6528

Aging the Southern Central Black Rhino (*Diceros bicornis minor*) by horn size and configuration, tooth emergence and wear

A compilation of aging information

from

John Goddard Peter Hitchins
Keryn Adcock Dr Peter Morkel Dr Peter Goodman
Hans Bjane Hansen Richard Emslie Dr Bob Keffin
Hanne Lindemann and Craig Reed
by Keryn Adcock

This compilation was sponsored by
Wild Solutions ®, the Endangered Wildlife Trust, and WWF (SA)

1997

Introduction - Why aging rhino is important

Careful management has become necessary to conserve the planet's remaining black rhino (c.2450 in 1995). As custodians of the largest numbers of black rhino, we in South Africa need to breed them up as fast as possible to even greater numbers, as a buffer against the poaching onslaught, and to maintain their genetic diversity for their long term evolutionary survival. (Rhino Management Group Conservation Plan for Black Rhino, Brooks 1989).

Knowing the age composition of our populations, helps us to understand observed levels of breeding performance, and to make informed removal and introduction decisions, toward maximise rhino numbers:

Age-related life history characteristics of black rhino important to management

- The average age at first calving (AFC) in *D.b.minor* is 6-8 years. AFC can be affected by the body condition (weight) of the female rhino, that is, her nutritional status, and thus the condition of the vegetation with respect to black rhino stocking rate. A female needs to be at or in excess of 80% of her full adult weight (Owen-Smith 1988) to successfully conceive and carry a calf full term.

  Although rhino of 4 years or so can conceive, this is probably only under exceptional conditions.

  Black rhino often exceed 80% of adult weight at about 5 years (c. 850kg vs c.1050kg), and it may take longer for them to reach this weight and successfully conceive or bear a calf, if nutritional conditions in the habitat are not right.

  Knowing female rhino ages helps one understand when a population's young females are likely to calve for the first time, and helps indicate the relationship between the vegetation condition and the breeding performance.

- Towards the end of a rhino's life, the cutting surfaces of its teeth wear down, and become less effective in biting off food and grinding it up. Years of eating chemically defended plants take their toll on the rhino's liver (like alcohol does in humans). Nutritionally, old female rhino will not be in as good a position to successfully conceive, carry and raise a calf, especially given the heavy energy demands of late pregnancy and lactation. Inter-calving intervals may lengthen, young calves not be successfully raised, and breeding performance may decrease as the rhino ages (probably from about 28 years old on).

- Male back rhino are sexually mature at 4 or so, but not socially mature. Normally males will not be very successful in getting themselves a territory, or mating, until about 10+ years old. In many smaller areas, mature black rhino carrying capacity is limited socially. Social unrest, fighting, injuries and death result from excess maturing males.

- Calves can become independent of their mother at 1.5-2, although they usually hang around mom if she lets them for many more years. Such independent animals at 3+ may look superficially like part of the adult breeding population, but if counted as adult will give a false idea of the breeding potential of the population. These sub-adults will need 3 or more years before they reach adulthood and breed.

- Sub-adults may be independent of their mother nutritionally, but their life skills, both social and in terms of getting by in the habitat, are still developing. Young rhino are often insecure, lonely and less effective at finding the right food, water, and avoiding life's hazards.

Translocations of rhino, which are highly stressful at the best of times, are far more so for youngsters. Experience in Africa indicates to us that translocating young rhino holds increased risks of mortality. The recommendation is that rhino, especially females, of <4 years old are not translocated, unless sub-adult only groups are taken and put into safe areas free of other rhino.

- Translocating old rhino to start new populations is not really worth the cost and effort, given the limited contribution these animals can make to build up rhino numbers.

About this document

This document aims to provide in one place, a guide to aging black rhino by various different methods.

This document is a summary of aging techniques from work done by the compiler and a number of other people, as detailed in each section and the references.

- These approaches to aging rhino apply only to *D.b.minor* in South Africa. The extent of their relevance to other sub-species of black rhino, or to this sub-species elsewhere, in Africa is unknown.

- No claim is made that exact ages can be given by these approaches.

People should add to and adapt this guide for their own populations as they feel necessary.

Contents:

1: Aging sub-adults (<7) by horn appearances (configuration)

This information comes from the annual photographs of Pilanesberg black rhino by Hans Hansen and Hanne Lindemann, the compiler; and some from photographs of known aged rhino in Hluhluwe-Umfolozi Park and Mkuzi. Craig Reed provided a photographic series of horn growth in calves up to 6 months old. This approach is a revision of the horn aging given in Emslie et. al. (1993).

Sub-adult black rhino (<7 years) can be aged quite well by horn appearance. Like recognising individual Chinese, models of Boeing, or wines, the ability to do this does not come overnight, but through paying attention and with careful observation.

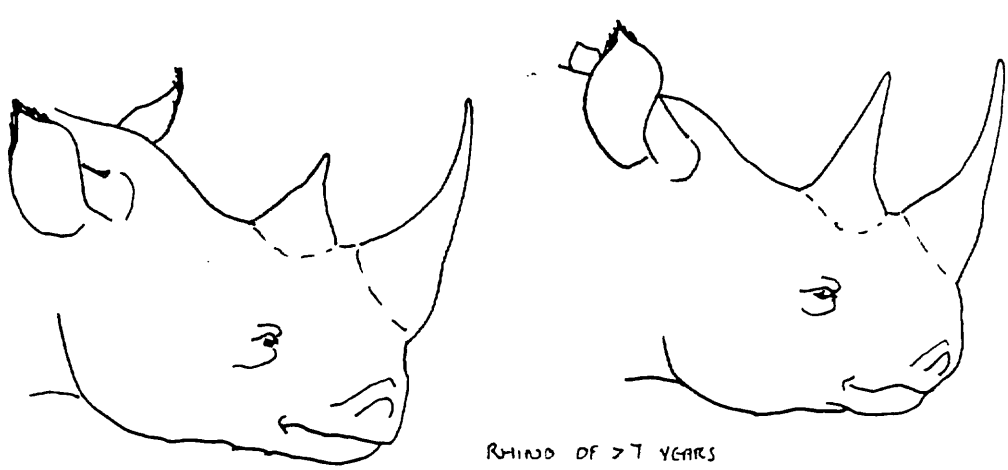
The figures show on average what rhinos' horns look like at different ages. Each rhino wears its horns differently, so look for the general jizz, not an exact match of your rhino's horns with the pictures. Look out for horns that have broken or been damaged so as to distort the dimensions.

- Look at the general relationship between the length and fatness of the front and back horns.
- Compare the length of the back horn to the length of the rhino's ear lobe.
- Note the dumpiness (or sharpness) of the horns, and the wideness of the horn bases, especially in the back horn.

NB: when you have photographs of black rhino, always write on them the date the photo was taken and the age or birth date of the rhino.

Telling rhino of >=7 versus younger rhino

In black rhino of 7-8 or so years old, the back horn is of similar size to the ear, *usually* over 15 cm tall (can be less- 12.5cm, or up to 24cm). The back horn base is quite wide, and tapers to a sharp point either from a side view as shown, or a front view (unless the tip has broken off as can often occur). The back horn often tapers so as to form a nipple shape, in males and females, especially in Umfolozi. Worn dents, cracks and an asymmetrical outline in the back horn is characteristic of animals of over 7 years.

