Determination of Age and Geographical Origin of African Elephant Ivory

Research project supported by the German Federal Agency for Nature Conservation and funded by the Federal Ministry for the Environment, Nature Conservation and Nuclear Safety

<u>Second progress report for the project part 'Geographical Origin'</u>
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Authors:
Stefan Ziegler, WWF Germany
Dorrit Jacob, University of Mainz
Karin Hornig, German Federal Agency for Nature Conservation

Translated from the original German version by Claudia Denkl, German Federal Agency for Nature Conservation

1. Project description

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. While maintaining strict protection these countries were given the opportunity to deal with elephant products. Nevertheless, so far CITES has only allowed one-off 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 isotope enrichment of certain chemical elements in the tusks of elephants is a good method to reliably identify the origin of elephant ivory. 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 consume. 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 substratum: 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 results of the analysis of about 500 geo-referenced ivory samples from museums, collections and big game hunters will allow the setup of a reference database. Isotope distribution maps of elephant ivory can be generated by using geo-statistic procedures. This database can be consulted for the determination of the geographical origin of illegal ivory and bring about a better coordination of protection measurements on international level.

2. Goals of the research project

Until the end of the year 2012 the following goals shall be reached:

<u>Development of a reference database for ivory:</u>
A method will be established that can be applied for the determination of the geographical origin and the validity of the geographical indication of ivory.

<u>Application of the reference database for the enforcement:</u>
The reference database for elephant ivory will be suggested to national authorities and the international community of states as a support to enforcement.

2.1 Operating schedule

Activities (quarter of the year)	**III 2010**	**IV 2010**	**I 2011**	**II 2011**	**III 2011**	**IV 2011**	**I 2012**	**II 2012**	**III 2012**	**IV 2012**
Literature review	X									
Collection of samples	X	X	X	X	X	X				
Measurement of isotopes	X	X	X	X	X	X	X	X		
Setup of the database	X	X								
Evaluation and analysis				X	X	X	X	X	X	
Press relations and awareness raising			X	X	X	X	X	X	X	X
Publication and presentation of results				X			X			X
Preparation of a side-event for CITES CoP 16										X
Creation of a manual for the database (structure, application spectrum)									X	X

3. Activities during the report period

The description of activities is based on the list of the planned activities as shown in paragraph 2.1 (columns coloured in grey).

3.1 Planned activities

<u>Collection of samples</u>: During the last six month the acquisition of samples can be regarded as successful. To the 89 existing samples from museums, 211 additional samples from 10 African countries could be added. An exact compilation of the samples received during the reporting period with detailed indication of origin is given in table 1.
The visit of two project participants to Burkina Faso and South Africa in February 2011 were very successful. In West Africa, 51 samples from two spatially separated areas *(Nazinga Game Ranch und Pama Reserve partielle de la Faune)* were collected in cooperation with the *Direction de la Faune et des Chasses*, the CITES Management Authority of Burkina Faso. In South Africa, 100 samples from nine protected areas could be acquired in cooperation with the CITES Management Authority of South Africa. In May 2011, 36 samples from eight different areas were provided by the CITES Management Authority of Malawi.
The cooperation with the *International Council for Game and Wildlife Conservation (CIC)* continued to be very successful. Big game hunters were addressed personally by members of the Executive Committee and agreed on providing samples from their trophies. 21 samples could be acquired through this approach. In February 2011, the main office of the German Hunting Council sent a letter to the 1.200 district chairmen, introducing the research project. Additionally, a press release was distributed which was also printed by several re-

gional associations of the German Hunting Council. Some big game hunters contacted the German Federal Agency for Nature Conservation upon this request directly and offered the provision of samples. It is also planned to visit some more big game hunters at their place of residence to take about 20 samples. An appeal published in the SSC Species e-Bulletin in February 2011 also lead to the provision of some samples.
Through the TRAFFIC office in Central Africa (office manager Mr. Germain Ngandjui) efforts were made to improve the cooperation with some Central African countries. Letters communicating the request for assistance were sent to authorities and scientific contacts in the Democratic Republic of the Congo, Gabon, Cameroon, Republic of the Congo, Chad and the Central African Republic on May 19th, 2011. In the course of the meeting of the CBD Liaison Group on Bushmeat and the ITES Central African Bushmeat Working Group in Nairobi in June 2011 the heads of the CITES Management Authority of the Democratic Republic of the Congo and the Central African Republic were addressed directly by the director of the TRAFFIC Africa and Europe program, Mr. Roland Melisch, asking for their support.
The zoos organized in the Council of the German Zoo Directors (VDZ) are also participating in the project. The zoos in Basel, Wuppertal and Hamburg ('Tierpark Hagenbeck') provided 10 ivory samples from elephants that spent the first years of their life in Africa. At the annual meeting of the VDZ in June 2011, the project was presented to the zoo directors by a project participant, asking for the provision of samples. High emphasis was placed on the need to obtain whole tusks for the distribution of heterogeneity of radioisotopes regarding the project part 'age determination of ivory'.
The private contacts of a project participant to Portugal mobilised seven samples from privately owned ivory, originating from Angola, Mozambique and Zimbabwe. The Royal Museum for Central Africa in Tervuren, Belgium also agreed to cooperate by providing their georeferenced tusks from the Democratic Republic of the Congo (about 100) for sampling. During a first visit, six samples from 5 locations of the former Belgian colony could be taken. The complete sampling will be executed in the late summer of this year.
Presently there are 300 samples of verified origin from 22 African countries in the database. Table 1 provides an overview of the samples. The assignment of the countries to the regions follows the classification of the African Elephant Database. Countries with sufficient material available for a statistical analysis are marked in green. No material could be obtained yet from 15 African range states which are bordered in red and hatched. For several countries some samples are available but their number is not sufficient for statistical testing.

Table 1: Origin and number of samples presently available in the reference database for African elephant ivory.

