pre 1947 (legal) or post 1947 (illegal), for example DNA profiling, microscopic analysis, stable isotope analysis and radiocarbon dating.

Analytical technique: Radiocarbon dating

Aging ivory is crucial to determine its legality of trade and by measuring radioactive carbon-14, for example in ivory antiques, this can determine whether the trade of an item is legal (Uno *et al* ., 2013). Radiocarbon dating can estimate the year the elephant died (ivory being obtained) which then determines whether this was pre or post 1947. This identifies whether the ivory was legally or illegally obtained. Carbon-14 was placed into the earth’s atmosphere between 1945 and 1980 due to a nuclear fallout (Schmied *et al* ., 2011), this meant that there was a significant rise in the levels of carbon-14 in the atmosphere and due to this more being absorbed by plants and animals.

The method of radiocarbon dating uses the ' bomb curve' dating graph (Smith, 2015) as a reference to the levels of carbon-14 in the atmosphere from around 1940-2000 (Schmied *et al* ., 2011). Levels found in ivory show whether it was taken from an elephant before or after the bomb explosion. One way of using this technique is to extract carbon from a sample as carbon dioxide and add this to calcium carbonate. The release of carbon-14 from the calcium carbonate is then measured (Brunnermeier *et al* ., 2012). Another way is to use an accelerator mass spectrometer machine and bombard the sample with cesium atoms. These atoms are used to split carbon into two lots with a ratio of carbon-14/carbon-12. The comparison of carbon-14 to carbon-12 is then measured to find the significant difference between the two carbons (Phys. org, 2015). The accelerator mass spectrometer counts the amount of carbon-14 present within the sample and figures are plotted on to the bomb curve graph (Smith, 2015). This shows the difference in carbon-14 levels in the sample to the levels in the atmosphere. Using an accelerator mass spectrometer is seen as a more improved and précised way, as small pieces of worked ivory can be tested (Phys. org, 2015).

Researchers used this method to test the accuracy of radiocarbon dating. They acquired samples from an elephant which died in Kenya in 2006 and samples from an African elephant in Utah in 2008 (Phys. org, 2015). The ivory samples, presented the same amount of carbon-14 as those found in grass and plants taken in the same years. As they acquired accurate results, they went on to analyse 29 samples which resulted in minimal carbon-14 levels consistent with the atmospheric levels of carbon-14 before the nuclear bomb. They were able to assign the tusks, to have been legally taken as carbon-14 levels support this (Phys. org, 2015).

The benefit of this technique is that it is a quick, simple and affordable test. One of the problems with this technique is that to gain the most accurate results, the samples most likely should be taken from the base of the tusk, as this part has the most recent carbon-14 levels present in the atmosphere just before death. To help aid in more accurate aging results, tests determining the strontium-90 levels within a sample can also be measured. Strontium-90 was also placed in the atmosphere at the time of the nuclear fall-out. Any ivory grown before 1955 would not have any signs of strontium-90 present, so along with naturally occurring levels of carbon-14 before 1955, this would give an exact determination that the ivory samples tested are in fact legal (Schmied *et al* ., 2011). However carbon-14 dating alone in may cases is a precise enough technique (Brunnermeier *et al* ., 2012) and can complement DNA analysis of ivory (Smith, 2015).

Analytical technique: Stable isotope analysis

Stable isotope analysis is the chemical elements found within chemical compounds such as food, which can determine the diet and trophic levels within a sample. This technique in relation to determining where ivory shipments have possibly come from provides a history of an elephant and what regions the ivory could possibly have come from. Nitrogen, carbon, oxygen and lead can be tested in the ivory samples to find the isotopic compositions gained from foods the elephant ate and therefore compare it to isotopic compositions found in the soils which the food (plants) grew

(Aggarwal, Habicht-Mauche and Juarez, 2008). From this the region in which the elephant originated from can be distinguished. As different regions within the world have different levels of nitrogen, carbon, oxygen and lead present, the levels can be tested and compared to the levels found within samples. The ratios of stable isotopes found in ivory samples can be compared to the levels found in the soil and plants in different regions of Africa or Asia.

