BASIC BIOLOGY AND ECOLOGY OF THE BLACK RHINOCEROS (*Diceros bicornis*)

Raoul du Toit

TAPE 1A 192

du Toit: We are here for the next few days to really pull rhinos apart--to talk about their organs, their red cells, their enzymes, what goes in them and what goes out of them, and all those sort of things. But before we do all that, I think it is important to try and put rhinos in their great context. We obviously look at them from the human perspective, but they belong somewhere else. We have got them in a corner and before we go shooting them and prodding them and generally messing them around too much, I think we need to just reflect on what they actually are as living animals out in their natural environment. I am going to try very briefly to present some sort of overview on that. I will probably go through briefly a portion of it, because I think what is more important is to allow time for discussion on any specific topics that people may be interested in towards the end. Although, because it is going to be a fairly broad ranging introduction, I think a number of people here are better qualified to speak on some of the aspects I will be touching than I am. So I think that we should allow *extra* interjection on those issues.

Let's look at rhinos, where they came from, where they are now. People talk about rhinos as living sort of dinosaurs that are really from the dinosaur age. They use the word fragile fossils--it is complete rubbish. Rhinos are perfectly well adapted animals. They were doing perfectly well until we came along pretty recently. If one looks in the not too distant geological past, the present day rhinos have evolved from a group of mammals that were the most ecologically diverse and successful group of large herbivores in the world, in relatively recent times. There were *at least six genera and hundreds of species*. There is contradictory information on the time scale of speciation of the 217 according to information presented at San Diego Rhino Conference a while back. The black rhinos have been in the fossil record in Africa for at least 7 to 10 million years. But lately analysis suggests the divergence of black rhinos from white rhinos more recently, 2 to 4 million years ago. Maybe we should have some comment on that at some stage. Whatever, the point is that they *seemed* among dinosaurs.

In terms of the subspecies issue, seven subspecies have been described, and are regarded as a sort of an official classification of rhinos based on skull measurements. A number of these *certain* subspecies have since been wiped out through poaching in Africa. People have questioned the validity of the surviving groups as well as those that have been wiped out. There has been some work done. I have been involved in looking at skulls, not that I think that is a particularly useful way of defining subspecies, but at least one can look at the skull classification work that has been done and pull it apart based on the *older* survey looking at larger samples; because of some of these *certain* subspecies have been erected after work that has been done on only ten samples, for instance ten skulls from a certain part of Africa. I still have not, to my embarrassment, analyzed and written up all that data from the black rhino skull *measurements in South*

Africa. But, the bottom line really is that there is very little difference and certainly these *certain* subspecies do not hold up in terms of skull measurements. There has also been biochemical work done which has shown relatively little or insignificant variation between black rhino breeding populations in Africa. There is obviously a need for further investigation in that light.

Apart from the issue of interpopulation variability, we have to consider the intrapopulation variability, and that obviously is a very fundamental topic in terms of conservation biology of black rhino, something you really have to worry about. How diverse are the remaining populations genetically? What sort of benchmarks have we got against which we can monitor the future genetic condition of these animals? The work that has been done I suppose is relatively limited compared to what should be done really, but the picture that comes out of it is that is not a great problem.

The *stratfort* protein electrophoretic work that is being done at the 255 Research Institute in Pretoria, using samples from the Zambezi Valley, has shown a very healthy level of mean heterozygosity in those animals. The *zooland* populations have a very low level, and that is not unexpected given the smaller fauna populations that were imprisoned in those areas in the 1930's in the 259. The Etosha population in Namibia shows an intermediate depth of heterozygosity between the *zooland* animals and the Zambezi. The work in the East African survey there was based on a very small sample size we see in print. Maybe Rick Kock can talk more on that. I presume these are zoo animals from East Africa.

R. Kock: Yes, they are zoo...

du Toit: I will suggest that there is really a problem in sample size there, because similar very limited sample sizes from the Zambezi have also shown very little heterozygosity; but if you increase the sample size, you start getting a much better picture.

M. Kock: The H's, can you explain the numbers, how you interpret those?

du Toit: It is simply a measure of heterozygosity. That level of 0.058 is just totally in terms of equation. I do not have the benchmark of what the normal numbers are, but they are below that. That is regarded as healthy. There is no cause for concern there. Maybe Colleen [O'Ryan] could comment on that.

