Prevalence and distribution of pig helminths in the Dongting Lake Region (Hunan Province) of the People's Republic of China

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Abstract

The prevalence of helminths in pigs was investigated in five rural communities situated on the embankment of Dongting Lake in Zhiyang County, Hunan Province, People's Republic of China, in an area known to be endemic for *Schistosoma japonicum*. The helminth prevalences identified on the basis of faecal egg count analysis were: *Oesophagostomum* spp. (86.7%), *Ascaris suum* (36.7%), *Metastrongylus* spp. (25.8%), *Strongyloides* spp. (25.8%), *Trichuris suis* (15.8%), *Globocephalus* spp. (6.7%), *Gnathostoma* spp. (4.2%), *Schistosoma japonicum* (5.0%) and *Fasciola* spp. (1.3%). Post mortem examinations of a small number of pigs depositing eggs of different helminth species revealed the presence of *Oesophagostomum dentatum*, *O. quadrispinulatum*, *A. suum*, *Metastrongylus apri*, *M. pudendotectus*, *T. suis*, *G. hispidum* and *Ascarops dentata*. Prevalences of all helminths, with the exception of *Oesophagostomum* spp., were higher in young pigs ($<$ 8 months old) compared with adult pigs. Prevalences of trematodes were very low, especially for *S. japonicum* which had decreased dramatically compared with previous reports from this area of P.R. China, whereas prevalences of nematodes were generally in agreement with those reported from other Yangtze River Provinces. Results from helminth prevalence studies in pigs, conducted in other provinces of P.R. China between 1987 and 1997, are presented and discussed. It was concluded that a government helminth control programme, implemented in 1995 to control *S. japonicum* infection in pigs in Hunan Province, may have resulted in a greatly reduced prevalence of *S. japonicum* in pigs in this region.

Introduction

Helminth infections pose serious health hazards to humans (WHO, 1987), while in pigs these infections

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mainly result in considerable economic losses due to reduced weight gains and condemnation of livers and intestines at slaughter (Murrell, 1986), and an increased feed to gain ratio (Stewart & Hale, 1988). However, certain helminths that infect pigs are zoonotic, e.g. *Schistosoma japonicum*, *Taenia solium* (cysticercosis), *Echinococcus granulosus* and *Trichinella* spp. Furthermore, different species of the same parasite genus occurring in communities inhabited by both humans and pigs create the possibility of cross-infection, as was suggested for *Ascaris* (Anderson, 1995) and *Trichuris* (Beer, 1976). Thus, many helminth infections in pigs are of both public health and agricultural importance.

In the People's Republic of China, high prevalences of helminth infections have been reported in humans (Hotez *et al*., 1997). In the agriculturally intensive Yangtze River Provinces of Anhui, Hubei, Hunan, Jiangxi, Jiangsu, Sichuan and Yunnan, intestinal nematode infections and infection with *S. japonicum* are common. In these endemic areas farmers keep pigs which may serve as reservoir hosts for these parasites. Furthermore, in rural areas low hygienic standards prevail which would increase the risk of helminth infection, as described by Peng *et al*. (1996) in Jiangxi Province. However, little is known about the helminth status of pigs in P.R. China and their zoonotic implications, since most of the research has yet to be published outside P.R. China.

The Dongting Lake District in Hunan Province in south central P.R. China is an area of high endemicity of *S. japonicum*, which infects both humans and livestock. Recently, Ross *et al*. (1997) reported *S. japonicum* prevalences of 15% and 24% in humans on two islands in the Dongting Lake. The most prevalent intestinal nematode species infecting humans in Hunan are *A. lumbricoides* (67.7%), *Trichuris trichiura* (20.2%) and hookworm (22.9%) (Hotez *et al*., 1997). However, only few data are available on the helminth status of pigs around the Dongting Lake. A prevalence of 25% of *S. japonicum* in pigs in the Dongting Lake Region has been reported previously (Hu *et al*., 1988). In the neighbouring Jiangxi Province, Peng *et al*. (1996) found a 58.6% *A. suum* prevalence in pigs in two villages where the prevalence of *A. lumbricoides* in humans varied from 61.4 to 74.0%. No further information on the helminth status of pigs around Dongting Lake was available to the authors at the start of the present investigation, the aim of which was to study the prevalence of helminths in outdoor pigs in the Dongting Lake Region of Hunan Province, P.R. China. Furthermore, in collaboration with the College of Veterinary Medicine, Beijing Agricultural University, a short overview is presented of previous Chinese studies on the prevalences of helminths in pigs published in Chinese journals from 1987 to 1997.

