Observations of the seasonal dietary preference of male *Gazella subgutturosa marica* Thomas, 1897 (Cetartiodactyla: Bovidae) along foraging trails of central Saudi Arabia, by Peter Low Cunningham 1,2

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Abstract: Seasonal dietary preferences of male Arabian Sand Gazelle were determined using direct observations of vegetation utilised along foraging trails in central Saudi Arabia. Twenty-one different plant species from 12 different families were identified as food items, of which six species have not previously been recorded in the diet from Saudi Arabia. The importance of forbs in the diet was confirmed with species selected throughout the year with the highest relative frequency of use including *Farsetia stylosa*, *Convolvulus lanatus* and *Neurada procumbens*. Knowledge of the diet and food preference is important for protected area managers.

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**Strategy and Action Plan to Reduce the Risk of Mass Mortalities of Reintroduced Ungulates in the Mahazat as-Sayd Protected Area in Saudi Arabia**

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**Introduction**

Many species of wild animals have distinct physiological and ecological advantages over traditional domesticated livestock species in arid and semi-arid areas. Amongst the most significant are an ability to thrive in the absence of surface water (by movement in time and space), to make optimal use of vegetative resources and their minimal impact on the environment. They also have improved disease-tolerant, heat-tolerant and drought-tolerant attributes and their reproductive production characteristics are more efficiently adapted to the arid conditions.

However, placing wild animals in enclosed protected areas introduces a variety of new management issues, especially during times of drought and food stress. These difficulties were witnessed firsthand during recent drought events that affected Mahazat as-Sayd protected area in Saudi Arabia (Islam et al. 2007). During several years between 1999 and 2008, drought conditions have been a factor in mass mortalities of several endangered species (e.g., Arabian Oryx, Red-necked ostrich, and the Sand Gazelle).

In response, the National Commission for Wildlife Conservation and Development (in collaboration with the National Wildlife Research Center) organized a workshop in August 2008 of experts to develop a strategic plan to minimize the mortalities of reintroduced animals within the Mahazat as-Sayd Protected Area.

**Background information on Reintroduction in Mahazat as-Sayd Protected Area**

Reintroduction programmes were started in 1989 to save those species which were on the verge of extinction in Saudi Arabia. The species are Arabian Oryx (*Oryx leucoryx*), houbara bustard (*Chlamydotis macqueenii*), Red-necked ostrich (*Struthio camelus camelus*), and Sand Gazelle (*Gazella subgutturosa marica*). These animals were captive-bred and released in Mahazat as-Sayd protected area in western-central Saudi Arabia. Since then in certain years during the drought period, these animals have been reported a large die-off. Mortality of Arabian oryx and reem gazelles has been surveyed in Mahazat as-Sayd since the reintroduction programme was started in 1989. In 1999 large numbers of animals were died during summer months and again in 2006, 2007, 2008 and 2009 similarly large number of mortalities of Arabian oryx, sand gazelle and Red–necked ostrich were recorded in Mahazat as-Sayd (Islam et al. 2008). In 2006 a total of 39 Arabian oryx, 679 sand Gazelles and 44 Red-necked Arabian Ostriches were found dead and in 2008, 159 oryx and 151 sand gazelle in the reserve during the
stressful period (Map 1). A direct effect of environmental drought like condition is suggested as the cause of the majority of death. Deaths were due to starvation because of reduced availability, accessibility and quality of food plants in the area. Artificial water support was started in mid-September 2008 to avoid population decreases to detrimental levels. Support for the re-introduced ungulate populations in Mahazat as-Sayd were continued until forage improved in quality.

Map 1: Locations of Arabian oryx, Sand gazelle and ostrich during 2006, 2007 and 2008 are mostly near the fence of Mahazat as-Sayd Protected Area in Saudi Arabia

Workshop Structure
From August 2-7, 2008, thirty-one experts from Saudi Arabia, Australia, Namibia, South Africa, and the United States met at the National Wildlife Research Center near Taif, Saudi Arabia, to discuss and develop a plan to reduce the risk of mass mortalities of reintroduced animals within the Mahazat as-Sayd Protected Area. These experts brought a wide range of expertise in botany, climatology, ecology, geospatial technologies, planning, water resources, veterinary medicine, and wildlife management (Islam and Knutson 2008).

