FUDMA Journal of Sciences (FJS)
ISSN online: 2616-1370
ISSN print: 2645 - 2944
Vol. 10 No. 11, June, 2026, pp 150 – 154
DOI: https://doi.org/10.33003/fjs-2026-1011-5516

Seroprevalence and Influences of *Echinococcus granulosus infection* among owned dogs in Lokoja, Kogi State, Nigeria

[1]Ngwamah, Jacob Sule, [2]Barguma, Simon Wilson, [4]Mathias, An'aaticha, [1]Shitta, Kefas. Babale, [3]Suleiman, Mohammed Nusirudeen, [1]AboveGodwin, O. Grace and [1]Atawodi, Joy Cecilia

[1]Department of Zoology, Faculty of Life Sciences Federal University Lokoja, Kogi State, Nigeria
[2]Department of Statistics, Faculty of Natural Sciences, Federal University Lokoja, Kogi State, Nigeria
[3]Department of Botany, Faculty of Life Sciences, Federal University Lokoja, Kogi State, Nigeria
[4]Department of Zoology, Faculty of Science, Adamawa State University, Mubi

*Corresponding authors' email: sngwamah@gmail.com Phone: +2348034546316

ABSTRACT

Human beings acquire cystic echinococcosis via fortuitous ingestion of *Echinococcus granulosus* (*EG*) eggs introduced into the surrounding by infected dogs. This research aimed to find out the presence of *EG* antibodies and the influencing factors responsible for their prevalence in owned dogs in Lokoja, Kogi State, Nigeria. Serum was extracted from the whole blood collected from 225 dogs within Lokoja metropolis were analyzed by indirect ELISA. The data on the demography, environmental factors and management of the dogs was obtained through a questionnaire administered to owners. Data were analyzed using descriptive statistics, univariate analysis, and logistic regression at α 0.05. The seroprevalence of *Echinococcus granulosus* infection was found to be 16.44% (37/225). Significant risk factors associated with seropositivity included poor educational background of dog owners [Odd Ratio (OR): 2.87; 95% CI: 1.44–5.99], native dog breeds (OR: 4.17; 95% CI: 1.96–6.72), range management system (OR: 1.37; 95% CI: 0.17–2.80), and deworming status, with dogs that were either inadequately dewormed or never dewormed showing increased risk (OR: 1.29; 95% CI: 1.13–2.64). Our findings indicate that local breeds generally receive less care compared to exotic breeds, and the absence of proper deworming practices constitutes a major driver of transmission. These factors may serve as predictors of *E. granulosus* seropositivity in the study area. Our study provides evidence of *E.gronulosus* infection in owned dogs, especially in those medicated by owners. Deworming practices should be based on the recommendations of a veterinarian to effectively prevent **EG** transmission from dogs to humans.

Received: 12 June 2026
Accepted: 25 June 2026
Published: 13 July 2026

Keywords: *Echinococcus granulosus sensu lato*, Seroprevalence, Dogs, Nigeria

INTRODUCTION

Cystic echinococcosis (CE), caused by the larval stage of the dog tapeworm Echinococcus granulosus sensu lato (EG), is one of the world's most widespread parasitic zoonoses (Acosta et al., 2014). It is a cosmopolitan disease characterized by a high incidence in some parts of Nigeria, that includes Lagos, Jos, Port Harcourt and Adamawa State. *Echinococcus granulosus* remains a major neglected public health issue on a worldwide scale, recently it has manifested in so many states globally due to its increasing host range and as pets worldwide [Pal and Dutta 2013]. It is highly endemic in Africa, Asia, and South America (Romig). The incidence of echinococcosis in South part of the Country Nigeria in 2015 was 12.5% (Adediran *et al*., 2014). Echinococcosis infection causes a serious financial cost due to human health costs and livestock production losses [WHO, 2021]. The disease infection is usually maintained among dog's and domestic ungulate (such as sheep, goat), more especially in rural areas where free range of livestock farming systen is high and where human feeding their dogs with offal and carcass is a normal practice [Rojo-Vazquez, 2011; WHO (2010] *Echinococcus granulosus* life cycle involves definitive hosts (dogs) and herbivours as intermediate hosts. Humans are accidental hosts where they acquire the infection through ingestion of the infective stage through consumption of the vegetables and water contaminated by eggs released by definitive host [WHO, 2021]. Dogs play a vital role in spreading *E. granulosus* to humans. Dogs become infected through ingestion of infected viscera of intermediate hosts (sheep; goat) that has the larval form of *E. granulosus*, through eating ungulate carcasses and fresh viscera supplied to them by owner [WHO, 2010]. Owing to complex life cycle and long time between infection and clinical symptom manifestation in man, precise examination of the risk factors for human infection can be difficult. Although, the examination of risk factors for intermediate host infections can give important details on the possible transmission to man and resultant public health problems [Mastin *et al*., 2015]. These possibilities could be innate, that is, elements related to the canine, such as breed, sex, age, and origination, or extraneous factors, which comprise of management practices by the owners and surrounding factors. Even though, *E. granulosus* infections in canines are symptom free, so many indicative devices are accessible. Detection of the antibodies in dog serum gives helpful proof for the monitoring of echinococcosis prevalence in specific areas (Acosta-Jamett *et al*., 2014; WHO, 2021)].