To determine the stable isotopes present, ivory samples are powdered and treated with hydrogen peroxide and tested to insure there is an isotopic shift (Cerling, Omondi and Macharia, 2007). The instrument used to measure stable isotope analysis is mass spectrometry. This measure's the levels within the ivory sample and can be compared to the levels found in the soil and food samples from specific regions (Aggarwal, Habicht-Mauche and Juarez, 2008). Results produced can be plotted on graphs showing the different levels of isotopes taken from samples and soils and the different variations of ratios of each isotope. Also maps of different regions for example Ethiopia can show which isotope levels are higher than others in another region such as Zimbabwe.

In a case in Kenya, elephant tusks were analysed from different regions in Kenya and central Africa, the carbon-12 and carbon-13 along with the oxygen-16 and oxygen-18, ratios were compared to results found in ivory samples confiscated by Kenyan customs. To help track down the poachers, they wanted to find out whether the ivory samples where obtained locally or from somewhere else in Africa or Asia (Cerling, Omondi and Macharia, 2007). From using stable isotope analysis they was able to distinguish where these confiscated pieces may have possibly come from. Comparing the carbon and oxygen levels found with sample soils taken from Kenya and central Africa, five of the carvings were found to have indistinguishable carbon and oxygen results to central Africa, whilst two carvings were very similar to the Kenyan forest (Cerling, Omondi and Macharia, 2007). In this analysis the limited number of samples from central Africa meant that the results taken from the carvings could not give a précised location. Stable isotope analysis found accurate levels of carbon and oxygen consistent with two carvings from the forest mountain elephant bred in Kenya and so was able to link this ivory shipment back to Kenya.

Although in studies dating back to 1990, found stable isotope analysis useful as nitrogen and strontium helped scientists in connecting confiscated ivory to three parks in south Africa, there is a belief that this technique still has a number of problems associated with it. One of the problems associated with stable isotope analysis is that this technique uses instrumentation that is very expensive to buy and run and the chemical separation techniques can be time consuming (Aggarwal, Habicht-Mauche and Juarez, 2008). Although this technique can track regions of where samples may originate from, if there is an unsufficient amount of data from previous studies of different regions, samples have nothing to be compared to. The strontium isotope itself has had success in helping in investigations of smuggled ivory, but the cost and time that is required to prepare samples, may slow down the commercial application of using this technique in years to come in the forensic industry (Aggarwal, Habicht-Mauche and Juarez, 2008).

Analytical technique: X-ray fluorescence analysis

X-ray fluorescence analysis is a technique which reveals the chemical elements present within a sample (Singh *et al* ., 2006). This technique can provide preliminary data to the analytical techniques mentioned above. X-ray fluorescence can distinguish ivory from a range of elephant populations in various regions of Africa and Asia (Kautenburger, Wannemacher and Müller, 2004).

To undergo this analysis, samples of ivory are polished and dried overnight and a small section of the sample is used for direct analysis (Kautenburger, Wannemacher and Müller, 2004). The instrument used for analysis is an X-ray spectrometer. When the sample is dried and examined, intensity peaks are given in a spectrum which shows various elements present and at what concentrations they appear at (Singh *et al* ., 2006). The different elements and their concentrations shown in the spectra for example are iron (Fe), silicon (Si), sulphur (S), strontium (Sr) and hafnium (Hf) (Singh *et al* ., 2006). Different samples will present different peaks of elements and different concentrations which can be use to distinguish between different breeds of elephants in different regions such as Africa and Asia.

In a study done by researchers to characterize elephant ivory between regions of Africa and Asia, results found elements of Sr and Hf to have longer intensity peaks and therefore higher concentrations in African ivory than in Asian ivory (Singh *et al* ., 2006). Another study carried out was able differentiate the ivory samples of two different elephant species within African, by the intensity peaks of elements such as Sr, Fe, Si and S and comparing them against reference samples taken from the same specie (Kautenburger, Wannemacher and Müller, 2004).

One of the main benefits of this technique is that it is a quick and cheap, non destructive technique that can be used for both quantitative and qualitative analysis (Kautenburger, Wannemacher and Müller, 2004). Given that the studies above both were able to conclude with positives outcomes, this technique however does have limitations. One of the problems of this technique is that there can be marginable differences/similarities in intensity element peaks, which can make characterizing ivory from different regions or different species quite challenging (Singh *et al* ., 2006). Another problem is with large numbers of ivory samples, validity of results may not always be achieved (Kautenburger, Wannemacher and Müller, 2004). On the other hand this technique is used as preliminary data and such analytical techniques like DNA and radiocarbon dating can help support findings.

