

Using spoor to determine the age and weight of subadult black rhinoceroses (*Diceros bicornis* L.)

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Spoor measurements of seven subadult black rhinoceroses (*Diceros bicornis* L.) (three males and four females) were measured during a structured release programme in Matusadona National Park, Zimbabwe. These measurements were then used to test for a relationship between spoor width and length, with the age and weight of the subadult rhinoceroses. In many areas where rhinoceroses occur it is not always possible to obtain visual records, and the ability to accurately assess the age of subadults from spoor will greatly assist management with determining recruitment rates into rhinoceros populations. The efficacy of the immobilization of rhinoceroses in the field would be greatly improved if the weights of subadults were known prior to darting. The results of this study found significant relationships between the spoor measurements and both age and weight, with spoor length being the best predictor variable. There is a need to determine the effect of soil substrate on these relationships. Although the spoor measurements were taken from the same area of ground, suggesting a similar soil substrate throughout, the measurements were taken from both dry and wet soil, depending on the season. It was also found that as the subadults reached maturity, variability in their spoor measurements increased. The results suggest that measuring spoor of subadults in the field could be a valuable management tool for determining recruitment and assessing drug dosages.

Key words: *Diceros*, rhinoceros, Matusadona, spoor.

INTRODUCTION

The endangered status of the black rhinoceros (*Diceros bicornis* L.) results in the need for intensive management. This inevitably involves close population monitoring and the immobilization of individual animals, as necessary.

In many areas where black rhinoceroses occur, the habitat and the behaviour of black rhinoceroses

makes visual sighting difficult. Thus mechanisms of identification and age determination based on indirect observations from spoor, middens and feeding stations are being developed. For effective rhinoceros population monitoring, it is necessary to determine the age of subadult rhinoceroses in order to estimate recruitment rates and mortalities. A method using indirect signs needs to allow for the estimation of age, without the rhinoceros having been observed.

When immobilizing rhinoceroses in the field, it is often not possible to assess the weight and age of the animal before preparing the immobilization drugs. If the ground-support team were able to estimate the weight and age of a rhinoceros prior to the animal being sighted and darted, this would reduce the chances of problems arising from the immobilization. It would also increase the cost-efficiency of an immobilization operation; etorphine (M99) is an expensive drug. Only a 3.5 mg differential dosage of M99 is required between the immobilization of a nine-month-old rhinoceros and an adult rhinoceros (C. Foggin, pers. comm., 2005). Optimum drug dosage is determined by rhinoceros body mass (Kock & Meltzer 2003), which has some relation to the age of the animal. Even if the ground-support team sees the animal, estimates of age and weight will be subjective and prone to observer bias.

An opportunity to perform an exploratory study on the relationship of black rhinoceros spoor to both their age and weight presented itself during a structured release programme in Matusadona National Park, Zimbabwe, between May 1998 and March 2001. Data were collected from seven subadult rhinoceroses (three males and four females), of which the ages were known. Measurements were taken from seven months of age until 42 months.

An analysis of these measurements reveals relationships in the data and suggests that monitoring and immobilization, using indirect signs, may be improved as a result of further, more extensive studies.

METHODS

Measurements

As part of the structured release programme, the seven rhinoceros subadults were held in bomas (fenced enclosures) at night and allowed to roam freely during the day under the supervision of a general hand and an armed National Parks Scout.

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The daily routine included weighing each rhinoceros as soon as they were let out of their bomas. Feeding the rhinoceroses horse cubes, while luring them onto a flatbed scale designed to weigh bull cattle, facilitated the weighing process. During the weighing process, body measurements, including both the length and width of spoor prints on the ground leading up to the scale, were taken. The ground between the boma and flat bed scale was swept before each rhinoceros was lured onto the scale, to ensure that a clear print was available for each measurement. The same piece of ground, approximately 10 × 3 m, was used for all the rhinoceros spoor print measurements over the entire study period. Although the substrate was soft, fine sand superimposed on hard ground, during wet weather the spoor print would make a more defined mark in the sand, giving the print sharper edges. Measurements were not taken while it was actually raining or if there was water lying on the ground after a large rainstorm. In an attempt to maintain a standard, and because the back spoor print tends to overlay the front spoor print, only the right back spoor print was measured. The spoor width was measured from the outside edge of one side toe to the outside edge of the other toe. The spoor length was measured from the outside edge of the front toe to the furthest point along the back of the foot (Fig. 1). Measurements were rounded to the nearest 5 mm.

