# The abattoir condemnation of meat because of parasitic infection, and its economic importance: results of a retrospective study in north-eastern Iran

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In nine districts in the north of Khorasan province, in north–eastern Iran, a 5-year retrospective study was carried out to determine the prevalences, in livestock slaughtered in abattoirs, of the parasitic infections responsible for the condemnation of the animals' carcasses and viscera (and the economic importance of such infections in terms of lost meat and offal). Between 20 March 2005 and 19 March 2010, 436,620 animals (45,360 cattle, 275,439 sheep, 115,674 goats and 147 camels) were slaughtered in the study area and the livers of 30,207 (6.9%), the lungs of 23,259 (5.3%) and the carcasses of 1072 (0.2%) of these animals were condemned. Almost all (92.4%) of the condemned livers, most (68.9%) of the condemned lungs but only 10.8% of the condemned carcasses were rejected because of parasitic infection.

The parasitic lesions observed in the condemned livers were attributed to *Echinococcus granulosus*, *Fasciola hepatica* and/or *Dicrocoelium dendriticum* (cattle, sheep and goats) or entirely to *E. granulosus* (camels). All the parasitic lesions observed in the condemned lungs (which also came from cattle, sheep, goats and camels) were attributed to *E. granulosus*. *Sarcocystis* cysts and/or *Taenia* cysticerci were found in ovine muscle while only *Taenia* cysticerci were detected in bovine muscle (no parasitic lesions were observed in the muscles of the goats and camels).

Parasites were responsible for 80.8% of the condemned organs or carcasses, and the value of the food lost because of parasite-related condemnation (based on market prices in 2010) was estimated to be U.S.\$421,826 (U.S.\$47,980 for cattle, U.S.\$316,344.0 for sheep, U.S.\$57,372 for goats and U.S.\$130 for camels). The parasites contributing most to the condemnation of otherwise marketable organs and muscles were *E. granulosus* (52.2%) and *D. dendriticum* flukes (29.5%). These parasites clearly remain too common and cause considerable economic loss in Khorasan and, presumably, other areas of Iran.

Livestock forms an important segment of the agricultural production to be found in the nine districts forming the northern region of Khorasan province, in north– eastern Iran, where, in 2010, approximately 1,400,000 sheep, 280,000 goats, 80,000 cattle and 1000 camels were kept (www. ivo.org.ir). Nonetheless, information on the food and money lost because of the parasiterelated condemnation of offal and meat in this region's abattoirs is very limited. The main aims of the present study were to determine the frequencies of such condemnation, among the slaughtered sheep, goats, cattle and camels, and the parasites and economic losses involved.

# ANIMALS AND METHODS

The study was based on a retrospective survey covering a 5-year period (20 March 2005–19 March 2010) and abattoirs in the nine northernmost districts (Bojnord, Ashkhaneh, Esfaraen, Jajarm, Shirvan, Raz, Faruj, Garme and Razavi Behkade) in Khorasan province, in north–eastern Iran.

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The study area receives 200–500 mm of rain/year and has air temperatures ranging between -8 and  $+34^{\circ}$ C.

Meat-inspection records from the study abattoirs were analysed. Part of the daily routine of each abattoir is to record the numbers and types of organs or carcasses condemned, and the reason for each condemnation, on standardized data sheets.

For the present study, the condemnation data were collated on a yearly (March-March) basis. In 2010, using information from meat markets in the study area, the commercial values of a sheep, goat, cattle or camel carcass and the liver and lungs from each of these types of ruminant were estimated. These commercial values were then used to estimate the economic loss represented by the parasite-related condemnations over the 5-year study period.

Version 16 of the SPSS software package (SPSS Inc, Chicago, IL) was used for the data analyses. Temporal trends in the risks that inspected liver, lungs or carcass (i.e. muscle) would be condemned because of parasitic infection were explored using  $\chi^2$  and Fisher's exact tests for trends (Armitage *et al.*, 2002), separately for each host and parasite genus. A *P*-value of  $\leq 0.05$  was considered indicative of a statistically significant difference or trend.

#### RESULTS

Over the 5-year study period, 436,620 animals (275,439 sheep, 115,674 goats, 45,360 cattle and 147 camels) were slaughtered in the surveyed abattoirs and the livers of 30,207 (6.9%) of these animals, the lungs of 23,259 (5.3%) and the carcasses of 1072 (0.2%) were condemned. Of the liver, lungs and carcasses that were condemned, 92.4%, 68.9% and 10.8%, respectively, were condemned because of parasitic infection.