The workshop was carried out utilizing a logical framework approach. Conceptualized in 1969, the approach has become a standard planning methodology used throughout the world (AusAID, 2005; World Bank, 2001). The workshop was organized around tasks outlined in the approach, specifically:
- Creating a problem tree
- Creating an objectives tree
- Identifying activities to be carried out
- Constructing a hybrid planning matrix and work plan

Figure 1. Problem tree related to mass mortalities of wildlife at the Mahazat as-Sayd Protected Area in Saudi Arabia

Workshop Activities and Results

3.1 Creating a Problem Tree

The first task of the group was to identify the range of problems being experienced in terms of the mortalities of animals in the Mahazat as-Sayd Protected Area. Each problem was then written on a card, placed on a wall, and organized in terms of cause and effects to form a problem tree. Through this process, the primary problem rises to the top of the tree and the causes are located in the bottom roots of the tree. The results of the problem tree analysis are shown in Figure 1.

The problem analysis revealed that the primary animals affected by mass mortalities in recent years are the Arabian oryx, Sand gazelle, and Red-necked ostrich. They were affected because their numbers substantially exceeded the carrying capacity of the protected area and emergency measures were not in place to handle the excess animals. As shown in the problem tree, there are several underlying factors that contributed to this situation:

1. Drought had reduced vegetation growth and, therefore, the carrying capacity of the protected area. Drought had also reduced the moisture content of the vegetation leading to water stress in the animals.
2. The biological nature of reem (breeding allows rapid population growth under favourable conditions).
3. Monitoring and research is lacking to assess and monitor carrying capacity in relation to the number of animals in the protected area.
4. The protected area lacks an early warning system to trigger alerts when animals are threatened with food shortage/dehydration.
5. The protected area lacks a contingency plan for managing animal populations during times of stress.

Additional concerns were also raised in terms of the public’s perception of and involvement in the management activities of the protected area. However, it was felt that these were largely outside the scope of the current problem and should be addressed as part of the National Wildlife Research Center’s (NWRC) overall mission.
3.2 Creating an Objectives Tree

In the next exercise, the problem tree was then transformed into an objectives tree. In constructing the objectives tree, each problem is re-stated as an objective to help stimulate discussion on how to turn negative problems into positive actions. While the problem tree shows the cause and effect relationships between problems, the objective tree shows the means by which results will be achieved. It is expected that the activities listed at the bottom of the tree are means to help achieve the desired aims listed above it in the hierarchy.

In this case, it was identified that several categories of activities must be carried out in order to fulfill higher aims. These include:

1. exploring rangeland best management practices to keep vegetation in the best condition possible while achieving the objectives of sustaining the selected animal species’ populations
2. establish a monitoring system and conduct research on vegetation dynamics and ecology, animal feeding habits, and habitat/species interactions in order to better determine carrying capacity in the protected area monitor and conduct research on oryx, reem, and ostrich population dynamics, and establish an early warning and management system to trigger contingency actions during crisis events.

It was felt that carrying out these types of activities would help managers at the Mahazat as-Sayd protected area:

1. make decisions to minimize the effects of drought on vegetation growth and to maintain or increase carrying capacity within the prevailing climatic conditions in the protected area
2. manage oryx, gazelle, and ostrich population growth within the carrying capacity of the protected area, and implement emergency feeding and watering measures to sustain animal life when necessary
3. make decisions on and implement game reductions options.

In turn, implementing these actions is expected to result in more proactive range and wildlife management in the protected area and, ultimately, the elimination of mass mortalities of Arabian oryx, Sand gazelle, and the Red-necked ostrich in the Mahazat as-Sayd Protected Area.

