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ORIGINAL ARTICLE

Occurrence of hydatidosis in camels (*Camelus dromedarius*) and their potential role in the epidemiology of *Echinococcus granulosus* in Kerman area, southeast of Iran

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Abstract A cross-sectional study was conducted during four seasons from October 2009 to October 2010 to assess the status of cystic hydatidosis in the slaughtered camels at Kerman abattoir. Hydatid cyst count and characterization were conducted based on routine meat inspection. Out of the total 217 camels examined visually and manually by palpation and incision, 45 (20.73%) were found harboring hydatid cysts. A significantly higher infection was detected in older camels ($P<0.05$) than younger ones. Of the total 45 infected, 21 (46.66%) had hydatid cysts only in the lung, nine (20%) in the liver, while the rest 15 (33.33%) had multiple organ infections. Of the 62 viscera harboring hydatid cysts, the highest (58.06%) was the lungs followed by the liver (38.75%), and the spleen (3.22%). Size assessment made on 361 cysts indicated that 140 (38.78%) were small, 128 (35.45%) medium, 33 (9.14%) large, and 60 (16.62%) were calcified. The distribution of characterized cysts in different organs based on their size was found to be statistically significant ($P<0.05$). In addition, out of the total 361 cysts collected, 58.17% were fertile, 25.20% sterile, and 16.62% calcified or purulent cysts. The rate of cyst calcification was higher in the liver than in the lung .There was a significant difference in fertility of cyst from different organs ($P<0.05$), those of lung origin being highly fertile. Likewise, out of the 210 fertile cysts subjected for viability test, 120 (57.14%) were viable. The results showed that hydatidosis is one of the major parasitic diseases in the study area. In light of the result obtained and the current situation in Kerman Municipal abattoir and its surrounding, warranting serious attention for its prevention and control.

Keywords Camel · Hydatidosis · Fertility · Viability · Abattoir · Kerman

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Introduction

Cystic echinococcosis (hydatidosis), caused by the larval stages of the tapeworm *Echinococcus granulosus*, is known to be one of the most important parasitic infections in livestock worldwide and one of the most widespread parasitic zoonoses (Craig et al. 2007; Cringoli et al. 2007). Adult parasites are found in the small intestine of dogs and other carnivores (Kassai 1999; Soulsby 1982). The intermediate hosts are a wide range of domestic (sheep, goats, cattle, and camels) and wild mammals and humans, in which the larval stages develop after oral infection with eggs (Gemmel 1990; Seimenis 2003). Food animals such as sheep, goats, cattle, camel, and pigs acquire the infection by ingestion of eggs from grass and water. Upon ingestion, the oncospheres (larval) penetrate the intestinal wall and reach visceral organs such as the liver, lung, heart, and kidney of animals and humans (Fakhar and Sadjjadi 2007).

The life cycle of *E. granulosus* involves domestic and wild carnivores as definitive hosts, which are infected by the ingestion of offal containing the larval forms (hydatid

cysts) with viable protoscoleces producing adult stage in the intestine. Dogs are the main source of infection, although in some areas jackals, hyenas, foxes, and wolves could also play a role as definitive hosts.

The suitable climatic and ecological features, traditional situations such as large numbers of small, ill-equipped and unsupervised abattoirs, home slaughtering, and big population of stray dogs, are only the main factors influencing the persistence of *E. granulosus* in the Mediterranean area (Seimenis et al. 2006). The ability of *E. granulosus* to adapt to a wide variety of host species contributes to the broad distribution of this parasite; in addition probably due to this wide spectrum of hosts there is a great genetic variability among *E. granulosus* strains (Thompson and McManus 2002).

Hydatid disease is a problem in Asia, the Mediterranean, South America, and Africa and also the prevalence of the disease has increased in Europe and North America in recent years (Khuroo 2002).Cystic hydatid disease, caused by *E. granulosus* is prevalent in most parts of Iran, especially in rural areas where offal from slaughterhouses is incorrectly disposed of/or where slaughtering is practiced on farms.

