Horn growth rates of free-ranging white and black rhinoceros

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The intrinsic and observed anterior horn growth of white and black rhinoceroses is discussed. The effect of age and horn rubbing on horn growth is explained. Species and sex related differences in horn size and mass are investigated.

Key words: Anterior horn growth, white rhinoceros, black rhinoceros, intrinsic horn growth, observed horn growth, horn length, horn circumference, horn mass.

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Introduction

Rhinoceros horn has been highly valued for centuries for its supposed poison detecting, medicinal and aphrodisiac properties (Martin 1980). In Yemen a dagger handle made of rhinoceros horn is considered to be an important status symbol (Martin 1987). As a result of these various forms of demand for horn, rhinoceroses have been hunted extensively throughout their African and Asian ranges.

The political upheavals in many African states over the past few decades resulted in, among other things, automatic firearms becoming freely available (Douglas-Hamilton 1983; Ruggiero 1990). This, coupled with a dramatic increase in the price of rhinoceros horn (Martin 1983a), led to an upsurge in poaching which saw Africa's black rhinoceros *Diceros bicornis* population dwindle from 65 000 in 1970 to about 3 800 in 1987 (Cumming & Du Toit 1989). Numbers of northern white rhinoceros *Ceratotherium simum cottoni* were reduced by poaching from 1300 in 1963, to only 15 in 1984 (Hillman-Smith 1990). Attempts to stop the decline by a total ban on trade in rhinoceros products, through listing the species on Appendix 1 of CITES, and underfunded anti-poaching projects to protect large rhinoceros populations in extensive conservation areas, have failed in most cases (Western 1989, 1990). Even the drastic and controversial step of dehorning black rhinoceroses in Damaraland (Leader-Williams 1989; Lindeque 1990) remains to be proven as a successful conservation tool.

For the last 2 000 years practitioners of traditional Chinese medicine have been using rhinoceros horn, in combination with other ingredients, as a fever-reducing drug. Westerners have been disparaging of the supposed medicinal properties of rhinoceros horn, but recent clinical work showed that it has a definite antipyretic action although only at very high dosages (But *et al.* 1990). The horn of saiga antelope *Saiga tatarica*, water buffalo *Bubalus bubalis* and cattle *Bos taurus domesticus* showed similar medicinal properties. Practitioners argue that instead of forbidding the sale and use of rhinoceros horn to save life, more effort should be spent farming and producing rhinoceros produces (But *et al.* 1990). Some authors have argued that to harvest and sell rhinoceros horn is a viable way to generate funds to safeguard rhinoceroses for the future (Penny 1987; Fiske 1988).

A summary of existing data on rhinoceros horn growth coupled with new information from a study undertaken in the Kruger National Park is presented here. Species and sex related differences in rhinoceros horns from the Kruger National Park, some of the Natal Parks and the Transvaal Nature Conservation Division are also investigated.

Materials and methods

Horn growth

Radio telemetry was used to locate specific animals during a study on habitat selection by white and black rhinoceros in the Kruger National Park. During the process of implanting radio transmitters into the anterior horns of the immobilized rhinoceros (Pienaar & Hall-Martin 1991), measurements were taken with a tape of the horn length along the anterior surface, and the basal circumference of the horn at the junction of the horn base and the skin. The straight line distance between the transmitter cavity in the lateral side of the horn and the horn base was also measured. All the marked rhinoceroses were adult animals.

After 12 months, two of the marked white rhinoceroses were recaptured and after 27 months a further four black rhinoceroses and four white rhinoceroses were recaptured. In each case the anterior horn length and basal circumference were measured again as well as the distance of the radio transmitter from the horn base. The difference between the successive measurements of anterior horn length was termed the "observed horn growth" for that specific time period.

The distance the transmitter cavity moved between implantation and recapture, relative to the base of the horn, was taken to be the "intrinsic horn growth" for that specific time period even though the overall horn length may not have increased due to wear on the tip.

Immobilized animals were subjectively classified into young adult (8-25 years) and old adult (>25 years) age classes using external criteria such as ear tears, scars, horn wear, anterior and posterior horn size, body size and known age.

