Trop Anim Health Prod (2009) 41:1179–1185
DOI 10.1007/s11250-008-9298-z

ORIGINAL PAPER

Hydatidosis of slaughtered animals in Ngorongoro district of Arusha region, Tanzania

E. Ernest · H. E. Nonga · A. A. Kassuku · R. R. Kazwala

Accepted: 8 December 2008 / Published online: 23 December 2008

Abstract A study on the prevalence of hydatidosis in cattle, goats and sheep was carried out in Ngorongoro district of Arusha region, Tanzania. A 4-years data records from four slaughter slabs were retrieved and analysed. In addition, meat inspection was done in the same slaughter slabs for nine months and 64 households were interviewed to assess the community awareness on hydatidosis. Results showed the overall prevalence of hydatidosis to be 47.9%. Species prevalence of 48.7%, 34.7% and 63.8% in cattle, goats and sheep respectively was recorded. Of 174 cysts examined in cattle, 37 (21.3%) were fertile, 126 (72.4%) were sterile and 11 (6.3%) were calcified. Out of 215 goats and 67 sheep cysts examined, 52 (24.7%) and 26 (38.8%) were fertile, 138 (64.2%) and 38 (56.7%) were sterile, 24 (11.2%) and 3 (4.5%) were calcified respectively. The higher percentage of fertile hydatid cysts in sheep and goats coupled with the practice of backyard slaughter of sheep and goats suggests that, these animals could be important intermediate hosts for the maintenance of the domestic life cycle of *E. granulosus* in the locality. Questionnaire survey revealed that 17.2% of the respondents were aware of hydatidosis but non of them were knowledgeable on its transmission. Up to 84.4% of the respondents had domestic ruminants and donkeys, while 89.1% had dogs. Of the households with dogs, only 19.3% had their dogs dewormed at least once in life time. Most of the households (87.7%) had their dogs managed freely and 77.2% of the respondents reported school children to be the closest friends of dogs in the family. The prevalence of *E. granulosus* infection in wildlife and the possible relationship of the domestic cycle to the sylvatic cycle operating in the same area are unknown and need to be studied.

Keywords Hydatidosis · Prevalence · Livestock · Slaughter slabs · Ngorongoro

E. Ernest (✉)
Tanzania Wildlife Research Institute,
P.O. Box 661, Arusha, Tanzania
e-mail: ernest2002eblate@yahoo.com

H. E. Nonga · R. R. Kazwala
Department of Veterinary Medicine and Public Health,
Sokoine University of Agriculture,
P.O. Box 3021, Morogoro, Tanzania

A. A. Kassuku
Department of Veterinary Microbiology and Parasitology,
Sokoine University of Agriculture,
P.O. Box 3019, Morogoro, Tanzania

Introduction

Echinococcus granulosus is one of the smallest cestode parasites that cause cystic echinococcosis, which is of major public health importance worldwide. The distribution of *E. granulosus* is higher in

developing countries especially in rural communities where there is close contact between the dogs, the definitive hosts, and various domestic animals, which may act as intermediate hosts (Eckert and Deplazes 2004; Radfar and Iranyar 2004). The outcome of infection in livestock is hydatid cyst development in the lung, liver or other organs (Eckert and Deplazes 2004; Jenkins et al. 2005). It has been suggested that *E. granulosus* may be maintained in an independent wildlife cycles in East Africa (Magambo et al. 2006). Cystic echinococcosis (CE) is highly endemic in sub-Saharan Africa. It has been reported in West African as well as the North African countries (Ahmad 2005). In all these areas, CE is prevalent in humans among the nomadic pastoralists (Magambo et al. 2006). The incidence in any country is closely related to the prevalence of the disease in domestic animals and is highest where dogs population is high (Magambo et al. 2006).

Studies in different parts of East Africa have shown varied distribution of CE. A recent study among the Karamojong community in Uganda has shown an average of 20 surgical cases of CE per year (Macpherson et al. 2004). In Turkana, the prevalence of CE in humans is about 2.5% (Zeyhle et al. unpublished data 2005) while Macpherson et al. 1989) reported a prevalence of 1.4% in Maasai people of Northern Tanzania. Hydatidosis has been recorded from several localities in the region. The most affected areas were the rural communities occupied by pastoralists and agro-pastoralists. Njoroge et al. (2002) reported a prevalence of 19.4%, 3.6%, 4.5% and 61.4% in cattle, sheep, goats and camels respectively in Kenya. The disease was also reported in domestic and wildlife in Uganda (Ocaido et al. 2004). Ngowi et al. (2004) reported a prevalence of 4.3% in pigs in northern Tanzania.

