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Prevalence of Taeniid Eggs in the Faeces of Domesticated and Free-roaming Dogs in Basrah, Iraq, and the Knowledge of Dog Owners on Cystic Echinococcosis

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Prevalence of Taeniid Eggs in the Faeces of Domesticated and Free-roaming Dogs in Basrah, Iraq, and the Knowledge of Dog Owners on Cystic Echinococcosis

Abstract

The larval stages (metacestodes) of some taeniids of carnivores, particularly *Echinococcus* spp., can result in severe disease for humans and livestock. The prevalence of taeniid eggs by direct examination of faecal smears in 335 free-roaming dogs (FRD) and owned domesticated dogs in Basrah Province was 10.1% (95% CI 7.1, 13.9). A structured questionnaire was administered to 86 dog owners to investigate the influence of socio-demographic factors and management and husbandry practices on their knowledge of cystic echinococcosis (CE). The results of a multivariable logistic regression analysis revealed that dog owners who fed offal had less knowledge of CE (OR=0.17, 95% CI 0.05, 0.53), while keeping a dog (s) tied up was associated with good knowledge (OR=7.0, 95% CI 2.1, 23.8). Dog owners who had a secondary or higher level of education also had better knowledge (OR=5.4, 95% CI 1.7, 17.3). It was concluded that an educational campaign should be developed for dog owners in Basrah to reduce the risk of disease in both humans and other animals.

Keywords

Cystic Echinococcosis, Knowledge of Dog Owners, Risk Factors, Taeniid Eggs

Cover Page Footnote

We would like to express our gratitude to the Ministry of Higher Education and Scientific Research in Iraq to research fund a PhD scholarship. Our thanks to the College of Veterinary Medicine/University of Basrah permitted us to test all the samples belongings to this work at the Parasitological lab.

1. Introduction

Although dogs play an important and beneficial role in society [1], they can carry a range of zoonotic diseases, including parasites [2]. Transmission of canine parasites to humans or other animals can occur through direct contact with the dogs or via indirect contact with contaminated food or water [3].

Dogs are considered the principal definitive host for several parasites belonging to the family Taeniidae, including *Taenia* and *Echinococcus* spp [4]. Taeniids have a wide global distribution and utilise a range of mammalian species in their life-cycles resulting in potential risk for human health and reduced productivity of livestock [5,6]. Canine taeniids require two hosts to complete their life cycle. The adult worm resides in the intestinal passage of the dogs (definitive hosts), while the larval stage is either a hydatid cyst, cysticercus or coenurus in the tissue of the relevant intermediate host (livestock, humans or other animals) [7,8]. Eggs are passed in the faeces of the definitive hosts and are accidently ingested by the intermediate host with contaminated food or water [9].

The eggs of taeniids are not easily differentiated on morphology [10] as they all contain a hexacanth or six-hooked embryo [11]. Taeniid eggs can survive on pasture, in soil and water following contamination with infected dog faeces and subsequently, wind and wildlife can disperse the eggs over long distances [12]. After ingestion by the intermediate host, the eggs hatch in the small intestine and penetrate the intestinal wall [11–13]. Subsequently, they are dispersed by the circulatory system to organs such as the liver and lungs where they develop into cysts or metacestodes (larval stage) [14].

Most of the canine taeniids are medically and economically important in parasitized humans and livestock [15] with the larval stages of *Echinococcus* spp. (hydatid cysts) [16] and *Taenia multiceps* (Coenurus cerebralis) [17] being of particular significance. Although infection in the intermediate host can be asymptomatic, it can result in severe pathologically changes to the affected organ(s) or even death of the animal/human [18]. Inspection of carcasses at slaughterhouses is an effective, quick and inexpensive means for determining infection in livestock [19]; however, knowledge of the carriage of taeniids in dogs is a key aspect of understanding the risk and biological transmission of these parasites to humans and other animals.

Dogs are infected with taeniid tapeworms after consuming the larval stages (usually the liver or lungs) in cattle, buffalo, sheep, goats, and pigs. The adult worms then develop in the small intestine within 1–3 months [11]. Many laboratory techniques have been developed to determine the prevalence in dogs, including serological assays, detection of antigen in the faeces (coproantigen), observing worms at necropsy or direct examination of eggs in the faeces [20,21].

Human behaviour can help to perpetuate the domestic life cycle of taeniid tapeworms through the feeding of dogs with affected viscera, the failure to appropriately dispose of organs with cysts, allowing dogs to wander and potentially scavenge from carcasses and rubbish and a failure to regularly administer suitable anthelmintics to dogs [22,23]. The presence of cystic echinococcosis (CE) or other taeniid species indicate high environmental contamination with the causative parasites and an absence of measures to control infection [24]. Owned or free roaming dogs constitutes the most important factors for the transmission of these zoonotic tapeworms to humans.