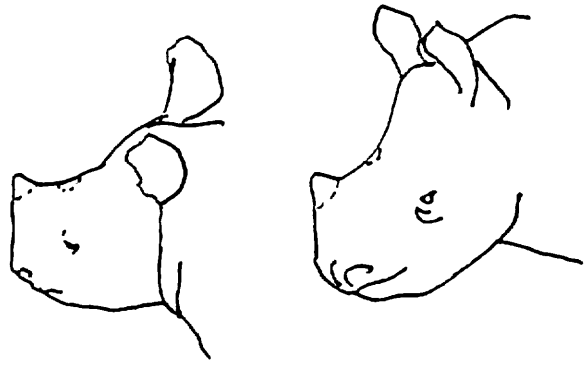


RHINO OF >7 YEARS

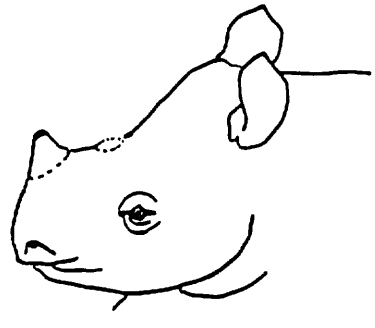
0-1 month

1-2 months

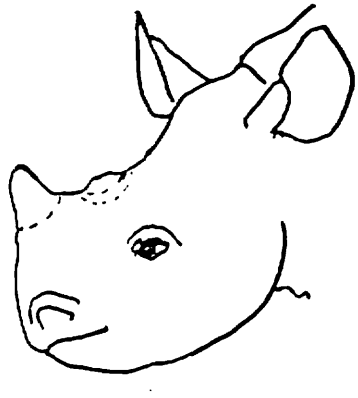
2-3 months

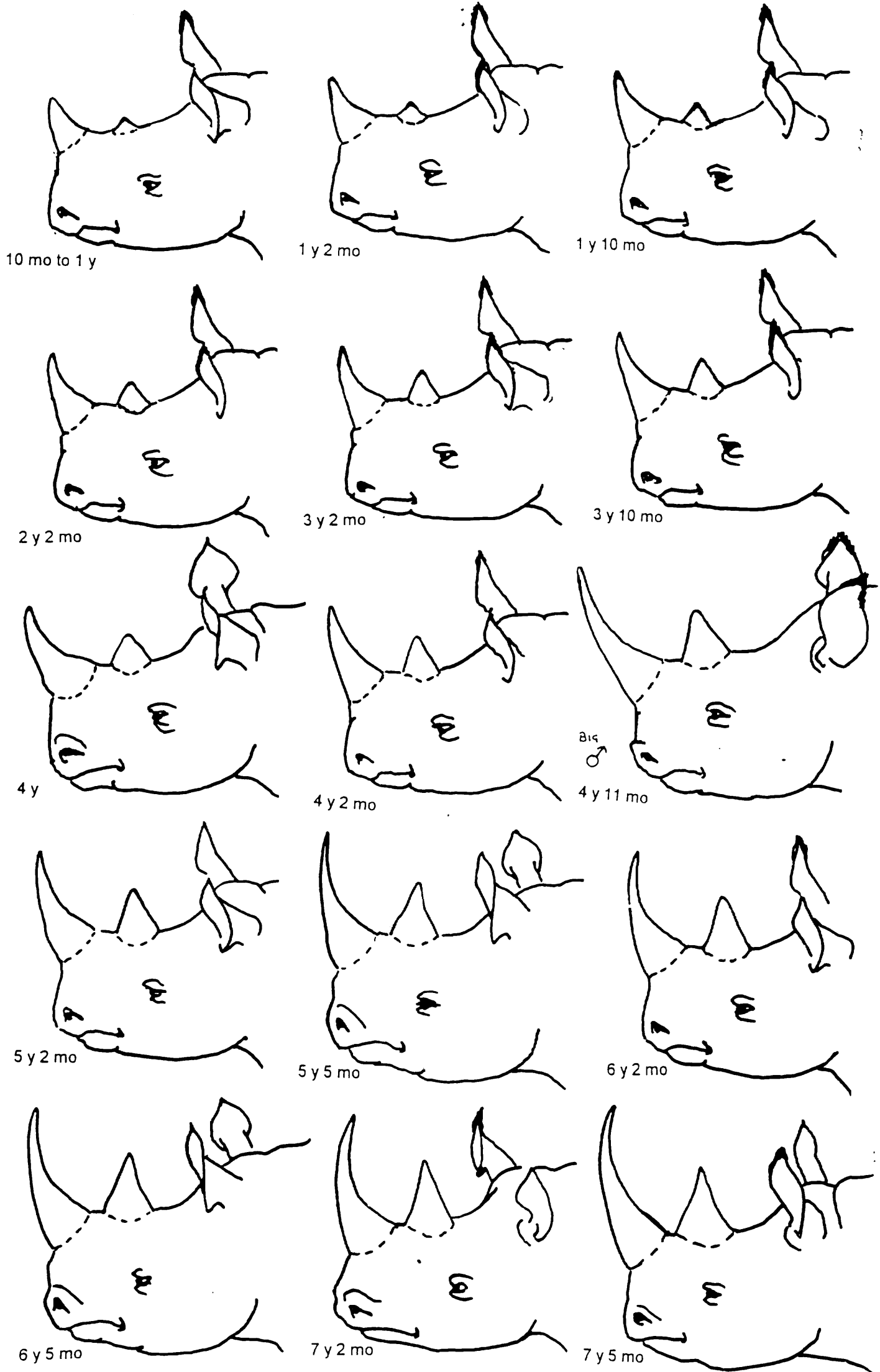


3-4 months



4-5 months

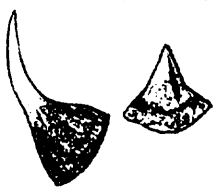



10 mo to 1 y
1 y 2 mo
1 y 10 mo
2 y 2 mo
3 y 2 mo
3 y 10 mo
4 y
4 y 2 mo
Big
4 y 11 mo
5 y 2 mo
5 y 5 mo
6 y 2 mo
6 y 5 mo
7 y 2 mo
7 y 5 mo

2: Aging sub-adults (<7) by horn measurements

For immobilized rhino or rhino mortalities, measurement of the length and basal circumference of the front and back horn can be used to age sub-adult and juvenile black rhino. *All four measurements are needed for a reasonable age estimate.* A very fuzzy estimate will be obtained with fewer measurements.

The length of the back horn (assuming it has never broken) can be used to roughly age adult females in most reserves (Goodman, pers. comm.) In females, the back horn is not worn as much as in males, and it usually increases in length as the rhinos age. Males usually wear their horns much more, and often have relatively short front and back horns which have fat bases and are thorn- shaped (especially in Umfolozi).



Horns of an older male

Aging sub-adult black rhino (<7 years old)

Horn size data from black rhino in Pilanesberg, Hluhluwe-Umfolozi, Itala, Ndumu , Eastern Shores and the Great Fish River Reserve was used to compile curves of each horn dimension versus rhino age up to 9 years.

NB: Although 9 years are given in the graphs, aging by horn dimensions as described below only works up to about 6.5 years.

To tell whether you have a rhino of 7 or more years, look at the body size and overall horn appearance (see Section 1 on aging by horn configuration). Rhino of 7+ years may age out at 6.5-8 if you try to use these graphs - don't.

The curves represent the current sum of available horn /age information, and give a good idea of what by far most rhino horn growth is like. *The occasional rhino does have one or more horn measurement that is atypical and falls outside the curve for its age.* Particularly, young males may be aged at older than they really are (by 1 to 1.5 year). Generally the age will be correct to within 6-8 months.

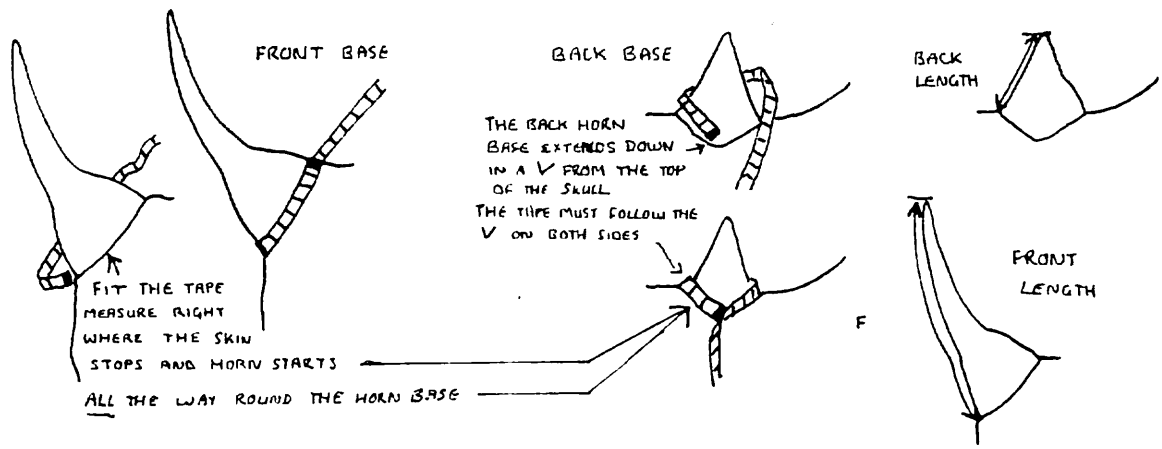
Horn measurements from *known* aged rhino can be used to update and modify the curves to suit the rhino in your particular area.

Taking horn measurements

- Horn measurements must be taken as accurately as possible (to the nearest 1/2cm) as shown below.
- When measuring horns removed off dead rhino, make sure the basal circumference is really the base of the rhino's horn as when it was alive. I.e., make sure the horn has not been hacked off leaving a bit of the base behind, or that the base has not been chewed by hyaena etc. Many horn measurements off mortalities are inaccurate because of this.

- **NB: The basal circumference (diameter) of the front, and especially the back horn, must be taken 2-3 times**, carefully, until you are satisfied you have accurate measures. These measurements are difficult to take and quite wrong readings can easily be obtained if one is not careful.

- Look out for any signs of horns having broken or been damaged in the past. Note such cases. Also look for and note any horn dimension that seems obviously unusual. In the case of broken/damaged horns, you may be able to extrapolate to the approximate size of the horn if it were undamaged.



Using the graphs of horn size versus age for sub-adult black rhino

- For each of the horn dimensions:

  Find the measurement on the upright (left) axis of the relevant graph.

  Go along until you reach the centre curve,*
  and going straight down from this point, read off the age and write it down.

  For the front horn length, use either the male curve or the female curve, depending on your rhino's sex. If the sex is unknown, take a reading between the male and female curve.

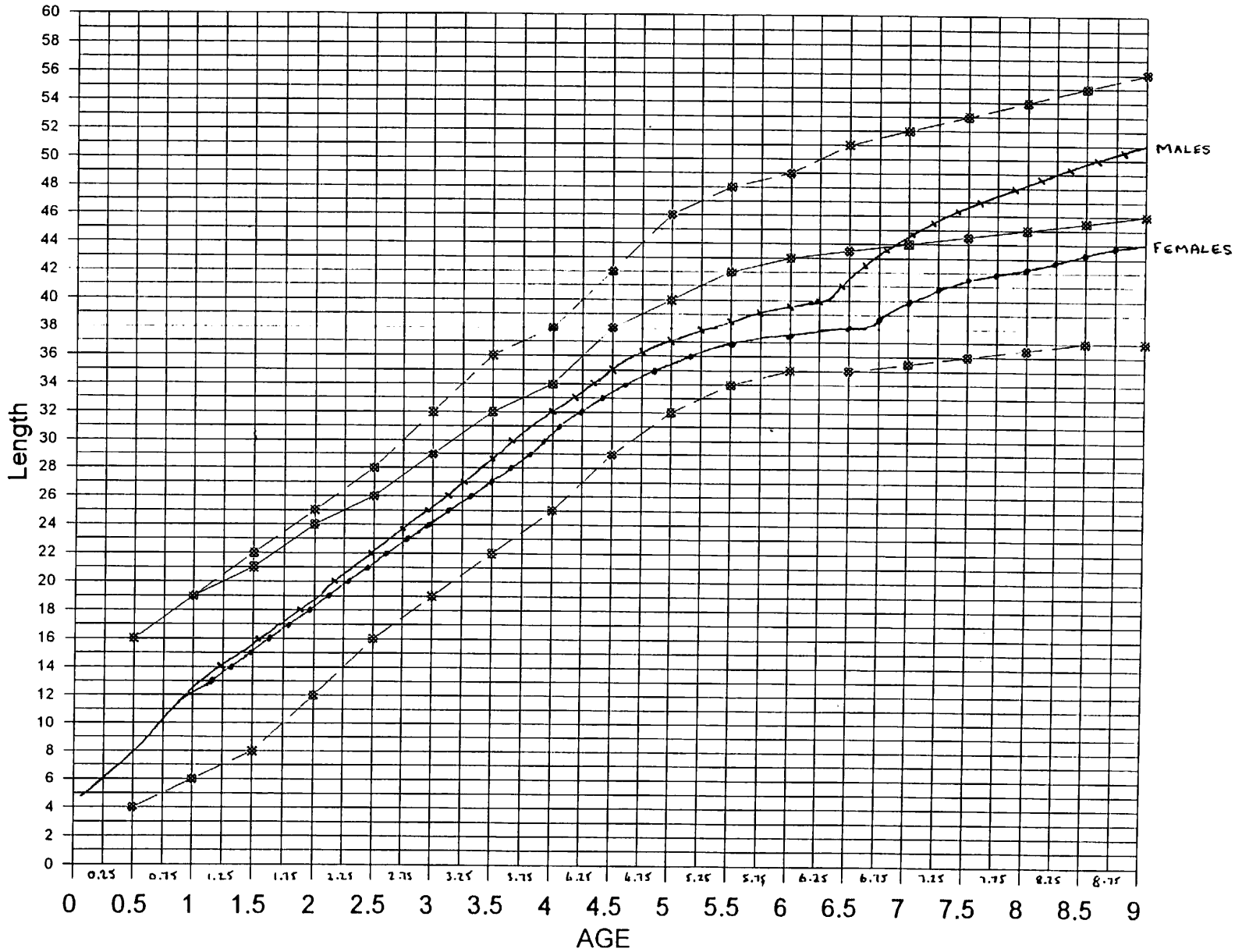
- Take the average of the 4 ages as the best estimate of your rhino's age.