O'Ryan: There is a paper that has come out recently in the Journal of Science where they mention this study and a couple other studies, and the whole story about this H's. There is no *real extra value if* you have higher values and lower values. And what is quite interesting is that in southern Africa apparently 277 high values, or healthy heterozygosity by proteins is not shown *in mitochondrial* DNA, and that 278*. I am not sure what is going on there. Those numbers are 279 back into the equation. It is a measure of how variable a population is and there is no absolute value of how variable or how much variability there is. The interesting thing is that in this part of the study that just came out they have got this apparent contradiction between the mitochondrial stuff, the DNA stuff, and protein stuff. No one knows what's going on there.

du Toit: But to what extent is the mitochondrial DNA stuff effecting the entire population variability? In other words population variability in the Zambezi Valley population, as compared with variability between Zambezi Valley and the *zooland* and Namibia.

O'Ryan: But the mitochondrial stuff... In the study that we did, we looked between populations. The largest population that had a intrapopulation study was the *zooland* population. We assayed up to 50 different rhinoceros individuals from the 290. They showed exactly the same pattern as the mitochondrial did, which could go back to this thing you said that 291* *1950's*. But the intrapopulation *variability of* individuals was zero. We have not found any different 292 within a population, and between populations either.

du Toit: So there is obviously a need for a lot more investigation. So pending equal ongoing investigation in this area, my aim in the situation is not of course to make a panic about the current genetic diversity in the black rhinos. We will see as we go along.

The bottom line really is that black rhinos are clearly extremely well adapted to a range of habitats in Africa. There are few animals that are as well distributed through habitat in Africa as well as the black rhinos have been. They *tend to be looked at* in semi-arid areas, not so much in equatorial forests. This relates to their nutritional ethology, which we will be talking more about tomorrow. They certainly have been a lot *distributed*. In fact to illustrate, I would like to move on to some slides now.

Rhinos live up in this part of the world. Very *verdant*, high rainfall, *rough* environment. Why is it always that they are found in this kind of environment? You can see that they do not really have very much vegetation diversity, and certainly not much quantity of browse for the animals. The Euphorbia growing on the river lines here is the major browse resource. I am not going to dwell too much on this because there is somebody far more qualified to talk about that, Pete Morkel. The river value is obviously very important in terms of providing the very limited water supplies as well as the browse resources along the edge of the rivers. They *all must be* competing browsers for these limited browse resources. Some areas are heavily *wooded* and start approaching the more savanna systems that we are used to in Zimbabwe going north. And here we have rhinos in Nairobi National Park in Kenya.

There were lots of rhinos in Africa until recently. In about 1963 there were over 70,000 rhinos in Africa estimated at that time. There have been two waves of depletion of black rhinos. The one source of pressure was during the colonial era, coming from colonial sport hunting from about 1880 up to 1930. That was combined with intensive hunting pressure to eradicate rhinos for agricultural development. Vast numbers of rhinos were killed by professional hunters who were employed basically as pest and vermin control officers to wipe black rhino out. That obviously was the major set back for the black rhinos, the expansion of human development in Africa.

Jessup: Are there any estimates as to what the numbers were and what they dropped to from 1880 to 1933?

du Toit: I do not think anyone has ever done it, it is a little bit academic. There would have been hundreds of thousands of rhinos. The figures of animals wiped out certainly is just staggering. One professional hunt in Kenya, maybe Richard [Kock] has got the figures, wiped out a thousand in a couple of years. There were massive 353 then. We tend to look at the current commercial poaching in Africa and lament that as a tragic twist in man's relationship with wildlife. But, we should not forget what happened early on which was *a factor worse then*. And so now we are in this place of petty commercial poaching for rhino and their horn.

Let us move on to the feeding ethology of black rhinos, a fundamental area. The black rhino is a browsing megaherbivore, along with elephant and giraffe. There are not many megaherbivores left as part of our large animal fauna of the world. Africa is better represented obviously than other places. Elephants and giraffe are the only other large browsers in the over 1,000 kilogram category. The black rhino is a hindgut fermentor, it is relying on the fermentation in the cecum and the large intestine, rather than fermentation in a compartmentalized foregut with remastication of ingesta, which is the strategy incurred by giraffe. There is some important elementary correlationships, *polyscale* relationships, that I think give us a useful perspective of looking at rhinos as part of the overall system and how they fit in with other animals.

As body mass increases, the specific metabolic requirements of an animal decrease. But, it is found that gut capacity remains a constant fraction of body mass. So as animals get bigger and bigger, they need less and less food in ratio to their body mass, but they retain the same ratio of gut volume to body mass. So, this in theory should mean that since these large animals can take in the same amount of food, that they actually need less. They can tolerate a low quality diet, and this is a basic principal of African ecology that was done by 387 and known as the 387 principal. But there are major constraints on the rate of ingestion of plant material, particularly for browsers. Browsers have patchy food resources compared to grazers. This is not only because the browse in a savanna system tends to be clumped, variable, and not as uniformly distributed as the grass resource; but also because as we will discuss tomorrow, there are matters of accessibility to height, or the feeding height range that rhinos can operate in. There is also the question of the suitability of that browse in terms of chemical defenses, and that sort of thing which is far less of an issue in terms of the grass resource. So the browsers have to move further to get access to the required browse resources. That means that they have to expend more energy and they need more, so it is a bit of a circle.

