Estimating age of immobilized elephants from teeth impressions using dental silicon

Henrik Barner Rasmussen[1,2]*, George Wittemyer[3,2] and Iain Douglas-Hamilton[2]

[1]*Department of Zoology, University of Oxford, South Parks Road, Oxford OX1 3PS, England;* [2]*Save the Elephants, PO Box 54667, Nairobi, Kenya;* [3]*Department of Environmental Science, Policy and Management, University of California at Berkeley, California, USA*

Abstract

High precision condensation dental silicon, Zetalabor™, was used to create moulds of the lower jaw molars from 22 immobilized African elephants (*Loxodonta africana* Blumenback) during radio collaring operations. These moulds were used to determine the elephant's age using Laws and Jachmann's molar aging criteria. The technique proved easy and fast and produced useful imprints in 90% of the cases. We found our age estimates, based on physical appearance, made prior to immobilizations were relatively accurate, with 75% within ±3 years and 95% within ±5 years from the age indicated from molar evaluation. When re-collaring the same individuals in 2–3 years, new moulds will be made to compare a known time period with the degree of tooth wear. This will provide verification of Laws age estimates from free-ranging elephants.

Key words: age estimation, dental moulds, elephants, immobilized, molar, Zetalabor™

Résumé

Le silicone dentaire Zetalabor™ (type condensation pour des empreintes de précision) fut employé afin de créer des moules des molaires de la mâchoire inférieure de 22 éléphants africains immobilisés (*Loxodonta africana*. Blumenback), pendant une opération pour les équiper de colliers radio-émetteurs. Ces moules furent utilisés afin de déterminer l'âge des éléphants selon les critères de Law et Jachmann sur le vieillissement des molaires. Cette technique s'avérait en même temps facile et rapide, et produisait des empreintes valables dans 90% des cas. Nous avons trouvés que les estimations d'âge basées sur l'apparence physique, que nous avions fait avant les immobilisations, furent relativement correctes, avec 75% dans une portée de +/−3 ans et 95% dans une portée de +/−5 ans de l'âge indiqué par l'évaluation des molaires. Nous prendrons de nouveaux moules dans 2-3 ans lorsque les mêmes éléphants se feront re-équiper de colliers, afin de comparer une période de temps connue avec l'étendu de la dégradation des dents. Cela nous permettra de vérifier les estimations d'âge des éléphants de terrain non cloissoné faites parLaws.

*Correspondence: E-mail: henrik.rasmussen@zoo.ox.ac.uk

Introduction

Estimating the age of live elephants is important both for assessing population age structures and for examination of age-related effects in behavioural studies. Criteria for the use of physical appearances, such as facial shape and tusk development, to estimate age have been developed (Moss, 1996). This method is assumed accurate to within ±3 years but has not been verified against known aged individuals and may be subject to large inter observer variability. Elephants grow throughout most of their life and shoulder height or hind foot length has been used as correlates of age (Hanks, 1972b; Lindeque, 1993; Lee & Moss, 1995). However, the low annual increment in size of older individuals (25+ years) and inter individual variance creates large confidence limits of age estimates for older age groups. Furthermore, due to possible inter population variation in growth rates resulting from genetic or environmental effects, this technique requires population-specific validation before being applied.

Age can be estimated more accurately using tooth development and wear. Two techniques have been developed; one based on the stage of molar progression (Laws, 1966) and the other based on the number of disappeared molar lamellae (Sikes, 1967). The original categories made by Laws tend to overestimate ages between 10–30 years and a correction has been applied

(Jachmann, 1988). The method by Sikes may be problematic due to varying number of molar lamellae in each of the six molars (Hanks, 1972a; Jachmann, 1988). Both methods suffer from being verified against relatively few known aged elephants in captive settings (Short, 1969; Jachmann, 1985).

For obvious reasons methods involving the measurement of tooth development is difficult to apply to live, free-ranging elephants, thus the less accurate methods involving height and physical appearance are generally used. Due to the technical advances in radio and GPS tracking of animals, increasing numbers of elephant studies involve immobilizing and collaring numerous individuals. This offers an opportunity to apply tooth-ageing techniques to live, immobilized elephants. These more accurately aged individuals can then potentially serve as standards from which the accuracy of other age estimates using physical appearance can be increased. The direct assessment of molar progression by hand during immobilizations has been applied (Whyte, I. pers. comm.) but cannot be verified by independent observers.

