Report for the Rufford Foundation

Conservation of Hartmann's mountain zebra and their Nama karoo habitat – Progress Report 2007

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Mountain zebras near to the Jakkalsdam waterhole, Gondwana Cañon Park, Namibia. Photo: Morris Gosling.

Introduction
Hartmann's mountain zebra are a protected species in Namibia and are of global conservation importance (IUCN Red List Category EN Endangered A1b). The current work aims to study the population ecology and behaviour of this species with a view to improving its conservation management. The intention is to carry out a long-term study and so this report is preliminary. My proposal to the Namibian Ministry of Environment and Tourism (MET) for research clearance is attached at Appendix A to provide further background. While it is intended to extend the study to other populations of mountain zebra, work to date has been confined to Gondwana Cañon Park (GCP), a 112,000 ha private park, and part of the adjacent Fish River Canyon National Park (FRNP) in southern Namibia. One of the aims of the study is to explore the interaction of mountain zebra with other herbivores and that with plains zebra is particularly important. The issues of competitive interference and ecological separation between zebra species are important from both theoretical and management viewpoints and, in addition, the potential risk of hybridization must be considered. Again this has theoretical interest but the practical issue of how to manage the two species when both occur in spatially limited protected areas must be considered since hybridization would pose a risk to the genetic integrity of mountain zebra populations and thus to their conservation. With the reintroduction of plains zebra to GCP in July 2006 it has become possible to study this question and some initial observations are presented after an outline of results to date on mountain zebra.

Mountain zebra study
I am adopting an individual-based approach to the mountain zebra study because it provides a powerful and rigorous basis for all of the basic and applied objectives listed in the Rufford and MET applications. Its drawback is that the accumulation of individual records requires a large initial investment of time and effort. Because of this it has been carried out in parallel with conventional techniques for population survey including fixed road transects, similar to those used in the GCP annual count. The initial focus has been in the mountainous northern part of GCP since this is the most important area in the park for mountain zebra. Following the reintroduction of a group of plains zebra in 2006 I have spent part of my time on the plains in the north of the park (between the Roadhouse, Holoogberg and the C12 – see Figure 1) in order to monitor the reintroduction and check on any interaction between plains and mountain zebra. A volunteer Peggy Poncelet completed a short pilot study on mountain zebra and two Newcastle students, Mark Ormiston and Poppy Frater completed undergraduate project studies under my supervision; all have written up the results of their work.

Individual records are obtained mainly using photography either from conventional photography in the field (Nikon D80) or camera traps. Cuddeback and Reconyx camera traps have been used to date with up to three in use. Camera traps are placed on trails leading to waterholes (Jakkalsdam, Jagpos and Quagga). Between March 2005 and August 2007 I have built up a record of 210 known individuals (all identified with a number of photographs) and individuals have been observed up to 55 times. Up to August 2007, 1,561 records of known individuals and their associates have been collected. I have developed a novel technique for identifying individuals (right and left sides) using a sort of bar code based on variation in stripe patterns and the filter function of the Excel database. This saves a lot of time but will eventually have to be replaced by pattern recognition software to reduce the large amounts of time needed. I am in correspondence with a group working on Grevy's zebra who have developed such software for that species and who have offered to modify it for mountain zebra.

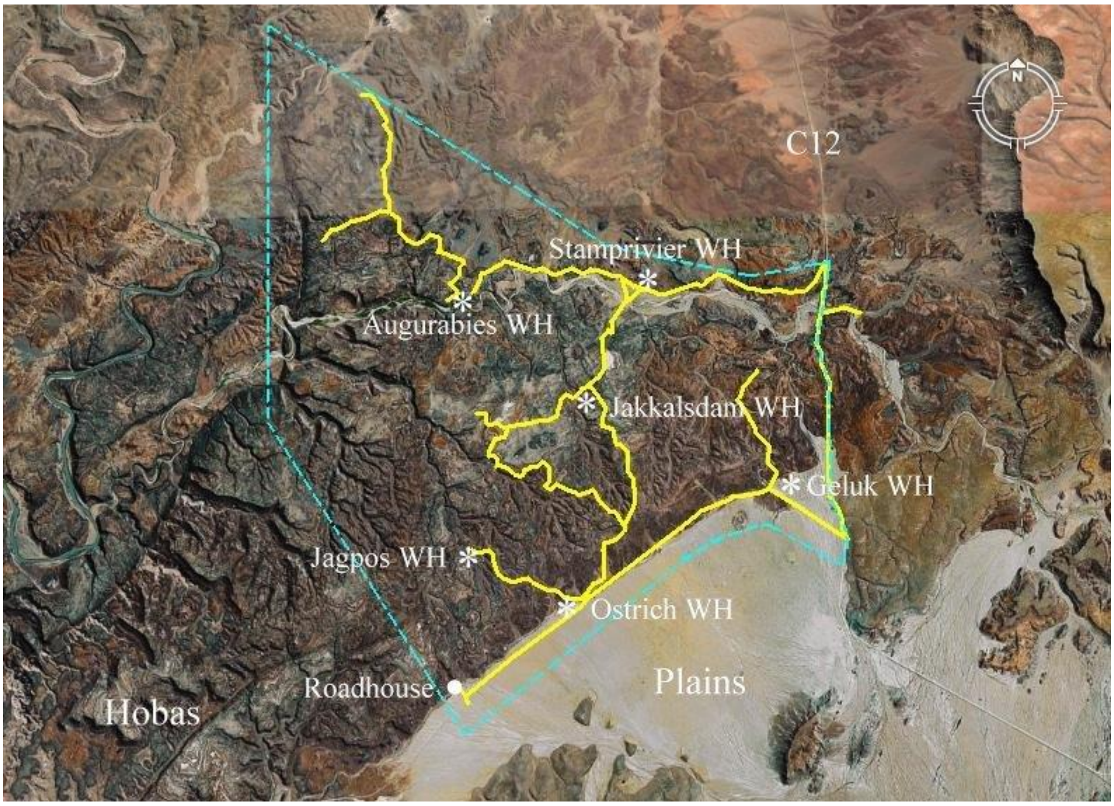

Figure 1: *The main study area in the northern part of Gondwana Cañon Park. The road transect described in the text is in yellow and the boundaries of the study area in blue. The water holes are all artificial boreholes except Augurabies which is a seasonal 'fountain' flowing in the Gaap River.*