Materials and methods

Study area

The survey was carried out in the Dongting Lake Region, Zhiyang County, in the northern part of Hunan Province, situated between west latitude 110° 43′ and 112° 55′ and north longitude 27° 58′ and 29° 31′. The climate is subtropical with an average annual temperature of 16.9°C (range: 4.4–29.2°C) and an annual rainfall of 1415 mm. The main agricultural production in the area is rice cultivation, while the lake is used intensively for fishing.

Five neighbouring villages (Zhi Te He, Shi Ma, Dong Cheng, Zheng Ming and Ming Lang) located along the embankment of Dongting Lake in an area known to be endemic for *Schistosoma japonicum* were selected for the survey. These villages are collectively inhabited by approximately 1800 families, who keep about 1700 pigs indoors and 700 pigs outdoors with access to the lakeside. Outdoor pigs per farm appeared to mainly consist of one sow with offspring and, in many cases, one castrated young boar. Other livestock included water buffalo, goats and poultry. In the current study only outdoor pigs were investigated, although a few faecal samples were collected from goats kept outdoors in different parts of the study area, for detection of *S. japonicum*.

Sampling procedures

The only data available were the prevalence of *S. japonicum* in pigs (25%) in the Dongting region reported previously by Hu *et al*. (1988) and the prevalences of intestinal nematodes in humans in Hunan as reported by Hotez *et al*. (1997). Since no further information was available, a 50% prevalence of helminth infection in pigs was assumed. Therefore, with a desired absolute precision of 10% and a 95% level of confidence, faecal samples were required from at least 96 pigs (Thrusfield, 1995) in order to obtain an accurate estimation of the helminth prevalence in outdoor pigs. Since the conditions under which the pigs were kept were similar in all five villages and no major geographic or geological differences existed, and because limited information was available on the age distribution of outdoor pigs, the 700 outdoor pigs were considered as one population.

Local veterinarians collected 100 faecal samples randomly in the study area from outdoor pigs only. When two or more pigs were found in one farm, faecal samples were taken from all animals. Fresh faeces were collected from the ground pointed out by the farmers, who also were able to distinguish between stools from different pigs. The faeces were transported to the laboratory of the Veterinary and Animal Husbandry Station in Yiyang and stored at 4°C prior to analysis.

In order to determine the species of worms identified by eggs in the faeces, post mortem examinations were carried out on ten pigs aged 6 to 12 months. The gastrointestinal tract and the internal organs were obtained at slaughter of pigs whose faeces were found to contain nematode and/or trematode eggs of interest. After necropsy, the gastrointestinal tract, including tongue and oesophagus, and the liver, heart, lungs and kidneys were examined for adult worms or cysts.

Faecal sample analysis

The number of nematode eggs in the faeces was determined using a concentration McMaster method (Roepstorff & Nansen, 1998), with a lower detection limit of 20 eggs per gram faeces (EPG). Schistosome and other trematode eggs were counted using a filtration/sedimentation method (Willingham *et al*., 1998). Additionally, a miracidial hatching test was carried out on the

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Table 1. Sample size, geographical and age distribution of pigs included in the survey.

Village	Growers (2–8 months)	Adults (> 8 months)	Total
Zhi Te He	3	7	10
Dong Chen	21	13	34
Shi Ma	23	6	29
Zheng Ming	9	9	18
Ming Lang	19	11	30
Total	75	46	121

same samples that were analysed for trematode eggs, to detect miracidia of *S. japonicum* (WHO, 1953).

