PRESENTATIONS
SESSION III
IN SITU POPULATION DYNAMICES AND CONSERVATION

FOCUS on BLACK RHINO: *Diceros bicornis bicornis* Population Dynamics and a Formula for Successful Conservation of the Species (2002 – 2012)

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ABSTRACT

In 1989, South Africa had less than 20 *Diceros bicornis bicornis*. This project alone has helped quadruple that number. *The Biodiversity Management Plan for the Black Rhinoceros in South Africa 2011 – 2020* [1], (BMP; Government Gazette, 25th January 2013), calls for 260 by 2020, and a longer term goal of 500.

This project, registered with South African National Parks,[2] supports a number of strategic objectives of rhino monitoring and management by studying separate sub-populations in four smaller parks within their historical range. The accumulated data assesses and measures performance towards the BMP goals.

Although data is available for over 21 years, and the first founder population was introduced to one study area in 1999, regular ground monitoring commenced in 2002, and numbers have increased from 5 to 72 rhinos. All rhinos are individually identifiable. The objectives were to monitor developmental stages, study all performance indicators, assess dispersal into new habitats, determine success/failure of translocation strategies, study behaviour and develop genealogy.

The experience with Shibula, returned to southern Africa from Lisbon Zoo in 1991, has been an inspiration, was invaluable, and is comprehensively documented.

Monitoring involved locating, identifying and observing individuals using a combination of methods and techniques: telemetry, tracking spoor, searching from vantage points and once located, a spotting scope used to identify individuals by means of unique ear-notches.[3]

Accomplishments included 133 field trips, over 1,000 days in the veldt and over 1,300 hours of rhino observations. Over 80,000 photographs were taken and 104 hours of video were filmed. On average, we identified at least 75% of the rhinos per field trip, attempted to locate 100% each year, and during 80% of sightings ensured rhinos were undisturbed and therefore observed natural behaviour and social interaction.

Average annual growth rate was 15% over 14 years in one area with the most rhinos. The study highlights the problems of developing small populations, and the impact of management interventions. Population constraints were forecast and relocations recommended. As poaching reached record levels in 2010, emphasis moved to focus on safety and security, which led to the project initiating specific plans, supplying equipment, manpower and anti-poaching training.

This study highlights the success of undisturbed populations, careful unobtrusive monitoring and the importance of security. These four sub-populations will contribute significantly to the overall growth and survival of the sub-species, and exceed by far the growth targets set by the BMP. The project methods have proved to be a valuable formula for the future.

This monitoring and security project was funded by the David Shepherd Wildlife Foundation (DSWF) and the authors personally.

INSPIRATION – SHIBULA

"Our dedication to black rhinos was inspired by Shibula in 1991 – a very special black rhino. Her return to Africa from Lisbon Zoo in Portugal, adapting to a new wild habitat and giving birth to eight calves is an all too rare good news conservation story." [3]

Shibula changed our lives. She was gentle and inquisitive and allowed us to get close to her and her first two calves. We followed her progress from the concrete enclosure in Lisbon Zoo, to her introduction to a wild population to the birth of her first calf, Dundi, to their separation and relocation to different parks, to the death of two of her male calves, to the birth of her eighth calf. Shibula was the motivation for us to give back and dedicate our lives to do whatever we could to help her sub-species survive. She is now completely wild.

INTRODUCTION

The Black Rhino Monitoring Project in South African National Parks, 2002 - 2012

Our objective in documenting data over ten years has always been to compile and analyse accurate information on these sub-populations of the south western black rhino *Diceros bicornis bicornis (D.b.b.)*, (hereafter referred to as rhino).

Shibula focused our conservation efforts on black rhinos in 1991. With very little knowledge, our learning curve was very steep, finally eliciting the following note from Dr. Michael Knight, Chairman of the AfRSG: *"In this case the DSWF monitoring project managed by Sue Downie and Lucky Mavrandonis is of **utmost** importance to the individual parks, SANParks in general, and myself as Chair of the SADC Rhino Management Group and IUCN SSC African Rhino Specialist Group. Lucky and Sue's unwavering dedication and attention to detail surpasses any other such rhino monitoring project in SANParks, and dare I say for any other state protected area in the country."* [4]

The Black Rhino Monitoring project (BRMP) could be a guideline for what is needed to protect this species - private focused involvement, private funding, independent analysis, many man-hours physically spent observing rhinos, area-specific rhino security plans, plus the passion to commit to a long-term project. We have been privileged to have had the opportunity of "walking with black rhinos" for many years.

Comments from Dr. Anthony Hall-Martin confirm this essential role of the private sector: *"It is now more than twenty years since Sue and Lucky began to work on the conservation of the black rhinoceros in South Africa ….. These efforts have made large new areas of habitat available for the southwest arid zone subspecies of the black rhinoceros, Diceros bicornis bicornis. On their watch a handful of these animals have grown into thriving populations ….. The monitoring of reintroduced black rhinoceros populations by Lucky and Sue has produced an impressive body of biological information of great value to science and to practical conservation."* [5]

We believe that this study gives practical details for the successful implementation of projects to ensure *D.b.b.* numbers reach the Biodiversity Management Plan for the Black Rhinoceros in South Africa[1] (BMP) targets set in 2013.

OBJECTIVES

The objectives of this project, a registered research project with SANParks [2] were to:

1) assess the population performance of the arid adapted ecotype of the black rhinoceros sub-species *D.b.b.* under management of SANParks in four parks,
2) facilitate the development of appropriate management strategies,
3) assess dispersal into new habitats post-release,
4) fund and assist in the implementation of individual security plans, and
5) since the publication of the BMP in 2013, evaluate how these sub-populations can assist South Africa in achieving the short and long term goals of the Plan for *D.b.b.*

STUDY AREAS

For security reasons, the four project areas are not identified by name, but by the first four letters of the Greek alphabet (Figure 1).

1. Alpha is an arid area of about 44'000 ha with *noorsveld* type vegetation in the Karoo Biome.[6] *Euphorbia coerulescens* or *noors*, a nutritious plant with a high fat content,[7] is one of the major plant species browsed by the black rhino.[8] After 2006, the area available to the rhino was about 35,000 ha and was home to 34 *D.b.b.* in May 2012, and probably 38 by December 2012. **2. Beta** is situated on the northern slopes of a mountain range, located in the transitional area between four biomes: grassland, Nama Karoo, thicket and savanna, vegetation types which are poorly conserved in South Africa.[9] A study by Brown & Bezuidenhout[10] found twelve major vegetation units in the expanded national park. The areas mainly utilised by the rhino are the *Pentzia globosa – Eragrostis obtusa* shrubland and the *A. Karoo – Rhus pyroides* woodland.

From 1995 to 1998 we were directly involved in fund-raising and facilitating the expansion of the park from 6,500 ha to 28,000 ha (430%). It was home to ten *D.b.b.* in May 2012, before the relocation of two sub-adult females.

3. Gamma is situated in the north, about 26,500 ha with two major biomes being savanna and Nama Karoo.[11] Both black and white rhinos (*Ceratotherium simum simum*) in the park use the flat savanna *Acacia mellifera* shrubland. Gamma was home to an estimated 15 *D.b.b.* in May 2012, but in December 2012, 16 were confirmed and possibly 17.

4. Delta is an arid area of ± 90,000 ha situated within the Nama Karoo Biome.[12] and was home to 12 *D.b.b.* in December 2012.

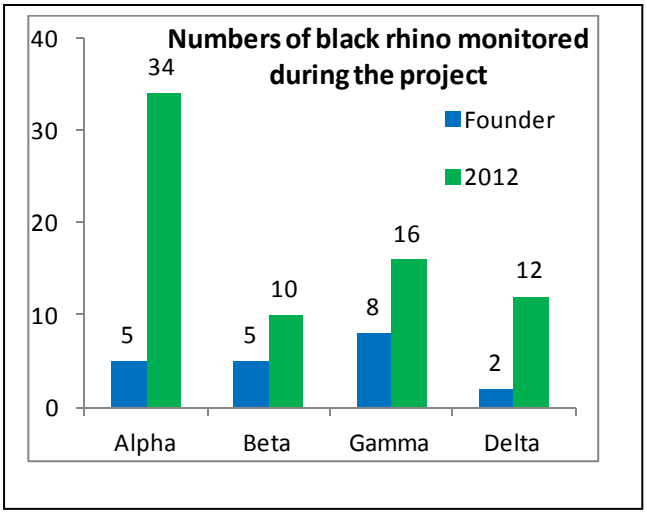


Figure 1. Founder populations and present numbers of rhinos in study populations.

METHODOLOGY

The necessity for accurately monitoring black rhino populations is not debatable, it is essential for such a valuable endangered species especially during the current poaching crisis.

The data collected in the veldt had to be accurate, reliable and precise, otherwise all future extrapolations would be suspect. The data had to be long-term to provide meaningful information. The major criteria we set for monitoring black rhinos were:

Summary of trips:	2002 - 2012
Number of field trips:	133
Trip days (including travelling):	1'234
Days in the field / veld:	1'002
Average % population identified per trip:	77.1%
% Sightings : rhinos undisturbed:	82.8%
Number of sightings (last 2.5 years):	454
Rhinos in sight:	1'303 hours
Sightings with more than one group:	27.1%
(Group denotes one single rhino or cow with calf)	
Average hours / day in the field (11 - 16 depending on the season	13 hours
Maximum number of hours with rhinos in sight on a trip:	24.5 hours
Tracked on foot in km (last 2.5 years)	922 km
Average km on foot per trip:	28.8 km
Maximum km on foot during a trip:	73 km
Kilometers in vehicle in study areas (last 2.5 years)	23'138 km
Total km for trips (2.5 years)	91'044 km
Estimate of total km travelled in 10½ years:	315'000 km
Digital photographs taken	80'956
Video footage taken	104 hours

The labour intensive, physical monitoring was not delegated, but carried out exclusively by the authors over the full ten year period. Personal goals were set: to positively identify 75% of rhinos on each trip; to ensure we remained undetected by the rhinos in 80% of sightings; and to attempt to see 100% of all rhinos once a year. Every effort was made to be unobtrusive, which resulted in studying undisturbed, relaxed rhinos and observing natural behaviour. We felt it was unethical to stress the rhinos unnecessarily. Every animal was known to us and individually identifiable by a pattern of ear-notches.

Table 1. Summary of various details of trips in ten years monitoring black rhino

A very successful tactic was to climb to vantage points, find rhinos up to 4 km away, and then plan our approach on foot without disturbing the rhino, getting as close as 20 metres. We often worked separately on any given day to double the coverage. This increased the danger significantly as it meant hiking alone with the ever present possibility of bumping into rhinos, buffalo or lion, which did happen.

Planning played a vital role, and each day key objectives for the trip were set. Trips were undertaken every month, and seven to nine days were spent in the veldt every month.

