

consacrés à l'helminthisme des animaux domestiques et sauvages
 ont éparpillés et ils n'étaient pas tous disponibles pour être inclus
 dans la communication. Les parasites décrits ont été classés selon la méthode
 de R. S. 2). Ils comportent 74 lombricoïdes, un acanthocéphale, une
 espèce de ténias et 24 espèces de trématodes. Les animaux domes-
 tiques sont des bovins, des poulets, des chiens, des ânes, des caprins, des
 porc-épics. Les animaux sauvages, hôtes étaient le buffe, le céphalophe et
 le duiker, l'élan, l'éléphant, la gazelle de Grant, la pintade, le
 héron, l'hippopotame, le milan, le Kob de
 la vipère clotho, le python, le rat, le reedbuck, le sitatunga, le
 sing et le zèbre.

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A SURVEY OF PARASITIC INFESTATION OF WILD HERBIVORES IN THE SERENGETI REGION IN NORTHERN TANZANIA AND THE LAKE RUKWA REGION IN SOUTHERN TANZANIA

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All animals carry some parasite burden, although, in the case of man and his domestic stock, modern hygiene and medicines have reduced this burden to relatively low levels. The incentive that has led to man's attack on parasites has primarily been the increased productivity that results from reducing the level of parasite infestations.

Wild animals carry a natural and often heavy—judged in the terms normally applied to domestic stock—burden of parasites without apparent ill-effects. It is incorrect to accept the evidence of this apparent healthy co-existence as indicative of the non-pathogenicity of parasites in wild animals, but rather that a favourable balance between the host and its parasite community has been established through an evolutionary process. Since parasites must feed, at some expense to the host, they may reduce the efficiency of the infested host animal and ultimately its productivity, and may become overtly pathogenic when their numbers greatly increase, or the animal is stressed.

Man's interference with natural ecosystems, largely mediated through reducing the ranges of wild animals, favours some parasites in the host parasite relationship by increasing the efficiency of the parasite's mechanisms of infestation, as seen at its most extreme in the case of zoological gardens. This is to a certain degree relevant also in East African situations, where National Parks and Game Reserves may become increasingly confined and contracted, and therefore parasites may play a greater part in the dynamics of wild animal populations as agents of mortality. Concentration of animals, overstocking and lack of rotational grazing allow parasites to increase within the host extremely rapidly, a fact well known in domestic stock. Moreover, many of the parasites of wild animals are of the same genera, often the same species, as parasites which infect domestic stock. Parasites, including viruses, bacteria and protozoa as well as helminth parasites, affecting both wild and domestic stock, may be of a significant influence on the livestock industry of East Africa, and the problems arising from this must not be under-estimated. On the other hand, parasites occurring in the muscles or organs of wild animals would render such infested meat unfit for human consumption. Even if there is not a direct threat of human infection from some of those parasites living in the flesh of game animals, the mere aesthetic considerations are likely to present problems in the marketing of wild animal meat.

Work on wild animal parasites from widely separated areas (Urquhart, Hay, Zaphiro and Spinage, 1960; Ortlepp, 1961; Condy, 1963; Dinnik, Walker, Barnett and Brocklesby, 1963; Roth and Dalchow, 1967; Dinnik and Sachs, 1968) suggests a wide diversity in both incidence and degree of parasitic infestation in wild host

species from different areas. These different characteristics of an area in respect of its parasite community are of considerable importance in a land-use context, and from the point of view of the ecology of the area. It would therefore be of great value to build up a picture of the geographical range, host specificity, clinical symptoms, infestation levels and general effects on productivity attributable to the various parasite species of East African game animals.