No.	Region in Africa	Country	Quantity of samples	High quality	From museums	From states	From private persons	From zoos / others
1	East	Ethiopia	0	-	-	-	-	
2	East	Eritrea	0	-	-	-	-	
3	East	Kenya	6	2	5	-	-	1
4	East	Rwanda	0	0	-	-	-	-
5	East	Somalia	1	0	-	-	1	-
6	East	Sudan	3	2	3	-	-	-
7	East	Tanzania	16	8	13	-	2	1
8	East	Uganda	3	1	3	-	-	-
9	South	Angola	5	5	2	-	3	-
10	South	Botswana	2	2	-	-	1	1
11	South	Namibia	8	7	-	-	8	-
12	South	Malawi	37	36	1	36	-	-
13	South	Mozambique	10	2	8	-	2	-
14	South	Zambia	0	0	-	-	-	-
15	South	South Africa	113	112	4	104	-	5

No.	Region in Africa	Country	Quantity of samples	High quality	From museums	From states	From private persons	From zoos / others
16	South	Swasiland	0	0	-	-	-	-
17	South	Zimbabwe	7	7	-	-	7	-
18	West	Benin	0	0	-	-	-	-
19	West	Burkina Faso	51	51	-	51	-	-
20	West	Ivory Coast	0	0	-	-	-	-
21	West	Ghana	2	2	2	-	-	-
22	West	Guinea	0	0	-	-	-	-
23	West	Guinea Bissau	0	0	-	-	-	-
24	West	Mali	0	0	-	-	-	-
25	West	Niger	0	0	-	-	-	-
26	West	Nigeria	2	2	2	-	-	-
27	West	Liberia	3	3	3	-	-	-
28	West	Senegal	0	0	-	-	-	-
29	West	Sierra Leone	2	2	2	-	-	-
30	West	Togo	4	4	4	-	-	-
31	Central	Equatorial Guinea	0	0	-	-	-	-
32	Central	Dem. Rep. Congo	7	7	7	-	-	-
33	Central	Gabon	1	1	-	-	1	-
34	Central	Cameroon	15	15	10	-	5	-
35	Central	Congo	2	2	2	-	-	-
36	Central	Chad	0	0	-	-	-	-
37	Central	Central Afr. Rep.	0	0	-	-	-	-

The number of samples from Burkina Faso, Malawi and South Africa (196 pcs./ 66% of the total quantity of samples) can be described as sufficient to draw statistically sound conclusions. The number of samples from Tanzania (16 samples) and Cameroon (15 samples) is still small but allows statistical testing. However attempts should be made to gain more geo-referenced material from these countries. If less than 10 samples per country are available, the results of statistical tests are questionable. Figure 1 shows the number of samples per country. It is obvious that samples from Western and Central Africa are still underrepresented in the database. Just 25 samples could be acquired from Central Africa so far, with 15 of them originating from Cameroon alone. No samples from Zambia are presently available.

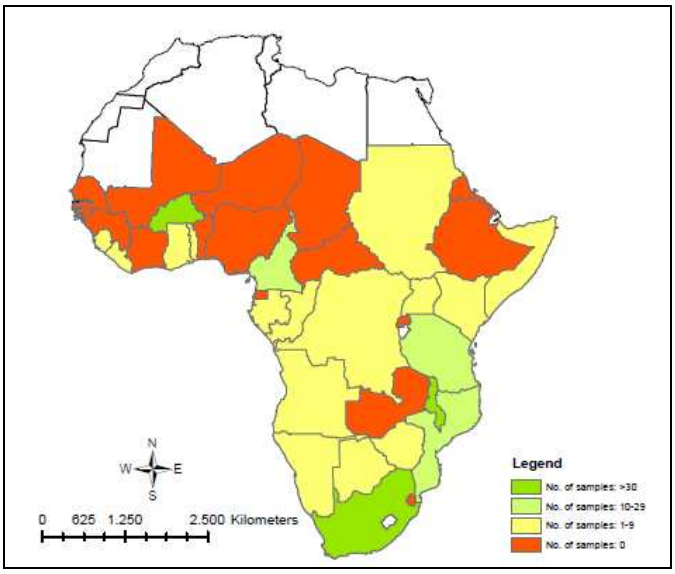


Figure 1: Origin and number of ivory samples per African elephant range state.

In this context it has to be emphasized that the allocation of the samples to countries does not reflect the biogeographic reality of the elephant habitats. Most of the elephant habitats are very heterogeneous concerning mean annual temperature, local precipitation, topography relief and geology. Additionally, most of the ivory samples from museums are not geo-referenced and often just has a country code so that the assignment to a climate zone or geological stratum is not possible. For this reason the quality of the data with regard to the geographical reference is very important. Reference values of high quality are available for trophies or samples acquired from the African range states where the exact location or even the geographical coordinates is known. Table 1 provides an overview of the spatial quality of the samples from the related elephant range states. Apart from Burkina Faso, Malawi and South Africa the existing samples (which are mainly from museums) are of low quality. However, exceptions are available from Cameroon, Tanzania, Angola, Botswana, Namibia and Zimbabwe. From these countries material of high spatial quality could be provided by big game hunters who have first-hand knowledge about the location of the elephant trophy hunt.

Within the past 12 month of project duration about 300 ivory samples could be inserted into the database. The results presented in this report illustrate that the acquisition of samples should be focused on some African countries to reach all the project goals in time. The acquisition of samples from all African elephant range states is unlikely to take place. For this reason an algorithm was created that provides a scientifically verified priority list. This list should serve as a guide for the acquisition of samples in the future. For this reason we calculated a priority index for the individual countries that represents the importance of ivory samples from the range states. The calculation of the index was made in three steps and uses different data given in table 3:

$$y(x) = Kö(x) \times A(x) \times Pop(x)$$

$y(x)$: specific product for country x
$Kö(x)$: number of Köppen climate zones in the elephant habitats in country x
$A(x)$: area of the elephant habitats in country x in km^2
$Pop(x)$: number of populations in country x

$$z(x) = \frac{y(x)}{n(x)}$$

$z(x)$: specific quotient for country x
$n(x)$: number of existent samples from country x
For countries where no samples are presently existing ($n = 0$) : $y = z$

For the reason of scoring the results from the second equation to values between 0 and 1, the highest value (z_{max}) among all the z(x) was identified which is at present Zambia with 22,073,580. By assuming this it has to be applied:

$$I(x) = \frac{z(x)}{z_{max}}$$

$I(x)$: priority index for country x
z_{max} : 22.073.580

Along with Zambia also Kenya, Tanzania, Mozambique, the Democratic Republic of the Congo, Gabon and Chad attained values higher than 0.1 and were identified as countries of highest priority with regard to the acquisition of samples. A priority index between 0.01 and 0.09 describes countries of subordinated but still high relevance for the acquisition of samples. 12 countries fall into this category (Ethiopia, Sudan, Uganda, Angola, Botswana, Namibia, Zimbabwe, Ivory Coast, Nigeria, Cameroon, Congo, Central African Republic). A priority lower than 0.01 indicates countries of subordinate priority, represented by countries with few elephants or small elephant habitats, but also countries from where sufficient samples are already existing, e.g. Malawi, Burkina Faso and South Africa. If no samples existed from the last two countries the index would be at 0.028 (Burkina Faso) and 0.342 (South Africa).

