Wildlife Disease Research and Economic Development

Proceedings of a workshop held in Kabete, Kenya, 8 and 9 September 1980

Editors: Lars Karstad, Barry Nestel, and Michael Graham

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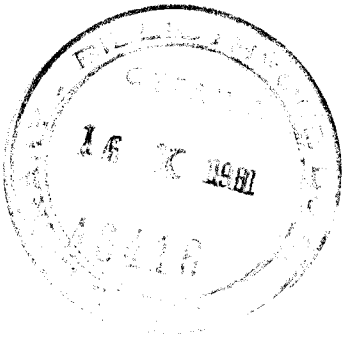

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The Public Health Significance of Cysticercosis in African Game Animals

P. Stevenson,[1] A. Jones, [2] and L.F. Khalil[2]

Tapeworm cysts are frequently found in the muscles of slaughtered cattle in East Africa and are well recognized as being both a public health risk and a significant cause of financial loss to the meat industry. The cysts are almost always the larval form of the tapeworm *Taenia saginata*, the adult of which occurs only in the small intestine of man.

In an attempt to control the infection in man, cattle slaughtered in Kenya are inspected for muscle cysts and infected carcasses are further processed by freezing or cooking to ensure that the meat, when released, does not contain viable cysts. It has been estimated (Grindle 1978) that the annual loss from cysticercosis in cattle in Kenya is about £1 million. This estimate does not consider the inhibitory effect that cysticercosis has probably had on the development of a lucrative export trade for the beef industry.

Wild herbivores can also be infected with tapeworm larvae and it is probable that game animals slaughtered for human consumption would be liable to the same or similar meat inspection procedures as domestic livestock. It is a matter of some importance, therefore, to determine whether cysticercosis in game animals will jeopardize human health or be a significant restraint on the development of an industry based on cropping wild animals for human consumption.

Taenia saginata — "The Beef Tapeworm"

The earlier belief of many cattle owners that antelopes were a common alternative host for the cysticerci of *Taenia saginata* (*Cysticercus bovis*) has been shown to be erroneous (Nelson et al. 1965; Dinnik and Sachs 1969a; Woodford and Sachs 1973). There are only a few reports of *C. bovis* being found in wild animals and the risk of man acquiring *T. saginata* from eating game meat is probably very small. Nelson et al. (1965) found one wildebeest (*Connochaetes taurinus*) to have *T. saginata* cysticerci out of 92 wild herbivores of 19 species examined in Kenya. *C. bovis* has also been described in the buffalo (*Syncerus caffer*) in Angola (Sousa Diaz 1950) and in *Gazella dorcas*, *Gazella rufifrons*, and other antelope in Chad (Graber 1959). However, in large surveys of game animals in East Africa no evidence has yet been produced to show that wild herbivores are of significance in the epidemiology of *T. saginata*. In the Serengeti (Dinnik and Sachs 1969a) and in the Ruwenzori (formerly Queen Elizabeth) National Park in Uganda (Woodford and Sachs 1973) many of the animals examined were found to harbour muscle cysts but none was identified as *C. bovis*. In Kajiado District, Kenya, all the muscle cysticerci from several hundred wildebeest were species other than *C. bovis* (Chana 1975; Khalil et al. 1980).

C. bovis has been reported (Le Roux 1957) in an oribi (*Ourebia ourebi*) but this animal was tame and it is suggested it may have received massive numbers of eggs of *T. saginata* especially if its attendant was infected (Woodford and Sachs 1973). A Thomson's gazelle (*Gazella thomsonii*) that had been hand-reared from a few days of age in Kenya was found to be heavily infected with muscle cysts thought to be *C. bovis* when examined at 9 weeks of age (Karstad, personal communication). Specimens of cysts from the heart of this animal were examined by the authors and although the cysticerci were well developed no hooks could be seen on the rostella suggesting that they may have been *C. bovis*, but this could not be confirmed. Attempts to infect Thomson's gazelle artificially with *Taenia saginata* cysticerci have been unsuccessful (Fay 1972). The animals were, however, caught in the wild and dosed with eggs when between 4 and 6 months of

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age, by which time, resistance to infection may have been acquired. It can be extremely difficult in Kenya to infect domestic cattle of over 4 months of age with *C. bovis* and, to achieve frequent infection, eggs must be given in the first few weeks of life (Urquhart 1961; Froyd 1964). *C. bovis* has also been reported in giraffe kept in captivity (Mobius 1871; Schwartz 1928; Buckley 1947, 1948; Price 1961) but it is possible that the infection may have been acquired from human contact after the time of capture. It must be considered a possibility, therefore, that *C. bovis* could become more prevalent in game animals if these were to be reared under domestic conditions where close contact with infected humans could occur.

