THE RETURN OF ARABIAN ORYX, *Oryx leucoryx*, TO THE SAUDI ARABIAN EMPTY QUARTER: DISEASE MONITORING FOR THE REINTRODUCTION PROCESS

Marc Ancrenaz, DVM*, Stéphane Ostrowski, DVM, Alain Delhomme, Technical Breeder
National Wildlife Research Center, P.O. Box 1086, Taif, Saudi Arabia

Introduction

The Arabian oryx, *Oryx leucoryx*, became extinct in the wild in 1972.[12] An intensive captive breeding program was established at the National Wildlife Research Center (NWRC), Taif, Saudi Arabia, in 1986 for the propagation and reintroduction into the wild of this antelope.[1] Following successful reintroduction into the Mahazat as-Sayd reserve, the National Commission for Wildlife Development and Conservation decided to release Arabian oryx into the desert of Rub al Khalib or Empty Quarter. Thirty-three animals were translocated and released in 'Uruq Bani Ma'arid protected area at the beginning of 1995.[2]

This paper presents the evaluation, the monitoring, and the control of disease agents with the potential to jeopardize the reintroduction process. Disease is here defined as "any impairment that interferes with or modifies the performance of normal functions, including responses to environmental factors such as nutrition, toxicants, and climate; infectious agents; inherent or congenital defects, or combinations of these factors."[19]

Monitoring and control of infectious agents

The translocation and reintroduction of captive Arabian oryx bred at the NWRC carries with it the risk of introduction of new diseases into the release area by the translocated oryx, and the risk that the released animals themselves will be vulnerable to diseases normally present at the release site.[11]

Sanitary care of the captive Arabian oryx bred at the NWRC

Shortly after the captive breeding of oryx was established at the NWRC, an outbreak of tuberculosis (TB) caused by *Mycobacterium bovis* occurred in the founder stock (called A-generation).[5] All the oryx present in the breeding were considered infected and were treated with isoniazid (10 mg/kg body weight), ethambutol hydrochloride (15 mg/kg BW), and rifampicin (10 mg/kg BW).[9] The treatment was given in drinking water every day for 9 months. Since the outbreak of TB, the calves (called B-generation) born from the founder animals are removed from the dam immediately after birth, and are hand-reared.[6] The B generation oryx in turn produce C-generation, mother-bred animals, suitable for reintroduction into the wild. Indirect and comparative ELISA tests are carried out regularly on the whole captive herd. Results of the serological tests show that the sanitary and medical measures undertaken at the NWRC have been successful in eradicating tuberculosis (Table 1). The releasable C-generation animals are free of tuberculosis.

Serological surveys carried out on the captive oryx[8] showed that *Brucella abortus*, *Pasteurella multocida* (types B and D), and *Akabane virus* occurred with an extremely low prevalence in the captive-breeding, while *Coxiella burnetti*, *Chlamydia psittaci*, *P. multocida* (type A), and *Parainfluenza 3 virus* occurred with a low but significant prevalence (Table 2). Infected animals are isolated from the reproductive herd, for as long as sero-conversion is associated with clinical symptoms.

The relatively high number of sero reactions against *P. multocida* and the absence of clinical symptoms confirms the possible free carriage of this bacterium in Arabian oryx. Stressful situations related with capture operations, crating, and transportations tend to produce a clinical recrudescence of a latent pasteurellosis in the captive oryx. In 1991 and 1992, four oryx died of acute pasteurellosis within 10 days following translocation. All the captive born animals are now injected with an inactivated vaccine (Lysopast, virus strains A and D, Rhône-Mérieux, France) at birth and once every year thereafter.

Lumpy skin disease (LSD) was first identified in Saudi Arabia in a captive Arabian oryx in 1989 (Ethiopia 1 strain).[7] One adult female showed a symptomatic infection and spontaneously recovered. Sheep freshly imported from African countries with LSD, could have been carriers of the virus and the origin of this infection. Arabian oryx appears to be fairly resistant to Capripoxviridae infection and since 1989, no symptoms of LSD infection have been recorded at the NWRC.

In order to avoid contact or even close proximity between the domestic stock and the oryx held at the NWRC, a fenced cattle-free area of 40 square kilometers has been established to isolate the captive breeding from the surrounding grazing range.

In addition, coprologic analyses are frequently carried out and show that a very low level of internal and external parasitism occurs in the breeding. All the animals are injected with 0.2 mg/kg BW SC ivermectin (Ivomec, MSD AGVET, Paris, France) at least once a year.

