# THE OCCURRENCE OF INFECTIOUS DISEASES IN MIXED FARMING OF DOMESTICATED WILD HERBIVORES AND DOMESTIC HERBIVORES, INCLUDING CAMELS, IN KENYA. I. VIRAL DISEASES: A SEROLOGIC SURVEY WITH SPECIAL REFERENCE TO FOOT-AND-MOUTH DISEASE.

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Source: Journal of Wildlife Diseases, 15(2) : 351-358

Published By: Wildlife Disease Association

URL: https://doi.org/10.7589/0090-3558-15.2.351

# THE OCCURRENCE OF INFECTIOUS DISEASES IN MIXED FARMING OF DOMESTICATED WILD HERBIVORES AND DOMESTIC HERBIVORES, INCLUDING CAMELS, IN KENYA. I. VIRAL DISEASES: A SEROLOGIC SURVEY WITH SPECIAL REFERENCE TO FOOT-AND-MOUTH DISEASE.

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*Abstract:* The prevalence of antibodies to the viruses of foot-and-mouth disease, rinderpest, infectious bovine rhinotracheitis and malignant catarrhal fever was determined in various species of domestic and domesticated wild ruminants on a ranch in the semi-arid zone of south-eastern Kenya.

Antibody to foot-and-mouth disease virus was found in buffalo *(Syncerus caffer),* eland *(Taurotragus oryx),* cattle *(Bos indicus),* sheep *(Ovis aries)* and goats *(Capra hircus).* None was found in oryx *(Oryx beisa)* and camels *(Camelus dromedarius).* The titres in eland and buffalo were due to natural infection and in cattle to vaccination and infection. Antibody to rinderpest virus was found in buffalo, eland, oryx, cattle, camel, sheep and goats. Most of these were vaccinated previously. Antibody to infectious bovine rhinotracheitis virus was found in cattle but not in buffalo, eland, oryx and camels. Antibody to malignant catarrhal fever was not found in any of the species tested.

An attempt was made to isolate foot-and-mouth disease virus from oesophageal-pharyngeal samples of four buffalo before a FMD outbreak and from four buffalo, 12 eland and 50 cattle 6-10 months after the outbreak. Foot-and-mouth disease virus was isolated from cattle 10 months after the outbreak but not from buffalo or eland.

Since foot-and-mouth disease is of major importance in cattle farming in Kenya, in the case of mixed farming with wild herbivores, both wild and domestic ruminants should be vaccinated. Likewise, it is recommended that all ruminants be vaccinated against rinderpest.

## INTRODUCTION

Galana Ranch covers an area of 5,000 km$^2$ in the semiarid zone east of Tsavo East National Park in Kenya. Domestication of oryx *(Oryx beisa),* eland *(Taurotragus oryx)* and buffalo *(Syncerus caffer)* was begun in 1970. The background and methods applied to the ranching of wild herbivores at Galana have been described by King and Heath.[16] Some 15,000 cattle are present, as well as approximately 65 sheep, 220 goats and 120 camels. Cattle were introduced in 1968.

At the time of this study there were 150 domesticated oryx herded in groups of 25-30 with sheep and goats; 15 domesticated eland herded with cattle or camels

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*(Camelus dromedarius);* and four domesticated buffalo kept with the cattle. All animals were herded over large areas; fences were not used with the exception that all animals were put into small enclosures at night, segregated by species.

A large variety of free-ranging wild herbivores also was present, including eland, oryx, buffalo, elephant *(Loxodonta africana),* giraffe *(Giraffa camelopardalis reticulata),* gazelle *(Gazella granti* var. *peteri),* zebra *(Equus burchelli),* warthog *(Phacochoerus aethiopicus),* lesser kudu *(Tragelaphus imberbis),* gerenuk *(Litocranius walleri),* rhinoceros *(Diceros bicornis),* waterbuck *(Kobus defassa),* Coke's hartebeest *(Alcelaphus buselaphus cokei)* and topi *(Damaliscus korrigum jimela).*

Although no major health problems were experienced with the domesticated wild animals, it was considered that after 7 years of close association with domestic livestock, a serologic survey might produce useful baseline data on the possible disease hazards and the preventive measures that might be indicated. The results of tests for viral diseases are reported here; results for bacterial and parasitic diseases will be given in parts II and III, respectively.

## MATERIALS AND METHODS

None of the domesticated wild animals, except the four buffalo, were chemically immobilized. The buffalo were immobilized by injection of xylazine[4] at 0.24 mg/kg body weight. Specimens were collected from 20 oryx and 14 eland (10 of the eland on four occasions) all by manual restraint in an ordinary cattle crush. Specimens were collected also from 61 cattle, 88 camels, 10 sheep and 12 goats.

Blood was collected and centrifuged in 10 ml vacuum tubes. The serum was frozen and transported on ice to the laboratories.