The calculation of the index values in table 2 is indented to identify countries from which samples are needed to make the database fully operational. Figure 2 depicts countries according to the database operational value: countries from where samples are of utmost importance are grouped in category 1. Category 2 comprises countries for increasing the informative value of the database, and category 3 countries are needed for the completion of the database (e. g. Malawi, that already provided useful samples).

Table 2: Priority index of the African elephant range states classified in highest, high and lower priority (colour-marked) used as guide for the acquisition of samples in the future.

No.	Region in Africa	Country	Quantity of samples	Köppen climate zones	Elephant habitat (km²)	Sub-popula-tions	Priority index
1	East	Ethiopia	0	5	39.593	8	0,072
2	East	Eritrea	0	2	5.277	1	< 0,01
3	East	Kenya	6	9	109.246	30	0,223
4	East	Rwanda	0	2	1.101	2	< 0,01
5	East	Somalia	1	2	4.623	1	< 0,01
6	East	Sudan	3	2	317.359	1	0,010
7	East	Tanzania	16	8	391.608	29	0,257
8	East	Uganda	3	5	16.133	12	0,015
9	South	Angola	5	3	406.315	5	0,055
10	South	Botswana	2	2	100.763	5	0,023
11	South	Namibia	8	4	108.463	7	0,017
12	South	Malawi	37	2	7.819	8	< 0,01
13	South	Mozambique	10	4	342.670	17	0,106
14	South	Zambia	0	3	204.385	36	1,000
15	South	South Africa	113	7	30.876	35	< 0,01
16	South	Swasiland	0	3	55	3	< 0,01
17	South	Zimbabwe	7	4	76.605	38	0,075
18	West	Benin	0	2	13.861	5	< 0,01
19	West	Burkina Faso	51	3	18.813	11	< 0,01
20	West	Ivory Coast	0	2	34.295	24	0,075
21	West	Ghana	2	2	22.115	9	< 0,01
22	West	Guinea	0	2	1.710	3	< 0,01
23	West	Guinea Bissau	0	1	1.278	2	< 0,01
24	West	Mali	0	2	39.391	1	< 0,01
25	West	Niger	0	2	2.577	2	< 0,01
26	West	Nigeria	2	4	23.373	12	0,025
27	West	Liberia	3	2	16.101	6	< 0,01
28	West	Senegal	0	1	1.100	1	< 0,01
29	West	Sierra Leone	2	2	1.848	4	< 0,01
30	West	Togo	4	1	5.104	5	< 0,01
31	Central	Equatorial Guinea	0	3	14.831	2	< 0,01
32	Central	Dem. Rep. Congo	7	7	265.892	14	0,169
33	Central	Gabon	1	3	217.632	9	0,266
34	Central	Cameroon	15	5	118.391	19	0,034
35	Central	Congo	2	4	147.048	4	0,053
36	Central	Chad	0	3	150.190	8	0,163
37	Central	Central Afr. Rep.	0	2	73.748	4	0,027

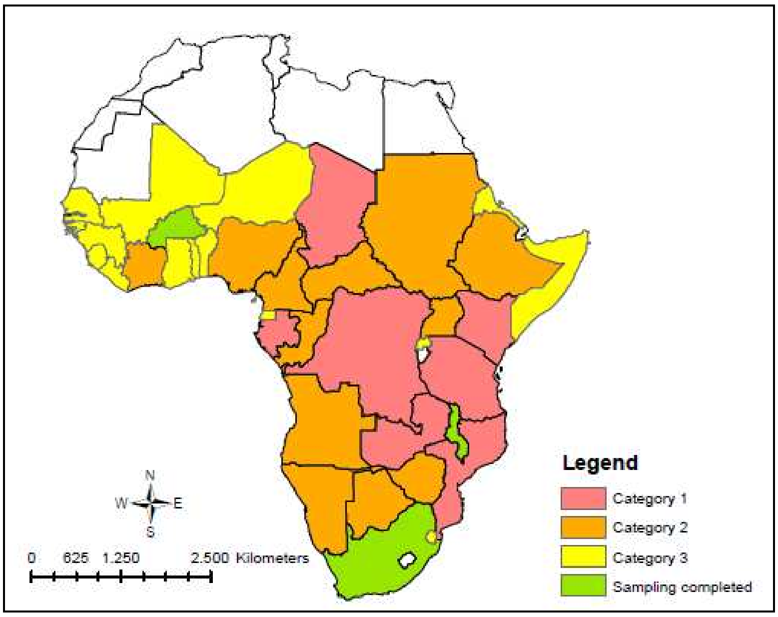


Figure 2: Priority of the African elephant range states with regard to the acquisition of ivory samples

<u>Measurement of the isotopes</u>: The activity ratio of strontium $^{87}Sr/ ^{86}Sr$ in the samples provided by museums was determined in April. This could only be done with 80 samples because ivory quantity of nine samples provided too little material and could not be used for the chemical extraction. The results were promising to some extent as they give an indication of the geological stratum and therefore confirm the theoretical assumptions in the scientific experiment. This is most obvious if samples are compared with different geographic origin from sedimentary rocks and volcanic areas.

<u>Interpretation and analysis</u>: We started with the analysis of some isotope-datasets. With the existing ivory samples a site-related assignment of the datasets was carried out. Besides the available data on geology, climate, altitude, vegetation (represented as proportion of plants with C_3 – and C_4 – photosynthesis pathways), distribution of hydrogen isotopes in the precipitation and distribution of the elephant habitats, an updated version of the Köppen-Geiger climate classification map was applied. This climate classification is based on the zoning of the world in 31 climate classes based on the temperature and the climate and is available in a special resolution of 0.5 degrees.

For the African elephant range, 13 climate classes are relevant. By clipping the elephant range map with the Köppen-Geiger climate classification map, it is possible to represent the absolute surface area of the elephant range at the various climate zones classes. This allows to predict the expected distribution of the water isotopes and the stable carbon isotope.

We also started with the evaluation of the isotope analysis, beginning with the results of the ivory acquired from museums. As mentioned further above a sound statistical analysis is only reliable if at least ten samples from the same elephant range state are available. Therefore, only the results of the analysis of samples from Tanzania, South Africa, Mozambique and Cameroon are presented here.

