Eco. Env. & Cons. 21 (3) : 2015; pp. (1175-1181)
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ISSN 0971–765X

Movement patterns of two Arabian Oryx (*Oryx leucoryx*) within a midsized reservation

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(Received 27 January, 2015; accepted 30 March , 2015)

ABSTRACT

Movement behavior of ungulates within a mid-sized arid rangeland reservation has implications for both conservation management and tourism. In this qualitative study, one male and one female Arabian oryx were tracked each 15 minutes for eight months using GPS collars in the 226 km^2 Dubai Desert Conservation Reserve. Results were consistent with wild animals of the species for movement response to time of day, temperature, and rainfall. However, the oryx routinely used only 4.5% of their available range, despite having much larger ranges in wild populations. During summer months,the oryx actively sought drinking water on an almost daily basis, but utilized shade only opportunistically. Results were consistent with domesticated ungulates for toleration of anthropogenic proximity in exchange for artificial food and water, but avoidance of the DDCR boundary fence. An edge of 0.5 -1.5 km from the fence was breached only occasionally at night, and was unrelated to anthropogenic activity outside the fence. As the edge represents 18-48% of the reserve, carrying capacity could be improved by using artificial feed and water points to encourage animals into this area.

Key words : *Anthropogenic effects, Arabian oryx, Conservation reserve, Edge effect, Heterothermy, Oryx leucoryx, Range*

Introduction

Conservation reserves that service luxury ecotourism are managed to balance the needs of the tourism operator with long-term sustainability, with the consequence that scientific principles of conservation are compromised (Ryan and Stewart, 2009). The 226 km^2 Dubai Desert Conservation Reserve (DDCR) protects an arid rangeland ecosystem, but also provides a home for artificially maintained Arabian Oryx (*Oryx leucoryx*) and other species. The aim of this qualitative study was to investigate the movement patterns of Arabian Oryx within this artificial habitat, and compare movement to that expected of domesticated and wild populations. Previous studies have relied on direct human observation of animal positions, and were therefore limited to daytime observations over a limited time period. In this study, 46700 position readings were taken over an eight month period, though only for two animals.

The species lends itself to ecotourism conservation, as it was once extinct in the wild (Henderson 1974). Reintroduction to unenclosed areas has been attempted with variable success in Oman in 1982 (Spalton *et al.*, 1999), Jordan in 1983 (Harding *et al.*, 2007); Saudi Arabia in 1990 (Wronski *et al.*, 2011); and Israel in 1997 (Gilad *et al.*, 2008). The population in the DDCR is one of several in the United Arab Emirates that provide an open but range-restricted

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captive environment.

The natural range and seasonal movements of free-living Arabian Oryx in the Arabian Peninsula is poorly understood (Seddon and Ismail, 2002). Movement is driven by access to food and water, and also to manage heat accumulation in the hotter months of the year. The species exhibits the largest body temperature variation of any known large mammal (Hetem *et al.*, 2012). Heterothermy is a response to the combination of low hydration levels and high ambient temperatures (Hetem *et al.* 2010). Several authors have posited that oryx will seek shade when ambient temperature is high, thus predicting that wild populations converged on lowland oases in summer and moved throughout the sand seas in winter (Child and Grainger 1990; Price 1989). Daytime foraging has been observed to decline in summer as oryx spent more time in the shade (Seddon and Ismail 2002). Under natural conditions, oryx do most of their feeding around sunrise and sunset each day. Fecundity is strongly influenced by season (Ismail *et al.*, 2011) and by access to crude protein in the preceding season (Spalton 1995).

Oryx are capable of surviving for many months without access to drinking water (Ostrowski *et al.* 2002; Williams *et al.* 2001) through an unusually low evaporative water loss, a reduction of water in urine and feces (Ostrowski *et al*. 2006), and use of heterothermy to minimize water loss for temperature regulation. The species is more dependent on water held within vegetation than on free-standing water (Price 1989), supporting the notion that water is a significant trophic currency in this environment (Allen *et al.*, 2013). Individuals released into unenclosed habitats dramatically increased their range in the two months after a significant rainfall, and narrowed their range when the nutritive quality of vegetation declined, though these rain-related migrations became more focused in oryx that had learned the landscape (Tear *et al.*, 1997). Individuals vary considerably in their migratory response to localized rainfall, despite the implications for reproduction and survival (Corp *et al.*, 1998). Individuals' chosen range is also affected by artificial water sources, which may reduce their utilization of available vegetation within a protected area (van Heezik *et al.*, 2003).

