

First survey of helminths in adult goats in Hunan Province, China

Ma, J.¹, He, S.W.², Li, H.², Guo, Q.C.³, Pan, W.W.⁴, Wang, X.J.⁵, Zhang, J.⁶, Liu, L.Z.⁷, Liu, W.^{1*} and Liu, Y.^{1*}

¹College of Veterinary Medicine, Hunan Agricultural University, Changsha, Hunan Province 410128, PR China

²Xiangxi Vocational and Technical College for Nationalities, Jishou, Hunan Province 416000, PR China

³Huaihua Vocational and Technical College, Huaihua, Hunan Province 418000, PR China

⁴Loudi Animal Husbandry and Fishery Bureau, Loudi, Hunan Province 417000, PR China

⁵Changsha Animal Health Supervision Institute, Changsha, Hunan Province 410006, PR China

⁶Hunan Animal Health Supervision Institute, Changsha, Hunan Province 410007, PR China

⁷Boehringer Ingelheim Pharmaceutical Company Limited, Changde, Hunan Province 415000, PR China

*Corresponding authors email: weiliupro@163.com (W. Liu); yiliupro@163.com (Y. Liu)

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Abstract. The objective of the present survey was to reveal the prevalence of helminths in adult goats in Hunan Province, the People's Republic of China. From July 2010 through February 2013, a total of 479 goats slaughtered in local abattoirs and markets were examined for the presence of helminths using a helminthological approach. Eighty-six percent of the examined goats were infected with at least one species of helminths. In total, 15 genera of helminths were found representing 2 phyla, 3 classes, 5 orders, and 11 families. *Oesophagostomum*, *Ostertagia* and *Haemonchus* were the most prevailing nematode genera, *Eurytrema* was the predominant trematode genus detected, whereas the infection of adult goats with cestodes was not common, with *Cysticercus tenuicollis* being the most common genus. The worm burdens showed obvious seasonal variation in that nematodes and cestodes were abundant in summer and winter, and the trematodes peaked in winter, which was consistent with the seasonal precipitation of Hunan Province. The geographical distribution of helminths in goats ascended with altitude. Goats in the mountainous areas were more severely infected with helminths than goats in the hilly areas, whereas infection of goats with helminths was much less in the lake areas. The present investigation highlights the high prevalence of helminths in adult goats in Hunan Province, China, which provides baseline data for assessing the effectiveness of future prevention and controlling measures against helminth infection in adult goats in this province and elsewhere.

INTRODUCTION

Infection of goats with helminths causes considerable economic losses to the livestock industry due to high morbidity and mortality (Nwosu *et al.*, 2007; Khan *et al.*, 2010; Desouky *et al.*, 2011; Cardoso *et al.*, 2012; Liu *et al.*, 2012; Cardona & Carmena, 2013; Domke *et al.*, 2013; Mogoye *et al.*, 2013). A few goat helminths are also infectious to humans, which can cause significant clinical human diseases, such as echinococcosis, coenurosis and fascioliasis, in countries of different continents and

latitudes including China (Mansoorlakooraj *et al.*, 2011; Ziaei *et al.*, 2011; Kheirandish *et al.*, 2012).

The People's Republic of China has been experiencing rapid economic development for several decades, and is among the world's largest producers of meat, skin, and milk of goats by the end of the year 2011 (FAOSTAS). Hunan Province is one of the fastest-growing provinces of China in recent decades, reaping considerable progress in agricultural industry. With approximately 102,000 tons of mutton being produced in 2011, Hunan Province becomes an important

mutton producer of the country (<http://www.agri.gov.cn/>) and the total number of goats in the province continues to steadily increase.

Hunan Province has a long tradition of goat farming which contributes to the rapid development of rural economy. However, the profitability and sustainability of the goat industry in the province are also severely endangered by helminths. Surveys concerning helminths infections of goats have been performed in some provinces in China previously, but unfortunately most of the studies were published in local journals (Zhang, 1983; Zhang, *et al.*, 1986; Yang, 1988; Du *et al.*, 1995). Given the lack of province-wide investigation of goat helminths, the present study was implemented to estimate the prevalence of helminths in adult goats in Hunan Province by *post-mortem* examination, which would provide baseline data for preventing and controlling helminths in goats.

