THE DIAGNOSIS AND CONTROL OF GAME DISEASES

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INTRODUCTION

The decimating effect of certain game diseases (Young 1969) emphasises the importance of adequate diagnostic methods and successful means of artificial control of infectious diseases among game animals.

The belief that game animals are not very susceptible to infectious diseases has been disproved by epizootic outbreaks of diseases like rinderpest, anthrax, salmonellosis and coccidiosis. The fact remains, however, that game are not often seen in an obviously sick state. Apparently perfectly healthy animals die without warning. Animals in the Pretoria Zoo, for instance, are inspected daily for signs of disease, yet 80% of some 280 mammals lost, had shown no such signs prior to death. This percentage may be even higher in wild birds and reptiles. Where wild animals do show signs of disease, the course of the infection may be very rapid and the chance of seeing a sick animal thus be limited.

A frequent evaluation of the health status of game in any Park, game farm or zoological collection is of the utmost importance and regular game inspections must be undertaken to detect the earliest signs of a developing epizootic. The eradication of an infectious disease among free-living wild animals is by no means an easy matter and its control can be severely hampered by a delayed or wrong diagnosis.

THE DIAGNOSIS OF DISEASE IN GAME

A sound knowledge of the pathognomonic signs of infectious diseases, is of the utmost importance and this knowledge can, in the case of many diseases, only be obtained by a study of the pathogenesis of these diseases in experimentally infected game animals.

Although some diseases do manifest certain pathognomonic or characteristic symptoms and lesions, the following general signs may be exhibited by a diseased wild mammal: A staring coat, drooping ears, hyperthermia, a swaying gait and lagging behind the herd with a tendency to hide in a secluded place and an inclination to lie down with the head held low. Other important signs include anorexia, diarrhoea and emaciation and the animal's senses appear to be dulled. Advanced cases may develop dehydration (sunken eyes, etc.), a mucopurulent discharge from the eyes and nostrils, dyspnoea, hyperthermia and finally paralysis or tetanic spasms with signs of pulmonary oedema.

Apart from examinations for typical clinical and post mortem signs and the careful consideration of possibly related epizootiological factors, the following specialised examinations may also be carried out to assist in the diagnosis of diseases in captive or free-living game animals.

(a) *Serological or immunological tests:* These tests are usually done on serum specimens of wild animals to indicate the presence of circulating antibodies against certain diseases. The finding of antibodies in a serum specimen demonstrates the immunity of the donor to a specific disease and antibody surveys have often indicated the unsuspected presence of an infectious disease in a region or a species. In this way serological tests demonstrated a smouldering infection of human Yellow fever in certain monkeys and bush-babies in Africa (McDiarmid 1960).

Immunological tests have also been done on serum specimens of animals in the Kruger National Park. A few buffalo serum samples reacted positively for blue-tongue. Of the 82 examinations done on game sera from this park to test for Wesselsbron disease antibodies, serum samples from four buffalo reacted positively. Antibodies against Rift Valley fever were found in serum specimens from hippopotami (Howell 1965) and one elephant. One serum specimen from a Burchell's zebra reacted positively for horse sickness and it is planned to infect zebras experimentally with horse sickness virus in order to study the pathogenicity, pathogenosis and immunogenesis of this disease in wild equines.

(b) *Isolation and identification of the infectious agent:* The isolation of infectious micro-organisms may be very difficult and specialised techniques are sometimes necessary for the collection of specimens and the ultimate isolation and identification of the infectious agent. It is not within the scope of this paper to describe all these techniques. It must be stressed, however, that all specimens should be collected in a sterile manner from fresh carcasses. Organ specimens may be cut in thick lumps and transported in a 50% aqueous solution of glycerine or in plastic bags in ice. It is always advisable to include a piece of spleen. The specimens to be collected will vary according to the disease suspected. The careless transportation of infected specimens may facilitate the spread of an infection and it is therefore advisable to obtain information regarding the collection and transportation of biological specimens from a veterinarian.

Parasites which are macroscopically visible may be collected and forwarded in preservatives, such as a mixture of 70% ethanol and 5% glycerine, to a taxonomist for identification.