A good understanding of the incidence of echinococcosis in dogs is an important tool in reducing its transmission to man and is the root for crafting a successful supervision program for the echinococcosis (WHO, 2021). Although, a few studies have been carrying out in north central Nigeria to explain the risk factors for echinococcosis in dogs which possibly remain at the prominent risk of infection in man. Observation of parasitic infections in animals is vital for decreasing the prevalence of human infection (Otero-Abad and Torgerson,2013). A few documentations are available in relation to the intrinsic and extrinsic components related with echinococcosis seropositivity in dogs found within north central, Nigerian. Hence, this study focused on evaluating the signs of *E. granulosus* seropositivity in dogs in Lokoja Kogi State.

MATERIALS AND METHODS

Study Area

This study employed a cross-sectional design conducted between March 2025 and January 2026. The research was carried out in Lokoja, the capital city of Kogi State, located in North Central Nigeria. Lokoja lies at the confluence of the Niger and Benue rivers. The city is situated at latitude 7°47′48″ N and longitude 6°44′25″ E, with an elevation of 166 meters (545 feet) above sea level. Indigenous groups in Lokoja include the Bassa Nge, Yoruba (primarily Oworo), and Nupe. In addition, several other ethnic groups such as the Kupa-Nupe, Hausa, Ebira, Igala, Igbo, Bini/Edo, and Tiv have more recently established communities in the area. The dog population in Lokoja was estimated at 1,127 [Pal and Dutta 2013], with approximately one dog per household and an average of eight humans per household [Pereira, 2021]. The Lokoja metropolitan area comprises two Local Government Areas (LGAs): Lokoja and Ajaokuta. Six locations within the study area were surveyed: 200 Unit, Adankolo, Zangon Daji, Crusher, and Ganaja Village.

Study Dogs

A total of 225 blood samples were collected from dogs within the study area. The sampling included dogs of varying ages, breeds, and sexes. Owners that did not provide consent, as well as those unavailable at the time of collection, were excluded from participation.

Sample Size

The sample size was determined using Thrusfield's survey formula [Romig, *et al*., 2011], based on a seroprevalence of 12.45% reported in a previous study (Adediran *et al*., 2014). A reliability coefficient of 1.96 at a 95% confidence level, a precision of 5%, and a 10% non-response rate yielded a total of 225 dogs. The study was conducted in two Local Government Areas (LGAs) of Lokoja: Ajaokuta and Lokoja. These LGAs were selected due to the presence of veterinary clinics and hospitals within their boundaries. Dogs were sampled using a total sampling technique across clinics, hospitals, and community settings until the required sample size was achieved.

Data Collection

A pre-tested structured questionnaire was administered to gather information on dog owners' sociodemographic characteristics, dog demographics, and management practices, including contact with other dogs, confinement, deworming, fecal disposal methods, and environmental variables such as the presence of an abattoir in the vicinity. Informed verbal consent was obtained from all participants, and confidentiality of responses was ensured.

Sample Collection

Blood samples (5 mL) were collected via cephalic venipuncture and transferred into plain specimen vials. Samples were transported to the departmental laboratory in insulated containers with ice packs. Following clot retraction, samples were centrifuged at 1,500 g for 5 minutes to obtain serum, which was subsequently refrigerated until analysis.

Serological Analysis

Serum samples were screened for *Echinococcus granulosus* antibodies using an indirect enzyme-linked immunosorbent assay (ELISA). A qualitative commercial kit (Canine *Echinococcus granulosus* ELISA Kit, Shenzhen Biobase Biotechnology Co., Ltd., China) was employed, and procedures were conducted in accordance with the manufacturer's instructions.