Oesophageal-pharyngeal (O-P) samples were collected by means of a probang[32] and placed in 5 ml volumes of cell culture medium.[2] O-P samples were stored and transported in liquid nitrogen or dry ice.

Sera were tested for antibodies to foot-and-mouth disease (FMD) by the metabolic inhibition test and to infectious bovine rhinotracheitis (IBR), rinderpest (RP) and malignant catarrhal fever (MCF) by virus neutralization tests in cell cultures.[12,18,21]

O-P samples were examined for FMD virus by inoculation of primary bovine thyroid cell monolayers.[30] FMD virus isolates were identified by the microcomplement fixation test using type-specific antisera.

## RESULTS AND DISCUSSION

### FMD (Tables 1 and 2)

**Eland:** During September and October, 1976 a FMD outbreak of the South African type 2 (SAT 2) was diagnosed by virus isolation from clinically infected cattle. Lesions were reported in cattle and domesticated eland. Clinical signs were similar in both species and included foot and mouth lesions, lameness, loss of appetite and loss of condition. Because of communication difficulties, it was not possible to attempt isolation of FMD virus from eland during the outbreak. Four months after the outbreak began, sera from the eland were collected and tested for neutralizing antibody. All 10 eland present during the outbreak had developed antibody titres of 1.35 or higher to FMD type SAT 2 virus; such titres are characteristic for exposure.[1,3] Six of the eight animals remaining in this group had antibody 10 months after the outbreak. An eland calf aged 3 weeks

[4] Rompun - Bayer, Leverkusen, W. Germany.

TABLE 1. Neutralizing antibody to FMD virus in domesticated wild animals and domestic animals at Galana Ranch (recorded positive when $Log_{10}$ reciprocal antibody titre is 1.35 or more).

| Species | August 1976 | | | | January 1977 | | | |
|---|---|---|---|---|---|---|---|---|
| | A | O | SAT 1 | SAT 2 | A | O | SAT 1 | SAT 2 |
| Buffalo | 0/4* | 0/4 | 0/4 | 0/4 | ND** | ND | ND | ND |
| Eland | 0/10 | 0/10 | 0/10 | 0/10 | 0/11 | 0/11 | 0/11 | 9/11 |
| Oryx | 0/10 | 0/10 | 0/10 | 0/10 | ND | ND | ND | ND |
| Cattle*** | 2/19 | 8/19 | 1/19 | 1/19 | ND | ND | ND | ND |
| Camel | 0/88 | 0/88 | 0/88 | 0/88 | 0/20 | 0/20 | 0/20 | 0/20 |
| Sheep | 0/10 | 0/10 | 0/10 | 0/10 | ND | ND | ND | ND |
| Goat | 0/10 | 0/10 | 0/10 | 0/10 | 1/2 | 0/2 | 0/2 | 0/2 |
| | March 1977 | | | | July 1977 | | | |
| | A | O | SAT 1 | SAT 2 | A | O | SAT 1 | SAT 2 |
| | ND | ND | ND | ND | 0/4 | 0/4 | 0/4 | 3/4 |
| | 0/12 | 0/12 | 0/12 | 8/12 | 0/14 | 0/14 | 0/14 | 6/4 |
| | 0/10 | 0/10 | 0/10 | 0/10 | ND | ND | ND | ND |
| | 7/10 | 9/10 | 3/10 | 10/10 | 29/32 | 30/32 | 19/32 | 26/32 |
| | ND | ND | ND | ND | ND | ND | ND | ND |
| | ND | ND | ND | ND | ND | ND | ND | ND |
| | ND | ND | ND | ND | ND | ND | ND | ND |

*Number of sera positive over total number tested
**Not done
***Biannually vaccinated

had maternal antibody (titre 1.95) 5 months after the outbreak. No antibody was found in six other eland calves born during the 10 months period subsequent to the outbreak. Six and 10 months after the outbreak attempts were made to isolate virus from O-P samples of 12 eland and 50 cattle. Type SAT 2 virus was isolated from 2 of 40 cattle (5%) at 10 months, but not from the eland.

Based on clinical signs and seroconversion, this is the first record of FMD in naturally-infected wild animals in Kenya. The very close contact with cattle infected with an apparently virulent strain of FMD SAT 2 virus resulted in clinical disease in the eland. While the virus could not be isolated from the eland 6 and 10 months after the outbreak, in contrast to the cattle where 5% remained carriers up to 10 months, significant antibody levels were present in eland up to 10 months after infection (Table 2). Eland have been shown to be susceptible to infection with SAT 1 serotype but the clinical disease was mild and virus could be recovered only from the throat for 32 days after exposure.[3] No antibody to FMD was found in 58 free-ranging eland from FMD-enzootic areas in Kenya[3] except for one with a titre of 1.35 to serotype O. Thus, while eland do not appear to be a reservoir for FMD in Kenya, under the special conditions of domestication, biannual vaccination would be of value.

