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Source: Journal of Wildlife Diseases, 16(3) : 431-438

Published By: Wildlife Disease Association

URL: https://doi.org/10.7589/0090-3558-16.3.431

THE RESPONSE OF SOME AFRICAN WILDLIFE SPECIES TO FOOT-AND-MOUTH DISEASE VACCINATION

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Abstract: The preservation of wildlife is of increasing importance in many countries in Africa but, due to hazards of possible transmission of disease from wild to domesticated species, the interests of the conservationist can conflict with those of the livestock owner. Foremost among transmissible diseases common to many species of both wild and domesticated animals is foot-and-mouth disease (FMD). The effects of FMD vaccination on three important wildlife species, African buffalo *(Syncerus caffer),* eland *(Taurotragus oryx)* and impala *(Aepyceros melampus),* are described. The pattern of response in all three species was similar to that of cattle but of a lower order. The implications are discussed and a vaccination protocol is suggested.

INTRODUCTION

In many countries in Africa the preservation of wildlife is becoming of increasing economic and aesthetic importance. However, as pressures from expanding human populations result in further decreases in areas solely available to free-living wild animals, hazards of possible disease transmission increase, not only from wild to domestic animals, but also from domestic to wild species.

In some parts of Africa larger wild mammals are now mainly confined to National Parks where, safe from human predators, population densities build up. In some areas parks are relatively small and surrounded by farmland, and in others individual farmers and ranchers, anxious to preserve some of Africa's natural heritage, maintain private game parks of indigenous species or allow indigenous species to graze freely with domestic animals. On some farms wild species such as eland *(Taurotragus oryx)* are actively ranched on an economic basis.

Foot-and-mouth disease (FMD) is particularly important in the context of possible interspecies transmission of disease. In addition to cattle, sheep, pigs and goats, nearly 70 wild species within more than 20 families of mammals have been found to be susceptible to either natural or experimental infection with FMD.[11] As more becomes known of the susceptibility of wild species to FMD and their possible roles in the spread and maintenance of the disease, veterinarians and biologists must take steps to understand and control disease hazards, particularly in isolated populations of rare species.

Limited studies have been made of experimental infection in some captured wild species in Africa,[1,8,12] but little is known of the effects of vaccination in wild animals. Some immobilised free-living African buffalo *(Syncerus caffer)* have been vaccinated against rinderpest[7] and anthrax vaccine has been administered to corralled wild bison *(Bison bison)* in Canada.[2] More recently de Vos *et al.*[5] have described vaccination

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against anthrax of the rare widely dispersed roan antelope *(Hippotragus equinus)* using helicopters and projectile syringes incorporating marker devices. Oral vaccination of captive foxes against rabies *(Vulpes vulpes)* has showed promise.[14]

This paper describes the effects of vaccination against FMD of some species of captured African wild animals.

MATERIALS AND METHODS

Experimental Animals

Buffalo. In Zimbabwe Rhodesia buffalo were captured from free-living herds in a National Park when they were estimated to be less than six months old and prior to natural infection.[4] After capture they were held in pens and monitored for serum neutralising (SN) antibody until maternally conferred immunity had waned. Vaccination took place when they were just over a year old.

In South Africa buffalo were born in captivity from dams captured from free-living herds in the Kruger National Park. They were repeatedly monitored for SN antibody and pharyngeal virus. At the time of vaccination, two years (two buffalo) and one year, two animals were fully susceptible but the third, infected in an earlier experiment, was still carrying type SAT1 FMD virus and had a SN antibody titre of 1 in 64 to that virus.

Impala. The impala *(Aepyceros melampus)* in Zimbabwe were captured as lambs and hand reared. They were vaccinated when approximately two years old.

The impala in South Africa were captured as adults in the Kruger National Park and their earlier disease history was unknown. Three, however, had been experimentally infected with type SAT1 virus in an earlier experiment and had low SN titres from 1:22 to 1:32 at the time of primary vaccination.

Eland. The eland were from the Zimbabwe National Experimental herd and were of varying ages. They were ranched under open range conditions and had no known history of FMD infection or vaccination.

Cattle. The cattle controls in Zimbabwe were purebred Friesian heifers held on a government experimental farm, and in South Africa adult Zebu animals on a private ranch. Both were in FMD-free areas. In neither case was there any history of FMD infection or vaccination.