RESULTS AND DISCUSSION

The questionnaire results revealed notable variation in the educational levels of the 225 dog owners surveyed. The largest proportion (39.56%) held secondary qualifications, making this group the most represented [table, 1]. Female dog owners accounted for 64.22% of respondents, compared to 35.11% male. Feeding practices also varied: 52.00% provided their dogs with well-prepared (cooked) meat, 30.22% offered offal, and 17.00% allowed their pets to scavenge from available sources. Among the 225 sampled dogs, 31.11% were foreign breeds, while the majority were local. Of these, 59 were male and 38.22% were female.

The overall seroprevalence of *Echinococcus granulosus* among the screened dogs was 16.44% (37/225), with further disaggregation shown in Table 2. Indigenous breeds of dogs were more than three times as likely to be seropositive [33 (18.86%)] compared to exotic breeds (8.00%). The results also indicate a higher seroprevalence in dogs owned by individuals with no formal education (42.86%), followed by those with primary education (22.22%). Marital status of the dog owners and the sex of the dogs showed no significant association with *E. granulosus* seroprevalence. Dogs younger than 2 years (24.28%) accounted for more than three quarter of the overall prevalence as compared to the older dogs (8.04). In the univariate analysis (Table 2), dogs that had never been dewormed (24.30%) showed a higher seropositive rate compared to those dewormed every six months (9.32%). Dogs that were served fresh meat (47.69%) showed a higher seropositivity rate compared to those served well-cooked meat (2.50%). The results indicated a higher prevalence among unconfined dogs compared to confined ones. There was also a significant difference based on the reasons dogs were kept by their owners: hunting dogs showed the highest seroprevalence (23.08%), followed by pet dogs (6.52%) and security dogs (5.83%).

Table 1: Demographic Variables of Respondents and their Dogs in Lokoja, 2025/2026 (N = 225)

Characteristics	N(%)
Educational Level	
No formal	14(6.22%)
Primary	63(28.00%)
Secondary	89(39.56%)
Tertiary	59(26.22%)

Characteristics	**N(%)**
Gender	
Male	79(35.11%)
Female	146(64.89%)
Reason for dog keeping	
Security	102(45.33%)
Hunting	60(26.66%)
Pet	43(19.11%)
Breeding	20(8.89%)
Mode of feeding	
Offal feeding	68(30.22)
Scavenging	40(17.78%)
Properly prepared meat	117(52.00%)
Breed	
Local	70(31.11%)
Exotic	155(68.89%)
Sex of dog owned	
Male	134(59.59%)
Female	86(38.22%)
Age of dog owned	
>2years	113(50.22%)
< 2years	112(49.77%)

Table 2: Factors Associated with Echinococcus Granulosus Seropositivity among owned Dogs in Lokoja, 2025 (n = 225)

Variables	**Positive (%)**	**Negative (%)**	**OR (95% CI)**	**p value**
Educational level				
No formal	6 (42.86)	8 (57.14)	2.87 (1.44, 5.99)	0.01*
Primary	14 (22.22)	49 (77.78)		
Secondary	12(13.48)	75(84.27)		
Tertiary	5(8.47)	54(91.53)		
Marital Status				
Single	17 (21.52)	62 (78.48)	1.72 (0.90, 3.29)	0.14
Married	20(13.70)	126(86.30)		
Age of dogs				
>2	28(24.28)	95(75.22)	1.41 (0.76, 2.61)	0.35*
>2	9 (8.04)	103(91.96)		
Confined				
No	30(18.75)	130(81.25)	1.37 (0.17, 2.80)	0.02*
Yes	7(10.77)	58 (89.23)		
Dog dewormed				
Yes	11 (9.32)	107(90.68)	1.29 (1.13, 2.64)	0.003*
No	26(24.30)	81(75.70)		
Eat raw meat				
Yes	31 (47.69)	34 (52.31)	1.26 (0.39, 4.03)	0.93*
No	4(2.50)	156 (97.50)		
Purpose of keeping				
Hunting	15 (23.08)	50(76.92)	3.19 (1.15, 8.84)	0.04*
Security	6 (5.83)	59(90.77)		
Breeding	2(4.08)	47(95.18)		
Pet	3(6.52)	43(93.48)		
Type of dog owned				
Local	33 (18.86)	142(81.14)	4.17 (1.96, 6.72)	< 0.001*
Exotic	4 (8.00)	46 (92.00)		
Sex of dog owned				
Male	16 (15.53)	87(84.47)	0.86 (0.47, 1.59)	0.75