(c) *Smear examinations:* Microscopic examinations of blood or organ smears, stained according to various techniques may sometimes reveal the presence of the aetiological agent. Anthrax may, for instance, be diagnosed in this way. Differential white cell counts can also be done on bloodsmears in order to determine the effects of the infection on the leucocytes and the myeloid and lymphoid tissues and to indicate the nature of the aetiological agent.

(d) *Histopathological examinations.* The pathogen or its lesions may sometimes be demonstrated by the microscopic examinations of specially sectioned and stained preparations of different tissues. The pathogenesis of infectious diseases can also be demonstrated by the microscopic examination of tissues of infected host animals at different stages of the infection.

Specimens for histopathological examinations are usually cut in thin slices and must preferably consist of diseased as well as unaffected parts of every organ. These specimens, which must be collected from fresh carcasses, can be preserved in 10% formalin and should be forwarded to a veterinary pathologist for further examination.

(e) *Splenectomies and corticoid injections:* Latent infections often flare up after the spleen of an infected animal has been removed or after the injection of corticoid preparations. This method is of course not used for routine diagnostic purposes but may be of great help in research work on the infectious diseases of game.

(f) *Clinical-pathological tests:* These tests are usually done to determine the nature and degree of damage done to various parts of the body and include a wide variety of different tests on the blood, secretions and excretions of animals. These tests are of much value in studying the pathogenesis of game diseases (Young 1966a; Young and Howell 1966) and can be of assistance to the clinician in determining the prognosis and in advising systemic treatment. In order to evaluate an abnormal blood-picture, haematological studies on different clinically healthy, wild African mammal species have been undertaken to determine the range of normal blood values for the different species (Young 1966b, 1966c; Young and Lombard 1967).

(g) *X-ray examinations:* A powerful X-ray unit is already used with considerable success at the Rudolph Bigalke Institute of the Zoological gardens in Pretoria for the examination of diseased zoo animals. Examinations of this kind usually do not reveal the cause of the condition but is a valuable aid in demonstrating the nature and extent of certain pathological lesions.

PREVENTIVE DISEASE CONTROL IN LARGE GAME PARKS

The value of well-planned preventive measures should be appreciated in the seemingly impossible task of controlling a developing epizootic of a highly infectious disease in large communities of very susceptible animals. These measures should be applied wherever possible to protect the natural fauna.

The only way by which diseases not enzootic in a Park can become established there, is for it to be introduced across the borders. It is therefore obvious that animal movements into a Park must be controlled, especially when their movements and migrations may lead them to and from areas, potentially infected with epizootic diseases. Game fences have been erected around parts of some parks and great success has been achieved in the prevention of mass movements of game over the fenced borders of the Kruger National Park.

Practical problems may arise however, and before any final decision to fence an area is taken, various factors should be considered, such as the species involved, the availability of adequate grazing and drinking water on both sides of the border and the type of fence to be erected. Various types of barriers may be used (Nel, Meeser, and van der Schijff 1955; Pienaar 1967). Both plain and barbed wire fences have been used with success and Meeser and Nel (1956) stated that constant patrolling and maintenance of fencing can prevent contact between cattle and game.

Where patrol is inconstant individual animals may make direct contact through a single fence. Although a single fence has been proved effective in certain outbreaks of epizootic diseases, a better, though much more expensive, arrangement is the erection of two parallel fences. In this manner an artifical animal-free zone or corridor can be created around a Park. The presence of cultivated areas next to the borders of parks may also assist in the creation of animal-free zones, but elephants unfortunately find them tempting and may break down fences to visit orchards and lands in the vicinity of restricted grazing areas.

An alternative to an animal-free zone is the presence of an immune or resistant population of domestic animals around a Park. In an area adjoining the northern border of the Kruger National Park, inhabitants are allowed to keep donkeys only, as these are not susceptible to and cannot transmit diseases like rinderpest or foot-and-mouth. Annual vaccination of all susceptible farm animal species against anthrax is compulsory in the whole of the Republic of South Africa and South West Africa. Unfortunately this vaccination program cannot be extended to game animals in the areas surrounding the Kruger National Park. The potential danger of anthrax to the park is, however, considerably minimised by the current annual vaccination policy.