Horn size and mass

Measurements of horn length, basal circumference (as described above) and horn mass were taken from a collection of horns originating from natural mortalities in the Kruger National Park, the Natal Parks and Transvaal Provincial Nature Conservation areas. Available measurements from adult animals captured for translocation in Natal and in the Kruger National Park were also included. Where the sex of an animal was not known the data were added to that of the population sample. Mean horn mass was ascertained for (i) adult rhinoceroses only, (ii) and all available rhinoceros horns (adults and juveniles), to give a mean horn mass for the entire population.

The Wilcoxon Rank Sum Test (Schlotzhauer & Littel 1987) was used to test for species and sex related differences in intrinsic anterior horn growth rate and horn size. The same test was used to ascertain any age related differences in the rate of horn growth. A paired t-test was used to compare the intrinsic and observed horn growth rates.

Results

Adult rhinoceros horn growth

The intrinsic anterior horn growth ranged from 25 to 66 mm per year with a mean of 50,5 mm ± 3,52 SD (Table 1). There was no difference in intrinsic horn growth between white (n=6) and black (n=4) rhinoceros (P=0,915; n=10). Also, no difference in intrinsic horn growth was found between rhinoceros males (n=4) and females (n=6) (P=0,2395; n=10).

Table 1
Intrinsic and observed mean yearly horn growth (mm per year) for four black and six white rhinoceroses in the Kruger National Park

No	Rhinoceros type	Sex	Age	Intrinsic horn growth	Observed horn growth
1	Black	Female	Young adult	53	-16
2	Black	Female	Young adult	62	-53
3	Black	Male	Old adult	38	-65
4	Black	Female	Young adult	58	-12
5	White	Male	Young adult	66	-18
6	White	Male	Young adult	60	-51
7	White	Female	Old adult	36	+4
8	White	Female	Old adult	25	-21
9	White	Male	Young adult	60	-2
10	White	Female	Old adult	47	+7
	MEAN ± 1 SD			4,31	25,2

Intrinsic horn growth was faster than observed horn growth (P=0,0001; n=10) (Table 1).

Mean yearly intrinsic horn growth at 59,8 mm ± 4,31 (n=6) for young adult rhinoceroses, was faster than for old adult rhinoceroses (n=4) at 36,5 mm ± 9,04 SD (P=0,0139 n=10).

Mean yearly observed horn growth was negative for both young adult (-25,3 mm ± 21,39 SD) and old adult (-18,8 mm ± 33,29 SD) rhinoceroses. This difference was not significant (P=0,7491; n=10).

Juvenile rhinoceros horn growth

The intrinsic horn growth rate of a rhinoceros is most rapid in young animals. A rhinoceros calf is born hornless. In the Kruger National Park the anterior horn of a white rhinoceros male calf was observed to pierce the skin at 5 weeks, and was 39 mm long at 3 months and 100 mm long at 7 months.

Horn size and mass

Adult white rhinoceroses have longer anterior horns than adult black rhinoceroses (P=0,0001; n=430). The mean anterior horn circumference of adult white rhinoceroses was greater than that of adult black rhinoceros (P=0,0001; n=285) (Table 2).

No difference in mean anterior horn length was found between male and female white rhinoceroses (P=0,177; n=179). White rhinoceros males had a greater anterior horn basal circumference than females (P=0,001; n=104) (Table 2).

Similarly, no difference in mean anterior horn length was found between male and female black rhinoceroses (P=0,082; n=112). Black rhinoceros males had a greater anterior horn basal circumference than females (P=0,005; n=96) (Table 2).

Adult white rhinoceros males had a longer anterior horn (P=0,001; n=169) and a greater basal circumference (P=0,001; n=123) than adult black rhinoceros males (Table 2). Similarly, adult white rhinoceros females had longer anterior horns (P=0,001; n=119) and a greater basal circumference (P=0,001; n=77) than adult black rhinoceros females (Table 2).

The mean mass of a sample population of white rhinoceros horns from the Kruger National Park, Umfolozi-Hluhluwe Game Reserve and the Transvaal Provincial Game Reserves was 4,3 kg ± 2,54 SD for the anterior horn (n=205) and 1,58 kg ± 1,07 SD for the posterior horn (n=188). This gives a total of 5,88 kg of horn per animal. White rhinoceros anterior horns mass ranged from 0,29 to 11,04 kg and from 0,01 to 4 kg for posterior horns. The sample population contained 25,8 % juveniles and 74,2 % adults.