We assumed that the values of our test samples derive from a bell-shaped normal distribution. Under this assumption, the calculated mean and standard deviation for the individual countries can be used to compute a density function for any isotope. We used the open source software R to compute these probability density functions for carbon (delta 13C) and the relation of hydrogen (D/H) for the countries mentioned above.

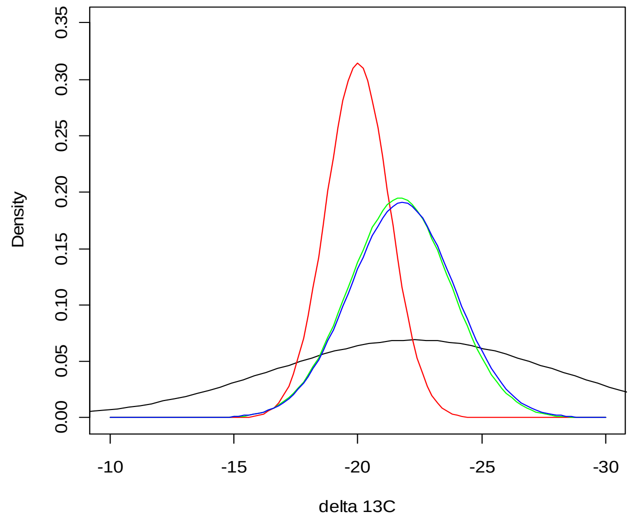


Figure 3: likelihood density function curve for delta 13C (black: Cameroon, red: Mozambique, green: Tanzania, blue: South Africa).

The density function of carbon delta 13C as illustrated in figure 3 shows that the four mentioned countries do not differ widely. Between Tanzania and South Africa there is hardly any difference concerning the density distribution. The curve of Mozambique is more distinct, but generally speaking there is a high uncertainty with regard to the allocation of samples based on their 13C-values. The relatively flat density curve of Cameroon is explained by the fact that there are five different Köppen climate classes in this country, reaching from humid-equatorial to dry and hot steppe climate. The existing samples from Cameroon are probably deriving from these different regions. Very low delta 13C-values indicate densely forested habitats whereas higher values are typical for savannah landscapes. In Mozambique there are also four different climate zones but nearly 83 % of the elephant habitats are situated in the equatorial zone with low precipitation in winter. This is reflected by the country's narrow density curve as shown in figure 3.

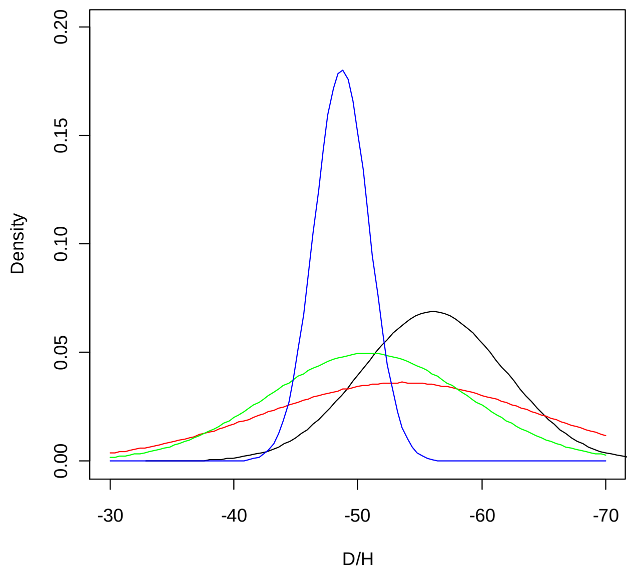


Figure 4: likelihood density function curve for hydrogen D/H (black: Cameroon, red: Mozambique, green: Tanzania, blue: South Africa).

The relation of deuterium (D, heavy hydrogen) and light hydrogen (H) in the samples seems to be more suitable for the determination of the geographic origin (fig. 4). Especially the density curves of Cameroon and South Africa are distinctively different. This is caused by the fact that certain natural processes prefer different stable hydrogen isotopes. The vaporisation of water, for instance leads to a process that is known as isotopic fractionation: heavy water – water that consists of a higher portion of deuterium – vaporises more slowly than light water. For this reason the vapour is enriched of hydrogen, whereas the remaining surface water is enriched in deuterium. Similar processes occur during the condensation, and therefore water in precipitation is usually lighter than the water of the ocean from which it originates.

The following figure 5 describes the relation of D to H in the atmospheric water throughout the African elephant range. The differences between the ranges in Cameroon and South Africa are distinctive and reconfirm the the different maxima of the density curves in figure 4. The distinctive distribution of the relation of D to H in figure 5 is based on the presumption that the percentage of deuterium in the atmospheric water decreases with increasing distance to the equator, but also with increasing altitude and continental climate. However, figure 5 also illustrates that a correct assignment of samples from Tanzania and Mozambique based on the ratio of hydrogen isotopes alone is difficult. This fact was also expected due to the curves in figure 4.