MATERIAL AND METHODS

During research work from 1964 to 1967 into game utilisation in the Serengeti region in northern Tanzania and the Lake Rukwa region in southern Tanzania a wide range of species have been shot in the course of studies of the suitability of wild animals as sources of protein for human consumption. (Sachs and Gleeson, 1967; Reinwald and Hemingway, 1967). The animals were shot in the neck in conditions allowed, and blood was collected immediately after death for subsequent testing of the serum for antibodies, mainly rinderpest (Taylor and Watson, 1968) and brucellosis (Sachs and Staak, 1966; Sachs, Staak and Grocock, 1968). Blood smears were made for the examination for blood parasites (Baker, Sachs and Laufer, 1967), ectoparasites were collected, and the general condition, age and sex of the animal noted. The weights and measurements of each animal were obtained (Sachs, 1967), and the meat production potential assessed by dissecting the dressed carcass into its components—lean meat, fat, bones and other offals (Ledger, Sachs and Smith, 1967). During this thorough examination, diseased or abnormal tissues and organs were collected for microscopic and histological examinations. It was further attempted to locate and count as many of the parasites visible to the naked eye as possible, and, when time permitted, the intestinal worm burden was surveyed. Such detailed autopsy was necessary in the first instance to establish levels of "normality" for the appearance of the carcass tissues and organs for further meat inspection work and for the infestation levels of parasites.

The results presented in the first part of this paper are confined mainly to the finding of parasites visible to the naked eye or whose presence can be diagnosed by characteristic lesions observed during a routine inspection. They include information on the incidence and infestation levels of parasites of wild herbivore species examined in two different areas, inferences about the relationship between host and parasite, and relevance of some parasites to meat hygiene and productivity. Table I is a summary of the results which will be discussed in some detail.

The species of the wild herbivores for which data are presented in Table I or which are mentioned elsewhere in this paper, include giraffe—*Giraffa camelopardalis*, buffalo—*Syncerus caffer*, zebra—*Equus burchelli*, warthog—*Phacochoerus aethiopicus*, eland—*Taurotragus oryx*, waterbuck—*Kobus defassa*, wildebeest—*Connochaetes taurinus*, hartebeest—*Alcelaphus buselaphus cokei*, topi—*Damaliscus korrigum*, impala—*Aepyceros melampus*, Grant's gazelle—*Gazella granti*, Thomson's gazelle—*Gazella thomsoni*, dik-dik—*Rhynchotragus kirki*, roan antelope—*Hippotragus equinus*, puku—*Kobus vardonii*, reedbuck—*Redunca redunca*, Uganda kob—*Kobus kob*, kudu—*Strepsiceros strepsiceros*, bushbuck—*Tragelaphus scriptus*, rhinoceros—*Diceros bicornis*, and elephant—*Loxodonta africana*.

External Parasites

Ticks

Buffalo, eland and giraffe were often found to carry heavy infestations of ticks

| Host Animal | Parasitic infestation with | | | | | | | | | | | |
|-------------|----------------------------|---|---|---|---|---|--------------------|---|---|---|---|---|
| | Ectoparasites | | | | | | Internal Parasites | | | | | |
| Giraffe | ○ | ○ | ○ | ○ | ○ | ○ | ○ | ○ | ○ | ○ | ○ | ○ |
| Buffalo | ○ | ○ | ○ | ○ | ○ | ○ | ○ | ○ | ○ | ○ | ○ | ○ |
| Zebra | ○ | ○ | ○ | ○ | ○ | ○ | ○ | ○ | ○ | ○ | ○ | ○ |
| Warthog | ○ | ○ | ○ | ○ | ○ | ○ | ○ | ○ | ○ | ○ | ○ | ○ |
| Eland | ○ | ○ | ○ | ○ | ○ | ○ | ○ | ○ | ○ | ○ | ○ | ○ |
| Waterbuck | ○ | ○ | ○ | ○ | ○ | ○ | ○ | ○ | ○ | ○ | ○ | ○ |
| Wildebeest | ○ | ○ | ○ | ○ | ○ | ○ | ○ | ○ | ○ | ○ | ○ | ○ |
| Hartebeest | ○ | ○ | ○ | ○ | ○ | ○ | ○ | ○ | ○ | ○ | ○ | ○ |
| Topi | ○ | ○ | ○ | ○ | ○ | ○ | ○ | ○ | ○ | ○ | ○ | ○ |
| Impala | ○ | ○ | ○ | ○ | ○ | ○ | ○ | ○ | ○ | ○ | ○ | ○ |
| Grant | ○ | ○ | ○ | ○ | ○ | ○ | ○ | ○ | ○ | ○ | ○ | ○ |
| Thomson | ○ | ○ | ○ | ○ | ○ | ○ | ○ | ○ | ○ | ○ | ○ | ○ |
| Dik-dik | ○ | ○ | ○ | ○ | ○ | ○ | ○ | ○ | ○ | ○ | ○ | ○ |
| Roan | ○ | ○ | ○ | ○ | ○ | ○ | ○ | ○ | ○ | ○ | ○ | ○ |
| Topi | ○ | ○ | ○ | ○ | ○ | ○ | ○ | ○ | ○ | ○ | ○ | ○ |
| Puku | ○ | ○ | ○ | ○ | ○ | ○ | ○ | ○ | ○ | ○ | ○ | ○ |
| Reedbuck | ○ | ○ | ○ | ○ | ○ | ○ | ○ | ○ | ○ | ○ | ○ | ○ |
| Zebra | ○ | ○ | ○ | ○ | ○ | ○ | ○ | ○ | ○ | ○ | ○ | ○ |

