Federal Agency for Nature Conservation

Determination of Age and Geographical Origin of African Elephant Ivory

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Research activities:
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In co-operation with the
International Council for Game and Wildlife Conservation (CIC)
German Hunting Association (DJV)

Necessity

In the 1980s, the international trade in ivory led to a dramatic decrease of the population in many African countries. In 1989 the international community listed the African Elephant on Appendix I of CITES and thus prohibited any commercial ivory trade. The strict trade prohibition and effective protective measures allowed the elephant populations in some African countries to recover, above all in Eastern and Southern Africa where they are increasing in number at an average annual rate of 4 %. Due to the stable or even growing numbers of animals in Southern Africa, in 1997 the populations of Botswana, Namibia and Zimbabwe and in 2000 the population in South Africa were downgraded to CITES Appendix II. While maintaining strict protection, these countries were given the opportunity to deal with elephant products. Nevertheless, so far CITES has only allowed onetime sales and does not allow free trade of products made of elephant ivory. One of the main arguments for the quasi trade prohibition is the fact that it is very difficult to distinguish legal ivory from illegal ivory in the markets, so that the legal ivory trade would provide a perfect cover for smuggling.

The data in ETIS (Elephant Trade Information System), the information and surveillance program for trade and smuggle of elephant products, furthermore show that since 2004 the illegal trade in ivory has been growing in some Central African countries. Since the 10th Conference of the Parties of CITES (Resolution Conf. 10.10) ETIS is being used by TRAFFIC, a joint wildlife conservation program of the WWF and the IUCN. The constant diminution of the elephant populations of the Ivory Coast, the Democratic Republic of Congo and the Central African Republic since 1981 implies that especially in those countries animals are killed by poaching.

In contrast, the countries of the southern part of Africa in particular are increasingly arguing that they should be allowed to trade ivory freely from the stocks they already hold so that they can raise the finances they urgently need for nature conservancy measures. Unfortunately, this method of generating income would not be without difficulties: If free trade was permitted, it would become increasingly difficult to differentiate between legal and illegal ivory at the point of sale and the legalized trade could be used as a cover for ivory smuggling and poaching. For the benefit of the effective protection of the west- and central African elephant population a control mechanism is essential that helps to identify the geographical origin and the age of contraband ivory.

At present an objective supporting instrument that meets court standards is not available for the CITES member states. In this context the development of a very exact method for age determination and the set-up of a database for the proof of origin of ivory can help to identify age and provenience of illegal ivory in order to better focus support enforcement and conservation measures on an international level. Only by this an objective transparency with regard to the provenance of ivory can be created that will help to avoid lengthy and therefore expensive discussions and negotiation processes and, where required, create legal compliance during implementation. Additionally, the project will help to specify and implement the CITES African Elephant Action Plan (CoP 15 Inf- 68) - in particular strategy 1.4 (Strengthen the enforcement of laws relevant to conservation and management of African elephants) - and the Regional Action Plan of the Central Africa Forests Commission (COMIFAC).

There scientific results of the development and the validation of the research methods will be published in scientific journals. In addition the database will be presented to the national authorities that are responsible for species protection and to the international community of states. Besides the CITES member states will get informed about the research project and the practical application methods at the next Conference of the Parties within the framework of a side-event.

Subproject 1:

Determination of Age of African Elephant Ivory by Compiling the Isotope Profiles of ^{14}C, ^{90}Sr, ^{228}Th/ ^{232}Th

Initial Position

Radiocarbon dating is considered to be a standard method for dating archaeological findings of biological origin. The principle is to determine the specific activity of radiocarbon in a sample of ivory and to allocate the result to a certain date applying the radiocarbon bombing curve. This date corresponds to the time of death of the elephant. But if it is to find out whether the death of an organism has occurred a short time or several decades ago radiocarbon dating is principally not able to show unambiguous results for certain time periods. This is due to the nuclear testing that caused an increase of $^{14}C/C$ in the atmosphere and therefore in the food chain, with the highest values being measured between the years 1962 and 1965. This change of the $^{14}C/C$ concentration is represented graphically by the so-called bombing curve. Comparing the results of the analysis of $^{14}C/C$ in a sample with the values of the bombing curve a time interval for the date of death of the elephant can be found out. But even with very exact determination methods it is impossible in certain time periods to allocate an unambiguous date. The reason for this is the curvilinear shape of the bombing curve due to the above mentioned maxima, so that for a certain value of ^{14}C /C in a sample two possible dates of death can be occurring, one of them before and one of them after the date of protection of the species. E. g. if the result of an analysis is 0.32 Becquerel per gram of carbon the years 1962 and 1980 have to be considered. To be able decide which of them is correct further analyses are necessary, like the determination of the activity of Strontium per gram of calcium ($^{90}Sr/Ca$) and of the relation of the Thorium isotopes ^{228}Th to ^{232}Th.