Although the workshop was on minimizing the effects of drought, we can consider rewording the goal below to make it more relevant for future management actions e.g. “To manage oryx and reem populations in Mahazat as-Sayd Protected Area within the environmental constraints”

![Objectives tree related to mass mortalities of wildlife at the Mahazat as-Sayd Protected Area in Saudi Arabia](image)

3.3 Analysis of Alternative Strategies

3.3.2 Strategy Typologies

As discussed in Section 3.2., three primary strategy typologies were identified for reducing the risk of mass mortalities of wildlife in the Mahazat as-Sayd Protected Area:

1. enhance range conditions in the protected area to buffer against drought,
2. more proactively manage oryx, gazelle, and ostrich population growth so as not to exceed carrying capacity, and
3. under exceptional conditions to provide supplemental feed and water when sources become limited by drought, overpopulation, or other environmental conditions.

It was determined that more focus should be placed on the first two types of options, which more closely simulate natural conditions, and to provide supplemental feed and water when sources become limited by drought, overpopulation, or other environmental conditions.

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3.3.3 Supplemental Feeding and Watering During Emergency Situations

Provision that include water and alfalfa provided at five different camps to animals in Mahazat since May 2008 that helped in minimizing the mortalities. It was observed in the second week of September (2008) that gazelle, oryx and ostriches have started breeding though the condition in the reserve was not suitable as it is completely dry all over. There was a possible danger that pregnant females might not come with the group to provision sites and if they don’t get sufficient food and water they might die and there will be a great loss to the reserve. Under the present extreme drought conditions the survival of cows and calves is not guaranteed in any
To deal with this situation, it was recommended that as many oryx and reem be immediately removed from the protected area as possible. There is currently not enough vegetation to support the population and additional deaths appear imminent unless preventative action is taken. Because translocation or other means of removal or not readily available, supplemental feeding and watering is deemed as necessary to reduce the likelihood of mass mortalities. Supplemental feeding should be focused in the pre-release camps to aid in capturing as many as possible of the animals.

Nonetheless, the removal of oryx and reem is to begin immediately by transferring supplemental feeding and water (currently going on in the protected area) to the west enclosure sites to lure animals for passive capture. Since many of the animals are currently on the east side of the protected area, it is expected that an enclosure may need to be constructed on that side to assist in the captures. If necessary, additional portable enclosures will be utilized throughout the reserve to ensure a large percentage of the animals are removed from the protected area.

If necessary, more active capture techniques may also be employed. However, there are concerns that active capture techniques would place additional stress on weakened animals resulting in higher mortalities. Therefore, passive techniques will first be utilized, although the NWRC is hiring an expert on capture techniques that will provide training to existing staff in case it becomes necessary. If necessary, the NWRC may also need to hire a capture team to assist in these activities.

Once an adequate number of animals are captured, supplemental feeding/watering can then resume throughout the protected area to maintain the populations of animals that could not be captured. If options become available, translocating some of the animals to other locations may also become a possibility. It was also noted that having the animals in the enclosures may also be a good time to conduct medical treatments, mark animals for identification, and genetic testing. Genetic testing is especially necessary to assist in the maintenance of genetic diversity in the herds.

It is felt that these emergency measures will help reduce stress on the vegetation and animals in the protected area for the short-term. However, it was felt that the long-term management of sustainable populations of oryx and reem will require an increased focus on managing populations within the carrying capacity of the protected area.

3.3.4 Manage Oryx, Gazelle, and Ostrich Population Growth Within the Carrying Capacity of the Protected Area

In an enclosed environment, such as the Mahazat as-Sayd Protected Area, oryx and reem populations can be expected to fluctuate (i.e., increase and crash) over time as part of natural population growth cycles. Such fluctuations can be more pronounced than in open systems with more severe effects on animal populations and vegetation. Drought and other environmental stressors can accelerate this cycle and its severity by substantially reducing the carrying capacity of the protected area. In this regard, carrying capacity refers to the maximum stocking rate possible which is consistent with maintaining or improving vegetation or related resources. It may vary from year to year on the same area due to fluctuating forage production.