The preventive isolation measures mentioned above can only be of value if the artificial importation of animals into parks is also controlled. Information regarding the distribution of most of the important diseases can usually be obtained from the Veterinary Department of every country and the transportation of game is usually controlled by these departments through a system of permits. The movement of game from potentially infected to clean areas can thus be controlled. The permit system may also be a valuable aid in the rapid tracing of the origin of outbreaks of infectious diseases, as well as their possible spread to other areas.

Newly introduced animals are preferably kept under observation in suitable quarantine enclosures. Special tests may be required to exclude the presence of latent infections in these animals. A lack of knowledge of the ability of different wild species to serve as carriers of latent infections and inadequate diagnostic techniques for the detection of latent infections unfortunately makes it impossible to declare any game animal free of all infectious diseases. While under observation, game animals can as a routine be treated for internal and external parasites to prevent the introduction of these into parks. Further research may indicate the necessity of artificial immunisation of some game species which are to be released in certain disease enzootic regions.

When a large park is continuously threatened by decimating epizootics it may be advisable to subdivide it by natural and artificial barriers into at least a few isolated areas. Artificial barriers in game parks may not be universally acceptable but one may have to choose between a park with well protected, healthy animals and one or two additional fences, or a park without either of these. The spacing of watering points may also contribute to the development of sparsely populated areas which act as animal-free zones. Such corridors are unfortunately of relative value only in the control of game movement. Moreover, they are very much less effective during the rainy seasons when game dispersal takes place. The creation of artificial barriers requires a sound knowledge of the grazing and migratory habits of the animals in the park and these barriers must obviously be placed in such a manner that the normal habits of the animals are minimally disturbed. The presence of existing natural barriers (high mountains etc.) may assist in the subdivision.

An infectious agent may also be controlled by the eradication of its vectors. Regular campaigns are, for instance, launched to prevent the reintroduction and establishment of tsetse-flies in the Kruger National Park. Great success has been achieved by the South African Division of Veterinary Services in the control of these bloodsucking and trypanosome-transmitting flies in their natural habitat (du Toit 1954).

The prophylactic vaccination of some of the animals in a park against the most important epizootic diseases to ensure the survival of at least some of the animals after epizootics, may also be considered. Harthoorn and Lock (1960) showed that four workers could immunise from twenty to thirty buffalo per day. This entailed immobilising, vaccinating and releasing the animals. I believe that many more animals may be vaccinated daily by fewer workers, provided that enough disposable syringes of the right kind are available and when only relatively small amounts of vaccine need to be administered by the intramuscular route. Dart syringes with a capacity of 1 ml., fitted with short, smooth needles were often used for the direct administration of vaccines to wild animals in the Pretoria zoo. These darts were fired with a Palmer cap chur gun and the total amount of the vaccine had been automatically injected into the musculature of the animals before the darts dropped to the ground. The Administration of an oral anthrax vaccine through the drinking water was suggested by Pienaar (1961). Other ways of mass vaccination of game will also have to be examined.

Brown and Scott (1960) immunised 72 wild animals of 12 different species against rinderpest, but experienced some mortality among the vaccinated animals. Harthoorn and Lock (1960) stated that immunity against this disease developed in buffalo after vaccination with rabbit attenuated virus.

The diversity in immunogenic properties of different strains of foot-and-mouth disease viruses, the short duration of immunity produced by inactivated vaccines and practical problems associated with game vaccination techniques, present major obstacles in the successful prophylactic immunisation of adequate numbers of game animals against this highly contagious virus disease. The possible value of vaccination for the control of active outbreaks of foot-and-mouth disease is discussed elsewhere.

Blesbok, previously immunised with one of the older types of anthrax vaccine, developed anthrax and died from the infection (Neitz 1936). Better results are to be expected with modern vaccines although the safety and immunogenic properties of these vaccines for use in wild-animal species must still be determined.

