

## Prevalence and seasonal incidence of larval and adult cestode infections of sheep and goats in eastern Ethiopia

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**Abstract** Sissay, M.M., Uggla, A. and Waller, P.J., XXXX. Prevalence and seasonal incidence of larval and adult cestode infections of sheep and goats in eastern Ethiopia *Tropical Animal Health and Production*, XXXX. A study on the prevalence and seasonal incidence of cestode parasite infections of sheep and goats was carried out in eastern Ethiopia for 2 years (May 2003–April 2005). During this period, viscera including liver, lungs, heart, kidneys and the gastrointestinal tract were collected from 655 sheep and 632 goats slaughtered at four abattoirs located in the towns of Haramaya, Harar, Dire Dawa and Jijiga. At the abattoirs the abdominal, thoracic and pelvic cavities as well as the muscle surfaces of all animals were visually examined for the presence of larval (cystic) stages of cestode parasites. The viscera were transported within 24 h to the parasitology laboratory of Haramaya University and were examined for larval and adult cestodes following standard procedures. The most prevalent metacestodes (larval cestodes)

were *Cysticercus ovis* (*Taenia ovis*), *Cysticercus tenuicollis* (*T. hydatigena*) and hydatid cysts (*Echinococcus granulosus*). In sheep, the overall prevalence was 26% for *C. ovis*, 79% for *C. tenuicollis*, and 68% for hydatid cysts. Similarly, for goats, the corresponding prevalence was 22%, 53% and 65%, respectively. The difference between sheep and goats in prevalence of *C. tenuicollis* was significant. The high prevalence of hydatid cysts in both sheep and goats indicates that cystic echinococcosis/hydatidosis is a public health problem in these regions which requires implementation of control measures, including public health education, strict meat inspection and control of stray dogs. The results of the survey also implies that infections of small ruminants with these metacestodes are responsible for condemnation of substantial quantities of affected organs and muscles and therefore of direct economic importance. Intestinal infections with adult tapeworms of *Moniezia expansa*, *Avitellina centripunctata* and *Stilesia globipunctata*, and bile duct infections with *Stilesia hepatica* were also common in both sheep and goats. In sheep, the overall prevalence of these tapeworms were 61%, 20%, 24% and 39%, respectively. Similarly, the overall prevalence of these parasites in goats was 53%, 21%, 27% and 36%, respectively.

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*Cysticercus ovis* · *Cysticercus tenuicollis* ·  
 Hydatid cysts · Echinococcosis ·  
*Echinococcus granulosus* · Sheep · Goat ·  
 Ethiopia · Africa

## Introduction

Ethiopia has the largest livestock population in Africa, estimated at 38 million cattle, 23 million sheep and 18 million goats, which are raised almost entirely by smallholder farmers throughout the country (Anonymous 2005). Small ruminants (sheep and goats) are particularly important resources of the country as they provide more than 30% of local meat consumption and generate cash income from export of meat, live animals, and skins (Ibrahim 1998).

It is well recognized that helminth infections of sheep and goats are major factors responsible for production losses in livestock in resource-poor regions of the world (Perry et al. 2002). Most of these losses are caused by gastro-intestinal nematode (roundworm) parasites, with the most important species being *Haemonchus contortus* (Urquhart et al. 1996). However, trematode (flake) and cestode (tapeworm) parasites may also contribute to detrimental worm burdens in the animals. In an abattoir survey by Sissay et al. (2007) the prevalence of nematode and fluke parasites were studied in small ruminants raised in the eastern regions of Ethiopia, which include the most important sheep and goat raising areas of the country. In this paper we present additional findings on cestode parasites found in sheep and goats.

Whereas nematode parasites generally have direct lifecycles, all cestodes have two-host lifecycles where sheep and goats can act as either definitive or intermediate hosts, depending on parasite species (Soulsby 1982; Urquhart et al. 1996). For example, *Moniezia* and *Avitellina* spp., where adult tapeworms are found in the guts of ruminants, have ground-living (oribatid) mites as their intermediate hosts. However, sheep and goats can serve as intermediate hosts to cestodes, which have carnivores, particularly canines, as their definitive hosts, e.g. *Taenia* and *Echinococcus* species. In these situations, sheep and goats carry the larval stages of the worms in their tissues, or body

cavities, in the form of fluid-filled cysticerci (with *Taenia* species), or hydatid cysts (with *Echinococcus granulosus*). These parasite structures range in size from a few mm to several cm and are thus macroscopically visible at slaughter, or necropsy.

