The reintroduction of Mountain gazelle
*Gazella gazella*

in Saudi Arabia

KEVIN M. DUNHAM, TERENCE B. KICHENSIDE, NICK LINDSAY1, FRANK E. RIETKERK2 & DOUG T. WILLIAMSON

The Zoological Society of London, Regent’s Park, London NW1 4RY, Great Britain and King Khalid Wildlife Research Center, NCWCD, PO Box 61681, Riyadh 11575, Saudi Arabia

Populations of large mammals throughout Saudi Arabia have declined dramatically during recent decades as a result of excessive hunting, using modern firearms and vehicles, and habitat degradation, largely due to overgrazing by domestic livestock (Alwelaei, 1989). The number of domestic animals increased sharply after oil revenues were used to subsidize the ownership of livestock. The purchase of water tankers and the drilling of boreholes were also subsidized and, as a result, pastures which were distant from permanent sources of drinking water and which previously were used seasonally, when rain provided temporary water sources, are now accessible to domestic livestock throughout the year. Some wild animals, such as the Cheetah *Acinonyx jubatus* and Arabian oryx *Oryx leucoryx*, became extinct in Saudi Arabia, while others, for example, the Mountain or Arabian gazelle

1Present address: Whipsnade Wild Animal Park, Dunstable, Bedfordshire LU6 2LF, Great Britain.

2Present address: Noorder Dierenpark Zoo, Biochron, Emmen, The Netherlands.
Gazella gazella and Sand gazelle Gazella subgutturosa marica, survive only in small numbers, occupying very limited parts of their former geographical ranges (Thouless et al., 1991).

The National Commission for Wildlife Conservation and Development (NCWCD), a Saudi Arabian government agency, is attempting to establish a network of protected areas throughout the country (Child & Grainger, 1990). Where suitable habitat is available, species which have recently become extinct in all or part of their range will be reintroduced into protected areas which lie within their former range (Buttiker & Grainger, 1989). The objective of the reintroductions is to restore the biological diversity of these areas to that which existed during the early part of this century. This paper describes a project by the Zoological Society of London and NCWCD to reintroduce Mountain gazelle into part of their former range in Saudi Arabia and reports on progress until the end of October 1992.

THE COLLECTION
Gazelles for reintroduction were available at the King Khalid Wildlife Research Center at Thumamah, 50 km north of Riyadh, where the climate is similar to that of the reintroduction area. All the gazelles released during this project are believed to have been born in captivity at the Center and in some cases the parents were known. There is no documented history of the gazelle collection between its establishment by the late King Khalid in 1980 and 1987 when the responsibility for management of the Center was given to the NCWCD. Thus, little is known about the number of founders or their origins. Because tagging of the gazelles in the collection started only in 1988, the age of animals born before 1987 is not known. Prior to 1987, management of the collection was poor and some animals died from malnutrition, injuries and disease (K. Habibi, pers. comm.). Since late 1987, the Center has been managed by The Zoological Society of London on behalf of the NCWCD.

Mountain gazelles at the Center are kept either in a large (> 50 ha) enclosure containing adults and young of both sexes, or in small pens. A major consideration in the management regime at the Center is the requirements of a programme to eradicate bovine tuberculosis, caused by Mycobacterium bovis, and the maintenance of small, isolated groups of gazelles is an integral part of this programme. The groups consist of either a single adult ♂ with several ♀♀ and their young, or several adult or subadult ♂♂. Each group selected for release comprised the animals from one pen. An advantage of this selection procedure was that it was known before the reintroduction that the animals were compatible with each other. A disadvantage is that, in a group containing adults and young, there was often a relatively high degree of relatedness between individuals. However, as far as was known, the adults were always unrelated.

The first group to be released comprised 19 gazelles, 1.7 adults (that is, over two years old), 2.3 subadults (between one and two years old) and 1.5 juveniles (less than one year old). For ease of transport, later releases were of smaller groups. To maximize the genetic diversity of the population as far as possible, the second and subsequent groups released were chosen because the gazelles in the group were unrelated to those already released.

