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Original Article

Seroprevalence and determinants of *Echinococcus granulosus* sensu lato infection among owned dogs in Ibadan, Nigeria

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Abstract

Introduction: Humans acquire cystic echinococcosis through accidental ingestion of *Echinococcus granulosus (EG)* eggs released into the environment by infected dogs. This study aimed to determine the presence of *EG* antibodies and their determinants in owned dogs in Ibadan, Nigeria.

Methodology: Sera from 185 dogs on routine visits to veterinary clinics were analysed by indirect ELISA. A questionnaire was administered to dog owners to obtain data on demographics, management, and environmental factors. Data were analysed using descriptive statistics, univariate analysis, and logistic regression at $\alpha_{0.05}$.

Results: The median age of the dogs was 20 months (range 2 – 96). The seroprevalence of *EG* infection was 33.51% (95% CI: 26.71, 40.32%). Low educational level of dog owners (OR: 2.8; 95% CI: 1.3, 5.8); local dog breeds (OR: 3.2; 95% CI: 1.7, 6.0); confinement (OR: 0.4; 95% CI: 0.2, 0.8); interaction with other dogs (OR: 3.2; 95% CI: 1.4, 7.3); self-dewormed dogs (OR: 2.6; 95% CI: 1.2, 5.9) and never dewormed dogs (OR: 4.39; CI: 1.9, 10.0) were significantly associated with *EG* seropositivity. Our results suggest also that local breed of dog (AOR: 2.4; 95% CI: 1.2, 4.9), self-deworming of dogs (AOR: 2.6; 95% CI: 1.1, 5.9) and the absence of any dog deworming treatment (AOR: 2.9; 95% CI: 1.2, 7.1) might be predictive of *EG* seropositivity.

Conclusions: Our study provides evidence of *EG* 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.

Key words: *Echinococcus granulosus sensu lato;* seroprevalence; dogs; Nigeria.

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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 [1]. It is a cosmopolitan disease characterized by a high prevalence in some parts of Africa, Australia, Eurasia, and South America [2,3]. CE remains a major neglected public health problem on a global scale and has recently emerged in several countries owing to its expanding host range and geographic spread [4,5]. CE is highly endemic in sub-Saharan Africa [6]. The prevalence of canine echinococcosis in South West Nigeria in 2014 was 12.45% [7]. Echinococcosis infection causes a significant financial burden owing to human health costs and livestock production losses due to condemnation of infected organs in food animals [8,9].

CE is usually maintained by a domestic cycle (dog/domestic ungulate), especially in rural areas where livestock farming represents a common practice and humans cohabit with dogs fed with raw livestock offal [10,11]. The life cycle of *EG* involves definitive hosts (dogs) and intermediate hosts (herbivores). Humans can act as aberrant hosts by acquiring the infection through accidental ingestion of eggs released by infected dogs, either directly or indirectly through contaminated food, especially vegetables and water [9]. Domestic dogs play an important role in transmitting *E. granulosus* to humans. Dogs acquire the infection through ingestion of infected viscera of intermediate hosts containing the larval form of *E. granulosus*, often by scavenging on ungulate carcasses [11].

Owing to the complex life cycle and long period between infection and clinical signs in human hosts, accurate investigation of risk factors for human infection can be challenging. However, the identification of risk factors for canine infections can provide useful information on the potential transmission to humans and consequent public health issues [12]. These risk factors could be intrinsic, that is, factors related to the dog, such as age, sex, breed, and origin, or extrinsic factors, which include management practices by the owners and environmental factors. Although *E. granulosus s.l.* infections in dogs are asymptomatic, several diagnostic tools are available. Serological detection of antibodies in dog sera and coproantigen detection provides supportive evidence for the surveillance of echinococcosis in endemic areas [1,9].

A sound understanding of the epidemiology of echinococcosis in dogs is a key factor in limiting its transmission to humans and is the basis for designing an effective control program for the disease [9]. However, very few studies have been conducted in Nigeria to elucidate the risk factors for echinococcosis in dogs which potentially remain at the greatest risk of infection in humans. Surveillance of parasitic infections in animals is crucial for reducing the incidence of human diseases [13]. Limited information is available regarding the intrinsic and extrinsic factors associated with *EG* seropositivity in Nigerian dogs. Consequently, this study aimed to determine predictors of *Echinococcus granulosus* seropositivity in dogs in the Ibadan area.