Free-ranging, scavenging dogs are prevalent within the urban, peri-urban and rural areas of the regions under study, and wild canines (hyenas and jackals) are also common in the latter areas. This raises concern regarding the important zoonotic cestode of canines, *Echinococcus granulosus*, the cause of hydatid disease, or cystic echinococcosis, in humans (Eckert and Deplazes 2004). Echinococcosis is of major public health concern throughout the developing world (Anonymous 2001; Traub et al. 2006), and earlier clinical surveys have shown high prevalences of echinococcosis amongst the human population in Ethiopia (Fuller and Fuller 1981; Lindtjorn et al. 1982). However, there is no comprehensive information about the prevalence of larval *E. granulosus* in ruminant livestock in eastern Ethiopia.

The present 2-year study involved the examination of carcasses and viscera for larval and adult cestode parasites from more than 600 sheep and 600 goats from 4 slaughterhouses located in different environmental regions in eastern Ethiopia.

## Materials and methods

### Study sites

The study was performed from May 2003 to April 2005 at four abattoirs located in the towns of Haramaya, Harar, Dire-Dawa and Jijiga in eastern Ethiopia. Descriptions of the study sites and meteorological data are presented in Sissay et al. (2007).

### Animals

Numbers and age of animals examined are shown in Table 1, and a detailed description is given in Sissay et al. (2007). From the questioning of the animal owners, or slaughterhouse personnel, it was established that in the majority of cases, the slaughtered animals had been raised in the farming areas located within the community boundaries for each town.

**Table 1** Numbers of animals examined for helminth parasites at four abattoirs in eastern Ethiopia, from May 2003 to April 2005

Species	Sex		Age		Abattoir places				Total
	Male	Female	Adult	Young	Alemaya	Harar	Dire Dawa	Jijiga	
Sheep	493	162	524	131	152	156	166	181	655
Goats	424	208	467	165	154	148	159	171	632
Both species	917	370	991	296	306	304	325	352	1287

### Parasitological examination

Post mortem procedures and parasitological examination methods are given in Sissay et al. (2007), but in addition, kidneys and hearts were sliced into small pieces and examined for larval stages of cestode parasites. Visual inspection of the musculature and serosal surfaces of body cavities of each slaughtered animal was also made for the detection of larval stages of cestodes. At the parasitology laboratory, the presence of adult tapeworms in the small intestine was established by visual inspection, and detected

worms were collected and stored in 2% formaldehyde for subsequent identification. Adult and larval cestodes were identified based on the morphological characteristics described in Soulsby (1982); Urquhart et al. (1996) and Kassai (1999).

### Data analysis

All data were entered into the Microsoft Excel program, and analyses, such as basic descriptive statistics, cross tabulation and chi-square tests in relation to region, animal species, age, sex, and