Veterinary preparations Healthy gazelles free of TB were selected for the reintroduction. Jaws and teeth were examined for lumpy jaw (abscesses caused by Actinomyces pyogenes and/or Fusobacterium necrophorum infection). After the death of one animal in the pre-release pen from necrobacillosis following a foot infection, care was taken to avoid animals with badly worn hoofs.

With the exception of tuberculosis, no serious contagious or infectious diseases
have been evident in the collection. Vaccinations for various diseases which are known to occur in the region need to be repeated regularly, which would not be possible for released animals. However, the first gazelles for release were given a vaccination against rinderpest, which gives good protection against peste des petits ruminants (PPR), a disease which occurs in the area and which is caused by a virus very similar, if not identical, to that causing rinderpest. Theoretically at least, one vaccination provides lifelong immunity. The last group of gazelles to be released was also vaccinated against foot-and-mouth disease, rabies and pasteurellosis. Although parasites were not considered to be a serious problem at the Center, it was thought that the move and release might be stressful for the animals and might lead to diminished immuno-competence. In order to kill the most prevalent internal parasites, faecal samples from gazelles selected for release were examined for parasites and infected animals were treated with ivermectin (Ivomec) (1 ml) injected subcutaneously.

**TB testing** The gazelles at the Center were subjected to a testing regime for TB which involved testing on three occasions, with at least three months between test periods. The procedure relied mainly on serological techniques, particularly the enzyme-linked immunosorbent assay (ELISA) test which was conducted in the Center's laboratory. The few animals which gave equivocal results for the ELISA test were not used for reintroduction unless subsequent tests were negative or revealed only the avian TB *Mycobacterium avium*. Avian mycobacteria do not appear to cause disease in gazelles, unless the animals are so debilitated that their immune system fails. Juveniles were considered to have the same test status as their mother; for example, an infant born to a ♀ which had been tested twice with negative results was considered free of the disease if one test was negative.

At the same time as one of the ELISA tests, an intradermal skin test was conducted on each animal using 0.1 ml of bovine PPD (purified protein derivative) obtained from the Centraal Diergeneeskundig Instituut, Lelystad, The Netherlands. Any changes in skin thickness were noted when the result was read after 72 hours.

When a blood sample was collected for the third ELISA test, a BTB (Blood Tuberculosis) test was also conducted, using a heparinized blood sample sent to the Deer Research Laboratory at the University of Otago in Dunedin, New Zealand. The BTB is a combined test which measures TB antibodies, lymphocytes and the inflammatory response to *Mycobacteria*. Individuals for which the results were positive or equivocal were culled and examined post mortem for lesions. No lesions were found in gazelles with avian titres.

**REINTRODUCTION AREA**

The reserve at Hawtah, known locally as the Special Ibex Reserve, is 150 km south of Riyadh in central Saudi Arabia (c. 23° 30'N and 46° 30'E) (Fig. 1). Rainfall is extremely variable from year to year throughout the region (Mandaville, 1990). Although mean annual rainfall in this area is about 50 mm (Habibi & Grainger, 1990), during 1991–1992 it was 115.5 mm. Precipitation is mainly confined to winter

![Fig. 1. Location of the King Khalid Wildlife Research Center and the Hawtah Reserve in central Saudi Arabia.](image-url)
and spring (November to April) and occasionally there are brief but heavy hailstorms. Frost may occur during winter. Summer is dry and very hot. Annual evaporation at Al Kharj, 100 km north-east of the reserve, is 3070 mm (Mandaville, 1990).

