Mountain Zebra Project – 4th progress report

Population ecology of Hartmann's mountain zebra: comparisons between protected areas in southern Namibia

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Mountain zebra breeding group drinking at Jakkalsdam in Gondwana Cañon Park in December 2011. The left hand animal is ZR122f (zebra/right/number/sex). It was over 2 years old when first identified in 2006, so is at least 7 years old in the photograph. Photo © Morris Gosling.

Introduction

This is the fourth progress report on a long-term study of the population ecology, social evolution and conservation of Hartmann's mountain zebra. The aim of the study is to provide information to help support the conservation of this sub-species in Namibia. Hartmann's mountain zebra is a protected species in Namibia and of global conservation importance (Novellie et al, 2002; IUCN Red List Category: Vulnerable) and there are indications that numbers are increasing under existing policies in Namibia. In addition to any increase within their natural range they have taken advantage

of the widespread provision of artificial water sources to expand into new areas and have been extensively reintroduced to support wildlife based economies, particularly in the communal conservancies in the north-west. Long term data collated by the Ministry of Environment and Tourism shows that the subspecies has increased in recent years and the latest published figure for 2004 was over 72,000 animals (Barnes et al, 2009). Some of the data contributing to this estimate are from well-designed aerial surveys by Ministry of Environment and Tourism biologists, but the largest numbers (76%) are from questionnaire returns from commercial farms. Long-term estimates from farms are available and these have increased by almost 3% annually for the 32 years up to 2004. This is low compared to the maximum possible presumably because of culling (2-3,000 are harvested each year) and periodic droughts. Because of the problems of counting mountain zebra in broken terrain, the figures from farms need to be checked using aerial surveys or mark-recapture procedures but, in the meantime, the figures give a preliminary overview of numbers in Namibia. Locally, mountain zebra may become so abundant that they come into conflict with livestock farmers over grazing and the main issues in their conservation are of managing a valuable resource, particularly in relation to sustainable consumptive and non-consumptive use (Barnes and de Jager, 1996).

My initial proposal to the Namibian Ministry of Environment and Tourism (MET) for research clearance is attached at Appendix A and the study reported here has been carried out under MET research permits 1063/2006, 1218/2007, 1498/2010 and 1498/2011. As intended, the study has been expanded to additional areas and results presented here include early results from a pilot study in the Naukluft National Park. Further data have been collected from the NamibRand Nature Reserve, a 172,200 ha private park which is open to the Naukluft National Park to the west and which has been studied since early 2010; and from Gondwana Cañon Park, a 126,000 ha private park that was established in 1997, and part of the adjacent Ai-Ais/Fish River Canyon National Park, and from Büllsport Guest Farm, a privately owned farm which promotes mountain zebra conservation and is adjacent to the Naukluft NP. The population in Gondwana Cañon Park has shown rapid increase in recent years and this represents a major conservation success for the park. Continuous updates and feedback have been provided about the results of the study to landowners and other stakeholders and to the Rufford Foundation who have provided the most important source of external funding.

The high degree of mobility within mountain zebras is well known but important detail is lacking. I have attempted to quantify the relationship between the numbers present in a protected area at any one time and the wider ('source') population from which these animals are drawn. This relationship is potentially of great importance for conservation management because the form of this relationship is important for determining the genetic viability of a population and its food and water resources. It also bears on the key issue of the role of fencing in population ecology and the link between the size of a protected area and the scale of interventions needed to manage zebra population. The relationship between the numbers present at any one time and the size of the 'source' population has been established in preliminary form for Gondwana Cañon Park and NamibRand Nature Reserve and further work is planned using records of individually known animals.

There have long been rumours of hybridization between mountain zebra and plains zebra (*Equus quagga burchelli*) in Namibia and observation by park staff in Etosha NP and recent preliminary genetic analyses support this possibility. Hybridization can occur naturally in hybrid zones without serious damage to adjoining species over evolutionary time, but, where it is affected by recent anthropogenic changes it may become a serious problem to the genetic integrity of one or both species that requires intervention to redress. Whether or not hybridization between mountain and plains zebra is such a problem is currently unknown and targeted research is needed to provide the information needed. In this report I summarise what is known to date.

Methods

As before I have adopted an individual-based approach (see photograph above) and this is starting to yield important information about birth and survival rates that will eventually contribute to life-history analysis and population models. The main practical techniques are camera trapping at water holes plus occasional field observations of wild groups. The individual-based approach also allows mark-recapture population estimates and such estimates were carried out in the northern areas of Gondwana Cañon Park (GCP) and NamibRand Nature Reserve (NRNR); details of the approach are given in previous reports. These estimates supplement the ongoing determination of numbers obtained from accumulating individually recognised animals, a process that goes on continuously as camera trap images are analysed. This exercise has become more useful as the owners of GCP and NRNR have acquired camera traps to create extensive monitoring networks.