MATERIALS AND METHODS

The study site

Hunan Province is located in the southeastern hinterland of China between the northern latitudes 25° to 30° and eastern longitudes 109° to 134°, and borders Hubei Province in the north, Jiangxi Province in the east, Guangdong Province and Guangxi Province in the south, Guizhou Province and Chongqing City in the west. The province covers an area of approximately a quarter of one million square kilometers, similar to the size of the Great Britain. Hunan Province comprises three basic topographical areas: the mountainous areas, the hilly areas, and the lake areas (Figure 1). Mountainous areas are widely distributed in Hunan and account for approximately 50% of the province, and possess appropriate condition for raising goats. The average altitude of the goat raising areas of the province is over 1,000 m in mountainous areas and below 50 m in the

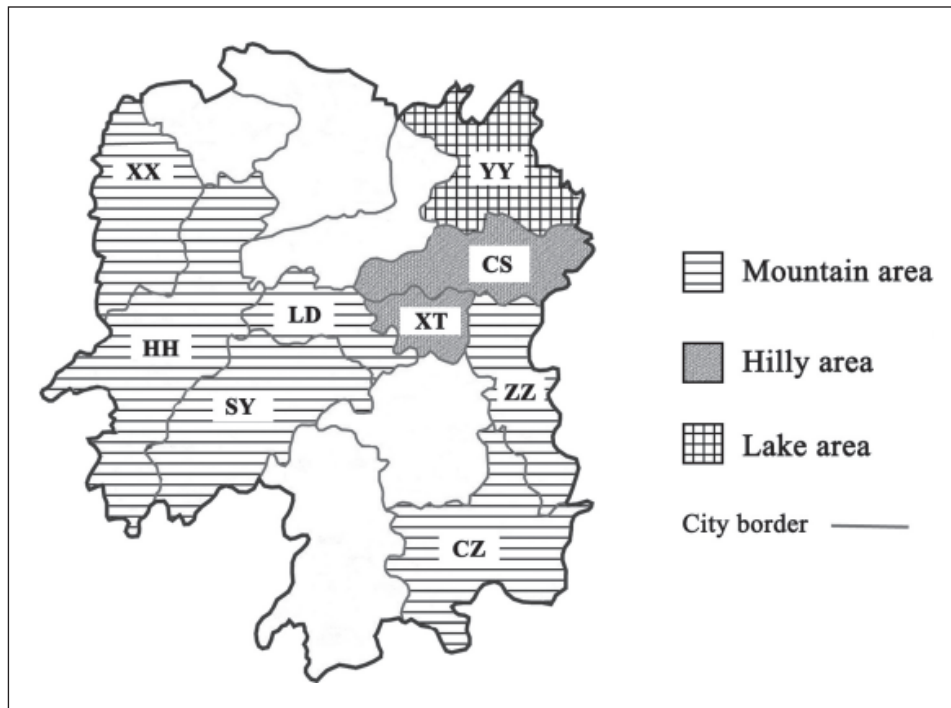


Figure 1. The map of Hunan Province, China showing survey areas where adult goats were sampled for the examination of helminth infection. The specific locations of sampling areas were labelled, namely Xiangxi Autonomous Prefecture (XX), Huaihua City (HH), Shaoyang (SY), Chenzhou city (CZ), Zhuzhou City (ZZ), Loudi city (LD), Changsha City (CS), Xiangtan City (XT) and Yueyang City (YY)

northern part of Hunan Province around Dongting Lake. Climatically, it features a subtropical monsoon climate, with an average annual temperature of about 16 to 18° C, and the average precipitation of 1200 to 1700 mm, which is more than twice of the national average. Hunan Province is divided into 14 administrative divisions, and the City of Changsha is the capital.

Sampling of goats

The present survey was performed from July 2010 to February 2013. A total of 479 adult goats aged between 6 months and 4 years were selected randomly from 24 cities and counties in the nine main goats-raising administrative districts (Table 1). The major species of goats raised are Boer goats and Nan Jiang meat goats, with Matou goats and Wuxue goats in the northwest Hunan and Black Goats in eastern Hunan.

Worm collection, counting, preservation and identification

Individual organs were removed from the carcasses of 479 slaughtered adult goats. Close inspection, such as separating, opening, and washing, were conducted on organs like rumen, abomasums, small and large intestines, livers, pancreas, lungs for the presence of helminths. Worm counts were

performed in all washings or a proportion of total washings depending on the total number of worms existing.

Nematode specimens were fixed and stored in warm ethanol 70% (v/v) that contains 5% glycerol before being cleared in lactophenol and identified to species according to existing descriptions and keys. The species of tapeworms and trematodes were fixed in ethanol (70%), stained with carmine, differentiated in acid-alcohol, dehydrated in serial concentrations of ethanol, cleared in xylene, mounted in Canada balsam and then identified morphologically to species based on the existing descriptions and keys (Wang *et al.*, 2006).