There are physical limitations on the feeding rate, the gape. In other words, the ability of an animal to open up its mouth and use its mouth to shovel food in is limited, particularly for a browser. A browser has to take in leafy matter and twigs, and it has to get its mouth on to these things. If it just gulps in a huge volume of plant woody material, it will have a very poor ratio of high quality food within that volume compared to not so valuable woody stuff. Whereas a grazing animal, like a hippo or white rhino, can develop a broad mouth and tunnel along like an auger and take up a reasonable quantity of food. An

elephant of course is adapted with its trunk to shovel a lot of food in. So there are problems with the actual physical limitations of an animal taking in volumes of food.

There are also problems in terms of passing that food through the system. Because while a gut can increase in volume in three dimensions, the inlet to the gut and the outlet from the gut are limited in terms of diameter, which is a two dimensional expansion. So it is all very well to increase the gut size, but you still have a problem with the rate of passage of material in and material out of that gut. That means there are limitations on the rate of ingestion. That means these large browsers like black rhinos have to feed at night. In fact, they are two to three times more active at night than at daytime. We will talk about that a bit further. Giraffe get around the problem as ruminants by remasticating stomach contents.

Rhinos are more selective browsers than elephants, with a longer fermentation time, in the order of 60 hours for ingestion, compared to about 50 hours for the elephant. Giraffe is 70 [hours] for ruminants. So elephants are adapting a strategy more of taking in very large quantities of relatively low quality browse, with in the constraints of the rate in which they can pass food in and pass food out of their digestive system. Rhinos are a highly bit more selective in their browsing, but still taking in large quantities and holding it for a while. In fact, since the time in which they can hold ingesta determines the degree of digestion, or the degree of fermentation, holding in material for this long period allows pretty high rate of digestion of cell wall material. So that is the sort of strategy they all follow.

The rhinos have a lot more competition from other ungulate herbivores than the giraffe or the elephant. Giraffe have the advantage of being able to reach up to a higher height range than the rhino, which are feeding at the height range where they are competing with eland and kudu and a range of other smaller browsers. These fundamental constraints on the nutrition of black rhinos obviously are the determining factors in terms of a lot of other aspects of the way in which they go about sorting themselves out in terms of their behavior, habitats they occupy, home ranges, and so on.

There is a problem of thermoregulation for a large animal like the black rhino. Because although they have got a fairly low metabolic rate compared to small animals, the musculature exertion that is required to get around to their browse resources generates a lot of heat. They have a relatively small surface skin area in relation to their volume, so there is a problem of dissipating heat. They are black animals, hairless, and therefore can radiate heat. They show a lot of behavioral response in terms of thermoregulation by resting in the shade during the heat of the day, using mud wallows, and moving at night; which in fact ties in with the need to move at night--they have to eat more. But they are also very prone to hypothermia, if their core body temperature falls it is a real problem for a black rhino, and it is a major constraint. Black rhinos drink every one to three days generally, mostly in the late evenings, early night.

This black rhino looks like it is eating grass, but in fact grasses only occupy about 1 to 3% of the feeding time of rhinos. They do eat grass, particularly in the wet season when the grass is more succulent and palatable. In fact, what this rhino is doing in East Africa in Nairobi, is selecting smaller legumulis forbes

in the grass sword. If you actually get out there and look around, you will see in fact that there is a good abundance of woody matter and forbes in that grass, and that is what is sustaining these animals. Forbes and small shrubs will make up between 30 to 75% of feeding time for black rhinos in the wet season. It would be expected that in the wet season with the greater raft of food available, that black rhinos would have reduced home ranges. But in fact, it is the other way around. In the wet season they tend to move over big areas, and that is because *out in the grassland area there are now* these forbes available for the rhinos to get to, which in the dry season or the winter period, they are not going for. East African habitats have a bimodal annual rainfall situation, two rains a year, compared to in southern Africa where we have only got one. That makes a big difference in terms of maintaining the browse quality. The bimodal rainfall, compared with the high portion of available forbes, combined with the fertile *organic* soils, allows a much better population density for black rhinos to exist in places like Kenya, compared to in southern Africa.