In Tanzania however, there is scanty information regarding the disease in both human and domestic animals. Ngorongoro district is one of the areas with large number of pastoralist societies who are normally considered to be the victims of the disease together with their animals. In order to design an effective control program, there is a need for reliable epidemiological data about the level of infection in various domestic animal species and the knowledge on risk factors that perpetuate the disease in the given locality. Therefore, the purpose of this study was to establish the prevalence of hydatidosis in livestock in Ngorongoro district through slaughter slabs survey.

Materials and methods

Study area

The study was conducted in Ngorongoro district of Arusha region, Northern Tanzania. The district is divided into two major parts, Loliondo Game Controlled Area and Ngorongoro Conservation Area. This is a multiple land use wildlife controlled area with total human population of 129,776 (Tanzania National Census 2002), inhabited predominantly by Maasai who practice traditional pastoralism, and of recently limited cultivation. Estimates of domestic dog densities, determined from the number of dogs per Maasai boma varied between 0.38 to 0.46 dogs/km^2 from 1992 to 1994 (Cleaveland et al. 2003).

Geographically, Ngorongoro district is positioned between longitude 35° and 36°E and latitude 2° and 4°S. Climatically, the district has both unimodal and bimodal rainfall patterns, with short rains starting in September and ending in December and long rains starting in March and ending in May/June. There are significant variations in rainfall distribution between highlands and lowlands. The highlands are bimodal and receive between 800 mm to 1,200 mm of rainfall and lowlands are unimodal receiving 500 mm to 700 mm of rainfall. The mean monthly temperature is 20°C, however during the cooler period (June - August) the mean average temperature drops to 17°C.

Study animals and sampling method

The study was both retrospective and prospective. Secondary data on previous meat inspection were retrieved from veterinary office records on the proportion of carcasses affected with hydatid cysts as from January 1998 and October 2001.

In prospective part, a questionnaire survey was used to determine the awareness of the people with regard to hydatidosis. A total number of 64 households were interviewed using pre-tested structured questionnaire. The households were purposively selected based on their accessibility and willingness to participate in the study. Furthermore, a nine month meat inspection was done in five slaughter slabs namely Loliondo, Endulen, Nainokanoka, Makao and Olbalbal in which cattle, goats and sheep were centrally slaughtered. Home slaughters were also inspected. In the slaughter areas, thorough meat

inspection was carried out with much empahasis on lungs, liver, spleen and heart. Each organ was assessed macroscopically either by visual inspection or palpation and where necessary one or more incisions were made in order to detect small hydatid cysts.

Hydatid cyst characterization: The infected organs from each positive animal were collected and recorded including the cyst location, morphology and volume of the fluid contents. Of the collected samples, individual cyst was carefully, opened and examined to identify whether it was a hydatid cyst and whether it was fertile, sterile or calcified. After opening, the cyst fluid was aspirated by using a 20 ml syringe to measure the volume of the cyst fluid. A drop of the cyst fluid was placed on the microscope glass slide and covered with cover slip and observed for presence of protoscolices on light microscope with X10 to X40 objective. For clear vision a drop of 0.1% aqueous eosin solution was added to equal volume of cyst fluid on microscope slide with the principle that viable protoscolices should completely or partially exclude the dye while the dead ones take it up. Infertile cysts were further classified as sterile or calcified. Sterile hydatid cysts were characterized by their smooth inner lining usually with slightly turbid fluid in its content with dead or without protoscolices. Typical calcified cysts produced a gritty sound feeling up on incision.

Data were analysed using Epi Info version 6 statistical software (Coulombier et al. 2001). Using statcalc, proportions of categorical variables were computed and further compared using chi-square test at critical probability of $P<0.05$. The strength of associations between dependent and independent variables were determined using 2×2 contingency tables.