For example: (from Appendix 2)
front base 54cm -> 7yrs back base 30cm ->3.2yrs
front length 38cm -> 5.2yrs back length 12cm -> 4.5yrs
Average age from horns = 4.98yrs (="Jules", known age 5+- 6months).

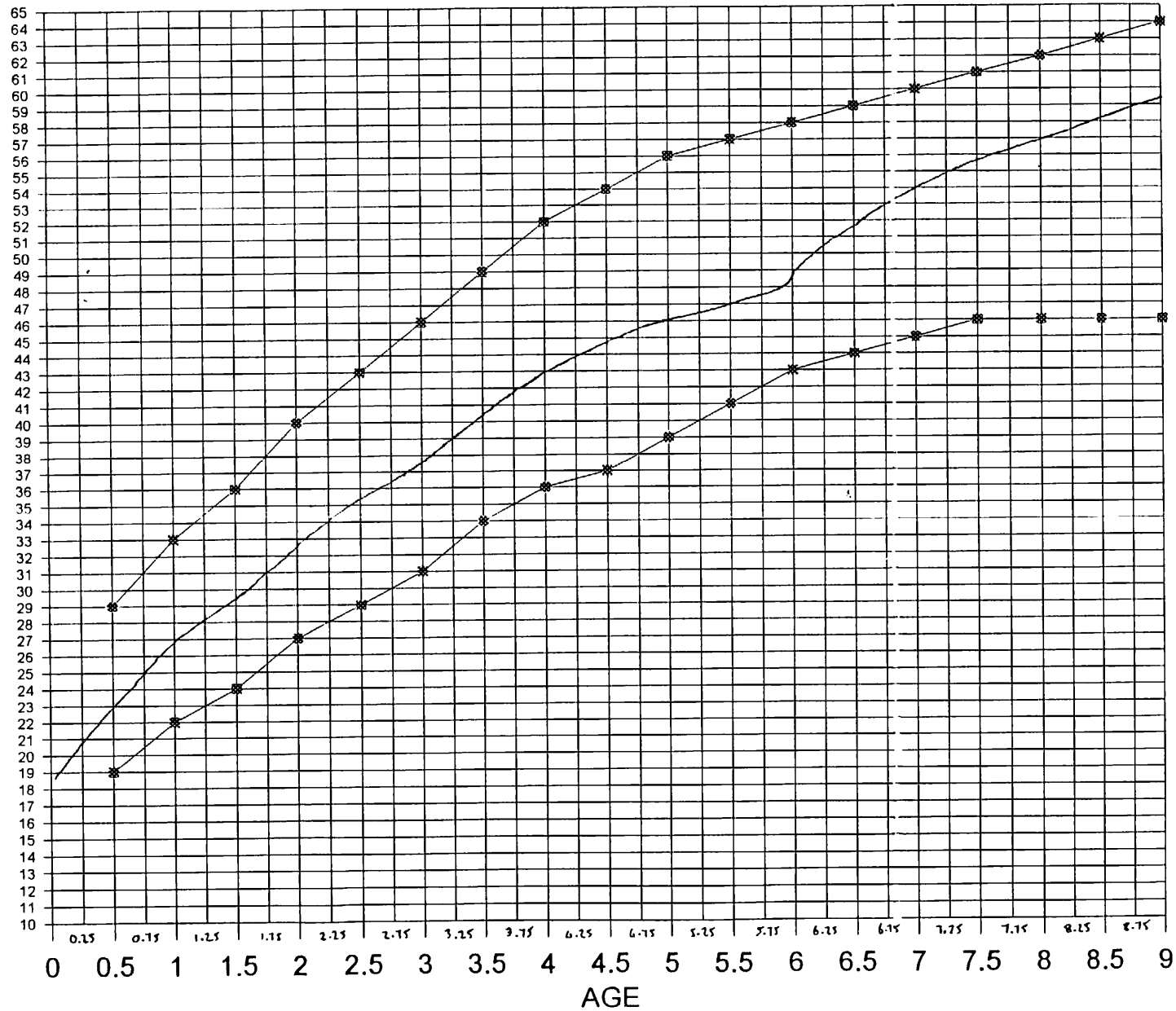
About the centre curves:
The centre curves represent a combination of 2 relationships between horn size and age:
1) for a given age, the average size of a rhino's horn
2) for a give horn size, the average age (0-9 years) of rhino with such a horn.

These relationships represent two realities:
1) horn size varies with age; and horn measurements are not exact.
2) although we have used "known-aged" rhino for this method, we do not know the exact ages of the rhino, i.e. our aging is fuzzy to a greater or lesser extent (see appendix 2)