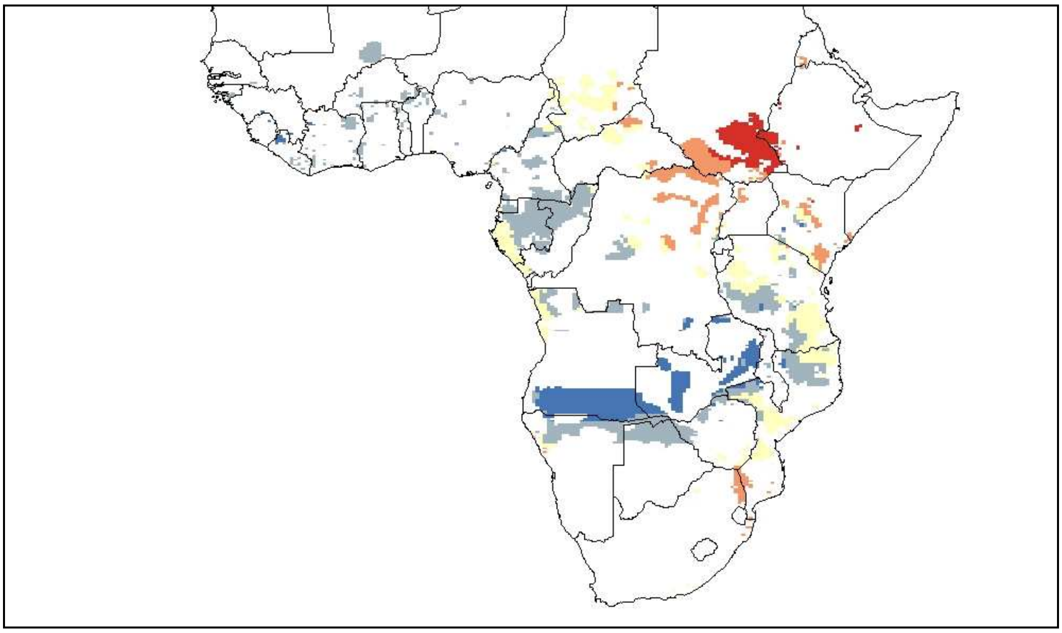
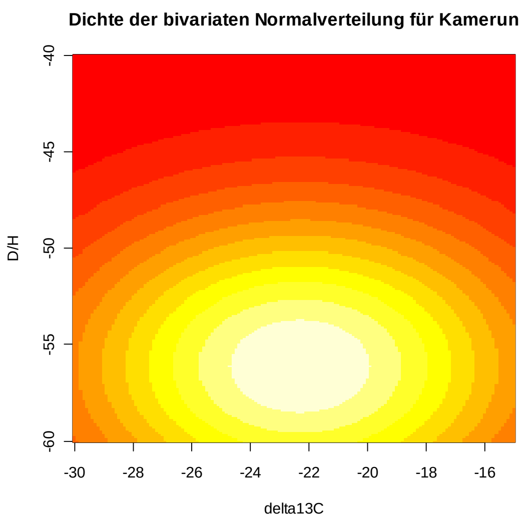


Figure 5: Spatial distribution of the D/H-values in the atmospheric water for the African elephant habitats. Blue: Areas with low D/H-values, red: Areas with low D/H-values

We conclude that the allocation of an unknown sample to one of the four countries of origin Cameroon, Tanzania, Mozambique and South Africa, based on just one variable, is limited. Therefore, both variables ‘delta 13C’ and ‘D/H’ were combined to create a bivariate random variable. Similar to a single random variable, it is possible to compute the density of a bivariate random variable. This density is illustrated – with the help of the open source software packet R - as colour intensity in the following figures 6 a-d.



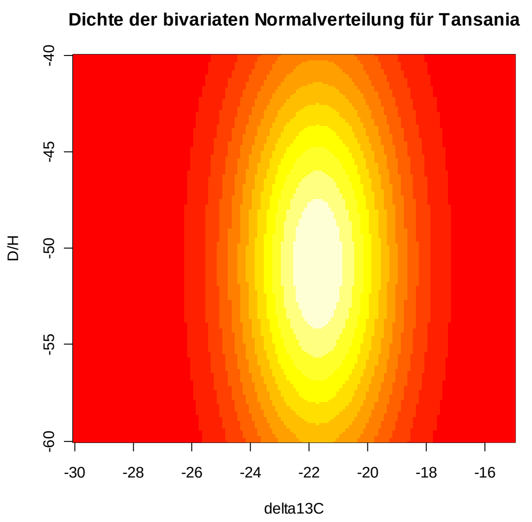
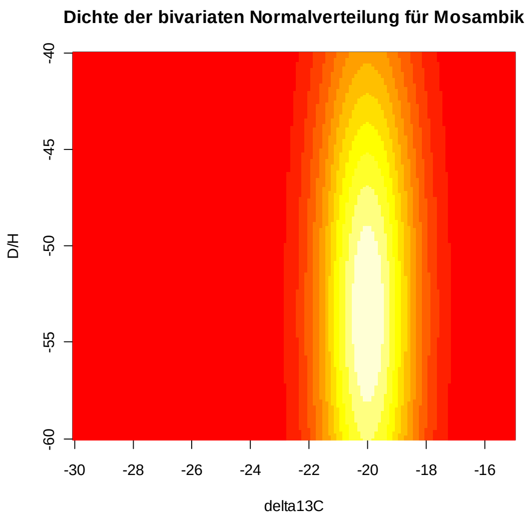


Figure 6a: density of the bivariate function for Cameroon with delta 13C and D/H as variables.	*Figure 6b: density of the bivariate function for Tanzania with delta 13C and D/H as variables.*



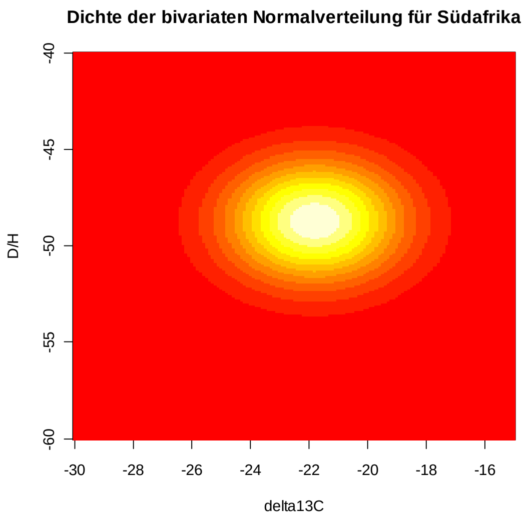


Figure 6c: density of the bivariate function for Mozambique with delta 13C and D/H as variables.	*Figure 6d: density of the bivariate function for South Africa with delta 13C and D/H as variables.*

By using the density function of the bivariate normal distribution, the ivory samples can be assigned with higher probability to their countries of origin. However, the accuracy for the individual countries varies and is highest for Cameroon: values between -24 and -22 for delta 13C and between -60 and -55 for D/H can be allocated to Cameroon unambiguously. Table 3 displays the expected probability for the correct allocation of samples. It is based on a hypergeometrical distribution of a statistical experiment without replacement of the ivory samples.

For example the expected value of correct allocation of the seven samples from Cameroon is 0.18 %. But, based on the delta 13C-values, 70% of the samples from Cameroon can be assigned correctly. And if delta 13C is combined with D/H, the correct allocation increases to 100%, which means that all the samples are assigned correctly. The probability for this to happen randomly is 0.00000076 %.

Concerning Mozambique, the correct allocation of the samples is increased to 62.5 % by combining two isotopes. In the case of South Africa, however, the combination of the isotopes seems to reduce the robustness, because the correct allocation of the samples with delta 13C as single isotope is 100 %. For Tanzania, the correct allocation of samples is only slightly above the randomly expected probability value, both for the individual isotopes and also for their combination. That means that carbon- and hydrogen-isotopes are apparently not applicable for the determination of samples from Tanzania.