Results

Retrospective study results

A total of 6331 domestic livestock were slaughtered and inspected in the period between 1998 to 2001. All slaughtered animals were adult and included 2677 cattle, 3047 goats and 607 sheep. The overall prevalence of hydatidosis was found to be 47.9%. Furthermore, Loliondo area had the highest prevalence of the disease (51.7%) followed by Makao (50.0%), Nainokanoka (48.1%) and Endulen (26.5%) (Table 1). A significantly ($p<0.001$, $X^2=128.7$) higher infection rate was recorded in goats (48.1%) than in cattle (42.3%) and sheep (9.6%). The distribution of the cysts by organs showed that lungs (69.2%) were the most affected organ, followed by the liver (28.5%), spleen (2.3%) and there were no cysts on the heart.

Prospective results

(a) Questionnaire survey results

A total of 64 households were interviewed during the study period. It was found that 11 (17.2%) of the respondents were aware of the disease. Neither of the respondents were knowledgeable of the transmission between human and livestock. Furthermore, it was found that, 54 (84.4%) of the respondents had livestock including cattle, goats, sheep and donkeys while 57 (89.1%) had dogs. Of the households which had dogs, 11 (19.3%) had their dogs dewormed at least once during lifetime. Fifty (87.7%) households managed their dogs under free range system and 44 (77.2%) reported that school children (7-17 years) were the closest dog's friend in the family. Home slaughter of food animals was preferred 58 (90.6%) than public slaughters. Up to 55 (85.9%) of the respondents reported to feed raw condemned materials to their dogs.

(b) Meat inspection results

The total of 1081 livestock including cattle (357), goats (619) and sheep (105) were inspected. The overall prevalence of hydatidosis in slaughtered livestock was 456 (42.2%). Higher prevalence was observed in sheep 67 (63.8%) than cattle 174 (48.7%) and goats 255 (34.7). There was a significant difference in prevalence between species ($p<0.001$, $X^2=40.5$). Location wise, the highest prevalence of hydatidosis was found at Makao (61.8%), followed by Olbalbal (44.3%), Nainokanoka (43.5%), Loliondo (35.9%) and Endulen (31.7%) (Table 2). There was a significant difference in the prevalence of the disease from one location to another ($p<0.001$, $X^2=40.7$). Table 3 summarizes the location of cysts in inspected animals. Most of the cysts were located in the lungs (61.4%) and liver (28.5%) and were spherical in

Table 1 Prevalence of hydatidosis in Ngorongoro district, a retrospective study

Study Area	Period of Study (Yrs)	Animal Species	No. Inspected	No. Infected	Prevalence (%)
Loliondo	1998/2001	Cattle	1141	676	59.2
		Goats	1288	581	45.1
		Sheep	0	0	0
Endulen	Jan - Oct 2001	Cattle	71	32	45.1
		Goats	321	61	19.0
		Sheep	261	80	30.7
Nainokanoka	1999/2001	Cattle	90	44	48.9
		Goats	839	368	43.9
		Sheep	214	138	64.5
Makao	Jan - Oct 2001	Cattle	1375	723	52.6
		Goats	599	225	37.6
		Sheep	132	105	79.5
Total			6331	3033	47.9

shape, unilocular and of variable sizes with cyst fluid ranging from 10 ml to 2000 ml.

It was observed that there were a total of 116 (25.4%) fertile, 302 (66.2%) sterile and 38 (8.3%) calcified cysts (Table 4). The category of cysts by animal species is summarized in Table 5

Discussion

The findings of this study shows higher prevalence of hydatidosis in cattle, sheep and goats slaughtered at different slaughter slabs in Ngorogoro district. The overall prevalence of hydatidosis in the district observed in this study was 47.1% which is higher than that reported by WHO/OIE (Anonymous 2001) and Njoroge et al. (2002) in the Sub-Sahara Africa regions that showed prevalence between 1% to 10%. However, similar higher level of infection rates of hydatidosis was reported by Kebede et al. (2008) in Ethiopia, Elmahdi et al. (2004) in Sudan and Azlaf and Dakkak (2006) in Morocco. In contrast, a low prevalence of hydatidosis was reported in cattle, sheep and goats in Libya (Kassem 2006) and Algeria (Bardonnet et al. 2003). The differences in prevalence of hydatidosis may arise due to differences in