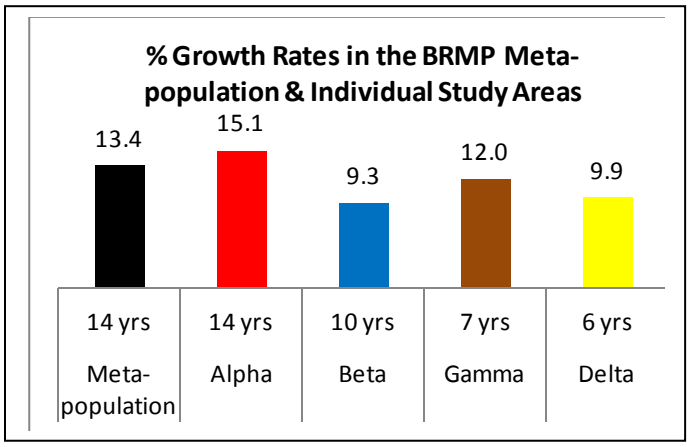
Essential equipment included Kowa scopes (20 - 60x), Canon EOS digital with 25,600 ISO (for night shooting), Sony video, Zeiss binoculars, Leica range finder and Kestrel weather station. Telemetry was used whenever possible; VHF transmitters and GPS satellite foot collars. Two Ford Ranger 4x4 vehicles were essential in the rough terrain.

SANParks have simplified monitoring by giving names to the rhinos. This makes it easier to communicate with field rangers, and we continued the practice.

RESULTS

Overall Growth Rates of the BRMP meta-population

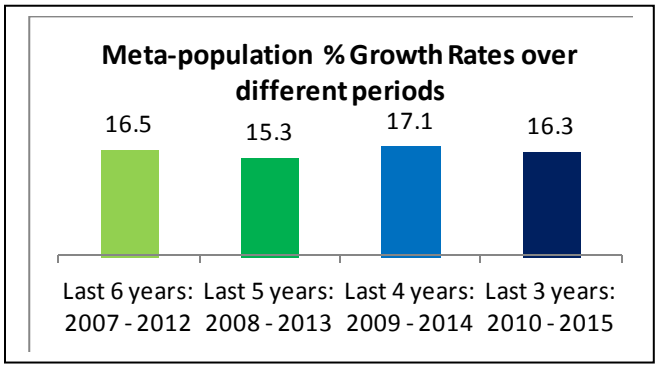
The key to the future of specific rhino populations is encapsulated in one single number - the growth rate - which is determined by a number of reproductive indicators. The growth number can be an oversimplification, and can be deceptive particularly in small populations, but mitigating biases due to small numbers in this study is the fact that the populations are 100% known. Negative events occurred in all the sub-populations. The numbers of rhinos are small, and there is acute awareness of how easily percentages could be exaggerated. However, the study focused on *Diceros bicornis bicornis* in South Africa where the total numbers are inherently very small. In December 2010, South Africa was home to only 171 *D.b.b.*, and only 100 in SANParks.[1] At this time, there were 56 rhinos in our study areas representing 56% of *D.b.b.* under SANParks management, and 32.7% of the entire South African meta-population. The numbers in this study may be small, but they form a significant percentage of the sub-species in South Africa.



The growth of 13.4% for the meta-population is excellent, even though it includes many negative biases, different introduction dates in each park, small founder populations and the introduction of immature animals.

Figure 2. Growth rates – each area

The lowest growth was recorded in Beta at 9.3% which is still far above average for black rhinos. At the upper end, we note that Bradley Fike [13] recorded an overall rate of 10%, while Benson Okita-Ouma[14] recorded growths of 5.5% to 11.5 % in the various areas. The BRMP growth of 13.4% is at the higher level recorded for black rhino. Alpha, with the most rhinos, over the longest period of time, showed the highest growth of the four study areas, at 15.1% over 14 years.

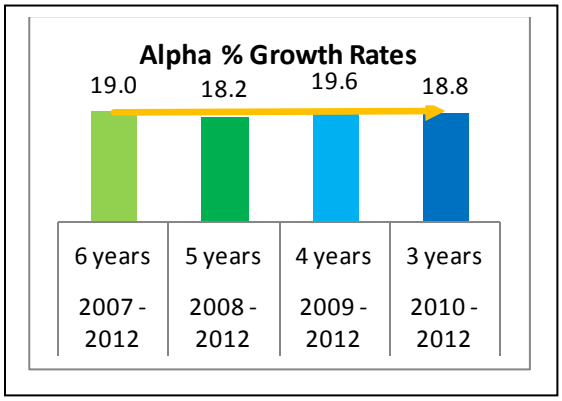


However, a far better gauge of growth for this project is to use the last 6 years (2007-2012) as illustrated in Figure 4 when all four parks were included in the study.

Figure 3. Growth Rates over different periods

This meta-population growth of 16.5% is not only more representative of the performance, but is consistent whether taking the last 3, 4, 5 or 6 years. A literature search has not revealed other populations with this level of sustained growth over 6 years.

Individual sub-population growth rates



Alpha, with a growth of 15.1% for 14 years reflects an even higher and consistent growth average of 19.0% over the last 6 years. The growth for 14 years is markedly lower at 15.1% due to incidents in 2005/2006 which resulted in six deaths after introductions.

Figure 4. Alpha - excellent performance maintained over time

In order to evaluate the influence of the incidents during which one newly introduced bull killed six rhinos (including three females), growth for this period i.e. 2005–2008 was only 7.7%. This clearly shows the impact of this single catastrophic event which resulted in the death of 31.6% of the population.

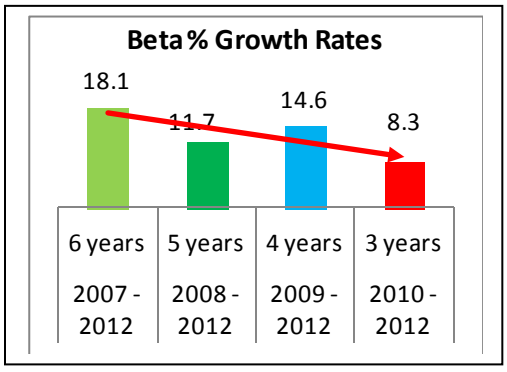
For the full implication, we need to consider that the adult female killed (Blom) had an excellent breeding record. She would have produced another three calves by 2012. The sub-adult female (Ntombi) would also have produced two calves. Therefore, potentially another five rhinos were lost. This population would have had 45 rhinos instead of 34 - this amounts to +32.4% or 11 more rhino. The overall growth would change from 15.1% to 17.3%.

Other negative factors for this area were a very small founder population (five), the unnecessary death of a female calf due to human interference in 2008, and the injury to the only breeding bull during immobilization which had a temporary negative impact by delaying conception in a few rhinos.

B. Beta (population introduced in March/April 2002 – Figure 5).

Beta showed a marked slow-down from 18.1% to 8.3%.

The major negative factors were again a small founder group (five), with a male skewed sex ratio (0.67♀ : 1♂) and the fact that the only mature bull had to be removed within the first year as he continually attacked the older female cow. In the first week of July 2005, the first calf in this area died due to human interference and the second cow, Dundi, only produced her first calf at 12½ years - no apparent reason.

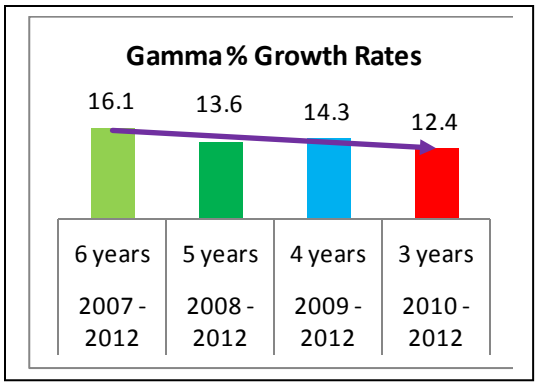


The subsequent precipitous fall in growth from 18% to 8% was due to a high tourist impact, interference from people eradicating alien species, and the building of major tourist roads into the previously exclusive areas inhabited by the rhinos. Also, carrying capacity had been exceeded. On the positive side, six of the seven calves born were female.

Figure 5. Declining growth, indicative of problems

C. Gamma (entire population relocated to new park in late 2006 – Figure 6)

This area also shows a slow down from 16.1% to 12.4%



A marked slowdown from 19.1% (2007 to 2010) to 12.4% (2010 to 2012) was due to the carrying capacity being exceeded. As opposed to the Beta area, mainly male calves have been born here. Of the ten calves born since introduction to Gamma, seven have been male. A clear indication of the stresses can be seen in the widespread destruction of *Acacia tortilis* trees.

Figure 6. Signs of problems

D. Delta (first *D.b.b.* introduced in 2005 – Figure 7)

Growth has moved very positively from 9.9% to 19.8%. Introductions took place in 2005, 2007 and 2008 without any breeding. In order to calculate growths, we simply took the founder population as seven in 2006. This had the negative impact of zero growths from 2007 to 2009. All the females were immature. Again, a very small founder population introduced over four years, and in 2007, the population was skewed to males (0.25♀: 1♂). The positives for this area are that it has a high carrying capacity, and that breeding has now started in earnest.

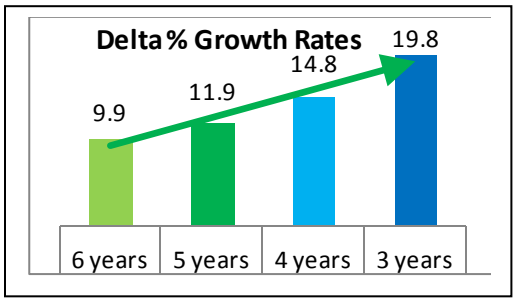


Figure 7. Excellent progress once breeding started

Reproductive Indicators

Parameters in blue	Very Poor to Poor	Poor to Moderate	Moderate to Good	Good to Excellent
Percentage Growth:	< 2.5%	2.5% - 5.0%	5.0% - 7.5%	> 7.5%
BRMP Meta-population:				13.4%
Inter-calving Interval:	> 3.5 yr	3.5 - 3.0 yr	3.0 - 2.5 yr	< 2.4 yr (30 m)
BRMP Meta-population:				2.2 y (26.9 m)
% Cows calving / year:	< 29%	29% - 33%	33% - 40%	> 40%
BRMP Meta-population:				47.0%
Average age at 1st calf:	> 7.5 yr	7.5 y - 7.0 yr	7.0 yr - 6.5 yr	< 6.5 yr (78 m)
BRMP Meta-population:			7 yr (83.7 m)	
Proportion calves 0 to 12 mths:				> 8.0%
BRMP Meta-population:				18.8%
Mortality Rate:				4% or less
BRMP Meta-population:				2.6%

We have recorded and analysed all the reproductive indicators listed in the literature by Raoul du Toit [15] and Mike Knight. [16]

We used Du Toit's parameters to rate the BRMP meta-population in May 2012.

