HALMSTAD UNIVERSITY

Bachelor's programme in Conservation and Diversity, 180 credits

BACHELOR THESIS

A survey of the available browse for the black rhinoceros (Diceros bicornis Linnaeus, 1758) in a farmland area in the Kunene region, Namibia

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Conservation biology, 22.5 credits

2015-09-01

A survey of the available browse for the black rhinoceros (*Diceros bicornis* ssp. *bicornis* Linnaeus, 1758) in a farmland area in the Kunene region, Namibia

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Bachelor thesis 22.5 credits, Halmstad University, September 2015.

The black rhinoceros (*Diceris bicornis* ssp. *bicornis* Linnaeus, 1758) is classified as critically endangered by the IUCN. In conservation strategies knowledge about the forage availability is a management priority. Hence the aim of this study is to investigate the browse availability for the black rhinoceros at a farm in northwestern Namibia, as an initial attempt to decide how many individuals that could be introduced to the area to further expand their range to secure the future of this critically endangered species.

To estimate the browse availability 19 sampling squares with a size of 50x50 meters were taken in those areas that were most representative of the vegetation. Trees and shrubs within the squares were counted and the height of each specimen measured and categorized into different height levels. As the black rhinoceros browse up to two meters above ground leaves and twigs from 0-2 meter height were pruned from different species and were then weighted to estimate the available biomass.

The average available biomass per hectare in the area was 3016 kg, by the time of the data collection. Based on calculations made the area would be able to feed 664 individuals. As these calculations and estimations were made with high margins and with caution not to overestimate the amount of available browse it is safe to suggest that a smaller population of black rhinoceroses could be introduced to the area without risking the browse to be insufficient.

Furthermore the vegetation of the studied area is found in a wider range, which means that the results potentially also could be applied regionally and used by other conservancies that consider becoming black rhino custodians.

Introduction

In the African savannas there is a high diversity of herbivores (du Toit & Cumming, 1999; Olff, Ritchie & Prins, 2002; Fritz et al., 2011). There are three different types; grazers, browsers and intermediate herbivores (Hofmann & Stewart 1972). Grazers ingest mainly monocot material and browsers feed on dicots such as herbs and twigs and leaves from trees and shrubs, whereas intermediate species have a mixed diet (Hofmann 1973; Demment & Longhurst, 1987; Langer, 1988; du Toit, 2003). The grazing and browsing pressure strongly influence the composition of the vegetation in savannas (McNaughton, 1998; De Knegt et al., 2008). An increase of grazers, such as cattle, has in many places led to overgrazing (Huntley, 1982). This has a negative effect on fire frequency (Roques et al., 2001) and it evokes small trees and bushes to grow and form dense thickets (Fynn and O'Connor, 2000; Wessels et al., 2004), a phenomenon that is commonly called bush encroachment (Trollope et al., 1989). Studies have shown that browsing animals, like the black rhinoceros (*Diceros bicornis* ssp. *bicornis* Linnaeus, 1758), could reduce this at an early stage by preventing the seedlings to establish (Roques et. al., 2001) and thus suppress the regeneration of woody plants (Levick et al., 2009).

Herbivores tend to minimize the cropping rate by feeding in dense vegetation (Belovsky, 1997), therefore thick scrubland seems to be the most suitable habitat for the black rhinoceros because of the high content of browse. In thick scrublands the black rhinoceros usually have a relatively small home range area and this habitat can support densities of up to 1.5 rhinoceroses per square kilometer, compared to open grassland savanna where they have a much larger home range area and therefore this kind of habitat can support much lower densities, down to 0.04 rhinoceroses per square kilometer (Tatman et al., 2000).

In the year 1960 there were 100,000 black rhinoceroses left in Africa. Since then the population has declined with 97,6%, with the lowest number in 1995 with only 2,410 individuals remaining (Emslie, 2012), due to anthropogenic disturbances, such as poaching, habitat loss, human-rhinoceros conflicts and political conflicts (Hutchins & Kreger, 2006). By the end of 2010 the population had increased to 4,880 individuals, thanks to successful conservation strategies, but the population is still 90% smaller than three generations ago and the black rhinoceros is thus classified as critically endangered by the IUCN (Emslie, 2011). There are three different subspecies of Black Rhinoceros left in the world today, roaming different areas of Africa; *Diceros bicornis bicornis*, *D. b. michaeli* and *D. b. minor*. A fourth subspecies, *D. b. longipes,* was declared extinct in 2011. 28 % of Africa's black rhinoceroses and more than 91 % (i.e. 1,750 individuals) of the total population of the South Western subspecies, *Diceros bicornis bicornis*, are found in Namibia (Save the Rhino International, 2015), while the rest of them are found in South Africa (Emslie, 2012).