Table 2 Prevalence of hydatidosis in different locations recorded in the prospective study

Location	Animal spp	Number slaughtered	Number infected	Species prevalence (%)	Location prevalence (%)
Loliondo	Cattle	135	51	37.8	35.9
	Goats	177	57	32.2	
	Sheep	17	10	58.8	
Endulen	Cattle	24	10	41.7	31.7
	Goats	150	45	30.0	
	Sheep	6	2	33.3	
Nainokanoka	Cattle	30	8	26.7	43.5
	Goats	183	69	37.7	
	Sheep	49	37	75.5	
Makao	Cattle	140	92	65.7	61.8
	Goats	30	13	43.3	
	Sheep	0	0	0.0	
Olbalbal	Cattle	28	13	46.4	44.3
	Goats	79	31	39.2	
	Sheep	33	18	54.5	
Total		1081	456	42.2	

Table 3 Location of cysts in the different animal species examined

Organ	Anima species			
	Cattle (%)	Goats (%)	Sheep (%)	Total
Lungs	114 (42.9)	127 (59.6)	39 (56.5)	280
Liver	48 (27.6)	59 (27.7)	23 (33.3)	130
Spleen	9 (5.2)	27 (12.7)	7 (10.1)	43
Heart	3 (1.7)	0 (0.0)	0 (0.0)	3

Table 5 Category of cysts by animals species

Cyst Status	Animal Species			
	Cattle (%)	Goats (%)	Sheep (%)	Total
Fertile	37 (21.3)	53 (24.7)	26 (38.8)	116
Sterile	126 (72.4)	138 (64.2)	38 (56.7)	302
Calcified	11 (6.3)	24 (11.2)	3 (4.5)	38
Species percentage	38.2	47.1	14.7	

environmental conditions that are conducive for the perpetuation of the parasite, abundance of infected definitive hosts, livestock husbandry, stocking rate, nature of the pasture and grazing patterns of animals. Generally, the prevalence of hydatidosis in Ngorongoro district may therefore reflect the actual situation of the same disease in other pastoral areas of the country where very little or no studies have been done.

This study has shown a remarkable variation in the prevalence of hydatidosis among locations within the district with the highest prevalence being recorded at Makao. The reason for the differences is not very clear, but may be due to the fact that Makao is a tourist center with high demand for meat such that animals slaughtered were from different locations within and outside the district, while animals slaughtered in other areas were from within the locality. Generally the variation in prevalence rate among different geographical regions could be ascribed to the strain differences of *E. granulosus* that may exist (McManus 2006). Other factors like difference in culture, social activities and attitudes to dogs may contribute to this variation (Craig and Zbigniew 2002; Arbabi and Hooshyar 2006).

Assessment of organ distribution of cysts indicated that in all the study areas, lungs (61.4%) and liver (28.5%) were the most frequently infected visceral organs in all the species. This is in agreement with the finding by Njoroge et al. 2002. This shows that the liver and lungs are the most common sites of hydatid cysts in domestic ruminants. The reason may be due to the fact that the lungs and liver posses the first great capillaries sites encountered by the migrating echinococcus oncosphere (hexacanth embryo) which adopt the portal vein route and primarily negotiate hepatic and pulmonary filtering system sequentially before any other peripheral organ is involved.

Table 4 Category of cyst by organs of origin

Organ	Cyst Status			
	Fertile (%)	Sterile (%)	Calcified (%)	Total
Lungs	73 (26.1)	189 (67.5)	18 (6.4)	280
Liver	35 (26.9)	81 (62.3)	14 (10.8)	130
Spleen	6 (14.0)	31 (72.1)	6 (14)	43
Heart	2 (66.7)	1 (33.3)	0 (0.0)	3