Infection of dogs with tapeworm (*Echinococcus* spp.) is endemic in regions of Europe, Africa, South and North America, the Middle East, and Asia [25]. The annual incidence cases of CE in humans in the Middle Eastern countries of Iran, Iraq, and Turkey have been reported at 3.27, 4.6, 6.4 cases/100 000 inhabitants, respectively [26–28]. However, CE is a preventable disease through dog control, use of regular anthelmintic in canines and good public hygiene and can be treated through surgical interventions [29] and anthelmintic therapy resulting in case fatality rate of less than 2% [30].

Cystic echinococcosis results in a significant economic burden from human health costs and livestock production losses. The global economic burden due to cystic echinococcosis in humans and the livestock industry has been estimated to be up to US $ 4 billion annually [31]. To date, CE remains a neglected zoonosis disease although it demonstrates socioeconomic impacts chiefly among poor communities [32,33].

In this study, direct smears of faeces from stray and owned domesticated dogs in Basrah province of Iraq were examined to determine the prevalence of taeniid tapeworms. A questionnaire was also administered to

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dog-owners to assess their knowledge of CE and the management practices adopted which could increase the risk of parasite transmission.

2. Materials and methods

2.1. Study area

This study was performed in Basrah Province, south Iraq. The province has extremely hot weather during the summer, with a mean temperature of 37.4 °C and a maximum temperature of 45 °C. The lowest mean summer temperature is 29.2 °C. The annual humidity is less than 50% and remains below 30% during the daytime [34].

2.2. Study design, questionnaire survey and sampling of dogs

The study was performed from March to July 2016. Of 314 livestock owners who were surveyed to assess their knowledge, awareness and practices toward CE [35], 86 owned at least one dog (total of 122 dogs from 16 villages in the six districts of Abu Al-Kasib, Al-Midaina, Al-Qurnah, Al-Zubair, Shat Al−Arab, and Al-Basrah. A further questionnaire was administered to the 86 dog-owners and included questions on management practices adopted (whether the dog was restrained or not; administered anthelmintics; fed offal; and how faeces from the dogs were disposed of; and the age and sex of the dogs). The level of knowledge on hydatid disease/echinococcosis was evaluated based on the answers to six questions: have you heard of hydatid cysts?; how can the disease be transmitted to humans?; have you ever seen a lesion of hydatid cyst in slaughtered animals? (a respondent was shown pictures of infected liver and lungs); do you know if buffalo, cattle, sheep or goats can be infected with hydatid cysts?; are you aware it can be dangerous to eat raw vegetables contaminated with dog' faeces?; and do you know if acquiring hydatid cysts can be dangerous to the human health? Correct responses were allocated a value of 1 and incorrect/not-known answers given a value of 0. The results were then summed for the six questions for each respondent. Participants with a knowledge score greater than the median (4) were considered to have good knowledge, while those participants with a score $\leq$ the median were categorized as having poor knowledge.

The number of stool samples to collect to estimate the prevalence of taeniid infections was determined using an expected prevalence of 30%, a precision of 5% and 95% confidence level [36]. The sample size required based on these assumptions (323) was then increased to 335 to account for potential unsuitable samples.

Approximately 25−50 g of fresh faeces (n = 122) were collected directly from the ground where the owned dogs were fed, slept or housed. In addition, 213 fresh canine faecal samples of free-roaming dogs (FRD) were collected off the ground from areas where these dogs clustered within a radius of three kilometres of the 16 villages surveyed. To avoid the potential for duplicate samples from the same dog in a location, stool samples were inspected to ensure that no other samples of a similar consistency and color were collected from the location on days of sampling. All stool samples were collected using a sterile disposable wooden spatula and placed in a container and labelled with information about the owned domesticated dog (age, sex, owner name) or FRD location prior to sending on ice to the Parasitology Laboratory at the Veterinary College, Basrah University. Samples were examined by microscopy on the same day as submission to the laboratory. Ten thin and ten thick slides were prepared from each faecal sample and examined under light microscopy at 4X, 10X and 40X to identify eggs of taeniids. Taeniid eggs were identified based on their ovoid shape and the presence of oncospheres (hexacanth embryo) [37−39].

2.3. Ethical statement

The questionnaire surveys and faecal collection were approved by the Human Ethics Committee (034/2016) and Animal Ethics Committee (R2755/15), respectively at Murdoch University, Perth, Australia. Also, official written approval forms the Ministry of Agriculture in Iraq and from Basrah Veterinary Hospital were obtained before commencement of the field work.

2.4. Statistical analyses

Questionnaire data were entered into a spreadsheet (Microsoft Excel, 2013) and statistical analyses were undertaken using SPSS version 20. The test prevalence and 95% confidence intervals (95% CI) for parasitism with taeniids were calculated in the sampled domestic and stray dogs from the six sampled districts. Univariable analyses were initially performed using a Chi-square test to compare knowledge about CE with socio-demographic characteristics of the respondents and the management practices adopted. Odds ratios

Table 1
Test prevalence of eggs of taeniids identified from the faecal samples of owned domesticated and free-roaming dogs surveyed.