Post mortem procedures

The tongue was examined macroscopically for the presence of encysted *Taenia solium* larvae. The oesophagus was sliced longitudinally and the muscle tissue inspected to detect any worms present. The trachea, bronchi and bronchioles were cut open and examined for lungworms. The bile duct was cut open, and subsequently the liver was sliced up and examined for liver flukes. The kidneys plus kidney fat were cut open and inspected for kidney worms. The stomach was cut open along the major curvature and the contents transferred to a bucket, sieved (mesh 100 μm) and macroscopically examined for stomach worms. Subsequently, the stomach wall was inspected for worms attached to or buried in the gastric mucosa. The small intestines were sliced longitudinally, their contents sieved (mesh 100 μm) and examined and the mucosa was inspected for worms attached to the intestinal wall. The large intestine was sliced longitudinally, its contents emptied into a 10 litre bucket and the intestinal wall washed carefully with physiological saline. The contents and washings were then suspended in 10 litres of 0.9% saline, from which a 10 or 20% subsample was taken while stirring. The sample was sieved through a 100 μm sieve and examined macroscopically for the presence of worms.

Analysis

Logarithmically transformed faecal egg counts were compared between age groups using a t-test assuming unequal variances. Prevalences of infection in growers and adults were compared using Fisher's Exact test. The degree of aggregation of the egg count distributions was estimated using the parameter of the negative binomial distribution, which is calculated as $k = mean^2$ / (variance – mean); k decreases as aggregation increases.

Results

Faecal samples were collected from 121 pigs: 75 growing pigs (2–8 months) and 46 adult pigs (>8 months) distributed over the five villages as shown in table 1. All samples were examined for nematode and cestode eggs, while 80 of these samples were also analysed for the presence of trematode eggs.

A total of nine helminth species were identified on the basis of faecal egg count analysis (table 2). Of the 121 pigs examined, 116 pigs (95.9%) deposited nematode eggs while trematode eggs were found in the faeces of only six out of 80 pigs (7.5%). Concurrent infections were observed in many pigs: 41 pigs (33.9%) deposited eggs of two helminth species, 15 pigs (12.4%) were infected with three species, 14 pigs (11.6%) deposited eggs of four species while in the faeces of three pigs (2.5%), eggs from five different helminth species were found.

Based on faecal egg count analysis, the most prevalent nematode species was *Oesophagostomum* spp. (86.7%). The strongyle eggs detected in faecal samples were assumed to be *Oesophagostomum* eggs, as in seven pigs that deposited strongyle eggs, moderate to high numbers of *Oesophagostomum* spp. but no *Hyostrongylus rubidus* or *Trichostrongylus* spp. were found at post mortem examination. The other species identified by faecal egg counts were *Ascaris suum* (36.7%), *Metastrongylus* spp. (25.8%), *Strongyloides* spp. (25.8%), *Trichuris suis* (15.8%),

Table 2. Prevalence of helminths in outdoor-reared pigs in the Dongting Lake District.

Helminth species	Prevalence (%) Total	Growing pigs	Adult pigs	Test for difference in prevalence growers and adults[a]
Nematodes				
Ascaris suum	36.7	43.2	26.1	$P = 0.079$
Oesophagostomum spp.	86.7	81.1	95.7	$P = 0.027$*[b]
Trichuris suis	15.8	18.9	11.9	$P = 0.308$
Metastrongylus spp.	25.8	32.4	15.2	$P = 0.053$
Strongyloides spp.	25.8	39.2	4.3	$P = 0.000$**
Globocephalus spp.	6.7	8.1	4.8	$P = 0.709$
Gnathostoma hispidum	4.2	5.4	2.4	$P = 0.648$
Trematodes				
Schistosoma japonicum	6.3	3.8	2.6	n.d.[c]
Fasciola spp.	1.3	1.3	0.0	n.d.

[a] Fisher's Exact test.
[b] * $P<0.05$; ** $P<0.001$.
[c] n.d., not done.

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Table 3. Faecal egg counts in outdoor-reared pigs in Dongting Lake District.