The largest number of observations to date is on ZR019m ('zebra/right side/number/sex) which has been photographed mainly at an artificial waterhole in GCP called Jakkalsdam (54 times out of 55 photographs). Another male, ZR012m has been photographed 9 times at the Jagpos waterhole and 19 times at Jakkalsdam, probably reflecting differences in their ranging behaviour. Groups are photographed whenever possible using conventional photography (mountain zebra always have large flight distances in GCP) and these records have revealed larger ranges. For example, ZL001m (zebra/left side/number/sex) has been photographed at Jagpos WH, at the Ostrich SWH (the seasonal water hole just north of the Ostrich WH) and Zebra WH (a seasonal water hole beside the D601 in Hobas, part of Fish River Canon NP) thus confirming movement between FRNP and GCP. These photographs and observations also reveal group membership. Association analysis can be used when photographs by camera traps contain more than one individual to define group membership and this can sometimes be confirmed in the field by photographs of entire groups. Thus ZR012m is usually alone or with a small stallion group while, in 2007, ZL001m has a harem of two females each with a foal. Such records will give differences in reproductive success between different harem groups which can be related to group ranges and variation in habitat quality.

Individual records will also be used to explore various aspects of population dynamics including estimates of total population size, the numbers of animals visiting particular water holes and estimates of population viability. Since all animals are 'marked' because they are individually recognizable the population, or sub-population, can be estimated using mark-recapture techniques. This technique does not rely on observing animals during road transects and so it avoids the known problem that mountain zebras often 'disappear' down gulleys or across ridges in response to the sound of approaching vehicles and thus escape detection. For example at Jakkalsdam in December 2005, 29 individuals were photographed in the first half of the month and 30 in the second half. Of the 30 in the second period 13 were 'marked' in the first period and mark-recapture technique gives an estimate of 66+/-9 mountain zebra using the waterhole in this month. A comparable estimate for this waterhole in December 2006 was 71+/-11. Eventually it will be possible to develop this approach to obtain continuous estimates of numbers at waterholes (the main current constraints are the reliability of camera traps and my time) and to relate this information to local impact on the karoo vegetation. Individual records will also allow identification of resident groups and groups that only occur in dry seasons (possibly immigrants from FRCP) and estimates of their relative survival. Condition, size and reproductive state can also be estimated from photographs taken by camera traps (and from other observations in the field) and can be linked to variation in the availability of food and water (including estimates of veldt condition).

Three censuses have been carried out in the northern area using an 87 km length of track (this has subsequently been extended to 110 km); see Figure 1. The approach used is distance sampling but the behaviour of the mountain zebra creates problems for this type of sampling. The distribution of the distances of zebra groups from the transect is shown in Figure 2 for two complete censuses carried out in July/August 2006. My interpretation of this distribution is that the close zebras are too close to escape the attention of the observers, an intermediate group detect the observer's car before it arrives and escape undetected, and a distant group are relatively undisturbed. The resulting distribution (and the low density of zebra groups) contravenes the assumptions of distance sampling and so the resulting estimate is not valid. With this in mind the preliminary estimate was 110 with upper and lower confidence limits of 39 and 303 respectively. This is obviously too low, particularly since 210 individuals have already been identified, but in any case the technique needs further development (or abandoning in favour of alternatives including air surveys or mark-recapture).

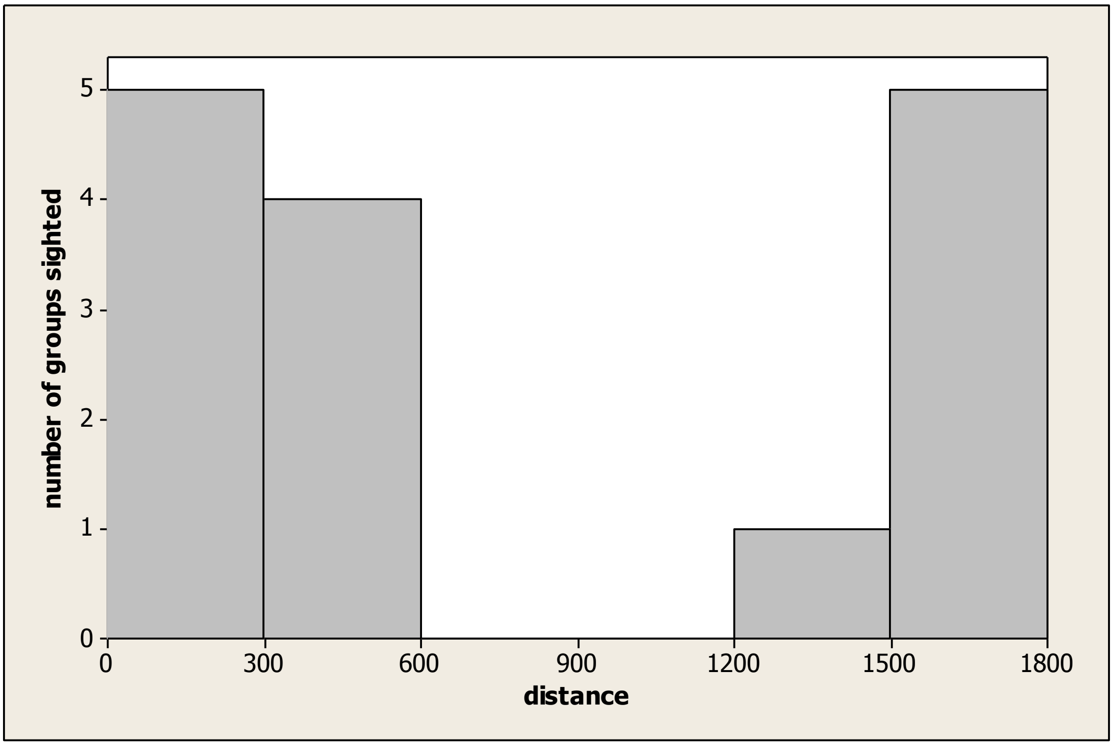

Figure 2: The *frequency of HMZ groups seen in 300m distance categories from the road transect using data collected from the two combined censuses. N=15 groups of HMZ.*

When the distances of all groups seen during July/August 2006 are combined a better distribution is obtained (Figure 3) but the ad hoc sampling used to obtain the distances does not allow population estimates.