Variables	Positive (%)	Negative (%)	OR (95% CI)	p value
Female	21(17.21)	101 (82.79)		

OR(95% CL) Means Odd Ratio at 95% confidence Level/interval

Discussion

The present study revealed higher seroprevalence of *Echinococcus granulosus* (EG) in dogs in Lokoja. Even though it is lower than the report from Lagos and Adamawa, where different diagnostic approaches—sedimentation and counting technique (SCT) and coproantigen ELISA—were employed respectively. Several diagnostic methods exist for detecting *Echinococcus* in definitive hosts. SCT is widely regarded as the reference standard for diagnosing *E. multilocularis* in definitive hosts due to its high sensitivity and very high specificity. Its major advantage lies in the ability to determine the exact intestinal worm burden during necropsy. However, SCT is impractical for large-scale epidemiological surveys. In contrast, coproantigen ELISA detects *E. granulosus* antigens in the feces of infected dogs and is more suitable for mass screening. Nevertheless, its positive predictive value may be compromised in regions with low *Echinococcus* prevalence, limiting its reliability under such conditions.

The finding of this study align with previous reports that documented lower seroprevalence values in South West, Nigeria (Adediran *et al*., 2014). Similarly, in Uganda, studies conducted in Moroto and Bukedea districts also reported lower prevalence of *Echinococcus granulosus* infection in dogs, though Zhan *et al*. 2023] employed microscopy followed by PCR confirmation of taeniid eggs. The seroprevalence observed in our study area indicates that *E. granulosus* infection has reached endemic levels among the dog population. High infection rates in dogs pose a considerable public health risk, particularly in Nigeria, where no official echinococcosis control program exists (Deplazes, *et al*., 2011).

Sex of the dogs showed no significance difference to seropositivity of *E. granulosus.* The slightly higher prevalence in females (17.21%) compared males'(15.53%) counterpart may be explained by their compromised immunity during gestation period and breast feeding (Pereira *et al*., 2021), who also reported no significant association between sex and prevalence in South West Nigeria and North West China, respectively. The slightly higher prevalence in males may be explained by their tendency to roam more widely due to territorial and hunting behaviors, as suggested by Budke *et al*., 2005.

Dogs younger than 2 years accounted for nearly one-quarter of the seroprevalence in this category, which was substantially higher than that observed in older dogs. This finding aligns with studies reporting higher prevalence in younger dogs compared to adults (26–30 months), as noted by Adebudo *et al*. (2023) and Mathias *et al*. (2023) in separate studies conducted in Ibadan and Adamawa State, respectively. The difference may be attributed to repeated antigen exposure and the development of stronger protective immunity (Zhang *et al*., 2015). However, our findings-consistent with Buishi *et al*. (2006) reported a positive association between younger dogs and *Echinococcus granulosus* infection in Turkana District, Kenya. In contrast, Adediran *et al*. (2014) that showed no significant association between age and seropositivity.

Breed differences were notable: indigenous dogs were approximately four times more likely to be seropositive compared to exotic breeds, echoing the findings of Adediran *et al*. (Adediran *et al*., 2014). This disparity likely reflects differences in owner attitudes and care, as exotic breeds are often regarded as status symbols and therefore receive greater attention and protection, while local breeds are considered less valuable.

Studies conducted in Nigeria indicate that the prevalence of *Echinococcus granulosus* in dogs is strongly influenced by their role, management system (confined vs. free-range), and access to raw animal offal. In this study, dogs kept solely for hunting showed a significantly higher prevalence compared to pet dogs and those kept for other purposes. However, this finding contrasts with the report of Awosanya *et al*. (2021), that observed a higher prevalence in security dogs than in hunting dogs.

Furthermore, as already suggested by Liu *et al*., 2018, the tendency to under feed the dog's due poverty level or provide them with poor diet quality food, encourages their predatory behaviors that increases the risk of acquiring *Echinococcus* infection. In this respect, rodents have been assumed to play a role in the transmission of *E. granulosus* acting as intermediate hosts preyed by not properly fed dogs and also as a result of poor feeding, many of the dogs are forced to scavenge on carcass and offal's contaminated with *E. granulosus.* Several authors reported similar findings in north Africa, especially in urban and suburban areas (Ohiolei *et al*., 2020; Abdel-Moein, 2016).