Namibia has taken action with several different strategies to protect the biodiversity. In 1990 the Ministry of Environment and Tourism (MET) was established, they work to protect Namibia's natural recourses and by doing so benefit all Namibians, both present and future generations (Save the Rhino International, 2015). Approximately half of the country is under conservation management and 19 % (over 130,000 square kilometers) is protected by legislation. Through their Community Based Natural Resource Management (CBNRM), which is a collaboration between the government, non-government institutions, communities, development partners and community-based organizations, they have had great success in conserving the wildlife and by doing so also mitigate poverty (MET, 2015). The CBNRM program has made it possible for communal conservancies to form, which are responsible to protect and monitor the wildlife within their boundaries. By attracting tourists and manage hunting in a sustainable way the wildlife has become a great source of income for rural communities. Today there are 82 registered conservancies in Namibia and several more in progress (NACSO, 2015). This has led the way for a secure range expansion of the black rhinoceros by translocation to communal conservancies; a program that is called the 'Custodianship program', meaning local conservancies become custodians for state-owned black rhinoceroses (all black rhinos in Namibia are owned by the government) which attracts tourists and thus generate an income in a sustainable and responsible manner (Save the Rhino International, 2015).

The conservation strategy of the black rhinoceros is to ensure a 5% annual population growth in southern Africa to minimize the loss of genetic diversity and to make sure that more rhinos are born than are poached (Emslie, 2001a,b). A high population growth can only be maintained if the available food is not a limiting factor. It is therefore crucial to know about the forage availability when considering introduction of the black rhinoceros to an area and is thus a management priority (Adcock, 2001).

The owners of Okutala African Quest, which is a farmland area in the Kunene region in Namibia, are interested in becoming black rhino custodians. Hence, the aim of this study is to determine the available potential browse for the black rhinoceros on their property, by doing a survey of trees and shrubs and estimate how many black rhinoceroses the browse can support. These numbers can then be helpful in deciding how many black rhinoceroses that can be introduced to the area, to further expand the range to secure the future of this critically endangered species.

Materials and Methods

The study area

The fieldwork was conducted on a farmland area in Namibia, called Okutala African Quest (19°32' S 15°46' E, Figure 1), which occupies an area of 24,000 hectare. It is situated in the Kunene region, approximately 25 km south of the Anderson's gate to Etosha National Park. The study area is relatively large compared to the average area size in the Rhino Custodianship Program scheme, which according to Birgit Kötting, manager of the MET Rhino Custodianship Scheme at the Etosha Ecological Institute, is 15,000 hectare (personal communication). The farm is fenced on all boundaries and there are several man-made, permanent water holes spread across the property.

Annual mean maximum and minimum temperatures for the area are 32°C and 5°C, respectively. Rainfall varies from year to year but with alternating wet- and dry season. The rain usually occurs between October-April with an average of 291 mm during this period of time (numbers are based on data taken between years 2000-2012) In the year 2013 the country suffered from a severe drought and by the time my data were collected, in February and March 2015, normally characterized by heavy rainfall, the precipitation was much lower than average and once again Namibia had to face a drought, just beginning to recover from the last one (worldweatheronline, 2015).

The vegetation in the farm area can be classified as mainly tree- and bush savanna. The most common tree in the area is Mopane (*Colophospermum mopane*). Other abundant species are *Acacia* sp., *Commiphora* sp., *Dichrostachys cinerea* and *Combretum apiculatum*. In most locations the vegetation was very dense and signs of bush encroachment can be seen.

Several browsers that may compete with the black rhino about the available food are present in the area, such as Eland (*Taurotragus oryx*), Klipspringer (*Oreotragus oreotragus*), Steenbok (*Raphicerus campestris*), Kudu (*Tragelaphus strepsiceros*), African Elephant (*Loxodonta africana*) and many more. It should also be noted that large insect populations present in the region, of example termites, could consume big amounts of plant materials.

