



## Factors affecting population dynamics of re-introduced mountain gazelles (*Gazella gazella*) in the Ibex Reserve, central Saudi Arabia

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### ABSTRACT

Mountain gazelle (*Gazella gazella*) in Saudi Arabia is listed as 'vulnerable' by the IUCN. At present the species' survival is secured by extensive captive-breeding programs and re-introductions into protected areas. Post-monitoring of released individuals is essential for evaluating the success of such re-introductions but managers have difficulties in deciding whether food, water and other resources are sufficient to sustain a stable population. This study reports on data collected during standardized road transect counts in two wadis of the Ibex Reserve into which gazelles were previously released, and aims to compare the success of both re-introduction attempts with resource availability and home range size. Results from step-wise backward multiple regressions identified food availability and population density as significant predictors for home range size. The low amount of available food may have increased the competition between non-related females and therefore led to an increased overlap between non-group members resulting in increased dispersal rates. This information will allow interpretation of habitat suitability and provides possible reasons for the population decrease at both study sites. The data will enable conservation managers to identify future re-introduction sites and will help improving the success of future re-introductions in Saudi Arabia or other parts of the species range.

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### 1. Introduction

The idmi or mountain gazelle (*Gazella gazella*) was once widespread along the coastal regions and mountain ranges of the Arabian Peninsula. In the Kingdom of Saudi Arabia they were recorded from the eastern coastal and highland plains (Thouless et al., 1991). Habibi (1991) described their range as restricted to the mountainous wadis and foothills of the western, southern and south-eastern parts of the Arabian Peninsula. Only a few records report on mountain gazelles naturally occurring in the central mountains, i.e. the Jebel Tuwaiq, of Saudi Arabia (Child and Grainger, 1990; Thouless et al., 1991) in which the Ibex Reserve is situated.

Mountain gazelles in Saudi Arabia are listed as 'vulnerable' by the IUCN (Mallon and Kingswood, 2001). At present the species' survival is secured by extensive captive-breeding programs and re-introductions into protected areas (Dunham et al., 1993; Dunham, 1995, 1997a,b). Two re-introduction programs in Saudi Arabia

(Ibex Reserve and Uruq Bani Ma'Arad protected areas) have been undertaken in the past two decades (Dunham, 1997b, c). Post-monitoring of released individuals is essential for evaluating the success of such re-introduction programs (Beck et al., 1994; Soorae and Seddon, 1998); however, cryptic species like mountain gazelles are extremely difficult to observe directly or to count regularly. A comparatively cost-intensive method to monitor released gazelles is radio tracking, while standardized monitoring and counting patrols on fixed road transects can provide reasonable population estimates with a comparatively low effort.

Territorial gazelle species, such as the mountain gazelle, show a high site-fidelity, which makes them dependent on sufficient resource availability (Grau and Walther, 1976; Walther et al., 1983; Dunham, 1999; Geffen et al., 1999). It is therefore essential to relate population density to the availability of limiting resources such as food (Norton et al., 1982; Hubbs and Boonstra, 1998) water (Dunham, 1994; Mendelssohn et al., 1995), space and shelter (Fabricius and Mentis, 1992; Elchuk and Wiebe, 2003).

Following the first re-introduction attempt in 1990 the population development of mountain gazelles in Wadi Ghabah (Wadi Mut'im system, Ibex Reserve) was closely monitored (Dunham et al., 1993; Dunham, 1997a,b, 1998a). Following the second major

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re-introduction into Wadi Jidr in 1993, the monitoring was extended to the Wadi Bawdan system. Between the end of 1998 and 2001 no systematic surveys of mountain gazelles in the Ibex Reserve were undertaken. To collected information on status and population development of mountain gazelles in the reserve, a standardized approach of wildlife monitoring was initiated in 2001 (Wacher et al., 2000).

This study reports on data collected during standardized road transect counts in two wadis of the Ibex Reserve, i.e. Wadi Ghabah and Wadi Nukhailan, into which gazelles were re-introduced between 1990 and 1995, and in 2007 respectively. The study further intends to compare the success of both re-introduction attempts in terms of population size and density, home range size and overlap, and resource availability. Two methods to estimate population size were used: i) extrapolation of count data using a fixed strip width (Bothma, 2002), and ii) extrapolation using a species and an area correction factor (Stuart-Hill, 2001). In order to test the reliability of estimates, I compared estimates with known minimum numbers of individually distinguishable gazelles obtained during an intensive long-term behavioral study between 2006 and 2008 (Wronski and Plath, 2009). Furthermore, population estimates in both wadis were related to home range size and overlap of individual females as well as to environmental factors such as rainfall, food availability and the availability of shelter. Models of optimal territory size (Waser and Wiley, 1979; Schoener, 1983; Adams, 2001) have shown that territory or home range size is adjusted according to rates of intrusion (competition by neighbors) and to the availability of food (or other important resources). Since home range or territory size is small in populations with a high density (Ebersole, 1980; Hixon, 1980; Adams, 2001) and home range size is predicted to be negatively correlated with resource availability (Myers et al., 1979; Temeles, 1987; Wronski et al., 2006), I predicted that re-introduction sites with small home ranges, and high resource availability (predominantly in core areas of female home ranges) have higher population densities than areas with large home ranges, and low resource availability. Animals often assess resource availability directly and defend areas containing sufficient quantities of food, or they generally attempt to maximize the exclusive area, but its size is constrained by competition with non-territorial individuals or neighboring territory owners (Norton et al., 1982; Norman and Jones, 1984; McFarland, 1986). Female Mountain gazelles form more or less stable groups of related females (matrilines) that differ from other temporary groups or solitary individuals (Dunham, 1999). I therefore, asked whether a wadi with a high resource availability experiences strong competition due to high gazelle density (expressed as intrusion by non-group members), or whether resource availability is sufficient enough to induce little or no competition between female groups.