The reserve, which covers some 2000 km², comprises a gently undulating, stony, limestone plateau, 800–1100 m above sea level. Plant biomass is low but is higher on the floor of several deeply incised wadi systems which dissect the plateau. *Acacia* bushes dominate the wadi vegetation and despite the low standing crop of plants, over 260 plant species grow in the area (E.F. Robertson & S. Collenette, pers. comm.). Some 1200 domestic Arabian camels *Camelus dromedarius* feed in the reserve. Domestic sheep *Ovis aries* and goats *Capra hircus* forage in some wadis and their number may increase to a few thousands in the months following high rainfall. The reserve also contains a nationally important population of about 250 Nubian ibex *Capra ibex nubiana*, with the highest density in the central wadi system, which is traditionally not used by sheep and goats. Potential predators include wolves *Canis lupus* (rare), feral dogs *Canis familiaris* (occasional) and Red foxes *Vulpes vulpes* (common), as well as migratory eagles.

The only parts of the reserve which are protected from camel foraging are the heads of two adjacent steep-sided wadis, Wadi Ghaba and Wadi Ghafar, which are part of the Wadi Matham system. During 1990, a 2 m high fence was erected across the mouth of both wadis to exclude camels but permit the movement of ibex and the gazelles. The Wadi Matham system is not used by domestic sheep or goats.

Local residents report that Mountain gazelles lived in the area of Hawtah reserve until they were eliminated by hunting about two decades ago. Recent reports of sightings indicate that very
small numbers of gazelles may occur in wadis to the north and south of the reserve, but the future prospects for these animals are probably poor. NCWCD rangers, one of whose main functions is to prevent hunting, are permanently resident in the reserve. They were informed about the project in advance and were involved in caring for the gazelles during the pre-release phase. To date, they have been successful in preventing hunting of the gazelles. The civic leaders of the local towns have been kept informed and, although the local people do not object to the project, there is some resentment of the camel fences which also act as barriers to vehicles. As well as using the reserve as communal grazing land for domestic animals, the people use the area for recreation, particularly picnicking and camping during the winter.

RELEASE SITES
Wadis Ghaba and Ghafar, about 700 m above sea level, are west-to-east draining wadis. Generally their sides are scree slopes with little vegetation cover, below near-vertical rock walls. The woody vegetation of the wadi floor is dominated by *Acacia tortilis* and *Acacia ehrenbergiana* bushes. After two years of protection from camels, *Acacia* bushes have noticeably larger canopy volumes than unprotected bushes and the herbaceous standing crop is also greater than in unprotected areas. In both wadis, there is a seep where reeds *Phragmites australis* and rushes *Typha domingensis* grow and where surface water can be found for several months after rain. The period of water availability during summer varies with the quantity and timing of rainfall during winter. In Wadi Ghaba, there is also a spring where water can be found throughout the year. Water is found in the river beds for only the few days after rain. Heavy rainfall (for example, 52.5 mm over three days during February 1992) causes widespread flooding in the wadis. Wadi Ghaba, the larger of the fenced wadis with a floor area of c. 3 km², was chosen as the site of the first releases.

PRE-RELEASE PHASE AT HAWTAH RESERVE
The gazelles were transported from KKWRC to the reserve by road, each animal contained in an individual crate. A rectangular pen of 0.25–0.5 ha was built in each wadi. The first of these was 2 m high with the lower half consisting of sheep electric fencing and the upper half of chicken wire. Because of the dry conditions the electric fence worked with reduced efficiency and subsequent pens were entirely of chicken wire. The pen was positioned to enclose a variety of natural vegetation, including grasses, forbs and bushes, so that the gazelles were exposed to a range of potential foods. Large boulders and *Acacia* bushes provided shady resting sites. A water trough was provided at one end of the pen and once the animals were released, a similar trough was placed outside. No drugs were used during transport but, at least ten minutes before being transferred from the crate into the pen, each gazelle was injected intravenously with haloperidol, 10 mg being the standard dose for an adult. Without the tranquillizer the gazelles tended to panic and run into the fence.

While in the pen, the gazelles were fed daily with alfalfa hay and concentrate food pellets. The first group remained in the pen for four weeks but observations revealed that they quickly settled into the new environment; within two weeks they were eating plants growing in the enclosure and some ♂♂ were mating with the ♀♀. Later groups therefore were penned for a minimum of two weeks before release.