Category	Total number sampled	Test prevalence (95% CI)	Odds ratios (95% CI)	P-value
Free roaming dogs	213	10.8 (7.0, 15.8)	1.2 (0.57, 2.6)	0.6
Domestic dogs	122	9.0 (4.6, 15.6)	1.0	
Total	335	10.1 (7.1, 13.9)		

(OR) and their 95% CI were also calculated. Factors with a $P \leq 0.25$ in the univariable analyses were offered to a multivariable binary logistic regression model using a backward stepwise method. Variables were retained in the final logistic regression model if the likelihood ratio test was significant ($P \leq 0.05$). The goodness of fit of the final model for the data was assessed with the Hosmer and Lemeshow goodness-of-fit test [40].

3. Results

3.1. Estimation of the prevalence of taeniid tapeworm

Taeniid eggs were detected overall in 10.1% (95% CI 7.1, 13.9) of the 335 faecal samples examined (Table 1). The prevalence for the FRD (10.8%; 95% CI 7.0, 15.8) was comparable to that for domesticated dogs (9.0%; 95% CI 4.6, 15.6) ($P = 0.6$). There was also no significant difference in the prevalence between districts ($P = 0.42$).

3.2. Socio-demographic characteristics of dog owners

All 86 dog owners who participated in this study were males with a mean age of 45.6 years (SD: 12.1). Approximately one-quarter of the dog-owners (23.3%) had never received any formal education, and 50% had only attained a primary school level of education. Most dog owners worked solely as farmers (75.6%) with the remainder also working as public servants.

Table 2
Univariable analyses of the dog owner's knowledge of cystic echinococcosis and their socio-demographic characteristics and management practices adopted (n = 86).

Variable	Categorised knowledge		OR (95% CI)	P-value
	Good	Poor		
Age (years)				
≤ 30	25 (33.3)	50 (66.7)	0.88 (0.23, 3.27)	0.84
> 30	4 (36.4)	7 (63.6)	1.00	
Education level completed				
Secondary & Tertiary	13 (56.5)	10 (43.5)	3.82 (1.40, 10.39)	0.007
Primary school or never attended school	16 (25.4)	47 (74.6)	1.00	
Main occupation				
Farmer	22 (33.8)	43 (66.2)	1.02 (0.36, 2.90)	0.96
Public servant	7 (33.3)	14 (66.7)	1.00	
Do you feed your dog uncooked viscera or internal organs?				
Yes	20 (54.0)	17 (46.0)	5.23 (1.98, 13.79)	<0.001
No	9 (18.4)	40 (81.6)	1.00	
Have you treated your dog (s) with antiworming medicines?				
No	28 (33.7)	55 (66.3)	1.02 (0.09, 11.72)	0.98
Yes	1 (33.3)	2 (66.7)	1.00	
Do you ever keep your dog(s) tied up outside?				
Yes	13 (65.0)	7 (35.0)	5.8 (01.98, 17.05)	<0.001
No	16 (24.2)	50 (75.8)	1.0	
What do you usually do with the s tools/droppings of your dog(s)?				
Leave where they are.	27 (33.0)	55 (67.0)	1.0 (0.27, 15.25)	0.48
Dispose of them in water canal, nearby stream, a nearby agriculture field or bury them.	2 (50.0)	2 (50.0)	2.04	

Table 3
Multivariable logistic regression model of factors associated with the dog-owner respondent's knowledge on cystic echinococcosis.

Variable	β*	S.E.#	P-value	Odds ratios (95%CI)
Constant	0.802	0.55	0.15	–
Dog restrained/confined tied up	1.949	0.623	0.002	7.0 (2.07, 23.78)
Dog free roaming	–	–	–	1.0
Dog is fed offal	−1.751	0.572	0.002	0.17 (0.05, 0.53)
Dog not fed offal	–	–	–	1.0
Attained a secondary level of education or higher	1.677	0.599	0.005	5.35 (1.65, 17.31)
Had either only attended primary school or had never attended school	–	–	–	1.0

*correlation coefficient.
Standard Error.

3.3. *Influence of socio-demographic characteristics and dog management practices on knowledge of cystic echinococcosis*

The association between knowledge about CE by the dog owners and their socio-demographic characteristics and management practices adopted are summarised in Table 2. A respondent who had a secondary or higher level of education was more likely to have a better level of knowledge on CE than owners who had only attended primary school or had not received any formal schooling. Owners who fed offal to their dogs or who didn't restrain/confine their dogs had lower levels of knowledge (Table 2). In addition, the majority of dog owners 95.3% (82/86) reported that they did not pick up and dispose of their dog's faeces but left them where they were deposited.

In the final logistic regression model (Table 3), respondents who had at least attended secondary school or who restrained/confined their dogs were more knowledgeable of CE (OR = 5.4, 95% CI 1.7, 17.3; OR = 7.0, 95% CI 2.1, 23.8, respectively). In contrast, respondents who fed uncooked offal to their dogs had lower knowledge about CE (OR = 0.17, 95% CI 0.05, 0.53). The model represented a good fit for the data (Hosmer—Lemeshow goodness-of-fit test, p = 0.48).

3.4. *Identification of risk factors for detection of taeniid tapeworm in dogs*

There was no significant association between the presence taeniid eggs in the faecal samples and the management and husbandry practices adopted by the dog owners (all P values > 0.25 in the univariable analyses), and consequently, a multivariable logistic regression model was not produced.