Various surveys throughout the country have indicated that hydatid cyst is commonly found in sheep, camels, cattle, and goats (Mobedi et al. 1970; Moghaddar et al. 1992; Oryan et al. 1994; Dalimi et al. 2002; Ahmadi 2005). Furthermore, human cases are regularly observed in the country and widespread recovery of adult worms has been reported from dogs, jackals, and wolves (Mobedi et al. 1973; Mehrabani et al. 1999; Maleky and Moradkhan 2000; Dalimi et al. 2002; Meshgi et al. 2009). So far three distinct cycles of *E. granulosus* have been suggested in Iran: a domestic cycle between dogs and livestock, a desert cycle between dogs and camels, and a sylvatic cycle between wild carnivores and wild ruminants. In the domestic cycle, the mean prevalence of *E. granulosus* in domestic dogs is 23.45%, which vary widely from 3.3% to 63.3% depending on the local condition (Eslami and Hosseini 1998). Sheep and camel (with 88% and 70% of fertilized cysts, respectively) are the most important intermediate hosts, and cattle (with 19% fertilized cysts), have been considered as the weakest intermediate host of *E. granulosus* in Iran (Hosseini and Eslami 1998; Rokni 2009).

The prevalence of infection and cyst fertility rates in sheep is high (Oryan et al. 1994; Hosseini and Eslami 1998; Mehrabani et al. 1999; Dalimi et al. 2002). Camels are found in the majority arid regions and commonly infected with *E. granulosus*, possessing a high cyst fertility rate (Mobedi et al. 1970; Moghaddar et al. 1992; Hosseini and Eslami 1998; Dalimi et al. 2002).

On epidemiological grounds, camels appear to be an important reservoir for human infection (Eckert et al. 1989; Rokni 2009). The systematic studies of the disease conditions, particularly those caused by helminthes in the camel, are few, and the published literature consists almost entirely of case reports, parasite records, and a few clinical trials of anthelmintic preparations long in use in other farm animals (Baraka et al. 2000). There are also few reports showing infection of camels of the southern and central provinces of Iran with this parasite. Hence, it is essential to obtain baseline data concerning prevalence of the disease before contemplating any rational control programs. Therefore, the aim of this study was to determine the frequency of infection of hydatid cysts in camel and to study the localization and fertility/sterility rates of hydatid cysts and the viability of their protoscoleces will also be investigated in Kerman Abattoir, southeast Iran.

Materials and methods

Study area

The study was conducted in Kerman city of Kerman province. Kerman is located at 30°17′13″N and 57°04′09″E southeast of Iran. The city's many districts are surrounded by mountains which bring variety to Kerman's year-round weather pattern, thus the northern part of the city is located in an arid desert area, while the highland of the southern part of the city enjoys a more moderate climate. The mean elevation of the city is about 1,755 m above sea level. Kerman city has a hot and arid climate and the average annual rainfall is 135 mm. Because it is located close to the Kavir-e lut (Lut Desert), Kerman has hot summers and in the spring it often has violent sand storms. Otherwise, its climate is relatively cool. The study was an active abattoir survey, which includes camel brought for slaughter to Kerman municipal abattoir.

Study design

Abattoir survey A cross-sectional study was conducted to determine up-to-date information on the prevalence and cyst characteristics of camel hydatidosis at Kerman municipal abattoir, southeast Iran during the four seasons from October 2009 to October 2010. For this purpose, the industrial slaughterhouse was visited periodically to examine the liver, lungs, and other organs of slaughtered animals for the presence of cystic hydatidosis. All camels presented on each visit day were examined.