The mean anterior horn mass of adult white rhinoceros was 5,16 kg ± 2,01 SD (n=163) and the mean posterior horn mass was 1,86 kg ± 0,98 SD (n=153). This gives a total of 7,02 kg of horn per adult.

Adult white rhinoceros males had heavier horns than adult females (P=0,001; n=212). For males the mean anterior horn mass was 6,12 kg ± 1,77 SD (n=91). The mean poste-

Table 2
Adult white and black rhinoceros anterior horn sizes (mm)

Rhinoceros type	Sex	Mean horn length	S.D.	*n*	Mean horn circumference	S.D.	*n*
White	Male & Female	578,6	119,42	289	644,3	6,65	167
White	Male	589,4	98,02	107	730,4	65,02	65
White	Female	583,4	141,94	72	610,0	34.36	39
Black	Male & Female	435,7	102.19	141	472,4	60,62	118
Black	Male	446,1	101,22	63	492,7	69,48	58
Black	Female	417,6	107,85	49	453,5	44,22	38

rior horn mass was 2,19 kg ± 1,1 SD (n=69), giving a total of 8,31 kg of horn per adult male. By comparison, adult females had a mean anterior horn mass of 4,02 kg ± 1,52 SD (n=33) and a mean posterior horn mass of 1,21 kg ± 0,65 SD (n=19), for a total of 5,23 kg of horn per adult female.

The mean mass of a sample population of black rhinoceros horns from the Kruger National Park and Natal Game Reserves was 1,72 kg ± 0,7 SD for the anterior horn (n=75) and 0,93 kg ± 0,5 SD for the posterior horn (n=74). This adds to 2,65 kg of horn per animal. Black rhinoceros anterior horn weights ranged from 0,18 to 3,799 kg and for posterior horns from 0,02 to 2,38 kg.

Discussion

Adult rhinoceros horn growth

The annual growth rate of anterior horns appears to decrease with age. Observations on recaptured rhinoceroses showed the intrinsic anterior horn growth rate decreased from 59,8 mm per year in young adults to 36,5 mm per year for old adult animals.

In the period from transmitter implantation to recapture the observed anterior horn lengths in most of the rhinoceroses decreased slightly. This is probably partly due to the antenna groove (Pienaar & Hall-Martin 1991) contributing to accelerated horn wear at the tip, although the rhinoceros' horn rubbing activities also influence observed anterior horn growth. Once the antenna groove has reached the horn tip, horn rubbing then causes pieces of the dental acrylic to break out of the antenna groove. The unfilled groove weakens the horn tip and this contributes to accelerated horn wear at the tip. The two white rhinoceros females with antenna grooves which had not yet reached the horn tip at the time of capture, were the only animals to show a positive observed horn growth (Table 1, numbers 7 & 10). In one of the black rhinoceros females (Table 1, number 2), the transmitter had moved up to the tip of the horn and the tip with the transmitter had broken off.

Klös (1969) noted observed horn growth in a captive female white rhinoceros from four to eight years of age and a male white rhinoceros from five to nine years of age. The female showed a mean annual observed anterior horn growth of 58,5 mm ± 8,16 SD and the male 47,8 mm ± 5,8 SD. This difference is not significant (P=0,323; n=9). The corresponding mean posterior horn growth was 15 mm per year and 18,3 mm per year respectively.

Bigalke (1945) studied a black rhinoceros female in captivity from 16 to 25 years of age and found the mean observed growth of the anterior horn to be 45,6 mm ± 7,6 SD per annum. During the last year no horn growth was observed.

Morkel (*pers. comm.*) noted anterior and posterior horn growth for a young black rhinoceros male and female (4-5 years) in Namibia. Observed anterior horn growth was 70 mm per annum compared to 50 mm for the posterior horn.

It appears that the growth rate of rhinoceros horns accelerates in the first year after horn loss. Bigalke (1945) and Klös (1969) found the anterior horn regenerates 110,4 mm and 103,4 mm (observed growth) respectively during the first year after loss. Accelerated growth after loss also seems to occur in the posterior horn. Hitchins (1990) noted observed posterior horn regrowth of 10 cm in two years for a black rhinoceros.