In this paper, we introduce a new technique to take tooth imprints from immobilized elephants using Zetalabor™, a fast-acting dental condensation silicon. This material provides a high precision mould of the molars within minutes that can be used to assign the age of an individual. If moulds are taken from the same individuals across multiple year intervals (for example during collar removal), tooth wear can be linked to a known time period and a revision of the current tooth aging technique can be made, helping to improve future aging techniques.

Material and methods

Study site and population

The immobilizations were carried out during 2002 in and around Samburu and Buffalo Springs National Reserves, Northern Kenya as part of Save the Elephants ongoing GPS tracking program. The population consists of approx. 900 individually known elephants (160 adult males and 220 breeding females), identified since 1997 by Save the Elephants monitoring program (Wittemyer, 2001). The year of birth of all adult individuals in the study population has been estimated as part of the monitoring program using the ageing criteria developed in the long-term elephant study in Amboseli (Moss, 1996).

Material and moulds

For the moulds, we used Zetalabor™ high precision condensation silicon from Zhermark® with Indurent Gel® catalyst. After adding the catalyst to the silicon and mixing for 2 min, this silicon hardens (within 6 min) without heating up, producing a hard but elastic mould that stays shape/dimensional stable for several days with only minor changes at later times.

After immobilization, the distance between upper and lower jaw was investigated by hand to assess if enough working space existed for tooth moulding, which was the case in most situations. Any grass or branches between the jaws were removed by hand to provide a clean molar surface for the mould. Thereafter, the catalyst was added to 400 g of pre-measured silicon. After mixing, the putty was inserted into the mouth by hand and pressed onto the molar surface in the lower jaw. During the hardening process, the substance was continuously worked around the tooth to improve the final mould.

The mould was then used to assign age categories according to Laws (1966) incorporating the adjustments suggested by Jachmann (1988).

Results

Dental moulds were made on ten adult bulls and twelve females. An example of one of the moulds can be seen in Fig. 1. All but two moulds (females) proved accurate enough to assign age categories.

The immobilized individuals ranged from an estimated age of 21–46 years. In Fig. 2, eight moulds representing the age range are shown. In approximately half the cases,

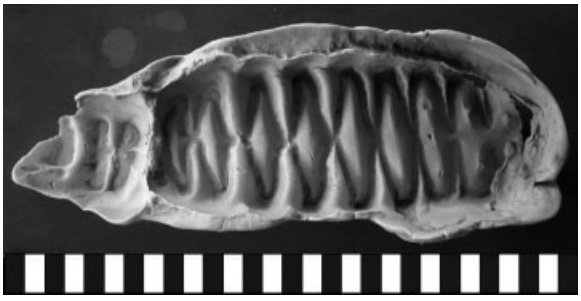

Fig 1 Mould of the lower jaw molars of a bull. Anterior end right, posterior end left. fifth molar in full use, sixth molar starting to wear on first two enamel loops. Age-group XVIII, 30 ±2 year old (Laws, 1966;Jachmann, 1988). 1-cm between measurement marking