During antemortem examination, each study animal was given an identification number with a label mark on their

Table 1 Prevalence of hydatidosis in different age and sex groups in camels slaughtered at Kerman municipal abattoir

Age groups (years)	Male		Female		Total (%)
	No. of camels	No. of infected camels (%)	No. of camels	No. of infected camels (%)	
<5	27	3 (11.11)	14	1 (7.14)	4 (9.75)
5–10	47	7 (14.89)	25	3 (12)	10 (13.88)
>10	61	19 (31.14)	43	12 (27.90)	31 (29.80)
Total	135	29 (21.48)	82	16 (19.51)	45 (20.73)

body. Age and sex, scoring of the study animals were also recorded. A total of 217 camels (83 females and 134 males) in three age groups (<5, 5–10, and >10 years old) were inspected for infection with cystic hydatidosis.

Postmortem examination was carried out through visual inspection or palpation, and where necessary, incision of visceral organs (lung, liver, heart, spleen, and etc.) and the presence of hydatid cyst and the organ distribution were recorded. Hydatid cysts were carefully removed and separately collected (in organ basis) in clean containers for further cyst characterization. Hydatid cyst characterization was made to assess the status of the cysts.

Examination of cyst size The size of the diameter of collected hydatid cysts on the affected organs was measured and classified as small (diameter less than 4 cm), medium (diameter between 4 and 8 cm), and large (diameter greater than 8 cm) (Schantz 1990).

Examination of cyst fertility and viability of protoscoleces The pressure of the cyst fluid was reduced by using a sterile hypodermic needle. Then cyst wall was incised with a sterile scalpel blade, and the content was transferred into a sterile container and examined microscopically (×40) for the presence of hydatid protoscolices. Similarly, the germinal layer was put in glycerin between two microscopic glass slides and examined for the presence of protoscoleces. The presence of protoscolices either attached to the germinal epithelium in the form of brood capsule or its presence in the cyst fluid was considered as indicative of fertility (Macpherson et al. 1985). Cysts which contained no protoscoleces as well as heavily suppurative or calcified were considered unfertile. Fertile cysts were subjected to viability test.

A drop of the sediment containing the protoscolices was placed on the microscope glass slide and covered with a cover slip and observed for amoeboid-like peristaltic movements with ×40 objective.

The viability of protoscoleces was assessed by the motility of flame cells together with staining with a 0.1% aqueous eosin solution (Smyth and Barrett 1980). The viability of protoscoleces was carried out for each fertile cyst per animal species and organ. For clear vision, a drop of 0.1% aqueous eosin solution was added to equal volumes of protoscolices in hydatid fluid on the microscope slide, with the principle that viable protoscolices should completely or partially exclude the dye while the dead ones take it up (Smyth and Barrett 1980; Macpherson et al. 1985). Furthermore, 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. Typical calcified cysts produce a gritty sound feeling up on incision (Soulsby 1982; Parija 2004).

Table 2 Frequencies and percentages of positive camels by age class, mean number, and viability of hydatid cysts at Kerman municipal abattoir

Age groups (years)	No. of infected camels (%)	Data on hydatid cysts (mean number and viability)						
		Number	Mean no.	Fertile	Sterile	Calcified/ caseous	Viable	Nonviable (%)
<5	4 (9.75)	29	7.25	21 (72.41)	5 (17.24)	3 (10.34)	16 (76.19)	5 (23.80)
5–10	10 (13.88)	68	6.8	52 (76.47)	10 (14.70)	6 (8.82)	33(63.74)	19 (36.53)
>10	31 (29.80)	264	8.51	137 (51.89)	76 (28.78)	51 (19.31)	71 (51.82)	66 (48.17)
Total	45 (20.73)	361	8.02	210 (58.17)	91 (25.20)	60 (16.62)	120 (57.14)	90 (42.85)

Table 3 Distribution of hydatid cysts in different organs of positive camel at Kerman municipal abattoir

Organs affected	Number of animals			
	Examined	Number of cases	Percentage	Relative frequency (%)
Lung only	217	21	9.67	46.66
Liver only	217	9	4.14	20
Lung and liver	217	13	5.99	28.88
Lung, liver, and spleen	217	2	0.92	44.4

Statistical analysis

The computer software, SPSS version 9.0 for Windows (SPSS Inc., Chicago, IL, USA) was used for analysis, and chi-square (χ^2) test was applied for comparison of rate of infections with regard to the hypothesized risk factors like age and cyst characteristics.