Juvenile rhinoceros horn growth

Dittrich (1967) reports a black rhinoceros calf with an anterior horn length of 40 mm at four months of age and 75 mm at eight months. Player (1967) observed a white rhinoceros male of 12 months old with an anterior horn of 152,4 mm and a white rhinoceros female at 18 months with an anterior horn of 209,6 mm long. Wallach (1969) describes a female white rhinoceros calf with an anterior horn length of 25,4 mm at two months and 63 mm at five months of age.

Bigalke *et al.* (1950) documented a female white rhinoceros whose anterior horn was 56 mm long at 12 months and 82 mm at 18 months. These measurements were, however, taken along the posterior surface of the horn using dividers. This method results in measurements being smaller than they would be if taken along the anterior surface with a tape as was done in the present study.

Lang (1960) made observations on two newborn Indian rhinoceroses *Rhinoceros unicornis*. One animal showed an anterior horn growth rate of 150 mm per year over the first 16 months which decreased to 21 mm per year over the next 17 months. The other animal showed an anterior horn growth rate of 110 mm per year over the first 12 months which decreased to 53 mm per year over the next nine months. These horn measurements were taken from the anterior base of the horn over the tip to the posterior base.

Player (1967) describes the anterior horn growth of a 34-month old white rhinoceros male and a 30-month old white rhinoceros female. Observed growth per annum from 12 months of age onwards was 101,6 mm for the female and 76,2 mm for the male.

It seems the intrinsic growth rate of the anterior horn of both species is about 150 mm in the first year of life and then slows down gradually as the animal ages. During the first year the intrinsic growth rate and the observed growth rate are almost the same as the anterior horn is still too short to rub properly. After the first year the observed growth of the anterior horn slows more rapidly than the intrinsic growth due to horn rubbing.

The result of different intrinsic and observed anterior horn growth rates are schematically illustrated in figures 1 & 2. The fastest horn growth is during the first year of life. The difference in annual intrinsic and observed horn growth can only be due to the animal's horn rubbing activities. In figures 1 & 2 the assumption is made that the amount of horn removed by rubbing each year is relatively constant throughout a rhinoceros's adult life. When the annual observed horn growth in old animals falls to below 0 mm, the horn length decreases (Fig. 1).

The consequence of horn rubbing will be different for each animal as individual rubbing frequency varies. With animals that rub their horns more the horn length reduction with age might be more extreme. This means that the length of the anterior horn of a rhinoceros at 40 years of age, could potentially be doubled if no horn wear took place (Fig. 2). The longest white rhinoceros anterior horn on record is that of a female and it measured 1588 mm (Lydekker 1908).

Horn size and mass

White rhinoceros horns are longer, greater in basal circumference and heavier than black rhinoceros horns. Groves (1971) made similar observations on the species-related differences in rhinoceros horn size. The reason the anterior horns of white rhinoceroses usually grow longer than the anterior horns of black rhinoceroses, even though the intrinsic growth rate seem to be similar, is probably due to the greater basal circumference suppressing the effects of horn rubbing.

The anterior horn of rhinoceros males has a greater basal circumference and is heavier than anterior horn of the female rhinoceros. This difference is also evident in the broader nasal bones of the male (Groves 1975). Groves (1971) also found that the anterior horns of black and white rhinoceros males are greater in basal diameter than those of females.

No significant sex-related difference in anterior horn length was found during this study. The statement that the anterior horn of a rhinoceros female is longer than that of a male has been made by various authors (Selous 1881; Sclater 1900; Groves 1971). In the present study, a number of rhinoceros females were observed to have very long and slender anterior horns. However, there was no evidence to suggest that the average length of the anterior horn of an adult female was greater than that of an adult male.

A sex related difference was noted in the shape of the anterior horn base for white rhinoceros. When viewed from below the base of the female anterior horn is egg shaped while that of the male is more square. The horn base of a black rhinoceros is round.

The mean mass of 5,88 kg of horn per white rhinoceros found in the present study differs considerably from that of 4 kg (Martin 1983b) used by Martin & Ryan (1990) in their calculations of estimated the number of poached rhinoceroses. As with this study, Martin (1983b, *pers. comm.*) also used a sample that included juveniles but does not give the sample size or the % of juveniles in the sample.