The preferred browse height for animals in our part of the world is about one half an inch to 1.2 meters. The rhinos use their horns quite a lot in shoving into bushes and snapping the bushes around and so on. But the horn 510 requirement for that. Rhinos are good at pushing over trees, they simply move over them, trees up to 4 meters high. The *carcassing* that causes the regrowth, the respark in vegetation, is quite important in terms of decreasing the availability of browse for other browsing animals. Rhinos are very significant growth phase facilitators for other browsing animals. One can see in some areas where there is a limited availability of preferred browse species, how much selective destruction, or sometimes how much *recarcassing* takes place as a consequence of rhino 533. There is a very important concept in terms of rhino browse species. It is not just the species of browse, but the size class of the browse that is important. A coin that has been termed by some of the people working on nutritional ecology of rhinos in South Africa is "spizers," which is species size browses. Some trees are very palatable as saplings, but become unpalatable as they get older. It is not just a question of the height range or the accessibility of that browse, it is a question of changes in its chemical composition, palatability, and acceptability to black rhino. So it is important not just to focus on particular species of vegetation, and presume that because rhinos seem to eat them that in areas that 548 a high proportion of those species, especially in that size, the size classes of that vegetation as well.

The bottom line for black rhinos in our situation in southern Africa is the dry season availability of good resources. It does not matter how much browse is available during the wet season, it is the dry season crunch that counts and 555 to what is going to be around in the dry winter period. We have learned that 557 in a number of situations in southern Africa. We will be talking about other aspects of rhino browsing in more detail tomorrow.

I will talk a bit further about the general habitat situation. This is to illustrate the issue of dry season browse resources. This is the 565 Ranch in Kenya which probably supports the highest density of black rhino reported in recent times. A large part of the reason for the high carrying capacity lies in the *poor* vegetation around the swamplands and that has also been a vital component in *around the city* where

poaching pressures reduce the rhino population 560 to nothing. This swamp vegetation is an important browse resource for black rhinos in this habitat. That obviously does not exist throughout all the Kenya area. This is 564 which is more typical of our southern African ecological circumstances for black rhinos and where there are serious *crisis measures* that have been taken into account.

I am going to focus on an area I am more familiar with, the Zambezi Valley in Zimbabwe; and just briefly outline the ecological situation there, and then put the rhinos in context of that situation. It is a little bit academic doing that, because there are only *20* rhino left there now, of several thousand that were there *18* years ago. In the course of doing some very extensive capture operations in this area we moved about *ten* of the rhinos out. We got a pretty good feel of where the rhinos like to be, where the highest densities were and so on. That has provided a very good perspective for us to evaluate habitat stability in other areas. In terms of the habitats in the Zambezi Valley... The main habitat types in the 598 these relative fertile areas, you have got low species diversity, a dominant 599. These areas of extensive brownish reddish vegetation are what we call *jest* communities, these are diverse thicket communities. We have got the flood bank systems along the Zambezi River which did support fairly large numbers of rhinos in the areas where there were not simply grass and they had a high diversity of browse species along the river systems. And we have got the escarpment communities, the very broken country which was good rhino habitat towards the east and along the Zambezi escarpment to the south. So those are the other main communities, the 614, the *jest* communities, the flood plain, the river 615 communities, and the escarpment community.

OK, let's look at 618 this is a very low species diversity and not very hospitable in the dry season. You can see there is virtually nothing there for rhinos. Therefore, a vast proportion of the Zambezi Valley is not good rhino habitat because of the dry season *crunch*. It is all very well in the wet season. After the rains there is plenty of good diversity of plant communities available for the animals, particularly along the tributary rivers. But that does not help animals in the dry season because rhinos do not 630 they do not really live in these areas in any great density. Another problem of course is the question of accessibility of browse. Although there is a lot of woody matter out here, there is very little actually in this particular area of typical 634 woodland that is within feeding height range of rhinos. What is there tends to be very heavily defended chemically.

BEGIN TAPE 1B

These *jest* communities are extensive areas of a dry thicket community on deep red sand. Again, there is obviously dry season constraints simply in terms of wood available, because the plants are deciduous. These communities tend to be adjacent to the 007 *communities* along the rivers where the rhinos have good access to water. And these are very important refuge areas for black rhino to move into during the daytime. In some areas you have got a really well developed sort of *ledge*, like a forest situation; really excellent rhino habitat and a good diversity of browse species. It is probably the best rhino habitat we have in Zimbabwe. In the dry season obviously things dry up a hell of a lot. These thicket areas are

extremely difficult to operate in. The fact that rhinos prefer that has given us some *serious lacks* in terms of the logistics of *getting them out of there*.

The escarpment areas, the broken areas, also constitute good habitat. Rhinos like diversity. Obviously terrain diversity is reflected in vegetation diversity. So these again are good areas for black rhinos, but terrible areas for those of us 015. Some areas are more open. Elephant pressure and fire has gotten these areas opened up quite considerably. 017 has provided good situations for black rhino, because elephants as I will discuss later, 019 in relation to rhino feeding ethology. The elephant damage, although it is reducing the total biomass of vegetation, it is making a lot of vegetation more accessible to 021.