In terms of wildlife management, the question becomes whether you manage animal populations (e.g., translocation, hunting, etc.) or let them die from “natural” causes when they exceed carrying capacity. In this case in a fenced protected area, it is felt that human intervention is necessary to save animal lives because managers have already created an unnatural environment for the oryx and reem. Under natural conditions, they would migrate outwards to new areas as resources become limited. The conservation status of oryx may also necessitate interventions in a fenced area.

With this in mind, the next question becomes what type of human intervention is required to manage population growth. In general, there are two potential strategies. The first is based on maximizing animal population growth rates, where animal numbers are kept high in comparison to carrying capacity to maximize the amount of stock that can be taken off each year through translocation or hunting. The second strategy is focused more solely on maintaining a viable animal population by keeping animal numbers relatively low in comparison to carrying capacity to reduce the need for management intervention.

The latter strategy was selected as the preferred choice in the case of the Mahazat as-Sayd Protected Area. Animal numbers are to be kept relatively low (60-70%) in comparison to carrying capacity in order to limit rapid population increases and crashes, and the need for management intervention to reduce the number of animals. However, several types of activities must be carried out in order to support this type of a management program: 1) a monitoring, early warning, and emergency management system must be established, 2) monitoring and research must be carried out to determine carrying capacity in the protected area, and 3) monitoring and research must be carried out on reem and oryx population dynamics.

3.3.4.1 Activities to Develop a Monitoring, Early Warning, and Emergency Management System

A sound monitoring system is essential for tracking factors that influence or are indicative of carrying capacity in the Mahazat
as-Sayd Protected Area. This includes parameters such as rainfall and water supplies; vegetation composition and condition; animal condition and numbers; and soil characteristics. With a solid monitoring system, an early warning and management system can also be developed, which alerts managers as conditions deteriorate and outlines what types of actions will be required to address the situation.

Several requirements were identified in order to develop a fully-functional system:

1) General recommendations
   • Ecologist, assistants, and other experts to assess vegetation and wildlife dynamics
   • Map and analyze conditions
   • Develop a GIS database to archive monitoring data
   • Include a monitoring and research update in special and annual reports
   • Review monitoring and research programs annually.

2) Meteorological/climatological/soil monitoring
   • Ensure that precipitation is measured consistently at all representative gauging sites in the protected area. It would be beneficial if temperature, humidity, solar radiation, and evaporation measurements were also measured at each site.
   • Take weather readings at the gauging sites on regular basis.
   • Work to establish real-time automated weather monitoring stations at all gauging sites to minimize the need for human monitoring
   • Develop representative soil moisture monitoring network
   • Analyse and interpret the data

3) Animal monitoring
   • Conduct aerial surveys of animals weekly during capture and seasonally for long-term monitoring to determine animal population fluctuations and distribution
   • Monitor birth rates and mortalities in order to analyze animal survivorship and model populations
   • Conduct training in body condition scoring to assess animal condition
   • Establish transects for body condition scoring
   • Mark animals for better identification

4) Vegetation monitoring
   • Create representative, permanent vegetation sampling plots to assess ongoing conditions
   • Create representative, permanent animal exclosures to assess ongoing natural conditions (at least 1 per vegetation type and 2 hectares in size)
   • Investigate vegetation monitoring via handheld spectrometer and remote sensing to increase the capacity for using satellite images to assess vegetation

5) Management recommendations
   • Conduct research on how to use this, and other data (e.g., rodent behavior), to determine early warnings of stress and triggers for action
   • Continue to investigate potential management options for reducing grazing pressure/animal numbers when necessary (e.g., the number of animals to be removed and how)

To assist the protected area managers in making management decisions while the full system is being researched and developed, the workshop participants proposed an early warning and management system that is based on available monitoring data and field experience. It is expected that the monitoring and management system will be enhanced as additional data become available and more experience is gained in determining the appropriate indicators, action triggers, and response measures.

