A rudimentary assessment of rhinoceros horn regrowth in Africa based on photographs

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Introduction

Calves of all rhino species are born without horns. The anterior front horn starts to grow first followed by the posterior horn from about six months. The horn grows throughout the life of the rhino but is reshaped and influenced by use; namely from fighting, being rubbed on hard surfaces and by natural breakage.

Wallach (1969) described a female white rhino calf with a front horn of 2.54 cm at two months and 6.3 cm at five months old. Bigalke (1950) recorded a female white rhino with a horn of 5.6 cm long at 12 months and 8.2 cm at 18 months. Player (1967) recorded a 12-month old male with an anterior horn of 15.24 cm and an 18-month old female with a horn of 21 cm. A 30-month old female's horn grew 10.2 cm from 12 months old, and the front horn of a 34-month male rhino grew to 7.6 cm by 12 months.

The annual growth rate of the anterior horn seems to decrease with age from around 6 cm/year in young adults and around 4cm/year in old adult animals (Cunningham and Berger 1994). A captive female white rhino showed a growth rate of around 6 cm/year (front horn) and 1.5 cm/year (rear horn) between four and eight years of age while a male, from five to nine years of age, showed front horn growth of 5 cm/year and rear horn 2 cm/year (Klös 1969).

Horn regeneration after natural loss

Apart from fighting and wear and tear, occasionally, horns have been known to split down their length and eventually the thin weak parts break off (from personal observation in May 2009 and June 2010). The cause for the splitting is unknown but it is speculated that it could be a consequence of inadequate nutrition on which more research is needed.

The measurement of the regeneration of the anterior horn of a 14-year old captive female black rhino after natural loss was reported in Bigalke (1946). The horn which was shed was found to weigh 4.2 kg and its measurements taken with a tape measure were: measurement along the median line of the anterior surface, 57 cm; measurement along the median line of the posterior surface, 51 cm.

After nine years of growth the regenerated horn was still 4.4 cm short anteriorly and 1.3 cm posteriorly of the measurements of the shed horn. It was deduced that approximately ten years of growth were necessary for the new horn to attain the length of the original shed horn.

Pienaar et al. (1991) noted that the horns of both black (Bigalke, 1946) and white rhinos (Klös, 1969), appear to grow back faster in the first year than in subsequent years after horn loss—front 11cm and 10 cm.

Horn regeneration after invasive loss

Rhino "dehorning" involves the removal of most of the anterior and posterior horns of a rhino through artificial means. Dehorning is usually undertaken to make the rhino less of a target of potential poaching for the illegal wildlife trade or, for certain males to prevent serious injury during fighting for dominance. Removal is usually carried out using a chainsaw or a handsaw leaving just a small stump at the base of the horn to ensure the horn plate is not damaged and from which regrowth will occur. Dehorning is estimated to result in the removal of 90% and 93% of the mass of horns in male and female white rhinos respectively (Kock and Atkinson 1993). The rate of re-growth of

horns after dehorning is similar for both black and white rhinos (Lindsey and Taylor, 2011).

Pienaar et al. (1991) recorded an average of 5.5cm growth per year for the anterior horn, obtained by measuring the movement of a microchip from the horn base annually, in six wild adult white rhinos. Older adult rhinos showed slower horn growth rates than younger rhinos, while horn growth was found to be more rapid in the first year after loss, than subsequent years.

The horn growth of two young, dehorned black rhinos which were translocated in Namibia were approx. 7–8 cm/year for the front horn and about 5 cm/year for the back horn (Morkel and Geldenhuys 1993). Horn regrowth in old animals also appeared to be slower than in younger animals. Accelerated annual horn growth can result in having to repeat the procedure by trimming every two to four years for dehorning to be a deterrent.

According to Kock (1993; Kock 1994), approximately one year after seven females and seven male white rhinos were dehorned in Hwange, Zimbabwe 1991, the horns had grown on average 6.9 cm for the front horn (males 6.8 and females 7.0) and 2.9 cm for the rear horn (males 3.4 and females 2.5).