The average prevalence for each parasite was calculated by dividing the amount of infected goats by the total number of goats examined, and was expressed as a percentage.

RESULTS AND DISCUSSION

A spectrum of 15 genera of helminths was found in naturally infected adult goats in Hunan Province, China in a total of 479 adult goats, displayed in Table 2. The species of worms and their predilection sites,

Table 1. Geographical origins (in Hunan Province, China) and number of adult goats examined in this survey

Geographical locations	No.	%
Mountainous area		
Xiangxi Autonomous Prefecture	240	50.1
Huaihua	90	18.8
Shaoyang	29	6.05
Chenzhou	27	5.64
Zhuzhou	12	2.51
Loudi	12	2.51
Hilly area		
Changsha	47	9.81
Xiangtan	10	2.09
Lake area		
Yueyang	12	2.51
Total	479	

Table 2. Species, organs of predilection, prevalence and intensity of infection of helminthes in adult goats in Hunan Province, China

Helminth species	Organs of predilection	Prevalence		Intensity of infection
		No.	%	
Trematoda				
<i>Eurytrema</i> spp.	Pancreas	157	32.8	1-3642
<i>Homalogaster paloniae</i>	Large intestine	46	9.60	1-50
<i>Paramphistomum</i> spp.	Rumen	41	8.56	1-609
<i>Ogmocotyle</i> spp.	Small intestine	31	6.47	1-36000
<i>Fasciola hepatica</i>	Liver	23	4.80	1-61
Cestoda				
<i>Cysticercus tenuicollis</i>	Mesentery, omentum majus, liver, pelvic cavity	54	11.3	1-168
<i>Moniezia</i> spp.	Small intestine	36	7.52	1-28
<i>Echinococcus granulosus</i>	Underjaw, diaphragm, muscles	3	0.626	1-3
Nematoda				
<i>Oesophagostomum</i> spp.	Large intestine	214	44.7	1-136
<i>Ostertagia</i> spp.	Ruman, small intestine	156	32.6	1-26109
<i>Haemonchus contortus</i>	Ruman, small intestine	134	28.0	1-597
<i>Trichuris</i> spp.	Large intestine	41	8.56	1-53
<i>Bunostomum trigonocephalum</i>	Small intestine	33	6.89	1-80
<i>Dictyocaulu</i> spp.	Bronchi	3	0.626	8-41
<i>Cooperia</i> spp.	Large intestine	1	0.209	1

prevalence and the intensities of infection ranges are recorded. These helminths represented 15 genera, 11 families, 5 orders, 3 classes, and 2 phyla. In the present study, 5 trematodes, 3 cestodes and 7 nematodes were identified. Eighty-six percent of the examined goats were infected with at least one species of helminth. *Oesophagostomum*, *Ostertagia* and *Haemonchus* were the most prevailing nematode genera, with prevalences varying from 28% to 44.7%. *Eurytrema* was the most common trematode genus, with a prevalence of 32.8%. The intensity of infection with trematodes and nematodes were usually high in most infected goats, whereas it was usually low for cestodes. *Cysticercus tenuicollis* was the most prevalent tapeworm of the three cestodes found in this investigation, with a prevalence of 11.3%.

Several preliminary surveys of helminth infection in adult goats in limited areas in Hunan Province were conducted in the last two decades (Wang, 1995; Fu *et al.*, 1999; Liang *et al.*, 2007; He *et al.*, 2008;

Tang *et al.*, 2008), and these surveys reported 18 genera which were not detected in the present investigation, namely *Cotylophoron*, *Calicophoron*, *Ceylonocotyle*, *Gastrothylax*, *Fiscoederius*, *Dicrocoelium*, *Orientobilharzia*, *Multiceps*, *Helictometra*, *Avitellina*, *Trichostrongylus*, *Strongyloides*, *Muellerius*, *Chabertia*, *Setaria*, *Nematodirus*, *Marshallagia* and *Coenurus cerebralis*. The reasons those helminths were not found in the present survey were most likely due to the changes in animal husbandry practice, animal welfare and the habitat of helminths and their vectors in this province. In addition, the brain, the abdominal cavity, the muscles and the spine were not examined in this study, so some helminths, such as *C. cerebralis* and *Setaria labiatopapillosa* may have been missed. Altogether, a total of 32 helminth genera have been recorded from adult goats in Hunan Province so far. The number of helminth genera in goats in Hunan Province was similar to that found in goats in other provinces in China (Zhang, 1983; Du *et al.*,

1995; Ning *et al.*, 2011), smaller than that in Sichuan and Zhejiang Provinces in China (Zhang *et al.*, 1986; Yang, 1988), but larger than that reported in Nigeria and Norway countries (Nwosu *et al.*, 2007; Domke *et al.*, 2013), possibly due to the difference in climates, sample size, animal welfares and animal husbandry practices.