**Table 2** Prevalence and position of larval cestodes in sheep slaughtered at four abattoirs in eastern Ethiopia

Abattoir site (number of investigated animals) and type of larval cestode	Number of infected animals	Position					
		Muscle	Omentum Mesenteries Peritoneum (A)	Liver (B)	Lungs (C)	A+B	B+C
Haramaya (n=152)							
<i>Cysticercus ovis</i> ( <i>Taenia ovis</i> )	39 (26%)	39 (26%)	nf	nf	nf	nf	nf
<i>C. tenuicollis</i> ( <i>T. hydatigena</i> )	115 (76%)	nf	51 (44%)	20 (17%)	nf	44 (38%)	nf
Hydatid cysts ( <i>Echinococcus granulosus</i> )	107 (70%)	nf	Nf	62 (58%)	32 (30%)	nf	13 (12%)
Harar (n=156)							
<i>Cysticercus ovis</i> ( <i>Taenia ovis</i> )	45 (29%)	45 (29%)	nf	nf	nf	nf	nf
<i>C. tenuicollis</i> ( <i>T. hydatigena</i> )	123 (79%)	nf	57 (46%)	17 (14%)	nf	49 (40%)	nf
Hydatid cysts ( <i>E. granulosus</i> )	116 (74%)	nf	Nf	68 (59%)	30 (26%)	nf	18 (16%)
Dire-Dawa (n=166)							
<i>Cysticercus ovis</i> ( <i>Taenia ovis</i> )	22 (13%)	22 (13%)	nf	nf	nf	nf	nf
<i>C. tenuicollis</i> ( <i>T. hydatigena</i> )	136 (82%)	nf	62 (45%)	16 (12%)	nf	58 (43%)	nf
Hydatid cysts ( <i>E. granulosus</i> )	96 (58%)	nf	Nf	56 (58%)	24 (25%)	nf	16 (17%)
Jijiga (n=181)							
<i>Cysticercus ovis</i> ( <i>Taenia ovis</i> )	62 (34%)	62 (34%)	nf	nf	nf	nf	nf
<i>C. tenuicollis</i> ( <i>T. hydatigena</i> )	144 (80%)	nf	56 (39%)	22 (15%)	nf	66 (46%)	nf
Hydatid cysts ( <i>E. granulosus</i> )	125 (69%)	nf	Nf	71 (57%)	34 (27%)	nf	20 (16%)
All abattoirs (n=655)							
<i>Cysticercus ovis</i> ( <i>Taenia ovis</i> )	168 (26%)	168 (26%)	nf	nf	nf	nf	nf
<i>C. tenuicollis</i> ( <i>T. hydatigena</i> )	518 (79%)	nf	226 (44%)	75 (15%)	nf	217 (27%)	nf
Hydatid cysts ( <i>E. granulosus</i> )	444 (68%)	nf	nf	257 (58%)	120 (42%)	NF	67 (15%)

(nf=not found)

season were done using the Minitab, version 14 (Minitab Inc., Quality Plaza, State College, USA).

## Results

### Prevalence of larval cestodes

In sheep, the overall prevalence of larval cestodes was 26% for *Taenia ovis* (*Cysticercus ovis*), 79% for *T. hydatigena* (*C. tenuicollis*), and 68% for *Echinococcus granulosus* (hydatid cysts) (Table 2). There were no significant differences in the prevalence of *T. ovis*, *T. hydatigena* and *E. granulosus* between the sheep slaughtered at the Haramaya, Harar and Jijiga abattoirs. However, the prevalences of *T. ovis* and *E. granulosus* in sheep slaughtered at Dire Dawa were significantly lower than for the other three abattoirs ( $P < 0.01$ ). The prevalence of *T. hydatigena* was not significantly different between the four abattoirs ( $P > 0.05$ ) (Table 2).

All cysticerci of *T. ovis* in sheep were found on the surface of muscles. The cysticerci of *T. hydatigena*

were found attached to the sheep omentum, mesenteries or peritoneum, or were attached to the liver surface (see Table 2). The proportions of hydatid cysts found in liver, lungs and both the liver and lungs from the same animals were 58%, 27% and 15%, respectively (Table 2). No cysticerci or hydatid cysts were found in kidneys or hearts.

For goats, the overall prevalence of cysticerci of *T. ovis* and *T. hydatigena*, and *E. granulosus* hydatid cysts were 22%, 53% and 65%, respectively (Table 3). There were no significant differences in the prevalence of *T. ovis*, *T. hydatigena* and *E. granulosus* between the four abattoirs (Table 3). The distributions of cysticerci in the organs of the goats were similar to that found in sheep. However, the proportion of cysticerci found in goat liver (34%) was twice that of found in sheep liver (15%) (see Tables 2 and 3). The proportion of hydatid cysts found in goat liver, lungs and in both liver and lungs were 55%, 30% and 16%, respectively. No cysts were found in kidneys or hearts of goats.

There were no significant differences in the overall prevalences of *E. granulosus* and *T. ovis* infections