4. Discussion

In this study, the overall prevalence of eggs of taeniid tapeworms in the sampled dogs was 10.1%. This was lower than the results of other canine faecal surveys conducted in Baghdad and Duhok province of Iraq, where eggs of *Taenia* and *Echinococcus* spp. were detected in 29.1 and 13.7%, respectively of stray dogs sampled [41—43]. A high prevalence of *Taenia* spp. (87%) was also observed in stray dogs from Kalar city of Sulaimani province (north governorate of Iraq) [44]. Studies conducted in other countries where taeniid tapeworms are endemic have also reported high prevalences: for example 34.4% in farm dogs from Xinghai county of Qinghai Province of China that attributed to neglect deworming dogs with praziquantel and lack of education programme to the dogs owners [45]; and 73.3% in domestic dogs from Ngorongoro (northern Tanzania) which are attributed to less awareness of the dog owners toward proper management and practices of their animals [46].

Taeniid eggs are spherical in shape, of between 25 and 45 μm in diameter, covered with a thick shell, brown in colour, and radially striated. Inside each egg is an oncosphere (or hexacanth embryo), containing three pairs of hooks [47]. However microscopic examination of canine stool samples has low reliability for identification of *Echinococcus* infection due to the similar morphology of all taeniid eggs [21,48]. Modern laboratory methods have been developed to differentiate the species of taeniids in dogs including antigen and DNA-based techniques. Copro-antigen ELISA and copro-DNA PCR are considered gold standard tests to detect *Echinococcus granulosus* and to discriminate them from other *Taenia* species carried by dogs [49–53]. It is recommended that future studies should use a PCR or ELISA to diagnose infections with *Echinococcus* to more accurately determine their real prevalence.

Management and husbandry practices of dog owners and their knowledge of CE were also assessed in the current study. Not surprisingly feeding uncooked offal and not restraining dogs were identified as risk factors for parasitism, as has been reported by others [54]. The logistic regression analysis for owner knowledge highlighted improved knowledge in dog owners who restrained or confined their dog(s) (OR = 7.0, 95% CI 2.1, 23.8). In contrast, those who fed offal were more likely to have a lower level of knowledge (OR = 0.17, 95% CI 0.05, 0.53). Similar findings have been reported elsewhere in Tanzania, Ethiopia and Uganda [55–58]. Ziadinov et al. [59], also observed that dogs which were restrained had a lower prevalence of *Echinococcus* (11%) compared with FRD (26%), most likely due to the latter population's potential for access to the larval stages presented in intermediate hosts.

In the present study, the respondents who had a secondary school or higher level of education (OR = 5.4, 95% CI 1.7, 17.3) had a better knowledge of CE than those who attended only primary school or who had never received any formal education. A similar recent study in Uganda demonstrated that a low knowledge level on CE was present in agro-pastoral and poorly educated people [57]. Similarly, a study conducted in Qinghai Province, China demonstrated that humans with alveolar echinococcosis were more likely to have a lower educational level compared to non-infected controls [60]. Such findings highlight the need for developing and implementing educational campaigns suitable for dog-owners in Basrah [35]. A key component of an educational campaign should be improving the knowledge of farmers and dog owners about CE and the parasite's life cycle. Confining/restraining, limiting access to offal and regular six-weekly administration of a suitable anthelmintic incorporating praziquantel are essential components for control of the parasite in dogs [61,62]. Control of the parasite in dogs will significantly reduce the risk of disease transmission to humans [63]. In La Rioja, Spain, a control programme, which included elimination of FRD, suitable disposal of offal from slaughtered sheep, disposal of dead sheep in pits, and treatment of domestic dogs with praziquantel at 45-day intervals, resulted in the prevalence of *E. granulosus* declining in dogs from 7.0% in 1987 to just 0.2% in 2000 [64].

In the current study, the majority of dog owners (95.3%) reported that they left the faeces of their dogs where they were deposited. Failure to remove and bury or dispose of dog faeces increases the risk of infection in humans and other livestock [65]. A similar finding was observed by Ref. [66] who reported that 95% of 353 pastoralists from South Sudan never disposed of their dog's faeces. Again, these findings highlight the need for a multi-pronged One Health approach to the diseases control with development and implementation of an educational campaign a key requirement for a successful outcome.

5. Conclusions

A relatively high (10.1%) prevalence of taeniid eggs was found in this study in the faeces of owned and FRD in Basrah. A low level of knowledge and awareness of CE by dog owners was found with few owners deworming their dogs, restraining them, or appropriately disposing of their dog's faeces. There is a need to improve awareness of dog owners about CE in Basrah through developing an educational programme which should include information on control of the FRD population, regular use of anthelmintics and restricting access of dogs to offal and carcasses.

Declaration of Competing Interest

The authors declared there is no conflict of interest.

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References

[1] I.D. Robertson, P.J. Irwin, A.J. Lymbery, R.C.A. Thompson, The role of companion animals in the emergence of parasitic zoonoses, Int. J. Parasitol. 30 (2000) 1369–1377, https://doi.org/10.1016/s0020-7519(00)00134-x.