END TAPE 1A

Let us discuss a little bit about the demography of the rhinos. The best records in terms of longevity of black rhinos obviously comes from zoos. There have been a number of documented cases of black rhinos surviving to over 40 years. They reach sexual maturity at about 5 years, there is some variation in that. There does seem to be a very strong relationship between the age in which animals reach sexual maturity, and the stocking rates in the areas with animals reaching sexual maturity considerably later, in situations where they do 027*. There is about a 15 month gestation period for black rhinos. The calving interval is generally between two and three years. The rhinos to my mind do not show a clear reproductive seasonally. Some people suggest a wet season heat, but I am not convinced about that. And again we need to do an organized 033.

Black rhinos will chase their calves off in order to have their second one. They are very solitary animals, and I will discuss that further in just a moment. When the first calf is two to two and a half years old, the mother will have her second calf and she will chase the first one away. That first one will now have to fend for itself and go through a fairly stressful period as it is trying to sort itself out.

R. Kock: Raoul, can I interject this? You mentioned 042, this very high density. You see black females with up to three calves together. I wonder if this has something to do with the density with the food availability, or what. What dictates the fact that the mother 045?

du Toit: I think it depends very much on the *food* availability. Somehow rhinos seem to regulate their sort of social organization and density through social interactions in relation to food resources.

Lukas: I think on that point also, that studies have shown that the young calf that has run off takes up with another female, an aunt, and then she will have a calf. So you see a female with different age calves, most likely the only calf that is hers is the one that is the youngest. The others are calves of other females. They have a much more tendency to accept a calf that is not their own and that hangs in their area. That has been documented in a few studies, especially east African studies. In the Ngorongoro you will probably see a mother there with three different aged calves, and the only one that is her calf is the new one. The other ones have come in and joined her, and they tolerate them.

du Toit: I am sure a lot of it has to do with the availability of feed resources, and it is a 054 situation 054. The mother certainly has to chase the old calf away, because otherwise it will be competing.

Lukas: It will be trying to nurse. Whereas a calf that comes to a strange female will not try to nurse off of her most likely. That is why they tolerate her.

du Toit: Maybe, that is interesting. Predation is obviously a factor to consider in the raising of calves. An adult rhino it is pretty immune to predators. There have been isolated cases of a lion putting down a large subadult, or even an adult rhino. But there is quite a lot of predation of calves in situations where you have particularly a number of hyena. Part of the problem relates to the fact that the mother tends to run in front of the calf, compared to the white rhino where the calf runs in front of the mother. There is a big difference in the predation of white rhino calves compared to black rhino calves *as a consequence* 063. When one wonders why, one can obviously stipulate that it is because black rhinos tend to be in thicker areas and it is actually much easier for the mother to force her way through the vegetation in front of the calf, and the calf to follow her. An therefore, there is a tendency in black rhinos of a slightly greater risk of predation. Whereas in white rhinos that live in more open country it is the other way around. But of course, it is a concept for sure.

Apart from predation, we do have die offs of black rhinos in the wild. These unfortunately have not been terribly well documented, and there is not a lot of information on that. I'll discuss that a bit further later on. There is really quite some important comparative information, 072 a zoo management situation we need to think about these die offs of rhinos that have been recorded in the wild. This predation problem leads to a high instance of earless rhinos caused in situations where they might have *missed his eyes.* Rhinos also get their tails cut off 077 quite a lot.

Let us talk about some of the things that affect black rhino out there. Filarial lesions 078. There is a big variation in the extent in which the lesions occur, according to the humidity, and the presence of flies, and possibly other factors. With the animals in 753 them being particularly prone to very large lesions which occur on certain places on the body in accordance to the age of the animal, in fact it is a way of aging the animals. In Zimbabwe, the filarial lesions generally occur in 084 and do not occur in the *wooded* and do not occur in the dry areas, the upland areas. They sometimes occur, but they are no big deal and I am sure if anyone *needs more commenting, Nancy [Kock] would not mind talking to them.*

I mentioned before, rhinos having to drink every one to three days. The distribution of watering points obviously is a major influence on the densities in which rhinos live and on the distribution of home ranges. The densities vary according to water distribution and according to the browse resources, anywhere from one black rhino to one square kilometer to one black rhino to 100 square kilometers. The rhinos are semiterritorial. They do not occupy strongly defended territories. They rather reside in home ranges, and there is considerable overlap of home ranges between one rhino and another rhino. It is quite clear that the rhinos are sorting themselves out behaviorally. Importance would be on the constraints of feeding

ethology, and it works pretty well. This distribution of home ranges does change, it shifts every now and then. Home ranges are typically about 10 to 30 square kilometers, in that range. But obviously in the years with limited browse resources such as Namibia, they get much bigger, and home ranges up to 500 square kilometers have been reported.