Results

Prevalence

The prevalence of hydatidosis in organs of 217 camels slaughtered at Kerman slaughterhouse, Iran, in different sex and age groups and different seasons is summarized in Tables 1 and 2. Forty-five out of 217 (20.73%) camels slaughtered and examined were infected with hydatid cyst, harboring one or more cysts involving different visceral organs (lung, liver, spleen). As many as 29 out of 135 males (21.48%) and 16 out of 82 females (19.51%) were found to be positive (Tables 3, 4, 5, 6, 7). The degree of prevalence between males and females was not statistically significant ($P>0.05$).

Rate of infection in different age groups (<5, 5–10, and >10 years old) was assessed and described (Table 1). Age prevalence has shown a statistically significant variation ($P<0.05$) with older groups having higher infections, but no significant difference was observed between males and females ($P>0.05$).

There was a direct relationship between the rate and intensity of infection and host age. The highest prevalence was recorded during autumn (23/17%) (Table 8). Prevalence of hydatidosis in different seasons was not significantly different ($P>0.05$).

Cyst distribution

The distribution of hydatid cysts by anatomical location is shown in Table 3. Of the 45 camels positive, 21 (46.66%) had cysts only in the lungs, 13(28.88%) in both the liver and lungs, nine (20%) in the liver alone. Therefore, the lungs were the predominant sites of the hydatid cyst, whereas the rest of the 115 (33.33%) infections involved multiple organs. About 96.77% (60 of 62) of all infected viscera is attributed to overall involvement of the lungs and liver. The chi-square test for differences of location was significant ($P<0.05$).

Cyst characterization

A total of 361 cysts were collected from the infected camels, 236 (65.37%) in the lungs, 118 (32.68%) in the liver, and seven (1.93%) in the spleen (Table 4). The mean number of cysts per animal was 8.02 (minimum, one; maximum, 18). Of the 62 viscera harboring hydatid cysts, the highest (58.06%) was the lungs followed by the liver (38.75%) then spleen (3.22%). The distributions of the hydatid cyst between organs of infected animals were significantly different in camels ($P<0.05$).

Cyst size

The sizes of the cysts found in each organ are reported in Table 5. Size systematic measurement of the cysts revealed that majority of large and medium-sized cysts were found

Table 4 Distribution and number of organs with hydatid cysts in infected camel slaughtered in Kerman municipal Abattoir

Organ	No. of organs infected	Relative prevalence	Cyst count			
			Mean/organ	Range	Total	Percentage
Lung	36	58.06	6.55	1–18	236	65.37
Liver	24	38.70	4.91	1–9	118	32.68
Spleen	2	3.22	3.5	1–4	7	1.93
Total	62	100	6.01	1–18	361	100

Table 5 Cyst size and counts in relation to organ involvement in camel slaughtered at Kerman Municipal abattoir

Organ	Number (%) of the different cyst sizes				Total
	Small	Medium	Large	Calcified	
Lung	79 (33.47)	104 (44.06)	30 (12.71)	23 (9.74)	236 (65.37)
Liver	57 (48.30)	23 (19.49)	3 (2.54)	35 (29.66)	118 (32.68)
Spleen	4 (57.14)	1 (14.28)	0 (0)	2 (28.57)	7 (1.93)
Total	140 (38.78)	128 (35.45)	33 (9.14)	60 (16.62)	361 (100)

in the lungs, while a large number of small-sized and calcified cysts were found in the liver. The variation in the size of cysts of different organs was significant ($P<0.05$).

Cyst fertility, viability, and sterility

Fertility status Out of 361 cysts tested for fertility, 150 (63.55%) cysts of lung, 57(48.30%) cysts of liver, and three (42.85%) cysts of spleen origins had detected protoscolices and hence, fertile. The rest were either sterile or calcified (Table 6). Fertility status of cysts from different organs have shown a significant difference ($P<0.05$), with cysts of lung origin being highly fertile.