Methodology

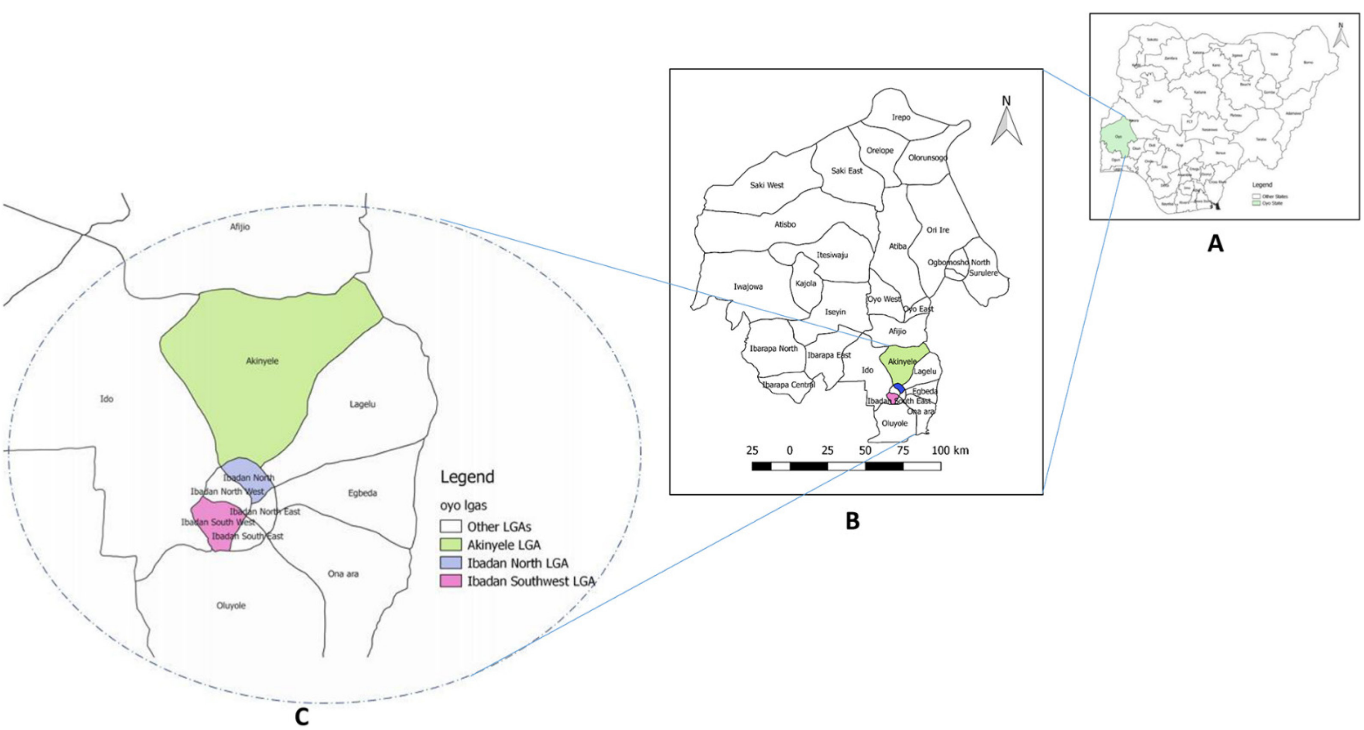
Study design and period

This cross-sectional study was conducted between June 2017 and August 2018.

Study Area

The study area was Ibadan, Oyo State. Ibadan is located in South West Nigeria. It is within the tropical forest zone but close to the boundary between the forest and derived savannahs. The city covers a total area of 3,080 square kilometers [14]. The dog population in South West Nigeria was estimated to be 1,427 [15] with approximately one household dog per 11 humans [16]. The human population in Ibadan was estimated to be 3,649,000 in 2021 [17]. Ibadan Metropolitan areas have 11 Local Governments Areas (LGAs): five urban and six semi-urban. These include Ibadan urban: Ibadan North, Ibadan North-East, Ibadan North-West, Ibadan South-East, Ibadan South-West, and Ibadan Semi-Urban: Akinyele, Egbeda, Ido, Lagelu, Ona Ara, and Oluyole LGAs [14]. Three of the 11 LGAs in the Ibadan metropolitan area were studied (Figure 1). These included two veterinary clinics and hospitals, each from

Figure 1. The map of Ibadan showing the Local Government Areas of the study sites.



the Ibadan North and Ibadan South-West LGAs, and a village community from the Akinyele LGA.

Study Participants

The study participants included dogs and their owners. All dogs of different ages, breeds, sexes, and health statuses presented at each veterinary clinic or hospital during the study period were sampled until the calculated sample size was reached (n = 185). Dog owners who refused consent and those who were absent at the time of sample collection were excluded.

Sample size and sampling

The sample size was estimated using the formula for survey by Thrusfield [18], with a seroprevalence of 12.45% from a previous study [7], and a reliability coefficient of 1.96 with 95% confidence level, precision of 5%, and 10% non-response rate, which gave a total of 185 dogs. The two LGAs in urban Ibadan were selected for this study because of the presence of tertiary, state- and privately-owned veterinary clinics or hospitals. The only two government-owned veterinary hospitals in Ibadan North LGA and two privately owned veterinary clinics in Ibadan South-West LGA together with the village community from Akinyele were included in this study. Dogs were sampled using total sampling techniques at the clinic, hospital, and community levels until the required sample size was obtained.