The re-growth of dehorned rhinos appeared to be slightly faster than horn growth in non-dehorned rhinos. Male white rhinos re-grew horn mass at a rate which is almost twice that of females. Female white rhinos reached a peak in horn regeneration at eight years, whereas the mass of horn regenerated by males approaches an asymptote slowly at >30 years of age (Rachlow and Berger 1997).

As can be seen, there is a paucity of information on how horns develop over a rhinoceros's lifespan. It is possible, with the human eye, to see changes in horn length of a rhino from photographs taken at different ages. The question is, can these changes be accurately quantified by measuring photographs using simple methodology?

Methodology

Head profile photographs of the Ziwa Rhino Sanctuary (ZRS) population were accessed from those taken for annual Master Identification (ID) files of two databases collated between 2005 and 2020. ID photographs require a clear profile view to be taken as close to right angles to the head as possible. The ID photographs are cropped so that only the head remained from the back of the ears to the front of the mouth and with both horns fully visible.

For the purposes of the analysis, the photographs were placed on the same horizontal plane by using the rotate facility in PaintShop Pro 9i software. A line between the eye and the front base of the anterior horn was used to create the horizontal aspect. The revised photographs were then cropped and saved so that only the head remained from the back of the ears to the front of the mouth and with both horns fully visible. These were further adjusted to a standard length of 3 cm between the eye and the front base of the anterior horn. This allowed for comparative measurements of two-dimensional hard copies to be made.

After trial and error, a measurement system using a ruler and the naked eye was chosen as being the simplest and most easily applied by anyone in the field. Individual measurements were taken for a mid-line of a horn from its base to its tip to represent the length.

Parallax affects measurements from photographs meaning detailed comparison of individual measurements are inappropriate. To overcome the inaccuracies caused by parallax, percentage growth rates were determined from individual measurements and placed in five classes:

A = 0 to10%; B = 11 to 30%; C = 31 to 59%; D = 60 to 89%; E = 90 to 100%

In order to illustrate the regrowth of horns, either removed naturally or by dehorning, the standardized photographs were printed out and re-growing horns traced onto tracing paper. The tracings were overlaid such that a single tracing could be made showing each growth stage.

The tracings were scanned in order to obtain each one as a jpg which was then imported into GIS using a Universal Transverse Mercator (UTM) reference system. This enabled shape files of each of the growth rings of the horn to be created. Outlines of each shape file could then be measured and presented as percentages of the final horn shape.

Two white rhinos—an adult female and a young male—were subject to veterinary intervention which enabled their horn lengths to be measured physically

Table 1. Percentage of horn growth for seven white rhinos from 1-14 years of age

Population 1			Population 2				
Age	%rear	%front	Age	%rear	% of final length	%front	% of final length
1			5		60		56
2	D	C	6	B	69	A	58
3	B	B	7	A	71	A	64
4	B	B	8	A	74	A	70
5	A	A	9	A	81	A	71
6	A	A	10	A	87	B	80
			11	A	93	A	86
			12	A	96	A	91
			13	A	96	A	93
			14	A	100	A	100

Note: Population 1 rhinos are 1-6 years, population 2 rhinos are 5-14 years.

Table 2. Percentage horn growth of three adult female white rhinos

Year	% increase rear	% increase front	Percentage of final length	
			%rear	%front
1	A	A	65	71
2	A	A	71	73
3	A	A	77	75
4	A	A	83	77
5	A	A	85	79
6	A	A	88	80
7	A	A	92	83
8	A	B	98	87
9	A	A	100	100

Note: the adult rhinos were believed to be around 15 years old in year 1.

and compared with photo records, on the same basis as used for the photographs (along a mid-line of the horn from the base to the tip). Up-to-date profile photographs were taken. By referring to previously taken annual photos it could be seen that the male had been dehorned in 2015 and the female had broken her front horn at the weak point where a transmitter had been fitted in 2010. It was, therefore, possible to estimate their horn re-growth rate over the relevant periods.