3.3.4.2 Activities to Determine and Monitor Carrying Capacity in the Protected Area

A strong monitoring program is essential for gathering basic information on bio-physical characteristics. However, additional activities and research are also necessary to determine the carrying capacity of the protected area over time. These activities include:

1. Researching vegetation species composition related to rainfall and the seasonality of rain
2. Researching key food species production in the protected area
3. Researching the dynamics of animal food species and competition between animal species
4. Research current vegetation recovery and dynamics
5. Research the use of existing models used in other regions to the Mahazat as-Sayd Protected Area

Investigating these issues will assist in determining carrying capacity in the protected area, which will assist in better managing wildlife populations.

3.3.4.3 Activities to Monitor and Analyze Reem and Oryx Population Dynamics

A thorough understanding of reem and oryx population dynamics is essential for designing appropriate early warning systems and informed population management strategies that meet the biological needs of sustainable animal populations and the management goals of the Mahazat as-Sayd Protected Area. Several activities are required to foster this understanding, including:

1. Analyzing animal survivorship (age class dependent) and modeling populations to understand mortality occurrence
2. Analyzing daily and seasonal movement patterns and diet selection
3. Researching animal reproduction in relation to precipitation to improve monitoring and early warning
4. Researching how species can be used as stress indicators (or triggers for action)
5. Researching intra- and inter-species competition
6. Evaluating genetic tests to ensure genetic diversity in the respective animal populations.
7. Researching the re-introduction of predators (i.e., wolves, cheetahs, and hyena) as a population control measure
It is expected that carrying out these activities will help in developing informed population management decisions, and maintaining a genetically diverse and sustainable animal populations.

3.3.2 Recommended Actions to Minimize Drought Effects on Vegetation Growth to Maintain or Increase Carrying Capacity

There is an increasing amount of work being done throughout the world to implement best range management practices to foster ecosystem resilience and maintain high carrying capacity. These are long-term management practices – the goal of which is to foster a resilient and highly productive environment that will produce more vegetation and be better able to withstand stresses, such as drought.

Several potential activities were highlighted that could contribute to fostering better range management at the Mahazat as-Sayd Protected Area, including:

1. Review literature on rotational grazing systems, and the use of water point spacing, location, and seasonality to promote preferred grazing
2. Research water harvesting opportunities, such as placing logs and vegetation in natural waterways or dam construction, which could promote the establishment of vegetation
3. Research options for and the effects of rangeland reclamation (e.g., breaking the ground surface for vegetation establishment)
4. Research the re-introduction of grazers and browsers (i.e., mountain gazelle and Cape hares) to modify grazing regimes and plant selection

Although important, it was felt that these were activities that could be carried out after the current situation has been stabilized and other immediate needs have been met (i.e., emergency management measures have been carried out, a monitoring system has been established, and other basic research on carrying capacity and animal population dynamics has begun).

4.1 Planning Matrix to Reduce the Risk of Mass Mortalities at the Mahazat as-Sayd Protected Area

Once the primary activities to be carried out were identified, the actions were incorporated into a planning matrix, shown in Appendix 1. In developing the planning matrix, workshop participants were asked to place a priority on each item, note indicators of success, timelines, and partners that would be responsible for addressing each task.

4.1.1 Action Priorities

As stated previously, the most pressing issue was to address the current emergency situation in the protected area. Therefore, all actions listed under “implementing emergency feeding and watering measures when necessary to prevent mass mortalities” were ranked highly versus less critical tasks.

Next, the tasks involved with managing oryx and reem population growth within carrying capacity of the protected area were rated highly. All of the tasks associated with establishing a monitoring system were all rated highly, along with most of the activities to help investigate carrying capacity and population dynamics.