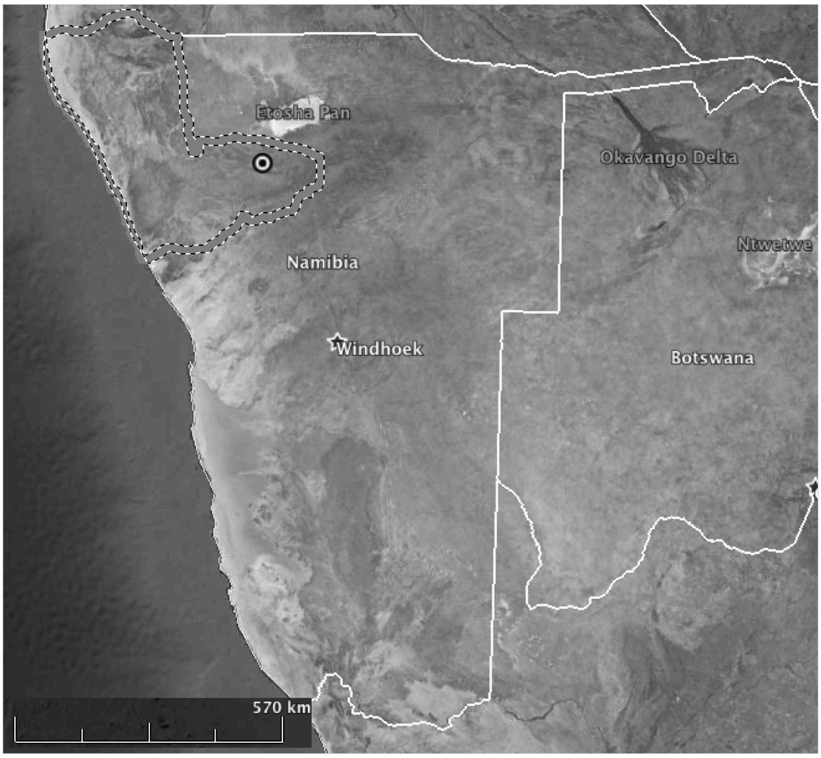

Figure 1. The data was collected on a farm, Okutala African Quest (19°32'46 S 15°46' E), in the Kunene region, Namibia. The round dot on the map shows the location of the farm and the marked area shows the Kunene region. The map is downloaded from Google Earth.

Data collection

The data was collected between the middle of February and the end of March. Reconnaissance surveys were done for estimating the different vegetation types to be able to select different sampling plots in the sites where the Black rhinoceros might go. In those areas that were most representative of the vegetation, sampling squares with a size of 50x50 meters were taken to estimate browse availability, but a greater proportion of the squares were located around the lodge, as the farm-owners would try to keep the rhinos around and close to the lodge-area to attract the tourists.

The available browse in the squares were counted and the height of each specimen measured and categorized into <1 meter or 1-3 meters. As the vegetation was very dense at most sites, it was difficult to get an overview of the sampling square and thus the 50x50 meter squares were divided into 4 adjacent 25x25 meter squares to get a better overview to be able to accurately count all specimens without missing some or count them more than once. A total of 19 50x50 meters sampling squares were taken (Figure 2). Since the mountains and the steep hills are inaccessible for the black rhinos (Landman et. al, 2006) no data was collected in these areas.

Generally browsers are selective in their feeding and eats predominantly young plant material and new shoots (Owen-Smith & Cooper 1983, Pellew 1984, Owen-Smith & Cooper 1987, Cooper et al. 1988, Owen-Smith & Cooper 1988, 1989, Illius & Gordon 1993, Kotze & Zacharias 1993, Breebaart 2000, van der Waal & Smit 2003).

To define the meaning of available browse, Pellew's (1983) definition of browse was adopted; 'the sum total of the plant material produced by a variety of woody species that is potentially edible to ungulates. It comprises all the green leaf and all the young unlignified (i.e. before secondary thickening) shoots of the current season's growth'. The black rhino normally browse at a maximum height of 2 meters above the ground (Smithers, 1983; Du Toit, 1990; Oloo, Brett & Young, 1994). To be able to estimate the weight of the available browse, leaves and twigs from 0-2 meter height were pruned from specimens of four frequently found species (*Colophospermum mopane, Combretum apiculatum, Dichrostachys cinerea* and *Commiphora glaucescens*) in the size category from 1-3 meters and were then weighted, to measure the biomass.

