International Journal for Parasitology: Parasites and Wildlife 4 (2015) 50–70

Contents lists available at ScienceDirect

International Journal for Parasitology: Parasites and Wildlife

journal homepage: www.elsevier.com/locate/ijppaw

History and development of research on wildlife parasites in southern Africa, with emphasis on terrestrial mammals, especially ungulates

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ARTICLE INFO

Article history:
Received 29 October 2014
Revised 9 December 2014
Accepted 10 December 2014

Keywords:
Wildlife parasites
Game species
Ungulates
History
South Africa

ABSTRACT

The history of wildlife parasitology in South Africa, and to some extent southern Africa, is reviewed, giving a brief overview of the early years and following its development from the founding of the Onderstepoort Veterinary Institute in 1908 until the turn of the century. An emphasis is placed on game species. The main findings on protozoan parasites, including those of carnivores, are presented, starting in the 1890s and leading up to the first decade of the 21st century. Important developments with regard to the studies of arthropod and helminth parasites took place during a period of three decades, starting from the 1970s. Because of the sheer volume of work done by parasitologists during this time, this particular part of the overview concentrates on South African authors or authors working in South Africa at the time, and is limited to hosts that are members of the order Perissodactyla and the superorder Cetartiodactyla.

1. Introduction

The rich diversity of wildlife found in South Africa awakened the interest of parasitologists from an early stage onwards. Much of the initial work on wildlife parasites was based on incidental findings, but South African parasitologists soon realized the importance of investigating the parasite fauna of wildlife in order to complement their studies on parasites of domesticated animals. They perceived the interrelatedness of the two host groups regarding the potential of wildlife serving as reservoirs for the parasites of livestock and vice versa. From the 1970s on an attempt was made to systematically examine the helminth fauna of each game species and to obtain insight into the composition of their protozoan, arthropod and helminth fauna.

2. Protozoa

After an early start in the 1890s, research into protozoa of wildlife lagged behind the other parasitology disciplines. For the next few decades there were sporadic reports only, probably since veterinary research was focused on diseases affecting livestock. The first systematic investigations of wildlife parasites commenced in the 1960s, with large-scale surveys conducted in the Kruger National Park (KNP) and other conservation areas. Generally, parasites could only be identified to genus level. Real progress could only be made once molecular characterization techniques had become established.

2.1. Hemoprotozoa

2.1.1. Trypanosomes

Shortly after discovering that nagana is caused by *Trypanosoma* spp. and that tsetse flies (*Glossina* spp.) are the vectors, Bruce (1897) confirmed the occurrence of trypanosomes in African buffalo (*Syncerus caffer*), blue wildebeest (*Connochaetes taurinus*), greater kudu (*Tragelaphus strepsiceros*), bushbuck (*Tragelaphus scriptus*) and spotted hyaena (*Crocuta crocuta*) by subinoculation of blood into susceptible dogs. In 1914, impala (*Aepyceros melampus*) and plains zebra (*Equus quagga*) were added to the list (Neitz, 1931), while gray duiker (*Sylvicapra grimmia*) and warthog (*Phacochoerus aethiopicus*) followed in 1921 (Curson, 1928). Much later, a *Trypanosoma theileri*-like parasite was described from spleen smears of a nyala (*Tragelaphus angasii*) (Bigalke et al., 1972).

2.1.2. Piroplasms

Blood smears made from wild animals shot in tsetse-clearing operations in KwaZulu-Natal (KZN) during the 1920s were screened for the presence of piroplasms. *Theileria* spp. were reported from bushbuck, greater kudu, reedbuck (*Redunca arundinum*), mountain reedbuck (*Redunca fulvorufula*), common waterbuck (*Kobus ellipsiprymnus*), blue wildebeest, steenbok (*Raphicerus campestris*),

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http://dx.doi.org/10.1016/j.ijppaw.2014.12.003

gray duiker, warthog and aardvark (*Orycteropus afer*), while the presence of *T. equi* in plains zebras, first reported in 1909, was confirmed (Neitz, 1931, 1933). Although no formal description was made, the name *T. tragelaphi* was coined for the piroplasm occurring in bushbuck (Neitz, 1931). Four decades later a small piroplasm, possibly *T. tragelaphi* and a *Babesia* sp. were reported from a bushbuck (Bigalke et al., 1972).