Martin (1983b) mentions a mean horn mass of 1,44 kg for a population of East African black rhinoceros (n=6425) adding to 2,88 kg of horn per animal (Martin & Ryan 1990). Martin (1983b) also gives a figure of 3,43 kg of horn per animal for the Zimbabwean black rhinoceros. The mean mass of 2,65 kg of horn per animal for the black rhinoceros from the Kruger National Park and Natal Game Reserves is similar to that for the black rhinoceros from East Africa.

Horn rubbing

It has been observed on numerous immobilized white rhinoceroses in the Kruger National Park and on carcasses were the sex could be established that for adult males the anterior horn base is usually rubbed smooth whereas for adult females the horn base are often frayed and fibrous (Fig. 3). In sub-adult animals (<8 years) this difference is not so obvious. Pienaar & Hall-Martin (1991) also found during a radio-telemetric study that

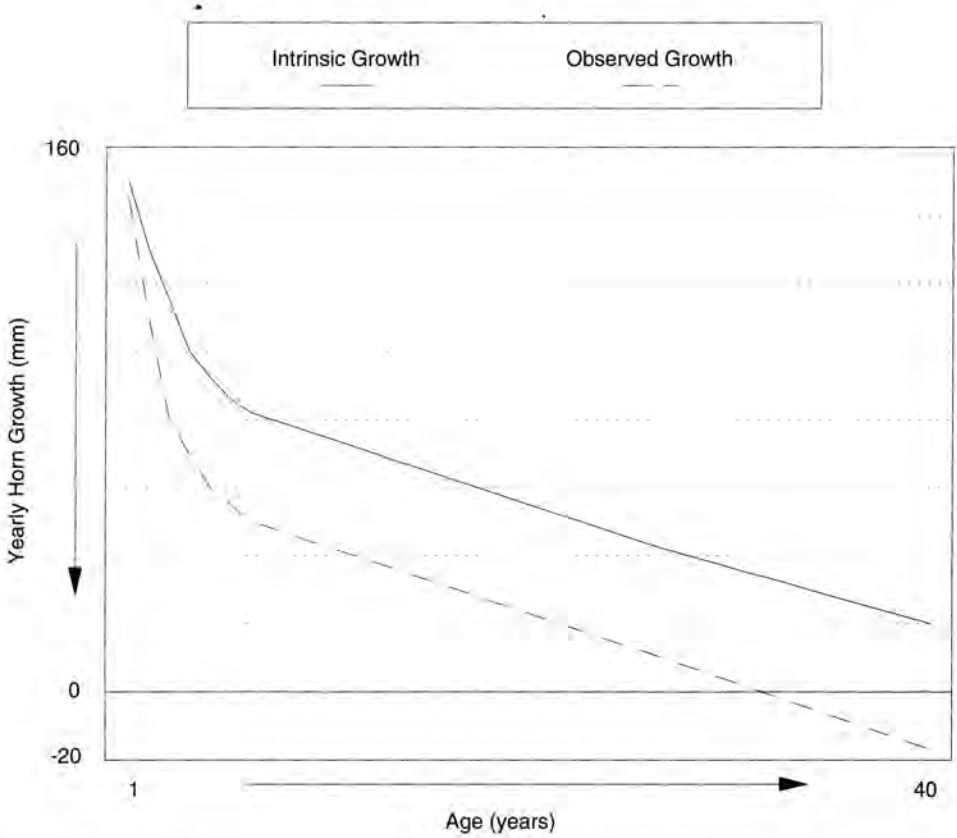

Fig. 1. Annual intrinsic and observed rhinoceros anterior horn growth (mm per year) illustrated schematically.

white rhinoceros males rubbed through the cable antenna faster than females do. It would thus seem that adult white rhinoceros males rub their horns more frequently than do females.

The reason why horn rubbing does not cause white rhinoceros male anterior horns to wear shorter than female's is probably because the male horns are greater in girth and heavier the female's. It has also been observed that a rhinoceros rubs it's horn length-wise and does not just rub the tip.

Lang (1960) studied a male and a female Indian rhinoceros in captivity for 6,5 years. The female showed an observed horn growth of 48 mm per year over this time span compared to 19 mm per year for the male. These measurements were taken from the anterior base over the tip to the posterior base. Lang (1960) states that the male rubbed his horn so much that it obscured growth. Laurie (1978) noted that with the Indian rhinoceros the male's horn is more often broken off or worn down by rubbing on trees.