Taenia solium — "The Pork Tapeworm"

Taenia solium, the other *Taenia* tapeworm that infects man and develops to the adult stage in the small intestine is acquired by eating the cysticerci (*Cysticercus cellulosae*) that occur in the muscles of pigs. This tapeworm has a scolex bearing a double row of hooks and thus has some resemblance to the cysts found in wild animals in East Africa. The tapeworm has the ability to use man as an intermediate host and cysticerci can develop in the nervous tissue and can sometimes result in serious disease. It is therefore necessary to determine whether wild animals in Africa are infected with this parasite.

Cysts resembling, but not confirmed to be, those of *C. cellulosae* have been recorded in a bush pig (*Potamochoerus choeropotamus*) in Southern Africa (Viljoen 1937). *C. cellulosae* has been described in a warthog (*Phacochoerus aethiopicus*) (Hamerton 1947) but this animal died after 10 years' residence in London Zoo and may have acquired the infection while in captivity. However, in the survey carried out by Woodford and Sachs (1973) no muscle cysts were found in 106 free-living warthogs examined in Uganda. The larval stages of *T. solium* have been described by Verster (1969) from the vervet monkey (*Cercopithecus aethiops*), bushbaby (*Galago* sp.), and rock hyrax (*Procavia capensis*). Differentiation by morphological features of the muscle cysts that have been found in wild herbivores in East Africa has shown that they are a species other than *C. cellulosae*. At present, there is no reason to believe that game animals likely to be used as a source of meat for human consumption would be involved in the transmission of *T. solium* to man.

In Kenya, *T. solium* cysticerci have only rarely been reported in domestic pigs (Solomon 1932; Viljoen 1937; Anon. 1962, 1963) but they are more commonly recognized in other African countries (Merle 1958; Verster 1966). If there is an expansion of the pig industry, it is possible that *T. solium* may become more widespread in East African countries. In such a situation, the spread of the parasite to the wild animal population could not be ruled out.

Nelson et al. (1965) suggested that many of the cases of cysticercosis in man in Africa may have been caused not by *T. solium*, as generally assumed, but by *Taenia* spp. from dogs or wild carnivores. However, the few reports of cysticercosis in man in East African countries, where there is a large population with wild carnivores, suggest that if there is a risk of infection with wild animal cysts, it is very low.

Larval Tapeworms in Wild Animals

Whether it is completely safe to eat game meat infested with muscle cysticerci of species other than *C. bovis* and *C. cellulosae* is still an unanswered question. At present, however, the available circumstantial evidence would suggest that the cysts are not infective to man. There are no reports of adult tapeworms of game-animal cysticerci ever being found in man despite the fact that the flesh of wild animals has been and continues to be frequently eaten by a large section of the human population in Africa. This is not unexpected because adult *Taenia* tapeworms exhibit a fairly high degree of host specificity, more so than do their larval stages. For example, no adult tapeworms of hyena have been recorded from lion although they eat the same prey. Immature tapeworms resembling those from the hyena and hunting dog have been found in lions but it was suggested that they are unable to reach maturity in a host seemingly unsuitable to them (Dinnik and Sachs 1972).

Although many of the cysticerci found in wild animals in Africa cannot yet be positively identified, several species have now been recognized. Adult tapeworms recovered from wild and domestic carnivores in Africa correspond in morphological features such as hook size, number, and shape with certain cysticerci in wild herbivores (Table 1). On this basis, it has been concluded that the larval and adult tapeworm are the same species and in a number of cases this has been supported by experimental infection of wild animals (Verster 1969).

Not all the cysts are found in the musculature of the host. Serosal cysticercosis is frequently encountered in game animals (Sachs 1969), the cysticerci either being attached to serosal surfaces or lying free in the peritoneal and pleural cavities. There is no

Table 1. Species of *Taenia* occurring in carnivores with larval stages in African game animals.[a]

Tapeworm	Final host	Common site of larval tapeworm
T. regis	Lion, leopard	Serosa in peritoneal and pleural cavities
T. simbae	Lion	Serosa in peritoneal and pleural cavities
T. gonyamai	Lion, cheetah	Muscle
T. crocutae	Spotted hyena, Brown hyena	Muscle
T. hyaenae	Spotted hyena, Brown hyena, Hunting dog	Muscle
T. olngojinei	Spotted hyena	Epidural space of sacrum
T. acinonyxi	Leopard, cheetah	Muscle
T. hydatigena	Dog, silver-backed jackal and other canines	Serosa in peritoneal cavity
T. multiceps	Dog and other canines	Brain, spinal cord

[a]Data compiled from Verster (1969) and authors' (L.F.K. and A.J.) own investigations.

evidence that they are infective to man although there is still debate as to the identity of many of these cysts. In parallel with the procedure in domestic livestock, in a heavily infected animal it may be considered necessary to condemn the offal at meat inspection.