In 1930 clinical babesiosis was reported from a wild-caught sable antelope (*Hippotragus niger*) transported to the Johannesburg Zoo, apparently the first ever report of this disease in a wild animal (Martinaglia, 1930). The parasite was later named *B. irvinesmithi*. Fatal babesiosis was also recorded in free-ranging sable antelope (Wilson et al., 1974; Thomas et al., 1982). Clinical babesiosis was reported from zoo-bred sable antelope imported into South Africa (McInnes et al., 1991), and a novel *Babesia* sp. from this host, possibly *B. irvinesmithi*, has been characterized molecularly (Oosthuizen et al., 2008).

A new genus name, *Cytauxzoon*, was coined when a hitherto unknown fatal infection in a gray duiker was described; the causative organism was named *C. sylvicaprae* (Neitz and Thomas, 1948). This was followed by the naming of *C. strepsicerosae* from greater kudu (Neitz, 1957). Piroplasmosis was incriminated in causing mortalities in sable and roan antelopes (*Hippotragus equinus*) in game reserves in the northern Transvaal (now Limpopo Province) (Wilson et al., 1974). A piroplasm isolated from a sable antelope carcass [now referred to as *Theileria* sp. (sable)] was successfully established and cultured *in vitro* (Stoltsz and Dunsterville, 1992). Subsequently, *Theileria* spp. associated with mortality in greater kudu, gray duiker, sable antelope and roan antelope were characterized molecularly (Nijhof et al., 2005). *Rhipicephalus appendiculatus* and *R. evertsi evertsi* have been identified as potential vectors of *Theileria* sp. (sable) (Steyl et al., 2012).

Fatal cytauxzoonosis was diagnosed in a young giraffe (*Giraffa camelopardalis*) translocated from Namibia to KZN, South Africa (McCully et al., 1970b). Both a *Theileria* sp. and a *Babesia* sp. have been reported from this host (Oosthuizen et al., 2009).

Fatal cytauxzoonosis was also reported in a tsessebe (*Damaliscus lunatus*) (Jardine and Dubey, 1996). Two novel *Theileria* 18S rRNA gene sequences which are phylogenetically very closely related to both *Theileria* sp. (sable) and *T. separata* have been identified in this antelope (Brothers et al., 2011). Hemoparasites prevalent in nyala in northern KZN included *Theileria* sp. (kudu), *T. buffeli, Theileri*a sp. (sable) and *T. bicornis* (Pfitzer et al., 2011)

East coast fever, caused by cattle-associated *T. parva*, was introduced into southern Africa in 1902 and finally eradicated in the mid-1950s (Lawrence, 1992). Shortly afterwards it was realized that African buffalo are natural hosts of *T. parva* that can be transmitted to cattle (Neitz, 1955). Due to its economic importance as a cause of Corridor disease in cattle, buffalo-associated *T. parva* is being studied intensively (*e.g.* Chaisi et al., 2011; Pienaar et al., 2011).

Between 1967 and 1969, thin blood smears were prepared from 106 healthy white rhinoceroses (*Ceratotherium simum*) in KZN immobilized for translocation. A *Babesia* sp. was seen in two animals (1.9%), while a small *Theileria* sp. was seen in 34 (32.1%) (Bigalke et al., 1970). Fatal babesiosis in black rhinoceros (*Diceros bicornis*) led to the characterization and description of *B. bicornis* and *T. bicornis* (Nijhof et al., 2003). Of 195 white rhinoceroses sampled in the KNP, 71 (36.4%) tested positive for *T. bicornis*, while 18 (9.2%) tested positive for *T. equi*; *B. bicornis* was not found (Govender et al., 2011).

Babesia thomasi was described from rock hyrax (*Procavia capensis*) (Jansen, 1952).