[2] P. Deplazes, F. van Knapen, A. Schweiger, P.A.M. Overgaauw, Role of pet dogs and cats in the transmission of helminthic zoonoses in Europe, with a focus on echinococcosis and

toxocarosis, Vet. Parasitol. 182 (2011) 41–53, https://doi.org/10.1016/j.vetpar.2011.07.014.
[3] F.J. Martinez-Moreno, S. Hernandez, E. Lopez-Cobos, C. Becerra, I. Acosta, A. Martinez-Moreno, Estimation of canine intestinal parasites in Cordoba (Spain) and their risk to public health, Vet. Parasitol. 143 (2007) 7–13, https://doi.org/10.1016/j.vetpar.2006.08.004.
[4] A. Lavikainen, A Taxonomic Revision of the Taeniidae Ludwig, 1886 Based on Molecular Phylogenies, Department of Bacteriology and Immunology. Haartman Institute, Research Program Unit, Immunobiology Program. Academic dissertation, University of Helsinki, Nummela, Finland, 2014.
[5] L.M. Lee, R.S. Wallace, V.L. Clyde, A. Gendron-Fitzpatrick, S.D. Sibley, M. Stuchin, M. Lauck, D.H. O'Connor, M. Nakao, Definitive hosts of a fatal versteria species (cestoda: Taeniidae) in north America, emerg, Inf. Disp. 22 (2016) 707–771, https://doi.org/10.3201/eid2204.151446.
[6] I. Schneider-Crease, R.H. Griffin, M.A. Gomery, P. Dorny, J.C. Noh, S. Handali, H.M. Chastain, P.P. Wilkins, C.L. Nunn, N. Snyder-Mackler, J.C. Beehner, T.J. Bergman, Identifying wildlife reservoirs of neglected taeniid tapeworms: non-invasive diagnosis of endemic *Taenia serialis* infection in a wild primate population, PLoS Neglected Trop. Dis. 11 (2017) 1–18, https://doi.org/10.1371/journal.pntd.0005709.
[7] L. Chervy, The terminology of larval cestodes or metacestodes, Syst. Parasitol. 52 (2002) 1–33, https://doi.org/10.1023/a:1015086301717.
[8] A. D'Alessandro, R.L. Rausch, New aspects of neotropical polycystic (*Echinococcus vogeli*) and unicystic (*Echinococcus oligarthrus*) echinococcosis, Clin. Microbiol. Rev. 21 (2008) 380–401, https://doi.org/10.1128/CMR.00050-07.
[9] J.R. Lawson, M.A. Gemmel, Hydatidosis and cysticercosis: the dynamics of transmission, Adv. Parasitol. 22 (1983) 261–308, https://doi.org/10.1016/s0065-308x(08)60464-9.
[10] D. Trachsel, P. Deplazes, A. Mathis, Identification of taeniid eggs in the faeces from carnivores based on multiplex PCR using targets in mitochondrial DNAD, Parasitology 134 (2007) 911–920, https://doi.org/10.1017/S0031182007002235.
[11] R.C.A. Thompson, A. Lymbery, Biology and systematics of *Echinococcus*, in: R.C.A. Thompson, A.J. Lymbery (Eds.), *Echinococcus* and Hydatid Disease, CAB International, Wallingford, UK, 1995, pp. 1–150.
[12] P.R. Torgerson, J. Pilkington, F.M. Gulland, M.A. Gemmell, Further evidence for the long distance dispersal of taeniid eggs, Int. J. Parasitol. 25 (1995) 265–267, https://doi.org/10.1016/0020-7519(94)00094-5.
[13] J.D. Smyth, M.M. Smyth, Self insemination in *Echinococcus granulosus* in vivo, J. Helminthol. 43 (1969) 383–388, https://doi.org/10.1017/s0022149x00004946.
[14] G.S. Garrido, A.S. de Aluja, F.C. Casas, Early stages of development of the *Taenia solium* metacestodes in pigs, J. Parasitol. 93 (2007) 238-24, https://doi.org/10.1645/GE-968R1.1.
[15] G. Baneth, S.M. Thamsborg, D. Otranto, J. Guillot, R. Blaga, P. Deplazes, L. Solano-Gallego, Major parasitic zoonoses associated with dogs and cats in Europe, J. Comp. Pathol. 155 (2016) 54–74, https://doi.org/10.1016/j.jcpa.2015.10.179.
[16] W. Zhang, D.P. McManus, Recent advances in the immunology and diagnosis of echinococcosis, FEMS Immunol. Med. Microbiol. 47 (2006) 24-4, https://doi.org/10.1111/j.1574-695X.2006.00060.x.