Blumer: There is some evidence in white rhinos of some die offs related to algae toxicity in some watering holes. Is there any evidence that has been documented with that in black rhinos?

du Toit: Yes, there is some interesting... I will cover that a bit later, in relation to some of 103. But no, I have not read anything about algae toxicity. That would be interesting.

Rhinos obviously suffer from a range of blood parasites and gut parasites. Again, this is not my area of competence, but it is obviously an issue. I do not know how important the gut parasites are, probably not very important in terms of stress to the rhinos. Similarly, they are well adapted to blood parasites, unless you put a lot of pressure on them. But these areas obviously offer a range of endemic diseases in black rhino in which they have become adapted.

I mentioned the theory of chips and rhino home ranges. Often what we see when rain has fallen and there is a bit of distribution of water, the rhinos that have been settled into an area now suddenly push off and start looking around in other areas. As the year wears on, and as the water availability becomes more stricter again, the rhinos will often go back and reoccupy the home ranges they occupied previously. So there is quite a bit of flexibility in relation to the season variation and the water and browse availability. These water holes play a very important role in the social organization of black rhinos. This is a typical Zambezi Valley watering hole. This is the place where rhinos come and socialize and make their contact with each other, their local "club meeting" in some ways. That has been their demise unfortunately in terms of the *pattern to poach*. It is so easy for someone to sit at a watering hole and wait or track them from a watering hole, because they are so regular in their visitation to certain water holes. There is a lot of social activity. Rhinos will advertise their dominance status and their reproductive status through dung scratch and urine spraying. So for rhinos to know what is going on they move *to a place with* a water hole, sniff around see who has been there, what they are up to, generally get the picture, and sort out their social organization around that.

One would tend to have a dominant bull occupying the home range that would overlap considerably with other rhinos, not just females, but also males. These home ranges, in terms of the largest one, would be located with the major focal area like a water hole in sync with these home ranges. Other home ranges 131 with overlapping areas around, with the focal area being on the edge of each of their areas. So there is a fairly well organized system in place with this behavioral interaction being fairly advanced. There is obviously a lot of interaction between males.

Here is a slide of a big rhino scrape. Rhinos tend to favor certain trees to scrape on. There is definitely some species that rhinos do not like. They crap on them and beat them to hell and pick other

species. It would be interesting to know why. A lot of it I am sure is related to the fact that they tend to maintain a scent 141 dung constituents in there that other rhinos are picking up that are preserved better on certain vegetation types than others, particularly 143. It is just a fact to consider, sending rhinos into a confined situation.

This is 145 Park and one or two rhinos. These old bulls often have very tacked ears. Probably from fighting and also because they tend to be a bit rough in pushing their way in through thick vegetation. Females have much more well preserved ears. These have been fighting obviously in a free ranging situation among rhinos, maintaining their social organization 151 bomas with their food resources and so on.

But the mortality is nothing like what occurs when you try to manage rhinos and shift them around. This problem of intraspecies aggression is one of the factors that really causes us complications in terms of moving animals around. It is all very well to make statements about moving one effective 156 breeding rhino generation to insure there is gene flow in the next population situation. But, practically to do that often becomes a big problem. The subadults when they are chased away from their mother, might be thought to be good candidates for that, but there are some problems with that. For one thing, the subadults are going through a very confused stage in their life. Just when they get the picture they go through a domestic upheaval, and they are still trying to sort themselves out. They are very dependent on their mothers in terms of assisting them with browse selection and actually access to some browse resources, particularly in the dry season when the vegetation is picked over. So, these little rhinos struggle a bit. We also find that the dominant bulls are not quite as tolerant of these subadults as you expect. There has been an increasing number of subadults being moved on the presumption that the big bulls will be more tolerant of them, but actually being wiped out totally.