Coenuri, the large cysts of *Taenia multiceps*, can also occur in African mammals and are not always found in the central nervous system. Verster and Bezuidenhout (1972) recovered a coenurus from the hindquarters of a gemsbok (*Oryx gazella*). The cyst was fed to a domestic dog and subsequently many adult *T. multiceps* were recovered from its small intestine. Again there is no evidence that man can become infected by eating meat harbouring this tapeworm.

A curious parasite has been described in certain East African antelopes. Wildebeest, hartebeest (*Alcelaphus buselaphus*), and topi (*Damaliscus korrigum*) have frequently been found to harbour cysticerci within the epidural space of the sacrum (Dinnik and Sachs 1969b; Woodford and Sachs 1973; Khalil et al. 1980). These are the larval form of *Taenia olngojinei* found in the spotted hyena (*Crocuta crocuta*), an animal with jaws strong enough to crack the sacrum and thus ingest the cysticerci.

The Effect of Cysticercosis on the Utilization of Game Meat

Meat infested with cysticerci is condemned primarily because of the associated risk of infection of man. However, even if it could be definitely established that game animal cysticerci are not a risk to man, heavily infected carcasses would not be sold because of the appearance of the meat. Dinnik and Sachs (1969a) describe one impala (*Aepyceros melampus*) they examined in the Serengeti area that had an extremely heavy infection and 165 muscle cysts were found in 0.5 kg of the *musculus biceps femoris* and *musculus semitendinosus*. However, they note that such a heavy infestation was seldom observed and generally only a few cysticerci were found in infected carcasses.

There is no doubt that the prevalence of infection of game animals with muscle cysticerci can vary markedly. For instance, Thomson's gazelles were found to be frequently infected with cysticercosis in Kenya (Fay 1971). In contrast, the same species of gazelle in the Serengeti region of Tanzania was seldom infected; whereas, the closely related Grant's gazelle (*Gazella granti*) in the same location was commonly heavily infested (Sachs and Sachs 1968). There is a definite need for research into the factors that may be involved in the prevalence rates of cysticercosis in game animals.

High prevalence rates of infection have been recorded in a number of antelope species in East Africa. In the Ruwenzori National Park, 8 of 11 bushbuck (*Tragelaphus scriptus*) and 11 of 14 reedbuck (*Redunca redunca*) harboured muscle cysts (Woodford and Sachs 1973). In the Serengeti, 60–80% of wildebeest, topi, kongoni (*Alcelaphus buselaphus cokii*), dik-dik (*Rhynchotragus kirki*), and Grant's gazelle were found to be infected (Sachs 1966). In Turkana District of Northern Kenya, 8 of 10 dik-dik had muscle cysts, the number in each carcass ranging from 1 to 14. In contrast, in 11

Grant's gazelles from the same region examined at the same time, only one live cyst was recovered from five animals that were totally dissected and one calcified cyst was recovered from the other six gazelles that were examined by multiple incisions into the musculature (Stevenson and Karstad, unpublished).

From the results of a pilot scheme carried out in the Serengeti area, it was estimated that the game meat liable to be rejected as a result of parasite infestation would be equivalent to 15–20% of the total carcass yield (Schindler et al. 1969). To avoid the loss of much valuable protein, it was recommended that the meat be canned and sterilized before being marketed (Glees et al. 1972). However, as pointed out by Woodford and Sachs (1973), the high proportion of herbivorous animals found to harbour muscle cysts in the Serengeti and the Ruwenzori National Park may not reflect the situation in game animals on farms or in hunting areas where the predator population may not be as large. A careful examination of the level of infection in a sample of animals is needed before any decision is made to crop a game animal population to provide meat for human consumption.

Of the 555 wildebeest examined by Khalil et al. (1980) from Kajiado District, Kenya, 59% were found to harbour muscle cysts. However, although the prevalence of infection would appear to be high, the level of infestation is generally low in wildebeest from this region (Chana 1975). If such a population was to be cropped to provide meat for human consumption, a decision would have to be made as to what treatment, if any, a lightly infected carcass should undergo.

The meat inspection rules laid down for the examination of carcasses of domestic cattle should not necessarily be applied to game animals at slaughter. The lack of evidence, to date, of a public health risk being associated with the cysticerci found in wild herbivores in Africa suggests that it may be unnecessary to reject as unfit for human consumption carcasses that are lightly infected with muscle cysts. However, there is undoubtedly a need for further research into the identity, life cycle, and infectivity of wild animal tapeworms. Unfortunately, final confirmation of the harmlessness to man of the muscle cysticerci in game animals must depend on the demonstration that ingestion of live cysts by human volunteers does not lead to the development of intestinal tapeworms.

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