Diseases encountered by translocated animals at the release site

The Arabian oryx appear to be susceptible to most pathogenic bacteria and viruses which may affect domestic ungulates.[14] According to the data available from the FAO Animal Health Yearbook and from the Saudi Ministry of Agriculture, the main infectious diseases present in the Kingdom are brucellosis, rinderpest, peste des petits ruminants, foot and mouth disease, bovine enzootic leukosis, and rabies. All captive oryx are vaccinated annually against rinderpest (Kabete strain type 0, Saudi Arabia Veterinary and Vaccines Institute, Saudi Arabia), rabies (Rabisin, Rhône Mérieux, France), foot and mouth disease (Aftovax, virus types O and C Asia 1, Rhône Mérieux, France), and pasteurellosis.

Anthrax and botulism occur sporadically in Saudi Arabia. Previous veterinary surveys failed to show that these diseases were enzootic in the proposed release sites of Arabian oryx within the Kingdom. So far, the oryx to be released have not been vaccinated against these

two diseases. In Oman, botulism caused the death of three adult zoo-bred Arabian oryx imported from USA and reintroduced into the wild.[17]

Sanitary preparation of the oryx to be released

Two months prior to the relocation, the oryx are isolated from the rest of the herd, kept in pre-translocation enclosures, and are boma-trained. During this period, they are injected with a booster dose of rinderpest, rabies, foot and mouth disease, and pasteurellosis vaccines. They are also dewormed and treated against external parasites. All the animals are blood sampled. Serial sera are kept frozen in a sera bank for each individual. Tuberculosis ELISA tests are carried out: two successive negative results are required before the reintroduction of any oryx. During the period of boma training, the animals are under a close veterinary surveillance and only the clinically healthy animals are moved to the new protected areas.

Monitoring and control of genetic fitness

Genetic constitution of the oryx population to be released

The genetic management program held in Taif aims to maintain at least 90% of the genetic variation in the original population over a period of 200 years[16] and to produce animals genetically fitted to survive in the wild. This goal is achieved in different ways.

- Maximization of the genetic diversity: Although the pedigree of most founders originating from the Late King Khalid Farm at Thumamah was unknown, a study of allozyme variation showed that the mean heterozygosity in the founder stock was relatively high and reflected the diverse origins of the animals.[18] In order to maximize the genetic diversity of the founder stock, animals from Bahrein (2.1), Qatar (4.1), Abu Dhabi (1.1) and USA (4.0) were imported from 1990 to 1994. These animals were included in the A generation of oryx to guarantee a good spread of their gene pool. Today, the captive herd of oryx held in Taif is the most genetically diverse in the world.

- Equalization of the Founder Representation and maximization of the effective population size: Because of the management of three different generations, some founders are still under-represented in B- and C-generations. When groups of captive-bred oryx are reintroduced in a new protected area, the missing or under-represented genetic lineages are added via the importation of oryx originating from Europe or via the relocation of wild born animals caught in Mahazat as-Sayd reserve.

- Management of the inbreeding: In small captive populations of ungulates, inbreeding induces a reduction in survival and reproduction rates and a decrease in resistance to disease.[15] The effects of the inbreeding depression become apparent when the inbreeding coefficient reach a value of 0.125 (one common grandparent). In Oman, survival of

wild-born juvenile Arabian oryx was reduced when the inbreeding coefficient exceeded 0.076;[17] far below the 0.125 value. This might reflect the more severe selective pressures to which desert-born oryx calves are subject, compared to animals kept in captivity.

In Taif, since the pedigree of the founders coming from Thumamah is unknown, it has been assumed that two different founders had one common grandparent. The matings to produce B and C generation oryx are managed in such a way to as possible avoid any known genetic relationships between the sire and the dam. Inbreeding coefficients of B and C generation oryx are ranging between 0.016 and 0.031, 0.008, and 0.031 respectively.

Management of the 17:19 Robertsonian Translocation

Cytogenetic studies of the captive population held in Taif revealed the presence of a chromosomal Robertsonian Translocation resulting from the fusion of the chromosomes 17 and 19.[4] The translocation spread out from oryx imported from Qatar, and is inherited according to a Mendelian co-dominant mode. A 17:19 translocation is not usually expressed phenotypically, but a reduced fecundity in heterozygotes has already been reported in cattle.[12] Following a workshop of the International Wild Arabian Oryx Panel, held in 1990 in London, it was decided to not reintroduce the carriers of the translocation into the wild, but to reintroduce only individuals with the normal karyotype (2n=58). The translocated oryx do not take part in the captive breeding programs, with the exception of a few individuals that have a high genetic value. Before being reintroduced in protected areas, the oryx are systematically karyotyped.

Environmental factors

The aim of reintroducing oryx in Saudi Arabia is to re-establish the species in several populations within the Saudi Arabian range that was documented in the 1930's. Today, five protected areas totalizing about 5000 square km and established within the former range of the species are managed by the NCWCD and are potential sites for the reintroduction of oryx.