Despite early statements that black-backed jackal (*Canis mesomelas*) could not be infected with piroplasms from domestic dogs (Lounsbury, 1903), *B. canis* (*sensu lato*) was successfully transmitted from domestic dogs to black-backed jackal and African wild dog (*Lycaon pictus*) (Neitz and Steyn, 1947; Van Heerden, 1980). Using molecular techniques, the presence of *B. rossi* was confirmed in African wild dog (Matjila et al., 2008).

In the 1930s, a small piroplasm, now called *B. cynicti*, was described from yellow mongoose (*Cynictis penicillata*), one of the main vectors of the rabies virus on the central plateau of Southern Africa (Neitz, 1938). It was subsequently found to be quite prevalent in three mongoose populations studied (Penzhorn and Chaparro, 1994).

Piroplasms, first reported in lion blood smears from the KNP in 1975, were subsequently found to be quite prevalent (Young, 1975; Lopez-Rebollar et al., 1999). Although initially regarded as *B. felis*, molecular characterization revealed the presence of a hitherto unknown species, later named *B. leo* (Penzhorn et al., 2001). *Babesia lengau*, which was subsequently described from cheetah (*Acinonyx jubatus*), as well as *B. felis* and *B. leo*, were subsequently reported from various other wild felids (Bosman et al., 2007, 2010).

2.2. Coccidia

2.2.1. Intestinal coccidia

Coccidiosis is a disease of intensification due to the build-up of sporulated oocysts in accumulated feces, facilitating ingestion of large infective doses. A further factor is immunosuppression of the host, due to stress. This is particularly relevant in free-ranging wild animals brought into captivity, even temporarily. Reports of intestinal coccidia from wildlife are few and far between and systematic studies are lacking.

Eimeria impalae was incriminated as causing fatal coccidiosis in juvenile impala captured during autumn/winter and subsequently held in a boma (Bigalke, 1964; Pienaar et al., 1964). A rare, aberrant coccidian causing small intrauterine polyps, also developing in uterine glands of impala ewes and sporulating *in situ*, was named *E. neitzi* (McCully et al., 1970a).

At least six different *Eimeria* oocyst types have been recovered from African buffalo feces (Penzhorn, 2000), while fatal coccidiosis in springbok (*Antidorcas marsupialis*) was reported on a game ranch (Lopez-Rebollar et al., 1997).

2.2.2. Tissue-cyst-forming coccidia

Unidentified sarcocysts were reported at routine carcass inspection of African buffalo, impala, nyala and eland (*Taurotragus oryx*) (Young and Wagener, 1968; Young and Van den Heever, 1969; Basson et al., 1970; Keep, 1970, 1971, 1972). In virtually all cases the complete life cycle of the organisms is not known. It has been reported, however, that vultures *Gyps* spp. are definitive hosts of a *Sarcocystis* species, presumably *S. melampi*, from impala (Markus et al., 1985).

Detailed morphological studies of sarcocysts from various South African host species were carried out during the 1990s. The cyst wall of a sarcocyst from African buffalo was morphologically similar to that of *S. fusiformis*, but dimorphism of the cyst organisms, not known from *S. fusiformis*, was noted (Bengis et al., 1997). *Sarcocystis melampi* was described from impala, while a sarcocyst from greater kudu was structurally indistinguishable from *S. hominis*, which occurs in cattle (Odening et al., 1998). Three new species were described from giraffe: *S. giraffae, S. klaseriensis* and *S. camelopardalis* (Bengis et al., 1998). Two new species were described from warthog: *S. dubyella* and *S. phacochoeri* (Stolte et al., 1998). Two new species were described from the hippopotamus (*Hippopotamus amphibius*): *S. hippopotami* and *S. africana* (Odening et al., 1997).

During routine carcass inspection in KNP, *Besnoitia* cysts were found in greater kudu, blue wildebeest and impala (Basson et al., 1965b). Further investigation revealed that they were closely related to *B. besnoiti*, and a live vaccine against bovine besnoitiosis was developed from this isolate (McCully et al., 1966; Bigalke et al., 1967, 1974). *Besnoitia* cysts have also been reported from a warthog (Keep and Basson, 1973).