An outbreak of tuberculosis in a captive herd of Arabian oryx (*Oryx leucoryx*): management

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An outbreak of tuberculosis due to *Mycobacterium bovis* in a herd of Arabian oryx (*Oryx leucoryx*) was managed by sanitary and medical measures. The sanitary measures included the isolation of infected animals, the monitoring of animals with a range of diagnostic tests and the hand-rearing of the progeny of the infected herd. All the infected oryx were treated with a mixture of isoniazid at 10 mg/kg bodyweight, ethambutol hydrochloride at 15 mg/kg bodyweight and rifampicin at 10 mg/kg bodyweight administered daily in the drinking water. These measures resulted in the cessation of mortalities, a decrease in the numbers of moderate and high risk animals and the production of tuberculosis-free animals for reintroduction into the wild.

THE Arabian oryx (*Oryx leucoryx*) is a medium-sized antelope of the subfamily Hippotraginae (Nowak and Paradiso 1983) weighing between 80 and 100 kg. It was considered extinct in the wild by 1972, but was saved from complete extinction by captive breeding programmes (Dolan 1976). The total number of captive oryx now exceeds 1000 animals. In 1986, the National Wildlife Research Center (NWRC) was established by Saudi Arabian authorities to breed and build up stocks of indigenous Arabian fauna, including the Arabian oryx, for their eventual reintroduction into the wild.

An outbreak of tuberculosis due to *Mycobacterium bovis* in the herd of Arabian oryx kept at the NWRC posed a dilemma to its managers. Outbreaks of bovine tuberculosis have been most effectively dealt with by test and slaughter policies (Blood and others 1983). However, the extreme genetic value of the oryx herd and the great cultural attachment that leaders in the Kingdom of Saudi Arabia had for them, precluded any consideration of destroying them. Major difficulties were initially experienced in identifying with confidence those animals which were infected with *M bovis*, in order to separate them from those which were not (Flamand and others 1994). This paper aims to explain how this problem was dealt with, how the disease was contained and how a tuberculosis-free herd was established from the infected founder group.

Sanitary and medical management

The 57 Arabian oryx transported to the NWRC in April 1986 originated from the late King Khalid's private collection in Thumamah near Riyadh (Seitre 1989). In June 1986 one animal suddenly died of tuberculosis (Haagsma and Poilane 1989) and by September 1987, 16 animals had died of the disease. The outbreak, and the problems encountered with the interpretation of the diagnostic tests are described in detail by Flamand and others (1994).

As the main goal of the NWRC herd was to breed oryx for reintroduction into the wild in Saudi Arabia, and there could be no question of releasing infected animals, it was felt by the managers of the herd that drastic measures were needed to clear it of infection. In August 1986, it had to be decided whether it was worth retaining these high risk oryx for reintroduction to the wild. The great genetic value of the herd in relation to the rest of the world herd (Greth and others 1992) held sway, and it was decided to try to eliminate the disease from them.

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Management of the infected herd

From August 1986 the oryx were systematically tuberculin skin tested and bled for an indirect ELISA test (Flamand and others 1994). The oryx were confined to small cages for reading the skin test, and then released into a confined section in an isolated corner of the NWRC. Over the next five months, all the oryx were captured, marked and divided into small groups of one male with five or six females, and placed in 25 ha enclosures containing natural vegetation and supplemented with hay ad libitum, fresh lucerne and concentrate pellets. During this period there was constant uncertainty about the validity of the skin and ELISA tests in the Arabian oryx, particularly because some originally negative animals developed clinical signs and died of tuberculosis, and some positive animals, on post mortem examination, revealed no tuberculous lesions (Flamand and others 1994).

Comparative ELISA tests and lymphocyte transformation tests were introduced to help improve the precision of diagnosis and stratify the disease risk (Flamand and others 1994). Because of recurrent reactivity in the immunodiagnostic tests, it was decided for safety reasons to consider all the oryx that had originally come from Thumamah, and their offspring born at the NWRC up until October 1987, as potentially infected with tuberculosis. This group of oryx constituted what was called the A generation herd. Once this decision had been taken, it allowed a positive management strategy to be developed to deal with the problem of trying to produce a tuberculosis-free herd from the available stock, so that the ultimate aim of reintroducing healthy individuals into the wild could be achieved.