| Host Animal | Parasitic infestation with |
|--------------------|--|
| Ectoparasites | Ticks |
| | Lice |
| | Flies |
| | Hippoboscid flies |
| | Sarcoptic mange |
| | Nematodes in skin |
| Internal Parasites | in head cavity |
| | in trachea or bronchi |
| | in trachea |
| | in respiratory tract |
| | in nasal cavity |
| | in head cavity |
| | in head cavity |
| | in head cavity |
| | in head cavity |
| | in head cavity |
| Internal Parasites | Muscular cysticercosis (larvae) |
| | Serous cysticercosis in thorax |
| | Serous cysticercosis in abdomen |
| | Intra-abdominal cysticercosis |
| | Echinococcosis |
| | Spirochaetosis |
| | Filaria in subcutis |
| | Nematode nodules in muscle |
| | Sarcocystis infection |
| | Setaria sp. |
| Internal Parasites | in abdominal cavity, internal organs and blood vessels |
| | Conical stomach flukes |
| | Liver flukes |
| | Liver tapeworms |
| | Liver nematodes |
| | Pentastomid larvae |

● = almost always encountered
○ = often encountered, usually heavy infestation
○ = observed to occur
○ = very rare finding

All other species were usually lightly (less than 10 ticks per animal) infested. Warthogs were notable in carrying soft ticks, *Argasidae*, as well as the more common hard ticks, *Ixodidae*. In a preliminary survey on ticks collected from various wild animals of the Serengeti, four species of Rhipicephalus, three Hyalomma- and four Amblyomma-species were identified.

Lice

Lice were found in very small numbers on most Serengeti herbivores, but none were recorded in the Rukwa population. A heavy infestation of lice seems to occur in sick animals. Brooks (1961) recorded *Damalinea parkeri*, *Linognathus lewisi* and *Linognathus* sp. near *tibialis* from Thomson's gazelle in the Serengeti. The lice occurring on the various other game species of the Serengeti collected by us have not yet been identified.

Fleas

The only non-carnivorous animal on which fleas were observed was the warthog.

Hippoboscid flies

The true parasitic hippoboscid flies, those with rudimentary wings resembling sheep kedds of domestic stock, were seen infrequently on Grant's gazelle and Thomson's gazelle in the Serengeti, and were recorded by Brooks (1961) as *Echistypus sepiaceus*. Winged forms of hippoboscid flies were seen on zebra, wildebeest and a variety of wild carnivores.

Sarcoptic mange

Thomson's gazelle in the Serengeti were found infested, often heavily, with mites of the genus *Sarcoptes*. Schiemann (1968) recently observed an infestation in Grant's gazelle, but no other species surveyed thus far showed any incidence of sarcoptic mange.

Nematodes in skin

Giraffe in the Serengeti area were not infrequently infested with skin lesions, not unlike mange, on the carpal joints, frontal parts of the shoulder and around the hooves. Sweatman (1964) studied our material and could not find any mites. However, small nematodes which could conceivably be associated with the skin lesions were observed.