Table 2. Comparing the BRMP meta-population study with R. du Toit's parameters

Comments on reproductive indicators

With the excellent growth rate recorded, it would follow that most parameters if not all, would be scored as "good to excellent". This was the case, with the surprising exception of age at first calf. Of 21 mothers, only six had their first calf at ages younger than 6.5 years. Fike [10] recorded 80 months as the average age at first calf, to our 83.7 months (Table 2), while Okita-Ouma [11] recorded 5.5 years (66 months) and 6.5 years (78 months) in two populations.

Other Parameters:

Sex ratios

After the relocations (see page 12) in May 2012 and April 2013, sex ratios improved as follows:

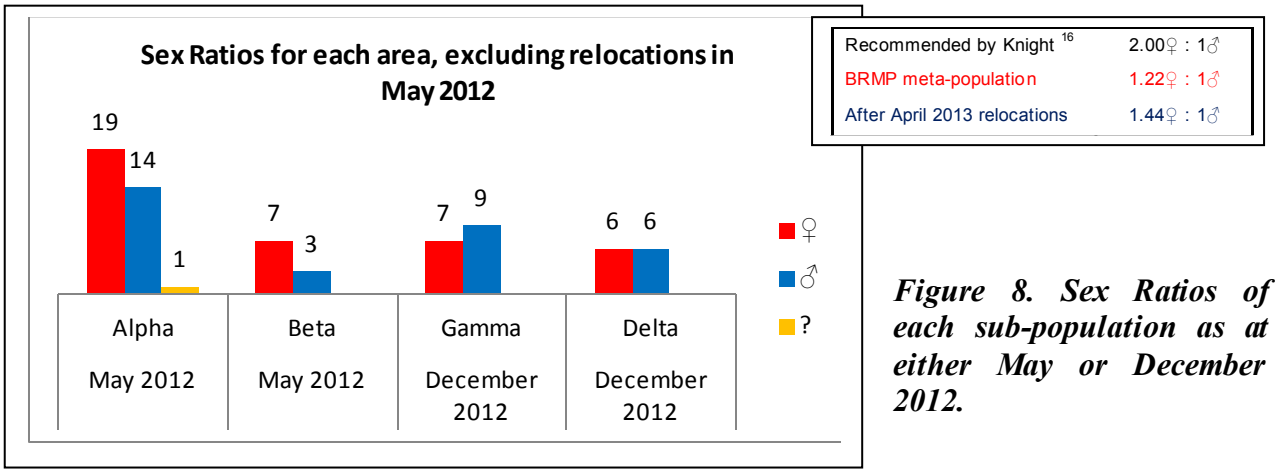


Figure 8. Sex Ratios of each sub-population as at either May or December 2012.

	Alpha	Beta	Gamma	Delta
Before relocations	1.36 : 1	2.33 : 1	0.78 : 1	1.00 : 1
After relocations	1.36 : 1	2.00 : 1	1.40 : 1	1.33 : 1

Table 3. Sex ratios ♀:♂ improved after relocations in May 2012 and April 2013

All populations now show a favourable sex ratio.

BRMP Meta-population Age Structure

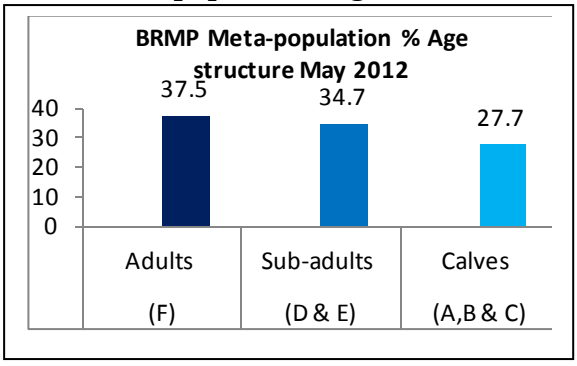


Figure 9. Percentage Age Structure for this Study in May 2012

Mortality

Although mortality for the meta-population, at 2.6%, is lower than either the 3% (Knight [16]) or 4% (Du Toit [15]) previously suggested, it is important to analyse these mortalities. Of a total of eleven deaths, only two (18%) were from natural causes (fighting in both cases). Significantly, although we recorded 56 births, no calves died from natural causes, but two calves (4 – 6 months) died after human disturbance.

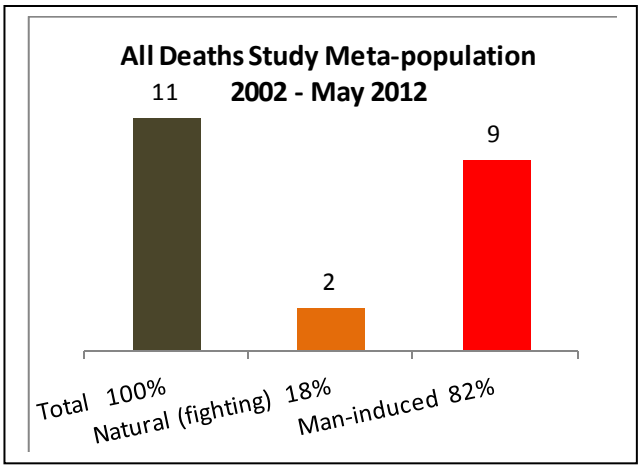


Figure 10. Analysis of deaths

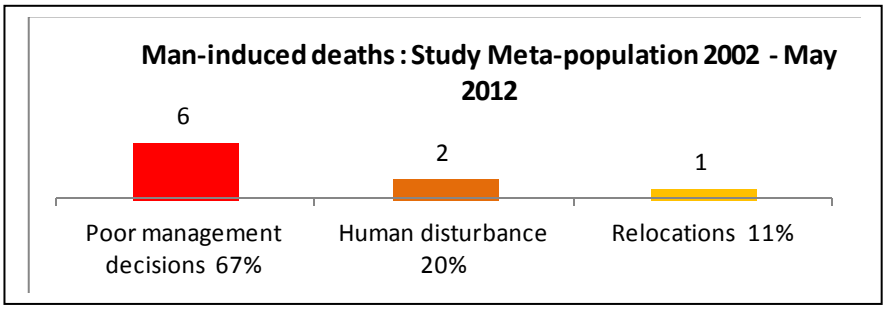


Figure 11. Man-induced deaths analyzed.

Reproductive Indicators for each sub-population:

	Alpha	Beta	Gamma	Delta
Growth Rate;	15.1%	9.3%	12.0%	9.9%
ICI;	25.3 m	32.4 m	28.3 m	24.0 m
% Cows calving / year;	50.4%	35.0%	44.0%	55.6%
Average Age at 1st calf:	79.7 m	78.0 m	94.3 m	82.5 m
Proportion of calves: 0 - 12 m:	17.6%	20.0%	12.5%	25.0%
Mortality Rate:	3.4%	2.0%	3.1%	0.0%
Sex Ratio F : M	1.36 : 1	2.33 : 1	0.78 : 1	1 : 1

The best reproductive indicators are in Alpha and Delta, mainly due to very little tourist impact in the former, and a very large area in the latter.

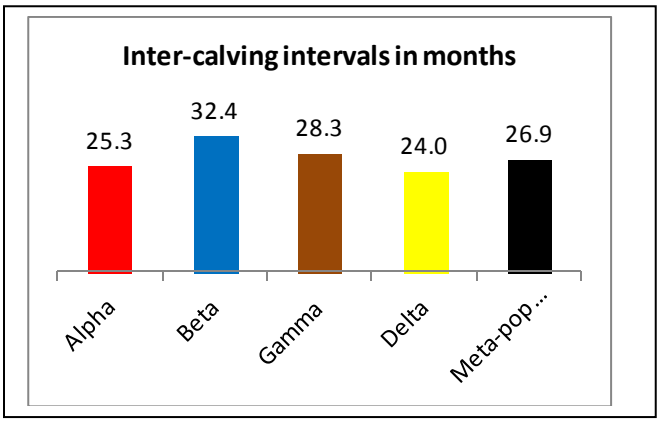
Table 4. A comparison of the four sub-populations' reproductive indicators

Body Condition: Each rhino's body condition is scored at every sighting by both authors independently, and the table below presents average individual body condition score over the period of the study. Results indicate no variability between seasons, and the scores are surprisingly consistent - the average for the meta-population was 4.41 out of 5. These body condition scores are a very good indicator of the suitability of the habitat in all areas.

	Alpha	Beta	Gamma	Delta	Meta-population
Range:	3.7 to 4.7	4.2 to 4.5	3.8 to 4.5	4.2 to 4.5	3.7 to 4.7
Average:	4.5	4.4	4.4	4.4	4.4

Table 5. Body condition

Inter-calving Intervals (ICI)



Alpha 8 cows with ICIs and 10 w ith calves.

Beta 2 cows with ICIs

Gamma 4 cows with ICIs

Delta 1 cow with ICI and 4 cows with calves

Figure 12: ICIs of sub-populations

The most productive cows: Ubhejane gave birth to calf # 13 at age 36 years

Cow	Number of calves	♀	♂	Area
Ubhejane	13	2	11	Gamma
Blom	11	10	1	Alpha
Faru	10	5	5	Beta
Nkombe	10	5	5	Gamma
Shibula	8	4	4	Alpha

Table 6 : The most productive cows in the BRMP meta-population

Percentage of cows calving per year

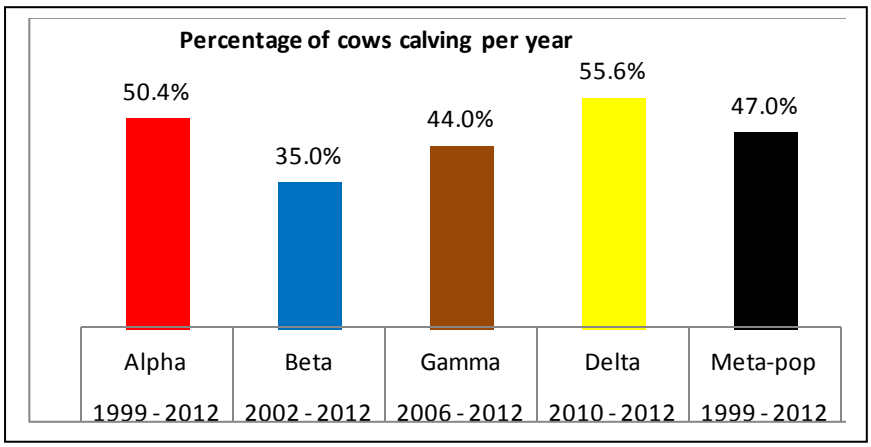


Figure 13. Percentage of Adult cows calving per year

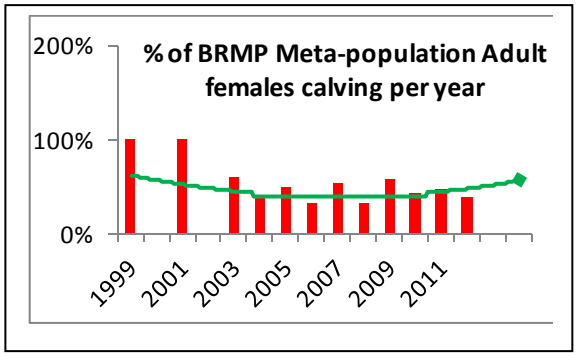


Figure 14. Average of 47.0% of adult cows calving /year.