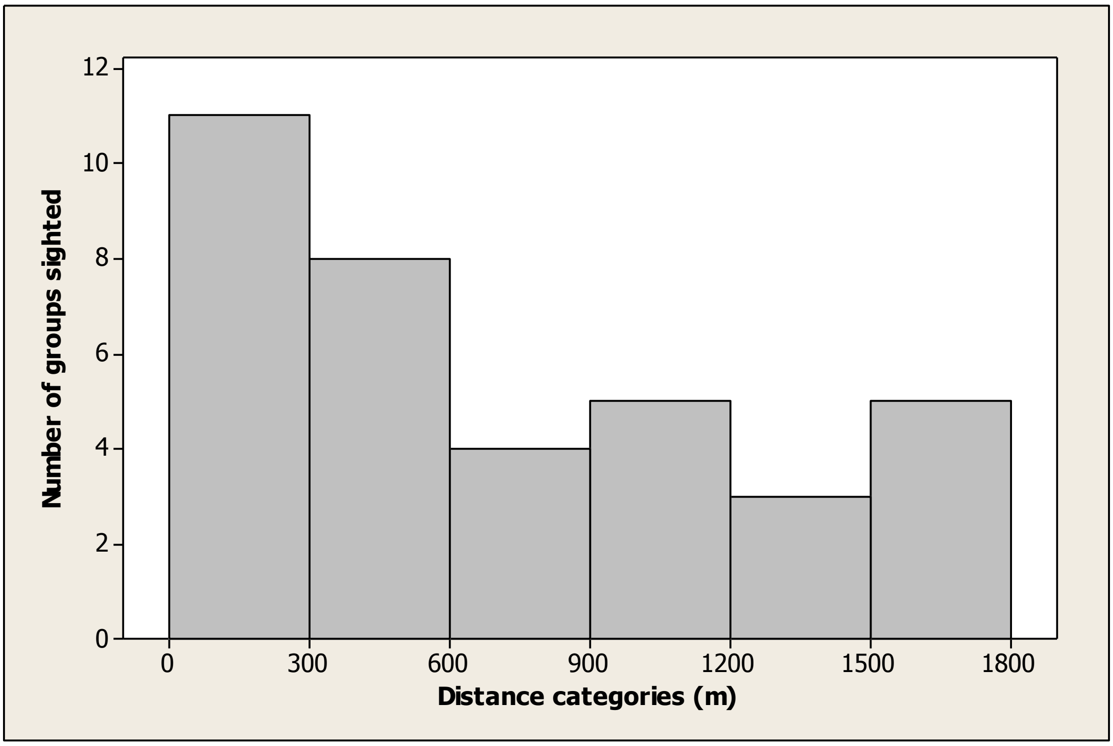

Figure3: The *frequency of HMZ groups seen in 300m distance categories from the road transect using data from all observations throughout July and August 2006. Observations without known distances and groups outside of the study area are not included. N=36 HMZ groups.*

While the overall estimates may be flawed, the relative numbers of zebras seen in different parts of the transect can be used to explore the relationship between zebra frequencies and surrogate measures of their presence. The two main surrogates are faeces, which have been used extensively in applied ecology to estimate animal densities, and rolling pits. Rolling pits are shallow depressions containing dust or fine silt that zebra enter and roll in. They are used when both wet and dry and observations of dominance interactions during rolling sessions suggest that they have both body care and social functions. We have used the frequency of freshly used rolling pits and faeces to test whether they can be used to predict mountain zebra densities, again using data from the July/August 2006 censuses. The results are encouraging with a near-significant correlation for rolling pits (Figure 4) and a significant correlation for faeces (Figure 5). When road transect estimates are corrected (probably using mark-recapture) these relationships can be placed on a quantitative basis. This approach will eventually provide a practical and relatively easy technique for park managers to estimate numbers and distribution of mountain zebra. Rolling pits are conspicuous from the air and could also be used as surrogates in extensive aerial surveys.