Warbles

Fly maggots resembling ox-warbles were not observed in the Serengeti animals. Reedbuck were often heavily infested in the Lake Rukwa area while roan antelope and puku were occasionally infested. Specimens examined by Zumpt (1968) were of the genus *Strobiloestrus*. Unfortunately, the parasites could not be further identified from the larvae collected. Therefore, hatching of the maggots should be attempted, as the examination of the adult fly is essential for identification of skin warbles.

Ectoparasites usually do not create problems in meat hygiene, except the

sarcoptic mange may cause considerable loss of condition and emaciation of the carcass. Ticks, mites, skin-nematodes and fly maggots, however, can damage the meat so as to make it commercially useless.

Internal Parasites

During our survey we classed the internal parasites conveniently into four groups, namely (1) parasites observed in the head cavities and respiratory tract, (2) the larval stages of tapeworms and other parasites occurring in musculature and connective tissue, (3) parasites found in the abdominal cavity, organs and blood vessels, and (4) the parasites of the intestinal tract.

The finding of parasites of groups 1, 2 and 3, i.e. parasites macroscopically visible or easily detectable due to characteristic lesions caused by them, was compiled in Table I. Group 2 must be considered of some importance in regard to meat hygiene, because judgment of a carcass as to its fitness for human food may depend on such findings, or the degree of infestation. Group 4 will be dealt with separately in the second part of this paper. The conical stomach flukes were included in Table I, as these parasites are so easily visible and can, contrary to the other parasites of the intestinal tract, be recorded during routine examination of an animal.

Parasites in Head Cavities and Respiratory Tract

Oestrid larvae

Topi, hartebeest and wildebeest were found to be often and heavily parasitised by oestrid larvae, i.e. maggots of flies of the family *Oestridae*, occurring in the nasal passage and the frontal sinuses of the head. Similar maggots, but somewhat smaller in size, were occasionally found in the trachea and bronchi. Very small oestrid larvae were recorded from the brain-case of wildebeest, which was often heavily infested.

The oestrid larvae of the Serengeti game animals were identified by Zumpt (1968), who recorded *Oestrus aureoargentatus* from topi and wildebeest, *Oestrus variolosus* from topi, wildebeest and hartebeest, *Kirkioestrus minutus* from topi, and *Gedoelstia cristata* from wildebeest and hartebeest. Giraffe was infested with *Rhinoestrus giraffae*, and zebra were parasitised by *Rhinoestrus usbekistanicus*. The parasites in the brain-case of wildebeest were identified as the first instar larvae of *Gedoelstia haessleri*.

Rhinoestrus usbekistanicus was originally described from the horse, but the oestrid larvae recovered from antelopes have not yet been found in domestic stock. Masai sheep and goats surveyed in the Serengeti area were infested with the common sheep nasal fly, *Oestrus ovis*, which was not recorded in the game material although close contact between wildlife and domestic animals occurs in the area.

Syngamidae in nasal cavities

Nematodes, very conspicuous because the male and female worms are attached to each other in permanent copulation thus forming a characteristic Y-shape, were frequently recovered from the Serengeti waterbuck, and the puku in the Rukwa area. The parasites belong to the family *Syngamidae*, of which family the gape-worm, *Syngamus trachea*, is a common parasite of fowl. Members of this family occurring in mammals are grouped in the genus *Mammomonogamus*. During our

Further investigations into the occurrence of this parasite in East African game animals, we found it in the nasal passage and pharynx of the Uganda kob and buffalo in Uganda and Bindernagel (1968) recorded *Mammomonogamus toxodontis* in the trachea of elephant in Uganda.

Lungworms

The common lungworm occurring in the trachea and bronchi of its host, *Dictyocaulus viviparus*, was recorded from topi, wildebeest and hartebeest, while *Dictyocaulus arnfieldi* was collected from zebra in the Serengeti.