The first group of gazelles was released into Wadi Ghaba during January 1991, although a few animals had escaped from the pen during the previous month. Another two groups were released during June and July. Three groups were released into Wadi Ghafar during 1992. To effect the release, one of the short sides of the
pen was removed and the animals allowed to find their own way out in their own time. Hay was provided near the outside water trough for about two months after release but after the first few days it was often ignored. After the first release, mineral salt blocks were provided because the animals had been used to them at KKWRC but they were ignored by the animals at Hawtah. Drinking water was provided throughout the year at one trough in each of the wadis.

One subadult ♂ died in the pre-release pen. Six days after arrival it was seen limping and was found dead ten days later. Post-mortem examination revealed that it had died from necrobacillosis due to an old hoof injury. Except for animals kept in stables during veterinary treatment, foot injuries were rare at KKWRC. This animal has been excluded from the data on the releases because it died while still in captivity.

POST-RELEASE MONITORING
During 1991, 10.19 gazelles were released, followed by 8.17 in 1992. The youngest animal was about one month old and the oldest was at least five-and-a-half years old. All released gazelles were ear-tagged, with differing colours, shapes, sizes and positions of the tags permitting the recognition of all individuals. In addition, 22 animals were fitted with a radio-collar before they were placed in the pre-release pen so that they could become accustomed to it. An intensive monitoring programme followed the releases; radio-collared animals were located on over 100 days during both 1991 and 1992.

Survival Three gazelles have disappeared and, in the absence of evidence to the contrary, are assumed to be dead. Eleven others are known to have died. For the animals monitored for more than one year, first year mortality was 34–45% (Table 1). During January 1992, four animals were killed and eaten by a wolf, which was seen twice, once when chasing an adult ♀ which it killed two days later and the second time near the carcass of a second ♀ which it had killed. A fifth gazelle disappeared during the same month. During May 1992, two gazelles were killed and eaten by a large canid and it is assumed that a wolf or wolves were also responsible for these deaths. Another ♀ was found dead 6 km from his territory and, although not killed by a wolf, it is thought probable that he was chased by one, as it was the first recorded instance of his leaving the territory. It is likely therefore that seven deaths and one disappearance were due to wolf predation or activity. No gazelles died when the wadis were flooded during February 1992.

Two adult ♂, aged three years, died from dehydration nine and ten days after release in June 1991. Post-mortem examination also revealed the presence of plastic netting in the rumen. These animals either did not find or did not use the water trough which was less then 200 m from the pen. Since the pen was already in use for another group, the two ♂ could not use the trough in the pen and ignored a small trough placed for them outside it. Although the internal trough was moved to make it accessible from both inside and outside the pen, it

<table>
<thead>
<tr>
<th>PERIOD AFTER RELEASE</th>
<th>NO. MONITORED</th>
<th>NO. DISAPPEARED</th>
<th>NO. DIED</th>
</tr>
</thead>
<tbody>
<tr>
<td>One month</td>
<td>54</td>
<td>1</td>
<td>2–3¹</td>
</tr>
<tr>
<td>Three months</td>
<td>54</td>
<td>2</td>
<td>3</td>
</tr>
<tr>
<td>12 months</td>
<td>29</td>
<td>2–3¹</td>
<td>8–10</td>
</tr>
<tr>
<td>21 months</td>
<td>19</td>
<td>3</td>
<td>11</td>
</tr>
</tbody>
</table>

¹For some individuals the date of death was not known precisely.

Table 1. Mortality of Mountain gazelles Gazella gazella released into Hawtah reserve during 1991 and 1992. The numbers of disappearances and deaths are cumulative throughout the 21-month period.
was too late to save them. Since this incident, water has always been available outside the pen, only about 10 m from the inside trough. Four other animals released at the same time survived without apparent problems.

An adult ♂, aged at least four-and-a-half years, died about five months after release. Because of the advanced state of decomposition no cause of death could be established by post-mortem examination. Of the 25 released in 1992 only one, a ♂ aged at least five-and-a-half years, died; this occurred between six and ten weeks after release but the carcass was not found until several weeks after death.