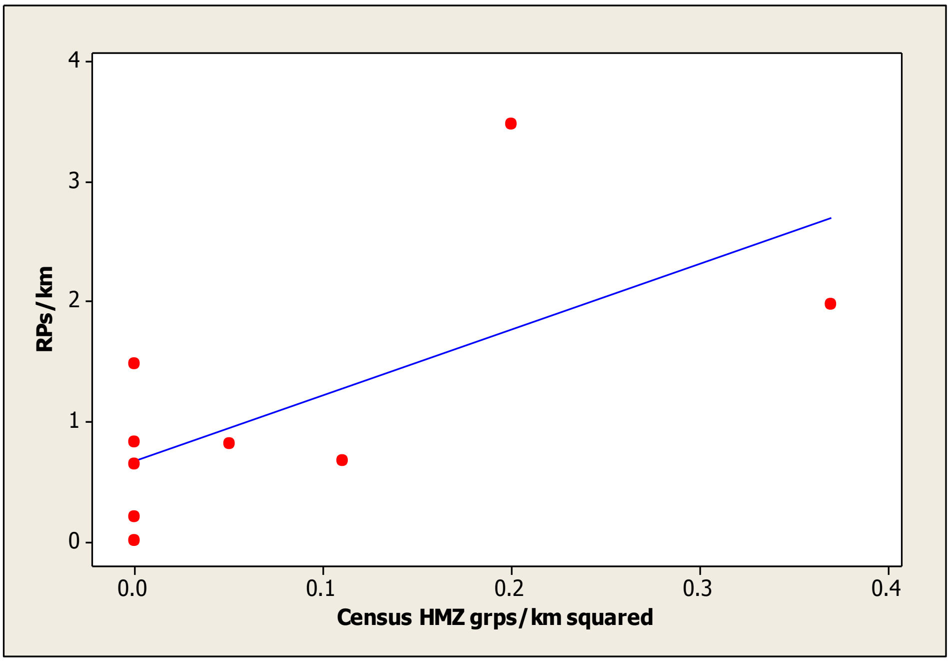

Figure 4: *The number of rolling pits(per km^2) observed in relation to the number of mountain zebra observed (groups/km^2) during the July/August 2006 censuses. Pearson correlation = 0.657, P=0.055.*

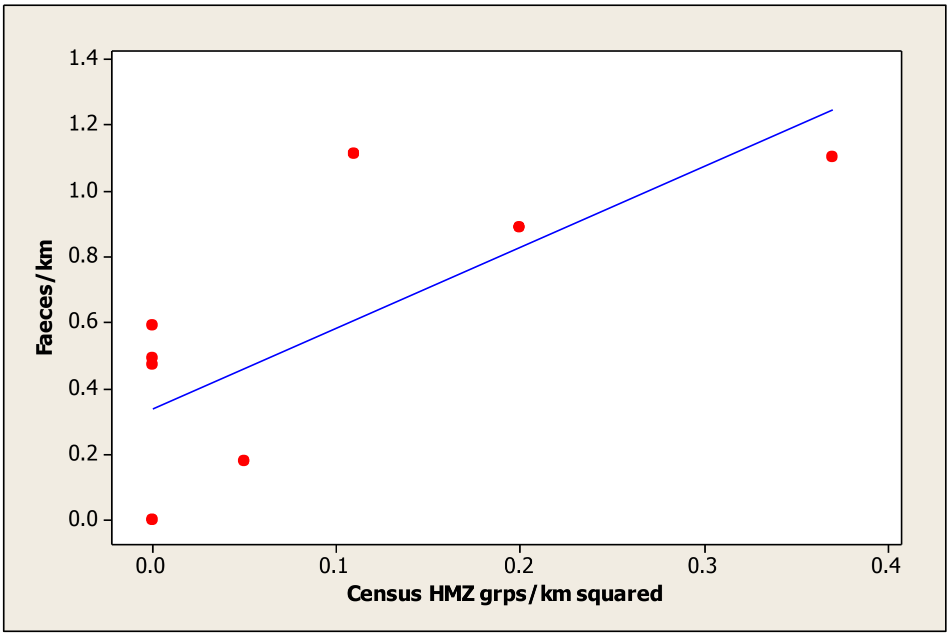

Figure 5: *The number of faeces(per km^2) observed in relation to the number of mountain zebra observed(groups/km^2) during the July/August 2006 censuses. Pearson correlation = 0.732, P=0.025.*

A crucial part of the work is the relationship between zebra distribution and variation in the karoo habitat. Some progress has been made in mapping patterns of topography and vegetation. Records were made of topography and substrate types every 300m along the road transect system and the occurrence and abundance of 30 indicator plant species (Appendix B) was recorded. The aim was to define plant communities but the results of association analysis was disappointing because overlap between communities was too great. As a result we have used topography types in subsequent analysis (Figure 6) and these prove to show some clear differences in zebra use. The dominant plant species for each topography category are shown in Figure 6.

Topography categories	**n**	**Dominant plant spp.**	**Substrate categories**	**n**
A. Upper catena	38	Zs, Ed, St	Rocky-Large slabs or blocks (Rl)	18
Rounded Hill top (Ht)	11	Ed, St, Zs	Rocky-Small boulders (Rs)	70
Large plateau (Pll)	23	Zs, Ed, St	Gravel (Gr)	125
Small plateau (Pls)	4	Su, St, Zs	Sand (Sa)	34
B. Slopes	109	St, Ed, Fc	Sand/fine gravel (Sg)	41
Steep slope (Stsl)	17	St, Fc, Prg	Fine clay or silt (Si)	15
Shallow slope (Shsl)	92	St, Ed, Zs		
C. Middle catena	25	St, Zs, Fc		
Ledge (Le)	8	St, Zs, Fc		
Flat shoulder of hill (FlSh)	10	Zs, St, Asb		
Saddle (Sa)	7	St, Zs, Su		
D. Lower catena	93	Su, Rt, St		
Flat, extensive open area (Flex)	66	Su, Rt, Ed		
Flat valley bottom (Flva)	27	Su, Ss, St		
E. Drainage channel	38	Su, Ss, Sc		
Drainage channel (Dc)	32	Su, Ss, Sc		
Drainage channel bank (Dcb)	6	Asb, Cc, Ed		
			Total habitat samples	303

Figure 6. *Topography and substrate categories. The relative proportions of the different categories are indicated by the number of times they were sampled. Plant species are listed in Appendix B. The five main topography categories are used to group zebra observations in the figures below. N = 303 sampling points along the road transect*

Zebra groups, rolling pits and faeces have been recorded systematically in three censuses in July, August 2006 and February 2007. The frequencies of these observations in relation to topography are shown in Figures 7, 8 and 9 below. Mountain zebra groups observed during censuses tended to concentrate on rounded hill tops and plateaus during the daytime censuses and to avoid drainage channels and valley bottoms (Figure 7).