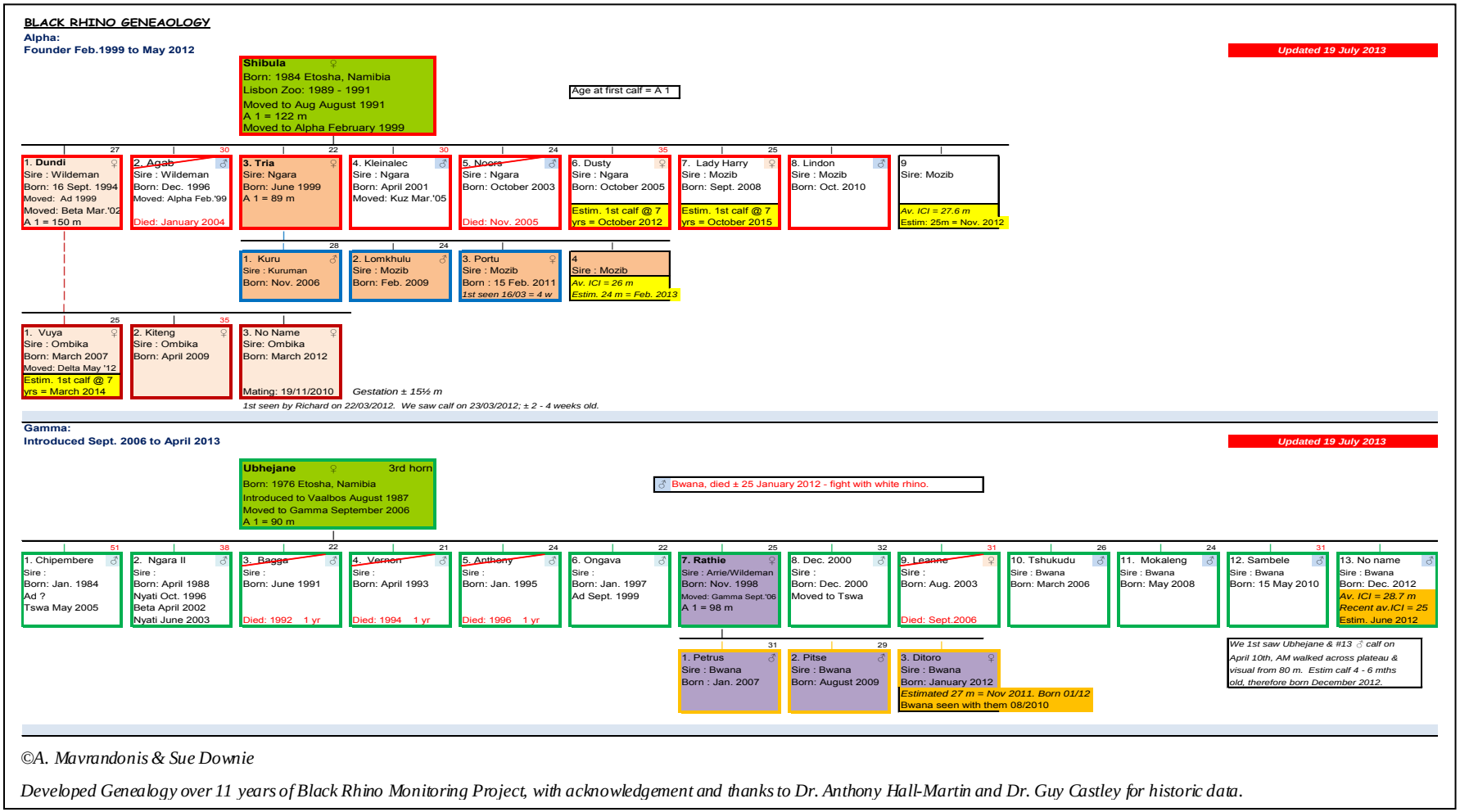
Gestation period

We have one accurate calculation of a black rhino cow's gestation period, i.e. not less than 465 days or 15.30 months, and not more than 475 days or 15.58 months. (Bertschinger 1994 states 15.4 months).

GENEAOLOGY

Shibula. The cow originally from Etosha, via Lisbon Zoo and finally to Alpha has given birth to eight calves known and seen, and a ninth was expected later in 2012.

Ubhejane. A founder introduced in August 1987, from Namibia and translocated to Gamma in September 2006, has given birth to thirteen calves. The last calf was born when she was 36 years old



Developed Genealogy over 11 years of Black Rhino Monitoring Project, with acknowledgement and thanks to Dr. Anthony Hall-Martin and Dr. Guy Castley for historic data.

Population Dynamics, Interventions Recommended

Interventions:

Interventions have inherent risks when immobilizing, transporting and releasing rhino, and can lead to additional problems. Therefore, it is our view that populations do best with the least interference. However, the regular ear-notching exercise does assist in positively identifying each rhino. We also believe that stable family units contribute to better growth rates, and that black rhinos have a complex social group structure which should remain intact if at all possible.

Three of the sub-populations needed assistance to ensure long term optimal growth, and it was decided that if carefully thought through and planned meticulously, the interventions would be beneficial at minimal risk. As usual, we committed ourselves to at least six weeks of post-release intensive monitoring of any translocations.

Warning signs in specific areas:

In our Population Dynamics report (October 2011),[17] we commented on the prevailing population growth rates, and how positive the situation appeared, however, there were numerous early warning signs, which in our judgment, needed to be addressed urgently.

Beta

Excellent sex ratio (3♀:1♂), but the ecological carrying capacity (ECC) should not be more than ten to twelve rhinos. The ICI of the two cows increased from 24 and 26 months to 35 and 37 months. Our estimate of ECC agreed with that of Castley.[18] For Beta there were too many rhinos and too many females.

Recommendation: Remove two five-year-old sub-adult females, which would reduce the total number of rhinos and marginally reduce the female sex bias.

Gamma

Sex ratio skewed to male (0.6♀:1♂). We estimated the ECC at 12-15 rhinos. Castley[18] used 0.055 per km^2 for the old park - this would give a maximum of eleven black rhinos. At the AfRSG meeting in Gamma in March 2010, it was suggested that the tree damage could be an early warning sign. Once again, the problem was too many rhinos, and in this case, too many males.

Recommendation: Remove eight sub-adults males, over two years, reducing the total population and improving the sex ratio. Move young males to a bull camp.

Delta

This is a large area, with too few rhino. To have a viable breeding group, this area needed more females.

Recommendation: Move the two sub-adult females from Beta to Delta.

Population Dynamics Conclusion

SANParks arrived at a different solution which did not address the problems of Beta and Delta. Our recommendations were finally accepted and carried out in May 2012, and April 2013. The short-term problems had been addressed, but the long-term issues remained – in essence more rhino habitat is needed.

TRANSLOCATIONS

Translocations	Rhinos
16	41
Deaths during 16 translocations:	0
Successful translocations:	100%
Capture problems in 3 of 16:	19%
Veld-to-veld in 7 of 16:	44%
Boma involved in 9 of 16:	56%
Post-release problems in 9 of 15:	60%
Post-release deaths in 3 of 14:	21%
Loss of body condition in 4 of 14:	29%
Attacked other rhinos in 3 of 14:	21%

Table 7. Translocation and release indicators.

Since 1991, we have been involved in 16 translocations with SANParks – all documented, photographed and videoed. We gave hands-on direct assistance, recorded measurements, facilitated sponsorship by DSWF and the authors personally for transmitters (VHF and GPS satellite foot collars), as well as transport for six rhinos from Namibia.

Although a total of 41 rhinos were translocated, none died during the 16 translocations, however there were several post-release problems (60%) and deaths.

It was obvious that intensive post-release monitoring was essential after the death of a three-year-old female, and we volunteered our services and included this in the project. The success or failure of a translocation is not only the physical capture and transportation of the rhinos, but also to ensure they survive and adapt in the new areas, and resident rhinos are not wounded or killed in the months after the translocation. Very clear guidelines are given in the IUCN publication [19] edited by Emslie *et al*, but in our experience, not always followed. Any translocation whether long or short should be properly and professionally planned and executed and should not be considered as a fun or recreational outing, no matter how many times it has been done before.

"Circus type audience/media and disturbance at release site where animals may get stressed, travel further post release and possibly injure themselves on nearby trucks or other physical barriers" [19] *[is a mistake]*

This should apply at captures as well. Unanticipated problems do occur, such as a cow suddenly standing up before the antidote was given. She had to be darted twice before being re-captured. Three months later she gave birth to her second calf. This was also the second time that the same cow had been translocated when heavily pregnant. Most problems could be avoided if the capture team communicated with rhino monitors/researchers prior to capture, and sensitive, intensive post release monitoring was carried out after every translocation.

Re-wilding of two tame black rhino

Shibula's journey

This was a complicated journey in 1991, from Lisbon Zoo, Portugal, to a national park in the north of South Africa, and involved travel by sea (8,560 km), air (820 km) and army truck (130 km). We were directly involved from the beginning. The journey was sponsored by David Shepherd and our pharmaceutical company Lagamed. The journey was documented by the environmental TV programme 50/50, and other partners in this amazing conservation story were SANParks, DSWF, Lisbon Zoo, South African Air Force and Army.

We travelled to Lisbon with the TV crew, the park warden and a vet to ensure a smooth transition from a tame zoo rhino to a wild rhino. She was trained to walk into her crate to find food, and her keeper and the vet accompanied her on the 13-day voyage to Cape Town. Shibula's arrival at the docks and transfer to the Air Force base with a traffic police escort, created much excitement and publicity. Her crate was loaded into a C130 Hercules aircraft

for the flight north to a town near the national park. We accompanied her on the flight and the final 130 km by road to her new home. At midnight, she slowly walked out of the confinement of the crate into a boma with African soil underfoot. We all slept alongside her boma.

Shibula spent about 3½ months in the boma, acclimatizing to the new diet and safely meeting the resident rhino. The gate was opened about an hour before sunrise, with only five of us sitting on top of her old crate in total silence. It was over an hour before she slowly walked the few steps outside the boma. She was released into a 1,000 ha camp. Shibula was so tame you could entice her to the vehicle by cutting an apple in half. She gave birth to her first calf on 16 September 1994, a female we called Dundagos, which means "we have achieved" in the Nama language.