Eighty-six percent of goats examined in this study harbored at least one helminth. Among all parasites detected, *Oesophagostomum*, *Ostertagia*, *Haemonchus*, *Eurytrema* were the predominant genera. It is remarkable that the intensity of *C. tenuicollis* infection in goats ranged from 1 to 168. This study found *Echinococcus granulosus* in underjaw, diaphragm and myocardium of adult goats, in addition to livers and lungs, which were unusual, because cysts of *E. granulosus* are usually found in livers and lungs (Calderini *et al.*, 2012; Rajabloo *et al.*, 2012).

The seasonal variations of helminth infection in adult goats in Hunan Province are given in Table 3. Unfortunately, information of helminths in adult goats in spring was not available in this survey because spring is the season for breed conservation of goat population for the year. The number and intensity of nematodes and cestodes peaked in summer and autumn, whereas the highest prevalence and intensity of trematode were in winter. The features of seasonal distribution of helminths in adult goats in Hunan Province were consistent with the variation in precipitation of the province. The abundant resources of water, light, and heat of Hunan Province are mainly synchronized and concentrated in the period from April through October, which are beneficial for the development and survival of nematodes and cestodes. This seasonal characteristic of helminths in adult goats in Hunan Province is similar to that found in Nigeria (Nwosu *et al.*, 2007). Also, the warm and humid climate in Hunan Province is suitable for the intermediate hosts, such as *Planorbis* and *Lymnaeidae*, to live, which facilitate the transmission of trematode larvae to goats to a large extent. Those larvae

develop to adult worms in the following months and cause several diseases, resulting in severe goat health problems mainly in winter. In addition, in the harsh winter, goat meat is critically needed for local people as a tradition to defend against the cold. As a consequence, parasiticides are widely overused in advance to prevent impacting the sales of goat meat in many localities of Hunan Province.

Helminth infection in goats in Hunan Province has a characteristic of geographical distribution, in that the number of species and the intensity of infection generally ascend with the increase of the altitude (Table 4). Adult goats in mountainous areas had much more severe helminth infection than those in hill regions, and goats in lake areas had the least helminth infection (Table 4). This may be related to the rainfall patterns in that mountainous areas have higher intensity and longer duration of precipitation than that of hilly areas, thus helminths are likely to flourish in the mountainous areas where the maximum rain fall occurs. Due to the unique terrain, the flat lake areas have less annual precipitation and tend to experience drought occasionally. Moreover, more goats are raised in mountainous areas where the ecological and environmental conditions are more favorable to high density and sustainable graving of goats. Lastly, the animal husbandry practice and welfare in mountainous areas are relatively poor in that some goats were not given anthelmintic, or the drugs were improperly used frequently.

In conclusion, the present survey revealed the high prevalence of helminth infection in adult goats in Hunan Province, China. Currently, the control of goat helminths in Hunan Province and other provinces of China depend almost totally on the use of anthelmintics, but the uncontrolled and immoderate use of these drugs has given rise to the development of resistance in helminths (Domke *et al.*, 2011; Bolajoko & Morgan, 2012). Therefore, integrated strategies and measures should be executed to control helminth infection in adult goats in Hunan Province and surrounding areas.