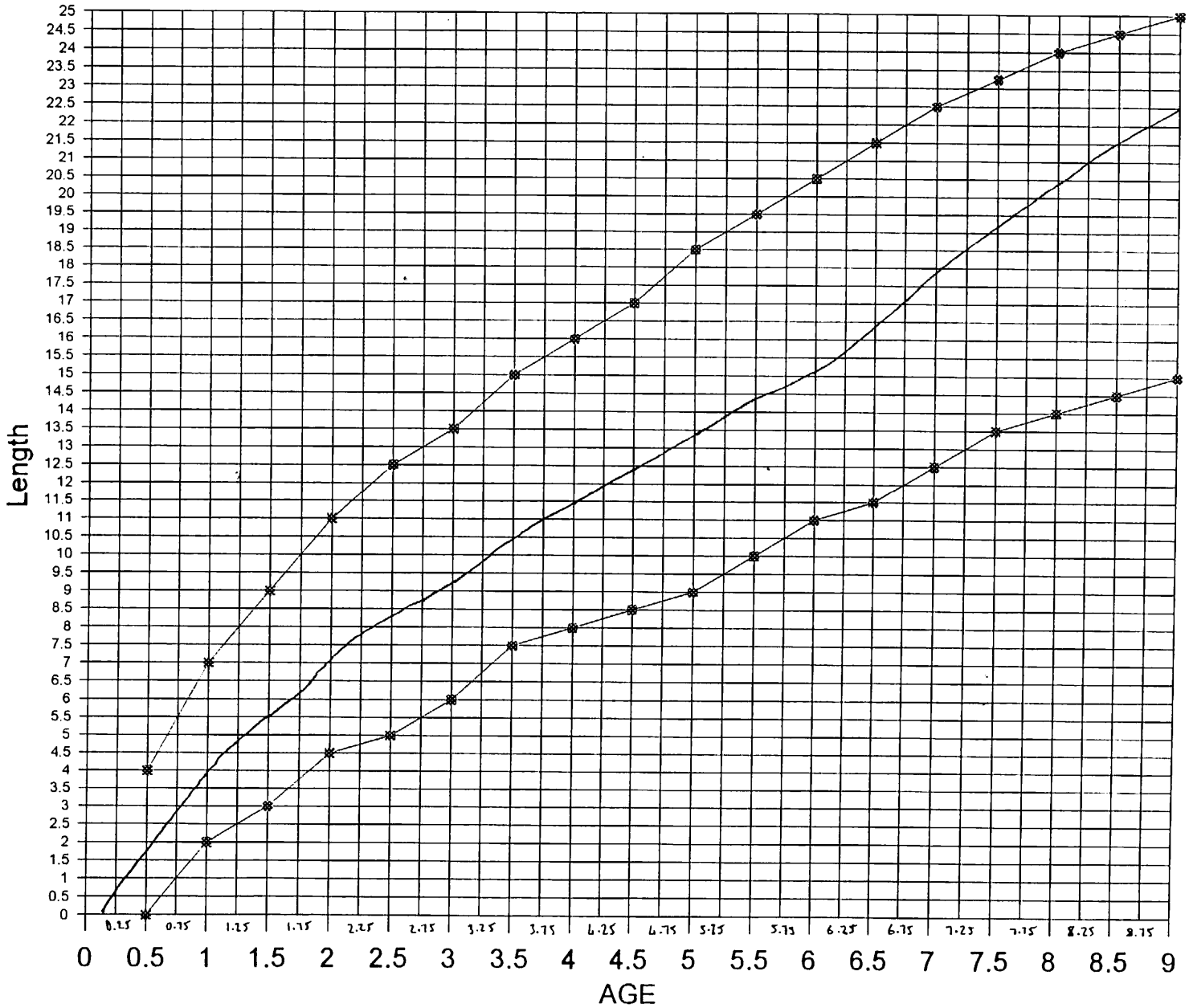
Front Horn Length



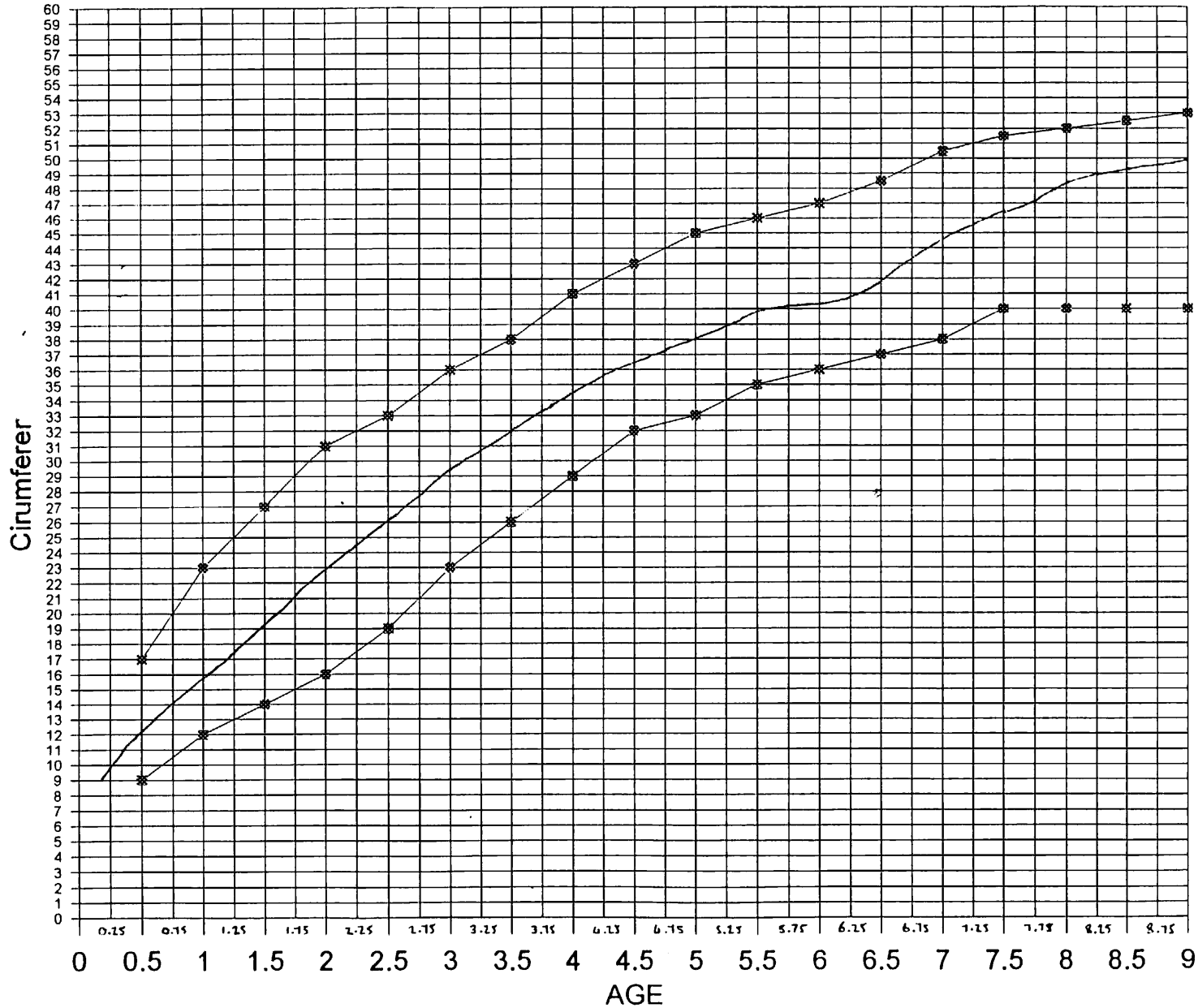
Front Horn Base



Back Horn Length



Back Horn Base



3: Aging black rhino by tooth emergence and wear

This summary comes from Hitchins (1978), Goddard (1970). The two's work has been merged and put in plainer English, using Hitchins' pictures, to form a single set of guidelines. Based on recent independent data consisting of tooth impressions of known aged animals, inspection of the teeth of dead animals of known age, and corresponding horn dimensions of dead rhino, the ages associated with particular tooth wear has been found to be closer to those given by Goddard for animals up to +- 14 years old (ie slightly younger than Hitchins') while Hitchins' ages are assumed to apply to rhino older than this. Goddard's criteria are also based on many more known-aged young rhino than Hitchins'.

Guidelines on aging by tooth height of premolar 3 are provided by Dr Pete Morkel.

Dead or immobilized rhino can be aged by this approach. ***Note that the accuracy of aging by tooth wear and emergence still needs to be more widely tested and improved, using more information from known-aged rhino.*** However, it seems that the approach is accurate to within about 10 months for rhino < 4 years old, to within 14 months for rhino up to 7, within 2.5 years up to 13, and to within 3-5 years thereafter as age increases.

Aging an immobilized black rhino

Aging by tooth emergence and wear

If time and conditions permit, tooth impressions can be obtained as described by Wucher (1994).

Otherwise, a rough idea of the rhino's age can be obtained by examining the front teeth (especially premolar 1-3. I have found that if the rhino is lying on its side, the mouth opens easily on its own and can be opened further with the help of a couple of people. The pre-molars can then easily be seen on the top and the bottom jaw, if the lip and corner of the rhinos mouth are pulled back.

- First decide whether you're dealing with a rhino of < 7 years old (i.e. body size is not that big, horn appearance like those of an animal of <7). A rhino of 7 or more years should have its permanent premolars fully erupted and in wear; the first premolar, (runty little thing) will be worn to well worn, and have no folds and holes left, but may still be dented.

- Look at the wear pattern on the premolars, and compare them to Hitchin's pictures.

- Rhino of +-4.5 to +-6.5 are losing their milk (deciduous) premolars and the permanent premolars are erupting (gum may be swollen in this area).

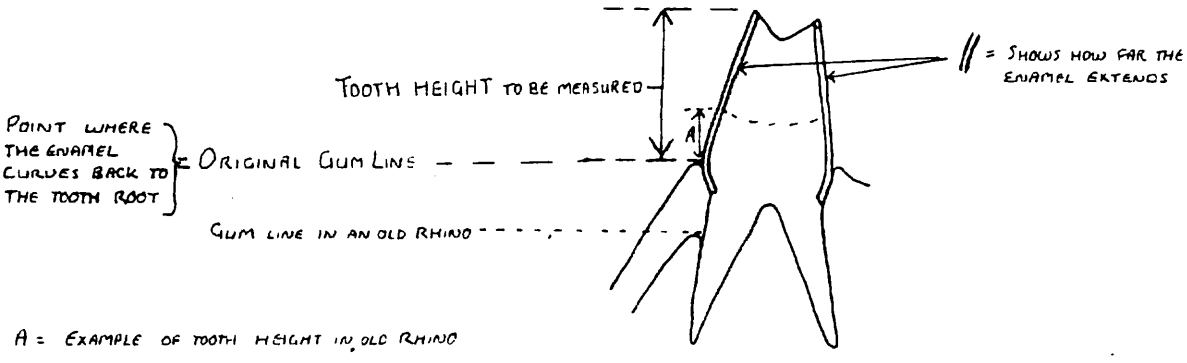
- Rhino of less than about 4 have their milk (deciduous) premolars (PM2 to PM4). Rhino of 3-4.5 have worn premolars that look a bit like those of a 8-10 year old rhino. The size of the animal and horn appearance should easily tell you whether you have a young rhino or a fully adult animal. If you can distinguish the individual teeth by feel, you will see that there are at most 5, with the last being molar 1, and molar 2 has not yet appeared or may be just piercing the gum.

- For rhino which seem to be 7 years or older, assess the wear on the premolars on the bottom jaw. You should at least be able to class the rhino as follows:
  7-9 (still has big dents in PM2) 10-18 (still has big dent in PM3)
  18-31 (still has small dent/slit in PM3) >31 (virtually no, or no slit in PM3)

Aging by tooth height on PM3

This technique is provided by Dr Pete Morkel.* It is based on the wear on the third permanent premolar (PM3), and is relevant to rhino of 7 or more years old. The technique is quick and easy to apply, and although less accurate than tooth impressions, is adequate to get a rough age estimate that can be used to make " on the spot" management decisions (such as not to bother translocating an old rhino to start a new population).

The aim is to measure the lateral (cheek) height of the tooth between the grinding surface and the original gum line. As rhino age, the gum line retreats. One must measure to where the original gum line was - with practice this can be done accurately enough:

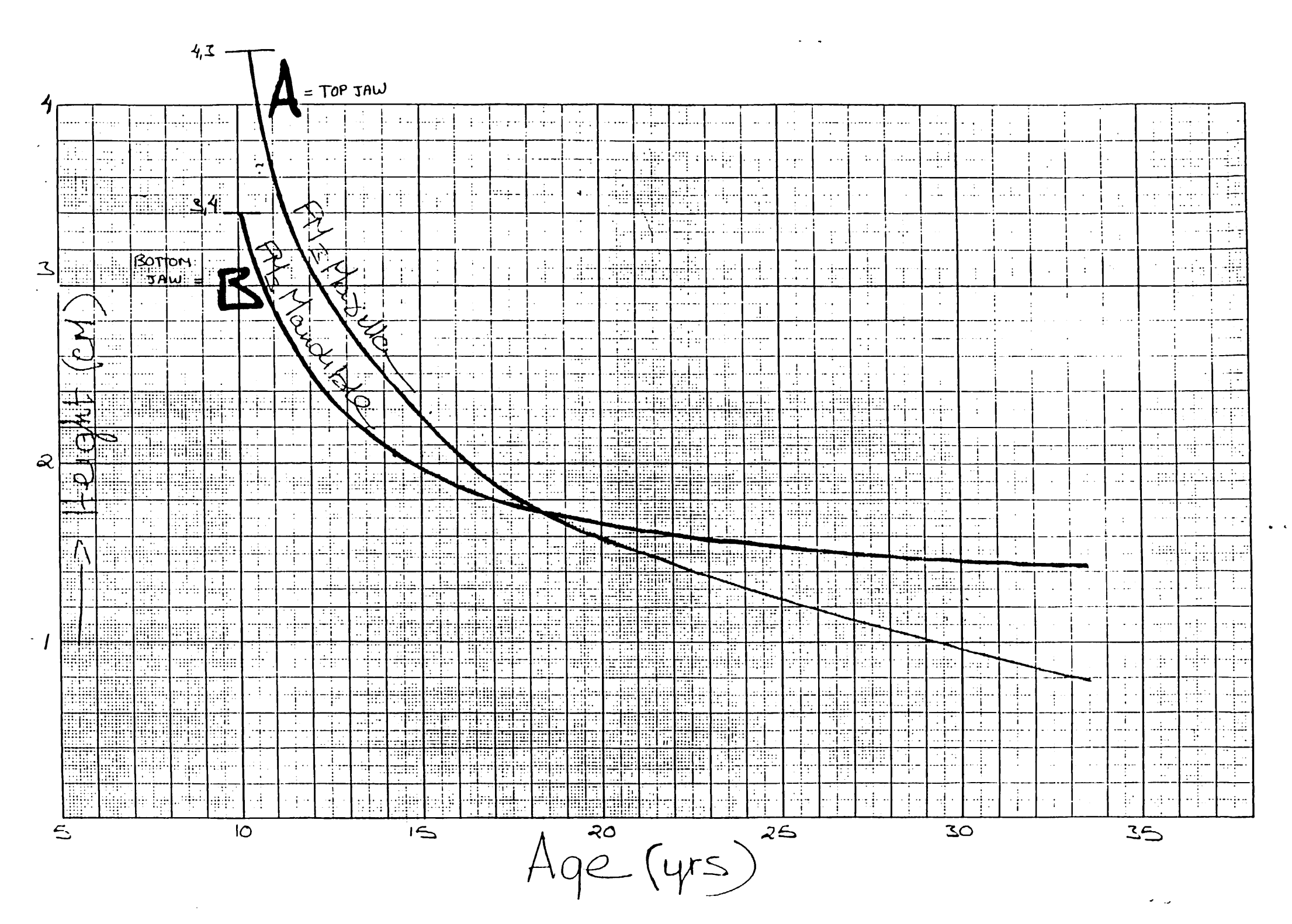


Cut off 5 cm of a plastic ruler to use in measuring the tooth height. Measure both the top and bottom jaws' PM3, or at least the top jaw's.

Read the rhino's age off the graph using the heights measured: (line A for the top jaw, line B for the bottom).

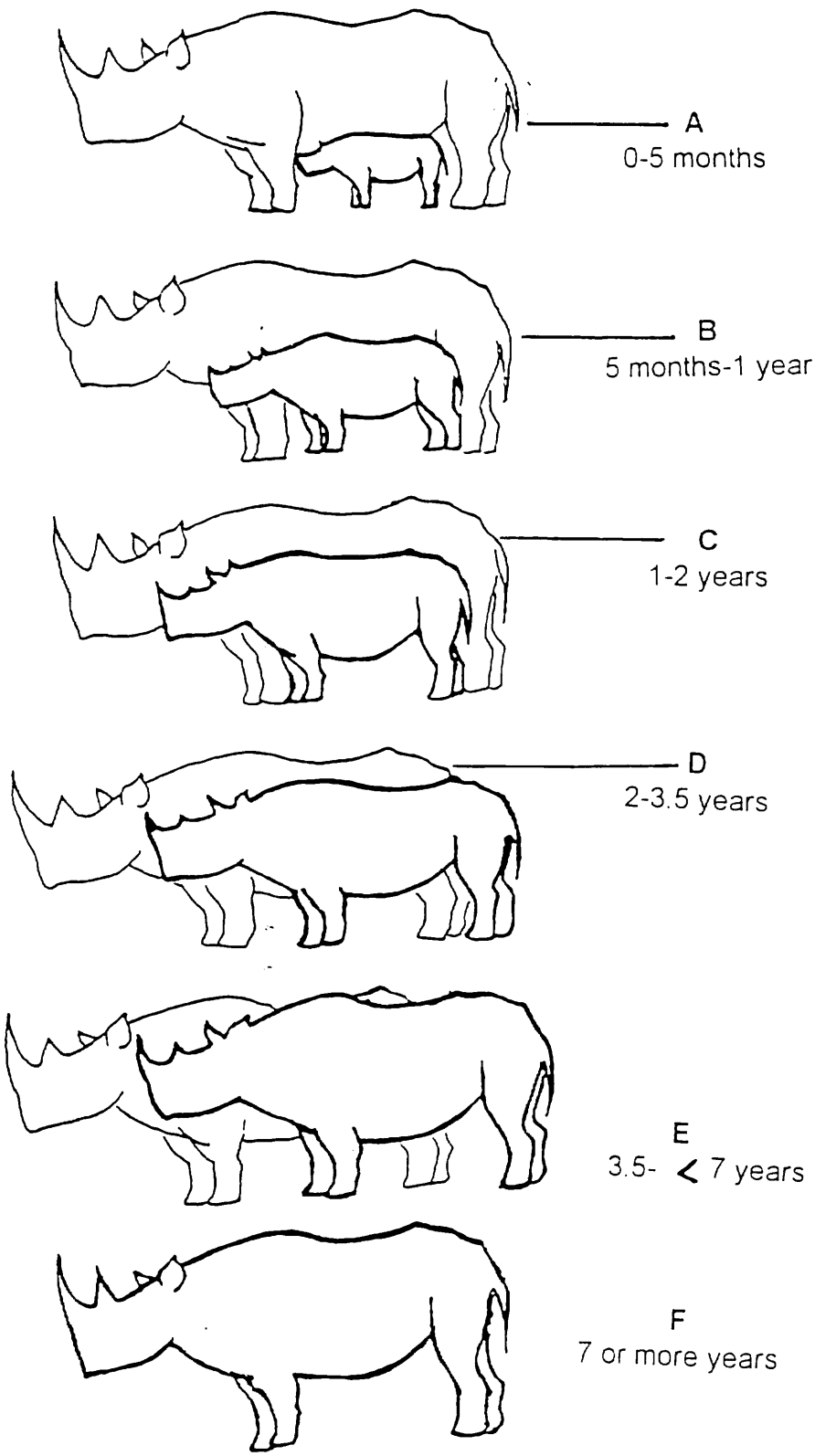
Moliform teeth do not wear down at a fixed rate. Because of their conical shape they wear down quickest the first few years after erupting. This explains the curved shape of the graph. The bottom jaw's PM3 is not as high as that of the top jaw, and does not wear down as far, explaining why line B is flatter than A.

* Dr Pete Morkel developed these curves for *D.b.bicornis* in Namibia. As highlighed before, the accuracy of these tooth wear approaches, especially for D. b.minor, needs to be more widely tested.


4,3
A = TOP JAW
4
3,4
BOTTOM JAW = B
3
RT Maxilla
RT Mandible
2
1
Height (CM)
5
10
15
20
25
30
35
Age (yrs)

Appendix 1. Ageing sub-adult black rhino by body size

From Hitchins (1970), Emslie et.al. (1993)



Appendix 2: Horn size and age data

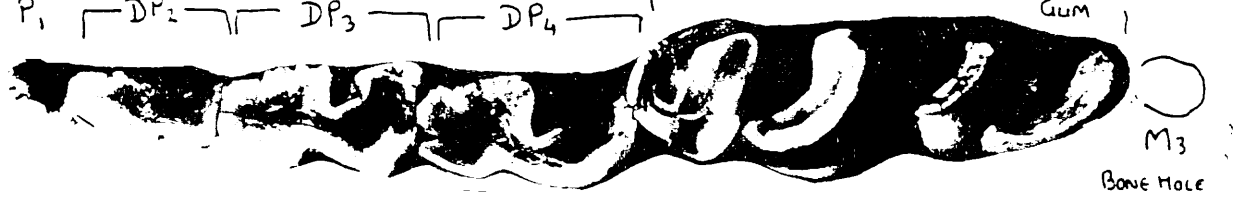
DATE	RHINO	Front Horn Length	Front Horn Base	Back Horn Length	Back Horn Base	Age	Sex	
04-Jul-94	UGR/SHAMWARI	23	20	4	10	1-2?		
	mk1620	10	23	2.5	13	0.75	F	
	mk1622	14.2	23.8	5.5	17.8	1	F	
15-May-90	NDU-2	28	29	20	26	35	U	
15-Oct-96	UGR-MADIKWE	25	43.5	11	34		F	
	mk1787	37.7	39.5	13.3	36.2	4.5-5.5	U	
15-Oct-96	UGR-MADIKWE	Base	45.5	13.5	39		F	
22-Jan-91	AVS-25	12.2*b	43.2	16.5	40.5	E-4-5	F	
	mk1628	40.5	46.2	12.5	40.5	6.5-7.5	M	
09-Jan-93	ITA-4	45	41.5	19.5	40.5	F	U	
	mk1667	43.5	45.5	14.6	41.6	6.5-7.5		
15-Oct-96	UGR-MADIKWE	39	52	15	43		M	
15-Oct-96	UGR-MADIKWE		53	15	43		F	
15-Oct-96	UGR-MADIKWE		51	16.5	47		F	
	mk1619	41.3	51	16.2	48.2	10	M	
19-Mar-95	ITA-5	45	61	19	49	F	F	
	mk1766	48.5	55.5	23.9	49.5	35	F	
	mk1780	49	54.2	17	49.5	11-12	F	
15-Jan-92	NDU-1	73	63	20	53		F	
15-Oct-96	UGR-MAD	44	65	20	56		M	Age
02-Jul-92	ITA-6	51	60	24	60	F	M	Confidence
PILANESBERG RHINO								(+-) in months)
05-Jun-96	HUGHEY	*41*	*51*	17		5.6	M	1
04-Jun-96	MOLEFI	*37.5*	*55.5*	18		5.1	M	2
19-Aug-94	BOITUMELO	*12*	*26*	3.5	14	1.3	M	1
	70	*17.8*	*29.5*	6	*14*	1.3		4
11-Mar-95	MOAGI	*17*	*29*	4	15	0.9	M	3
03-Apr-96	TIKI	*11*	*30*	3.5	*17*	1.1	F	1
	72	*20.32*	*31.5*	5.1	19	1.5	M	4
06-Jun-96	MOTHUSI	*16*	*33*	6	*20*	1.4	F	0.5
06-Jun-96	ROBIN	*10*	*34*	5	*21*	1.2	F	1
18-Feb-94	CATALINO	*20*	*28.5*	7	23.5	2.7	M	2