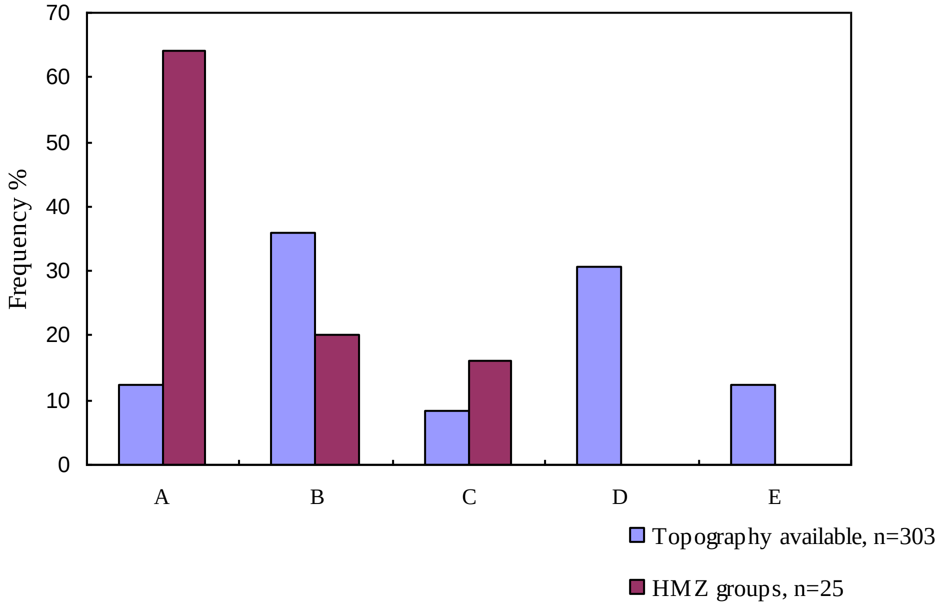

Figure 7: *The distribution of mountain zebra groups in five main topography categories (see Figure 5) compared with the availability of each category. Chi-square analysis shows that the zebra are non-randomly distributed with more than expected on upper catena levels (x^2= 51.218, d.f.=4, p<0.001.*

A similar distribution was found for freshly used rolling pits (Figure 8) suggesting that they are mainly used during daytime resting periods; rolling pits also occur more frequently than expected on ledges and shoulders of hills and on ‘saddles’ between hills features that are often used by zebras for resting and for their trails.

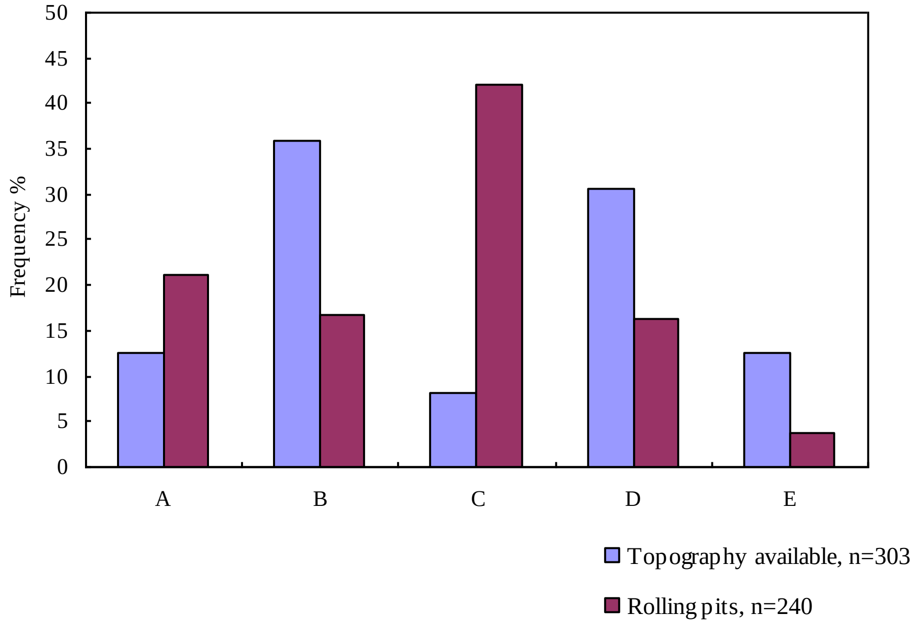

Figure 8. *Hartmann's mountain zebra rolling pits percentage occurrence within the different topography categories (see fig. 2 for diagrammatic description) compared to availability of each topography category. Chi-square analysis shows that the rolling pits are non-randomly distributed with more than expected on upper catena levels and on ledges, shoulders and saddles between hills (x^2= 115.199, d.f. =4, p< 0.001).*

In contrast faeces are concentrated in valley bottoms and drainage channels (Figure 9) at lower altitudes and these areas probably represent nighttime feeding areas.

A clear pattern thus emerges of night time feeding in low areas where grass cover is most abundant and retreat to higher altitudes in the daytime for resting and social behaviour focussed on rolling pits. The reason for this daytime retreat is presumably anti-predator behaviour but it is undoubtedly reinforced by intense hunting by man which still occurs throughout the current mountain zebra range (and is presumably responsible for the huge flight distances that are characteristic of the species in GCP). The management implications of these results will be refined as the work progresses but they already suggest that informed conservation action should consider the need for both feeding and daytime refuge areas; these considerations will also affect the placement of water holes.