Results

How a rhino horn develops from birth to 15 years of age is illustrated in Figure 1. The photographs used to create the illustration were used to obtain comparative horn length measurements for the analysis (see Table 1).

Table 1 shows an estimate of the rate of growth of rhino horn from birth to age 15 years. The first six years are from one population at the ZRS and then from five years to 15 years old from another East African population. For the population starting at five years old there is a column (% increase in length) which compares the length at each year as a percentage of the length of the final year which, at 14 years is considered mature.

Percentage growth increases are greatest in the early years of the life of a rhino for both anterior and posterior horns but from around five years of age, the

annual growth rate is below 10%. Between year one and two, the growth rate was over 50%.

At five years old, both horns were over 50% of the length of the mature horn (14 years) (anterior 56%, posterior 60%) while the annual incremental increase was mostly less than 10%.

How horns develop in older rhinos, from 15 years old, is considered in Table 2 which shows the incremental increase in horn growth for three females believed to be around 15 years old at the start of the study. All nine annual increases for both horns were less than 10%, apart from one for the anterior horn at 15.2%. This demonstrates that the horns continue to grow through to an age of 24 years (± 20 years).

Only one study could be found which contained photographs and measurements of the development of rhino horns and to which the measurement system could be applied. Table 3 is the analysis of the actual measurements taken of the regeneration of an anterior horn of a captive black rhino in South Africa over a 10-year period. The average growth per year was 5.3 cm being annually slightly more in the early years, consistent in the mid years and growing less in the later years. This is also represented in the proportion of the final length reached with the first year's increase, around 20% of the final length and the remaining yearly increases of around 10%.

The regrowth of horns lost due to natural causes was analysed from photographs of two adult white rhinos (see Table 4). The percentage of anterior horn regeneration after natural horn loss for the two rhinos—an older male and a younger female (illustrated in figure 2, drawing 4) —shows a larger initial increase in growth followed by erratic incremental growth.

The percentage posterior horn regeneration after natural horn loss was analysed for three adult white rhinos. The results are illustrated in figure 2, drawings 1, 2 and 3, and presented in Table 5 as a percentage of the final length and the final area. Both follow a similar pattern to that found with the anterior horns in Table 4 of a large annual initial new growth which tapers down during the following years, although the time gaps are not uniform.

The rate at which horn grew back was estimated from photographs for three white rhino adult males (see Table 6 and illustration in figure 2: Taleo, Moja and Hassani).

The pattern of regeneration of both horns, although not uniform, again shows a general trend from higher incremental percentage growth after dehorning, tapering to smaller incremental percentage growth for both length and area measurements. The photograph data also show several months with little or no growth recorded after the initial spurt.

Discussion

There is little detailed research published on the rate of re-growth of rhino horns when removed either naturally or artificially. This paper attempted to gain some further insight by using measurements from photographs.

An attempt was made, using the methodology reported above and the details published in Bigalke (1946), to determine whether it was possible to calculate actual horn growth lengths from horn measurements taken from photographs. The five photographs published in Bigalke appear to be taken at right angles and the photographs could be standardised to the same size using the distance between the rear of the posterior horn and the front of the anterior horn. However, the length measurements obtained bore no resemblance or consistency with the actual lengths as published. Even a small amount of parallax and differences in focal distance clearly affects the measurements and cannot be corrected by simple photo manipulation.

The analysis of the photo measurements of the anesthetised, 20-year old, adult female white rhino in relation to the known actual final measurements showed its front horn length had grown at around 2.75 cm per year over a 10 year period. This single result differs markedly from the 5.5cm per year recorded in Pienaar et al. (1991) although it was reported that horn growth was found to slow as the rhinos aged.

The anesthetised dehorned young male white rhinos' rear horn had grown 2cm per year and front horn 7cm per year since dehorning over a 5-year period. This compares with the results of Kock (1993, 1994) of 3.4cm for the rear horn and 6.8cm for the front horn after one year of growth.

While published data on the amount of horn growth suggests consistency of growth in length/year, the data produced from the photographs suggest that growth is not at all consistent.