In the 22 years that Shibula has been in the wild she has given birth to eight calves that we know of and a ninth was expected in 2012. Two of her calves have had three calves each. The goal of her translocation was to increase the small founder population and improve the growth rate of *D.b.b.* in South Africa – which she did by another 15 black rhinos, eight of which are females. The forethought, planning, care and time devoted to her translocations resulted in a successful outcome. Thanks to Dr. Anthony Hall-Martin.

Thandi and Kapela – two hand-raised black rhinos

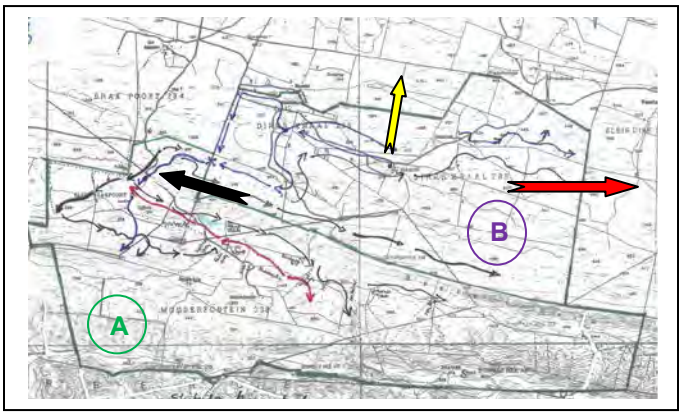
Thandi (*D.b.b.)* and Kapela *(D.b. minor)* were both born in bomas and were cared for at a rehabilitation facility. We travelled to Pretoria to see both baby rhinos every month to monitor their progress and photograph their growth and development, which has helped us to age calves in the veld. They had continual diarrhoea, from an almost exclusive diet of milk formula and juice. From our observations, calves start browsing with their mother's supervision at two months of age.

At eight and nine months of age, Thandi and Kapela were moved together to a boma in a national park. After 13 months, they were released into a 400 ha enclosure with limited tourist access. Unfortunately, private lodges had access and bad behaviour resulted in Kapela taking an intense dislike to vehicles, which has compromised his re-wilding in a private reserve. Thandi at 5½ years was relocated to Delta and released with a younger female (~ 3 years old), into bomas for three weeks. Thereafter, we prevailed in providing a temporary release camp, far from tourists, and we intensively monitored their final release from the bush camp for about six weeks, with daily monitoring by one of us.

Three days after release and on a very hot day (38^0C) during which we established they had not drunk water for at least 24 hours, we found both young rhinos on top of a very steep treeless hill. Previously, they had only had water from a concrete reservoir. Together with two field rangers we took 60 litres of water and two troughs to the rhinos, and then persuaded them to follow Sue down a less difficult slope. [20] It was an intensely moving experience, and the intervention was essential in the circumstances. Subsequently, they learned to drink in pools of water in the rivers, met the resident bull and both have had calves. A very long journey, and ultimately a successful re-wilding of a rhino hand-reared from birth.

We estimate that the 17 rhinos produced by Shibula, her calves and Thandi account for approximately 8.5% of all *D.b.b.* in South Africa. Both exercises were very costly in time and money, but very well worth the effort in the long-term.

DISPERSAL



A Rhino camp 4,540 ha

B Rhino camp 3,179 ha

A + B Total available to rhinos 2005 to 2007 = 7,719 ha

Map # 1 : Rhino camps in Alpha showing dispersal

Over ten years, we followed up on ten of fourteen translocations (71%). One release (7%) in 1991, was before the project started; another two we were only able to monitor intermittently. We found one old bull dead a few days after an ill-conceived release in an inappropriate area. All observations have been plotted on 1:50,000 topographical map.

After translocations where either all rhinos were known to each other, or a great deal of effort and care was taken (releasing far from resident rhinos, erecting a temporary holding camps), together with intensive post-release monitoring, the rhinos established themselves successfully. In established populations, dispersal has taken one to two years after fences were removed. (See map).

Some dispersals were forced when two young bulls were introduced to two separate adjacent areas with an inadequate fence separating the camps. Sadly, six rhinos died (including three females). Once the offending bull was relocated and the fences removed, dispersal continued at a steady pace.

Pregnant cows often moved to different, less populated areas to have calves and then remained in the new range. In Delta, within days after introduction a young bull went on a 30 km walk over a weekend, lost body condition by the time he returned, but then he stayed in the vicinity. A young female walked 41 km in 16 hours, spent a small percentage of that time along a boundary fence, and when she returned to the starting point also settled in the area with a bull for some time. She moved into the hills when she was ready to calve.

In Gamma with ± 26,500 ha, the black rhinos utilised only about 5,500 ha. When the breeding bull died, the oldest of the sub-adult males was seven years old and pushed two other young males to the outskirts into marginal habitat.

BEHAVIOUR

Studying behaviour was not an original objective of this project, but followed naturally due to the time spent in proximity to rhinos without being detected. The behaviour discussed may be viewed as anecdotal as it was not a formal scientific ethology study – more a behavioural field study. The observations have ecological validity and are based on over 1,300 hours of studying natural behaviour of undisturbed rhinos, while the interpretations are our own personal opinion.

The black rhino is characterized as having poor eye-sight, being aggressive and solitary. Our opinion differs markedly. Rhinos have superb motion detection[21], and the slightest movement focuses their attention immediately and accurately. In over ten years of tracking

and walking with rhinos, with many unexpected close encounters, we have never been aggressively charged, even by mothers with calves. They assess the threat, may mock charge to get the object to move and so identify it. Once the threat has been assessed, the rhino will walk away or run a short distance and turn back, always with head held high. Serious charges are normally silent with head down, which we have witnessed from a distance.

Although in biological terms solitary means not living in herds, and this is accurate for black rhino, they do have a complex social system. In 27.1% of our sightings involved three or more, and sometimes up to ten black rhinos, sometimes within 30 m of each other, close together interacting.

Social interactions involved nose-to-nose contact (greeting), and sub-adult related or unrelated females acting as surrogate mothers by engaging the calf while the mother browsed, which helped a lactating cow improve condition quicker. If rhinos are too close and not welcome, a growl will suffice to move them apart. The length of a greeting and co-mingling can indicate individual likes and dislikes between rhinos. Black rhinos have a wide range of vocalizations, from high pitched squeak between a cow and her calf, to squealing, snorting, growling and even roaring. Rhinos appear to "visit" a mother with a new calf, thereby introducing it to the local population. Mothers encourage their calves to browse beginning at just 2 months of age, and this is important due to the high number of orphans resulting from poaching incidents. Hand-raised calves should have access to browse to prevent diarrhea from too much milk formula. Calves run behind their mother in times of stress, but when safe and relaxed they often run in front.

"The main function of Flehmen is to transfer air containing pheromones and other scents to the vomeronasal organ, a chemosensory organ." [22] This explains our observations of all age groups, both male and female, displaying the Flehmen response, even calves in response to their mother's urine.

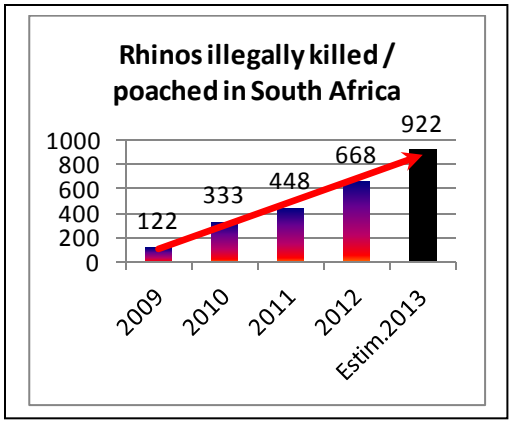
Three matings were observed out in the open during the day. In 2008, we observed the mating process over four hours, a mere 102 m from us. After the bull attempted to mount the cow for the tenth time, he rested his head on her rump in total exhaustion. In another observation, the 19 month old calf stayed close to its mother and not more than 30 m from the mating adults. All were completely relaxed. Successful bulls that have sired many calves have exhibited caution and patience when approaching females and often waited for the female to initiate contact.

We have regularly observed cows using their horns to break higher branches to get to the new shoots for their calves and themselves. They place the branch between the two horns and lever it down or use their chins to push down the branch. Not only do rhinos use rubbing rocks, but they often lick the rock afterwards – possibly licking blood from crushed ticks. Rhinos sleep when tired day or night. Sub-adults appear to sleep longer without moving, whereas cows get up regularly to suckle young calves. However, a mother can sleep for five hours before standing up, as a very small calf can suckle while the mother is lying down. Mothers also often change position every one to two hours. We have often observed what can only be described as "playful" activity, mostly among calves and sub-adults, but on a few occasions adults have joined this activity of chasing each other around bushes and suddenly changing direction.

Black rhinos often move high up on hills or ridges and we believe that in summer, it is for the cool winds, and in winter, for warmth due to a temperature inversion and better browse.

The above summary of behaviour recorded was observed regularly and the patterns repeated by different rhinos in different areas and we believe the activities to be natural black rhino behaviour, which can be attributed to the general population.

SECURITY



Rhino poaching in South Africa continues unabated.

* Official figures to 07 August 2013 indicate 553 dead rhinos.[23] A conservative extrapolation means over 900 rhinos will be killed in 2013.

Figure 15. Rhinos killed in South Africa from 2009, to an estimate for 2013

Kruger has deployed unmanned drones, two surveillance aircraft, the army, and are using tracker dogs, but the carnage continues at ever higher levels. In order to accurately assess the presence of poachers and extent of the killing, intelligence starts with effective monitoring and knowledge of every population.

In mid- 2010, we realized we were as guilty as everyone else - expressing outrage and merely counting the numbers killed. One rhino poached in our areas would not simply be a number, but a known individual. SANParks and the Government were putting all their resources into Kruger, while leaving the smaller parks vulnerable and chronically short on ranger density per hectare, as well as equipment. In one study area, ranger density was at 22% of levels suggested by Du Toit. [15] We identified the threats in the four project areas and developed security plans according to the specific threats.

Security Plans

By October 2010, we had viable security plans for each park proposed by the section rangers and ourselves. Approval was granted from SANParks head office. Funding would be sponsored by the David Shepherd Wildlife Foundation and the authors personally.

To date funding has covered items such as: overtime payments for existing field rangers, employment of new field rangers, basic and advanced anti-poaching courses and fire arm courses, and 3) new contract staff (!Khu Bushmen trackers) specifically for rhino protection. In addition the funding has allowed the purchase of five Kawasaki Mule 610 all terrain vehicles to ensure mobility of field rangers, basic equipment such as two-way radios, binoculars, cameras and spotting scopes, material for a bush camp, ranger personnel kits, sponsored private pilot's license for two senior staff, construction of look-out platforms, signs and CCTV cameras on the perimeter fences, electric access gates and spot lights, a Wendy house Observation Post and overnight accommodation and a fully equipped Ford Ranger 4x4 Pick-up.