Previous reintroduction of Arabian oryx in Mahazat as-Sayd

The first reintroduction of oryx in the Kingdom was carried out in 1990 in Mahazat as-Sayd, a 2200 square km protected area.[10] A study carried out to assess the quantity and quality of the plants preferred by oryx showed that the area could meet the species' nutritional requirements.[3] A fence was erected to preclude illegal hunting and domestic stock. Sixty-eight oryx representing from all the different blood lines of Arabian oryx found in the world, were released between 1990 and 1993. The population of Arabian oryx has shown a rapid constant growth and at the beginning of 1995, it numbered 180 animals. The sex and age structure reflected a good future reproduction potential with a predominance of young animals. Natural mortality rates have been very low and the main cause of mortality was injuries inflicted during fights, with at least 12 recorded instances. When reintroduced into

suitable protected habitats, captive born oryx have shown that they were able to survive and to generate self-sustainable populations. In Mahazat as-Sayd, the released animals have survived without drinking; there is no permanent water point in the reserve. They also learnt to graze the native vegetation with no apparent ill-effects.

Reintroduction of Arabian oryx in Uruq Bani Ma'arid

Wildlife vanished from Uruq Bani Ma'arid as a result of over-hunting. The reserve is a complex linear system of reddish sand dunes dissected by numerous eastward-draining wadis. The wadis are covered by a rich and varied vegetation suitable for the reintroduction of Arabian oryx. Thirty-three oryx (28 captive born animals, bred at the NWRC; 5 wild born animals caught in Mahazat as-Sayd) were translocated and released in early 1995 into the unfenced reserve. The two main threats to the operation are the occurrence of illegal hunting and the heavy overgrazing associated with large numbers of camels found in the reserve. Camel surveys have shown that between 100 and 300 camels graze in the 2000 square kilometer core area of the reserve where the oryx have been released.[19] This may result in strong competition for food between the released animals and the camel herds.

Conclusion

When illegal hunting and competition for food with domestic animals were prevented, previous reintroductions of Arabian oryx in Saudi Arabia have shown that healthy captive-born animals are able to establish self-sustaining, free-ranging populations. The new reintroduction process of Arabian oryx carried out in the Empty Quarter will determine if animals are still able to survive in the wilds of Saudi Arabia, where environmental conditions have been extensively modified as a result of the tremendous increase in domestic animal numbers, since the extirpation of the oryx.

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	Generation	1986	1987	1988	1989	1990	1991	1992	1993	1994
Population	A	48	55	45	42	43	44	-	47	49
	B	-	-	16	17	31	61	85	-	109
	C	-	-	-	-	-	15	11	-	20
Low risk	A	37 (77%)	25 (45%)	11 (24%)	30 (72%)	39 (91%)	38 (86%)	-	15 (31%)	45 (92%)
	B	-	-	8 (50%)	17 (100%)	29 (94%)	52 (85%)	77 (91%)	-	100 (92%)
	C	-	-	-	-	-	15 (100%)	11 (100%)	-	20 (100%)
Doubtful	A	9 (19%)	22 (40%)	25 (56%)	6 (14%)	3 (7%)	6 (14%)	-	29 (61%)	3 (6%)
	B	-	-	7 (44%)	0	2 (6%)	9 (15%)	8(9%)	-	9 (8%)
	C	-	-	-	-	-	0	0	-	0
High risk	A	2 (4%)	8(15%)	9 (20%)	6 (14%)	1 (2%)	0	-	4 (8%)	1(2%)
	B	-	-	1 (6%)	0	0	0	0	-	0
	C	-	-	-	-	-	0	0	-	0

TABLE 1. Progression of tuberculosis infection in the N.W.R.C. Arabian oryx herd from 1986 to 1994.

Pathogens	1987	1988	1989	1990	1993
Pasteurella multocida (type A)	5/19	4/38	5/58	6/78	-
Pasteurella multocida (type B)	0/19	0/38	1/58	0/78	-
Pasteurella multocida (type D)	0/19	0/38	4/58	1/78	-
Lumpy skin disease	1/19	1/38	1/58	2/78	-
Parainfluenza 3 virus	6/19	6/38	10/57	12/78	0/13
Coxiella burnetti	0/18	4/35	7/50	6/72	2/13
Chlamydia psittaci	1/18	0/35	2/51	5/74	0/13
Brucella abortus	0/19	1/38	0/56	1/78	0/13
Bluetongue virus	0/19	0/38	0/58	1/78	-
Akabane virus	0/19	0/38	0/58	0/77	-
Paratuberculosis	-	-	-	-	0/13
Leptospirosis (13 serovars)	-	-	-	-	0/13
Bvine viral diarrhea	-	-	-	-	0/13
Leucose	-	-	-	-	0/13

TABLE 2. Prevalence of antibodies to bacterial and viral pathogens in the captive herd of Arabian oryx held at the NWRC.