Table 3: Expected and tested probability for individual and combined isotopic values. The quantity of the samples in the statistical experiment is n + m = 34; with n = quantity of samples from other than test country and m = quantity of samples from the test country; number of tests

	Single isotope (C or D/H)			Combined isotopes (C and D/H)		
Country	Correctly assigned samples	Expected probability	Test probability	Correctly assigned samples	Expected probability	Test probability
Cameroon	7 (m=10)	0.0018	0.7	10 (m=10)	0.0000000076	1
Mozambique	2 (m=8)	0.355	0.25	5 (m=8)	0.0028	0.625
Tanzania	2 (m=12)	0.0778	0.16	3 (m=12)	0.1995	0.25
South Africa	4 (m=4)	0.00002	1	0 (m=4)	0.5909	0

Summary and future prospects: Based on the fact that mostly samples of low geographic quality were available, the results of the statistic analysis are very promising. Additional geo-referenced samples will increase the accuracy and power of the statistics. It is remarkable that for some countries only two isotopes are sufficient to reach high test probability. But we also observed that there is not a sufficient sensibility for some countries concerning the applied stable isotopes. For these countries better methods have to be developed.

Press relations: During the report period, the German Hunting Association (DJV) carried out active press relations and communication measures to acquire samples for the project. In various newsletters, published by the regional hunting associations and in different hunting journals several articles introducing the project and requesting for samples were printed. Another article was published in the local newspaper of Hamburg (Hamburger Abendblatt). The project was presented several times on meetings and conferences, at last at the general assembly of the CIC in St. Petersburg, and was looked upon very favourably. The leaders of the National Delegations assured their commitment. Besides, the project was described in detail in the CIC newsletter (see annex 1).

Short television reports with two project participants were broadcasted on the German channel WDR and the TV channel of Mainz University, Campus TV. They can be assessed at the links mentioned below (in German):

http://www.wdr.de/mediathek/html/regional/rueckschau/2011/07/11/lokalzeit_bonn.xml

http://www.campus-tv.uni-mainz.de/wordpress/der-kampf-gegen-elfenbeinschmuggel

Publication and presentation of the results: A paper was sent to the European Geosciences Union General Assembly 2011 in Vienna (see below). Unfortunately, the presentation had to be cancelled because the two involved scientists were not able to travel to Austria due to other commitments

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Isoscapes: a panacea to determine the provenance of illegally traded ivory?

Stefan Ziegler (1), Dorrit Jacob (2), and Markus Boner (3)

(1) WWF, Frankfurt, Germany (stefan.ziegler@wwf.de), (2) University of Mainz, Germany (jacobd@uni-mainz.de), (3) Agroisolab, Jülich, Germany (m.boner@agroisolab.de)

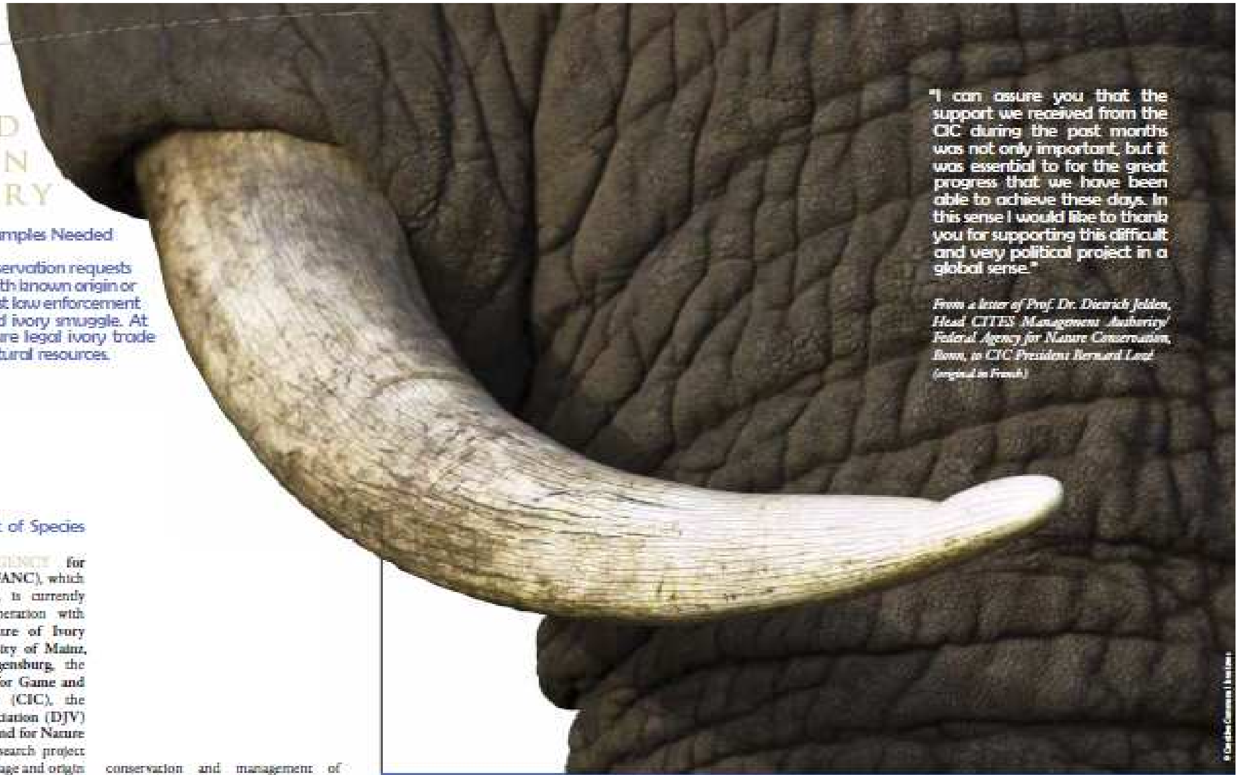
In the 1980s, the international trade in ivory led to a dramatic decrease of the African elephant population in many African countries. In an attempt to counter this decline, in 1989, the international community listed the species in Appendix I of the Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES) thus prohibiting commercial ivory trade. Data from the CITES-affiliated information and surveillance system for trade and smuggle of elephant products show that since 2004, the illegal trade in ivory has been growing in several African countries. Long-term preservation of many of the African elephant populations can be supported with a control mechanism that helps with the implementation of remedial conservation action. Therefore, setting up a reference database that predicts the origin of ivory specimens can assist in determining smuggling routes and the provenance of illegal ivory. Our research builds on earlier work to seek an appropriate method for determining the area of origin for individual tusks. Several researchers have shown that the provenance of elephant ivory can be traced by its isotopic composition, but this is the first attempt to produce an integrated isotopic map of elephant ivory provenance. This map, termed "Isoscapes" systematically integrates a number of different databases from biology, geology as well as isotopic measurements of ivory to eventually allow a statistical determination of the provenance for seized ivory. We are referring to data of the African Elephant Specialist Group (AESG) from the International Union for the Conservation of Nature (IUCN), which has monitored the spatial distribution of elephant populations in Africa on a regular basis and has published their numbers in status reports. These reports contain vector data which spatially represent the range of the different elephant populations in Africa, and thus provide information on local vegetation and climate. Up to now, we collected 93 ivory samples of known geographical origin from museums and private collections in Europe, comprising 18 African elephant range states. However, most museum material did not provide additional information on the finding spot other than the country of origin. We applied a combination of various routine geochemical analyses to measure the stable isotope ratios of carbon, nitrogen, oxygen, hydrogen and sulphur. A regression function for the isotope composition of hydrogen in precipitation and collagen in ivory was developed and applied to overcome the problem of imprecise origin of some of the museum material. We further refined the likely source of provenance of this museum material by comparing the measured stable isotope ratios of carbon with superimposed layers of the MODIS Vegetation Continuous Fields and the Global Land Cover Map 2000 to predict spatial variations in the relative abundances of C3 and C4 vegetation which serve as food plants for elephants. We then computed isoscapes for hydrogen and carbon in elephant ivory using ordinary kriging. Our results suggest that combined maps for a range of isotopic parameters have the potential to provide predictable and complementary markers for estimating the origin of elephant ivory.