During the first year after release, mortality of animals less than two years old when released was lower than the mortality of animals which were more than three years of age (Fig. 2) (14±67%; $G_{adj} = 8.3; df = 1; P < 0.01$).

**Births** There were at least 38 gazelles born from March 1991 to October 1992. At least 27 of these were conceived in the wild. Births occurred in all months of the year except December. For young conceived in the wild, there were peaks in the seasonal distribution of births during July–August 1991, January–February 1992 and August–September 1992. All the calves were singletons. Seven ♀♀ are known to have produced three calves each since release. For the first few weeks of life, youngsters were frequently alone, resting under bushes.

All 14 of the young born during 1991, including those born during the hot summer months, were alive at the end of that year. The behaviour of gazelles born in the wild at Hawtah was not obviously different from that of their captive-born parents.

**Food and water** The released gazelles and their offspring were mixed feeders, eating grasses, forbs and shrubs. One surprising discovery was the fact that they frequently ate the leaves of the shrub *Calotropis procera*. Both growing and fallen leaves were eaten. Occasionally gazelles were observed to stand on their hind legs, resting the forelegs on the bush, to reach leaves growing above their normal level. Latex from *Calotropis* leaves contains the cardiac glycoside calotropin (Miller & Morris, 1988) and the leaves are not eaten by domestic livestock, including the camels in the reserve. Since the 1991/1992 winter, a browse line has been apparent on the *Calotropis* bushes growing behind the camel fence, whereas none was present where the camels foraged.

Gazelles were occasionally seen to drink from the water troughs. Rarely a territorial ♂ was seen outside his territory near the trough. However, although regular checks were made for footprints, there was no evidence that any gazelles drank at the perennial spring in Wadi Ghaba and few have been seen as far up the wadi as the seep. The evidence available suggests that the gazelles did not drink water frequently. However, since most visits to monitor the animals were made during the day, the possibility that they drank from the trough more often at night cannot be eliminated.

**Ranges** Adult ♂♂ established exclusive ranges from which other ♂♂, including
subadults, were excluded. Males holding adjacent territories were occasionally seen to engage in ‘air-cushion fighting’, that is, fighting as though an invisible cushion is present between their horns (Habibi et al., 1993). Territory size decreased as additional animals were released and the density of $\Delta$ increased. Subadult $\Delta$ often shared their range with other subadult $\Delta$ and adult $\varnothing$ had ranges which were often larger than $\varnothing$ territories, so that they moved through the territories of several $\varnothing$. There was considerable overlap between the ranges of $\varnothing$, although $\varnothing$ with overlapping ranges were often alone or accompanied only by their offspring. The most common sighting was of one or two adult $\varnothing$, one or both accompanied by a juvenile, sometimes with an adult $\varnothing$ but often without.

The majority of released gazelles stayed within the fenced sections of the wadis, but animals born in the wild and some of the released gazelles became permanently resident outside the fenced areas. Most released gazelles have established ranges within 5 km of their release site but two wild born animals were seen 17 km east of their parents’ release site. Three animals released into Wadi Ghafar moved to Wadi Ghaba, a journey of only 3 km, where they were regularly seen in the company of animals released into that wadi. This evidence of mobility justifies the decision to treat the animals in the two wadis as a single population for the purpose of genetic management.

DISCUSSION
Monitoring of the behaviour and ecology of the released animals revealed that there were important similarities with the behaviour of wild populations. Mountain gazelles in Lower Galilee, Israel, are also mixed feeders, eating mainly grasses during the winter and an increasing proportion of woody browse during the dry months (Baharav, 1981). The social behaviour of the released gazelles, in particular the territorial behaviour of the adult $\Delta$ and the small group sizes, is similar to the behaviour of gazelles in the northern Negev region of Israel and on the Farasan Islands in the Red Sea (Walther et al., 1983; Habibi et al., 1993). Breeding throughout the year has also been reported on the Farasan Islands (Habibi, 1992). High survival of the summer-born young at Hawtah, compared with the captive animals in the large enclosure at KKWRC, is probably due, at least in part, to the numerous shady resting sites provided by boulders and shrubs at Hawtah. By hiding, new-born animals were able to reduce their exposure to solar radiation, predators and the attentions of adults other than their mother.