Walnut-size nodules in the lung tissue of most topi and hartebeest in the Serengeti and less frequently in wildebeest, were found to contain a rather large, 10-30 cm. long blackish nematode, *Protostrongylus africanus*, belonging to the family *Protostrongylidae*. The finding of this parasite in only one impala and one Thomson's gazelle out of a great number of these species examined are considered indicative for facultative parasitism.

Small protostrongylid nematodes, barely visible to the naked eye but easily detected due to the characteristic lesions caused by them mainly on the posterior margin of the lung lobes, were frequently found in topi, hartebeest, wildebeest, impala, Grant's gazelle and Thomson's gazelle of the Serengeti. Both large and small protostrongylid lungworms were not seen in the Rukwa area.

A detailed study of parasitic pneumonia in the Serengeti antelopes has been published by Dinnik and Sachs (1968), who recorded the minute lung nematodes *Protostrongylus gazellae* in Thomson's gazelle and Grant's gazelle, *Protostrongylus etoshai* in topi, wildebeest and hartebeest, *Pneumostongylus cornigerus* in topi and hartebeest, and *Pneumostongylus calcaratus* in all five antelope species just mentioned as the most common and least host-specific lung nematode occurring in the Serengeti.

Whereas both *Dictyocaulus viviparus* and *D. arnfieldi* are known to occur in cattle and horses respectively, the lung nematodes of the family *Protostrongylidae* recorded in this survey have thus far been only recovered from antelope.

Larval stages of Tapeworms and other Parasites in Musculature and Connective Tissue

Muscular cysticercosis

Cysticerci in the musculature of food animals have considerable importance in the aspect of meat hygiene, since cysts capable of giving rise to human tapeworm infestation cannot be differentiated macroscopically from those which do not have human beings as definite hosts. From an aesthetic point of view, meat inspectors would regard an animal carcase carrying numerous larval tapeworm cysts as unfit for food (as would most consumers), even if the larval tapeworms in the flesh were known to be harmless.

Wildebeest, hartebeest, topi, Grant's gazelle and dik-dik in the Serengeti, and the Rukwa reedbuck, were frequently heavily infested with muscular cysticerci. Buffalo, eland, waterbuck and impala in the Serengeti, and roan antelope, topi and puku in the Rukwa area carried occasionally and less numerous cysticerci in the musculature. Thomson's gazelle seemed to be exceptionally "clean". Sachs (1966) supported the hypothesis that Thomson's gazelle have a certain natural resistance against infection with muscular cysticercosis, after he had examined

animals of this species and found none infested. However, in further cysticercosis research we have found three Thomson's gazelles out of a total of some 90 animals lightly infested with muscle-cysticerci. This very low infection-rate of the Thomson's gazelle compared with more than 70% of the Grant's gazelles infected with muscular cysticercosis is an extremely fascinating biological point, since both animals of the same genus, with similar food habits, living in close relationship and often together in the same herds.

Further research confirmed that the adult tapeworms mainly involved in the muscular cysticercosis of antelopes in the Serengeti were *Taenia hyaenae* of the spotted hyaena (*Crocuta crocuta*) and *Taenia gonyamai* of the lion (*Panthera leo*) (Sachs, 1968).

As hooked cysts were recovered from the musculature of cattle in the Masai land (Nelson, Pester and Rickman, 1965), the possibility remains that also domestic stock may be infected by tapeworms occurring in wild predators. On the other hand, larval stages of the human tapeworm *Taenia saginata*, which have no hooks, were recorded from various game species, including wildebeest (Nelson *et al.*, 1965), which findings indicate that the problem of muscular cysticercosis in wild herbivores must not be under-estimated.

Serosal cysticercosis

This term was used by us for those cystic stages of tapeworms found in both the abdominal and thoracic cavity attached to the serosal surfaces of the digestive tract, omentum, liver, mediastinum and the serous membranes of heartsac and pleura of the lungs forming bladder-cysts of various sizes, but which are of no major significance in meat hygiene considerations.

Serosal cysticercosis was found infrequently in the thorax but was often encountered in the abdominal cavity, especially of Thomson's and Grant's gazelle. The condition was not observed in the Rukwa area. Preliminary studies on the morphology of serosal cysts collected from the abdominal and pleural cavity of various wild herbivore species in the Serengeti indicate that these larval tapeworm stages are not *Cysticercus tenuicollis* as erroneously suspected by various investigators.