Annex 1: Newsletter of the CIC

ORIGIN AND AGE OF AFRICAN ELEPHANT IVORY

CIC Calls for Support: Ivory Samples Needed

The International Council for Game and Wildlife Conservation requests the owners of ivory, in particular of hunting trophies with known origin or age, to support a research project. The project will assist law enforcement agencies in the fight against elephant poaching and ivory smuggle. At the same time, such information is relevant for future legal ivory trade along the lines of CBD's goal of sustainable use of natural resources.



"I can assure you that the support we received from the CIC during the past months was not only important, but it was essential to for the great progress that we have been able to achieve these days. In this sense I would like to thank you for supporting this difficult and very political project in a global sense."

From a letter of Prof. Dr. Dietrich Jelden, Head CITES Management Authority/ Federal Agency for Nature Conservation, Bonn, to CIC President Bernard Lozé (original in French)

Hunters in Support of Species Conservation

THE FEDERAL AGENCY **for Nature Conservation (FANC)**, which is an **IUCN** member, is currently running in close cooperation with the **International Centre of Ivory Studies of the University of Mainz**, the **University of Regensburg**, the **International Council for Game and Wildlife Conservation (CIC)**, the **German Hunting Association (DJV)** and the **World Wide Fund for Nature Germany (WWF)** a research project on the determination of age and origin of ivory from the African elephant *(Loxodonta africana)*. The major objectives of the project are to create a reference database for the geographical origin of African elephant ivory and to develop a readily available, precise method for the designation of the age of ivory. The entire undertaking is part of Germany's contribution to the implementation of the **CITES** African Elephant Action Plan and in particular its strategy 1.4 "Strengthening the enforcement of laws relevant to conservation and management of African elephants". Hence the project shall provide at the latest in early 2013 a useful and readily available enforcement tool to assist in the fight against illegal trade in ivory, which will enable African elephant range states to better control any ivory trade under CITES.

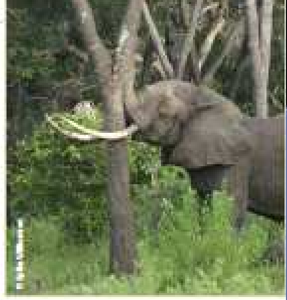
The project is in principle based on the isotopic composition of ivory. For the data-base about 500 ivory samples from African range states will be analyzed and the results combined with the IUCN-SSC African Elephant

Contact

Any owner of ivory who would like to support this important research project with small samples of a quarter gram (origin of ivory must be known) and/or with 10 gram samples (age of ivory must be known) is kindly invited to contact FANC about details and procedures:
Mrs. Karin Hornig *(hornigk@bfn.de)* or Mrs. Claudia Denkl *(denklc@bfn.de)*.

CIC members may also contact the President of the CIC Tropical Game Commission, Dr. Rolf D. Baldus *(rolfbaldus@t-online.de)*.

Shipment of such samples within the European Union does not require any paperwork.



Specialist Group's vector data which spatially represent the range of the different populations and thus provide information on the geology, vegetation and precipitation. For the purpose of the designation of the age of ivory not only the specific activity of radiocarbon, 14C, will be measured but also the specific activity of the strontium isotope 90Sr (related to the element calcium 90Sr/ Ca) and the activity ratio of the thorium isotopes 228Th/ 232Th, which makes the method very precise and reliable.

More detailed information about the project, both in English and in French, can be accessed on the FANC's website: *www.bfn.de >> English version >> CITES-button >> under the heading "Current Issues".*

The 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 CITES authorities of the African elephant range states and to the international community of states. Furthermore plans are underway to inform all CITES parties about the details of the research project and the practical application methods during a side-event at the 16th Conference of the Parties in Bangkok, Thailand in 2013.

1/4 Gram of Ivory Needed

As there are still not enough ivory samples throughout the African elephant's distribution range available for the project, the FANC and the CIC would like hereby to ask for further assistance.

Origin of ivory project: samples of 0,25 gram are only needed. They can be taken from inside the nerve-canal or from the base without damaging the tusk. Origin of ivory must exactly be known.

Age of ivory project: 10 grams of ivory are needed from the base of the tusk. As this will leave a visible mark, it will not practically apply to hunting trophies, but more to ivory in stockpiles etc. The year of the death of the elephant must be known.