Wild scavengers may play a very important role in the removal of infected carcasses in a park. Similarly, the destruction of sick inviduals of the more abundant game species by wild predators and man can only have a beneficial effect on the remaining members of the herd. The treatment of sick animals of all species and particularly of the rarer species must be undertaken whenever it is considered advisable. Nevertheless animals which may remain carriers of the infection after treatment, should preferably be removed from a herd when the rest of the herd is thought to be free of the infection.

Where the culling of excessive numbers of game is practiced, hunters must endeavour to destroy diseased animals and runts first, before sacrificing the more vigorous and healthy members of the herd. During culling operations carcasses and organs of herbivores, infected with the intermediate stages of parasites of carnivores, must be destroyed to prevent super-infestations in scavengers around processing plants. The incidence of schiztosomiasis among wild animals and of cysticercosis in certain meat-producing game animals may also be reduced by the availability of adequate hygienic facilities and the education of park labourers.

It is well to bear in mind, whenever the destruction of surplus animals in a park is considered necessary, that disbalances and their complications, including the flare up of certain diseases, may occur subsequent to culling activities. Neitz and Marais (1932), for instance, warned against population explosions of rodents which may potentiate the danger of human bubonic plague when too many small carnivores are destroyed during rabies campaigns.

PREVENTIVE DISEASE CONTROL IN GAME FARMS AND ZOOLOGICAL COLLECTIONS

The principles of prophylactic control remains basically the same but must be adapted to local circumstances.

The introduction of infections via imported animals must be prevented and newly introduced animals must therefore be kept under observation in suitable quarantine enclosures. Diseases imported with infected animals from other countries may not only endanger the lives of animals in a zoo, but may also present a hazard to wild and domestic animals. The importation of animals from countries, harbouring certain dangerous infectious diseases, is for this reason not allowed by most veterinary departments.

The feeding of zoo animals must also be rigidly controlled to prevent the introduction of parasites and other pathogenic material with the food. Grass-hay is often contaminated with ticks, moulds and toxic plants. Muscle-meat and organs, used for the nutrition of carnivores, may be infected with cestode cysts and pathogenic bacteria. Outbreaks of anthrax and food poisoning have been caused in zoo animals by infected food. Anthrozooponoses are also sometimes transmitted to zoo animals by the ingestion of food, offered to them by infected humans. It is therefore advisable that the feeding of zoo animals by visitors be prohibited and only uncontaminated food of a good quality be fed to captive animals.

Close contact may exist between game and domestic stock on game farms and animals in zoos are commonly exposed to anthropozoonoses and zoonoses of domestic pet animals. Direct contact can of course be eliminated by effective barriers. In certain ape-houses in zoos the more valuable ape species are separated from the public by glass-windows. Railway and existing farm fences may sometimes assist in the creation of effective barriers or even animal-free zones around game farms. Most zoos are situated in cities and are well isolated from surrounding farms and domestic farm animals while dogs and cats are generally not allowed in zoos as these may be responsible for outbreaks of fatal virus diseases in wild carnivores.

The larger carnivores of the Pretoria zoo are annually vaccinated against these infectious diseases by means of the Palmer cap-chur gun and dart-syringes. All the felines, genets and civets are immunised against feline infectious panleucopaenia and the canines, hyenas and aardwolves against canine distemper and infectious canine hepatitis. In spite of the fact that all three of these diseases are frequently diagnosed in domestic carnivores in Pretoria and that individual dogs and cats do sometimes succeed in entering the zoo, none of these infections has developed in captive carnivores in the Pretoria zoo, since the employment of this annual vaccination program.

The artificial immunisation of wild herbivores before their release on game farms may also help to protect them against the effects of diseases such as heartwater. Heartwater is known to infect springbok with fatal results (Neitz 1944). Two young springbok were recently injected with heartwater-infected blood. Both animals developed a severe temperature reaction but recovered upon systemic treatment with tetracyclines. Depending on the results of further experiments, young springbok may in future be artificially immunised against this disease before their release on heartwater-infected farms. Grosskopf (1958) immunised eight young eland with heartwater-infected sheep blood. Further experimental work may also indicate the necessity for immunisation of game animals against some of the other infectious diseases of domestic stock.