**Table 3** Prevalence and position of larval cestodes in goats slaughtered at four abattoirs in Eastern Ethiopia

Abattoir site (number of investigated animals) and Type of larval cestode	Number of infected animals	Position					
		Muscle	Omentum Mesenteries Peritoneum (A)	Liver (B)	Lungs (C)	A+B	B+C
<b>Haramaya (n=154)</b>							
<i>Cysticercus ovis</i> ( <i>Taenia ovis</i> )	26 (17%)	26 (17%)	nf	nf	nf	nf	nf
<i>C. tenuicollis</i> ( <i>T. hydatigena</i> )	80 (52%)	nf	33 (41%)	30 (38%)	nf	17 (21%)	nf
Hydatid cysts ( <i>E. granulosus</i> )	94 (61%)	nf	nf	45 (48%)	30 (32%)	nf	19 (20%)
<b>Harar (n=148)</b>							
<i>Cysticercus ovis</i> ( <i>Taenia ovis</i> )	33 (22%)	33 (22%)	nf	nf	nf	nf	nf
<i>C. tenuicollis</i> ( <i>T. hydatigena</i> )	66 (45%)	nf	38 (58%)	20 (30%)	nf	8 (12%)	nf
Hydatid cysts ( <i>E. granulosus</i> )	93 (63%)	nf	nf	53 (57%)	25 (27%)	nf	15 (16%)
<b>Dire-Dawa (n=159)</b>							
<i>Cysticercus ovis</i> ( <i>Taenia ovis</i> )	37 (23%)	37 (23%)	nf	nf	nf	nf	nf
<i>C. tenuicollis</i> ( <i>T. hydatigena</i> )	92 (59%)	nf	40 (44%)	29 (32%)	nf	23 (25%)	nf
Hydatid cysts ( <i>E. granulosus</i> )	107 (67%)	nf	nf	59 (55%)	36 (34%)	nf	12 (11%)
<b>Jijiga (n=171)</b>							
<i>Cysticercus ovis</i> ( <i>Taenia ovis</i> )	45 (26%)	45 (26%)	nf	nf	nf	nf	nf
<i>C. tenuicollis</i> ( <i>T. hydatigena</i> )	98 (57%)	nf	44 (45%)	34 (35%)	nf	20 (20%)	nf
Hydatid cysts ( <i>E. granulosus</i> )	118 (69%)	nf	nf	70 (59%)	30 (25%)	nf	18 (15%)
<b>All abattoirs (n=632)</b>							
<i>Cysticercus ovis</i> ( <i>Taenia ovis</i> )	141 (22%)	141 (22%)	nf	nf	nf	nf	nf
<i>C. tenuicollis</i> ( <i>T. hydatigena</i> )	336 (53%)	nf	155 (47%)	113 (34%)	nf	68 (20%)	nf
Hydatid cysts ( <i>E. granulosus</i> )	412 (65%)	nf	nf	227 (55%)	121 (30%)	nf	64 (16%)

(nf=not found)

between sheep and goats. However, there was significance difference in the overall prevalence of *T. hydatigena* infection between sheep and goats (see Tables 2 and 3).

#### Prevalence of adult cestodes

The overall prevalence of adult tapeworm infections in sheep was 61%, 20%, 24% and 39%, for *Moniezia expansa*, *Avitellina centripunctata*, *Stilesia globipunctata* and *Stilesia hepatica*, respectively (Table 4). Similarly, the overall prevalences of these parasites in goats were 53%, 21%, 27% and 36%, respectively (Table 5). There were no significant differences in the prevalence of any of these cestodes between sheep and goats, males and females, young and adults, wet and dry seasons, or between abattoirs (see Tables 4 and 5).

#### Discussion

The most important finding of this survey, from a human health standpoint, was the high prevalence of hydatid cysts in the slaughtered animals-being 68% in sheep and 65% in goats (Tables 2 and 3). Although there is no information about the prevalence of human hydatidosis in the particular study region, the large numbers of roaming dogs and other canines, the intimate association between animals and humans and poor hygienic practices, strongly suggests that this is likely to be also a significant human health problem.

Our results indicate a generally higher prevalence of *E. granulosus* cysts in sheep and goats compared to studies in other regions of the country. Koskei (1998) reported a prevalence of bovine hydatidosis of 61% in Assela (south-east Ethiopia), 20% in Makale (north Ethiopia) and 28% in Debre Zeit (central Ethiopia).