Costs: Since October 2010, total costs have been R1,706,000 (US$ 170,600) of which R1 million sponsored by DSWF and the balance by the authors.

Results

No rhinos have been lost, regardless of poaching activities close to the BRMP areas. Motivation of the field rangers increased. Sadly, we believe that there is not nearly a powerful enough collective will to save rhinos from extinction. It is simply about money.

Cagan Sekercioglu, ornithologist and professor at the University of Utah who runs an award winning conservation group in his native Turkey says it all; ".. the government talks about conservation, but its priority is to convert nature into cash" (National Geographic interview, May 2013).

FORECAST (2012 - 2022) : Number of black rhinos in four project areas

	Last 3 years Growth Rate 2010 - 2012	Forecast Growth Rate 2013 - 2022	Final estimate of numbers 2012	Forecast numbers 2022	Relocate	Population after relocation
Alpha	+18.8%	+11.7%	38	114	-19	95
Beta	+8.3%	+9.9%	7	17	-7	10
Gamma	+12.4%	+8.8%	17	39	-27	12
Delta	+19.8%	+13.4%	14	49	-6	43
Meta-pop	+16.5%	+11.1%	76	219	-59	160

Table 8: Forecast for each sub-population of the number of rhinos in ten years time

Assumptions:

Conservative future growth of 11% (at present 16%). Forecasts done per individual animal, with longer ICI's than at present. Births at +7 years old for individual female rhinos. New calves - assumed 50% female. Mortality of 2% per year. Cows older than 36 years excluded.

Results:

The four sub-populations of 76 animals will increase to 219 by 2022. To keep populations at optimum growth, we will have to relocate 59 rhinos or 27% of the population. This will leave 160 rhinos in the four areas.

Future Problem:

The habitats and the breeding populations are excellent. But the carrying capacities are limited in all four parks when projecting to 2020 or 2022. I f South Africa is to reach the targets set by the BMP, it is critical that more national parks are prepared to receive black rhinos, and more private reserves need to agree to a custodianship arrangement. Expansion of the parks in the project areas is another way forward, i.e. acquisition of land. A Development Plan linking Graaff-Reinet to Cradock [24] is an example of an initiative that should be pursued as a priority.

Time Frame

As the purchase of land and expansion of national parks is a long term endeavour, these initiatives should start immediately. The project organized by the authors to expand Beta took ten years (1996 to 2006) taking it from 6,500 ha to 28,000 ha. Even preparing existing parks to receive black rhinos can take three to four years.

BMP TARGETS

Biodiversity Management Plan for the black rhinoceros in South Africa 2011–2020 [1] requires:

In the **short** term (10 year goal - by 2020) a meta-population of 260 *D.b.b.* In the **long** term (no date given), a meta-population of 500, with one population of at least 100, and another with at least 50. An average growth rate of at least 5%.

The BRMP's accomplishments towards the BMP Targets

- One population can be maintained at 90-100 rhinos, and a second population can be kept at 40-50 rhinos, which confirms the BMP target can be accomplished.
- The present growth rate of 16% for the BRMP meta-population, and a future growth reliably predicted at a minimum of 11%, will achieve the BMP minimum of 5%.
- In 2010, the BRMP areas made up 32.7% of all *D.b.b.* numbers in South Africa. If this ratio is maintained, then the 219 rhinos in the four areas will make up 33% of the total South African meta-population in 2022, giving a total of 670 *D.b.b.* (BMP target of 500 rhino), or 134% of the long term target..
- The four study areas will have 179 rhinos or 69% of the short term BMP target of 260 by 2020. If we assume this contribution to the meta-population is maintained at 33%, the total rhinos will be 542 (double the BMP target of 260).

Black rhinos are not yet the major target of poachers. The biggest threat to achieving the targets for *D.b.b.* is the present lack of additional land or areas to which excess animals from the study area can be relocated. This is not stressed sufficiently in the BMP and it is our belief that the acquisition of additional habitat / land should be at the core of the BMP. This becomes even more essential if the BMP recommendation in section 5.1.2.2 is to be followed, i.e. "do not stock with more than 40% of the estimated capacity for the area in question".

TERMINATION of the Project in three of four areas

A large part of this project, which started in 1991 with the repatriation of Shibula from Lisbon Zoo, was abruptly terminated by the SANParks regional manager in charge of three of the four areas on 16th May 2012, due to a dispute involving the computer access codes for GPS satellite foot collars. Senior directors and the Chairman of the AfRSG met with us in an attempt to reconcile disparate views, but the regional manager refused to meet with us. We were all unable to convince him that the dispute should be resolved in the best interests of the rhinos. We continue to work in one research area, providing monitoring and financial support ourselves. A 4x4 vehicle was donated in April 2013, and total security costs will amount to almost R300'000 for this financial year.

CONCLUSION and RECOMMENDATIONS

This ten-year study by external researchers with international and local funding has deomonstrated that the four sub-populations of *D.b.b.*, given good habitat and limited human interference, can breed at a rate of 15% over 14 years, and will contribute significantly to the survival of the sub-species in South Africa by exceeding the BMP targets and growth rate of 5%. However, is there the will to make the effort required to make more land available, improve the levels of monitoring and do what is best for the rhinos and not what is politically expedient?

Factors critical to continuing this success, are:

- Careful and unobtrusive monitoring is essential to ensure reproductive indicators remain positive. Interventions should be undertaken only when necessary.
- Black rhinos breed best where the tourist impact is kept to a minimum. Areas should be dedicated for breeding black rhinos with limited tourist access, and one or two areas specifically for "surplus" bulls where tourists can see black rhinos.
- **Beta** is an example of how high tourist density and obtrusive monitoring impacted negatively on the animals. One month after the abrupt termination of the project, a

field ranger was severely injured and nearly killed by a cow which had been separated from her calf. The calf later died. We recommend that Beta should not be a breeding area, but rather a camp for "surplus" bulls, which would satisfy tourists.

- Long-term investment and partnership with the private sector can play a pivotal role in developing rhino areas and monitoring to provide independent analysis of progress and performance.
- The forecast of these populations indicates it is imperative to find new areas for the surplus animals, and to acquire more suitable habitat for black rhino. This is the single most important component to ensure the future of the species.
- The study also validates the value of a long-term investment to rehabilitate rhinos. In this study, two rehabilitated females resulted in 18 additional rhinos.
- Formal ethology studies should be pursued to better understand black rhinos, but such observations should be done in an unobtrusive manner, which our study proves is possible.
- Above all, a dedicated senior rhino manager or coordinator within SANParks is vital for the future of rhinos in national parks.
- Security plans for all areas with rhinos.
- Respect for dedicated external researchers working closely and sharing information with SANParks is essential.

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David Shepherd: for his generosity in donating paintings. The David Shepherd Wildlife Foundation and former CEO Melanie Shepherd, for support and funding the monitoring and security projects. Eastern Cape Motors and Greg Williamson, for keeping our vehicle safe in between monitoring trips at no charge. Other donors: De Villiers Family Trust, JD Group of Companies, JMD Trust, Peter & Elsbeth Metz. Melanie Adendorff for caring for Thandi, Kapela and Danny in the bomas. John Adendorff for coming to the rescue of Ntombi and others. All the Field Rangers including: Alec Nomvulo, Johnson April, Piet Booysens, Pokkie Benade, Chocolate Bosch, Donovan Antonie, Surprise Mlambo, Robert Rikhotso, Richard Ockers from whom we learnt about walking in the veld and the terrain, and who have worked long hours and showed incredible interest in our project. !Khu Bushmen: Marteu Tami, Augustu Chamba, Tiber Likongo, who have the most remarkable tracking skills, and an amazing work ethic, we worked together in the veld with mutual respect. We salute them. Dr. Anthony Hall-Martin: senior researcher for this project. Dr. Guy Castley: first to see the potential of our monitoring contribution. Dr. Hector Magome, Dr. Mike Knight, Dr. Hugo Bezuidenhout, Dr. Markus Hofmeyr, Dr. David Zimmermann, Dries Engelbrecht, Dr. Peter Bradshaw, Norman Johnson, Deon Joubert, Pumla Mzazi, Mzwandile Mjadu, Riaan Nel, Robyn Woods, Johan de Klerk, Nico van der Walt, Abel Ramavhale. Dr. Pete Morkel: keeping contact and always available for advice. Dr. William Fowlds: for assisting Blom.

Besides the rhinos, our greatest motivation came from the field rangers and the Bushmen. We thank them for that and their dedication to the rhinos.

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Addendum to: **Focus on Black Rhino : *D.b.bicornis* Population Dynamics 2002 - 2012**

Alpha Population Detailed Growth Rate Analysis :

Annexure Y

Alpha

	End Year Population Numbers	Yearly Growth	Methods of adjustment for Introductions (4), Removals (2) in 2005. (See Data sheets Annexure X).			Method of Adjustment for Removal (1 ♂) in 2006, & Introduction (1 ♂) in 2007, plus using the (A) method.		
			(A) Exclude 2 from 2005	(B) Totally exclude growth of 2005	(C) Change the base of 2004 by adding 2, to calculate growth for 2005.	Exclude 2 from 2005, plus 1 removal in 2006 & 1 introduction in 2007		
Founder:	5							
1999	7	40.0%						
2000	7	0.0%						
2001	9	28.6%						
2002	9	0.0%						
2003	12	33.3%						
2004	12	0.0%			14		12	0.0%
2005	15	25.0%	(-2) 13	8.3% [a.] Exclude year 2005	15	7.1%	13	8.3%
2006	13	-13.3%				(+1)	14	7.7%
2007	16	23.1%				(-1)	16	14.3%
2008	18	12.5%						
2009	22	22.2%						
2010	26	18.2%						
2011	32	23.1%						
May 2012	34	6.3%						
3 Methods of Dealing with 2012								
1. Average annual growth for 13.42 years.		**16.3%**	15.1%	15.6% (12.42 yrs)	15.0%			16.0%
2. Worst case, ignore potential births after May, i.e. 14 years.		**15.6%**	14.5%	14.9% (13 years)	14.4%			15.3%
3. [b.] Accurate forecasts predicted 4 births June to December 2012. (Growth 18.8% for 2012)		16.5%	15.3%	15.9% (13 years)	15.3%			16.2%
Average of all Growths for (A), (B) & (C)				15.11%				
and including bulls 2006 / 2007								15.29%
Finally excluding the partial 2012 year (growth for 13.0 years)			15.1%	15.6%	15.0%			

NOTES:

1. a. Method used by B. Fike. The Demography and Population Dynamics of a Re-introduced Black Rhinoceros population on the Great Fish River Reserve, Eastern Cape Province (January 2011). Thesis submitted to Rhodes University for a degree of Master of Science. Page 109.

b. Every single rhino is known and accurate forecasts of births was routine, using historic inter-calving intervals.