Helminth species	Arithmetic mean EPG				Test for difference in EPG between growers and adults[a]
	Total	Growing pigs	Adult pigs	Min–max	
Nematodes					
Ascaris suum	1534	2378	128	0–45120	*P*=0.003**[b]
Oesophagostomum spp.	1104	822	1574	0–11160	*P*=0.014*
Trichuris suis	196	312	4	0–20640	*P*=0.029*
Metastrongylus spp.	76	91	52	0–1520	*P*=0.062
Strongyloides spp.	381	608	3	0–21840	*P*=0.000***
Globocephalus spp.	27	24	32	0–980	*P*=0.897
Gnathostoma hispidum	5	8	<1	0–480	*P*=0.224
Trematodes					
Schistosoma japonicum	0.28	–	–	0–12	n.d.[c]
Fasciola spp.	0.04	–	–	0–3	n.d.

[a] t-test assuming unequal variances using log(EPG+10) transformed data.
[b] * $P<0.05$, ** $P<0.01$, *** $P<0.001$.
[c] n.d., not done.

Globocephalus spp. (6.7%) and *Gnathostoma* spp. (4.2%). *Globocephalus* eggs were distinguished from strongyle eggs on the basis of their size as, in the current study, the eggs were observed to be distinctly smaller than those of *Oesophagostomum* spp.

Trematode eggs were found in faeces of only six out of 80 pigs. The prevalence of *Schistosoma japonicum* was thus approximately 6.3%, while *Fasciola* spp. eggs were found in only one pig (1.3%). Miracidia of *S. japonicum* were observed in the faeces of four of the five pigs that were found to deposit *S. japonicum* eggs in their faeces but not in the faeces of any other pigs. Additionally, faecal samples were collected from ten goats that had access to the lakeside in the study region and five goats were found to have *S. japonicum* eggs in their faeces.

Cestode eggs were not recovered from any of the pigs. Protozoan cysts were frequently observed: *Eimeria* spp. in approximately 25% of the samples examined for nematode eggs and *Balantidium coli* in more than 95% of the samples examined for trematode eggs. *Isospora suis* cysts were not detected in any of the pigs.

Overall, the prevalences of all helminths (as indicated by faecal egg counts), except *Oesophagostomum* spp., were higher in growing pigs than in adult pigs (table 2). Table 3 shows that egg counts of *A. suum* ($P<0.01$), *T. suis* ($P<0.05$) and *Strongyloides* ($P<0.0001$) were significantly higher in growing pigs than in adult pigs, whereas *Oesophagostomum* egg counts were significantly higher in adult pigs ($P<0.05$). No significant differences in age distribution were observed for the other helminth species. The frequency distributions of faecal egg counts for the four most prevalent nematode species in the pigs examined were overdispersed (fig. 1A–D). The following estimates for the degree of aggregation were obtained: $k=0.061$ for *A. suum*, $k=0.029$ for *Oesophagostomum* spp., $k=0.011$ for *T. suis* and $k=0.108$ for *Metastrongylus* spp., indicative of heavily overdispersed distributions. *Strongyloides* egg counts were also overdispersed ($k=0.029$, figure not shown).

Post-mortem examinations were carried out on ten pigs depositing nematode eggs in their faeces, to obtain adult worms for identification (table 4). *Ascaris suum* and *Oesophagostomum* spp. were isolated from seven pigs and microscopic examination of 108 adult *Oesophagostomum* revealed that 78.7% of the worms were *O. dentatum*, while 21.3% were identified as *O. quadrispinulatum*. Six of seven pigs harboured both species. *Metastrongylus* spp. were isolated from four pigs: three pigs harboured *M. apri* while the fourth pig harboured both *M. apri* and *M. pudendotectus*. Adult *Ascarops dentata* were recovered from the stomach of two pigs, one of which also harboured one male *Gnathostoma hispidum*. No *Strongyloides* spp. or *Globocephalus* spp. were found at post mortem examination.

Table 5 lists 14 studies on the prevalences of pig helminths, grouped by province, carried out in P.R. China from 1987 to 1997 and it indicates that *Ascaris suum*, *O. dentatum*, *T. suis* and *M. apri* are the most prevalent helminths in Chinese pigs. *Gnathostoma hispidum*, *Hyostrongylus*, *Strongyloides*, *Fasciola* and *Fasciolopsis* are less common, although prevalences of more than 25% are occasionally reported. A prevalence of 10–23% of *Schistosoma* in pigs in Yunnan Province was reported on

Table 4. Number and species of worms recovered at post mortem from pigs.