Predation by wolves or a wolf was the principal cause of death. This had not been anticipated before the reintroduction because large carnivores are rare in Saudi Arabia. The reintroduced gazelle population will be vulnerable to extermination by wolves, a natural predator, as long as they are present in relatively small numbers in only two adjacent wadis. However, as the size and range of the population within the reserve increases, the threat which predation poses to the success of the reintroduction will probably diminish. The planned release of gazelles into a third wadi, more than 20 km south-west of the previous sites, during 1993 should increase the size and range of the population.

During the reintroduction of zoo-born Golden lion tamarin *Leontopithecus r. rosalia* in Brazil, it was found that young animals survived longer after release than old animals (Kleiman et al., 1991). At present, it is unclear whether the higher survival of young gazelles at Hawtah is due to the higher life expectancy of young as compared with older animals or the ability of the young to adapt to new conditions better than older individuals. Animals at KKWRC which were more than three years old during 1991, were born to parents which had received an inadequate diet. Thus, it is likely that their birth mass was low and their growth rate slow. In Red deer *Cervus elaphus* the
effect of low birth mass is apparent during later life, leading to low adult size and rank (Albon et al., 1983). It would not be surprising if this also applied to other ungulates. Thus older gazelles released at Hawtah may have been less fit than younger animals not only because of age but also because their nutritional status in early life was poor. If this theory is correct, with the improved management techniques now in use, the survival of older gazelles released during future reintroductions should improve. A reflection of previous poor management is the presence of foreign objects in the rumen of some older animals.

The gazelles in Hawtah are surviving without management intervention except for the provision of drinking water. However, the importance of the water troughs is unclear and further study of their use is planned to determine if the animals would survive without this provision. Mountain gazelles live on the Farasan Island despite the absence of permanent sources of freshwater for drinking (Habibi, 1992).

The vegetation of most of Hawtah reserve is heavily utilized by resident domestic livestock, whose owners daily provide them with supplementary food, suggesting that the density of livestock exceeds the carrying capacity of the vegetation. The owners also take water to their stock, thereby maximizing the time that the animals can spend in the reserve. There is little doubt that the high livestock numbers will reduce the potential size of the gazelle population. It is estimated that several hundred gazelles could live in the reserve even with the present high density of domestic livestock but if the domestic animals were removed, a gazelle population of several thousands is likely. At present, there appears to be little interaction between the gazelles and the ibex. Ibex feed in the wadis during the summer and autumn, but they also feed on the scree slopes, which are used by the gazelles for resting but not for feeding.

It is still too early to judge if the reintroduction will be successful but progress so far is very encouraging. The number of births is more than double the number of
deaths and the NCWCD rangers have been successful in preventing hunting of the reintroduced population.

ACKNOWLEDGEMENTS

The NCWCD rangers at Hawtah are thanked for their work with the gazelles. The reintroduction described here represented the culmination of a major management programme at KKWR, which involved the capture of and health checks on hundreds of gazelles. All the staff, past and present, of KKWR contributed to the programme, in which Saeed Mubarek and Hany Tawwany played major parts. Our thanks to Nigel Brown, Khushal Habibi and Fay Robertson for commenting on a draft of this paper. The reintroduction was funded by the NCWCD.

PRODUCTS MENTIONED IN THE TEXT

Haloperidol: tranquilizer (20 mg ml⁻¹), manufactured by Kyron Laboratories Pty Ltd, 84 Main Reef Road, Benrose 1094, South Africa.

Ivomec: anthelmintic injection (1% weight by volume of ivermectin), manufactured by MSD Agvet, Hertford Road, Hoddesdon, Herts EN11 9BU, Great Britain.

REFERENCES


Manuscript submitted 15 December 1992