**Table 4** Prevalence of intestinal and bile duct tapeworms in sheep by sex, age and season, during May 2003 to April 2005 in four abattoirs in eastern Ethiopia

Abattoir site (number of investigated animals) & Tapeworm species	Overall prevalence	Sex		Age		Season	
		Male	Female	Adult	Young	Wet	Dry
Haramaya (n=152)							
<i>Moniezia expansa</i>	63%	61%	69%	61%	75%	65%	59%
<i>Avitellina centripunctata</i>	17%	19%	10%	17%	15%	14%	20%
<i>Stilesia globipunctata</i>	28%	29%	27%	28%	25%	30%	26%
<i>Stilesia hepatica</i>	38%	38%	35%	36%	50%	35%	41%
Harar (n=156)							
<i>Moniezia expansa</i>	58%	55%	67%	53%	71%	62%	53%
<i>Avitellina centripunctata</i>	21%	21%	21%	23%	17%	28%	14%
<i>Stilesia globipunctata</i>	29%	30%	25%	29%	30%	30%	28%
<i>Stilesia hepatica</i>	40%	37%	51%	34%	57%	41%	39%
Dire-Dawa (n=166)							
<i>Moniezia expansa</i>	67%	64%	73%	65%	75%	67%	67%
<i>Avitellina centripunctata</i>	26%	15%	19%	15%	22%	16%	17%
<i>Stilesia globipunctata</i>	22%	21%	25%	23%	26%	28%	22%
<i>Stilesia hepatica</i>	33%	31%	38%	36%	19%	32%	33%
Jijiga (n=181)							
<i>Moniezia expansa</i>	56%	56%	57%	58%	51%	60%	52%
<i>Avitellina centripunctata</i>	27%	27%	24%	28%	22%	28%	25%
<i>Stilesia globipunctata</i>	25%	31%	27%	33%	31%	33%	27%
<i>Stilesia hepatica</i>	35%	34%	39%	36%	27%	42%	28%
All abattoirs (n=655)							
<i>Moniezia expansa</i>	61%	59%	65%	59%	69%	63%	60%
<i>Avitellina centripunctata</i>	20%	21%	19%	21%	20%	20%	21%
<i>Stilesia globipunctata</i>	24%	21%	23%	22%	25%	25%	20%
<i>Stilesia hepatica</i>	36%	35%	41%	30%	37%	38%	35%

**Table 5** Prevalence of intestinal and bile duct tapeworms in goats by sex, age and season, during May 2003 to April 2005 in four abattoirs in eastern Ethiopia

Abattoir site (number of investigated animals) & Tapeworm species	Overall prevalence	Sex		Age		Season	
		Male	Female	Adult	Young	Wet	Dry
Haramaya (n=154)							
<i>Moniezia expansa</i>	54%	55%	52%	54%	55%	56%	51%
<i>Avitellina centripunctata</i>	20%	19%	22%	23%	14%	20%	21%
<i>Stilesia globipunctata</i>	27%	27%	24%	29%	31%	26%	27%
<i>Stilesia hepatica</i>	35%	33%	39%	35%	36%	38%	32%
Harar (n=148)							
<i>Moniezia expansa</i>	54%	55%	52%	54%	56%	47%	61%
<i>Avitellina centripunctata</i>	22%	25%	17%	23%	19%	27%	17%
<i>Stilesia globipunctata</i>	26%	28%	24%	26%	23%	25%	29%
<i>Stilesia hepatica</i>	40	43%	33%	38%	44%	42%	37%
Diredawa (n=159)							
<i>Moniezia expansa</i>	51%	56%	42%	53%	46%	48%	55%
<i>Avitellina centripunctata</i>	13%	11%	17%	14%	10%	13%	14%
<i>Stilesia globipunctata</i>	28%	25%	32%	25%	27%	28%	30%
<i>Stilesia hepatica</i>	46%	46%	48%	43%	56%	42%	52%
Jijiga (n=171)							
<i>Moniezia expansa</i>	53%	50%	60%	53%	55%	57%	49%
<i>Avitellina centripunctata</i>	26%	25%	30%	22%	39%	26%	27%
<i>Stilesia globipunctata</i>	23%	24%	22%	25%	26%	21%	25%
<i>Stilesia hepatica</i>	36%	37%	35%	40%	25%	38%	35%
All abattoirs (n=632)							
<i>Moniezia expansa</i>	53%	54%	51%	53%	53%	51%	55%
<i>Avitellina centripunctata</i>	21%	20%	23%	21%	19%	21%	20%
<i>Stilesia globipunctata</i>	27%	29%	28%	29%	32%	28%	30%
<i>Stilesia hepatica</i>	39%	40%	38%	39%	43%	40%	38%

Mersie (1993) recorded a 21% prevalence of bovine hydatidosis in eastern Ethiopia and Bekele et al. (1988) reported a prevalence of 16% in sheep slaughtered in Addis Ababa (central highlands).