Of the cattle livers, lungs and carcasses that were inspected, 10.22%, 6.74% and 0.004%, respectively, were condemned because of parasitic infection (see Table 1).

The corresponding values for sheep (6.96%, 4.09% and 0.04%), goats (3.54%, 1.45% and zero) and camels (8.84%, 14.28% and zero) were generally similar (Table 1).

# Livers

The parasitic lesions observed in the livers of the slaughtered cattle, sheep and goats were caused by three parasite species: Dicrocoelium dendriticum (detected as adult flukes), Echinococcus granulosus (detected as hydatid cysts) and Fasciola hepatica (detected as adult flukes). Of the cattle livers inspected over the survey period, 5.33% were condemned because they harboured D. dendriticum, 4.15% because they held hydatid cysts and 0.73% because they were found to contain F. hepatica (Table 2). The corresponding values for the livers of sheep (3.88%, 2.65% and 0.42%), goats (2.3%, 1.03% and 0.2%) and camels (zero, 8.84% and zero) are also shown in Table 2.

## Lungs

Of the lungs that were condemned over the study period because of parasitic infection (6.74%, 4.09%, 1.45% and 14.28% of the inspected lungs from cattle, sheep, goats and camels, respectively), all were rejected because they contained hydatid cysts (Table 3).

## Carcasses

All of the carcasses rejected because of parasitic infection came from sheep or cattle. Over the entire survey period, 0.04% of the inspected sheep carcasses were condemned because muscles were found to contain *Sarcocystis* cysts and 0.0007% of the inspected sheep carcasses and 0.004% of the inspected cattle carcasses were condemned because muscles were found to contain *Taenia* cysticerci (Table 4).

## **Temporal Trends**

In the study abattoirs, the probability that an inspected liver would be condemned

		Value for the period:								
Animals	Variable	2005–2006	2006–2007	2007-2008	2008–2009	2009–2010	2005–2010			
Cattle	No. slaughtered	9188	8968	7239	10,625	9340	45,360			
	FREQUENCY OF CO	ONDEMNATION	(%)							
	Liver	8.73	10.26	9.04	10.87	11.82	10.22			
	Lungs	5.59	6.09	6.93	6.82	8.25	6.74			
	Carcass	0.01	0.01	0	0	0	0.004			
Sheep	No. slaughtered	45,742	71,155	59,365	58,683	40,494	275,439			
	FREQUENCY OF CONDEMNATION (%)									
	Liver	6.71	6.78	6.8	7.6	7.44	6.96			
	Lungs	3.89	3.43	3.13	5.82	4.36	4.09			
	Carcass	0.03	0.07	0.03	0.03	0.01	0.04			
Goats	No. slaughtered	23,856	26,866	22,693	20,516	21,743	115,674			
	FREOUENCY OF CONDEMNATION (%)									
	Liver	2.96	3.94	3.13	3.64	4	3.54			
	Lungs	1.37	1.83	1.25	1.47	1.25	1.45			
	Carcass	0	0	0	0	0	0			
Camels	No. slaughtered	18	33	24	12	60	147			
	FREOUENCY OF CONDEMNATION (%)									
	Liver	0	0	4.16	16.66	16.66	8.84			
	Lungs	5.55	0	4.16	41.66	23.33	14.28			
	Carcass	0	0	0	0	0	0			

TABLE 1. The numbers of cattle, sheep, goats and camels slaughtered at abattoirs in the nine northernmost districts of Khorasan province, between 20 March 2005 and 19 March 2010, and the percentages of the resultant livers, pairs of lungs and carcasses that were condemned by meat inspectors

TABLE 2.	The reasons	for the liver	condemnations	at abattoirs	in the	nine	northernmost	districts	of	Khorasan	pro-
vince, between	n 20 March	2005 and 19	) March 2010								