CONCLUSION

The present study revealed that a substantial proportion of dogs in the Lokoja area have been exposed to *Echinococcus granulosus*, thereby posing a significant risk of transmission to humans. Factors contributing to the persistence of the parasite cycle were identified, particularly among local dog breeds that often receive no anthelmintic treatment from their owners. Most of the dogs included in the study were free-ranging, which increases their exposure to risk factors and contributes to the high transmission rate observed in the area. To address this, mass education is essential to inform dog owners about the benefits of proper deworming, feeding, and general management practices. The importance of seeking professional veterinary guidance for effective deworming protocols cannot be overstated, as such measures are critical in reducing the risk of *E. granulosus* and other zoonotic parasites spreading to humans.

REFERENCE

Abdel-Moein, K. A., Hamza, D. A. (2016). Norway rat (*Rattus norvegicus*) as a potential reservoir for *Echinococcus granulosus*: A public health implication. *Acta Parasitologica, 61*(4), 815–819. https://doi.org/10.1515/ap-2016-0110

Acosta-Jamett, G., Weitzel, T., Boufana, B., Adones, C., Bahamonde, A., Abarca, K., Craig, P. S., & Reiter-Owona, I. (2014). Prevalence and risk factors for echinococcal infection in a rural area of northern Chile: A household-based cross-sectional study. *PLoS Neglected Tropical Diseases,* *8*(6), e3090. https://doi.org/10.1371/journal.pntd.0003090 (doi.org in Bing).

Adebudo, L. I., Ndiaye, S., Ajayi, I., Olugasa, B. O., Bonelli, P., & Awosanya, E. J. (2023). Seroprevalence and determinants of *Echinococcus granulosus* sensu lato infection among owned dogs in Ibadan, Nigeria. *Journal of Infection in*

Developing Countries, *17*(12), 1814–1820. https://doi.org/10.3855/jidc.18518

Adediran, O. A., Kolapo, T. U., & Uwalaka, E. C. (2014). *Echinococcus granulosus* prevalence in dogs in southwest Nigeria. *Journal of Parasitological Research, 2014*, Article 124358. https://doi.org/10.1155/2014/124358

Awosanya, E. J., Ligali, Z., Duedu, K. O., Peruzzu, A., Masala, G., & Bonelli, P. (2021). Prevalence of *Echinococcus granulosus* sensu lato in owned dogs in Lagos State, Nigeria. *Veterinary Sciences*, *8*(6), 101. https://doi.org/10.3390/vetsci8060101.

Budke, C. M., Deplazes, P., & Torgerson, P. R. (2006). Global socioeconomic impact of cystic echinococcosis. *Emerging Infectious Diseases*, *12*(2), 296–303. https://doi.org/10.3201/eid1202.050499

Budke, C. M., Campos-Ponce, M., Qian, W., & Torgerson, P. R. (2005). A canine purgation study and risk factor analysis for echinococcosis in a high endemic region of the Tibetan plateau. *Veterinary Parasitology*, *127*(1), 43–49. https://doi.org/10.1016/j.vetpar.2004.08.024

Deplazes, P., van Knapen, F., Schweiger, A., & Overgaauw, P. A. M. (2011). Role of pet dogs and cats in the transmission of helminthic zoonoses in Europe, with a focus on echinococcosis and toxocarosis. *Veterinary Parasitology*, *182*(1), 41–53. https://doi.org/10.1016/j.vetpar.2011.07.014

Hambolu, S. E., Dzikwi, A. A., Kwaga, J. K., Kazeem, H. M., Umoh, J. U., & Hambolu, D. A. (2014). Dog ecology and population studies in Lagos State, Nigeria. *Global Journal of Health Science*, *6*(2), 209–220. https://doi.org/10.5539/gjhs.v6n2p209 (doi.org in Bing)

Liu, C. N., Xu, Y. Y., Cadavid-Restrepo, A. M., Lou, Z. Z., Yan, H. B., Li, L., Fu, B., Gray, D. J., Clements, A. A., Barnes, T. S., & Jia, W. Z. (2018). Estimating the prevalence of *Echinococcus granulosus* in domestic dogs in highly endemic areas for echinococcosis. *Infectious Diseases of Poverty*, *7*(1), 77. https://doi.org/10.1186/s40249-018-0462-0 (doi.org in Bing)