[17] J. El-On, I. Shelef, E. Cagnano, B.M. T, *Taenia multiceps*: a rare human cestode infection in Israel, Vet. Ital. 44 (2008) 621–631.
[18] P. Moro, P.M. Schantz, Echinococcosis: a review, Int. J. Infect. Dis. 13 (2009) 125–133, https://doi.org/10.1016/j.ijid.2008.03.037.
[19] M.F. Abdulhameed, I. Habib, S.A. Al-Azizz, I. Robertson, Cystic echinococcosis in marketed offal of sheep in Basrah, Iraq: abattoir-based survey and a probabilistic model estimation of the direct economic losses due to hydatid cyst, Parasite. Epidemiol. Control. 3 (2018) 43–51, https://doi.org/10.1016/j.parepi.2018.02.002.
[20] J. Eckert, Predictive values and quality control of techniques for the diagnosis of *Echinococcus multilocularis* in definitive hosts, Acta Trop. 85 (2003) 157–163, https://doi.org/10.1016/s0001-706x(02)00216-4.
[21] T.S. Barnes, P. Deplazes, B. Gottstein, D.J. Jenkins, A. Mathis, M. Siles-Lucas, P.R. Torgerson, I. Ziadinov, D.D. Heath, Challenges for diagnosis and control of cystic hydatid disease, Acta Trop. 123 (2012) 1–7, https://doi.org/10.1016/j.actatropica.2012.02.066.
[22] P.L. Moro, A. Guevara, M. Verastegui, R.H. Gilman, H. Poma, B. Tapia, V.C.W. Tsang, H.H. Garcia, R. Pacheco, C. Lapel, E. Miranda, The cysticercosis working group in Peru (CWG), cysticercosis as a major cause of epilepsy in Peru, Lancet 341 (1993) 197–200, https://doi.org/10.1016/0140-6736(93)90064-N.
[23] M. Alishani, K. Sherifi, A. Rexhepi, A. Hamidi, M.T. Armua-Fernandez, F. Grimm, D. Hegglin, P. Deplazes, The impact of socio-cultural factors on transmission of *Taenia* spp. and *Echinococcus granulosus* in Kosovo, Parasitology 144 (2017) 1736–1742, https://doi.org/10.1017/S0031182017000750.
[24] J. Eckert, P. Deplazes, Biological, epidemiological, and clinical aspects of echinococcosis, a zoonosis of increasing concern, Clin. Microbiol. Rev. 17 (2004) 107–135, https://doi.org/10.1128/cmr.17.1.107-135.2004.
[25] P. Deplazes, L. Rinaldi, C.A. Alvarez Rojas, P.R. Torgerson, M.F. Harandi, T. Romig, D. Antolova, J.M. Schurer, S. Lahmar, G. Cringoli, J. Magambo, R.C. Thompson, E.J. Jenkins, Global distribution of alveolar and cystic echinococcosis, Adv. Parasitol. 95 (2017) 315–493, https://doi.org/10.1016/bs.apar.2016.11.001.
[26] U. Gonlugur, S. Ozcelik, T.E. Gonlugur, S. Arici, A. Celiksoz, S. Elagoz, R. Cevit, The retrospective annual surgical incidence of cystic echinococcosis in Sivas, Turkey, Zoonoses Public Health 56 (2009) 209–214, https://doi.org/10.1111/j.1863-2378.2008.01186.x.
[27] M.F. Abdulhameed, I. Habib, S.A. Al-Azizz, I. Robertson, A retrospective study of human cystic echinococcosis in Basrah province, Iraq, Acta Trop. 178 (2018) 130–133, https://doi.org/10.1016/j.actatropica.2017.11.011.
[28] M. Ebrahimipour, C.M. Budke, M. Najjari, R. Cassini, N. Asmarian, Bayesian spatial analysis of the surgical incidence rate of human cystic echinococcosis in north-eastern Iran, Acta Trop. 163 (2016) 80–86, https://doi.org/10.1016/j.actatropica.2016.08.003.
[29] V. Velasco-Tirado, M. Alonso-Sardon, A. Lopez-Bernus, A. Romero-Alegria, F.J. Burguillo, A. Muro, A. Carpio-Perez, J.L. Munoz Bellido, J. Pardo-Lledias, M. Cordero, M. Belhassen-Garcia, Medical treatment of cystic echinococcosis: systematic review and meta-analysis, BMC Infect. Dis. 18 (2018) 1–19, https://doi.org/10.1007/s40588-018-0091-0.