Vaccination

A commercially prepared trivalent type SAT1, 2 and 3 BHK suspension cell culture vaccine incorporating alhydrogel and saponin adjuvants was used in Zimbabwe, and a similar bivalent SAT1 and 2 vaccine was used in South Africa. ☑ The virus strains used in the preparation of these vaccines were Bot 1/68 (SAT1) isolated from a field outbreak in Botswana in 1968, Rho 2/72 (SAT2) isolated from an outbreak in Rhodesia in 1972 and Bec 1/65 (SAT3) isolated in Botswana in 1965.

Vaccination in all cases was subcutaneous. A standard cattle dose of 3 ml was used throughout.

The larger buffalo were immobilised using projectile syringes when necessary to facilitate vaccination and bleeding. Smaller animals were caught by hand, sometimes with a net in the case of the impala.

Eland were handled in crushes. Their horns were tied to horizontal bars in the crush for bleeding.

Neutralisation Tests

Sera were inactivated at 56 C for 30 min and assayed in virus neutralisation tests on monolayers of IB-RS2 cells in microtitre plates.[6] Virus for test in each case was prepared from the respective

☑ Wellcome Foundation Ltd., Pirbright, England.

vaccine virus strains and was, therefore, homologous.

Serum neutralising titres are expressed as the reciprocal of the final dilution of serum present in the serum/virus mixture at the 50% end point.[13]

RESULTS

Serum neutralising antibody responses of groups of buffalo and impala following FMD vaccination are compared to those of cattle in South Africa (Fig. 1), and those of buffalo, impala and eland in Zimbabwe are similarly compared (Fig. 2). In each country all the animals were vaccinated at the same time with the same vaccine. The curves are plotted from the geometric means of all the animals in each group at the time of bleeding and include animals which apparently failed to respond.

The numbers of animals in each group with measurable antibody responses following the initial, repeat and booster vaccination, are given in Table 1 and the range of titres recorded in each species is shown in Table 2.

Results in both countries were comparable and the pattern of response in all three wild species was similar to that of cattle but of a lower order. In general, eland responded to both initial and booster vaccinations with higher SN titres than buffalo or impala, but titres in buffalo tended to persist longer than those in other species.

Serum neutralising titres against all three virus types were low in all species after primary vaccination but were markedly improved following a second

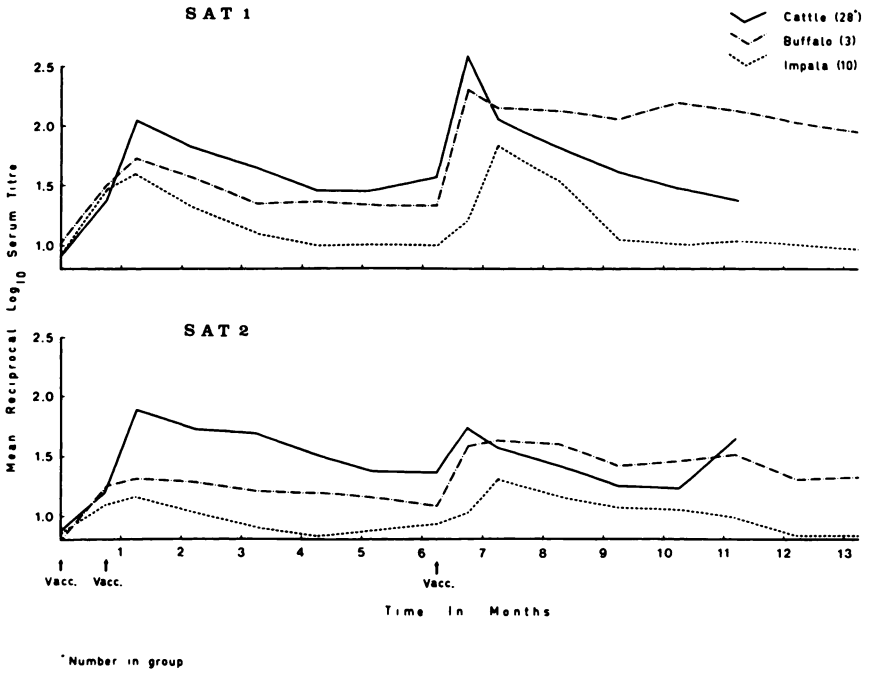

FIGURE 1. Geometric mean serum neutralising antibody responses in buffalo, impala and cattle in South Africa following FMD vaccination.