To allow for the monitoring of individual animals, limiting the further transmission of tuberculosis and administering medication the animals were placed in individual enclosures, measuring 8 m by 30 m. These were constructed of ringlock fencing, 1·8 m high. The 42 pens were divided into two parallel blocks of 21, with a corridor in between which allowed access for feeding. Each pen was provided with a fixed hay-rack, manger and drinking bowl and had an area 8 m x 4 m at one end provided with two lateral wall panels and a shade cloth cover for shelter from sun, wind or rain. The sexes were alternated in the pens, so that a female would always be next to a male, and her oestrous period could be detected by the adjacent male's behaviour; no male was adjacent to another male to avoid fights. At the time of its oestrous period, a female would temporarily be moved to the male's enclosure for mating and its treatment would continue while it remained in the male's pen. The animals would remain confined all their life to this isolated corner of the NWRC, though not necessarily in the treatment pens. Males were invariably kept in their pens, but females were allowed out into 2 ha enclosures during their pregnancies, and brought back into the individual enclosures about one month before the expected date of parturition.

Treatment

In May 1987, nine animals which were clearly infected with tuberculosis were first treated experimentally for the disease. Three antibiotics were used: isoniazid (Rimifon; Hoffmann-La Roche) tablets at 10 mg/kg bodyweight, ethambutol hydrochloride (Myambutol; Lederle) tablets at 15 mg/kg bodyweight, and rifampicin (Rifadin; Lepetit) capsules at 10 mg/kg bodyweight. These drugs were adopted after tests had shown that the strain of *M bovis* was sensitive to each of them (J. Haagsma, personal communication).

At first the medication was given dry, mixed with the concentrate pellets. These were eaten once the animal got used to the

TABLE 1: Growth of the herd of Arabian oryx at the National Wildlife Research Center during and after the outbreak of tuberculosis

	May 1986	*1987	1988	1989	1990	1991	1992	1993
Number of oryx (A and B generation)	57	38	46	62	76	97	111	141

* Counted on January 1 each year

taste, but tests showed that the drugs did not attain adequate therapeutic levels in the blood (L. Durand, unpublished observations). The drugs were then dissolved or suspended in water by mixing them in warm water with a magnetic stirrer for one hour. Each animal's dose was then diluted with more water to make it more palatable, but the volume never exceeded 3 litres, so that it would finish it. The medication was given in the mornings, and measurements of the water consumption showed that almost all the animals were drinking at least three quarters of the water. In hot summer weather another 3 litres of water would be given in the afternoons. The oryx were fed only dry food so that they would be sufficiently thirsty to drink the unpalatable medication. The animals were fed on a diet of dried hay ad libitum, a bunch of about 500 g freshly dried lucerne, and 400 g of concentrate pellets containing 16 per cent protein. When provided in the drinking water, the antibiotics attained adequate blood levels for effective therapy. This could have been due to the closure of the oesophageal groove during drinking, so that the medication was delivered directly to the abomasum, whereas when they were given in solid form the drugs were diluted in the ruminal contents.

After the feasibility study was finished and judged to have been successful, all the A generation individuals were treated for nine months, beginning in June 1988.

Management of the tuberculosis-free herd

The calves born after October 1987 were removed from their dams immediately after they were born, so that an infected female could not transmit the infection to her calf either when she licked and sniffed it after birth, or through the milk when the calf sucked. Transmission of the disease in utero was considered unlikely because this form of transmission is rare (Francis 1958) and because the dams were being treated with antibiotics, thus further reducing the likelihood of transmission to the calf. These calves constituted the B generation.

The individual treatment pens made the supervision of the pregnant dams much easier, and whenever a dam was thought to be close to term, it was inspected every two hours during the day and night. The calves were removed as soon as possible after birth and immediately weighed, injected with gammaglobulins (Gammaserine; Sanofi Santé Animale) and given their first bottle of milk replacer mixture about six hours later. Very few problems were encountered with this protocol, the greatest problem being the recognition of the day of impending calving.

The calves were placed in a nursery in isolation for the first eight days of life, and then reared with a maximum of three other similarly aged calves. This peer group of calves lived together for their first year of life until they had all been found free of tuberculosis by the diagnostic tests.

On the basis of this protocol and the clinical state of the animals it was felt that the B generation were unlikely to be infected with tuberculosis. It was decided that they should be tested at one, one-and-a-half and two years of age. After the second negative test the calves could be regrouped if required. Any B generation calf which had repeated positive tests was removed, placed with the A generation animals and treated. The other members of that animal's peer group would then be carefully monitored at three month intervals.

Results

The main significant result was that no death due to tuberculosis occurred after September 1987. Post mortem examinations of 27 oryx which had died of various causes between 1987 and 1992, revealed no gross lesions indicative of tuberculosis infection. No B or C generation oryx showed clinical signs typical of tuberculosis.

As soon as some thinner oryx began to be treated, their condition generally improved.

Table 1 shows the growth in size of the herd between May 1, 1986 and December 31, 1992. Only the A and B generation oryx have been included because the young C generation oryx were introduced into protected areas and left the herd when they were adolescent. Table 2 shows the development of the outbreak of tuberculosis, based on the test results in the years 1986 to 1992, in terms of the numbers of animals with a high, doubtful and low risk of developing tuberculosis. After a maximum number of doubtful and high risk individuals in 1988, the numbers gradually decreased.