There has been considerable research on the sustainability of populations in Oman and Saudi Arabia released into unenclosed habitats, from population, behavioral, and genetic view points. However there has been scant research on the design of fenced reserves in the 100 – 1000 km^2 range. This reserve size is likely to limit the vegetation-seeking migratory patterns of the species, particularly if there is a significant edge effect of the reserve boundary. Oryx qualify as a species expected to be negatively impacted by roads, by exhibiting a large range and low natural density (Fahrig and Rytwinski, 2009), but the influence of fences is unknown.

Materials and Methods

The 226 km^2 DDCR consists of gently undulating sand with occasional gravel plains, elevation 200m, approximately 60 km from the Arabian Gulf and 25 km from the Hajar mountain range. Predominant vegetation varies between *Leptadendia pyrotechinca*, *Calotropis procera*, and a range of dwarf shrub spp. Within the DDCR there are four natural clusters of *Prosopis cineraria* and at least 18 sites of naturally occurring *Acacia tortilis* individuals or groups. Several abandoned farms provide artificial mature stands of *Prosopis cineraria*. Additionally, several thousand trees have been planted and receive irrigation, but were too small to provide substantial shading. Drinking water is provided at seven sites throughout the DDCR, as well as from irrigation pipe malfunctions. Supplementary feed is provided daily at shifting locations. Within the center of the DDCR is the Al Maha luxury tourist resort, at which there is irrigated foliage and shade.

Density of oryx within the DDCR at the time of the study was estimated at 1.1 head km^{-2}(Gallacher 2010), significantly higher than the estimated densities of between 0.016 and 0.20 head km^{-2} in the similar habitats of Oman and Saudi Arabia (Mésochina, *et al.*, 2003; Spalton *et al.*, 1999).

Tellus 2D GPS collars (Televilt, Sweden) were placed on four Arabian oryx in 2006. One collar malfunctioned after three days and another remains lost in the desert. The two remaining collars collected movement data for eight months at 15 minute intervals (16 Nov 2006 to 12 Jul 2007, and 10 Oct 2006 to 15 Jun 2007 for an adult male and female oryx respectively) before malfunctioning, a total of 46700 position readings. The peak months for solar radiation are May-June, while the hottest months are July-August. The first collar stopped recording when average daily temperature was within 1.5^{o}C of the August 2007 average of 37^{o}C.A significant rain

event occurred in December 2006, followed by a minor rainfall in February 2007.

Results

Range

Both oryx spent almost all their time within a well-defined range. They were rarely stationary, but usually did not venture far from their home base. The female occasionally spent 12-24 hours exploring new areas. The male made similar explorations but for a shorter time and over shorter distances. Roaming peaked during February-March, when more than 90% of time was spent away from frequented sites (see 'frequented sites' below).

The male was moved to the far northern part of the DDCR in Jan 2007, ten weeks after it was collared, for reasons unrelated to this study. It stayed in this area for six days, staying uncharacteristically close to a feeding site, and then returned to its original 9.99 km^2 area 17 km away in a 36 hour period, via an almost direct route. The female spent the first 5 months in its original 9.85 km^2 area, close to the Al Maha resort. It then wandered for two days before settling in a 9.41 km^2 area 6 km to the south, where it stayed for the remaining 3 months. From here it made day-trips back to the northern location, approximately one day-trip every two weeks, traveling there around dawn and returning around sunset. On its first day-trip (28 April 2007) it wandered through much of its original area, including the resort. On its second trip (6 May 2007) it returned to a plantation that it had previously frequented, and thereafter it returned each day-trip to spend daytime hours (approximately 9am – 4pm) at this plantation.