Helminth species	Number of pigs	Mean number of worms (range)
Ascaris suum	7	11 (1–41)
Oesophagostomum spp.	7	1346 (10–5000)
Metastrongylus spp.	5	32.8 (1–124)
Ascarops dentata	2	5.5 (2–9)
Trichuris suis	1	200
Gnathostoma hispidum	1	1

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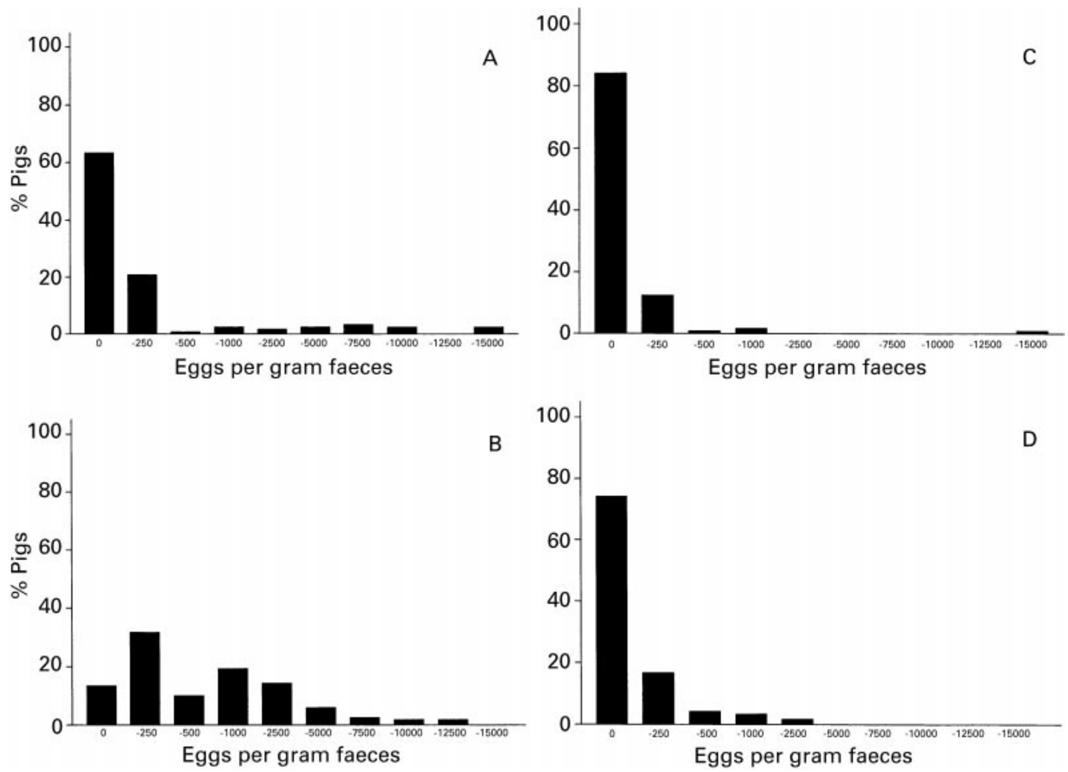

Fig. 1. Frequency distributions of faecal egg counts in 121 outdoor pigs in the Dongting Lake Region, Hunan Province, P.R. China. (A) *Ascaris suum*, (B) *Oesophagostomum* spp., (C) *Trichuris suis* and (D) *Metastrongylus* spp.

one occasion, but the species was not identified (Huang *et al*., 1988).

Discussion

The results of the present study show that nematode infections are very common in outdoor pigs in the Dongting Lake Region of the People's Republic of China. Nematode prevalences were largely comparable with those described for the other Yangtze River Provinces (see below). However, trematode prevalences were much lower than anticipated in an area where schistosomiasis particularly is considered common in humans and livestock.