This is the biggest rhino bull I have ever seen or dealt with. He was actually to come across here to the states in 1989, and the shipment was canceled due to a ***botch in the*** transfer arrangement. This guy stood in his crate for about four to five days. He was too big to lie down. He was on his feet the whole time. Eventually I got permission to take him down to 171 the nearest available ranch which had rhinos. This ranch which was 100 square kilometers and had received four bulls in 1986. Those bulls had sorted themselves up into territories of about 25 square kilometers each. 173*. We took this guy down there specifically because it was the closest one. We wanted to get him out of his crate as quickly as possible. He backed up and put himself in a mud wallow. He got out of the mud wallow ready to kill somebody, having been obviously dreaming about it for the last four days. He was released, and within about a period of about three months he gradually shifted himself around the ranch, got to know who was who, and started trying to sink his home range on an area of total activity, came upon another bull's range and was wiped out. Everyone of the male rhinos subsequently introduced on that property was either killed or chased off the property by those four original bulls. So this problem of male dominance and intraspecies aggression is a very serious one. I think it has been even more of a complication in Kenya. I think it reflects the

difficulties of trying to manage rhinos in small areas. It is really only in this 184 area of Zimbabwe where we have got small properties that we have had this problem at this kind of level. In fact, I can not remember 186 mortality occurring elsewhere in Zimbabwe. In Kenya I think it runs at about 10%. But it is only in our 187 area on the small properties where we have had this problem. So long as *one particular rhino* 188 *got a problem.*

A real important aspect of rhino ecology is the ecological integration of the interaction with other wildlife species; and as much as wildlife also domestic cattle. We have been establishing rhinos in areas of Zimbabwe that have been cattle ranching country. In fact with the degradation caused by cattle stocking, the bush *erosion* was in fact 195 to black rhinos. So there we were in fact 196. The other major influence on black rhino is elephant. And that can be both positive and negative.

This is in Tsavo East National Park in Kenya, showing some of the habitat that is very similar to that dry deciduous forest *we call jest* in Zimbabwe 200 dense woodland with understory very favorable for black rhinos. As you can see, there is a lot of browse out there, very thick stuff, perfect rhino habitat. But elephants can wipe it out quite quickly. In Tsavo in 1961 there was a drought, *not in* 1961 but the year before, and a hell of a lot of elephant pressure. There were large die offs of rhino. In fact 300 rhinos died along a section of the 207 river in Tsavo East. In 1971 the same thing again occurred. There were deaths of about 6,000 elephants that year out of a total population of about 40,000. That is when the habitat in these areas of 210 density was reduced to this open grasslands situation. It was not the drought they say that killed the rhino, there was water available, it was just the lack of vegetation, of browse resources for them caused by the elephant pressure. I think it would be very fascinating to try and dig out some of the records of those rhino mortalities. The limited information I have seen mentions a couple of interesting things. One is that these rhinos died with these dark crusty blood *forms* on them. There was some speculation that that was due in part from flies, but does not seem to be the only possible cause for that. I have not seen any detailed reports on that, maybe Rick [Kock] could *dig up something out of the records coming out of Tsavo*, it would be very interesting to look at them. Another interesting thing that occurred is there was a very marked increase in intraspecies aggression. A lot of these rhinos were moved by other rhinos, according to one report that I saw. And certainly from 224 we see rhinos moving out to *stocking* rates that *caters* often in over browsing of developing vegetation. The instance of aggression between those rhinos, even between females has gone right up in fact 227 significant mortality. It is often very difficult to work out the approximate cause of death. Some *managers* will tell you that the rhinos died because it was killed by another one, but 220 life threatening themselves, but there seems to be a sense of a general loss of condition, increased parasite burdens, and things like that. And the bottom line is of course nutrition. So that is the situation we have in Tsavo, with a hell of a lot of rhinos dying. As you can see, this is a large number of rhino skulls lying outside of 233*.

A different situation occurred in *Tituwe* Game Reserve in South Africa. Think of it the other way around because of the loss of elephants from that area. There was a major habitat change, due to acacia

growing into a evergreen forest type community. That evergreen forest community was far less suitable for black rhinos. The various factors involved here interact in quite an interesting way. Elephants were wiped out because elephants were not in their upland 244 woodland. The acacia species thickened up and got to a much higher size class than they would normally be maintained at. As the vegetation thickens up and the acacia trees thicken up there is diffuse light penetration. The acacia are 249 species that will grow quickly as *regrowth* species, but they do not regenerate well under canopy situations. So what you have got now in these thickets is getting towards a closed canopy, you have got increased stem 252 down the trunks, reduced light penetration. There is a lot of bird seeding going on, birds coming in and perching on the bottom woodland and defecating seeds from the evergreen forest species. Gradually the acacia community goes through a stage of succession into an evergreen woodland community, which is far less suitable for black rhinos, because mainly of problems with plant chemistry and accessibility.