Table 3. Length of growth of a regenerating anterior horn of a captive adult black rhino (Bigalke 1946)

Date (month/year)	Length (cm)	Average growth per year (cm/yr)	% Increase in length
10/1928	0.00	7.9	0
04/1929	6.35		
08/1929	8.89		17
02/1930	12.95		
06/1930	14.10		
10/1930	15.87		30
10/1930	15.87	5.3	
07/1931	20.00		
04/1932	22.86		
02/1933	26.35		
10/1933	31.75		60
10/1933	31.75	5.1	
10/1934	36.83		70
10/1934	36.83	5.1	
04/1935	39.43		
10/1935	41.91		79
10/1935	41.91	5.7	
04/1936	45.10		
10/1936	47.62		90
10/1936	47.62	3.2	
10/1937	50.80		96
10/1937	50.80	2.2	
10/1938	53.00		100
		10 yrs = 5.3cm/yr	

Table 4. Percentage anterior horn regeneration after natural horn loss for two adult white rhinos

ADULT MALE			ADULT FEMALE		
Time gap	New growth	% Final length	Time gap	New growth	% Final length
4m	E+	25	12m	E+	18
12m	D	43	11m	B	38
12m	B	50	17m	C	46
12m	D	82	8m	A	63
11m	B	100	11m	C	65
			12m	A	90
			9m	A	100

Table 5. Percentage posterior horn regeneration after natural horn loss for three adult white rhinos

ADULT FEMALE 1				ADULT FEMALE 2				ADULT FEMALE 3			
Time gap	New growth	% Final length	% Final area	Time gap	New growth	% Final length	% Final area	Time gap	New growth	% Final length	% Final area
11m	C	37	21	13m	D	29	21	12m	B	18	
15m	B	43	26	12m	B	50	42	11m	B	38	
13m	B	49		11m	B	57		17m	C	46	46
12m	B	56		17m	B	71	54	8m	A	63	57
11m	B	62		8m	A	86		11m	C	65	
17m	A	68	57	11m	A	93		12m	A	90	90
8m	A	74		12m	A	100	100	9m	A	100	100
11m	A	77	61								
12m	A	80									
6m	A	86									
4m	A	100	100								

Table 6. Horn regeneration by three adult male white rhinos following dehorning

Approx age	Rear Moja	Time gap	% Final length	% Final area	Rear Taleo	Time gap	% Final length	% Final area	Rear Hassani	Time gap	% Final length	% Final area
15			32				37				40	
16	D	10m	55	40	D	8m	60	52	C	10m	57	55
17	B	13m	63	72	B	12m	67	79	B	17m	67	55
18	C	12m	71	72	C	15m	90	79	A	10m	70	80
19	A	11m	91	86	A	11m	97	100	A	11m	73	80
20	A	11m	100	100	A	11m	100	100	C	11m	100	100
approx age	front Moja	time gap	% final length	% final area	front Taleo	time gap	% final length	% final area	front Hassani	time gap	% final length	% final area
15			26				34				22	
16	D	10m	48	40	B	8m	44	58	D	10m	41	44
17	C	13m	68	73	C	12m	62	70	C	17m	59	69
18	A	12m	74	73	B	15m	78	85	B	10m	65	69
19	A	11m	81	87	A	11m	84	96	B	11m	76	95
20	B	11m	100	100	B	11m	100	100	C	11m	100	100

With small sample sizes, imprecise photography and rudimentary measuring techniques, the data was collected and analysed in order to determine if there were trends that could be elicited and what those trends were in order to guide managers. It is not meant to be and is not presented as a scientific, statistically analysed treatise, but is hoped might encourage more published research work.

Lastly, due to the paucity of information available on how horns develop over years for the different species and the effect of nutrition in particular on growth rates, further comparative studies in different countries are encouraged.