Finally, the long-term range management strategies were viewed as important but less critical tasks, at this time. However, since many of the activities are based on the need for additional funding, opportunities may arise that change the priority of some of the tasks.

4.1.2 Indicators of Success

Workshop participants also identified a variety of indicators of success for each action item identified. These are general indicators that progress is being made on the item and they are expected to be updated on a periodic basis as the efforts continue in the future.

4.1.3 Timelines

Initial timelines were provided for each action item to set a benchmark for action. In general, it was felt that most of the management actions to address the current emergency situation must be started immediately and completed within one year to minimize ongoing mass mortalities. Similarly, the establishment of a monitoring system and activities to evaluate carrying capacity and population management strategies should begin immediately and have made significant progress within 18 months. Finally, the long-term range management studies may not be an immediate concern but should have made some progress in seeking funding with 18 months. The timelines provided are expected to be assessed periodically (e.g., every six months) to monitor progress and adjust for changing funding and management environments.

4.1.4 Partners

The implementation of many of the identified actions will require partnerships between many different entities although, ultimately, the National Wildlife Research Center (NWRC) and the National Commission for Wildlife Conservation and Development (NCWCD) will be held accountable for fostering progress and implementing the proposed recommendations.

Several representatives of other partner organizations also attended the workshop and express expressed an interest in working with the NWRC and the NCWCD. These include organizations such as the King Khalid Wildlife Research Center (KKWRC), King Fahd University of Petroleum and Minerals (KFUPM), The King Abdulaziz City for Science and Technology (KACST), and the National Drought Mitigation Center (NDMC) in the United States. A variety of other organizations are also expected to participate as the projects continue.

5.1 Advisory Services and Review

It is recommended that an external advisory group of relevant professionals and stakeholders be developed to provide ongoing review and recommendations on the tasks outlined in this document. The group could hold meetings or teleconferences on a more frequent
Genetic Data Yield Intriguing Insights into the Evolutionary History of the Common Eland
by Eline Lorenzen PhD, Natural History Museum of Denmark, University of Copenhagen

Background
During my PhD at the University of Copenhagen, I worked on population genetics of African antelopes. Population genetics is the study of genetic variation and genetic evolution within species, and the field is pivotal in understanding the roles of geographical history and ecology in shaping species diversity. Because demographic processes such as population structuring, hybridization, introgression, and cryptic speciation may not be apparent to the human eye, population genetics can be used to gain useful insight into species demographic histories, and to infer species evolutionary scenarios. Reports on the outcomes of the studies I have been involved in have all been published in GNUSLETTER. This is the last of such reports, and gives a summary of our work on the common eland, which is found across East and southern Africa and is the world’s largest antelope. We used genetic data from the mitochondrial genome of individuals sampled from all over the present-day range of the species to investigate the phylolgeography (geographic distribution of genetic lineages) and demographic history of the species (Fig. 1).

Figure 1. Demographic history of common eland distribution

Split between East and southern Africa
We found that the common eland was split in two genetically and geographically distinct groups (Fig. 2). One group encompassed all individuals from southern Africa: Namibia, Botswana, Zimbabwe and Zambia. The other group comprised all individuals sampled in East Africa: Tanzania, Uganda, Kenya, and Ethiopia. A third intermediate group comprised three individuals from Zambia, which I will not go into more detail with here. The split between the two major lineages suggested a long period of isolation, during which populations diverged. The present-day locality of the samples indicated that one lineage originated in southern Africa, the other in East Africa.

The African continent has experienced continuous dramatic fluctuations between hot-humid and cold-arid climates since the common eland emerged as a species c. 600,000 years ago. Pollen records and climate simulations indicate that during the hot-humid periods, dense tropical forest expanded across central Africa from coast to coast. Such forest cover would isolate common eland surviving in the arid savannah habitat still present on either side (east and south), and would act as an impenetrable and effective barrier to gene flow between regions. If this barrier persisted for a considerable period of time, the common eland in east and south would differentiate. Such a scenario is supported by our data.

References