[30] P.R. Torgerson, B. Devleesschauwer, N. Praet, N. Speybroeck, A.L. Willingham, F. Kasuga, M.B. Rokni, X.N. Zhou, E.M. Fèvre, B. Sripa, N. Gargouri, T. Fürst, C.M. Budke, H. Carabin, M.D. Kirk, F.J. Angulo, A. Havelaar, N. de Silva, World health organization estimates of the global and regional disease burden of 11 foodborne parasitic diseases, 2010: a data synthesis, PLoS, Med. Plus 12 (2015), e1001920, https://doi.org/10.1371/journal.pmed.1001920.

[31] C.M. Budke, P. Deplazes, P.R. Torgerson, Global socioeconomic impact of cystic echinococcosis, Emerg. Infect. Dis. 12 (2006) 296—303, https://doi.org/10.3201/eid1202.050499.

[32] B. Otero-Abad, P.R. Torgerson, A systematic review of the epidemiology of echinococcosis in domestic and wild animals, PLoS Neglected Trop. Dis. 7 (2013) e2249, https://doi.org/10.1371/journal.pntd.0002249.

[33] A. Khan, K. Naz, H. Ahmed, S. Simsek, M.S. Afzal, W. Haider, S.S. Ahmad, S. Farrakh, W. Weiping, G. Yayi, Knowledge, attitudes and practices related to cystic echinococcosis endemicity in Pakistan, Infect. Dis. Poverty. 7 (2018) 1—15, https://doi.org/10.1186/s40249-017-0383-2.

[34] A.S. Hadeel, M.T. Jabbar, C. Xiaoling, Remote sensing and GIS application in the detection of environmental degradation indicators, Geo Spatial Inf. Sci. 14 (2011) 39—47, https://doi.org/10.1007/s11806-011-0441-z.

[35] M.F. Abdulhameed, I. Habib, S.A. Al-Azizz, I. Robertson, Knowledge, awareness and practices regarding cystic echinococcosis among livestock farmers in Basrah province, Iraq, Vet. Sci. 5 (2018) 1—10, https://doi.org/10.3390/vetsci5010017.

[36] R.M. Cannon, R.T. Roe, Livestock Disease Surveys- a Field Manual for Veterinarians, Bureau of Rural Science, Department of Primary Industry. Australian Government Publishing Service, Canberra, 1982.

[37] A. Jabbar, Z. Swiderski, D. Mlocicki, I. Beveridge, M.W. Lightowlers, The ultrastructure of taeniid cestode oncospheres and localization of host-protective antigens, Parasitology 137 (2010) 521—535, https://doi.org/10.1017/s0031182009991260.

[38] M. Sirois, Laboratory Procedures for Veterinary Technicians, sixth ed., Elsevier, St. Louis, Missouri, 2015.

[39] J.A. Lackenby, Immunological Studies on the Protective Immune Response against Taeniid Cestode Parasites, Faculty of Veterinary and Agricultural Science, The University of Melbourne, Australia, Melbourne, 2017.

[40] D. Hosmer, S. Lemeshow, Applied Logistic Regression, second ed., John Wiley and Sons Inc, London, 2000.

[41] R.H. Hasson, Stray dogs internal parasites from baquba city , diyala province, Iraq, J. Nat. Sci. Res. 4 (2014) 75—80.

[42] A.M. Hadi, A.A. Faraj, Prevalence of gastrointestinal helminthes and Protozoa among stray dogs in Baghdad, Iraqi, J. Vet. Med. 1 (2015) 1—4.

[43] T.A. Muhamed, L.T.O. Al-barwary, Prevalence of intestinal parasites in the intestine of dogs (Sheep-Keeper, owned, pet and stray) in Duhok province, kurdistan region, J. Vet. Sci. Technol. 7 (2016) 2—4, https://doi.org/10.4172/2157-7579.1000379.

[44] M.M.M. Bajalan, Prevalence of intestinal helminths in stray dogs of Kalar city/Sulaimani province, Iraqi, J. Vet. Med. 34 (2010) 151—157.

[45] Z. Guo, W. Li, M. Peng, H. Duo, X. Shen, Y. Fu, T. Irie, T. Gan, Y. Kirino, T. Nasu, Y. Horii, Epidemiological study and control trial of taeniid cestode infection in farm dogs in Qinghai province, China, J. Vet. Med. Sci. 76 (2014) 395—400, https://doi.org/10.1292/jvms.13-0504.

[46] E.S. Swai, M. Miran, B. Kasuku, A.A. Nzalawahe, Taeniasis in non-descript dogs in Ngorongoro, Tanzania: prevalence and predisposing factors, Onderstepoort, J. Vet. Res. 83 (2016) 1—6, https://doi.org/10.4102/ojvr.v83i1.1013.

[47] Cysticercosis OIE, Terrestrial Manual, 2014, pp. 1—11. https://www.oie.int/fileadmin/Home/eng/Health_standards/tahm/2.09.05_CYSTICERCOSIS.pdf.

[48] P. Deplazes, A. Dinkel, A. Mathis, Molecular tools for studies on the transmission biology of *Echinococcus multilocularis*, Parasitology 127 (2003) S53—S61, https://doi.org/10.1017/s0031182003003500.

[49] J.C. Allan, P.S. Craig, Coproantigens in taeniasis and echinococcosis, Parasitol. Int. 55 (2006) S75—S80, https://doi.org/10.1016/j.parint.2005.11.010.

[50] Y. Huang, W. Yang, J. Qiu, X. Chen, Y. Yang, D. Qiu, N. Xiao, Y. Xiao, D. Heath, A modified coproantigen test used for surveillance of *Echinococcus* spp. in Tibetan dogs, Vet. Parasitol. 149 (2007) 229—238, https://doi.org/10.1016/j.vetpar.2007.08.026.

[51] A. Villeneuve, L. Polley, E. Jenkins, J. Schurer, J. Gilleard, S. Kutz, G. Conboy, D. Benoit, W. Seewald, F. Gagné, Parasite prevalence in fecal samples from shelter dogs and cats across the Canadian provinces, Parasites Vectors 8 (2015) 1—10, https://doi.org/10.1186/s13071-015-0870-x.