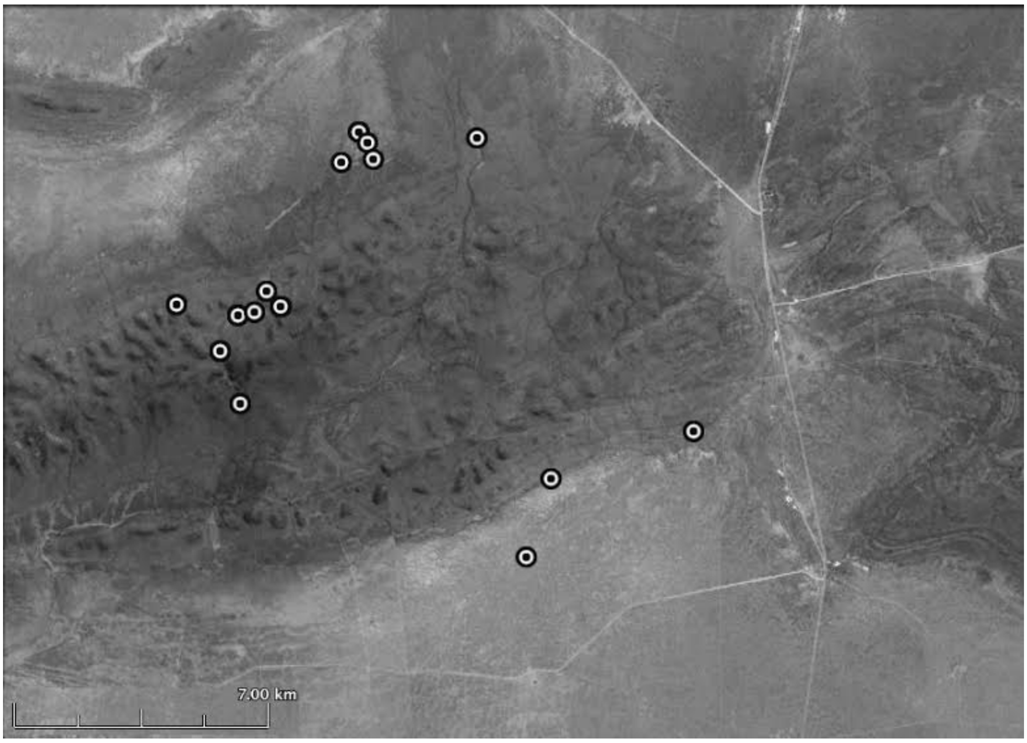

Figure 2. 19 50x50 meters sampling squares were taken in areas that were most representative of the vegetation. The white dots with a black middle represent a sampling square. (Only 15 of the 19 sampling squares are visible here because 4 of them are so close to other dots that they can't be seen in this map). The map was downloaded from Google Earth.

Data analysis

The biomass of each sampling square was calculated, using the weight of the weighed species in size categorie 1-3 meters (*Colophospermum mopane*, *Combretum apiculatum*, *Dichrostachys cinerea* and *Commiphora glaucescens*) to multiply with the number of specimens of the certain species. For the rest of the species that were not weighted, a mean value of the weighted ones was used. For the specimens in size category <1 meter the weight of the 1-3 meter specimens, of each species, was divided in 2. Based on the reconnaissance surveys an assumption was made that the sampled sites well represented the vegetation in the whole area and the average biomass per square (0.25 hectare) was calculated and multiplied with 4 to get the average biomass (kg) per hectare.

Results

The most abundant species that was encountered was *Colophospermum mopane* which accounted for 33.55 % of all counted specimens and was found in all of the 19 sampling squares. The second most common species, *Combretum apiculatum* (16.30%), was found in 11 sampling squares while the third and fourth most abundant species, *Catophractes alexandrii* (9.48%) and *Petalidium englerianum* (9.10%) was only found in three and one of the 19 squares respectively, where they on the other hand were relatively numerous and dominated the vegetation cover. In comparison, the least abundant species that were encountered, *Boscia albitrunca, Acacia erioloba, A. karroo* and *A. kirkii*, all accounted for 0.04% each of the counted specimens and were only found in one of the sampling squares. All 9 identified *Acacia* species together were relatively abundant and accounted for 12,5 % of the counted specimens, where *Acacia reficiens, A. mellifera* and *A. newbrownii* were the most numerous ones (Table 1).