The seven rhinoceroses came into the management programme at different times and were in the programme for different lengths of time, and over different age spans: (7–39 months; 8–40 months, 10–44 months, 11–36 months, 16–33 months, 14–31 months and 18–21 months). The exact age of each rhinoceros was known as they were born in a semi-captive environment. The average weight data covers the ages 7–43 months, and the average spoor length and average spoor width data covers the ages 11–44 months. The small data size means that there are dependencies in the measures: the same individuals were used to provide the weight and spoor data over an extended period, an inevitable consequence of the nature of the release programme for which it would not have been possible to collect independent data from a larger sample of rhinoceroses. Although sexually dimorphic, with female black rhinoceroses being heavier than males, the two were grouped together, as treating them separately would further reduce the sample sizes used for analysis.

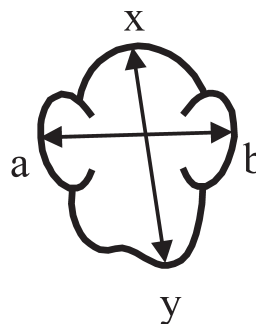


Fig. 1. Diagram indicating where spoor measurements were made from subadult rhinoceros in Matusadona National Park. The width was measured from a to b. The length was measured from x to y.

Analysis

The variables that were measured are known to change with age as shown in Fig. 2. Using the inverse of these allometric relationships it can then be proposed that age or weight be predicted from the spoor width or spoor length.

Four linear regressions were undertaken using spoor length and width (cm) as the predictor variable, and age (months) and weight (kg) as the dependent variables.

The assumption of independence of data does not hold as the same seven rhinoceroses have been used to determine the average spoor and weight measures for each age month, and therefore a high correlation between spoor measurements and the age of growing animals would be expected. However, the analysis also investigated the correlation between weight and spoor measurements, and the regression models produced enable a numerical prediction of age and weight from actual spoor measurements.

RESULTS

Despite the large degree of variability in spoor measurements, all four relationships were found to be significant (Figs 3 & 4). The strongest predictor of age was found to be spoor length (spoor length/age: $r^2 = 95.4\%$, $n = 263$, $P < 0.01$; Fig. 3a), with a slightly weaker correlation between spoor width and age (spoor width/age: $r^2 = 94.2\%$, $n = 266$, $P < 0.01$; Fig. 3b). It was also observed that the strongest predictor of weight was spoor length (spoor length/weight: $r^2 = 95\%$, $n = 260$, $P < 0.01$; Fig. 4a) followed by a weaker correlation between spoor width and weight (Spoor width/weight: $r^2 = 90.9\%$, $n = 263$, $P < 0.01$; Fig. 4b).