[52] R. Chaâbane-Banaoues, M. Oudni-M'rad, J. Cabaret, S. M'rad, H. Mezhoud, H. Babba, Infection of dogs with *Echinococcus granulosus*: causes and consequences in an hyperendemic area, Parasites Vectors 8 (2015) 1—9, https://doi.org/10.1186/s13071-015-0832-3.

[53] I. Buishi, A. Fares, M. Hosni, Coprological survey of *Echinococcus granulosus* and management in owned dogs of southern Tripoli, Libyan J. Vet. Med. Sci. 1 (2015) 1—4.

[54] P. Craig, A. Mastin, F. van Kesteren, B. Boufana, *Echinococcus granulosus*: epidemiology and state-of-the-art of diagnostics in animals, Vet. Parasitol. 213 (2015) 132—148, https://doi.org/10.1016/j.vetpar.2015.07.028.

[55] E. Ernest, H.E. Nonga, A.A. Kassuku, R.R. Kazwala, Hydatidosis of slaughtered animals in Ngorongoro district of Arusha region, Tanzania, Trop. Anim. Health Prod. 41 (2009) 1179—1185, https://doi.org/10.1007/s11250-008-9298-z.

[56] L. Nyakarahuka, Knowledge, Attitude and Practices towards Cystic Echinococcosis in Pastoral Communities in Kasese District, Uganda, Public Health, Makerere University, Uganda, 2011.

[57] L. Omadang, M. Chamai, E. Othieno, A. Okwi, F.O. Inangolet, F. Ejobi, P. Oba, M. Ocaido, Knowledge, attitudes and practices towards cystic echinococcosis in livestock among selected pastoral and agro-pastoral communities in Uganda, Trop. Anim. Health Prod. 50 (2018) 11—17, 10.1186%2Fs40249-017-0383-2.

[58] D. Gebremichael, A. Feleke, G. Tesfamaryam, H. Awel, Y. Tsigab, Knowledge, attitude and practices of hydatidosis in pastoral community with relation to public health risks in ayssaita, northeastern of Ethiopia, Global Vet. 11 (2013) 272—279, https://doi.org/10.5829/idosi.gv.2013.11.3.7570.

[59] I. Ziadinov, A. Mathisa, D. Trachsela, A. Rysmukhambetovac, T.A. Abdyjaparovd, O.T. Kuttubaevd, P. Deplazesa, P.R. Torgersona, Canine echinococcosis in Kyrgyzstan: using prevalence data adjusted for measurement error to develop

transmission dynamics models, Int. J. Parasitol. 38 (2008) 1179–1190, https://doi.org/10.1016/j.ijpara.2008.01.009.

[60] P.M. Schantz, H. Wang, J. Qiu, F.J. Liu, E. Saito, A. Emshoff, A. Ito, J.M. Roberts, C. Delker, Echinococcosis on the Tibetan Plateau: prevalence and risk factors for cystic and alveolar echinococcosis in Tibetan populations in Qinghai Province, China, Parasitology 127 (2003) 109–120.

[61] P.R. Torgerson, D.D. Heath, Transmission dynamics and control options for *Echinococcus granulosus*, Parasitology 127 (2003) 143–158, https://doi.org/10.1017/s0031182003003810.

[62] P.S. Craig, D. Hegglin, M.W. Lightowlers, P.R. Torgerson, Q. Wang, Echinococcosis: control and prevention, Adv. Parasitol. 96 (2017) 55–158, https://doi.org/10.1016/bs.apar.2016.09.002.

[63] P.L. Moro, P.M. Schantz, Echinococcosis: historical landmarks and progress in research and control, Ann. Trop. Med. Parasitol. 100 (2006) 703–714, https://doi.org/10.1179/136485906X112257.

[64] S. Jiménez, A. Pérez, H. Gil, P.M. Schantz, E. Ramalle, R.A. Juste, Progress in control of cystic echinococcosis in La Rioja, Spain: decline in infection prevalences in human and animal hosts and economic costs and benefits, Acta Trop. 83 (2002) 213–221, https://doi.org/10.1016/s0001-706x(02)00091-8.

[65] M.M. Reyes, C.P. Taramona, M. Saire-Mendoza, C.M. Gavidia, E. Barron, B. Boufana, P.S. Craig, L. Tello, H.H. Garcia, S.J. Santivanez, Human and canine echinococcosis infection in informal, unlicensed abattoirs in Lima, Peru, PLoS Neglected Trop. Dis. 6 (2012) 1–6, https://doi.org/10.1371/journal.pntd.0001462.

[66] S. Wumbiya, M. Francis, E. Wilfred, G. Nasinyama, S. Eystein, M. Adrian, M. Munyeme, M. Clare, N. Daisy, M. Bernadette, A. Jubara, B. James, W. Mwansinga, Knowledge attitude and practices towards cystic echinococcosis among pastoral communities in greater kapoeta south Sudan, J. Vet. Med. Res. 4 (2017) 2–11.