Gondwana Cañon Park (GCP) and Ai-Ais/Fish River Canyon NP

Background information about mountain zebra in GCP is available from ground counts but there are problems about estimating numbers in this way because of zebra escape behaviour in response to vehicles in broken terrain. Mark recapture procedures using known individuals identified over defined periods can potentially overcome this problem and we carried out the first estimate of this kind in 2011. We used four camera traps, widely spaced at key water holes, in the 30,000 ha northern, mountainous part of the park in the dry season when most mountain zebra visit water holes every day. The 'mark' and 'recapture' periods were 6 days at the start of October and November respectively. The number of individuals identified in the first period was 73, in the second 220, and the number seen in both, 57. The difference between the two periods may have been because the camera installations had been improved at the start of the exercise and some zebras deterred from approaching (mountain zebra are extremely cautious when approaching water if anything about the situation is unfamiliar). However, the difference in numbers should not affect the procedures and the estimate from these data was 287+/-16 (+/-SE) mountain zebras which yields a density of about 0.96 mountain zebra/ km^2. The total number of individuals actually identified during the two sampling periods was 237 and the fact that this is high relative to the estimate, plus the reasonably small error estimate gives some confidence.

It is hard to say what proportion of the northern population of GCP we sampled, but bearing in mind how far and quickly mountain zebra move (which may enhance 're-mixing' and thus the realism of the mark-recapture assumptions) it is probably over 80%. The 2011 estimate from road transects for the whole Park (which has recently been expanded to about 126,000 ha) was 367. The northern area has historically contained 85.4% of the mountain zebra seen in the Park, so the calculated number from the road transect count for comparison with the mark-recapture estimate is about 313. The estimates are quite close and give some confidence about population size and thus the increase in numbers that has occurred since the Park was established in 1997.

The number obtained by enumeration of known individuals in 2011 (388) should be regarded as an indication of the 'source population' for the area. Because of their mobility, not all of these animals will be present in the area, or even in the Park, at any one time. In fact it is quite surprising that the mark-recapture estimate is so high (74%) relative to the 'source' numbers which suggests that the northern area of Gondwana Cañon Park is a key area for the wider population. Presumably the reason is that this area contains a reliable, abundant water supply plus a good food supply. The animals are generally in good condition, even in the late dry season, so do not appear to have reached carrying capacity, at least in years with average rainfall. The movements between FRCNP and GCP in the dry season must be driven by some, as yet unknown, relationship with the dry season water supply in the National Park, presumably the remaining pools in Fish River itself, and the relative availability of food there.

NamibRand Nature Reserve (NRNR)

We attempted a similar mark-recapture estimate in the northern part of the NRNR, an area of about 30,000 ha, using camera traps at 5 water holes. Unfortunately, equipment failures meant that cameras were not always operating simultaneously and so a simple analysis pooling data from all the water holes could not be used. Instead, I adopted an approach starting with separate estimates for the most commonly used water holes. The largest numbers were at Moringa water, the most north-easterly water source where mark and recapture periods of 48 hours each in October-November yielded an estimate of 158+/-12 mountain zebra. The next highest numbers, from slightly different sampling dates, were 87+/-13 and 77+/-17 at the two other main water holes. These estimates cannot be simply summed because of overlap in use, so I quantified the overlap and corrected the numbers using the proportion of animals that occurred exclusively at each water hole during the sampling period. The adjusted values were then summed giving an estimate of 235 mountain zebra for these three key waterholes. A simple average of the standard errors for the three sites gave an estimate of 235+/-14. This value is higher than that from 2010 but the procedure was simpler in that year and is not strictly comparable. The 2011 value is based on 196 individuals actually identified at the three water holes, 83% of the estimate, and despite the methodological difficulties is probably quite realistic.

The other two water holes sampled in the north-west of NRNR (one at Sossussflei Desert Lodge) had fewer visits from mountain zebra, so a formal estimate could not be carried out. However 24 individuals were identified over the last three months of the year, bringing the total for the northern area to about 259. There is a high level of connectivity between the two water holes in the north-east but none with the three main water holes sampled in the north-west. We believe that the mountain zebra living in the north-west are probably the southern edge of a sub-population that extends northwards beyond the boundaries of NamibRand and I am currently analysing the first results from camera trapping outside the northern boundary in a neighbouring property called Geluk. Although this work is at an early stage, 35 new animals have been found (and added to the ID library) and 5 animals (two in a breeding group and three bachelors) that had previously been seen inside NRNR have been identified. These are thus the first known individuals who definitely move in and out of the reserve.

There were thus about 259 mountain zebra in the 30,000 ha northern part of NamibRand Nature Reserve (235 from the 3 north-eastern water holes plus 24 known at Sossusvlei Desert Lodge) giving a density of 0.86/km^2. These were the numbers present in part of the Reserve out of a source population of over 424 (the numbers of individuals identified or otherwise known to have been present in 2011) and so represent about 61% of the wider population. From the point of view of population management this is good news for the reserve because the chance of a larger population remaining genetically viable is higher. However, it also means that the conservation of the wider population, in the Nubib mountains and beyond, is dependent on actions beyond the boundaries of the Reserve and thus on wider co-operation between landowners.