Both oryx approached the boundary fence infrequently, and only at night. The male typically kept a distance of 1.5 km (Fig. 1), approaching the fence twice at night and both times staying less than three hours. The female kept a distance of 500 m, approaching the fence seven times. On one occasion it stayed the entire day at a feeding site in this edge.

Fig. 1. Map of commonly roamed areas (yellow, male oryx; orange, female oryx) and frequented locations within the Dubai Desert Conservation Reserve (black line). Map scale is 15 km N-S x 16 km E-W. An interactive version can be viewed at Tiny.cc/OryxDDCR.

Daily movement

Oryx movement peaked around sunrise and sunset, regardless of the season (Fig. 2), during which they moved an average of three times the distance than that of other times. On very rare occasions they moved faster than walking speed, peaking at 6.8 (male oryx) and 7.5 (female oryx) km h^{-1}. Movement in the afternoons decreased linearly with increasing temperature (Fig. 3) but showed no correlation at other times of day. Effect of afternoon ambient temperature (12 – 5 pm) on the average distance moved by two oryx (B and C) each 15 minutes, Fig. 3) but showed no correlation at other times of day. Temperature measured by the collars showed a consistent daily pattern throughout the year, with the coldest time of day at sunrise and peak temperature at around 2 pm (Fig. 4). Peak temperature was an hour earlier than the same measure recorded at three fixed weather stations within the DDCR, suggesting that oryx avoided heat at 3pm more effectively than at 2pm, possibly due to the increased available shade. The median daily range was just 0.64 and 1.32 km^2 for the male and female respectively.

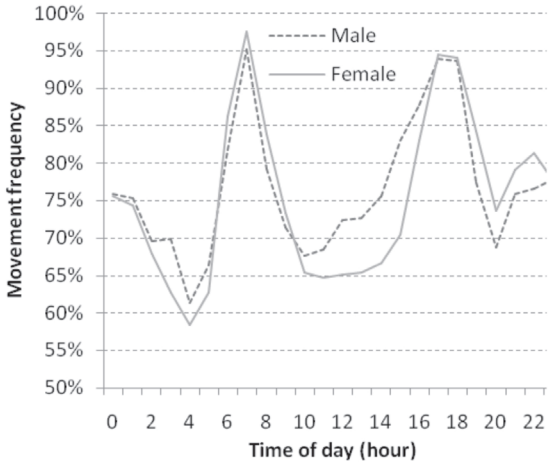

Fig. 2. Frequency of oryx movement throughout the day. An animal was considered to have moved if its position had changed more than 10 m since the position from 15 minutes before.

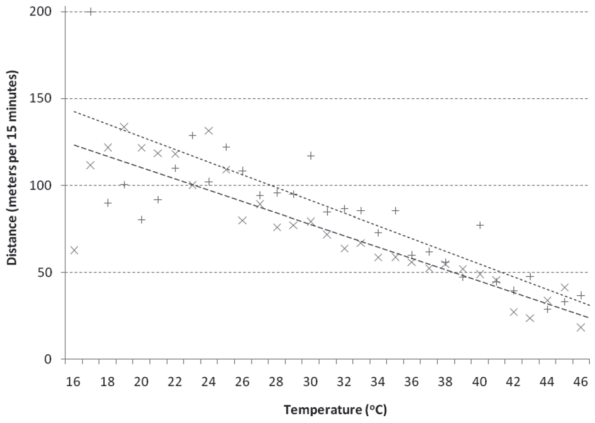

Fig. 3. Effect of afternoon ambient temperature (12 – 5 pm) on the average distance moved by two oryx each 15 minutes.

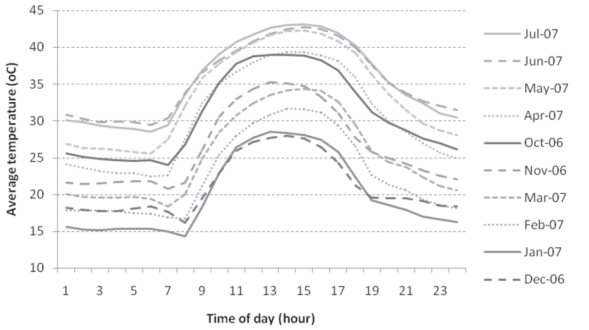

Fig. 4. Intra-day temperature change during the study period, averaged from data collected at the necks of two oryx.