Other means of prophylactic treatment, routinely employed in the Pretoria zoo, include long term oral therapy with antibiotics of newly introduced psittacine birds for the control of psittacosis and the regular deworming of all carnivores and of herbivores in grass camps.

Internal parasites are sometimes controlled in domestic stock by the continuous addition of low concentrations of anthelmintics to salt-licks. The effect of different anthelmintics on all the different parasite species of wild herbivores has not yet been determined but game often suffer from exactly the same parasitic infestations as domestic farm animals. Low level anthelminitic treatment of wild herbivores may therefore also be of much value on game-farms and in zoological collections. Thibenzole (M.S.D.), which is often used for low level therapy in domestic stock, has already been widely used on many species of wild herbivores and no toxic effects have so far been observed.

Wild carnivores have been treated with "Lintex" (Bayer) for tapeworms, and "Ancaris" (B. W. Co.), a preparation containing piperazine adipate and thenium, for the control of nematodes. In addition to "Lintex", wild primates were also dewormed with Piperazine, "Alcopar" (B. W. Co., a bephenium—containing preparation) and in exceptional cases with "Methyridine" (I.C.I.). The latter drug has been used with great success for the control of certain parasites but must be used with care in primates when administered by a parenteral route as toxic symptoms may develop.

"Malathion" (S.A. Cyanamid) was used on wild carnivores and birds for the control of external parasites and B.H.C.—containing preparations were used for the same purpose on wild herbivores.

Regular mechanical cleansing of all animal enclosures in zoos is of the utmost importance in preventing superinfestations with parasites in game and in preventing the flare-up of other infections. Sick individuals should preferably be removed from healthy animals and treated in special hospital stables. Contaminated bedding must be destroyed and the enclosures thoroughly disinfected to prevent the spread of an infection.

Specific preventive control programs may be compiled for use in zoological collections and on game farms. I have merely attempted to indicate some of the principles to be considered in the planning of such programs. The concept of preventive disease control in zoological collections is universally accepted, but information regarding its practical application is very limited. Veterinarians at many zoological collections are, however, now working on game diseases and I believe that the few examples of medicinal therapy, quoted in this paper, will soon be outdated and replaced by more modern ways of treatment.

THE CONTROL OF ACTIVE OUTBREAKS OF EPIZOOTICS IN GAME

Except for a difference in approach, most of the principles of preventive disease control, described above, also apply in the control of active outbreaks of epizootics. Owing to practical management problems, the control of infections in game animals can be expected to be much more difficult than the control of the same diseases in domestic stock. This is particularly true for free-living wild animals. The control measures will of course vary from one disease to another and may be influenced by different environmental and other factors. It is almost impossible to present a complete program of action for the control of all infectious diseases in parks. The following principles are however of importance in the artificial control of natural epizootics.

(a) *A rapid and accurate diagnosis:* For this purpose well-trained personnel must be at hand and all suspicious cases of disease must be reported to them without delay. Adequate facilities must be provided to these workers for the examination of specimens and the confirmation of diagnosis.

(b) *Immediate organisation of activities:* Local arrangements for the control of an epizootic may be made by the state veterinarian of the region. In South Africa outbreaks of all scheduled diseases are immediately reported to the Director of Veterinary Services by the regional state veterinarian and further country-wide arrangements for the control of the infection may be made by the Director. In some cases technical assistance may be arranged for the infected region.

(c) *Census and isolation of infected animals:* A quick survey must be undertaken to determine the total distribution of the infection. Then various methods should be employed for the restriction of game movements between infected and clean areas. Existing fences, where strategically placed, will be of great help. Temporary barriers may be erected. Relatively simple barriers, such as the bush fence employed during the rinderpest outbreak of 1938-1941 in Tanzania, may prove useful where a more effective fence cannot be erected in time (Thomas and Reid 1944).