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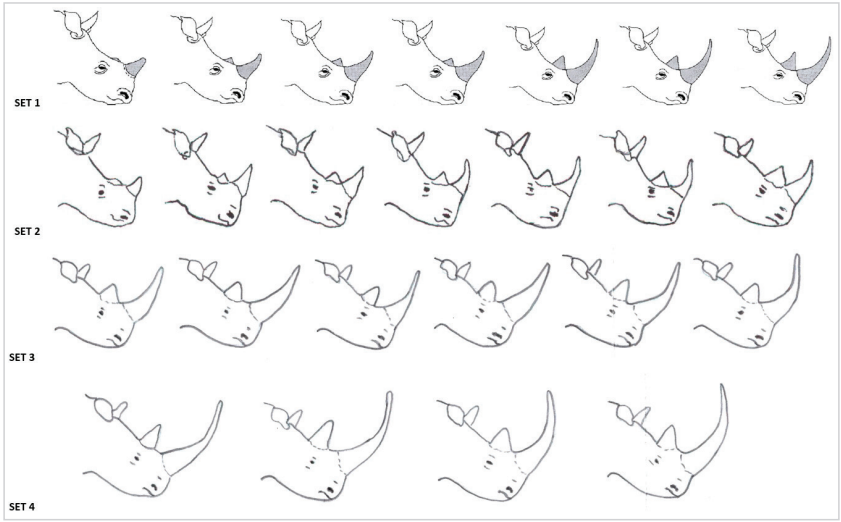

Figure 1. Natural horn growth as a rhino ages.
Set 1 is taken from the Monitoring African Rhino Trainee's Guide (Adcock and Emslie 2007).
Set 2 is taken from photographs of a wild population taken at 1 year, 2 years, 3 years, 3.5 years, 4 years, 5 years and 6 years old to compare with those of the advisory Set 1.
Set 3 is taken from photographs of a wild population taken at 5 years, 6 years, 7 years, 8 years, 9 years, and 10 years old.
Set 4 continues from Set 3 for 11 years, 12 years, 13 years and 14 years old.

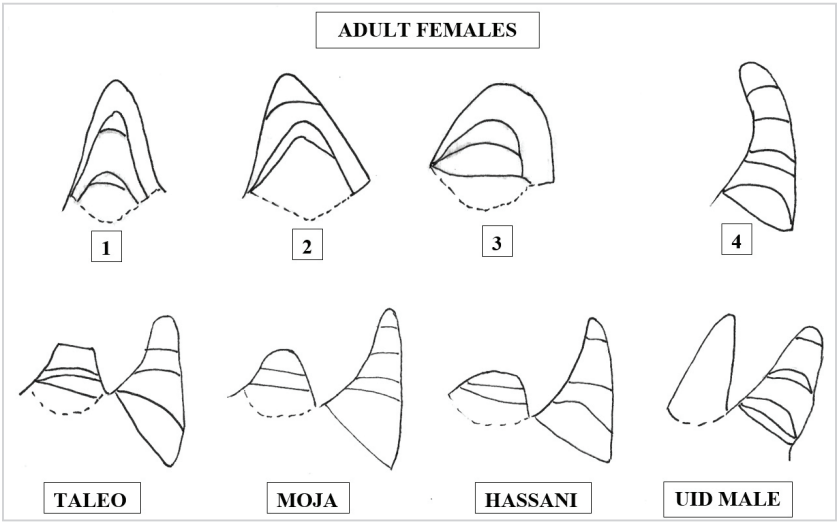

Figure 2. Horn regrowth from natural or artificial dehorning.
Drawings 1, 2 and 3 illustrate approximate annual horn regrowth for posterior horns from three adult females.
Drawing 4 is the anterior horn of one adult female who lost her horn naturally.
Drawings Taleo, Moja and Hassani illustrate approximate annual horn regrowth following dehorning for three adult males while the drawing UID male illustrates the approximate annual horn regrowth following natural loss.
The analysis of the photo measurements of the two anesthetized rhinos in relation to the known actual final measurements showed that the adult female front horn length had grown at around 2.75 cm per year between 2010 and 2021. The young male's rear horn had grown 2 cm per year and front horn 7 cm per year since dehorning in 2015.

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