The available biomass per square varied a lot between different sampling squares, from 150.51 kg to 2,089.28 kg with an average of 754.30 kg ± 563.39 SD. The average available biomass per hectare in the area was 3016 kg, by the time of the data collection. That would generate a total of 72,380,000 kg available potential browse for the black rhinoceros at the whole property of Okutala (based on the available vegetation at that point in time alone).

Table 1. Encountered potential browse species (≤3 meters) for the black rhinoceros on the property of Okutala. Figures are based on number of plants observed in 19 different sampling squares with a size of 50x50 meters each. The biomass of the browse is calculated with mean values of biomass per square. The standard deviations of these values are consistently high but are not shown in this table.

plant species	specimens/hectare (≤3m)	browse/hectare (kg)	presence in number of sampling squares (out of 19)
Colophospermum mopane	7,148	16,291.88	19
Combretum apiculatum	3,464	5,010.88	11
Catophractes alexandrii	2,020	6,488.12	3
Petalidium sp.	1,940	4,316.52	1
Terminalia prunioides	1,556	4,886.24	17
Dichrostachys cinerea	1,332	5,606.48	17
Acacia reficiens	928	3,364.28	5
Acacia mellifera	812	2,438.64	5
Acacia newbrownii	624	2,429.72	4
Commiphora glandulosa	272	2,556.04	9
Rhigozum brevispinosum	188	208.32	2
Commiphora glaucescens	148	631.92	8
Acacia luederitzii	136	569.60	3
Grewia retinervis	124	275.92	2
Grewia flavescens	88	391.60	3
Acacia senegal	84	356.16	4
Acacia nilotica	72	249.20	2
Grewia villosa	68	160.22	5
Grewia bicolor	64	231.40	2

Commiphora mollis	32	124.64	5
Croton gratissimus	28	115.72	2
Ziziphus mucronata	24	97.92	2
Combretum imberbe	24	80.12	1
Tarchananthus camphoratus	24	71.20	1
Searsia marlothii	24	24.00	2
Kirkia acuminata	20	89.00	1
Prosopis sp	16	71.20	1
Grewia flava	16	35.64	2
Commiphora africana	8	26.72	1
Cissus nymphaeifolia	8	17.80	1
Acacia kirkii	4	17.80	1
Acacia karroo	4	17.80	1
Acacia erioloba	4	8.92	1
Boscia albitrunca	4	8.92	1

Discussion

I found that the average available biomass per hectare in the area was 3016 kg, by the time of the data collection, which would generate a total of 72,380,000 kg available potential browse for the black rhinoceros on the whole property of Okutala. According to Hillman-Smith and Groves (1994) an adult black rhinoceros has an average daily intake of 23.6 kg of wet weight, mixed browse. Another study by Maddock et al. (1994) suggests that they eat 37.8 kg per day whereas a third study, by Emslie & Adcock (1993), proposes they have a daily intake of 28.2 kg wet browse. If the mean of these numbers (29.87 kg ± 7.25) were used to estimate how many black rhinoceroses the potential available browse is sufficient to feed per year, it would be enough food for 6,639 rhinos. These numbers are based on the findings of one point in time alone and on the assumption that browse production equates to utilized browse biomass. However several studies (Kruger 1994; Emslie and Adcock 1994; Von Holdt 1999 and Bothma et al. 2004) suggests that browsers seldom utilize more than 10% of the availably browse, even during drier periods, hence the area would be able to feed 664 individuals, i.e. 2.78 rhinoceroses per square kilometer. Bearing in mind that these estimations do not take other browsing animals in to consideration and thus all of the standing browse would not be available for the black rhinoceros alone to utilize. Furthermore, the estimates are based on the daily requirements for browse and do not take the territoriality, home range, sex ratios and the herd structure of the species into account. It reports the available potential browse and has not taken in consideration the nutrient content in the different browse species, neither the black rhinoceros preference or dislike of them. This number is corroborated by Tatmans' (2000) similar findings that thick scrublands supports 1.5 black rhinoceroses per square kilometer.