Fences and natural barriers must be constantly patrolled and game kept away from these barriers on both sides. This can be done effectively during the day by means of suitable land vehicles such as Landrovers or by light aircraft, especially helicopters. The selective burning of veld and the closing of all drinking places in the vicinity of barriers may assist in the creation of animal-free zones between clean and infected regions.

The removal of any potentially infected material from the infected area must be prohibited and the movement of people through the barriers must be strictly controlled.

(d) *Destruction of infectious material:* All potential sources of infected material in the infected area must be destroyed or rendered safe, and the transport of such material from one place to another must be avoided even within the infected region. Carcasses may be buried preferably after treatment with chemicals such as unslaked lime, or may be burned. All pathogens are fortunately not as resitant as anthrax spores. Rinderpest and foot-and-mouth disease viruses are, for instance, relatively fragile and cannot exist for long periods in the veld. Sporulated anthrax bacilli may, however, remain viable and infectious for many years outside an animal's carcass and are very resistant to the usual methods of sterilisation. Pienaar (1960 and 1961) described various methods, employed in the successful control of outbreaks of anthrax in the Kruger National Park.

(e) *Immunisation and treatment of animals in an infected area:* The advisabilityof immunisation or treatment will largely depend on the disease concerned, the degree of distribution of the infection and the availability of effective methods and suitable facilities for vaccination or treatment.

Immunisation of game with anthrax vaccine, administered by means of dart-syringes to individual animals or through any other medium may, depending on the results of further research, assist in the control of the infection. It may be advisable to vaccinate animals in the adjacent clean areas as well, as the development of immunity may take a considerable time.

In the case of rinderpest, vaccination may also be attempted to protect susceptible species in the face of an active outbreak. The immunogenic and clinical effects of the newer vaccines on game animals have, however, not yet been determined.

To the best of my knowledge, foot-and-mouth disease vaccination has not yet been attempted in the control of an active outbreak in free-living game animals. According to Lambrechts (1967) and Weiss (1967), artificial immunisation of sufficiently large numbers of susceptible game species in areas adjoining infected regions, with vaccine, produced from the responsible strain of virus, may play some role in arresting the spread of foot-and-mouth disease. Although inactivated vaccines may be found adequate in most cases, and immunity with longer-lasting properties may be obtained with attenuated live virus vaccines. It must, however, be stressed that experiments to this effect have not yet been done and that such an undertaking may be hampered by various practical problems.

Outbreaks of other infectious diseases, should be treated on merit: outbreaks of canine distemper in overpopulated areas may, for instance, be overcome by the capture, vaccination and temporary isolation of some of the susceptible animals. With an outbreak of canine rickettsiosis during the breeding season of Cape Hunting dogs, the administration of tetracyclines through drinking water and meat, placed in the close vicinity of their breeding ground, may prove to be of some value. Animals with mange may be captured and again released after treatment with effective insecticides. Various other methods and techniques are possible. The examples given must be regarded as tentative. More definite recommendations for the control of every specific disease condition can only be made after additional research on the control of game diseases.

The control of outbreaks of infectious diseases in zoological collections is less complex, as the handling, treatment, immunisation and isolation of animals can be accomplished with relative ease. Carcasses of infected animals are found and can be destroyed much sooner and the nature of the environment usually lends itself better to disinfection, The principles, described for the control of natural epizootics may, with certain modifications, also be applied to the control of infectious diseases on game farms and in zoological collections.

CONCLUSIONS

1. Regular inspections of game must be undertaken in order to detect any early signs of disease and developing epizootics.

2. More accurate diagnostic methods are required for the detection of latent infections in game animals.

3. The development of effective disease preventive control measures is of the utmost importance in preventing the introduction of new infectious diseases into parks, game farms and zoological collections.

4. With active outbreaks of epizootics, absolute isolation of the infected regions is of primary importance.

5. More research work is urgently required to establish practical ways of prophylatic vaccination of game animals in parks against some of the most dangerous epizootic diseases and the successful treatment of animals in an isolated infected region.