Conclusion

From examining three various analytical techniques used in the illegal trade of elephant ivory, it is possible to say that these techniques along with other analytical techniques such as DNA can aid in finding the year ivory was obtained and therefore assign whether samples being traded are legal (antique) or illegal (modern). Although radiocarbon dating is one of the most recent techniques, out of the three, it has become one the most successful techniques as it can pin point the exact year ivory was obtained from an accurate reading of carbon-14 in a sample and comparing it to the bomb curve data. Although it has a short half-life, hopefully in the future another test will be discovered. Unlike X-ray fluorescence which needs confirmatory tests such as DNA and radiocarbon dating for results to coincide with, stable isotopes with more research can lead to more precise and accurate results.

Nevertheless all techniques have and will be continually used in the forensic industry.

References

Aggarwal, J., Habicht-Mauche, J. and Juarez, C. (2008). Application of heavy stable isotopes in forensic isotope geochemistry: A review. *Applied Geochemistry* , 23(9), pp. 2658-2666.

Brunnermeier, M., Schmied, S., Müller-Boge, M. and Schupfner, R. (2012). Dating of ivory from 20th century by determination of 14C by the direct absorption method. *Applied Radiation and Isotopes* , 70(8), pp. 1595-1602.

Cerling, T., Omondi, P. and Macharia, A. (2007). Diets of Kenyan elephants from stable isotopes and the origin of confiscated ivory in Kenya. *African Journal of Ecology* , 45(4), pp. 614-623.

Kautenburger, R., Wannemacher, J. and Müller, P. (2004). Multi element analysis by X-ray fluorescence: A powerful tool of ivory identification from various origins. *Journal of Radioanalytical and Nuclear Chemistry* , 260(2), pp. 399-404.

Phys. org, (2015). *Age and legality of ivory revealed by carbon-14 dating can fight poachers* . [online] Available at: http://phys. org/news/2013-07-age-legality-ivory-revealed-carbon-. html[Accessed 7 Jan. 2015].

Schmied, S., Brunnermeier, M., Schupfner, R. and Wolfbeis, O. (2011). Age assessment of ivory by analysis of 14C and 90Sr to determine whether there is an antique on hand. *Forensic Science International* , 207(1-3), pp. e1-e4.

Singh, R., Goyal, S., Khanna, P., Mukherjee, P. and Sukumar, R. (2006). Using morphometric and analytical techniques to characterize elephant ivory. *Forensic Science International* , 162(1-3), pp. 144-151.

Smith, R. (2015). *Cold War Radioactivity Can Date Illegal Elephant Ivory* . [online] National Geographic. Available at: http://news. nationalgeographic. com/news/2013/06/130701-elephants-ivory-poaching-trade-science-animals/ [Accessed 7 Jan. 2015].

Uno, K., Quade, J., Fisher, D., Wittemyer, G., Douglas-Hamilton, I., Andanje, S., Omondi, P., Litoroh, M. and Cerling, T. (2013). Bomb-curve radiocarbon measurement of recent biologic tissues and applications to wildlife forensics and stable isotope (paleo)ecology. *Proceedings of the National Academy of Sciences* , 110(29), pp. 11736-11741.

Wasser, S., Mailand, C., Booth, R., Mutayoba, B., Kisamo, E., Clark, B. and Stephens, M. (2007). Using DNA to track the origin of the largest ivory seizure since the 1989 trade ban. *Proceedings of the National Academy of Sciences* , 104(10), pp. 4228-4233.

Worldwildlife. org, (2015). *Illegal Wildlife Trade | Threats | WWF* . [online] Available at: http://www. worldwildlife. org/threats/illegal-wildlife-trade[Accessed 7 Jan. 2015].

Wozney, K. and Wilson, P. (2012). Real-time PCR detection and quantification of elephantid DNA: Species identification for highly processed samples associated with the ivory trade. *Forensic Science International* , 219(1-3), pp. 106-112.

Wwf. org. uk, (2009). *Forensics help fight ivory fraudsters* . [online] Available at: http://www. wwf. org. uk/wwf_articles. cfm? unewsid= 3159[Accessed 7 Jan. 2015].