In this paper we also present a review of helminth prevalences in the Yangtze River Provinces of P.R. China, hitherto not published in English. The use of this overview has certain limitations since information on age distribution and husbandry systems in most cases was not available. However, the results from the surveys carried out in Jiangxi, Guizhou, Hubei and Yunnan show that helminth infections are common in pigs in the Yangtze Provinces. Furthermore, a comparison of these results with reports from Northern China (Gansu, Liaoming and Hailongjiang) indicates that helminth prevalences in pigs may fluctuate between provinces.

A comparison with Chinese literature further showed that four helminth species predominate in pigs in P.R. China: *Oesophagostomum* spp., *A. suum*, *T. suis* and *Metastrongylus* spp. Our observations are in agreement with this, although the prevalence of *Oesophagostomum* spp. in these Chinese studies was generally lower and showed considerable variation, whereas the *T. suis* prevalence in our study was slightly higher compared with previous Chinese reports. Furthermore, in our study a high prevalence was also found for *Strongyloides* spp., but adult worms of *Strongyloides* were not recovered. It may be difficult to distinguish between eggs of *Strongyloides* and *Ascarops* using light microscopy, as both are larvated and have approximately the same size. A complicating factor is that *Strongyloides* eggs may not be distinguished from the eggs of free-living nematodes. This is particularly a problem when faeces are collected from the ground (Roepstorff *et al*., 1998), which was the case in the present study and might explain why no *Strongyloides* worms were found in any of the pigs examined. On the other hand, no free-living nematodes were observed in any of the faecal samples examined in the current study. Interestingly, none of the authors in the Chinese studies report the finding of *Ascarops* or *Globocephalus*. In contrast, *Fasciolopsis* was found in five studies in considerable numbers but this trematode was not detected in our study.

The host age prevalences of nematodes in the present study are in agreement with those reported by Li *et al*. (1992) and Xiong (1993), who found that *Ascaris suum* and *T. suis* are more common in young pigs, whereas *Oesophagostomum* spp. and *Metastrongylus* spp. are more

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Table 5. Prevalences of pig helminths reported from different provinces of P.R. China between 1987 and 1997.

Reference	Age of pigs	*Ascaris suum*	*Oesophagostomum dentatum*	*O. quadrispinulatum*	*Trichuris suis*	*Metastronglyus apri*	*M. pudendotectus*	*Strongyloides*	*Hyostrongylus*	*Gnathostoma*	*Fasciola*	*Fasciolopsis*
Jiangxi												
Jiang *et al.* (1987)	n.m.	39.3	3.1		0.2	35.0				2.6	0.4	
Yang (1990)	n.m.	20.0	98.0	13.0						11.0		19.0
Li (1992)	n.m.	7.6			11.7	25.5#		7.4		34.9		15.2
Xiong (1993)	3mo–4yr	3.1–39.6	7.3–31.3*		2.1–23.8	1.4–37.5#						
Xu *et al.* (1993)	n.m.	58.1	10.3*		12.6	11.9#		7.1		14.1		
Guizhou												
Zhao *et al.* (1990)	2–12mo	53.0	85.4*		28.0	32.0		7.0		4.0	6.0	7.0
Du (1995)	n.m.	34.6	15.3	18.5	4.5	13.7			1.6		0.5	2.2
Pan & Yang (1997)	n.m.	34.2	26.0			16.3#						
Hubei												
He & Tao (1989)	n.m.	31.0	5.7*		3.4	17.4#		6.8				
Yunnan												
Huang *et al.* (1988)	n.m.	17.9–66.3	10.0–84.2	11.9–88.2	8.6	3.3–49.0	8.1–18.0	11.1	5.4–100.0	18.0	28.6	37.5
Gansu												
Hui (1997)	2–6mo	86.3	46.9*		51.9	50.6#						
Liaoming												
Li *et al.* (1992)	3mo–4yr	1.6–26.1	3.4–80.6*		3.2–30.5							
Hailongjiang												
Yang *et al.* (1993)	2–6mo	42.8										
Yang (1996)	n.m.	54.2	12.5	18.5	4.5	13.7	4.2					

* Species not identified, assumed to be *O. dentatum*; # species not identified, assumed to be *M. apri*; n.m., not mentioned.

prevalent in older pigs. Age prevalence differences in nematode infection have also been reported in Europe (e.g. Jacobs & Dunn, 1969; Roepstorff & Jorsal, 1989; Roepstorff *et al.*, 1998) and Africa (e.g. Ajayi *et al.*, 1988; Permin *et al.*, 1999).