The environment of the animal also influences its horn rubbing efforts. Groves (1971) mentions that rhinoceroses in captivity sometimes show abnormal abrasion of their horns. The amount of horn rubbing also varies between individual animals. Some animals rub their horns more vigorously than others. An adult male white rhinoceros, followed on a cool overcast day in the Kruger National Park over a distance of two kilometres, was observed to rub his horn on nine separate occations. Owen-Smith (1973) also noted that horn rubbing frequency increased on cloudy days when the animals spent less time sleeping.

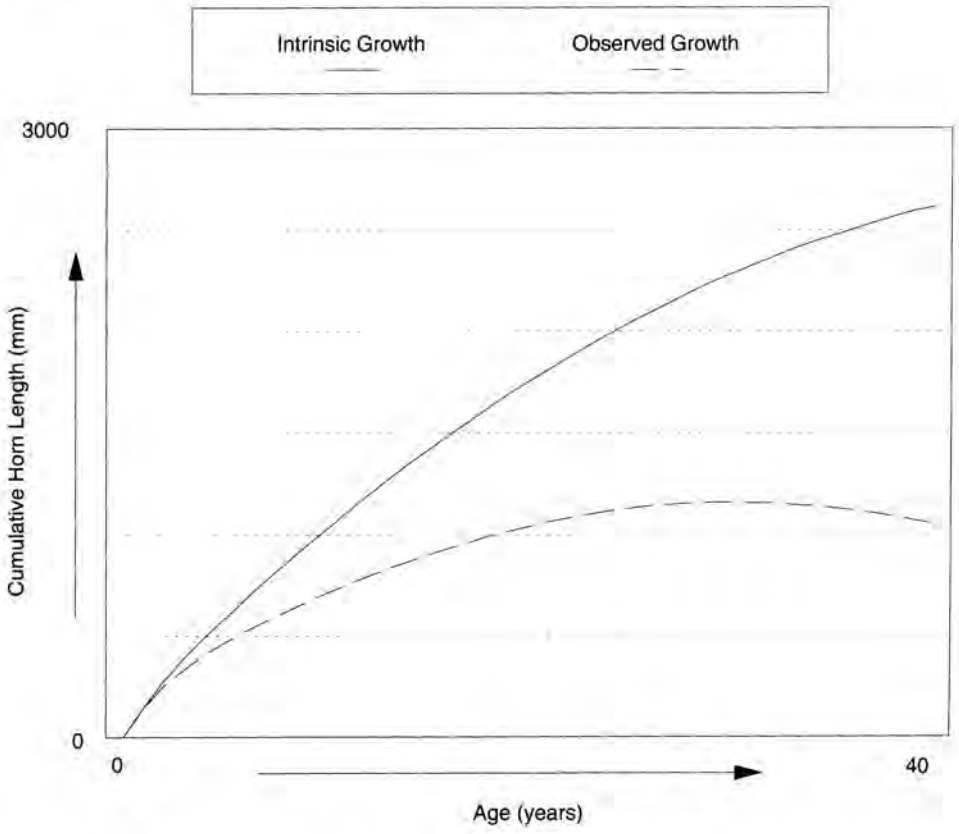

Fig. 2. Cumulative intrinsic and observed rhinoceros anterior horn growth (mm) schematically illustrated.

Fig. 3. The anterior horn base of a male and female white rhinoceros. The horn base of the male is rubbed smooth and is more massive while that of the female is more fibrous and slender.

In the present case it is felt that the presence of a radio transmitter in the horns did not cause an increase in the animals' horn rubbing activities. With the absence of any sensory stimulus and the fact that the transmitters did not protrude from the horns, it is unlikely that the animals were aware of the transmitters.

Conclusions

The intrinsic anterior horn growth for the sample of adult white and black rhinoceroses in the Kruger National Park ranged from 25 to 66 mm per year with a mean of 50,5 mm. The anterior horns of young adult (8-25 years) white and black rhinoceros exhibit an intrinsic growth rate of 59,8 mm per year. Old adult (>25 years) white and black rhinoceros exhibit a slower intrinsic growth rate of 36,5 mm per year. Rapid observed anterior horn growth (100 mm) seems to occur in the first year after loss. White rhinoceros horns are larger and heavier than black rhinoceros horns. Rhinoceros males have heavier horns than rhinoceros females and the female horn is usually more slender although not necessary longer than the male's.

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