A total of 210 fertile cysts originating from the lungs, liver, and spleen were tested for viability and described (Table 7).The viability rate of protoscoleces of liver fertile cysts (71.92%) was significantly higher than that of lung cysts (51.33%) and spleen (66.66%) ($P<0.05$).

Discussion

Hydatid disease is one of the major parasitic problems in man and livestock in Iran. The present study showed that 20.73% of camels were infected with hydatid cysts. The prevalence of hydatid cyst has been reported in Iran from 11.4% to 70% in camels (Ahmadi 2005; Rokni 2009). It was documented that a prevalence of 11.2 was recorded in Ahvaz abattoir (Khalili 1962); 64% in Tehran abattoir (Mobedi et al. 1970); 42.8% in south of Iran (Afshar et al. 1971); 11.4% in Khorasan province (Motakef et al. 1976); and 35.2% in five provinces of Iran (Ahmadi 2005). So that reports show that camel hydatidosis is widespread in Iran.

The findings of this study showed the existence of high prevalence in camels slaughtered at municipal abattoirs. However, the extent to which results were documented from different locations tends to show variable scales. This variation could be attributed to differences in culture, social activity, attitude to dog in different regions, host age factors, abundance of final infected hosts, stocking rate of livestock, and management of studied animals (Macpherson et al. 1985; Ibrahim 2010).

Our findings showed that male camels were more infected than females. The most probable explanation for the high infection rate in male animals in our study could be attributed to the practice of slaughtering large numbers of male camels than females in the abattoir.

No significant difference was observed between females and males in the infection rate of hydatidosis ($P>0.05$). Therefore, it seems that the sex of examined animals has no effect on infection by hydatid cysts.

A significant variation was observed in the rates of infections between age groups where animals above 10 years of age were highly infected. This could be mainly due to the fact that aged animals have longer exposure time to eggs of *E. granulosus* in addition to weaker immunity to combat against the infection (Himonas 1987).

In this study, it has been established that hydatid cysts occurred most commonly in the lung (80%) and followed by liver (53.33%). Livers and lungs were the most frequently infected visceral organs examined. This is explained by the fact that livers and lungs possess the first great capillary sites encountered by the migrating *Echinococcus oncosphere*

Table 6 Fertility/sterility of cysts collected from different organs of camels slaughtered at Kerman municipal abattoir

Organ	Fertile cyst (%)	Sterile cyst (%)	Calcified (%)
Lung	150 (63.55)	63 (26.69)	23 (9.74)
Liver	57 (48.30)	26 (22.03)	35 (29.66)
Spleen	3 (42.85)	2 (28.57)	2 (28.75)
Total	210 (58.17)	91 (25.20)	60 (16.62)

Table 7 Viability statuses of fertile cysts collected from organs of camels slaughtered at Kerman municipal abattoir

Organ involved	Viable cyst (%)	Nonviable cysts (%)	Total
Lung	77 (51.33)	73 (48.66)	150
Liver	41 (71.92)	16 (28.07)	57
Spleen	2 (66.66)	1 (33.33)	3
Total	120 (57.14)	90 (42.85)	210

Table 8 The structure of the sampled host populations by the season

Season	Male		Female		Total (%)
	No. of camels	No. of infected camels (%)	No. of camels	No. of infected camels (%)	
Summer	16	3 (18.75)	7	1 (14.28)	4 (17.39)
Autumn	52	12 (23.07)	30	7 (23.33)	19 (23.17)
Winter	39	8 (20.51)	26	4 (15.38)	12 (18.46)
Spring	28	6 (21.42)	19	4 (21.05)	10 (21.27)
Total	135	29 (21.48)	82	16 (19.51)	45 (20.73)

(hexacanth embryo) which adopt the portal vein route and primarily negotiate hepatic and pulmonary filtering system sequentially before any other peripheral organ is involved (Kebede et al. 2009). The finding that the lungs of camels were found to be more commonly infected with hydatid cysts than the livers is in agreement with the previous findings of Ahmadi (2005) and Ibrahem and Craig (1998). This might be due to the fact that camels are slaughtered at an older age, during which period the liver capillaries are dilated and most oncospheres pass directly to the lungs; additionally, it is possible for the *E. oncosphere* (hexacanth embryo) to enter the lymphatic circulation and be carried via the thoracic duct to the heart and lungs in such a way that the lung may be infected before or instead of the liver (Arene 1985).