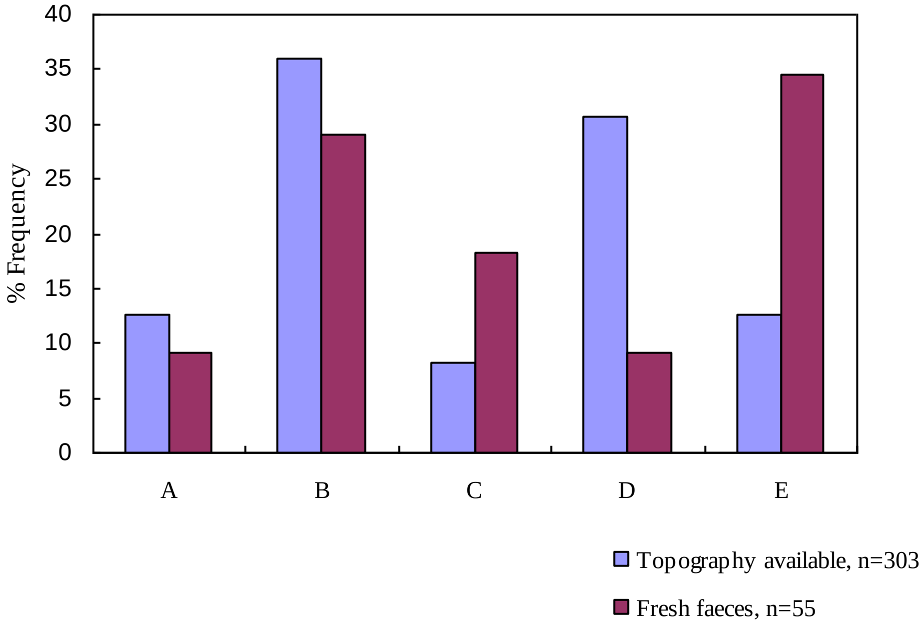

Figure 9: *Hartmann's mountain zebra fresh faeces percentage occurrence within the topography categories (see fig. 2 for diagrammatic description) compared to availability of each topography category. Chi-square analysis shows that faeces are non-randomly distributed with more than expected on lower catena levels (x^2= 27.880, d.f. = 4, p<0.001)*.

The availability of water is crucial both for basic spatial ecology and also for practical conservation planning. Some preliminary work on this area is summarised in Figure 10. This suggests that mountain zebra often feed or rest at particular distances from water. Perhaps these distances are a trade-off between the need to stay within reach of water while getting access to food resources and avoiding areas disturbed by man.

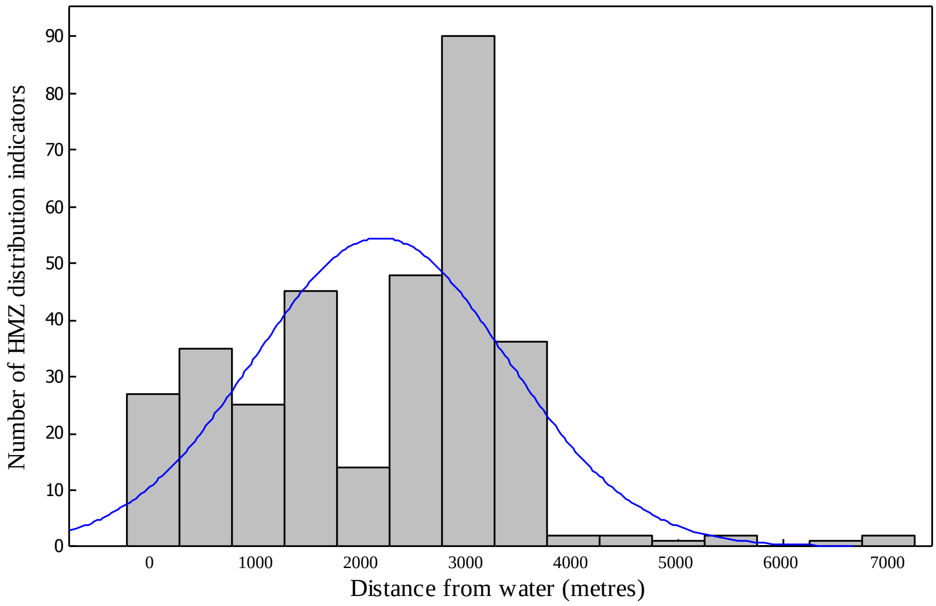

Figure 10. *The distribution of combined indicators of mountain zebra presence (observed groups, rolling pits and fresh faeces) in relation to distance from water. Anderson-Darling normality test indicated significant deviation from the normal distribution (A-sq=7.57, p<0.005), Mean distance from water = 2169.8±1208.5metres. Sample size for all HMZ distribution indicators is 332.*

Plains zebra reintroduction
26 plains zebra were reintroduced in July 2007. The release was 'hard' with the animals held only briefly in a boma before release. Most animals have become resident on the plains and drink from waterholes including Ostrich and Geluk. A few animals moved into the mountainous area in the north and onto the grassy flood plain in the Gaap river valley near the Augurabies gate. One animal was photographed at the Jakkalsdam camera trap. All animals were photographed on release for individual recognition and it is intended to use a similar individual-based approach to their population ecology to that in the mountain zebra study.

The most commonly seen groups in July 2007, a year after the release are a stallion group of 8 or 9 males and two harem groups of 7 and 8 respectively; some mature males in the stallion group are showing a tendency to isolate and may soon establish harem groups. There are 3 foals born after the release, 2 in one harem group and 1 in the other (meaning that both harem stallions are fertile). One further foal was found separated from its mother in March 2007 and it subsequently died, despite attempts to rear it. A number of the females are pregnant. The group of 7 is accompanied by an adult male mountain zebra and I will return to this important observation below. The adult sex ratio of plains zebra in these three groups is 11 males to 10 females. All animals are in good condition. Of the 24 animals in the three main groups, 21 were released in 2006 and so 5 of the original group are currently unaccounted for. Some of these may still be in the Gaap river flood plains – a group of 3 was seen there in February 2007.

Relationship between mountain and plains zebra
There is debate about the potential for hybridization between mountain zebra and Burchell's zebra, some claiming that it has already occurred (for example in the Otjivasandu area of Etosha NP) and some saying this is just hearsay. No genetic analysis has been carried out to test the suggestion and we do not know whether or not these two species can produce fertile hybrids.