Naukluft National Park and BüllsPort Guest farm

The Naukluft Park is an extension of the Namib-Naukluft National Park that projects eastwards into the Naukluft Mountains. With permission of the Ministry of Environment and Tourism (MET) and the help of park staff, I have explored a number of water sources along the western border of the park with a view to monitoring a significant proportion of the mountain zebras in the park. A pilot camera trap position was established at one permanent water hole (called Panorama) in the north-western part of the park with the aim of estimating numbers and starting to build up an ID library of the zebras using the waterhole. Air counts have been carried out in the Naukluft Park by the MET and I was informed that there are around 4,000 mountain zebra in the area. I have been monitoring

individuals at Panorama since October 2011 and after 5 months have identified 338 animals, which, if the four thousand total estimate is correct, is some 8.5% of the total. Some social groups are quite regular visitors but some visit rarely so must be using other water sources. As at other sites a key aim is to establish which water sources are visited by individuals and, at a population level, the degree of overlap between the various water holes.

Büllsport Guest Farm is in the Naukluft Mountains and lies just outside the eastern boundary of the Naukluft National Park. The owners encourage a small population of mountain zebra by providing permanent water and the zebra are much appreciated by the visitors to the farm who often see then during walks and horse rides. The population of the farm is probably continuous with that of the Naukluft National Park which it adjoins. Numbers are monitored as at other sites using the analysis of images from three camera traps. 233 individuals were identified or otherwise known to have been present in 2011 although not all of these will have been present on the farm at any one time; 205 have already been identified in the first few months of 2012.

Hybridization

There have long been rumours of hybridization between mountain zebra and plains zebra in Namibia and this is consistent with other cases of hybridization between other, quite distantly related pairs of equid species, notably Grevy's and plains zebra. My own interest in this issue started with observations of male mountain zebra becoming attached for long periods to particular breeding groups of plains zebra. This has been seen twice in NamibRand Nature Reserve and once on Gondwana Cañon Park (GCP), both areas where plains zebra have been re-introduced in recent times. In GCP the mountain zebra male was attached to one breeding group and rejoined it, even after mingling with other groups at water holes. It was subordinate to the plains zebra group stallion and this is also likely in the case of at least one male in NamibRand. This latter male was repeatedly injured presumably in combat with a plains zebra male. No obvious hybrids have been seen in either area and these observations suggest that gene flow from male mountain zebra to female plains zebra may be unlikely because male plains zebra are larger and able to defend their females. Despite this, the observations show a remarkable behavioural attachment between individuals of the two species which raises the possibility of hybrid mating. A greater danger could arise when males compete for access to female mountain zebra because in this case the larger plains zebra stallions may win.

In addition, there is regular ecological overlap. Mountain zebra and plains zebra have broadly distinct habitats but they often overlap. For example in NamibRand, plains zebra move up into the foothills of the Nubib mountains in the late dry season as the grassland of the plains are depleted. And in Gondwana, mountain zebra in early 2012 are moving down onto the plains near Holoogberg as the wet season green flush appears and, possibly, as the mountain zebra population expands. Where the two species overlap, they often occur at the same water holes. They never drink at the same time (in my experience) but may do so within a few minutes of each other and water holes are clearly places where these water-dependent species may start the process of forming social bonds.

More immediately important is the situation in Etosha National Park. Hybridization has been reported there for some time and an earlier student (who unfortunately did not finish his studies) photographed animals that appear to be hybrids. I visited Etosha last October and spoke to a warden about the hybridization issue. His view was that there were probably many hybrids in the western part of the park and that this may have come about because the normal western movements of mountain zebra into the mountainous areas to the west of the park may have been prevented when the boundary fence was erected. Hybrids reported elsewhere may also be partly due to restrictions of movement by fencing but this remains to be investigated.

Clearly there is an urgent need for targeted research into this problem with a view to designing appropriate management practices. Preliminary analysis of DNA collected in previous studies of zebra in Etosha reveal some evidence for hybridization between the two species; for example one plains zebra had ~30% genetic assignment to mountain zebra (Pauline Kamath, pers comm.). Hopefully a wider genetic study to test these findings and explore the causes will start soon and, using an individual-based approach, I will be helping to look at the behavioural and ecological basis of mate choice across the two species.

There are many unknowns at the moment. Mountain zebra and plains zebra have clearly remained separate in evolutionary time so why is a problem occurring now? Or are the hybrids confined to a hybrid zone that will not affect the main populations? We cannot answer these questions at the moment but the possibility that confinement and fencing is creating a new and potentially dangerous situation should be tested. Hybridization may be occurring in the west of Etosha NP because the fence at the western end of Etosha prevents natural movements by mountain zebra, and thus ecological separation from plains zebra. The risk of hybridization may also occur elsewhere in Namibia when plains zebra are introduced into enclosed farms in mountain zebra habitat; or reintroduced into areas which previously contained plains zebra but where spatial dynamics have been altered by fencing. Thus in spite of the fact that some mountain zebra populations are increasing in Namibia, a new threat may be emerging. Hybridization is potentially the most important conservation threat that they face.

Acknowledgements

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Appendix A: Research proposal to MET (11 April 2006).

Population ecology of Hartmann's mountain zebra

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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.

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