DATE	RHINO	Front Horn Length	Front Horn Base	Back Horn Length	Back Horn Base	Age	Sex	
05-Jun-96	MAGDALENE	*14*	*33.5*	5.5	*25*	1.3	F	1
28-Aug-91	TOTALINA	*22*	*32*	10	*26*	2.8	F	2
12-Aug-92	GEORGE	*25.5*	*36*	7.5	27	2.8	M	3
15-Oct-94	MPOFU	*19.5*	*35*	8	29	2.3	M	1
13-Aug-92	DAVE	*23*	*39*	10.5	30	2.2	M	1
28-Aug-91	KUMI	*26*	*42*	10	*30*	3.7	FF	2
12-Aug-92	DUDU	*28*	*43*	10	31	3.4	M	2
	71	*24.13*	*40.3*	7.62	31.8	2.3	M	4
08-Oct-93	HUGHEY	*27*	*39*	12	32	3.0	M	1
20-Aug-91	IMPIA	*27*	*42*	10	*32*	3.3	F	6
28-Sep-95	BONEPELE	*24.5*	*42*	9	*32*	2.7	F	0.5
31-Aug-91	HOOKEDNOSE	*38*	*50*	9	33	4.9	M	15
02-Sep-91	BAHATI	*34*	*44*	15	37	4.7	F	6
16-Oct-94	MOLEFI	*36*	*45*	13	37	3.5	M	1
27-Aug-91	JULES	*38*	*54*	12	39	5.0	M	6
24-Aug-91	FILANA	*42*	*45*	16	*40*	6.5	F	0.5
12-Aug-92	HAIRYEAR	*30*	*52*	25	40	>22	F	60
03-Jun-96	HANSA	*47*	*59*	22	40	14.3	M	6
15-Aug-92	BUGLEHORN	*46*	*48*	27	42	>25	F	60
03-Jun-96	TOTALINA	*37*	*49*	22	42	7.6	F	2
03-Jun-96	MPOFU	*33*	*51*	15	43	3.9	M	2
17-Aug-91	TONY	*51*	*59*	20	43	7.6	M	6
05-Jun-96	FILANA	*51*	*47*	26	44	11.3	F	6
04-Jun-96	BUGLEHORN	*63.5*	*52*	30.5	44	>25	F	60
31-Aug-91	BRUCE	*40*	*57*	16	44	7.2	M	6
24-Aug-91	SCAR	*54*	*60*	18	44	>22	M	60
14-Aug-92	HANSA	*40.5*	*55.5*	22	44.5	10.5	M	6
27-Sep-95	DUDU	*45.5*	*58*	16	46	6.5	M	3
03-Sep-91	GIJIMA	*36*	*47*	21	47	>20	F	60
06-Jun-96	GEORGE	*51*	*56*	20	47.5	6.6	M	2
02-Oct-95	SUZY	*32*	*52*	21.5	50	11.7	F	6
04-Jun-96	DUDU	*50*	*56*	18	50	7.2	M	3

3y 5mo / 3y 8mo

HVI

GVII = 4y



ERUPTING – MAY BE PIERCING GUM

BONE HOLE

PERMANENT P2 HAS DISPLACED MILK DP2 AND IS ERUPTING

P3 (PERMANENT) MAY OR MAY NOT HAVE DISPLACED DP3

P3 BELOW GUM

JUST ABOVE GUM LEVEL

4y 6mo / 5y 6mo

HVII

≈ GVIII

± FULLY ERUPTED

DP4 OR P4

IF BELOW / NEAR BONE SURFACE – 5y 1mo to 6 YEARS

5y 7mo / 5y 11mo

HVIII

GIX ≈ 6 - by 6mo

IF M3 ABOVE BONE SURFACE ~ 6 to 6.5 yrs

6y 6mo / 7y 6mo

HIX

GX = 7

IF AT OR ABOVE BONE THEN ~ 6.5

WELL WORN

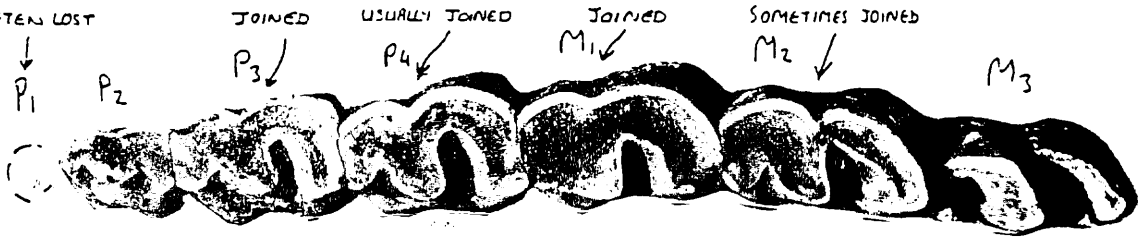
IF ⅓ TO ⅔ OUT OF BONE, THEN ~ 7+

JOINED | SOMETIMES JOINED | USUALLY NOT JOINED | MARKED WEAR | LIGHT WEAR

8 years

HX

≈ GXI



OFTEN LOST

JOINED

USUALLY JOINED

JOINED

SOMETIMES JOINED

FULLY ERUPTED – V. LIGHT WEAR

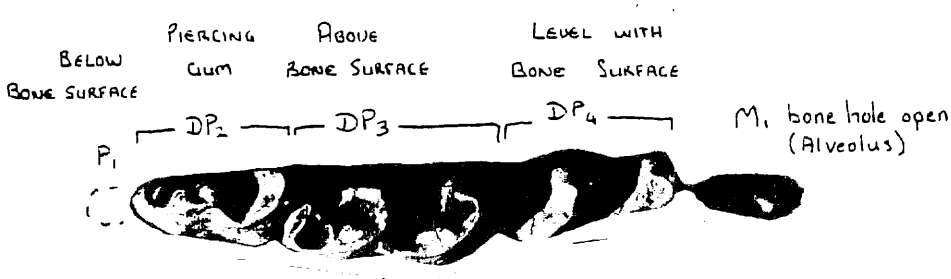
AGING BY TOOTH EMERGENCE AND WEAR
From Hitchins (1978) and Goddard (1970)

These descriptions are for teeth in the skull of dead rhino. The original gum line is where the tooth side curves back to the root, often shown approximately by a change in color of the tooth (top area above gum line is darker).

HI HIX etc = Hitchins' age class GI GIX etc = Goddard's age class

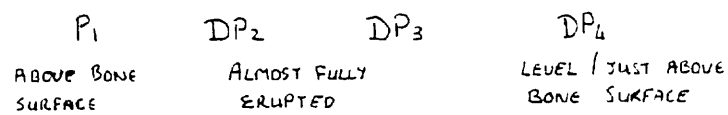
DP = Decidous premolar - milk premolar P = Premolar (permanent) M = Molar