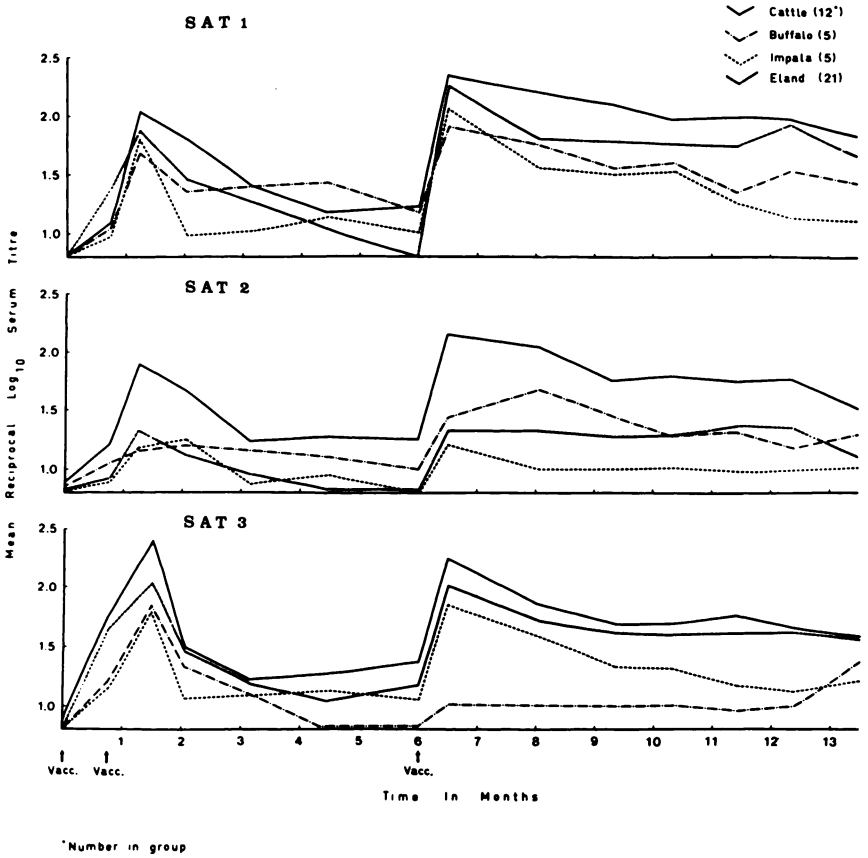

FIGURE 2. Geometric mean serum neutralising antibody responses in buffalo, impala, eland and cattle in Zimbabwe following FMD vaccination.

vaccine dose 21 days later. Titres then dropped rapidly, to zero in many animals, after four to six months. Booster vaccinations, however, given at six months, produced very satisfactory secondary responses to the type SAT1 virus component in all species and to the SAT3 component in cattle, eland and impala. Type SAT2 responses, although reasonably good in cattle in Zimbabwe (Fig. 2), were variable in other species and of a low order. In South Africa the SAT2 responses were disappointing in all species particularly after the booster vaccination, and may have been due to deterioration of the vaccine during storage.

The rise in type SAT2 SN antibody in the cattle controls in South Africa between the 10th and 11th months (Fig. 1) is not understood. All animals in the group were affected but there was no evidence of FMD infection nor history of further FMD vaccination. The cattle were, however, vaccinated with a killed spore anthrax vaccine during this period.

All animals in these experiments in both countries were believed to be without previous experience of FMDV either from infection or vaccination, ex-

TABLE 1. Numbers of animals of each species with serum antibody responses following primary vaccination, repeat vaccination at 21 days and booster vaccination at 6 months.

	SAT 1	SAT 2	SAT 3
BUFFALO			
Primary vaccination	4/8	5/8	5/5
Repeat vaccination	7/8	6/8	5/5
Booster at 6 months	7/7	7/7	4/4
IMPALA			
Primary vaccination	11/18	8/18	5/5
Repeat vaccination	13/18	10/18	5/5
Booster at 6 months	16/17	10/17	5/5
ELAND			
Primary vaccination	17/20	8/20	18/20
Repeat vaccination	18/20	14/20	19/20
Booster at 6 months	15/16	19/20	16/16
CATTLE			
Primary vaccination	31/40	30/40	11/12
Repeat vaccination	37/40	37/40	12/12
Booster at 6 months	17/17	15/17	12/12

Note: The reduced numbers in some of the groups at the time of the booster vaccination were due to slaughter in the case of cattle and natural deaths among the captured animals.

cept for the one buffalo and three impala in South Africa previously mentioned. These three animals produced classical secondary responses after primary vaccination with titres very much higher than others in their groups (Table 2). Three of the 28 cattle controls in South Africa also developed marked type SAT1 virus secondary responses on initial vaccination without further rise of antibody titre following the second vaccine dose. It must, therefore, be presumed that these three animals had, in fact, been sensitised previously to FMDV.