In examining the condition of cyst viability, it was revealed that, a higher proportion of the cysts were sterile (66.2%) and moderate proportions were fertile (25.4%). The cyst fertility rates was variable and high in sheep (38.8%), goats (24.7%) and cattle (21.3%) as was also reported by Dalimi et al. (2002) and Kebede et al. (2008). Thus the three hosts appear to be important intermediate hosts of *E. granulosus* in Sub-Sahara Africa. This finding contradicts that reported by Macpherson (1985) that cattle are poor hosts for *E. granulosus* and may therefore not be an important source of infection to dogs. The variation in fertility rate among different species and in different geographical zone could be due to the differences in strain of *E. granulosus* (McManus 2006). The greater infectivity of hydatid cysts from sheep and goats and the common practice of backyard slaughter may reflect their importance as intermediate hosts for the perpetuation of the domestic cycle of *E. granulosus* in the Ngorongoro district. Moreover, the higher fertility rates which was observed in this study in all infected animal species highlights the hazards that these animals may pose indirectly to people in Ngorongoro district and possibly other parts of the country where the pastoralism is practiced.

The study showed that majority (82.8%) of the respondents was not aware of hydatidosis and all were not knowledgeable on the transmission of the disease between human and livestock. This finding is in

agreement with other studies in the world that have reported ignorance of the community as one of the risk factor for the existence of the disease in rural areas (Craig and Zbigniew 2002). It was further observed that majority of households (84.4%) in Ngorongoro district had livestock including cattle, goats, sheep and donkeys which are the intermediate host of the cestode parasite. Similarly, many households (89.1%) had dogs which were not dewormed regularly and were managed under free-range system. Backyard slaughter of small ruminants and disposal of raw condemned organs through offering to dogs were the common practice, a situation which may lead to the increased environmental parasitic load. Furthermore, school children (7-17 years old) being the closest friends of dogs signifies that they were a group at high risk of getting the infection. Indeed, our own data (Ernest et al. unpublished) showed that up to 76% of CE in humans in Ngorongoro district were diagnosed in school children.

It is therefore concluded that owing to the presence of socio-economic conditions favorable for hydatidosis and high level of infection in livestock signifies that the disease is of great importance in Ngorongoro district. This warrants serious attention for its prevention and control. We therefore advice the government to enforce legislation on meat inspection, improving the slaughter slabs, restrict backyard slaughter and improve veterinary services. However, public health education about the disease and its control is highly recommended to the community. The findings of this study merit for more extensive epidemiological investigations involving livestock, dogs, wildlife and humans within and outside the study area.

Acknowledgements The authors wish to thank NORAD for financial assistance. Much more thanks are due to Dr. Sarah Cleavelands, Dr. Shirima, G. M. and Mr. Paulo Tango for their great contribution to the success of this work.

References

Ahmadi, N. A., 2005. Hydatidosis in camels (*Camelus dromedarius*) and their potential role in the epidemiology of Echinococcus granulosus in Iran. *Journal of Helminthology*, **79**, 119–125. doi:10.1079/JOH2005279

Anonymous, 2001. World Health Organization Office International des Epizooties. *WHO/OIE manual on echinococcosis in humans and animals: a public health problem of global concern.* World Organization for Animal Health, Paris, France.

Arbabi, M., Hooshyar, H., 2006. Survey of Echinococcosis and Hydatidosis in Kashan Region, Central Iran. *Iranian Journal of Public Health*, **35**(1), 75–81.

Azlaf, R. and Dakkak, A., 2006. Epidemiological study of the cystic echinococcosis in Morocco. *Veterinary Parasitology*, **137**, 83–93. doi:10.1016/j.vetpar.2006.01.003

Bardonnet, K., Benchikh-Elfegoun, M.C., Bart, J.M., Harraga, S., Hannache, N., Haddad, S., Dumon, H., Vuitton, D.A. and Piarroux, R., 2003. Cystic echinococcosis in Algeria: cattle act as reservoirs of a sheep strain and may contribute to human contamination. *Veterinary Parasitology*, **116**, 35–44. doi:10.1016/S0304-4017(03)00255-3

Cleaveland S., Kaare, M., Tiringa, P., Mlengeya, T. and Barrat, J., 2003. A dog rabies vaccination campaign in rural Africa: impact on the incidence of dog rabies and human dog-bite injuries. *Vaccine*, **21**, 1965–1973. doi:10.1016/S0264-410X(02)00778-8

Coulombier, D., Fagan, R., Hathcock, L. and Smith, C., 2001. Epi Info 6 version 6.04. A word processing, database and statistical program for public health. Centers for Disease Control and Prevention, Delaware, USA.