Hydatid cyst condition tended to follow a size-dependent pattern in that most of the small cysts were calcified. This can be due to the host defense mechanisms of killing more efficiently with parasitic larvae at the early stage of development (Himonas 1987).

The reason for the higher percentage of medium and large cysts in the lungs is due to the softer consistency of the lungs, while the higher yield of calcified cysts in the liver could be attributed to the relatively higher reticuloendothelial cells and abundant connective tissue reaction of the organ. The higher number of calcified cysts in the liver could be attributed to the relatively higher reticuloendothelial cells and abundant connective tissue reaction of the organ. Likewise, the high proportion of small cysts may be due to the immunological response of the host which might preclude expansion of cyst size (Lahmar et al. 1999).

The overall percentage of fertile cysts in the present study was 58.17. Various surveys throughout the country have indicated that high cyst fertility rate is commonly found in camels (Mobedi et al. 1970; Moghaddar et al. 1992; Hosseini and Eslami 1998; Dalimi et al. 2002), hence they are potential sources of infection to dogs. Cysts, depending on the geographical situation, host, site, size, and type of cyst may have different rates of fertility (Dalimi et al. 2002). In the present study, the fertility rate of lung cysts (63.55%) was higher than that of liver cysts (48.30%) and spleen (42.85%) whilst the viability rate of protoscoleces of liver fertile cysts (71.92%) was significantly higher than that of lung cysts (51.33%) and spleen (66.66%). This is in agreement to the finding of Ahmadi (2005) in camels slaughtered at different abattoirs of five provincial regions in Iran. Ahmadi (2005) reported that the fertility of cysts in the lungs (69.7%) of camels in Iran was higher than that in the liver (58.7%) and spleen (50.0%) whilst the viability rate of liver fertile cysts (80.3%) was higher than that of lung cysts (55.8%) and other organs (57.1%).

Cystic echinococcosis is widespread in this study area. It was documented that a prevalence of 7.2% was recorded in cattle, 9.2% in sheep, and 6.8 in goats slaughtered in Kerman slaughterhouse, southeast Iran (Sharifi 1996), whilst the present study shows that 20.73% of camels were infected with hydatid cysts.

Published data showed that the prevalence in camels is higher than those in other animals (cattle, sheep, goat) in the area, camels clearly have an important role to play in the continuation of the *E. granulosus'* life cycle in the area (Sharifi 1996; Ahmadi 2005). This is in agreement with the findings of this survey. In *E. granulosus* endemic areas of Iran, it is evident that the majority of *E. granulosus*-infected livestock animals can potentially act as reservoirs of human infection (Daryani et al. 2009). This has important implications for hydatid control and public health.

Hydatidosis is one of the major parasitic diseases in the study area, in light of the result obtained and the current situation in Kerman municipal abattoir and its surrounding, warranting serious attention for its prevention and control.

Enforcement of legislation that will strictly prevent backyard and roadside slaughtering practices; establishment of policy on dog keeping and handling, including registration, treatment, and elimination of stray dogs; creation of public awareness regarding hydatidosis; promoting construction of standard abattoirs with their appropriate disposal pits particularly in rural areas; and conducting obligatory meat inspection services and further detailed investigation into the basic local epidemiological factors governing the spread of

hydatidosis in the different zones of the region involving different hosts as well as the existing status in humans would be mandatory to establish regional control strategy are recommended. This will significantly reduce the transmission of cysts from slaughterhouses to potential hosts in this region.

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