Table 3. Seasonal prevalence of helminthes in goats in Hunan Province, China

	No. goats	No. parasites	Nematodes			Trematodes			Cestodes					
			Parasites	Prevalence		Parasites	Prevalence		Parasites	Prevalence				
				No.	%		No.	%		No.	%	No.	%	
Summer	143	10	<i>Oesophagostomum</i> spp.	71	49.7	1-136	<i>Eurytrema</i> spp.	12	8.39	1-185	<i>Cysticercus tenuicollis</i>	30	21.0	1-39
			<i>Ostertagia</i> spp.	83	58.0	1-26109	<i>Homalogaster paloniiae</i>	11	7.69	1-23	<i>Moniezia</i> spp.	24	16.8	1-28
			<i>Haemonchus contortus</i>	117	81.8	1-548	<i>Paramphistomum</i> spp.	11	7.69	14-137	<i>Echinococcus granulosus</i>	1	0.700	1
			<i>Trichouris</i> spp.	4	2.80	1-53								
Autumn	94	12	<i>Oesophagostomum</i>	33	35.1	2-41	<i>Eurytrema</i> spp.	10	10.6	4-374	<i>Cysticercus tenuicollis</i>	6	6.38	1-168
			<i>Ostertagia</i> spp.	20	21.3	1-934	<i>Homalogaster paloniiae</i>	10	10.6	1-42	<i>Moniezia</i> spp.	8	8.51	1-23
			<i>Haemonchus contortus</i>	14	14.9	1-597	<i>Paramphistomum</i> spp.	6	6.38	16-503				
			<i>Trichouris</i> spp.	14	14.9	1-52	<i>Fasciola hepatica</i>	9	9.57	2-448				
			<i>Bunostomum trigonocephalum</i>	11	11.7	2-38	<i>Ognocotyle</i> spp.	6	6.38	6-20				
Winter	242	15	<i>Oesophagostomum</i> spp.	110	45.5	1-129	<i>Eurytrema</i> spp.	135	55.8	1-3642	<i>Cysticercus tenuicollis</i>	18	7.44	1-12
			<i>Ostertagia</i> spp.	56	23.1	1-25100	<i>Homalogaster paloniiae</i>	25	10.3	1-50	<i>Moniezia</i> spp.	4	1.65	1-2
			<i>Haemonchus contortus</i>	3	1.24	1-139	<i>Paramphistomum</i> spp.	24	9.92	1-609				
			<i>Trichouris</i> spp.	23	9.50	1-34	<i>Ognocotyle</i> spp.	22	9.09	1-36000				
			<i>Bunostomum trigonocephalum</i>	20	8.26	1-80	<i>Fasciola hepatica</i>	17	7.02	1-61				
			<i>Dictyocaulus</i> spp.	3	1.24	8-41								
			<i>Cooperia</i> spp.	1	0.413	1								

Table 4. Geographical prevalence of helminthes in goats in Hunan Province, China

No. goats	No. parasites	Nematodes			Trematodes			Cestodes						
		Parasites	Prevalence No. %	Intensity	Parasites	Prevalence No. %	Intensity	Parasites	Prevalence No. %	Intensity				
Lake area	12	9	<i>Oesophagostomum</i> spp.	7	58.3	3-15	<i>Eurytrema</i> spp.	1	8.33	1-185	<i>Cysticercus tenuicollis</i>	2	16.7	1-12
			<i>Ostertagia</i> spp.	2	16.7	10-14	<i>Homalogaster paloniæ</i>	2	16.7	1-23				
			<i>Haemonchus contortus</i>	2	16.7	10-31	<i>Ognocotyle</i> spp.	2	16.7	2-5				
			<i>Trichouris</i> spp.	2	16.7	3-22								
			<i>Bunostomum trigonocephalum</i>	3	25.0	4-17								
Hilly area	57	11	<i>Oesophagostomum</i> spp.	18	31.6	1-129	<i>Eurytrema</i> spp.	1	1.75	1-221	<i>Moniezia</i> spp.	3	5.26	1-2
			<i>Ostertagia</i> spp.	21	36.8	1-25100	<i>Homalogaster paloniæ</i>	1	1.75	1-21	<i>Cysticercus tenuicollis</i>	1	1.75	1
			<i>Haemonchus contortus</i>	14	24.6	21-44	<i>Ognocotyle</i> spp.	1	1.75	1-79				
			<i>Trichouris</i> spp.	13	22.8	1-34	<i>Eurytrema</i> spp.	11	19.3	2-36000				
			<i>Bunostomum trigonocephalum</i>	14	24.6	1-80								
Mountainous area	410	15	<i>Oesophagostomum</i> spp.	163	39.8	1-136	<i>Eurytrema</i> spp.	153	37.3	1-3642	<i>Cysticercus tenuicollis</i>	51	12.4	1-168
			<i>Ostertagia</i> spp.	53	12.9	1-400	<i>Homalogaster</i>	40	9.76	1-50	<i>Moniezia</i> spp.	32	7.80	1-28
			<i>Haemonchus</i>	96	23.4	4-597	<i>Paramphistomum</i> spp.	37	9.02	4-432	<i>Ethinococcus granulosus</i>	1	0.244	1
			<i>Trichouris</i> spp.	28	6.83	1-52	<i>Ognocotyle</i> spp.	18	4.39	1-500				
			<i>Bunostomum trigonocephalum</i>	16	3.90	1-40	<i>Fasciola hepatica</i>	23	5.61	1-61				
			<i>Dictyoacanthus</i> spp.	3	0.732	1-41								
			<i>Cooperia</i> spp.	1	0.244	1								

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