^{90}Sr was not evidenced in the environment before approximately 1955 because the most significant source of releases to food chains of vertebrates is the nuclear weapon testing. The results of the latest research show that a significantly increased value of $^{90}Sr/Ca$ is characteristic for ivory that was acquired between 1960 and 1970. Lower values of $^{90}Sr/Ca$ indicate a time of death before 1960 or after 1980. If the value of $^{90}Sr/Ca$ is below the detection limit, the time of death is considered to be before 1955.

^{228}Th and ^{232}Th are naturally occurring radionuclides that are also stored in the ivory. Analyses of human bones showed that the ratio of ^{228}Th/ ^{232}Th is significantly above unity if the death occurred not longer than 40 years ago and above unity if the death occurred about the year 1990. If the time of death is dated back more than 40 years the ratio of ^{228}Th/ ^{232}Th approximates to unity. As the chemical composition of ivory is similar to that of human bones it is to be assumed that the same relation exists.

Therefore by the combination of the analyses of these radionuclides the correct time of death can be calculated with a sufficient high degree of certainty. Errors can be detected much easier combining the results of three different analyses per each sample instead of only one. Thus the determination of the time of death is only recommendable by means of the analysis of all three elements ^{14}C, ^{90}Sr, ^{228}Th/ ^{232}Th.

Chemical analysis

Determination of the specific activity of radiocarbon ($^{14}C/C$)
The carbon (consisting of the isotopes ^{12}C, ^{13}C and ^{14}C) is released from a sample of ivory as carbon dioxide by combustion and subsequently accumulated as carbonate. From this carbonate the carbon is released as carbon dioxide and is stored in a so called scintillation cocktail. This scintillation cocktail enables the detection of ionising radiation caused by the β-decay of ^{14}C. From the result the pMC-value (percentage Modern Carbon, content of ^{14}C in a sample) can be calculated. Besides the determination of the amount of the stable carbon stored in the scintillation cocktail is necessary. The more exact the mass of the carbon is known the smaller is the possible time range of death for the elephant.

Determination of the specific activity of the strontium isotope ^{90}Sr related to the element calcium ($^{90}Sr/Ca$)

For the determination of $^{90}Sr/Ca$ the residue of the combustion of the ^{14}C analysis is used. At present only a part of the residue can be used for the determination of $^{90}Sr/Ca$ because the rest is needed for the thorium analysis. ^{90}Sr is purified from several interfering radionuclides (mainly potassium ^{40}K) applying ion exchange chromatography. The detection of the ionising radiation is performed applying low-level-β-counting with gas filled detectors. From the result of counting the activity of ^{90}Sr can be calculated.

Determination of activity ratio of the thorium isotopes ^{228}Th/ ^{232}Th

Also for the determination of ^{228}Th and ^{232}Th a part of the residue of the combustion of the ^{14}C analysis is needed. The contained thorium is purified applying several steps. Due to the high content of phosphates the chemical yield of thorium is limited to about 60%. The detection of the α-emitters ^{228}Th and ^{232}Th is done applying α–spectrometry with silicon detectors. Form the results the activity ratio of ^{228}Th and ^{232}Th is calculated.