In our study, hydatid cysts in sheep and goats occurred most frequently in the liver and lungs, which are the predilection sites for *E. granulosus* in the intermediate host, however the heart, kidneys, spleen, the omentum and other organs were also affected. The location of cysts and cyst morphology is influenced not only by host factors, but also by parasite factors such as the strain of *E. granulosus* involved (Eckert and Deplazes 2004). The high prevalence of hydatid cysts in the slaughtered animals also indicates that cystic echinococcosis causes considerable economic penalties, due to condemnation of affected animal organs at the slaughterhouse. Such losses are of particular importance in Ethiopia, which has low economic output and where sheep and goat production are major livestock industries.

The dog is most likely the principal source of both human and animal echinococcosis in Ethiopia, as indicated by several prevalence studies in dogs in the country. For example, 20–50% of dogs in Assela, Debre Zeit and Makele (Koskei 1998), 22% in eastern Ethiopia (Mersie 1993), 24% in Gondar, 10% in Debre Zeit and 21% in south Omo (Jobre et al. 1996) have been reported as being infected with *E. granulosus*. However, wild carnivores (specifically hyenas, jackals and foxes) may also play a role in the transmission dynamics of *E. granulosus*, particularly in the study areas where large populations of these animals are found scavenging around human settlements.

Currently, information on the prevalence of human cystic echinococcosis in Ethiopia is scanty. A previous study, based on retrogressive hospital data analyses and interviews with physicians, has shown that on average 20 human hydatid cases were diagnosed and surgically treated each year at the



Arbaminch hospital, in south Ethiopia (Lobago 1994). Furthermore, Koskei et al. (1998) reported 4 human cases at the Assela hospital (south east Ethiopia), and 10 human cases at the Tigray region hospital (north Ethiopia) during a 5-year period (1992–1997). These reported low numbers of hydatidosis patients are most likely not representative of the true situation since it can be anticipated that a majority of hydatidosis patients will not seek medical attention, nor will they eventually be subjected to a post mortem examination. Clearly, the status of human hydatidosis in Ethiopia needs to be more comprehensively investigated.

Infections of sheep and goats with larval stages of *T. hydatigena* and *T. ovis* are also important because they cause economic losses due to condemnation of infected organs and carcasses (Bekele et al. 1992). Our study showed high prevalences of these parasites whose occurrence adds to the economic losses due to presence of *E. granulosus* cysts. However, although massive infections with e.g. *T. hydatigena* can cause severe disease and mortality in sheep (Gånheim et al. 1998), there are few indications that latent cysticercosis has obvious effects on the productivity of sheep and goats.

Intestinal adult cestode infections with *Moniezia expansa*, *Avitellina centripunctata* and *Stilesia globipunctata*, and bile duct infections with *S. hepatica* were found to be reasonably common in both sheep and goats in all study regions, and the prevalences of these parasites were similar in the two hosts. Surprisingly, there were no major differences in prevalence of tapeworms between young and adult sheep. This agrees with the findings from other African studies (Fakae 1990; Fritsche et al. 1993), although Fagbemi and Dipeolu (1983), reported higher levels of *M. expansa* in young goats compared to adult animals in Nigeria. There were no effects on the prevalence during dry and wet seasons, which is noteworthy since one could anticipate that the arthropod intermediate hosts would be favoured by a moist microclimate in the pasture. Although the pathogenic effects of these infections are likely to be of minor importance, livestock owners are concerned at the presence of tapeworm segments in the dung of their animals and often resort to inappropriate and expensive treatment.

In conclusion, this study has shown that cestode parasites, particularly the larval cestode infections of

*T. ovis*, *T. hydatigena* and *E. granulosus* are highly prevalent in sheep and goats raised by smallholder farmers in eastern Ethiopia. Further information concerning the importance of these parasites in other domestic livestock and wildlife is required. Due to the high prevalence of hydatid cysts, the study indicates that echinococcosis is of public health importance in the region. Thus, the status of *Echinococcus* infection in humans in Ethiopia needs to be investigated and we suggest that appropriate control measures are undertaken. These should include public awareness and education programmes, revision and upgrading of meat inspection legislation and procedures, and more authoritative efforts to reduce the stray dog population.

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