Frequented sites

One hundred frequently visited sites were identified, which corresponded to one or both of the oryx appearing at the site for least 13 position readings. Sites were mapped onto Google satellite data and classified into seven types (Table 1). An oryx was defined as using a site whenever it was positioned within 20 meters.

Results showed that both oryx spent time around a single drinking water site only during the summer months (Fig. 5), and only during the middle of the day (Fig. 6). During these months they each visited their respective water site once every one to two days. Time in plantation sites showed a similar pattern, though less distinct. The male switched to occupying resort sites during summer months, while the female spent a small amount of time in the shade of a naturally occurring tree.

Before the December 2006 rains, both oryx exhibited a pattern of frequenting favored shrub sites at night, and sand or roadside sites during the day. A few weeks after the rain both oryx switched dramatically to a roaming pattern, visiting frequented sites less often and for shorter durations. A daytime pattern began to reestablish around late March, and by mid-April both oryx were spending most of their

Table 1. Description of the different types of frequented sites identified in the study. A frequented site was one in which at least 13 position readings were logged.

Site type	Water	Food	Shade	Description	Number
Water point	Yes	No	No	An artificial pond providing groundwater at surface level.	2
Roadside	No	Yes	No	DDCR staff provide feed at rotating locations adjacent to internal roads. Hence, occupation of one of these sites was likely due to accessing a feeding point	13
Trees	No	No	Yes	Trees provide shade, but not feed since camels had removed all vegetation below 3 meters.	1
Sand	No	No	No	Area without landmarks or large vegetation	30
Plantation	Some	Some	Some	Artificially planted trees which are occasionally irrigated. Trees were too small to provide much shade at the time of the study.	10
Resort	Some	Some	Yes	Area with a large amount of irrigated amenity horticulture, but also close to human activity	7
Shrub	No	Some	Some	Sandy area with a large shrub present, which the Oryx may or may not have been using	37