	Value for the period:							
Variable	2005–2006	2006–2007	2007-2008	2008–2009	2009–2010	2005–2010		
% OF CATTLE LIVERS CONI	DEMNED BECAUSE	OF:						
Fascioliasis	1.2	1.2	0.63	0.47	0.13	0.73		
Dicrocoeliasis	2.9	4.5	4.36	6.62	7.69	5.33		
Hydatid cyst(s)	4.5	4.4	4.04	3.77	3.98	4.15		
Non-parasitic cause	0.92	1.1	1.65	1.01	1.27	1.17		
% OF SHEEP LIVERS CONDE	MNED BECAUSE C	DF:						
Fascioliasis	0.61	0.62	0.28	0.31	0.21	0.42		
Dicrocoeliasis	2.8	3.05	4.41	4.75	4.49	3.88		
Hydatid cyst(s)	3.2	3.1	2.1	2.5	2.13	2.65		
Non-parasitic cause	0.54	0.25	0.48	0.41	0.66	0.44		
% OF GOAT LIVERS CONDE	MNED BECAUSE O	F:						
Fascioliasis	0.29	0.33	0.09	0.15	0.09	0.2		
Dicrocoeliasis	1.7	2.09	2.06	2.56	3.2	2.3		
Hydatid cyst(s)	0.93	1.51	0.97	0.92	0.71	1.03		
Non-parasitic cause	0.13	0.21	0.26	0.27	0.16	0.2		
% OF CAMEL LIVERS COND	EMNED BECAUSE	OF:						
Fascioliasis	0	0	0	0	0	0		
Dicrocoeliasis	0	0	0	0	0	0		
Hydatid cyst(s)	0	0	4.16	16.66	16.66	8.84		
Non-parasitic cause	11.11	27.27	16.66	8.33	1.66	15.64		

	Value for the period:							
Variable	2005–2006	2006–2007	2007–2008	2008–2009	2009–2010	2005–2010		
% OF CATTLE LUNGS CONI	DEMNED BECAUSE	OF:						
Hydatid cyst(s)	5.59	6.09	6.93	6.82	8.25	6.74		
Non-parasitic cause	1.89	3.07	2.58	1.59	2.6	2.31		
% OF SHEEP LUNGS CONDE	MNED BECAUSE C	DF:						
Hydatid cyst(s)	3.89	3.43	3.13	5.82	4.36	4.09		
Non-parasitic cause	1.82	1.9	1.17	0.81	3.17	1.69		
% OF GOAT LUNGS CONDE	MNED BECAUSE O	F:						
Hydatid cyst(s)	1.37	1.83	1.25	1.27	1.25	1.45		
Non-parasitic cause	0.74	1.57	1.16	0.78	2.11	1.28		
% OF CAMEL LUNGS COND	EMNED BECAUSE	OF:						
Hydatid cyst(s)	5.5	0	4.16	41.66	23.33	14.28		
Non-parasitic cause	22.22	24.24	16.66	0	11.66	15.64		

TABLE 3. The reasons for the lung condemnations at abattoirs in the nine northernmost districts of Khorasan province, between 20 March 2005 and 19 March 2010

because of parasitic infection was higher in 2009–2010 than in 2005–2006, whether the liver came from a cow (11.82% v. 8.73%; P<0.001), sheep (7.44% v. 6.71%; P<0.001), goat (4.00% v. 2.96%; P<0.001) or camel (16.66% v. 0%; P=0.1). Similarly, the probability that an inspected pair of lungs from a cow (8.25% v. 5.59%; P<0.001), sheep (4.36% v. 3.89%; P=0.001) or camel (23.33% v. 5.55%; P=0.17) would be condemned because of parasitic infection was

higher in 2009–2010 than in 2005–2006, although goat livers showed the opposite trend (1.25% condemned because of parasitic infection in 2009–2010, compared with 1.35% in 2005–2006; P=0.026). The corresponding values for carcass/muscle condemnation because of parasitic infections were generally much lower but, for cattle (0% condemned because of parasitic infection in 2009–2010, compared with 0.01% in 2005– 2006) and sheep (0.01% condemned because

TABLE 4. The reasons for the carcass/muscle condemnations at abattoirs in the nine northernmost districts of Khorasan province, between 20 March 2005 and 19 March 2010