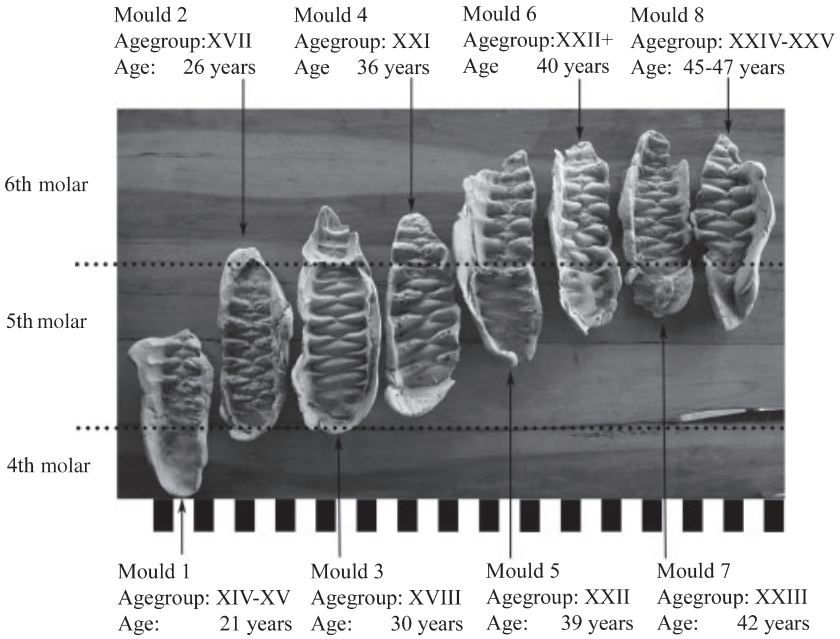

Fig 2 Example of eight moulds of lower jaw molars from bulls arranged according to age. Note that some moulds are incomplete, missing the posterior part. However, enough information is preserved in the mould to assign age group. Age groups according to Laws (1966) and Jachmann's (1988) revision. 1-cm between measurement marking

the material could not be pressed all the way to the back of the last molar and thus gave an incomplete mould (see mould 1 and 4 in Fig. 2). However, enough information was preserved in the mould to assign an age.

To evaluate the accuracy of the age estimates based only on physical appearance, the 20 estimates based on moulds were combined with the eleven estimates based on hand assessment of molar progress and six molar estimates from the jaws of known dead individuals. Of these 37 individuals, 28 (75%) of the age estimates based on physical appearance were within ±3 years from the molar age and only two (5%) deviated more than 5 years (Fig. 3) with a tendency for slightly underestimating the age of bulls and overestimating females.

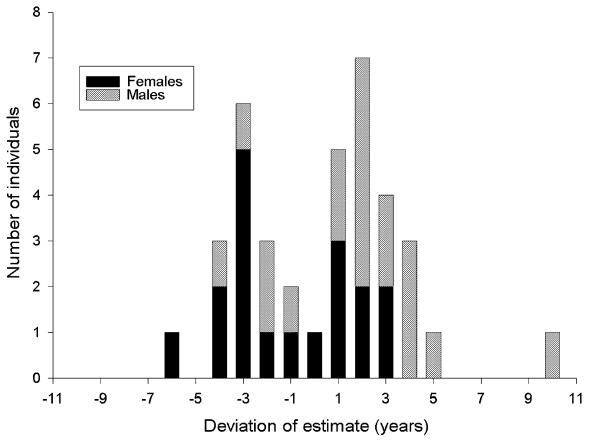

Fig 3 Deviation of age estimate based on physical appearance from estimated based on molar state. 75% of estimates based on physical appearance were within ±3 years and 95% within ±5 years from molar age

Discussion

The Zetalabor™ condensation silicon proved highly suitable for obtaining good imprints of the lower jaw molars in the majority of cases. Obtaining a good mould in females turned out to be slightly more difficult than males, probably due to the generally smaller size of females resulting in a smaller working space between the upper and lower jaws. The two cases where the moulds failed completely were caused by adding an un-precise amount of Indurent Gel catalyst, resulting in the material hardening too fast to shape it properly in one incident and the material not hardening enough in the other, and thereby breaking apart when pulled from the mouth. With experience and care when measuring out the catalyst, such incidences can be reduced or avoided. Further, using clean hands or vinyl gloves when mixing and applying the 'putty' is important,

as impurities in the material will adversely affect the settings of the material. Other materials on the market were not tested. However, other brands with similar specifications are likely to have similar performance as long as the material does not heat up during the hardening phase (like dental acrylic) and stays elastic to enable the removal of the mould. A very fast acting material (hardening within <4 min) is not recommendable as difficult conditions during the operation, such as place and position of the head may require a few minutes of working time in order to shape the material properly around the molars.

The mould produced by Zetalabor^{TM} stays dimensionally stable for at least a couple of days with only minor changes thereafter. However, to preserve the mould it is recommendable to make a cast of the mould using e.g. dental acrylic. This has the additional advantage of producing a 'positive' copy of the molar.