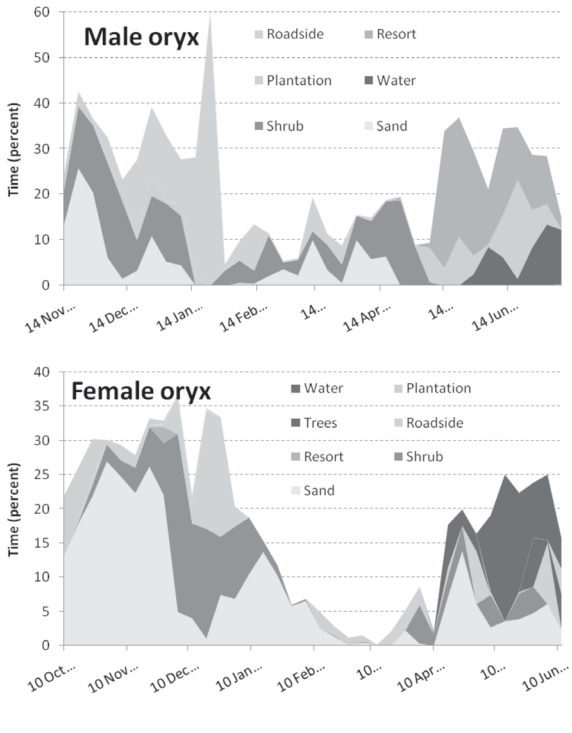

Fig. 5. Percent of total time spent at defined hotspot locations, by week

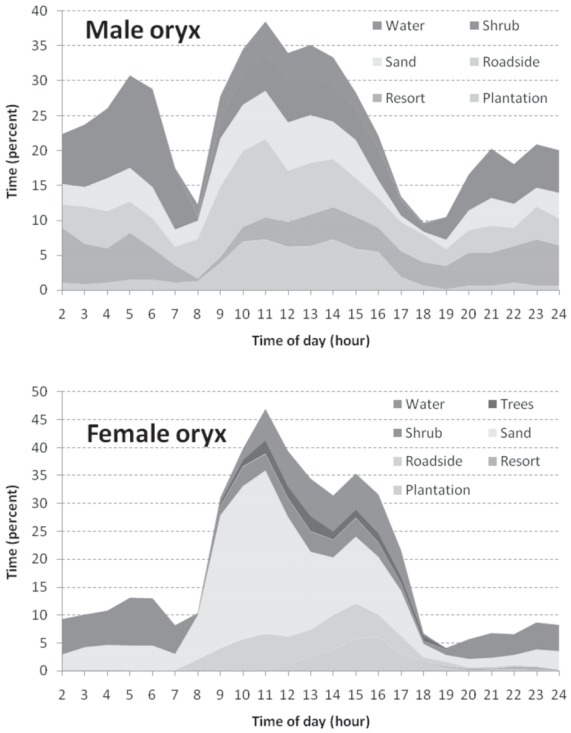

Fig. 6. Percent of total time spent at defined hotspot locations, by hour of the day

daylight hours in a single location, chosen afresh each day.

Herding

The two Oryx spent most of the period apart, but were in close proximity for 48 days (17 Nov 2006 to 3 Jan 2007). During this time they started moving toward each other at 6 : 15 – 6 : 30 each morning, typically forming a herd at 7:15 – 7:45 am, though it would be later if they started further apart. They then dispersed at a time that ranged from a few hours to the next day, separating by 1.0 – 6.5 km (median 2.7 km). On three evenings they remained herded until the next day.

Discussion

The two oryx in this qualitative study demonstrated characteristics of both natural behavior and anthropogenic influences. Movement peaked at sunrise and sunset, and patterns of roaming throughout the period were consistent with oryx grazing on fresh rain fed vegetation. The observed range of 10 km^2 was far smaller than the available 226 km^2 available, and to the 200 km^2 approximate range of oryx herds 6-8 years after reintroduction in Oman (Tear *et al.*, 1997). Oryx actively sought water in the summer months, but their use of shade was more incidental. With an ad lib supply of drinking water they appear to not need shading for thermoregulation, though it is still used if readily available.

Feeding sites were utilized during daylight but not by a regularized pattern. Sites are regularly moved to prevent piosphere formation (James *et al.*, 1999), and some sites may have been overlooked by both animal and researcher. This study is therefore insufficient to determine frequency of artificial feeding, but it appeared that oryx attended these sites sporadically.

In general, oryx avoided anthropogenic influences unless there was a known source of water, food or shade. The subdued flight response in these circumstances suggests a domesticated population (Stankowich, 2008). However, while the oryx moved around areas that included internal DDCR roads, outbuildings, and the luxury resort of Al Maha, both oryx remained wary of the DDCR perimeter fence, maintaining a safe distance of 0.5 to 1.5 km during daylight hours, and breaching it only rarely at night. Oryx are clearly seen for distances of up to 3 km, due to their highly reflective coat (Price, 1989), but it is rare to see an oryx from the Dubai - Al Ain six-lane night-illuminated highway, which shares a 6 km border with the DDCR. An edge effect of 0.5-1.5 km appears sufficient to ensure that animals are usually hidden from direct line-of-sight by dune undulations. Only half of the DDCR boundary borders anthropocentric developments. The other half borders undeveloped regions of Abu Dhabi and Sharjah Emirates, but the edge effect appears persistent.In the DDCR this edge represents 18-48% of the reserve, and may be a reason why oryx have rarely traversed the 6.8 km wide corridor linking the southern DDCR to the smaller northern DDCR.

Consideration of edge effects is therefore essential for optimizing the utilization of available vegetation with a reserve of this size range. When artificial feed and water sites were provided near the boundary, oryx modified their behavior to utilize these anthropogenic resources, but did not linger sufficiently to fully utilize the natural resources. This behavior could be modified through the placement of anthropogenic resources at the DDCR boundary. Increased conditioning could be construed to be increased domestication, but would also improve the herbivory utilization of the DDCR.

Acknowledgments

The author would like to thank Mr Greg Simkins, conservation manager of the Dubai Desert Conservation Reserve, for supporting the project and managing the animals. This project was supported financially through the Zayed University research office.

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