*. 35 Calves were born in the period 1999 to May 2012.

2. Growth rates for the last 6, 5, 4 and 3 years in the Paper are straightforward as they exclude the 2005/2006 introductions and bull relocations of 2006/2007. Calculations can be verified from the year end population numbers, left.
As verification of Alpha population growths of 19.0%, 18.2%, 19.6% and 18.8% over 6, 5, 4, and 3 years, if we exclude the partial 2012 year, then the last 5 years growth is accurately +19.8% (+23.1, +12.5, +22.2, +18.2, +23.1).

3. Final assumptions of growth used in the Paper.

- Used growth of 15.1%, i.e. 13.42 years and method (A) above
- Correlates with average of all methods (15.11%).
- Correlates exactly with period of 13 years (excluding 2012), i.e. 15.1%.
- Ignores the bull removal and introduction of 2006 / 2007, as this pushed up growth to 16%.

Therefore our average annual growth figure of 15.1% is conservative.

Addendum to: **Focus on Black Rhino : *D.b.bicornis* Population Dynamics 2002 - 2012**

Annexure Y

Beta Population Detailed Growth Rate Analysis :

Beta

	End Year Population Numbers	Yearly Growth	Adjustment due to removal of one ♂ within a year of introduction, due to serious harrassment of a cow.		For interest sake, add back calf killed by low flying helicopter & her progeny.	
Founder 2002:	5					
2003	4	-20.0%	Founder: 4		4	
2004	5	25.0%	5	25.0%	5	25.0%
2005	4	-20.0%	4	-20.0%	5	0.0%
2006	4	0.0%	4	0.0%	5	0.0%
2007	6	50.0%	6	50.0%	7	40.0%
2008	6	0.0%	6	0.0%	7	0.0%
2009	8	33.3%	8	33.3%	9	28.6%
2010	8	0.0%	8	0.0%	9	0.0%
2011	8	0.0%	8	0.0%	10	11.1%
May 2012	10	25.0%	10	25.0%	12	20.0%
Average annual growth:		9.3%		12.6%		13.9%

No adjustments for timeframe of early termination in 2012, as no possibility of more calves being born after May 2012

Adult cow (with a 2-year-old male calf), seriously injured by the only young adult bull.

NOTES:

1. No introductions and no problem with year 2012, as not possible for any more calves to be born.
2. Therefore growth needs no adjustment whatsoever, and is accurate at +9.3%.
3. However, one bull was removed within a year of establishing the breeding group, due to continuous harassing of a cow.
4. Therefore, more accurately, he should not be included in the founder population. This results in a more realistic growth of +12.6%, moving the founder to 2003.
5. Hypothetically, if poor management helicopter actions during a census had not killed a female calf, the growth rate after adding her and any possible progeny back, would have been +13.9%.
6. For the purposes of the study, we used the end year population number for growth of +9.3% even though 12.6% would have been more realistic / accurate.
7. A total of 7 births in 10 years.
8. ✸ Serious note should be taken of the extremely poor growth for the first 4 years (as is, minus 3.75% or excluding the bull +1.25%).
   This was due to the fact that the remaining bull was still a sub-adult.
   This shows the serious consequences of small founder populations, with poor sex ratios, and a single immature bull.

Addendum to: **Focus on Black Rhino : *D.b.bicornis* Population Dynamics 2002 - 2012** **Annexure Y**

Gamma Population Detailed Growth Rate Analysis : **Gamma**

(A)	End Year Population Numbers	Yearly Growth	Adjustment for loss of one ♀ immediately after translocation & release into new park. (B) Add back one		(C) Remove from founder		(D) The loss of future offspring in 2010 & 2012 due to one female's death.	
Founder: Oct. 2006	8		8		7		8	
2006	7	-12.5%	8	0.0%	7	0.0%	8	0.0%
2007	9	28.6%	10	25.0%	9	28.6%	10	25.0%
2008	10	11.1%	11	10.0%	10	11.1%	11	10.0%
2009	12	20.0%	13	18.2%	12	20.0%	13	18.2%
2010	14	16.7%	15	15.4%	14	16.7%	16	23.1%
2011	15	7.1%	16	6.7%	15	7.1%	17	6.3%
May 2012	16	6.7%	17	6.3%	16	6.7%	19	11.8%
Methods of Dealing with 2012								
1. Average annual growth for 6.42 years.		**12.1%**		12.7%		14.0%		14.6%
2. Worst case, ignore potential births after May 2012.		**11.1%**		11.7%		12.9%		13.4%
3.Forecast of one more calf (growth 2012 = 13.3%.		12.0%		12.5%		13.8%		14.3%
Average of Growths for (B) & (C)				12.5%				
Finally excluding the partial 2012 year (growth for 13.0 years)			12.5%		13.9%			

NOTES:

1. The vertical column A shows populations as is, with a growth of + 12.1%, taking into account the early termination. If we ignore the worst case scenario of no further calves born from May to December 2012, the growth figure is either +12.1% or 12.0%. We chose the most conservative of 12.0% for the paper.
2. However, we strongly believe that an adjustment is necessary for the one female sub-adult death immediately after translocation & release into the new park. (The old park was deproclaimed, and all the animals were relocated to the new park in September & October 2006 - a massive translocation exercise).
3. We used two methods to adjust for this one rhino, i.e. adding back to all years, or subtracting her from the founder population. The worst growth in each of these scenarios was 11.7% and 12.9%, or an average of 12.3%. If we exclude 2012, then B and C reflect growths of 12.5% and 13.9%.
   We selected 12.0% which is still very conservative.
4. As a matter of interest, the death of a young female during translocation, is not only one rhino, but also her progeny. Growths could have been between 13% & 14% (see section highlighted green). This of course was ignored for the calculation of growth.
5. Although Annexure X shows 2005 with 7 and 2006 with 7 the actual number of black rhinos translocated to the new park (founder) by October 2006 was 8, but a sub-adult female died soon after release, therefore the year end number was 7.

Addendum to: **Focus on Black Rhino : *D.b.bicornis* Population Dynamics 2002 - 2012**

Delta Population Detailed Growth Rate Analysis :

Annexure Y

Delta

	End Year Population Numbers	Yearly Growth	Notes / Explanation of introductions & removals	Adjustments to cope with introductions & sub-adults, i.e. assume founder population to be 7 in 2006 (there were 7 rhino in 2008 after all introductions).	
Founder 2005:	2		2 sub-adult ♂		
2006	2	0.0%	2 sub-adult ♂	Founder 7	
2007	4	100.0%	Introduced 3 & removed 1. Remaining 2 sub-adults were 1 ♂ & 1 ♀.	7	0.0%
2008	7	75.0%	Introduced 3, all sub-adult ♀	7	0.0%
2009	7	0.0%	No breeding - all sub-adults.	7	0.0%
2010	8	14.3%	One ♀ calf born.	8	14.3%
2011	10	25.0%	Two ♂ calves born.	10	25.0%
2012	12	20.0%	Two calves born 1 ♀ & 1 ?.	12	20.0%
Average annual growth:		33.4%	No breeding for 5 years from 2005 to 2009. Then 5 calves in 3 years as population matured sexually.	Average growth:	9.9%
This figure is totally distorted due to the tiny founder (2 ♂), & frequent small introductions.				Note: By adjusting the founder number & year, this indicates zero growth for 3 years. This is an unfair reflection of performance, as no growth was possible with a population of sub-adults. Therefore, a fairer representation of growth is over the last 3 years when rhinos reached maturity. This growth is +19.8% and is on a par with the best population in the Alpha area.	

Notes for all four project areas:

To explain high growths in small populations, the often used argument is that one birth in a population of two is 50%, and so the figures are exaggerated out of all proportion.
While true, it is our contention, particularly with the four populations in our project, that negative factors far outweigh the positive distortions in small populations.

Alpha: Very small founder and huge losses (6), as a result of one introduction.
Beta: Very small founder, removal of only adult bull, because he seriously injured a cow, and death of a ♀ calf.
Gamma: Death of one female sub-adult, and negative sex ratio.
Delta: No growth from 2005 to 2009 (5 years) due to immature population & staggered introductions.

Therefore, if planned better at the outset, these four populations would have grown even faster than the impressive record we have documented.

Addendum to : Focus on Black Rhino : *D.b.bicornis* Population Dynamics 2002 - 2012