The distribution of nematode parasites is usually aggregated, i.e. the majority of worms are harboured by a small proportion of the host population. In pigs, this has recently been demonstrated for *A. suum* in experimentally and naturally infected pigs using worm counts (Roepstorff, 1997; Boes *et al.*, 1998a). In the present study this was confirmed on the basis of faecal egg counts. However, aggregated *A. suum* egg counts have been observed previously (Roepstorff, 1997; Nilsson, unpublished results). Our study also shows that the distributions of *T. suis*, *Metastrongylus* spp., *Strongyloides* spp. and *Oesophagostomum* spp. in naturally infected pigs in the Dongting Lake area are also overdispersed. This indicates that the majority of pigs harbour few or no worms, whereas a relatively few pigs harbour the majority of worms. It should be borne in mind, however, that our observations are based solely on faecal egg counts and especially *A. suum*, *T. suis* and possibly *Metastrongylus* spp. egg counts (thick-shelled, resistant eggs) could be false-positive due to coprophagy and/or geophagy (Boes *et al.*, 1997, 1998b), which may lead to an overestimation of the number of lightly infected animals and hence the prevalence of infection.

Trematodes, especially *Schistosoma japonicum*, were apparently not common in outdoor pigs from the surveyed area at the Dongting Lake. This finding is surprising since Hunan Province is known to be endemic for human schistosomiasis (Hotez *et al.*, 1997) and a 25% *S. japonicum* prevalence has previously been reported in pigs (Hu *et al.*, 1988). Furthermore, the *S. japonicum* prevalence in goats appeared to be as high as 50% in the present study. However, towards the end of the study period, discussions with the local veterinary authorities revealed that in 1995, as part of the provincial schistosomiasis control programme, the central Chinese government encouraged the local farmers to confine their pigs and financed the building of pig houses on many farms. As a result more than two-thirds of the total pig population in the study region were confined. It is possible that non-confined pigs that were still raised outdoors were also more restricted in their access to the lakeside, and this would have further influenced the decrease in the prevalence of both *S. japonicum* and nematodes. Wu *et al.* (1992) suggested that controlling schistosomes in pigs may limit transmission to humans. However, the role of other reservoir hosts, e.g. goats and water buffalo, in the transmission of *S. japonicum* should also be investigated in order to obtain a more complete epidemiological picture.

Interestingly, results from the *S. japonicum* miracidial hatching test (four positive pigs) and faecal egg counts (five positive pigs) were comparable. This supports the Chinese attitude that infection status may be adequately assessed using the miracidial hatching test, as opposed to the more labour-intensive faecal egg count technique, when a qualitative assessment is acceptable.

Cestodes were not encountered in any of the pigs examined. This may suggest a minor role for cestode

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infections in Hunan Province, in contrast to, for example, Sichuan Province where cysticercosis (*Taenia solium*) is common in pigs in the south of that province (Dr Qiu Dongchuan, Sichuan Institute of Parasitic Diseases, Chengdu, personal communication). However, the number of pigs examined post mortem in the present investigation was low and more pigs need to be examined to make any further deductions concerning cestode infections.

In conclusion, the results of our study indicate that, although the prevalence was low in pigs, *S. japonicum* is still highly endemic in the study region. They furthermore show that nematode prevalences in outdoor pigs in the Dongting Lake area are high. However, the impact of nematode infections on pig production was not determined, and although many farmers treat their pigs with anthelmintics at least once during the fattening period, no information was obtained about the type of drug used and the frequency of anthelmintic treatment. Further studies are needed to establish whether routine anthelmintic treatment would be cost-effective and whether prevention and control programmes for helminth infections in pigs are advisable.

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