There has been a general decline in black rhinos 260 over a number of years. Recently the investigation has reached a strong conclusion that is has been due to the habitat change that has actually *introduced* 263 has changed to some extent. But apart from that *change*, there was an interesting die off again in 1961, the same year as the first major die off in Tsavo. It was 46 black rhinos, which was 15% of the total 267 died. But this was not due to nutritional stress. There are several reports on this mortality. The mortalities occurred over a reasonable stretch of time of about four months. Five of the rhinos that died were subjected to relatively detailed pathological examinations, but those were inconclusive as to the cause of death. The deaths occurred in an area of high density of black rhinos, a really high density for southern Africa; 1.7 rhinos per square kilometer, which is unprecedented for 275. But there was no indication that mortality was due to nutritional stress. In fact, there was not a drought going on, unlike in Kenya. There had been rainfall throughout the year. There were a lot of *seasonal pans*, all filled with water throughout the dry season. The animals were in good condition. The deaths occurred in all age and sex classes as well through the population. Whereas with other population crashes 280 tends to wipe out one segment of the population, either the very small animals or the very old ones. An interesting feature was that all but two of the dead rhinos were found within 500 meters of the water. The animals died close to the water. We have had some deaths occur in Zimbabwe and other places with rhinos seeming in good condition, coming to water, drinking, and dying when seeming just fine. Pete Morkel had a case in Namibia as well. There seems to be a pattern going on with that that is worth thinking about. What Evan [Blumer] was saying earlier about the algael situation in white rhinos may be something.

Another suggestion which I think bears some consideration is that under certain conditions one would have blooms of toxic *terrestrial* vegetation, poisoned plants growing up that would crop up only once in maybe 5 or 10 years. It maybe that the rhinos eat those things and there is some physiological thing going on, I am not sure. That has been a speculation to account for the deaths that occurred in Zimbabwe. But, the pattern is not entirely clear. Some of the animals showed partial paralysis, some of these that died in *Tituwe* in 1961. In several cases they started to charge people and collapsed 299. And that ties into a

report from the 300 area in Zimbabwe we have *similar mortality with a subadult seen* where the animal was obviously seemingly paralyzed when it died 302. So there is a complicated situation we have only begun to understand.

Because we do not know anything about black rhinos and because we have burnt our fingers in a big way in our attempts to translocate these animals from small areas of prime management intensity, we are falling back on a very very cautious approach in Zimbabwe and South Africa, and I am sure in Kenya as well. We have approached adaptive management where we try to put rhinos in a situation monitoring them extremely closely in terms of their body condition 309 regular monitoring of animals with recording of their body condition. Breeding success is also important. I am inclined to think that interbirth interval is the major consideration or measuring criteria to use. Because if one considers an animal that is raising its calf, and other one that seems to be 314 in some areas 314 the interbirth interval may even reduce as the rate of survival of calves increases. So I think it is the overall *negative* reproductive rate that needs to be considered and looked at very closely. Possibly also, the age of first conception 318. Fighting is a strong possibility, in fact I am convinced of that. As animals start running short of food resources they start fighting each other a lot more. Changing home ranges in an area could also be reflected of absorption. Obviously 323 itself. Looking at the browse species and seeing how rhinos handle certain browse resources is vital. We will talk more about that tomorrow.

I think there is also some promising work that could be done in terms of looking at the physiological aspects of black rhinos in inducing stress situations while looking at excretory products, looking at metabolites found in urine. Maybe we can talk more about it tomorrow. But for instance taking something like *glucuronic* acid 330 Zimbabwe.

The bottom line really is that we need to be very safe and we can not pretend to be *rhino farmers*. In our situation in Zimbabwe, because of the much lower black rhino carrying capacity we can not really adopt some of the ecological indexes the same as the Kenya sanctuary have got, which can put large numbers of rhino in small areas. We simply have not got the carrying capacity.

The approach that is 337 is trying to take a stab and guess what the maximum ecological carrying capacity is for an area, then of that, to give you a target population size. Because the whole point of putting rhinos somewhere is to breed them, you want the rhinos at a population size where one has got 341 population at the point of maximum population *density one wanted to go through*. Then of that total size again, to give you a *final* number, because you do not want to have to find yourself having to run around *managing rhinos, you might be better off to introduce them*. By the time you have done all of that you actually have got pretty big areas to be able to introduce a reasonably sized rhino population. So that puts a big constraint on the type of breeding set ups that we 348 situation.

So I will try to cover a range of issues here and then point to some of the field management issues *going on now* 350. To what extent *is the relevancy* in a zoo situation remains 351, and needs to be raised obviously. But it is interesting to see in contrast an animal like in New Orleans Park Zoological Society with

our type of situation. An animal in a confined area obviously can not range around, it is producing a very small quantity of dung. It must be spending a lot of its time wondering what it should be doing, because normally a black rhino would be out walking at night 357 pumping a lot of food through its system. So it is under very different circumstances, obviously 358 in terms of its nutritional aspects. We have got to find a way to make it all work and making that rhino more comfortable *in a smaller space* and certainly on its nutrition 362.

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