The hand-rearing of the B generation proved highly successful. Ninety oryx were hand-reared and only five died before they were weaned at four months, a mortality rate of 5·5 per cent. Two deaths were ascribed to pasteurellosis, one to congenital malformation, one to polyarthritis and one to zootechnical problems. One female which was classified as high risk and showed high levels of reactivity in all the diagnostic tests was transferred from the B generation to the A generation and treated.

Discussion

No similar management exercise had, to the authors' knowledge, ever been attempted on such a scale. The cessation of morbidity or mortality due to tuberculosis during the five year period was an encouraging sign of success. The results in Table 2 are a good indication of the improvement of the herd's status, even if the reliability of some of the tests was doubtful in individual oryx. Four diagnostic tests were used for each individual to define its tuberculosis status, thus minimising the risk of misjudgment should there be an abnormal result in one of the tests (Flamand and others 1994). Moreover, the reliability of the tests at the herd level was more satisfactory.

TABLE 2: Progression of tuberculosis infection in the herd of Arabian oryx at the National Wildlife Research Center from 1986 to 1992

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

The improvement in the condition of the oryx after treatment could have been due to a number of factors other than the cure of the tuberculosis, such as the elimination of social pressure because they were penned individually, the reduction in the amount of exercise and the provision of an adequate food supply. Treatment was successful in controlling the disease as can be seen from the results of the post mortem examination of one oryx that stayed at Thumamah and had always displayed high reactivity to all the tests performed. It was treated for nine months according to the protocol used at the NWRC. The administration of antibiotics was associated with a dramatic decrease in its ELISA titre during the treatment period. Four months after the end of the treatment, the ELISA and lymphocyte transformation tests were negative, suggesting that the animal was no longer harbouring active infection. The animal was euthanased to identify lesions typical of tuberculosis and evaluate the efficacy of the treatment. The lungs showed extensive scar tissue and many fibrotic, nodular, calcified and apparently inactive tubercles. *M bovis* was isolated from one lung lesion which was not completely calcified in the centre and from one lymph node. Only very few bacilli were present (F. Rietkerk and J. Haagsma, personal communication).

The B generation female that was transferred to the A generation was the calf of a female which was always highly reactive to the diagnostic tests. It may have been the result of transmission in utero.

The elimination of tuberculosis from this herd of Arabian oryx was very costly and could be justified only by the rarity of the specimens and their genetic value. The management protocol of treating all the oryx and removing their calves at birth, combined with an improved testing protocol helped to create a tuberculosis-free generation of oryx, whose calves have proved suitable for release into the wild.

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Short Communications

Spongiform encephalopathy in a greater kudu (*Tragelaphus strepsiceros*) introduced into an affected group

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THE pattern of incidence of spongiform encephalopathy in greater kudu (*Tragelaphus strepsiceros*) born at Regent's Park indicates that maternal and horizontal transmission may have occurred in the herd (Kirkwood and others 1992, 1993, Cunningham and others 1993, Kirkwood and Cunningham 1994). This report describes a case in a 39-month-old female which provides further evidence that the disease in kudu is communicable either directly or indirectly from one animal to another.

Two female kudu born at Marwell Zoological Park, Hampshire, were transferred to join the four kudu at Regent's Park on August 14, 1990. On November 22, 1992, 27 months after the transfer, one of these animals (born on August 5, 1989) was euthanased after showing progressive neurological signs consistent with spongiform encephalopathy for eight weeks. The initial signs included intermittent mild head-tilting and mild head tremor associated with head movements, occasional slight swaying of the hindquarters, excessive lip movements, hindlimb muscle tremors, and an abnormal, hunched, posture. One day, a month before the death of this animal, the group of kudu had been kept under constant observation between 09.30 and 16.00, and during this time it had spent only 17 per cent of its time ruminating, compared with 37 to 47 per cent in the other four kudu. Decreased rumination has been observed in cattle with bovine spongiform encephalopathy and sheep with scrapie (Austin and Simmons 1993). Other signs observed at that time included intermittent abnormal carriage of the head and the ears, lateral head movements when walking, occasional loss of balance while grooming, hypermetria, head and flank rubbing, possible excessive grooming of flank and hindfeet, nose wrinkling and possible hyperaesthesia.

The diagnosis of spongiform encephalopathy was confirmed by light microscopy of fixed brain tissue which also revealed extensive neuropil vacuolation in the medulla, and by the detection of scrapie-associated fibrils in unfixed samples from the frontal lobe and spinal cord.

In contrast with previous cases in kudu and other zoo ungulates, in which the clinical course of the disease has been no longer than three weeks (Jeffrey and Wells 1988, Fleetwood and Furley 1990,

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