0-2 mo **HI**

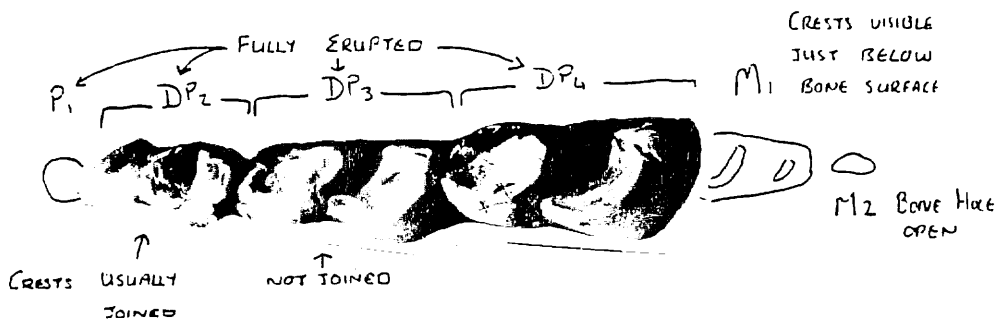


~4 mo **HII**

GII ~6 mo

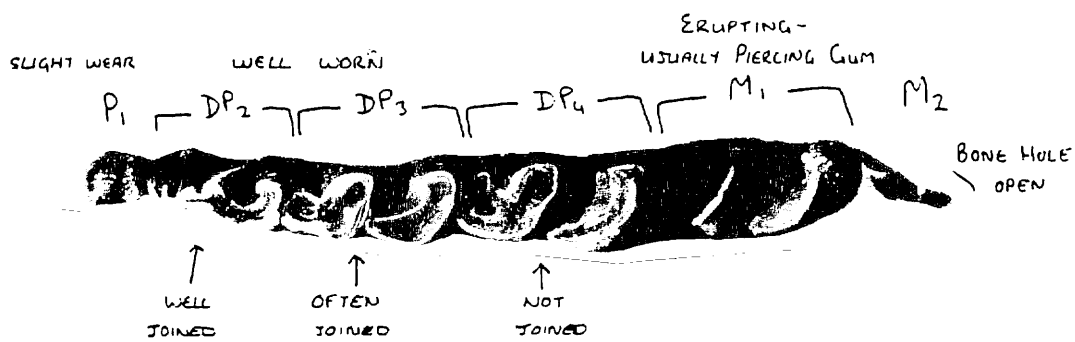


1 year **HIII**
≈GIII



GIV

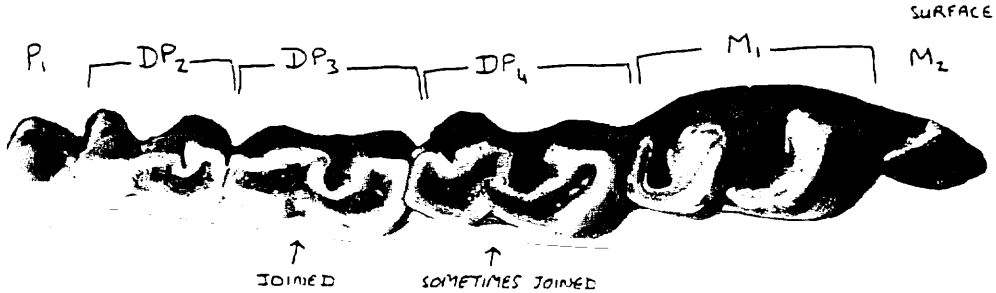
1y6mo+ **HIV**



GV≈2y

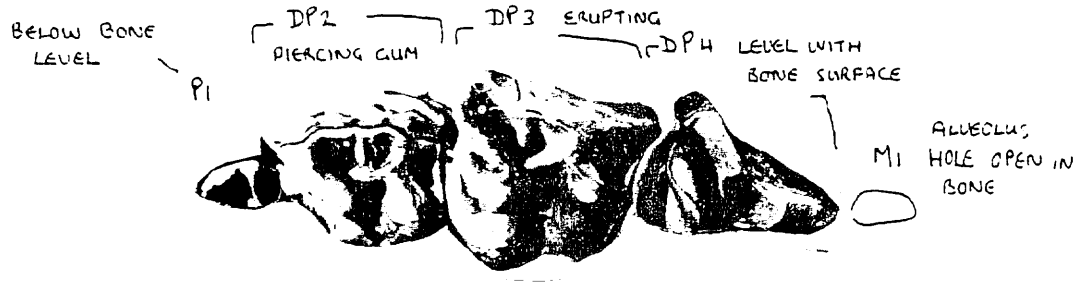
2y3mo 2y6mo **HV**

GVI≈3y



0-2mo

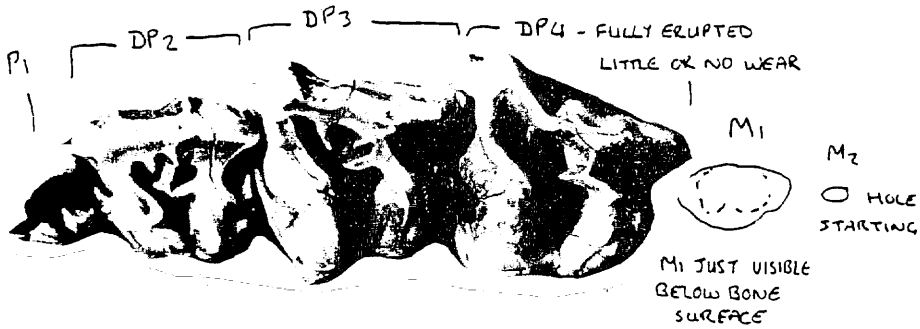
HI



HII

1year

HIII

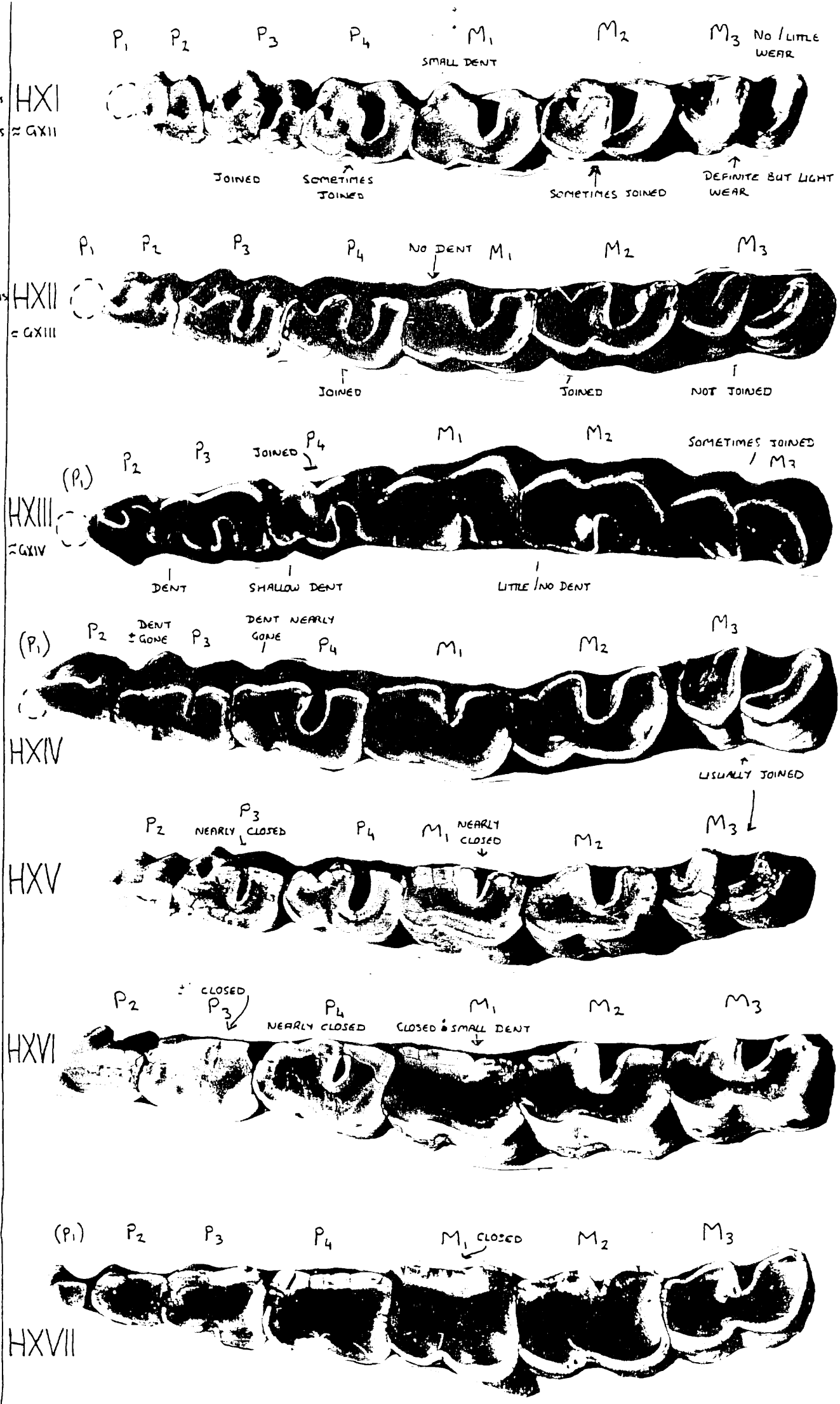


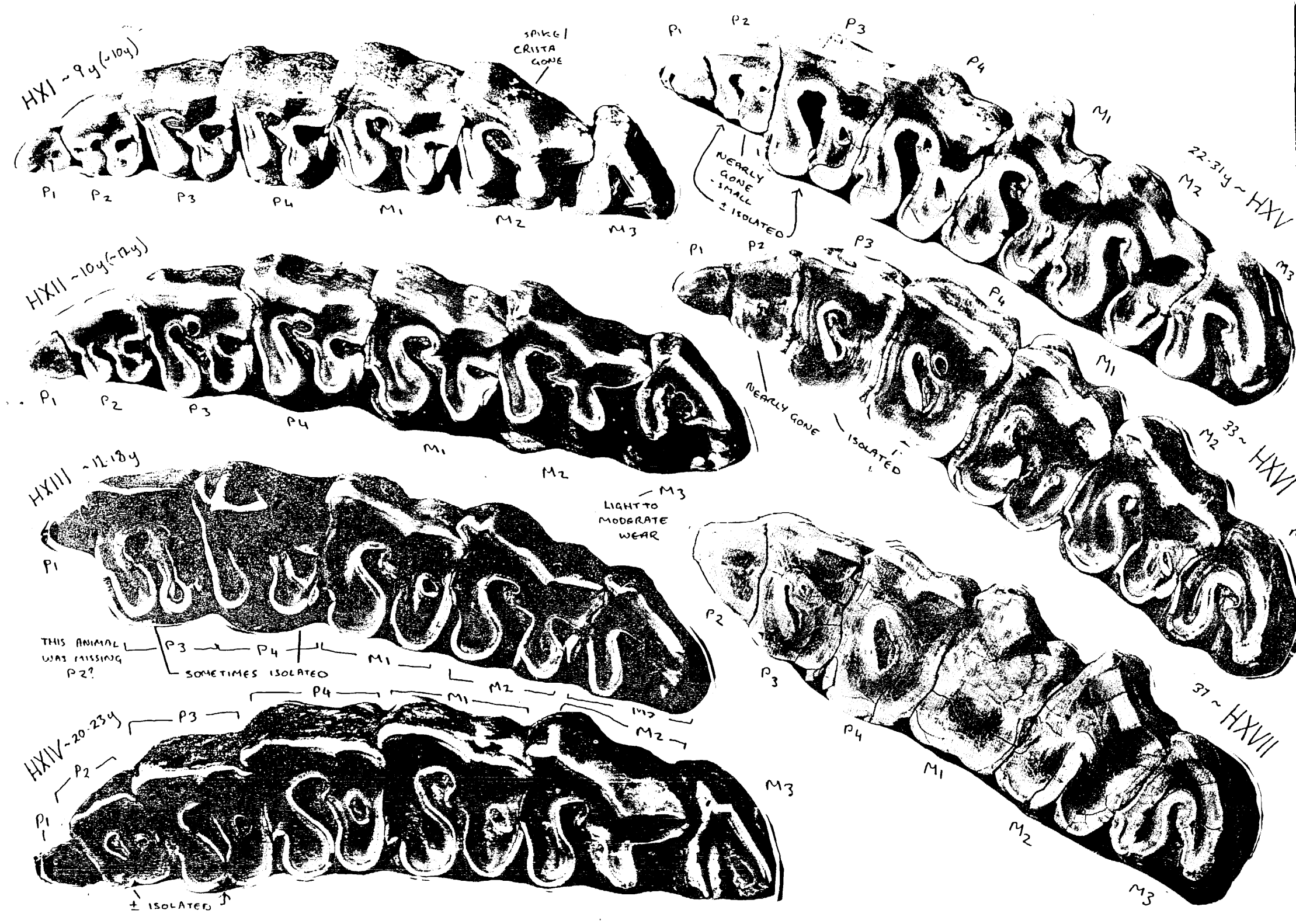
1y6mo

HIV

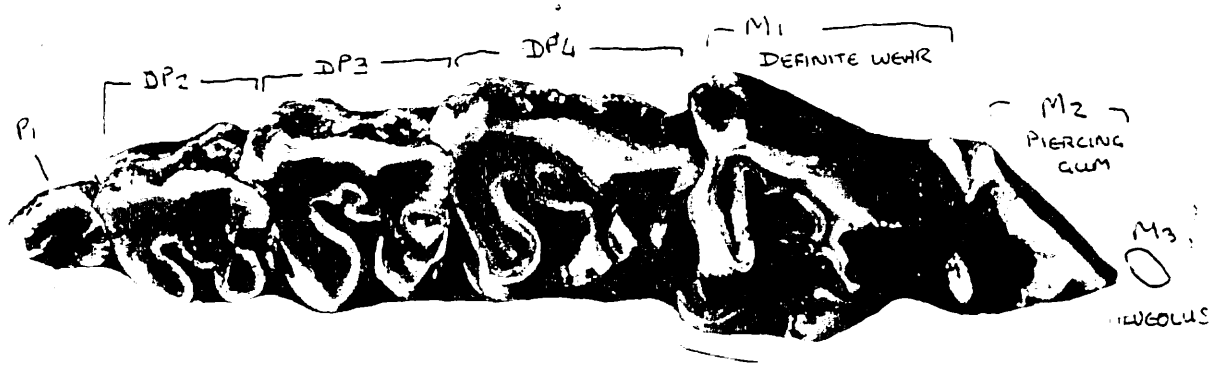
2y3-6mo

HV

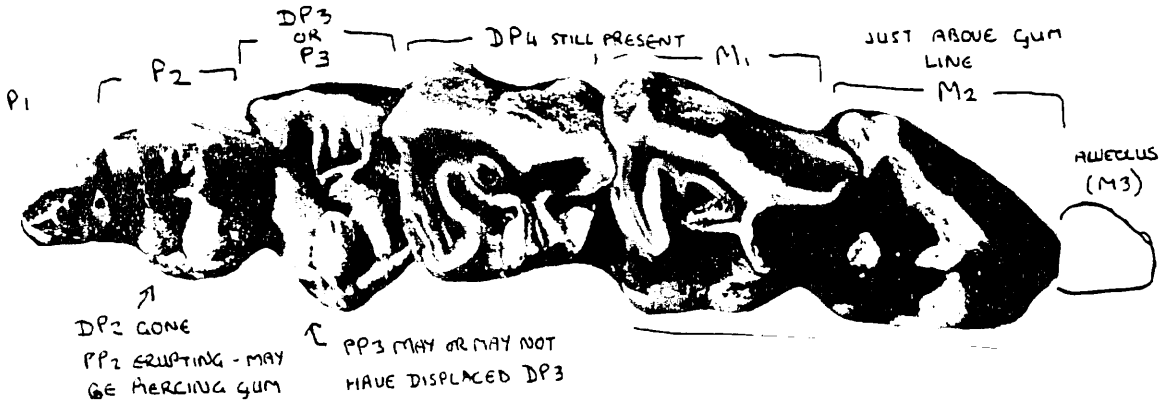

P1 P2 P3 P4 M1 M2 M3 No / little wear
small dent
c. 9 years / ~10 years
HXI
≈ GXII
Joined
Sometimes joined
Sometimes joined
Definite but light wear
P1 P2 P3 P4 No dent M1 M2 M3
c. 10 years ~>12 y
HXII
= GXIII
Joined
Joined
Not joined
P2 P3 Joined P4 M1 M2 Sometimes joined / M3
(P1)
11 or 12 yrs to ~18 yrs
HXIII
≈GXIV
Dent
Shallow dent
Little / no dent
(P1) P2 Dent ± gone P3 Dent nearly gone P4 M1 M2 M3
20-23 y
HXIV
Usually joined
P2 P3 nearly closed P4 M1 nearly closed M2 M3
22-31 y
HXV
P2 ± closed P3 P4 nearly closed M1 closed & small dent M2 M3
c. 33 y
HXVI
(P1) P2 P3 P4 M1 closed M2 M3
c 37 y
HXVII


HX1 ~ 9y (~10y)
SPIKE / CRISTA GONE
P1 P2 P3 P4 M1 M2 M3
HXII ~ 10y (~12y)
P1 P2 P3 P4 M1 M2 M3
HXIII ~ 12.18y
LIGHT TO MODERATE WEAR
P1 P2 P3 P4 M1 M2 M3
THIS ANIMAL WAS MISSING P2?
P3 SOMETIMES ISOLATED
HXIV ~ 20-23y
P1 P2 P3 P4 M1 M2 M3
± ISOLATED
P1 P2 P3 P4 M1 M2 M3
NEARLY GONE - SMALL ± ISOLATED
22-31y ~ HXV
P1 P2 P3 P4 M1 M2 M3
NEARLY GONE
ISOLATED
33 ~ HXVI
P2 P3 P4 M1 M2 M3
37 ~ HXVII

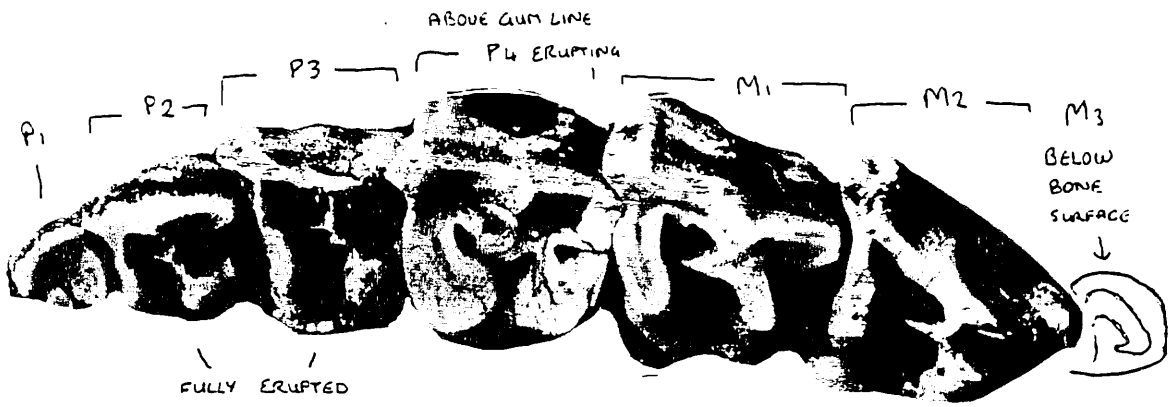
3y5·8mo HVI



4y6mo
5y6mo HVII

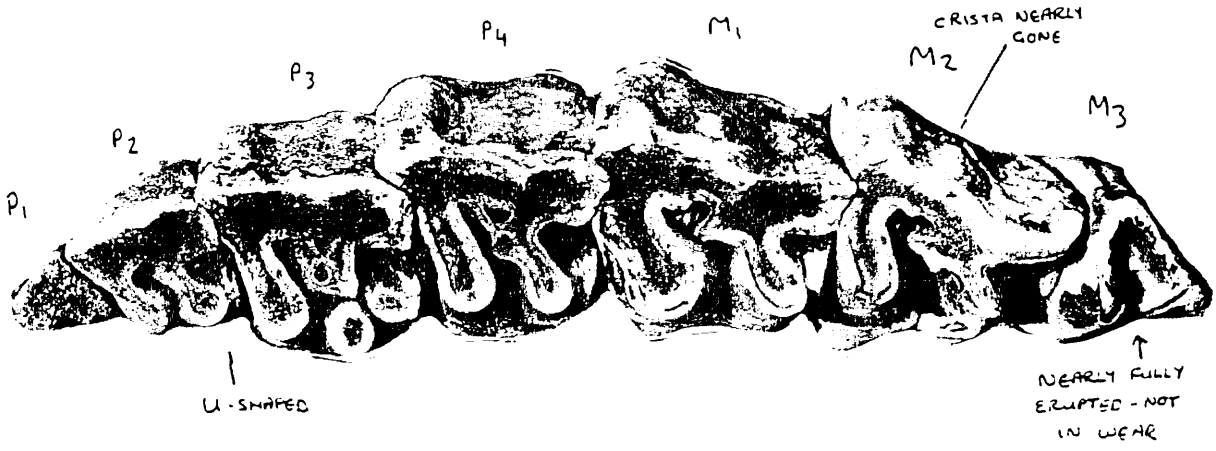


5y7·1mo HVIII



6y6mo
7y6mo HIX