Activities:

- Acquisition of dated ivory samples with a wide range of ages.
- Improvement of the $^{14}C/C$-analysis with regard to a more accurate determination of the amount of stable carbon stored in the liquid scintillation cocktail. By this the time of death of the elephant can be determined very accurately.
- Development of a combined method for the analysis of ^{90}Sr and ^{228}Th/ ^{232}Th in a single procedure to reduce possible errors and to enable the analysis of higher sample amounts.
- Increasing the chemical yield of the thorium analysis (currently at about 60%).
- Survey of the separation of ^{40}K as most important interfering radionuclide from the ^{90}Sr-preparation.
- Validation of isotope profile method applying independent dated samples.
- Screening of ivory with respect to further radionuclides (e.g. caesium ^{137}Cs, lead ^{210}Pb, plutonium ^{238}Pu, $^{239/240}Pu$, ^{241}Pu) to check whether they can also be used for age determination
- Analysis of about 20 unknown ivory samples for statistical purposes.
- Testing of the method of isotope profiles of ^{14}C, ^{90}Sr, ^{228}Th/ ^{232}Th to tissues of other species e.g. tortoise shell, coat, rhino horn.
- Documentation of the results e. g. in the internet and in scientific journals
- Development of a concept for the presentation of the results at a side-event of the 16th CITES Conference of the Parties in the year 2013

Subproject 2:

Determination of the geographical origin of elephant ivory
Creation of a reference database for the enforcement authorities

Level of knowledge

The isotope enrichment of certain chemical elements in the tusks of elephants is also a good method to reliably identify the origin of elephant ivory. Additionally, the isotope database offers information on the geographic origin of other species of similar trophic level (e.g. rhinoceroses).

The geographical origin of ivory is determined by a combination of various geochemical routine analyses. Most common and most successful is the determination of the isotopic composition of the element strontium (Sr). But the composition of the stable isotopes carbon (C), nitrogen (N), oxygen (O), hydrogen (H) and sulphur (S) also allows a reliable assessment of the provenance, as elephants ingest these isotopes with the food they eat. For example, the isotopic composition of the element strontium in the food consists of the isotopes ^{87}Sr and ^{86}Sr that are combined in a distinct ratio that is related to the chemical composition of the geological subsoil: young volcanic regions such as the East African Rift are characterized by a low $^{87}Sr/^{86}Sr$ ratio, whereas older parts of the earth's crust have a high $^{87}Sr/^{86}Sr$ ratio. Carbon and nitrogen isotopes can serve as indicator for the climate zone the elephant lived in. A very low $\delta^{13}C$ ratio indicates densely forested habitats, a high ratio is indicative of savannah landscapes. In a similar way, a low $\delta^{15}N$ ratio suggests humid conditions, whereas in drier elephant habitats a rather high ratio can be expected. Hence a relatively correct determination of origin is possible by defining the chemical composition of the tusks.

The spatial distribution of the elephant populations in Africa and their numbers have been monitored since 1995 on a regular basis by an expert panel of the International Union for Conservation of Nature (IUCN) and published in status reports. The data contained in the status reports consist of vector data which spatially represent the range of the different populations and thus provide information on geology, vegetation and precipitations. These spatial data as well as the results of the analysis of about 500 geo-referenced ivory samples from museums, collections and private big game hunters will allow the setup of a reference database for the proof of origin of ivory. In the course of the project, the historic material will be complemented by recent samples from African elephant range states. Isotope distribution maps of elephant ivory can be generated by using geo-statistic procedures (the so-called "kriging"). This database can be consulted for the determination of the geographical origin and the verification of the declaration of origin of ivory.

Activities in order to reach the objectives of the research and development project

Setup of an elephant ivory reference database:

- Documenting and analysing existing examinations of other relevant studies.
- Collecting elephant ivory reference samples of determined geographical origin.
- Mobilizing big game hunters in Europe in order to obtain reference samples of African elephant ivory.
- Classifying and processing of current ivory samples from Africa.
- Laboratory measurement and cataloguing of the isotope signals extracted from the reference samples.
- Consolidation of existing reference databases on geology and vegetation.
- Setup of a geographical information system that spatially represents the factors geology, climate, vegetation and elephant population.
- Statistical analysis of the isotope signals and spatial distribution pattern of the reference samples by means of abiotic factors.
- Determination of the heterogeneity of the isotope distribution in a whole tusk.
- Combination of the above mentioned results and setup of a reference database as well as an isotope distribution map of elephant ivory.
- Documentation of the results e. g. in the internet and in scientific journals
- Development of a concept for presenting the results at a side-event of the 16^{th} CITES Conference of the Parties.