**Buffalo:** No antibodies to serotypes O, A, SAT 1 and SAT 2 were detected in the four buffalo 1 month prior to the outbreak. Ten months after the outbreak, all were still negative for O, A, and SAT 1 but three of the four had antibody to SAT 2 (mean titre 1.8). Although FMD virus

TABLE 2. $Log_{10}$ reciprocal antibody titres to FMD type SAT 2, in domesticated eland naturally exposed in September 1976.

| Animal Number* | Jan. 1977 4 months p.e.** | March 1977 6 months p.e. | July 1977 10 months p.e. |
|---|---|---|---|
| 7 | 1.5 | 2.25 | 1.5 |
| 9 | 1.5 | ND*** | ND |
| 14 | 1.95 | 1.5 | 1.8 |
| 15 | 1.5 | 1.5 | 1.5 |
| 22 | 1.65 | 1.65 | 1.8 |
| 23 | ND | 1.5 | 2.1 |
| 24 | 1.8 | 1.05 | 1.05 |
| 25 | 1.5 | 1.5 | 1.5 |
| 31 | 1.65 | ND | ND |
| 32 | 1.5 | 1.65 | 0.9 |
| mean titre | 1.62 | 1.58 | 1.52 |
| %>1.35 | 100% | 88% | 75% |

*all animals were serologically negative to all FMD serotypes 1 month before the SAT 2 outbreak
**post exposure
***not done

could not be isolated and clinical FMD was not seen, antibody indicates that the buffalo were exposed to FMD virus type SAT 2, probably as a result of the outbreak in the cattle. Antibodies to one or more of the above types of FMD virus have been found in 70 of 107 free-ranging buffalo from four FMD-enzootic areas in Kenya[4] and this confirms findings in other African countries.[9,10,11] Also, SAT 1 and 2 viruses have been isolated from buffalo in Kenya[4] and in other African countries.[9,10,11] Contact experiments with carrier buffalo and susceptible cattle did not result in virus transmission to the cattle but buffalo to buffalo transmission did occur.[4,6] Although FMD virus is found among wild buffalo in Kenya, there appears to be little risk in maintaining a herd of tame buffalo on a cattle ranch, since virus transmission from buffalo to cattle does not readily occur.

**Oryx:** No antibody was found in the oryx which were herded in the vicinity of the infected cattle but which had no direct contact with them as had the eland.

Very little is known about oryx and FMD. Serologic results indicated that these animals had not been in contact with FMD virus. The 10 oryx tested in March, 1977 were caught in January, 1977 on the ranch and likely had been in the enzootic area during the outbreak of September, 1976. Further study is needed, but at present there is no indication that preventive measures should be taken.

**Cattle:** Antibody to all four serotypes was found in the cattle. However, the cattle had been vaccinated against these serotypes routinely, while the SAT 2 antibody titres had also been stimulated by natural exposure to virus.

**Camel:** The absence of antibody in the 88 camels examined in August, 1976 is an indication that they probably are not susceptible to FMD. The camels were obtained from the northern area of Kenya several years previously, where FMD types A, O, C and SAT 2 are known to have occurred. None of the camels were reported to have clinical signs and none developed antibody subsequent to

the SAT 2 outbreak on the ranch. These results are similar to the findings of Leese[15] in India and Richard[25] in southern Ethiopia. At present there is no indication that preventive measures are necessary.

**Sheep and goats:** Antibody to serotypes A, O, SAT 1 and SAT 2 was not found in 10 sheep and 12 goats, except in one goat to serotype A. Sheep and goats were not examined for virus and antibody after the outbreak as they do not play a significant role in the epizootiology of FMD in Kenya.[2] Animals of exotic breeds imported for upgrading of the indigenous stock should be vaccinated.

## RP (Table 3)

Titres due to infection or natural exposure were recorded (a) in one of two adult buffalo, 6 years after the time of capture, (b) in 1 of 78 adult camels, (c) in 1 of 10 sheep and (d) in 2 of 11 goats. These titres likely are the result of exposure 6 or more years earlier. Vaccination resulted in titres in one of two buffalo; three of six eland and 1 of 17 oryx, 2 to 3 years after the last vaccination, as well as in two of five eland calves of vaccinated dams. Annual vaccination resulted in antibody in 16 of 23 of the cattle.