	Value for the period:						
Variable	2005–2006	2005–2006 2006–2007 2007–2008 2008–2009 2009–2010					
% OF CATTLE CARCASSES (	CONDEMNED BEC.	AUSE OF:					
Sarcocystis cyst(s)	0	0	0	0	0	0	
Cysticercosis	0.01	0.01	0	0	0	0.004	
Non-parasitic cause	0.81	0.83	1.11	0.68	1.15	0.9	
% OF SHEEP CARCASSES CO	ONDEMNED BECAU	USE OF:					
Sarcocystis cyst(s)	0.03	0.07	0.03	0.03	0.01	0.04	
Cysticercosis	0.002	0	0.001	0	0	0.0007	
Non-parasitic cause	0.16	0.13	0.21	0.1	0.44	0.19	
% OF GOAT CARCASSES CO	NDEMNED BECAU	ISE OF:					
Sarcocystis cyst(s)	0	0	0	0	0	0	
Cysticercosis	0	0	0	0	0	0	
Non-parasitic cause	0.008	0.007	0.008	0.004	0	0.006	

of parasitic infection in 2009-2010, compared with 0.03% in 2005-2006), they declined over time (see Table 1).

The frequencies of liver condemnation because of D. dendriticum flukes increased between 2005-2006 and 2009-2010, from 2.9% to 7.69% in cattle, from 2.8% to 4.49% in sheep, and from 1.7% to 3.2% in goats (P < 0.001 for each). The frequencies of liver condemnation because of F. hepatica flukes showed the opposite trend, however, decreasing — from 1.2% to 0.13% in cattle, from 0.61% to 0.21% in sheep, and from 0.29% to 0.09% in goats (P<0.001 for each) — over the same period (Table 2). Although the corresponding frequencies of the condemnation of bovine, ovine and caprine liver because of E. granulosus cysts showed decreases - from 4.5% to 3.98% (P=0.083), from 3.2% to 2.13% (P<0.001), and from 0.93% to 0.71% (P=0.009) over the study period, respectively - the frequencies of the condemnation of camel liver because of such cysts increased, from 0% in 2005-2006 to 16.66% in 2009-2010, although not significantly (P=0.1; Table 2).

## **Economic Losses**

The total value of the meat and offal lost because of parasite-related condemnation in the nine study districts over the 5-year study period was estimated to be U.S.\$421,826 (based on market prices in 2010). Of this total, U.S.\$47,980 was associated with the condemned cattle carcasses and viscera, U.S.\$316,344.0 with the condemned sheep carcasses or viscera, U.S.\$57,372 with the condemned goat carcasses or viscera and just U.S.\$130 with the condemned camel viscera.

## DISCUSSION

Although abattoir-based surveys have some limitations, they are an economical way of gathering useful information on livestock disease. The present results, which provide useful baseline data for any future attempt at controlling the parasites involved, indicate that, in the north of Khorasan, several helminths (but particularly *E. granulosus*) cause considerable economic loss because infected organs and muscles have to be condemned.

The prevalences of *E. granulosus* infection recorded in the present study, in the slaughtered livestock — 4.15% in cattle, 2.65% in sheep, 1.03% in goats and 8.84% in camels — were, in general, lower than reported from the neighbouring countries of Saudi Arabia (Ibrahim, 2010), Iraq (Saeed et al., 2000) and Jordan (Kamhawi et al., 1995) and from other regions of Iran (Oryan et al., 1994; Ansari-Lari, 2005; Arbabi and Hooshyar, 2006; Daryani et al., 2007; Ahmadi and Meshkehkar, 2010). Interestingly, over the 5-year study period, E. granulosus infection appeared to become significantly rarer in cattle brought to slaughter (with similar, but not statistically significant, trends among the sheep and goats). This recent improvement in the health of the local livestock may be the result of greater awareness of echinococcosis among the farmers and the increasing likelihood that offal containing hydatid cysts will be destroyed and not left accessible to dogs. It may also be associated with a national programme, undertaken in recent years, to control rabies, which included the elimination of many stray dogs. There was no evidence of a decrease in the prevalence of E. granulosus infection among the camels brought to slaughter in the study area (in fact a marked increase was observed, although this was not statistically significant because relatively few camels were slaughtered), perhaps because traditionally-managed camels are more likely to be exposed to E. granulosus eggs excreted by wild canids than herds of sheep, cattle and goats. It is unclear why, compared with the goats, the slaughtered sheep were almost three-fold more likely to be found harbouring hydatid cysts but this may reflect differences in grazing behaviour (Torgerson et al., 1998), or different genotypes of E. granulosus affecting the goats and sheep (Varcasia et al., 2007).