Intrasacral cysticercosis

Wildebeest occasionally, topi and hartebeest frequently had cysts in the lumen of the vertebra of the sacrum bone. These cystic tapeworm stages resemble serosal cysticerci in size, but the location inside the sacrum bone of their host's body made this finding a rather unusual one. It would be reasonable to suspect that the hyaena is the host of the adult tapeworm of this larval stage, since the hyaena would be the most likely carnivore to crack and devour the sacrum vertebra thus completing the life-cycle of these sacrum cysts.

Echinococcosis

The larval stages of the Echinococcus tapeworm of carnivorous animals, hydatid cysts, were occasionally encountered in the lung tissue of wildebeest in the Serengeti and puku in the Rukwa area. They were likewise observed in the liver of giraffe and warthog, in the latter rather frequently. The finding of larval Echinococcus cysts in wild herbivorous animals indicates that adult tapeworms may be carried by some wild predators. While working with wild carnivores one should be aware of the seriousness of human Echinococcus-infection.

Sparganosis

Some wild animals of the Serengeti showed occasional infestation of the connective tissue in the vicinity of the tendons of the hock-joint with larval stages of a tapeworm of the family *Diphyllobotriidae*. The whitish, long, tape-like parasites known as *spargana*, may also occur in the musculature. They were frequently found in the flesh of the neck and head, especially the muscles near the root of the tongue of warthog. There is no record of spargana in Rukwa.

Preliminary investigations into the nature of spargana by Dinnik (1968) have revealed that most probably tapeworms of the genus *Spirometra*, which were found frequently in hyena and lion, are the adult stages of the spargana recovered from wild herbivores.

Filaria in subcutis

Small whitish nematodes of the family *Filariidae* were infrequently encountered, usually immediately after skinning, superficially in the subcutaneous connective tissue of both herbivorous and carnivorous Serengeti animals, but were not found in the Rukwa area. Our material was examined by Shoho (1967) who described a new species recovered from the Serengeti giraffe, *Pseudofilaria giraffae*. The other filariform nematodes found in the subcutaneous tissue of various antelopes are awaiting identification.

Nematode nodules in musculature

Infrequently nodules resembling muscle-cysticerci in shape and size were collected from buffalo in the Serengeti. The nodules contained small brownish nematodes which have yet to be identified.

Sarcocystis-infestation

A heavy infestation with "Miescher's tubes" containing the small spores of the genus *Sarcocystis* was frequently encountered in buffalo, Thomson's gazelle, waterbuck and warthog of the Serengeti. Shape and size of the whitish sarcocysts in the flesh vary considerably in the various wild animal species. In the Thomson's gazelle, there were usually small cysts measuring 0.5 × 0.2 cm. with tapered ends. In waterbuck the cysts may have a similar spindle-shape form but measure about 2.0-3.0 cm. long and 0.2-0.4 cm. wide. Whereas the buffalo had very large sarcocysts of about 5.0 cm. long and 2.0 cm. wide (and even larger), mainly found in the oesophagus, wildebeest and topi were infested with small, barely visible, elongated cysts of about 4.0 cm. long and 0.1 cm. wide, and in warthog and carnivorous animals the sarcocysts were only detected during microscopic examination of muscle specimens. The marked differences in shape and size suggest that the various game animals harbour different species of *Sarcocystis*.

Parasites in Abdominal Cavity, Organs and Blood Vessels

Setaria

Almost all wild herbivores in both the Serengeti and the Lake Rukwa area were found to harbour large white nematodes of the family *Filariidae* living free in the abdominal cavity, with an apparent preference to the pelvic cavity in Thomson's and Grant's gazelles. Waterbuck, buffalo, zebra and reedbuck were usually

vily infested. In giraffe, impala and dik-dik the parasites were recorded in only one case for each species.