The susceptibility of buffalo and eland to RP is well documented.[17,19,28,31] Mortality can be severe in both species but since antibodies have been found, some cases do recover. Far less is known about oryx, but their involvement in the last major outbreak of RP in northern Kenya in 1960-1963 was reported by Stewart.[31] The camel is known to be susceptible to RP[33] but clinical disease has not been reported in camels in Africa.[25] Antibodies to RP have been found in other countries but not in camels from northern Kenya tested in 1961.[27]

RP did not occur in cattle on the ranch after 1970, and in 1971 the last clinical case in a free-ranging wild animal, a kudu, was reported. Through yearly vaccination of cattle, the disease currently is well controlled in domestic animals and, apparently, also in wild animals, free-ranging as well as domesticated. During the early years of domestication, the wild animals were vaccinated with the bovine kidney tissue culture vaccine. Since many cases of RP in wildlife are considered to have originated from cattle,[29] control of the disease in cattle in Kenya

TABLE 3. Neutralizing antibody to Rinderpest, Infectious Bovine Rhinotracheitis and Malignant Catarrhal Fever viruses in domesticated wild animals and domestic animals at Galana Ranch August 1976 - July 1977.

| Species | RP | IBR | MCF |
|---|---|---|---|
| Buffalo | 2/4[1,2] | 0/4 | 0/3 |
| Eland | 5/11[3] | 0/11 | 0/7 |
| Oryx | 1/17[4] | 0/10 | 0/14 |
| Cattle | 16/23[5] | 26/28 | 0/10 |
| Camels | 1/78 | 0/37 | 0/41 |
| Sheep | 1/10 | ND[6] | 0/7 |
| Goats | 2/11 | ND | 0/2 |

[1]Number of sera positive over total number tested
[2]One positive animal vaccinated in 1972
[3]Six animals including three positive ones were vaccinated in 1972, 1973, 1974
[4]Seven animals including the positive one were vaccinated in 1972, 1973, 1974
[5]Yearly vaccinated
[6]Not done

reduces the risk for infection of the wildlife; however without vaccination, RP could spread through the wildlife. Vaccination of the domesticated buffalo, eland and oryx should be continued.

### IBR (Table 3)

Antibody to IBR was detected in 26 of 28 (95%) cattle but not in the other species. This high prevalence in cattle is comparable to previous reports.[12] The importance of IBR for livestock in Kenya is not clear but Reyemamu[26] indicated that the disease might be involved in reproductive failures in cattle in Tanzania. Further study is needed to determine the role of IBR in cattle on this ranch.

Antibodies to IBR were reported in eland in Kenya (30%) and Tanzania (74%)[22] but were not found in 40 eland in another study in Tanzania.[26] Antibodies to IBR are prevalent in cattle over 25 months of age in a large part of Kenya (62%)[12] and Tanzania (39%).[26] Whether IBR virus is transmissible by contact from cattle to eland is not known but transmission does not seem to occur readily, as evidence by the absence of antibody in 11 eland after several years of close contact with infected cattle on this ranch and in the 40 eland in northern Tanzania.[26]

Naturally-occurring clinical disease caused by the IBR virus has not been reported in free-ranging wild animals but pustular vulvovaginitis developed in eight newly captured wildebeest after corticosteroid treatment.[13]

Antibody to IBR has not been found in oryx but the total number tested is small (10 in this study and five by Rampton and Jessett[22]). Likely the oryx, being a bovid, could become infected, and testing the 150 domesticated oryx on this farm should be continued.

The only indication that the camel might be susceptible to IBR comes from Burgemeister[5] who reported antibody in three of 52 camels in Tunisia. Antibodies to IBR were not found in the 37 camels tested on Galana Ranch.

### MCF (Table 3)

MCF has not been recorded on the ranch and virus neutralizing antibody could not be detected in any of the species tested.

In East Africa this disease is closely related to the presence of wildebeest,[19,20] which do not occur on the ranch but small numbers of free-ranging Coke's hartebeest and topi are present. Although this virus has been isolated from the Coke's hartebeest[24] and antibody has been found in both species,[23] apparently these two species do not transmit a virulent MCF virus to cattle. Reid and Rowe[23] reported MCF antibody in all of three oryx tested but did not indicate the area of origin and did not comment on the significance of these findings. The 14 oryx sera tested in this study were negative but a larger number needs to be tested.

### Other viral diseases

Other viral diseases like bluetongue, Wesselsbron disease, Rift Valley Fever and Middelburg virus disease[17] which have been reported in free-ranging wild animals in other areas, have not been studied because there were no reports of clinical cases, moreover, the vectors are not considered to be present in this area.[7,34]

Clinical cases of camelpox were not observed, although camelpox has been reported from northern Kenya.[8]

### Acknowledgements

**The authors are grateful to Dr. E.C. Anderson and his staff of the Wellcome Institute in Embakasi, Kenya, for performing the laboratory tests for FMD, as well as for his and Dr. L. Karstad's review of the manuscript.**

This study was made possible by the assistance of the board of directors and staff of the Galana Game and Ranching Ltd. This paper is published with the kind permission of the Director of Veterinary Services, Kabete, Kenya.

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*Received for publication 16 January 1978*