DISCUSSION

The choice of species and number of animals included in these experiments was governed by various factors including availability of captured animals and handling facilities, but consideration was also given to the possible role and importance of each species in the epizootiology of FMD.

All three species selected often occur in large herds. Free-living impala are frequently infected under natural conditions in South Africa, and numerous strains of FMDV have been involved.[10] The disease in impala is clinically severe and infection is readily transmitted to other impala, and very possibly to other species. Free-living buffalo under natural conditions are maintenance hosts to the SAT FMD virus types, perpetuating virus for very long periods in the absence of clinical signs, but only rarely initiating disease in other species.[9] Clinical disease may occur, however, in captive or isolated buffalo devoid of circulating antibody and spread to cattle has taken place under experimental conditions.[3,16] Although eland have been shown to be susceptible to different strains of FMDV and may be infected naturally in the field, their role in the transmission of infection is doubtful (Anderson, E.C., unpubl.). However, as eland are ranched, sharing their habitat with cattle in several areas at risk to infection with FMD, studies of vaccination in this species are important.

Serum neutralising antibody responses to vaccination in all these wild

TABLE 2. The range of reciprocal SN antibody titres in animals of different species which responded to vaccination with FMD vaccine.

	SAT 1	SAT 2	SAT 3
BUFFALO			
Primary vaccination	8-22 (512*)	8-22 (90)	8-22
Repeat vaccination	8-90	11-45	45-128
Booster at 6 months	22-178(2048*)	11-90 (256)	8-16
IMPALA			
Primary vaccination	8-90 (1024*)	8-45	8-22
Repeat vaccination	16-178	8-45	16-178
Booster at 6 months	11-256	8-22	32-90
ELAND			
Primary vaccination	8-178	8-32	16-512
Repeat vaccination	16-708	11-256	11-1024
Booster at 6 months	22-2048	11-178	16-355
CATTLE			
Primary vaccination	8-64 (708†)	8-178	11-512
Repeat vaccination	16-512	16-355	90-1024
Booster at 6 months	64-1024	22-512	64-1400

*Highest titres recorded in the single buffalo and three impala known to have been infected previously with SAT 1 virus.

†Three of the control cattle evinced apparent secondary responses at primary vaccination and must be presumed to have been previously sensitised to FMDV, in spite of the negative disease history.

Titre in parenthesis is highest titre among these three.

species were generally lower than those of cattle and there was a considerable variation in the responses of individual animals, particularly to type SAT2 virus. The dose of vaccine used, a standard cattle dose, may not have been optimal for all species. The variation in response, however, may have been a function of the potency of the vaccine at the time of vaccination rather than a reflection of the ability of the animal to respond.

Correlations between SN antibody titres and resistance to challenge have not yet been established in wild species, but convalescent titres following experimental and contact infection with some strains of virus have been recorded.[8,1] Convalescent titres in buffalo and eland were of a similar order to those of cattle and, by analogy, it could be argued that protective levels of immunity may also be similar. Convalescent titres of impala, however, have been found to be lower than those of cattle and titres following vaccination may have a different significance.

While it is not suggested that the large scale control of disease in free-living wild animals is at present practicable, these preliminary trials indicate that the vaccination of certain wild species at risk, where feasible, would be worthwhile, particularly in the establishment and maintenance of FMD-free herds as in Zimbabwe, or when wild species are coexisting with domestic animals on enclosed farms or ranches.

It is recommended at this stage that initial vaccinations should be given as a double dose with an interval of approximately 21 days between doses. To maintain acceptable levels of immunity, booster vaccinations should be given after 4 to 6 months and thereafter at 6-month intervals. Until more experience is gained of the effects of vaccination of unusual species, it is suggested that, where possible, results of vaccination should be monitored in terms of SN antibodies and, when opportunity occurs, efforts should be directed to establishing correlations between antibody titres and protection from virus challenge.

Acknowledgements

The authors wish to thank the Director and Mr. J. Posnett of the Department of National Parks and Wild Life Management in Zimbabwe for the use of the National eland herd, the National Parks Board in South Africa for providing buffalo and impala, Dr. J. Krige for vaccinating and bleeding the control cattle in South Africa and Messrs C.A.W. van Niekerk, D.C. Joubert, A. Wilkinson, N. Moyo and Doctella for technical assistance.

We also wish to thank Mr. I.T. Barnett and all the members of the Serum Assay Unit at Pirbright for testing the sera.

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Received for publication 2 January 1980