The information on the correlation of resource availability, home range size and population density obtained from these re-introduction attempts will help to identify habitat suitability for Mountain gazelles in both Wadi systems and provides possible reasons for the population decrease observed at both re-introduction sites since 1995. Moreover, the data will enable conservation managers to identify future re-introduction sites and will help improving the success of future re-introductions in Saudi Arabia or other parts of the species natural range.

## 2. Material and methods

### 2.1. Study area and population

The Ibex Reserve (23°30'N, 46°30'E) near Hawtat Bani Tamim in the Jebel Tuwaiq mountains of central Saudi Arabia was established during 1988 by the National Commission for Wildlife Conservation

and Development (NCWCD; now Saudi Wildlife Commission, SWC) to protect the last Nubian ibex (*Capra nubiana*) in the central parts of the Kingdom. Annual rainfall in the study area is low and highly variable (average 78.2 mm, s.d. = 60.55 mm; range 3–212.5 mm, 1991–2008; Robinson, 2008) and precipitation occurs mainly during winter and spring. The summer is dry and hot (mean temperature 40 °C). The reserve covers 1870 km<sup>2</sup> and comprises an undulating, stony, limestone plateau, 800–1100 m asl, which is deeply incised by wadis. Plant standing crop is sparse on the plateau, but greater in wadis, where *Acacia tortilis* bushes and trees dominate the vegetation. This study was carried out on two re-introduced mountain gazelle populations in two wadis of the Ibex Reserve, i.e. Wadi Nukhailan as part of the Wadi Bawdan system in the southern portion of the reserve and Wadi Ghabah as part of the Wadi Mut'im system in the eastern part of the reserve. The wadi floor in Wadi Nukhailan has an extension 19.26 km<sup>2</sup>, that of Wadi Ghabah 6.94 km<sup>2</sup>. Wadi Ghabah represents the stony upper part of the Wadi Mut'im system (wadi head) with a rather loamy soil texture (Robertson, 1999), while Wadi Nukhailan represents the wider and lower lying part of the Wadi Bawdan system, with a more sandy soil texture.

Mountain gazelles were re-introduced into the Ibex Reserve from a captive-breeding stock at King Khalid Wildlife Research Centre at Thumamah, in an effort to re-establish the locally extinct population. Several releases were made, the first being in 1990 when 19 animals were released into the Wadi Mut'im system (Wadi Ghabah), followed by another 10 animals in 1991 (Wadi Ghabah) and by 25 animals in 1992 (Wadi Gafar; Dunham, 1997a). Between 1993 and 1995, 30 mountain gazelles were released into the Wadi Bawdan system (Wadi Jidr, Dunham, 1997a). During the years following the re-introduction, ear-tagged and radio-collared gazelles were intensively monitored and their dispersal patterns and home range extensions were established (Dunham, 1997a,b, 1998a, 1999, 2000, 2001). By the beginning of 1995 it was estimated that about 185 mountain gazelles inhabited the reserve (Dunham, 1997a,c). In 1998–1999, a survey to determine the status and distribution of mountain gazelles in the reserve was carried out by Dunham (2001), reporting that although only a few gazelles were seen in the central and lower parts of Wadi Mut'im, signs of their recent presence were regularly recorded. Between the end of 1998 and 2001 no systematic surveys of mountain gazelles in the Ibex Reserve were undertaken. In order to obtain regularly and systematically collected information on status and development of mountain gazelles in the reserve, a standardized approach of wildlife monitoring was initiated in 2001.

### 2.2. Road transect counts and density estimates

Between 2001 and 2006 road transect counts were carried out once a month, in 2007 every second month and in 2008 only in August and November. In this study, I used data obtained from road transects counts assuming that all animals along the line of the transect (track) were seen (Lancia et al., 1994). Count routes along two wadis in the Ibex Reserve, i.e. Wadi Nukhailan and Wadi Ghabah, were established in 2001 and followed the course of the wadi on already existing patrol routes (Wacher et al., 2000). In Wadi Ghabah (mean width of 260 m) the count route (9.5 km) runs on either side of the wadi allowing counting to only one side from the track. In Wadi Nukhailan (mean wadi width 600 m) the count route (13.2 km) runs in the middle of the wadi, allowing for counting on both sides of the track. All count routes necessarily double back over themselves due to the constraints imposed by the landscape (i.e. elongated, narrow wadis). Each count therefore included only gazelles encountered during the inward journey, while animals encountered during the return journey were neglected. Independent of season, all counts started at sunrise and

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