Mastin, A., Van Kesteren, F., Torgerson, P. R., Ziadinov, I., Mytynova, B., Rogan, M. T., Tursunov, T., & Craig, P. S. (2015). Risk factors for *Echinococcus* coproantigen positivity in dogs from the Alay Valley, Kyrgyzstan. *Journal of Helminthology*, *89*(6), 655–663. https://doi.org/10.1017/S0022149X15000590

Ohiolei, J. A., Li, L., Ebhodaghe, F., Yan, H. B., Isaac, C., Bo, X. W., Fu, B., & Jia, W. Z. (2020). Prevalence and distribution of *Echinococcus* spp. in wild and domestic animals across Africa: A systematic review and meta-analysis. *Transboundary and Emerging Diseases*, *67*(6), 2345–2364. https://doi.org/10.1111/tbed.13592

Oluwaseyi, O. (2014). *Classification of Ibadan as a city region*. Academia.edu. https://www.academia.edu/7911033/Classification_of_Ibadan_As_A_City_Region

Otero-Abad, B., & Torgerson, P. R. (2013). A systematic review of the epidemiology of echinococcosis in domestic and wild animals. *PLoS Neglected Tropical Diseases*, *7*(6), e2249. https://doi.org/10.1371/journal.pntd.0002249

Pal, M., & Dutta, J. B. (2013). Echinococcosis: An emerging and re-emerging cyclozoonosis of global importance. *International Journal of Livestock Research*, *3*(1), 5–13.

Pereira, M. T., Nowaszyk, R., Payan-Carreira, R., Miranda, S., Aslan, S., Kaya, D., & Kowalewski, M. P. (2021). Selected uterine immune events associated with the establishment of pregnancy in the dog. *Frontiers in Veterinary Science*, *7*, 1–16. https://doi.org/10.3389/fvets.2020.613953

Pukuma, M. S., Anaaticha, M., & Nuwanyada, E. (2023). Seroprevalence of human cystic echinococcosis in some local government areas in Adamawa State, Nigeria. *Journal of Animal Research International*, *20*(1), 4827 https://www.ajol.info/index.php/ari/ianticl/view/247056

Romig, T., Omer, R. A., Zeyhle, E., Hüttner, M., Dinkel, A., Siefert, L., Elmahdi, I. E., Magambo, J., Ocaido, M., Menezes, C. N., Ahmed, M. E., Mbae, C., Grobusch, M. P., & Kern, P. (2011). Echinococcosis in sub-Saharan Africa: Emerging complexity. *Veterinary Parasitology*, *181*(1), 43–47. https://doi.org/10.1016/j.vetpar.2011.04.022 (doi.org in Bing).

Rojo-Vazquez, F. A., Pardo-Lledias, J., Francos-Von Hunefeld, M., Cordero-Sanchez, M., Alamo-Sanz, R., Hernandez-Gonzalez, A., Brunetti, E., & Siles-Lucas, M. (2011). Cystic echinococcosis in Spain: Current situation and relevance for other endemic areas in Europe. *PLoS Neglected Tropical Diseases*, *5*(1), e893. https://doi.org/10.1371/journal.pntd.0000893 (doi.org in Bing).

Thrusfield, M., Christley, R., Brown, H., Diggle, P. J., French, N., Howe, K., Kelly, L., O'Connor, A., Sargeant, J., & Wood, H. (2018). *Veterinary epidemiology* (pp. 270–295). John Wiley & Sons.

World Health Organization. (2021, May 17). *Echinococcosis*. World Health Organization. https://www.who.int/news-room/fact-sheets/detail/echinococcosis (who.int in Bing)

WHO (2010) First WHO report on neglected tropical diseases: Working to overcome the global impact of neglected tropical diseases. Available: https://apps.who.int/iris/handle/10665/44440 Accessed: 10 May 2023

Zhang, W., Zhang, Z., Wu, W., Shi, B., Li, J., Zhou, X., Wen, H., & McManus, D. P. (2015). Epidemiology and control of echinococcosis in Central Asia, with particular reference to the People's Republic of China. *Acta Tropica*, *141*, 235–243. https://doi.org/10.1016/j.actatropica.2014.03.014 (doi.org in Bing) (bing.com in Bing).