Origine et Datation de l'ivoire de l'Eléphant d'Afrique – Appel à soutien du CIC pour la collecte d'échantillons d'ivoire

Le CIC demande aux propriétaires d'ivoire de soutenir son projet de recherche. Actuellement, l'Agence fédérale pour la conservation de la nature (FANC, « The Federal Agency for Nature Conservation »), mène conjointement avec le Centre international des études de l'ivoire de l'université de Mayence, l'université de Regensburg, le CIC, l'Association allemande de chasse (DJV) et le Fonds mondial pour la nature Allemagne (WWF Germany) un projet de recherche sur la détermination de l'âge et de l'origine de l'ivoire de l'éléphant d'Afrique. Les objectifs principaux de ce projet consistent à créer une base de données de référence de l'origine géographique de l'ivoire de l'éléphant d'Afrique ainsi qu'à développer une méthode précise et aisément accessible de détermination de la datation de l'ivoire. Le projet devrait procurer, au plus tard début 2013, un moyen opérationnel utile et aisément accessible permettant de favoriser la lutte contre le commerce illégal de l'ivoire ; cela permettra aux Etats de l'aire de répartition de l'éléphant de mieux contrôler le commerce de l'ivoire sous l'égide de la CITES.

Le principe du projet se fonde sur la composition isotopique de l'ivoire. Une information plus détaillée sur le projet, en anglais et en français, est accessible sur le site Internet de la FANC (www.bfn.de » English version » » CITES bouton» sous le titre "Current Issues").

Les résultats scientifiques du développement et la validation des méthodes de recherche seront publiés dans des journaux scientifiques. De surcroît, la base de données sera présentée aux autorités nationales de la CITES des Etats de l'aire de répartition de l'éléphant d'Afrique ainsi qu'à la communauté internationale des Etats.

¼ de Gramme d'ivoire est Demandé

La FANC et le CIC sollicitent votre concours : Projet origine de l'ivoire : des échantillons de 0,25 gramme seulement sont nécessaires. Ils peuvent être prélevés à l'intérieur du canal nerveux ou sur la base sans endommager la défense. L'origine de l'ivoire doit être connue avec précision.

Projet datation de l'ivoire : 10 grammes d'ivoire sont nécessaires, à prélever sur la base de la défense. Comme cela laissera une marque visible, ce procédé ne concernera pas, en pratique, les trophées de chasse, mais plutôt de l'ivoire stocké dans des réserves etc... La date de la mort de l'éléphant doit être connue.

Contact : Tout propriétaire d'ivoire qui souhaiterait soutenir cet important projet de recherche avec des petits échantillons est convié à entrer en contact avec la FANC pour connaître les détails et modalités. Les membres du CIC peuvent également s'adresser à Rolf Baldus.

« Je peux vous assurer que le soutien que nous avons reçu du CIC pendant les derniers mois n'était pas seulement important, en plus il était essentiel pour achever le grand progrès ce qu'on avait pu faire jusqu'à ces jours-là. Dans ce sens je voudrais bien vous remercier d'avoir agréé de nous supporter dans ce project difficile et très politique au sens mondial. »
D'après une lettre du Prof. Dr. Dietrich Jelden, Chef de l'organe de gestion de la CITES/Agence Fédérale pour la Conservation de la Nature (BfN), Bonn, à Bernard Lozé, Président du CIC

Geografische Herkunft und Alter von Elfenbein des Afrikanischen Elefanten – Elfenbeinproben gesucht: CIC bittet seine Mitglieder und alle Afrikajäger um Unterstützung

Das deutsche Bundesamt für Naturschutz (BfN) führt in enger Zusammenarbeit mit dem Internationalen Zentrum für Elfenbeinforschung der Universität Mainz, der Universität Regensburg, dem CIC, dem Deutschen Jagdschutz Verband (DJV) und dem WWF Deutschland ein Forschungsprojekt zur Ermittlung von Alter und geografischer Herkunft von Elfenbein des Afrikanischen Elefanten durch. Die Hauptziele des Projektes sind eine Referenz-Datenbank für die geografische Herkunft von Elfenbein und eine neue und präzisere Methode zur Altersbestimmung von Elfenbein. Damit soll der Kampf gegen die Elefantenwilderei und den illegalen Handel mit Elfenbein effizienter werden. Auch für den zukünftigen legalen Handel unter dem Dach von CITES sind solche Informationen wichtig, um zu verhindern, dass legalem Elfenbein illegales beigemischt wird.

Detaillierte Informationen über das Projekt, auch auf Englisch und Französisch, enthält die BfN Website (www.bfn.de » CITES-Link » Überschrift „Aktuelles"). Die wissenschaftlichen Ergebnisse werden nach Beendigung des Projektes Anfang 2013 veröffentlicht, und die Datenbank wird allen nationalen CITES-Behörden in den Verbreitungsstaaten des Afrikanischen Elefanten offen stehen.

Ein Viertel Gramm Elfenbein benötigt

Für die Datenbank zur geographischen Herkunft von Elfenbein werden Proben von 0,25 Gramm benötigt. Sie werden innen im Nervenkanal oder an der Basis des Stoßzahns entfernt, ohne den Zahn zu beschädigen. Die Herkunft des Elfenbeins muss genau bekannt sein.

Für die Entwicklung der Methode zur genauen Altersfeststellung werden Proben von jeweils zehn Gramm Elfenbein von der Basis des Stoßzahns benötigt. Da dies zu einer Beschädigung des Zahns führt, kommen hierfür Jagdtrophäen nicht in Frage. Solche Proben werden eingelagertem Elfenbein entnommen. Das Jahr, in dem der Elefant erlegt worden bzw. verendet ist, muss genau bekannt sein.

Kontakt: Besitzer von Elfenbein, die das Projekt mit Proben unterstützen möchten, wenden sich bitte an das BfN für weitere Informationen über das Verfahren.

CIC Mitglieder können auch den Präsidenten der Kommission Tropisches Wild, Dr. Rolf D. Baldus, kontaktieren.

„Ich kann Ihnen versichern, dass die Unterstützung, die wir in den vergangenen Monaten vom CIC erhalten haben, nicht nur wichtig, sondern auch entscheidend war, um die erheblichen Fortschritte, die wir in diesen Tagen erreicht haben, zu verwirklichen. In diesem Sinne möchte ich mich bei Ihnen für diese Unterstützung auf globaler Ebene in diesem schwierigen und politisch wichtigen Projekt bedanken."
Aus einem Brief von Prof. Dr. Dietrich Jelden, Leiter der CITES-Behörde / Bundesamt für Naturschutz, Bonn, an CIC Präsident Bernard Lozé (Original in Französisch)