The most frequently found species was *Colophospermum mopane,* which accounted for 33.55 % of all counted specimens. Studies shows that C. mopane is the dominant tree or shrub throughout the subtropical parts of southern Africa between 9° S and 25° S (Henning 1976; Mapaure 1994; Sebego 1999; White 1983) and that mopane woodland covers more than a quarter of the 1.5 million square kilometers of savanna in southern Africa (Mapaure 1994; White 1983). According to Birgit Kötting (personal communication), manager of the MET Rhino Custodianship Scheme at Etosha Ecological Institute, the black rhinoceros do not prefer to browse from this abundant species if there's other species available, but they highly prefer other frequently encountered species in the studied area, such as *Acacia* sp. *Terminalia prunioides*, *Dichrostachys cinerea*, *Combretum apiculatum* and *Catophractes alexandrii* , *Grewia* sp. (personal communication). This means that the potential browse is possibly less than first calculated but as estimates were done with only 10% of the standing browse one can assume that it doesn't influence the amount of available browse significantly.

The average biomass per hectare was calculated with a mean value of the biomass of all sampling squares together. The standard deviation of this mean value was very high (± 563,39) and therefore no precise calculations could be done and estimations cannot be fully trusted. However, one should keep in mind that the data was collected under a limited period of the year in terms of browse production, because of the lack of rain. Therefore one can assume that there would be more available browse in years with good rain. However, to avoid supplement feeding to be needed, I suggest that the amount of browse during the dry season, or draughts like in this specific case, should be the amount to decide how many black rhinoceros that the available browse could support. To improve the precision of the available browse, I suggest for future studies, to collect data in all seasons, over several years, to gain knowledge about the annual variations of the vegetation to get a better understanding of the browse availability.

A previous study of the vegetation by Göttert et.al (2010) in a fenced area close to Okutala, showed a similar vegetation composition to that of Okutala. The area they studied was divided into two sub-areas, where *C.mopane* dominated one of the areas with 34.8% of the total vegetation cover, which is very similar to the findings of my study where *C.mopane* accounted for 33.55% of all counted specimens. The other sub-area was dominated by *Acacia* spp., which accounted for 53.4% of the total cover, where the most common *Acacia* sp. was *A.reficiens* and *A.luederitzii*, two frequently found Acacia sp. also in my study. Other common species in their study, as well as in mine, were *Catophractes alexandrii* and *Terminalia prunoides*. This indicates that that the vegetation in the area of my study is found in a wider area, at least south of Etosha National Park, which would mean that my results potentially could be applied regionally and used by other conservancies that considering to become black rhino custodians. The amount of availably biomass could also be used in calculating browsing capacity of other species that feeds of the same height level as the black rhinoceros does, meaning every farm with similar vegetation could theoretically use my results to calculate how many browsing animals their property could hold, for example goats and browsing game species such as Eland (*Taurotragus oryx*), Klipspringer (*Oreotragus oreotragus*), Steenbok (*Raphicerus campestris*) and Kudu (*Tragelaphus strepsiceros*) to mention a few.

Similar studies done in the subject seems to focus on models, that requires more variables for estimating browse production, such as seasonal production, soil composition etc., and are therefore not directly comparable to this study (Sanon, 2007; Penderis & Kirkman, 2014). Since I collected the data under a period of about two months, it only shows how the vegetation looked like that specific point in time alone and annual variations are therefore not taken in consideration. However, the results of my study work as a first, helpful step in the attempt to introduce black rhinoceroses to the area.

Even though the difficulties to with this study alone report a precise and certain amount of available browse in the area, calculations and estimations were made with high margins and with caution not to overestimate the amount of available browse. I therefore think it is safe to suggest that a smaller population of black rhinoceroses could be introduced to the area without risking that the browse would be insufficient. These results are valuable for further work with the introduction of the endangered black rhinoceros to the property of Okutala, to further expand the range of this critically endangered species.

Acknowledgements

I wish to express my sincere thanks to my advisor in Sweden at Halmstad University, dr. Göran Sahlén, for his patience, motivation, and knowledge. His guidance helped me in all the time of research and writing of this thesis.

My sincere thanks and gratitude goes to my advisor in Namibia, dr. Simone Herzog, residential veterinarian at Okutala African Quest. Without her this thesis never would have been possible to follow through.

I also want to express my gratitude to the founders of Okutala African Quest, Kobus and JJ Smit, for giving me the opportunity to do the research for my Bachelor thesis at their farm.

My thanks go to Birgit Kötting for taking her time to see me in person at Etosha Ecological Institute to answering my questions about the black rhinoceros.

I also want to thank the National Botanical Research Institute for providing me with information about known species in the area, which was helpful for the species identification.

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