Shoho (1967), who examined the material from the Serengeti and Lake Rukwa, attributes to these parasites a high degree of host-specificity, and recorded *Setaria coronata* from waterbuck, *S. bouleengeri* and *S. graberi* from reedbuck, *S. poultoni* from topi, hartebeest and wildebeest, *S. hornbyi* from roan antelope, *S. africana* from eland, *S. nelsoni* from buffalo, *S. sachsi* from giraffe and *Gazelofilaria tanganyikae* from Thomson's and Grant's gazelle.

Monical stomach fluke

These conspicuously pear-shaped parasites were found mainly in the rumen, but also often in other parts of the digestive tract, of almost all antelopes and buffalo in the Serengeti and the Rukwa area. Dinnik (1968) identified the collected specimens as *Paramphistomum phillerouxi*, *Paramphistomum sukumun*, *Paramphistomum nikari*, *Calicophoron raja*, *Cotylophoron cotylophorum*, *Stephanopharynx secundus* and *Carmyerius mancupatus*. Most frequently *Calicophoron raja* and *Paramphistomum phillerouxi* were recovered, and were found to show no specificity towards their hosts. All these stomach fluke species, except *Stephanopharynx secundus*, occur in domestic stock (Dinnik, 1964), and were also recovered from cattle in the area adjacent to the Serengeti National Park.

Liver flukes

Buffalo, eland, wildebeest and topi in the Serengeti area were found to infrequently harbour a small number of liver flukes in the common bile duct or the gall bladder which were identified by Dinnik (1968a) as *Fasciola gigantica*. The parasite has not been recorded from the Rukwa area to date.

Liver tapeworms

Eland, waterbuck and impala of the Serengeti were almost invariably found to be heavily infested with liver tapeworms of the genus *Stilesia*, which parasites appear to be specific for these three wild herbivore species.

Liver nematodes

The livers of impala were usually found to be infested with small, brownish nematodes, *Cooperioides hepatica*. The bile ducts were dilated and pus-filled nodules containing numerous parasites were observed. *Monotondella giraffae* was recovered from the bile ducts and the *ductus choledochus* of Serengeti giraffe. Zebra frequently had heavy infestation of the liver tissue with nodules of about 3.0 cm. diameter, containing a large nematode believed to be a larval stage of *Strongylus* sp. The zebra in the Rukwa area seemed to be even more heavily infested with these liver-roundworms than those in the Serengeti.

Pentastomid larvae

Most antelopes, warthog and buffalo of the Serengeti showed an infestation with small, whitish, tongue-shaped larvae of 0.4-0.7 cm. long belonging to the family *Pentastomidae*. The parasites were found in antelopes mainly under the capsule of the liver and kidney curled up in the tissue, but also in the lymph nodes of the lungs, whereas in buffalo the intestinal lymph nodes seemed to be favoured. The larvae were also found free in the abdominal cavity after having left their location in the various organs and leaving characteristic cavern-like lesions in liver and kidneys.

They were observed in the *vena portae* of the liver and in the heart ventricles thus indicating that they occur free in the blood stream. The parasites were not seen yet in game animals of the Rukwa area.

Comparative morphological studies of the small larval stages found in herbivores and the adult pentastomids occurring in the nasal cavities of carnivorous wild animals led to the recording of a new species, *Linguatula multiannulata*, in the spotted hyena (von Haffner, Sachs and Rack, 1967).

Schistosomes

None of about 350 Serengeti and Rukwa game animals of various species examined for this parasite by carefully checking the mesenteric blood vessels was found infested with schistosomes. *Schistosoma bovis*, however, was found to be common in cattle and sheep in the vicinity of the Serengeti National Park, and schistosomes of other species are known to occur in situtunga, wildebeest, waterbuck, reedbuck and other antelopes in Zambia (Dinnik and Dinnik, 1965).

Other parasites known to occur in wild herbivores in East Africa but not found during our survey, were *Elaeophora* and *Thelazia*, whose occurrence in buffalo in Uganda was recorded by Dinnik *et al.* (1963), *Gongylonema* in the oesophagus of buffalo, which Bindernagel (1968) observed in Uganda and *Cordophilus*, which we saw in the heart-muscle of a kudu shot in central Tanzania, and which was also observed by Bindernagel (1968) in the bushbuck in Uganda.