8 years HX



References

Adcock K. Box 1212 Hilton tel: 0331 434065. Horn size, appearance and age relationships; drawings; and aging of Pilanesberg black rhino.

Brooks PM (1989, 1990). Conservation Plan for the black rhinoceros (*Diceros bicornis*) in South Africa, The TBVC states and Namibia. *Rhino Management Group.*

Emslie RH, K Adcock, HB Hansen (1993). Fine tuning the Rhino Management Group age class system.

Goddard J (1970). Age criteria and vital statistics of a black rhinoceros population. *East African Wildlife Journal* 8:105-121.

Hansen HB. Denmark 0945 86281109. Pilanesberg black rhino aging and photographic series. **Hanne Lindemann** as above.

Hitchins PM (1970). Field criteria for aging the black rhinoceros *Diceros bicornis* L. *Lammergeyer* 33:45-48.

Hitchins PM (1978). Age determination of the black rhinoceros *(Diceros bicornis* L) in Zululand. *South African Journal of Wildlife Research* 8: 71-80.

Keffin Bob Dr. Ostrich Farm, Box 232 Sun City 0316, tel: 01465 22148. Horn size data from immobilised black rhino in Pilanesberg.

Morkel P Dr . SA National Parks Board, Box 10040, 8306 Hadison Park, Kimberly, tel: 0531 25488. Aging by tooth height of premolar 3.

Owen-Smith RN (1988). Megaherbivores. The influence of very large body size on ecology. *Cambridge University Press.*

Reed C. Hluhluwe/Umfolozi Park (trails) tel: 035 5620287. Photographs of horn growth of black rhino calves (0-6months).

Wucher M (1994). A technique for making dental impressions and casts of immobilised black rhinoceros *(Diceros bicornis)* and white rhinoceros (*Ceratotherium simum*). IN Proceedings of a Symposium on Rhino as Game Ranch Animals. *South African Veterinary Association Wildlife Group.*