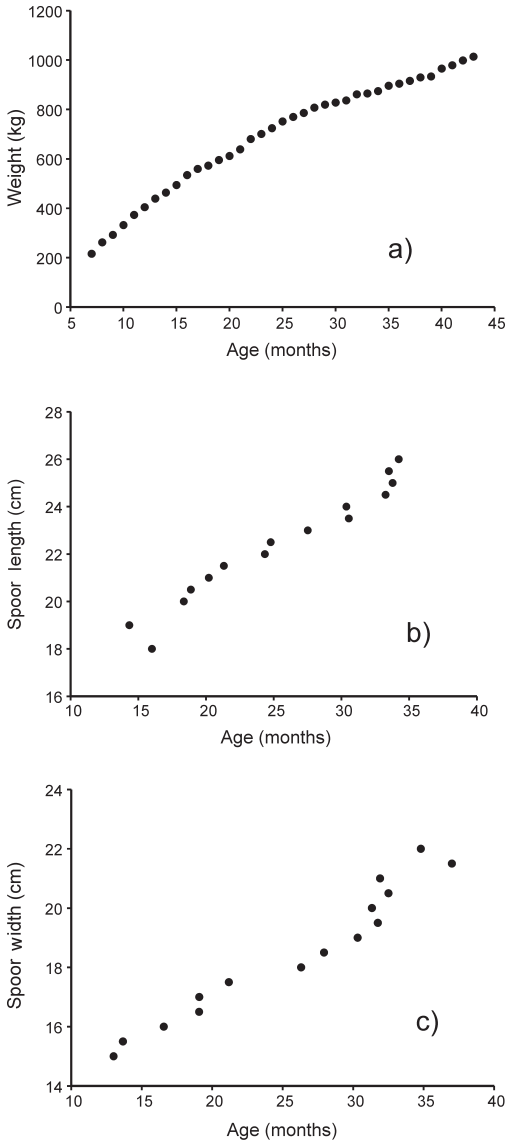


Fig. 2. Diagram showing the relationship between (a) age (months) and weight (kg), (b) age (months) and spoor length (cm), and (c) age (months) and spoor width (cm) for seven subadult black rhinoceroses in Matusadona National Park.

DISCUSSION

Despite the limited sample size and the dependencies in the data, this exploratory analysis demonstrates the potential usefulness of a weight and age prediction tool.

These results suggest that spoor measurements could be used to estimate the age of subadult rhinoceroses for monitoring purposes. The advantages of such a tool are that the rhinoceroses do

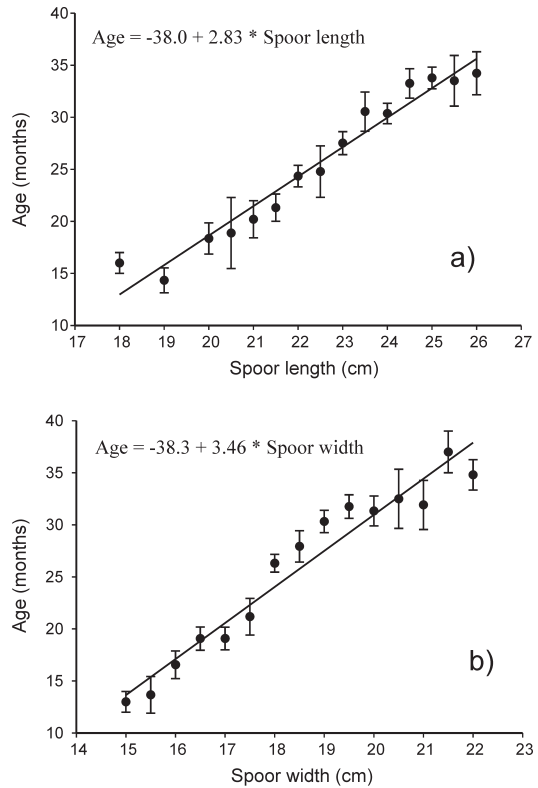


Fig. 3. Diagram showing the relationship between spoor measurements (cm) and age (months) for seven subadult rhinoceroses in Matusadona National Park. Data collected between May 1998 and March 2001. **a**, Spoor length as the predictor variable and age as the dependent; **b**, spoor width as the predictor variable and age as the dependent.

need not be disturbed by attempted visual sightings and there is less subjectivity in spoor measurement than in visual age estimation. As many areas that have black rhinoceros populations have limited resources and a limited number of skilled staff, there is considerable potential benefit through indirect population monitoring.