SUMMARY

The rather irregular and sometimes indefinite manifestation of clinical signs by diseased game animals necessitates the employment of specialised diagnostic techniques for the identification of infectious diseases and an evaluation of their effects on infected animals. The value of some of these diagnostic aids in the study of game diseases is briefly discussed.

The potential danger of certain infections to game calls for the development of adequate disease preventive measures wherever wild animals are protected. General principles of disease control are discussed and various suggestions are made as to the practical application of these principles in the control of game diseases in game parks, on game farms and in zoological collections.

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REFERENCES

BROWN, R. H. and SCOTT, G. R. 1960. Vaccination of game with Lapinised Rinderpest Virus. *The Vet. Rec.*, 72: 1232.

DU TOIT, R. 1954. Trypanosomiasis in Zululand and the control of tsetseflies by chemical means. *Onderstepoort J. vet. Res.*, 26: 317.

GROSSKOPF, J. P. W. 1958. Hartwater immunisasie van elande (*Taurotrachus oryx oryx*, Pallas). *Jl. S. Afr. vet. med.* Ass., 29: 329.

HARTHOORN, A. M. and LOCK, J. A. 1960. A note on the prophylactic vaccination of wild animals. *Brit. Vet. J.*, 116: 252.

HOWELL, P. 1965. Personal communication.

LAMBRECHT, M. C. 1967. Personal communication.

MCDIARMID, A. 1960. Diseases of free-living wild animals. Animal Health Branch Monograph No. 1, F.A.O., Rome.

MEESER, M. J. N. and NEL, T. G. 1956. The impact of intensive cattle farming on game and game preservation in the vicinity of the Kruger National Park. *Jl. S. Afr. vet. med. Ass.*, 27: 251.

NEITZ, W. O. 1936. Anthrax: Death in Blesbok (*Damaliscus albifrons*) following the use of goat anthrax vaccine. *Jl. S. Afr. vet. med. Ass.*, 7: 119.

NEITZ, W. O. 1944. The susceptibility of the Springbok (*Antidorcas marsupialis*) to heartwater. *Onderstepoort J. vet. Sci. Anim. Ind.*, 20: 25.

NEITZ, W. O. and MARAIS, I. P. 1932. Rabies as it occurs in the Union of South Africa, 18th Report of the Director of Veterinary Services and Animal Industry, Union of South Africa.

NEL, T. G., MEESER, M. J. N. and VAN DER SCHIJFF, H. P. 1955. Game fences: A general survey. *Jl. S. Afr. vet. med. Assi.*, 26: 281.

PIENAAR, U. DE V. 1960. 'n Uitbreek van miltsiekte onder wild in die Nasionale Kruger Wildtuin. *Koedoe*, 3: 238.

PIENAAR, U. DE V. 1961. A second outbreak of anthrax amongst game animals in the Kruger National Park. *Koedoe*, 4 :4.

PIENAAR U. DE V. 1967. Personal communication.

THOMAS, A. D. and REID, N. R. 1944. Rinderpest in game. A description of an outbreak and an attempt at limiting its spread by means of a bush fence. *Onderstepoort J. vet. Sci. Anim. Ind.* 20: 7.

WEISS, K. E. 1967. Personal communication.

YOUNG, E. 1966a. Muscle necrosis in captive red hartebeeste (*Alcelaphus buselaphus*) *Jl. S. Afr. vet. med. Ass.* 37: 101.

YOUNG, E. 1966b. A preliminary report on blood findings in twenty species of wild mammals. *Jl. S. Afr. vet. med. Ass.* 37: 95.

YOUNG, E. 1966c. Notes on the blood composition of the red hartebeest, *Alcelaphus buselaphus*. *International Zoo Yearbook*, 6: 291.

YOUNG, E. and HOWELL, P. 1966. Bluetongue in the Cape Buffalo, *Syncerus caffer caffer* Sparrman. Unpublished data.

YOUNG, E. 1969. The significance of infectious diseases in African game populations. *Zool. afr.* 4: 275-281.

YOUNG, E. and LOMBARD, C. J. 1967. Physiological values of the African Elephant, *Loxodonta africana*. *The Veterinarian*, 4: 169.