The theoretical position is that reproductive isolation has clearly occurred in evolutionary time to produce the two separate species. However this does not mean that hybrids cannot occur: many good species have hybrid zones between them which are maintained within limits by mechanisms that have been studied by generations of population geneticists. A problem arises when these natural situations are disrupted by man and in particular by various types of enclosure. In spatially limited areas (such as fenced reserves) hybridization can compromise the genetic integrity of an entire population and this becomes a matter of importance when, as in the case of Hartmann's mountain zebra, the population is of a species of global conservation importance (they are officially IUCN Red List Category EN Endangered A1b).

Burchell's or plains zebra have been reintroduced into GCP and consequences for the mountain zebra population thus become a research priority. The approach is to explore the ecological and behavioural mechanisms that could result in hybridization, or conversely, in reproductive isolation. For example the two species could simply occupy different habitats, or, if they occur together, individuals of one species might prefer to mate with their own species and reject the other. Thus I aim to investigate relevant spatial ecology, behavioural interaction and genetics. This study aims to tackle the problem for the benefit of GCP and the overall management of the two species in Namibia.

Information collected so far shows that while there are broad differences in habitats selected, plains zebra penetrate some distances into mountain zebra habitat. For example at least one has visited Jakkalsdam. During the most recent field work in July 2007 however most Burchell's zebra (24 out of a maximum of 29) were spending most time on the plains.

I have seen a number of behavioural interactions between the two species. In the first case shortly after the release in 2006, a group of plains zebra was filing along a trail (presumably a mountain zebra trail) north of Geluk farm and approached a group of mountain zebra. The mountain zebra reacted with alarm and turned and ran away out of sight before contact was made. On another occasion a group of 3 plains zebra and 8 mountain zebra were in close association about 1km inside the Augurabies gate. As I approached the mountain zebra turned south and fled (characteristically) over a hilltop and the plains zebra ran along the valley towards Stamprivier.

I have also seen Burchell's zebra in a separate group in this area in the grassy flood plains of the Gaap river.

The most interesting and worrying observation is that of a young adult male mountain zebra that has been attached to a group of 7 plains zebra in the area to the south of the Ostrich WH for over 6 months. This attachment is at the individual level with the mountain zebra following the same group of 7 even after it has mixed with then separated from another group of Burchell's. There is a large Burchell's stallion in the group which is larger than the mountain zebra and the mountain zebra usually remains a short distance away. On one occasion there was a mutual display between the two males involving display defaecation and the mountain zebra then walked away and grazed some 300m from the group. However defence of Burchell's harems is generally at low intensity and the mountain zebra sometimes mingles within the group. In general this mountain zebra behaves like a Burchell's zebra and its flight distance is less than other mountain zebra in GCP.

The male involved is ZL010m (ZR071m) which was photographed at the Jagpos and Jakkalsdam water holes in 2005 and 2006 before the Burchell's zebra release. Possibly this male became attached to the group of Burchell's when it separated from its natal group. This is a normal stage of life history development and could potentially occur for any young adult male that encounters a group of plains zebras. Thus I do not believe there is any merit in removing this male; rather, for the moment, we should try to learn from this incident (and others of the same kind that may occur).

Three Burchell's foals existed in the population in July 2007 and all have been photographed on both sides. All have typically Burchell's stripe patterns and so there is no indication that the mountain zebra has successful mated with females in its adopted group. Subject to research approval, I will also collect faecal DNA from known individual mountain and plains zebra when resources are available (a grant will be needed to cover the costs of the lab work).

Acknowledgements
I am grateful to the Gondwana Cañon Park Board for access to GCP, their support in providing accommodation and other resources for research on mountain and plains zebra. The Namibia Nature Foundation has kindly provided office facilities and other help. I thank the Rufford Foundation and the University of Newcastle for financial support. Peggy Poncelet, Mark Ormiston and Poppy Frater assisted in the field. I am grateful to the MET for access to Fish River Canyon NP. The work is carried out under MET research permit 1063/2006.

Appendix A: Research proposal to MET

Population ecology of Hartmann's mountain zebra

PI: Prof. L.M. Gosling

Description of the proposed research

Objectives

We aim to carry out a long-term study of the population ecology of a newly protected population of Hartmann's mountain zebra (*E. z. hartmannae*: IUCN Red List Category EN Endangered A1b) and the interaction with their karoo habitat. The initial study area will be Gondwana Cañon Park, a recently established 112,000 ha reserve in southern Namibia. When the study of the Gondwana population is well-established, the study area will be extended to a wider area of southern Namibia since the Gondwana animals are part of the population that ranges widely across private and government-owned land in the south.

Specific aims are to estimate the mountain zebra population size within Gondwana Cañon Park and its seasonal and year-to-year variation, to estimate the factors limiting population size and the carrying capacity of the park under different rainfall patterns. These objectives are complicated by the movements of zebra within and outside the park and these movements, in relation to water and sward characteristics, will be a key focus of the study.

The limiting factors may be most easily detected by comparison with an area of high rainfall and we aim to collaborate with Okatumba Wildlife Research in Okomitundu Farm to carry out such studies of mountain zebra population ecology.

Motivation

Mountain zebra, *Equus zebra*, are an endangered species (IUCN Red List Category EN Endangered A1a) and Hartmann's mountain zebra are a 'Specially protected Species' in Namibia. However, locally in Namibia, they reach densities that may cause conflict with livestock farmers (Novellie et al 2002) and in low rainfall areas they may potentially damage the fragile plant communities on which they depend. Annual road transects in Gondwana Cañon Park show that the population is increasing (from estimates of 40 to over 400 in the past five years) and the park managers need to know what numbers the park can support without long-term damage to the vegetation of the park. In the absence of large predators (except small numbers of leopards), the population is probably limited by water and food, but the interaction of these two factors is poorly understood. Spatially explicit approaches are needed to measure the importance of various water sources and the local impact on plant communities within range of these sources.