These results also indicate that the weight of a subadult rhinoceros could be determined from spoor measurements. This is particularly useful in determining drug dosage when subadult rhinoceros immobilization is contemplated. In most immobilization operations, especially in areas where the rhinoceroses are not habituated to the presence of humans, the veterinarian has to prepare the drugs in advance of an immobilization. An estimate of the rhinoceros weight in advance of the immobilization, as a result of spoor measurement, will assist the veterinarian in determining a safe and efficient

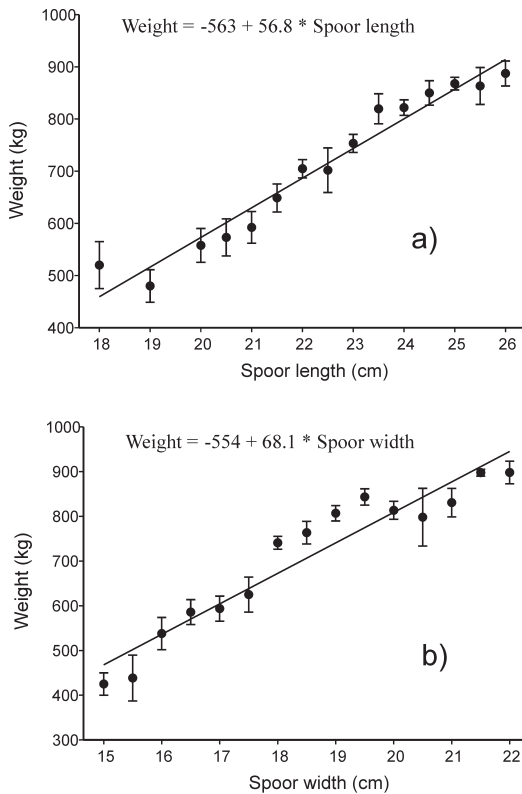


Fig. 4. Diagram showing the relationship between spoor measurements (cm) and weight (kg) for seven subadult rhinoceroses in Matusadona National Park. Data collected between May 1998 and March 2001. **a**, Spoor length as the predictor variable and weight as the dependent; **b**, spoor width as the predictor variable and weight as the dependent.

dose. The field staff tracking the rhinoceros in advance of the immobilization can measure the spoor and then relay the information back to the veterinarian.

Although the results indicate that a significant relationship exists between two spoor measurements and the age and weight of subadult rhinoceroses, the variability around each spoor measurement is a cause for concern. It is likely that a spoor measurement would give a range of possible weights, and this should be taken into consideration when determining the dosage of M99. A larger field study would determine whether the variability recorded during this study is too large for the precision needed for immobilization operations.

As the rhinoceroses grow older and heavier, the width and length measurement becomes more unreliable as a predictor for the age or weight of the

animal. One possible reason for this is that the spoor begins to reach its maximum while the animal is still increasing in age or weight, as would be expected. It appears that an asymptote will be reached, after which point the relationship will no longer hold. However, as this asymptote appears to be reached at the point where the rhinoceroses would be classified as nearing adulthood, the relationship between spoor measurement and age or weight would still be useful in monitoring recruitment and mortality within a population, and assessing the drug dosages required.

Finally, it must be noted that spoor measurements were only taken on one type of substrate. Variability in substrate is known to have a significant impact on the size of spoor (Smallwood & Fitzhugh 1993) and it is possible that spoor measurements from a variety of substrates would affect the relationships presented in this paper. In a soft sandy substrate, the foot will tend to sink more and give a slightly larger spoor measurement as the wall of the foot pushes more sand aside. A hard substrate with a thin powder layer will only reflect the minimum contact between foot and ground, effectively making the spoor appear smaller. Spoor prints in a very muddy soil could be distorted as the rhinoceros might 'move' within each spoor print as it tries to maintain ground contact. Spoor measurements from the same group of rhinoceroses in a variety of substrates should be analysed to determine if the relationship is still significant.

As an exploratory study, this research suggests that the use of spoor measurement to determine both age and weight has potential in rhinoceros management in areas of dense habitat, or where rhinoceroses are not habituated to the presence of humans, and where resources in terms of finances and manpower are limited. A more reliable prediction tool could be produced if collaborative research between existing projects were to contribute independent data sets.

With greater collaboration and the production of a more valid data set, a specialized measuring ruler could be designed for use in the field. The ruler gradations could then correspond to the predicted age or weight of a rhinoceros against a measured spoor.

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