Unfortunately, although the prevalence of echinococcosis is known to be highly dependent on the age of the potential host (Torgerson et al., 1998), the abattoir records analysed in the present survey included no data on the ages of the animals at slaughter. In Jordan, Torgerson et al. (1998) reported prevalences in 1-, 2- and 3-year-old sheep of 27%, 47% and 62%, respectively, while the corresponding prevalences in goats were 6%, 11% and 16%, respectively. If the animals being slaughtered are mainly young animals, the prevalences of infection estimated at slaughter may therefore give an underestimate of the total burden (and threat to the local human population) posed by echinococcosis. In the present study, hydatid cysts were only found in about 2%-3% of the sheep livers, 1.0%–1.5% of the goat livers, 3%-6% of the sheep lungs and 1.2%-1.8%of the goat lungs. Even if all the sheep and goats included in the survey were just 1 year of age when slaughtered, the prevalences of infection in the sheep and goats, as indicated by condemnation because of E. granulosus infection, are somewhat lower than the prevalences seen in 1-year-old sheep and goats in Jordan (Torgerson et al., 1998) and Tunisia (Lahmar et al., 1999), indicating relatively low infection pressures.

One of the most common causes of liver condemnation seen in the present study was the presence of flukes, especially D. dendriticum. Compared with those recorded in an earlier study in Iran, on livestock losses at an abattoir in Fars province (Ansari-Lari and Moazzeni, 2006), the prevalences of F. hepatica infection detected in the livers of the cattle (0.73%), sheep (0.42%) and goats (0.20%) included in the present study were slightly lower while the corresponding prevalences of D. dendriticum infection (5.33%, 3.88% and 2.3%, respectively) were slightly higher. In Iraq, an abattoirbased survey in Basrah revealed hepatic fascioliasis in 0.13% of the cattle, 0.72% of the sheep and 3.30% of the goats brought to slaughter (Mahdi and Al-Baldawi, 1987). In a later but similar investigation in Saudi

Arabia, the corresponding prevalences were 1.20%, 0.04% and 0.00%, respectively (Over *et al.*, 1992).

Among the ruminant livestock kept in northern Khorasan, it appears that the prevalence of *D. dendriticum* infection has increased over the last 5 years while the prevalence of *F. hepatica* infection has decreased (although liver flukes typically cause long-lasting, chronic infections, making it difficult to see short-term changes in infection pressure). The eggs of *D. dendriticum* are probably more resistant to drought conditions than those of *F. hepatica*, and *D. dendriticum* has wild 'reservoir' hosts (Taylor *et al.*, 2007).

The parasitic lesions observed in ovine muscle were caused by Sarcocystis cysts (seen in 0.04% of the slaughtered sheep) or Taenia cysticerci while those seen in bovine muscle were all attributed to *Taenia* cysticerci. The prevalences of cysticercosis in the slaughtered cattle and sheep investigated in the present study (0.004% and 0.0007%, respectively) were lower than those reported in other regions of Iran (Oryan et al., 1994; Khaniki et al., 2010). No Sarcocystis cysts were detected in any of the slaughtered cattle but this result is based only on macroscopic examinations by meat inspectors. When Nourollahi Fard et al. (2009) recently studied 480 cattle from Kerman, in south-central Iran, they found none of the cattle to have Sarcocystis cysts that were visible by macroscopic examination even though, using microscopy and tissue digestion, all of the animals were found to be infected with Sarcocystis.

There are indications that the prevalences of cysticercosis and sarcocystosis (detectable by macroscopic examination) in the cattle and sheep brought to slaughter in the study area have decreased over the last 5 or 6 years. The elimination of stray dogs in the national anti-rabies programme and an increasing awareness of the risks, for humans, of eating raw or undercooked meat may have led to these improvements.

In conclusion, in the present study area, parasites were found to be responsible for

80.8% of offal/carcass condemnations and an associated economic loss approaching U.S.\$0.5 million. The estimate of the economic loss is, almost certainly, a gross underestimate of the total financial loss as it takes no account of the premature deaths, low body weights and sub-optimal milk and wool yields that can result from parasitic infection (Perry and Randolph, 1999). Thus, although the losses incurred as a result of parasiterelated meat condemnation are probably too low to justify a region-wide campaign for the anthelmintic treatment of livestock, such a campaign may be a reasonable option if it leads to a marked increase in productivity as well as a marked decrease in condemnation.

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