The conservation of animals living in the arid south depends critically on movement in relation to unpredictable and patchy patterns of rainfall and plant productivity. The agencies responsible for conservation in the south of Namibia need to understand plant-herbivores interactions across large and heterogeneous areas of semi-desert. These areas may also change as some fences are removed to give greater freedom of movement; for example in Gondwana and between Gondwana and Fish River Canyon NP. The need for management intervention is generally reduced with greater freedom to move in relation to habitat variation. However, the changes that occur as such plans are implemented will require parallel understanding of ecological processes so that it is possible to modify management plans. The motivation of the project is to provide the underpinning ecological understanding that will allow rational conservation planning.

The SSC Equid Specialist Group's Status and Action Plan for Mountain Zebra (Novellie, 2002) includes the Recommended Action of '*Improving the protected area system*'. The work proposed here will provide the ecological knowledge needed to support this objective. It is also relevant to the Recommended Action of '*Promoting the maintenance of mountain zebras on farmland*' since the zebra population under study moves across private land as well as government-owned protected areas.

Research questions

- What is the population size of mountain zebra in Gondwana Cañon Park and surrounding areas and how does it vary between seasons?
- What is the carrying capacity of mountain zebra in Gondwana Cañon Park, under different rainfall patterns?
- What factors limit the mountain zebra population?
- Does competition with other large herbivores play a role?
- Is there evidence of density-dependent variation in reproduction?
- What are the main patterns of movement of mountain zebra in relation to variation in water, rainfall and plant productivity in space and time?
- How many animals use each of the main watering points in Gondwana Cañon Park and what is responsible for the variation?
- How do spatial constraints imposed by water dependence effect local plant communities?
- What are the main food plants for zebra in Gondwana Cañon Park? How does use vary seasonally and spatially?
- Does body condition vary seasonally and can it be predicted from forage conditions?
- How does group size, reproductive performance and condition differ in an area of high rainfall (Okomitundu)?
- What are the most appropriate long-term monitoring mechanisms available for zebra in the greater Gondwana area?
- What management options are most appropriate for zebra and their habitat in the Nama Karoo biome of the Gondwana / Fish River Canyon Parks.

Previous relevant research by Principal Investigator

I carried out my PhD on hartebeest (*Alcelaphus buselaphus*) in Kenya (Gosling 1974, 1975) and while currently based in the UK, I have returned to Africa to work on other alcelaphines such as topi (*Damaliscus lunatus*) and the population biology of hirola (*Beatragus hunteri*) a threatened alcelaphine in north-east Kenya (Gosling, 1987, 1990). Recently I have supervised a PhD study of hartebeest biogeographical variation throughout Africa which included field data collected in the Seeis Conservancy, Namibia under MET research permits 442/2001 and 591/2002; four papers have been prepared from this work and have been submitted for publication. I am currently supervising a PhD study on the ecology and conservation biology of giraffes in Etosha NP under MET research permits 560/2002, 760/2004 and 876/2005; the student, Rachel Horner, has finished field work and has returned to the UK to carry out DNA analysis before writing up; one joint paper has been prepared and will be submitted shortly. Further details of publications on ungulates including reviews of mating strategies (Gosling, 1986) are given in my CV. I am familiar with the work of colleagues who work on equid ecology and am a member of the SSC Equid Specialist Group.

Approach and methodology

The study will be carried out mainly in the field using 4x4 vehicles, telescopes and binoculars. Dependence on existing water sources and karoo habitat will be assessed using field survey (fixed road transects) and camera traps over wet and dry seasons. Fixed camera positions will be used for long-term monitoring of plant growth and vegetation transects will be used to estimate plant biomass and grazing intensity. Data on rainfall and its spatial variation are collected by Gondwana Cañon Park. Estimates of numbers visiting all main water sources will be obtained using individual recognition and mark-recapture techniques. Movements and group membership will be determined by observations of known individuals during field surveys, by camera traps and, in the future, by GPS tag tracking. Body condition will be estimated using camera trap images. Demographic data including age structure and individual-based, spatially explicit population models (De Angelis & Gross, 1992) will be used for estimates of population viability (cf Novellie et al 1996).

Study species and collections

Vegetation samples will be collected for identification and as reference material for faecal analysis. Fresh faecal samples will be collected for future faecal analysis and, when the identity of the individual zebra is confirmed, for future DNA analysis.

Involvement of MET

No practical assistance will be required from the MET although discussion about the wider context of wildlife conservation in the areas around Gondwana Cañon Park and Fish River Canyon NP would be valuable.

Outputs

Reports will include project reports to the MET and papers submitted to international journals. The data obtained will be made available to the park owners for conservation management.

<u>*References*</u>

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L.M. Gosling, Newcastle upon Tyne,
11 April 2006

APPENDIX B: Indicator plant species used in preliminary habitat analysis in northern GCP.

Latin names	Abbreviations
Acacia erioloba	Ae
Acacia melifera	Am
Aptosimum spinescens	Asb
Unidentified species ('rosemary')	As
Boscia foetida	Bf
Calicorema capitata	Cc
Catophractes alexandri	Ca
Chloris virgata	Cv
Cleome suffruticosa	Cs
Enneapogon desvauxii	Ed
Euphorbia virosa	Ev
Euphorbia gregaria	Eg
Forsskaolea candida	Fc
Indigofera sp	I
Unidentified species *('foxglove')*	K
Kissenia capensis	Kc
Parkinsonia africana	Pa
Petalidium setosum	Ps
Enneapogon sp (purple rock)	Prg
Rhigozum trichotomum	Rt
Schmidtia kalihariensis	Sk
Sisyndite spartea	Ss
Stipagrostis ciliata	Stb
Stipagrostis hochstetiana (?)	Sc
Stipagrostis namaquensis	Sn
Stipagrostis obtusa	So
Unidentified grass ('tussock')	St
Stipagrostis uniplumis	Su
Tripterus microcarpa	Tm
Zygophyllum stapffii	Zs
Unidentified Zygophyllum sp	Zygl