Craig, P. S. and Zbigniew, P., 2002. *Cestode Zoonoses: Echinococcosis and Cysticercosis*. An Emergent and Global Problem. IOS press Ohmsha, NATO Science Series, Vol. 341, 395pp.

Dalimi, A., Motamedi, G., Hosseini, M., Mohammadian, B., Malaki, H., Ghamari, Z. and Ghaffari, F. F., 2002. Echinococcosis/hydatidosis in western Iran. *Veterinary Parasitology*, **105** (2), 161–171. doi:10.1016/S0304-4017(02)00005-5

Eckert, J. and Deplazes, P., 2004. Biological, epidemiological, and clinical aspects of echinococcosis, a zoonosis of increasing concern. *Clinical Microbiology Reviews*, **17**(1), 107–135. doi:10.1128/CMR.17.1.107-135.2004

Elmahdi, I. E., Ali, Q.M., Magzoub, M. M., Ali Abrahim, A. M., Saad, M.B. and Romig, T., 2004. Cystic echinoccosis of livestock and humans in central Sudan. *Annals of Tropical Medicine and Parasitology*, **98**, 473–9. doi:10.1179/000349804225003578

Jenkins, D. J., Romig, T. and Thompson, T. R. C. A., 2005. Emergence/re-emergence of Echinococcus spp.—a global update. *International Journal of Parasitology*, **35**, 1205–1219. doi:10.1016/j.ijpara.2005.07.014

Kassem, H. H., 2006. Hydatidosis - echinococcosis in Libya (review article). *Journal of Egyptian Society of Parasitology*, **36**(2), 21–26.

Kebede, N., Mitiku, A. and Tilahun, G., 2008. Hydatidosis of slaughtered animals in Bahir Dar Abattoir, Northwestern Ethiopia. *Tropical Animal Health and Production*, doi:10.1007/s11250-008-9152-3.

Macpherson, C. N. L., 1985. Epidemiology of hydatid disease in Kenya: a study of domestic intermediate hosts in Maasailand. *Transaction of the Royal society of Tropical Medicine and Hygiene*, **79**, 209–217.

Macpherson, C. N. L., Craig, P. S., Romig, T., Zeyhle, E. and Watschinger, H., 1989. Observations on human echinococcosis (hydatidosis) and evaluation of transmission factors in the Maasai of northern Tanzania. *Annals of Tropical Medicine and Parasitology*, **83**, 489–497.

Macpherson, C. N. L., Siefert, L., Francis, B., Kabuusu, R., Butler, B. and Bakamanume, B. 2004. Human cystic echinococcosis in Uganda. *International Archieve of Hydatidosis*, **35**, 42.

Magambo, J., Njoroge, E. and Zeyhle, E., 2006. Epidemiology and control of echinococcosis in sub-Saharan Africa. *Parasitology International*, **55**, 193–195.

McManus, D. P., 2006. Molecular discrimination of taeniid cestodes. *Parasitology International*, **55**, 31–S37.

Ngowi, H. A., Kassuku, A. A., Maeda, G. E. M., Boa, M. E. and Willingham, A. L., 2004. A slaughter slab survey for extra intestinal porcine helminth infections in northern Tanzania. *Tropical Animal Health and Production*, **36**, 335–340.

Njoroge, E. M., Mbithi, P. M., Gathuma, J. M., Wachira, T. M., Magambo, J. K. and Zeyhle, E. A., 2002. Study of cystic echinococcosis in slaughter animals in three selected areas of northern Turkana, Kenya. *Veterinary Parasitology*, **104**, 85–91.

Ocaido, M., Siefert, L. and Baranga, J., 2004. Helminth risk associated with game and livestock interactions in and around Lake Mburo National Park, Uganda. *African Journal of Ecology*, **42**, 42–48.

Radfar, M. H. and Iranyar, N., 2004. Biochemical profiles of hydatid cyst fluids of *E. granulosus* of human and animal origin in Iran. *Veterinarski Arhir*, **74**(61), 435–442.

Tanzania National Census., 2002. (http://www.tanzania.go.tz/census/report2.htm).