Alpha : Population Performance : 1999 - 2012 Actual rhinos

Annexure X

Alpha

Updated : 21 June 2013

Black Rhinoceros : *Diceros bicornis bicornis*			Actual:													To May	Forecast		
	February 1999 - May 2012	Founder	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
Total		5	7	7	9	9	12	12	15	13	16	18	22	26	32	34			
Founder	+ 5 (3 female & 2 male)																		
Introduced	+ 5 (2 female & 3 male)		0	0	0	0	0	0	4	0	1	0	0	0	0	0			
Removed	- 3 (3 male)		0	0	0	0	0	0	-2	-1	0	0	0	0	0	0			
Deaths	- 8 (4 female & 4 male)		0	0	0	0	0	-1	-2	-4	0	-1	0	0	0	0			
Births	+ 35		2	0	2	0	3	1	3	3	2	3	4	4	6	2			35
Total number of rhino:																			
1		Blom	Blom	Blom	Blom	Blom	Blom	Blom	Blom	Blom	Blom	Blom	Blom	Blom	Blom	Blom			
2		Khora	Khora	Khora	Khora	Khora	Khora	Khora	Khora	Khora	Khora	Khora	Khora	Khora	Khora	Khora			
3		Shibula	Shibula	Shibula	Shibula	Shibula	Shibula	Shibula	Shibula	Shibula	Shibula	Shibula	Shibula	Shibula	Shibula	Shibula			
4		Agab	Agab	Agab	Agab	Agab	Agab	Agab	Agab	Agab	Agab	Agab	Agab	Agab	Agab	Agab			
5		Ngara	Ngara	Ngara	Ngara	Ngara	Ngara	Ngara	(Ngara)	(Ngara)	(Ngara)	(Ngara)	(Ngara)	(Ngara)	(Ngara)	(Ngara)			
6			Tria	Tria	Tria	Tria	Tria	Tria	Tria	Tria	Tria	Tria	Tria	Tria	Tria	Tria			
7			Quattro	Quattro	Quattro	Quattro	Quattro	Quattro	Quattro	Quattro	Quattro	Quattro	Quattro	Quattro	Quattro	Quattro			
8					Kleinalec	Kleinalec	Kleinalec	Kleinalec	(Kleinalec)	(Kleinalec)	(Kleinalec)	(Kleinalec)	(Kleinalec)	(Kleinalec)	(Kleinalec)	(Kleinalec)			
9					Darling	Darling	Darling	Darling	Darling	Darling	Darling	Darling	Darling	Darling	Darling	Darling			
10							Kara	Kara	Kara	Kara	Kara	Kara	Kara	Kara	Kara	Kara			
11							Ntombi	Ntombi	Ntombi	Ntombi	Ntombi	Ntombi	Ntombi	Ntombi	Ntombi	Ntombi			
12							Noors	Noors	Noors	Noors	Noors	Noors	Noors	Noors	Noors	Noors			
13								Guy	Guy	Guy	Guy	Guy	Guy	Guy	Guy	Guy			
14		^ Introduced							Sasha ^	Sasha	Sasha	Sasha	Sasha	Sasha	Sasha	Sasha			
15		(Removed)							Helen ^	Helen	Helen	Helen	Helen	Helen	Helen	Helen			
16		Died							Gamka ^	(Gamka)	(Gamka)	(Gamka)	(Gamka)	(Gamka)	(Gamka)	(Gamka)			
17		Females							Kuruman ^	Kuruman ^	Kuruman ^	Kuruman ^	Kuruman ^	Kuruman ^	Kuruman ^	Kuruman ^			
18		Males							Nomvula	Nomvula	Nomvula	Nomvula	Nomvula	Nomvula	Nomvula	Nomvula			
19									Nonny	Nonny	Nonny	Nonny	Nonny	Nonny	Nonny	Nonny			
20									Dusty	Dusty	Dusty	Dusty	Dusty	Dusty	Dusty	Dusty			
21										Stillborn	Stillborn	Stillborn	Stillborn	Stillborn	Stillborn	Stillborn			
22										Tula	Tula	Tula	Tula	Tula	Tula	Tula			
23										Kuru	Kuru	Kuru	Kuru	Kuru	Kuru	Kuru			
24											Mozib ^	Mozib	Mozib	Mozib	Mozib	Mozib			
25											Intaba	Intaba	Intaba	Intaba	Intaba	Intaba			
26											Thathu	Thathu	Thathu	Thathu	Thathu	Thathu			
27												DarlJul08	Darl Jul08	Darl Jul08	Darl Jul08	Darl Jul08			
28												Lady Harry	Lady Harry	Lady Harry	Lady Harry	Lady Harry			
29												Troy	Troy	Troy	Troy	Troy			
30													Nova	Nova	Nova	Nova			
31													Lomkhulu	Lomkhulu	Lomkhulu	Lomkhulu			
32													Ziva	Ziva	Ziva	Ziva			
33													Pemberi	Pemberi	Pemberi	Pemberi			
34														Deca	Deca	Deca			
35														Sanka	Sanka	Sanka			
36														Lindon	Lindon	Lindon			
37														Pendy	Pendy	Pendy			
38															Nell	Nell			
39															Portu	Portu			
40															Vukile	Vukile			
41															Pula	Pula			
42															Nonny 07/11	Nonny 07/12			
43															Kara 12/11	Kara 12/11			
44																Danile			
45																Khora 05/12			
46																			

Addendum to : Focus on Black Rhino : *D.b.bicornis* Population Dynamics 2002 - 2012

Annexure X

Beta : Population Performance : 2002 - 2012 Actual rhinos

Beta

Updated : 16 May 2013

Black Rhinoceros : *Diceros bicornis bicornis*

		Actual:										To May	Forecast		
	Founder	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	**2012**	2013	2014	2015
Total	5	5	4	5	4	4	6	6	8	8	8	10			
Introduced		0	0	0	0	0	0	0	0	0	0	0			
Removed		0	-1	0	0	0	0	0	0	0	0	-			
Deaths		0	0	0	-1	0	0	0	0	0	0	0			
Births		0	0	1	0	0	2	0	2	0	0	2			

Total number of rhino:															
1		Faru	Faru	Faru	Faru	Faru	Faru	Faru	Faru	Faru	Faru	Faru			
2		Alfred	Alfred	Alfred	Alfred	Alfred	Alfred	Alfred	Alfred	Alfred	Alfred	Alfred			
3		Dundi	Dundi	Dundi	Dundi	Dundi	Dundi	Dundi	Dundi	Dundi	Dundi	Dundi			
4		Maleka	(Maleka)	(Maleka)	(Maleka)	(Maleka)	(Maleka)	(Maleka)	(Maleka)	(Maleka)	(Maleka)	(Maleka)			
5		Ombika	Ombika	Ombika	Ombika	Ombika	Ombika	Ombika	Ombika	Ombika	Ombika	Ombika			
6				Kamaia	Kamaia	Kamaia	Kamaia	Kamaia	Kamaia	Kamaia	Kamaia	Kamaia			
7	(Removed)						Diala	Diala	Diala	Diala	Diala	Dia			
8	^ Introduced						Vuyakasi	Vuyakasi	Vuyakasi	Vuyakasi	Vuyakasi	Vuya			
9	Died								Petra	Petra	Petra	Petra			
10									Kiteng	Kiteng	Kiteng	Kiteng			
11												Faru 03/'12			
12												Dundi 03/'12			

Addendum to : Focus on Black Rhino : *D.b.bicornis* Population Dynamics 2002 - 2012

Annexure X

Gamma : Population Performance : 2002 - 2012 Actual rhinos

Gamma

Updated : 16 May 2013

Black Rhinoceros : *Diceros bicornis bicornis*

	Actual:											Forecast		
	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
	Vaalbos	Vaalbos	Vaalbos	Vaalbos	Mokala Sept	Mokala	Mokala	Mokala	Mokala	Mokala	Mokala	Mokala	Mokala	Mokala
Total	8	9	9	7	7	9	10	12	14	15	16	11		
Introduced	0	0	0	1	8	0	0	0	0	0	0	0		
Removed	0	0	0	-3	0	0	0	0	0	0	0	-5		
Deaths	0	0	0	-1	-1	0	0	0	0	0	-1	0		
Births	1	1	0	1	0	2	1	2	2	1	2	0		
Total number of rhino:														
1	Ubhejane	Ubhejane	Ubhejane	Ubhejane	Ubhejane	Ubhejane	Ubhejane	Ubhejane	Ubhejane	Ubhejane	Ubhejane	Ubhejane	Ubhejane	Ubhejane
2	Nkombe	Nkombe	Nkombe	Nkombe	Nkombe	Nkombe	Nkombe	Nkombe	Nkombe	Nkombe	Nkombe	Nkombe	Nkombe	Nkombe
3	Rathie	Rathie	Rathie	Rathie	Rathie	Rathie	Rathie	Rathie	Rathie	Rathie	Rathie	Rathie	Rathie	Rathie
4	Wildeman	Wildeman	Wildeman	Wildeman	Wildeman	Wildeman	Wildeman	Wildeman	Wildeman	Wildeman	Wildeman	Wildeman	Wildeman	Wildeman
5	Ub.Dec'00	Ub.Dec'00	Ub.Dec'00	(Ub.Dec'00)	(Ub.Dec'00)	(Ub.Dec'00)	(Ub.Dec'00)	(Ub.Dec'00)	(Ub.Dec'00)	(Ub.Dec'00)	(Ub.Dec'00)	(Ub.Dec'00)	(Ub.Dec'00)	(Ub.Dec'00)
6	Nk. Dec'00	Nk. Dec'00	Nk. Dec'00	(Nk. Dec'00)	(Nk. Dec'00)	(Nk. Dec'00)	(Nk. Dec'00)	(Nk. Dec'00)	(Nk. Dec'00)	(Nk. Dec'00)	(Nk. Dec'00)	(Nk. Dec'00)	(Nk. Dec'00)	(Nk. Dec'00)
7	Gustav	Gustav	Gustav	(Gustav)	(Gustav)	(Gustav)	(Gustav)	(Gustav)	(Gustav)	(Gustav)	(Gustav)	(Gustav)	(Gustav)	(Gustav)
8	Tiffiny	Tiffiny	Tiffiny	Tiffiny	Tiffiny	Tiffiny	Tiffiny	Tiffiny	Tiffiny	Tiffiny	Tiffiny	Tiffiny	Tiffiny	Tiffiny
9		Leanne	Leanne	Leanne	Leanne	Leanne	Leanne	Leanne	Leanne	Leanne	Leanne	Leanne	Leanne	Leanne
10				Bwana ^	Bwana	Bwana	Bwana	Bwana	Bwana	Bwana	Bwana	Bwana	Bwana	Bwana
11				Jabula	Jabula	Jabula	Jabula	Jabula	Jabula	Jabula	Jabula	(Jabula)		
12					Tshukudu	Tshukudu	Tshukudu	Tshukudu	Tshukudu	Tshukudu	Tshukudu	(Tshukudu)		
13						Petrus	Petrus	Petrus	Petrus	Petrus	Petrus	(Petrus)		
14						Dju-ba	Dju-ba	Dju-ba	Dju-ba	Dju-ba	Dju-ba	Dju-ba		
15							Makoleng	Makoleng	Makoleng	Makoleng	Makoleng	(Makoleng)		
16	Male							Mosu	Mosu	Mosu	Mosu	Mosu		
17	Female							Pitse	Pitse	Pitse	Pitse	(Pitse) ?		
18	(Removed)								Sambele	Sambele	Sambele	(Sambele) ?		
19	^ Introduced								Nema	Nema	Nema	Nema		
20	Died									Bwani	Bwani	Bwani		
21											Ditoro	Ditoro		
22											Ubhej 12/12	Ubhej 12/12		
23														

Addendum to : Focus on Black Rhino : *D.b.bicornis* Population Dynamics 2002 - 2012 **Annexure X**

Delta : Population Performance : 2005 - 2012 Actual rhinos **Delta**

Black Rhinoceros : *Diceros bicornis bicornis*

Updated : 16 May 2013

	Actual:										
	2005	2006	2007	2008	2009	2010	2011	**2012**	2013	2014	2015
Total	2	2	4	7	7	8	10	12			
Introduced	2	0	3	3	0	0	0	-			
Removed	0	0	-1	0	0	0	0	0			
Deaths	0	0	0	0	0	0	0	0			
Births	0	0	0	0	0	1	2	2			
Total number of rhino:											
1	Kaba	Kaba	Kaba	Kaba	Kaba	Kaba	Kaba	Kaba			
2	Nantie	Nantie	Nantie	Nantie	Nantie	Nantie	Nantie	Nantie			
3			Dhora	Dhora	Dhora	Dhora	Dhora	Dhora			
(Removed) 4			(Mpumalela)	(Mpumalela)	(Mpumalela)	(Mpumalela)	(Mpumalela)	(Mpumalela)			
^ Introduced 5			Vuka	Vuka	Vuka	Vuka	Vuka	Vuka			
Died 6				Thandi	Thandi	Thandi	Thandi	Thandi			
7				Sukulu	Sukulu	Sukulu	Sukulu	Sukulu			
8				Mia	Mia	Mia	Mia	Mia			
9						Darina	Darina	Darina			
10							Letse	Letse			
11							Gooee	Gooee			
12								Nxao			
								Thandi Oct.			