Parasites of the Intestinal Tract

The bulk of the internal parasites occurring in an animal is found in its digestive tract, in the case of ruminants especially in the abomasum, small and large intestines. Some of the larger helminths are easily visible after the stomach and intestines are cut open, as, for example, conical stomach flukes, tapeworms, hookworms and some larger nematodes in the colon. Most of the intestinal parasites, however, are small and barely visible to the naked eye. Therefore the parasitic infestation of the intestinal tract cannot be assessed by a routine inspection which would be sufficient to detect those parasites mentioned in the previous chapters. The degree of infestation of the intestinal tract would normally be ascertained by a "total worm count" with subsequent identification of the helminths involved. This procedure requires a great deal of time, special equipment, skilled personnel and plenty of water at one's disposal, an unlikely condition when working with game animals in the field.

Worm egg count

An assessment of the intestinal worm burden of a live animal can be made by the examination of faecal samples for the presence of worm eggs. The worm egg output of an animal is frequently in direct proportion to the number and species of the gastro-intestinal parasites present. Many techniques have been devised for an accurate count of the worm eggs excreted with the faeces. Although reliable only with certain restrictions, the various worm egg counting methods have the great advantage that it is not necessary to kill the animal for such survey. Assessing the

number of worm eggs being passed out on to the ground with the host's faeces is of considerable importance, as well for a wild herbivore population as for a herd of domestic animals in a limited area, as these eggs hatch and the infective larvae wait an opportunity to infect a suitable herbivore host. The continued use of a restricted and small range by high densities of herbivores, wild or domestic, must be expected to result in high infestation levels of intestinal worms, and the higher the worm egg output the higher the hazard of re-infestation.

An attempt was made to examine the worm eggs in the faeces of a variety of herbivorous wild animals of the Serengeti National Park by counting the worm eggs in a diluted faecal sample and assessing the output of "eggs per gramme faeces". The resulting figure will supply an index of the level of infestation, but sample variance and the variance inherent in the egg production of female worms parasitising the intestinal tract are likely to be of a high order, so it would be unwise to consider the result of the counts as having more than indicative value.

We performed the counting of worm eggs as outlined in the Laboratory Manual of the Helminthology Section, Onderstepoort Veterinary Research Laboratory, and the method used is given below:

Collection of droppings

Wild animals were observed with binoculars in the natural environment. The fresh warm faeces were collected immediately after defaecation, recording the approximate age, sex and general condition of the defaecating animal. The faecal sample, about 10 to 20 grammes, was put into a numbered paper cup and returned to the field laboratory. Some samples were collected from shot animals from which a total intestinal worm count was also performed in order to correlate egg counts and worm counts, as well as the worm species involved. These results, which have shown clearly that in most cases the worm-egg output was in a direct proportion to the number of worms present, will be the subject of another paper.

Preparation of the faecal emulsion

The faecal pellets of one animal were ground together in a mortar to effect complete mixing. Two grammes (for buffalo four grammes) of faeces were weighed out and placed in a plastic bottle together with some 8-10 steel ball bearings. Fifty-eight ml. (for buffalo 56 ml.) of a 40%-50% sugar solution was added, and the bottle was vigorously shaken for two to three minutes to prepare a faecal emulsion. One or two drops of amyl alcohol were added to the mixture to break excessive formation of air bubbles.

Examination and calculation of number of worm eggs

A fixed volume of the faecal emulsion was transferred to three McMaster slides using a wide-mouthed pipette. The slides were allowed to stand for two minutes during which time the thin-shelled, light worm eggs rise to the surface and are then counted under the microscope. The number of worm eggs per gramme (e.p.g.) was then obtained by multiplying the number of eggs actually counted by the known dilution factor, i.e. $\times 200 : 6$, except in buffalo where the total number of eggs is multiplied by $100 : 6$.

No attempt to differentiate the various worm eggs, which would have been possible for a few nematode species, was made. The e.p.g. therefore indicates the number of those eggs excreted with the faeces whose specific weight was lighter