The assignment of the molar number (M1-M6) proved straightforward. Measurement of length and width of the molar imprints was done to assign molar number. However, this was unnecessary as the age difference between the same molar state of consecutive molars are large, especially in 15+-year-old individuals. For example mould#5 in Fig. 2 would give either age-group XIV (20 years) if the mould represented molars M4 and M5, or age-group XXII (39 years) if the mould represent M5 and M6, a difference large enough to tell apart having seen the live animal.

A complete mould was not obtained in all cases, with the missing part being the extreme posterior end. In the event where imprints of two molars could be seen, an age group could easily be assigned even with a missing posterior part as the necessary information for age group assignment exists in the degree of wear of the far-most (oldest) molar (Fig. 3 moulds 1, 4, 5, 6). In case no evidence of two molars could be seen in an incomplete mould (Fig. 3 mould 8), an attempt to feel the posterior part by hand was made during the immobilization. Even without the use of this undocumented information, imprints of a large enough part of the molar were present in all cases to assign an approximate age based on the possible 2–3 consecutive age groups. Comparing the age estimates based on physical appearance with that obtained from molar state showed that 75% were within ±3 years and only a single individual (Bull, molar age 40 years) was severely overestimated by 10 years. This supports the previous assumption that elephants can be relatively accurately aged by their physical appearance. However, using the technique described in this paper can provide a number of known aged individuals that can be used as reference points hereby increasing the accuracy of estimates of the remaining individuals in a population using height and physical appearance.

The age groups and associated ages presented in this paper follow the age groups described by Laws (1966) incorporating the changes proposed by Jachmann (1988). These ages may not be as accurate as described by Laws, especially for 30+-year-old individuals. However, by taking multiple moulds of a group of individuals in various age groups, separated by 2–3 years, it will be possible to assign duration to a specific amount of wear and development. Hence, this technique could provide a 'ground truthing' of Laws aging technique on free-ranging elephants.

Acknowledgements

We wish to thank Zenith Dental, Denmark for donating the Zetalabor^{TM} material. Furthermore, we would like to thank the Kenyan Office of the President and the Kenya Wildlife Service for permission to work in Samburu and Buffalo Springs National Reserves. David Daballen, Lugard Lenaiyasa and Daniel Lentipo provided valuable help during the immobilizations. This work was supported by The International Elephant Foundation, Iain Douglas-Hamiltons's Dawkins Prize and Save the Elephants donors.

References

HANKS, J. (1972a) Aspects of dentation of the African elephant, *Loxodonta africana*. *Arnoldia* **5,** 1–8.

HANKS, J. (1972b) Growth of the African elephant (*Loxodonta africana*). *E. Afr. Wildl. J.* **10,** 251–272.

JACHMANN, H. (1985) Estimating age in African elephants. *Afr. J. Ecol.* **23,** 199–202.

JACHMANN, H. (1988) Estimating age in African elephants: a revision of Law's molar evaluation technique. *Afr. J. Ecol.* **26,** 51–56.

LAWS, R.M. (1966) Age criteria for the African elephant, *Loxodonta africana*. E. *Afr. Wildl. J.* **4,** 1–37.

LEE, P.C. & MOSS, C.J. (1995) Statural growth in known-age African elephants (*Loxodonta africana*). *J. Zool. Lond.* **236,** 29–41.

LINDEQUE, M. (1993) Post-natal growth of elephants *Loxodonta africana* in Etosha National Park, Namibia. *J. Zool. Lond.* **229,** 319–330.

MOSS, C. J. (1996) Getting to know a population (Chapter 7). In: *Studying Elephants* (Ed. K. F. KANGWANA). African Wildlife Foundation, Nairobi.

SHORT, R.V. (1969) Notes on the teeth and ovaries of an African elephant (*Loxodonta africana*) of known age. *J. Zool. Lond.* **158,** 421–425.

SIKES, S.K. (1967) The African elephant, *Loxodonta africana:* a field method for the estimation of age. *J. Zool. Lond.* **154,** 235–248.

WITTEMYER, G. (2001) The elephant population of Samburu and Buffalo Springs National Reserves, Kenya. *Afr. J. Ecol.* **39,** 357–365.

(Manuscript accepted 2 July 2005)