Data Collection

A pre-tested structured questionnaire was used to obtain information on dog owners' sociodemographic characteristics, dog demography, and management practices such as contact with other dogs, confinement status, deworming status, dog faecal disposal methods, and environmental variables such as the presence of an abattoir within the vicinity. Informed verbal consent was obtained from the study participants and confidentiality of the data was maintained.

Samples Collection

Whole blood samples (5 mL) were aseptically collected by venipuncture from the cephalic veins of dogs and dispensed into plain specimen vials. The samples were transported in ice packs using transit containers to the laboratory at the Department of Veterinary Public Health and Preventive Medicine, University of Ibadan, Ibadan, Nigeria. In the laboratory, clotted blood samples were centrifuged at 1,500 g for 5 minutes to obtain serum after clot retraction. Serum samples were stored at -20 °C until further laboratory analysis.

Serological Analysis

Dog serum samples were analyzed using an indirect enzyme-linked immunosorbent assay (ELISA) to detect *Echinococcus granulosus* antibodies in dog serum. A qualitative commercial kit from Shenzhen Biobase Biotechnology Co., Ltd., China (Canine *Echinococcus granulosus* ELISA Kit) was used. The test was performed according to the manufacturer's instructions.

Data Analysis

All data obtained from the study were coded, entered into Microsoft Excel 16.0, and analyzed using EpiInfo software version 7.2.2®. Descriptive analyses such as frequencies, means, and proportions were also performed. Associations between the outcome variable, seropositivity to *E. granulosus* among dogs, and independent variables, such as demographics, management, and environmental factors, were assessed by calculating the odds ratio (OR). Significant differences in the associations were determined using the chi-square test. Factors significant at $p \leq 0.02$ in the univariate analysis were considered in the multivariate logistic regression to determine predictors of EG seropositivity. Only significant factors ($p < 0.05$) were retained in the final model. A stratified analysis to control for confounding variables was also performed.

Table 1. Demographic variables of respondents and their dogs in Ibadan, 2018 (n = 185).

Characteristics	n (%)
Educational level	
No formal	12 (6.49)
Primary	7 (3.78)
Secondary	19 (10.27)
Tertiary	147 (79.46)
Gender	
Male	146 (78.92)
Female	39 (21.08)
Marital Status	
Single	57 (30.81)
Married	128 (69.19)
No. of dogs owned	
1	97 (52.43)
> 1	88 (47.57)
Type of dog owned	
Local	63 (34.05)
Exotic	122 (65.95)
Sex of dog owned	
Male	103 (55.68)
Female	82 (44.32)
Age of dog owned	
< 24 months	97 (52.43)
≥ 24 months	88 (47.57)

Results

The results of the questionnaire showed that the mean age of the 185 dog owners was 35.7 ± 11.3 years, and 79.7% (147/185) had at least a secondary level of education. The median age of the 185 dogs screened was 20 months (Range: 2 – 96 months), with 55.7% male. As shown in Table 1, most of the dogs examined in this study were exotic breeds, of which 38.0% were Alsatians.

The overall apparent seroprevalence of *Echinococcus granulosus* among the screened dogs was 33.5% (62/185) and further disaggregation is as shown in Table 2. Local (indigenous) breeds of dogs were about three times more likely to be EG seropositive (OR: 3.17; 95% CI: 1.66–6.02) than the exotic breeds. Age of the dogs showed no significant relationship with EG seropositivity.

In the univariate analysis (Table 2), dogs that had never been dewormed before and those dewormed by the owners themselves (self-medication) were about four (OR: 4.39; 95% CI: 1.92–10.04) and three (OR: 2.64; 95% CI: 1.19 – 5.90) times, respectively, more likely to be EG seropositive than those dewormed by veterinarians.

Table 2. Factors associated with *Echinococcus granulosus* seropositivity among owned dogs in Ibadan, 2018 (n = 185).

Variables	Positive (%)	Negative (%)	OR (95% CI)	*p* value
Educational level				
Non-tertiary	20 (52.6)	18 (47.4)	2.77 (1.34, 5.77)	0.01*
Tertiary	42 (28.6)	105 (71.4)		
Marital Status				
Single	24 (42.1)	33 (57.9)	1.72 (0.90, 3.29)	0.14
Married	38 (29.7)	90 (70.3)		
No. of dogs owned				
1	36 (37.1)	61 (62.9)	1.41 (0.76, 2.61)	0.35
> 1	26 (29.5)	62 (70.5)		
Confined				
Yes	45 (29.4)	108 (70.6)	0.37 (0.17, 0.80)	0.02*
No	17 (53.1)	15 (46.9)		
Dog dewormed				
Yes	44 (28.6)	110 (71.4)	0.29 (0.13, 0.64)	0.003*
No	18 (58.1)	13 (41.9)		
Practice home slaughter				
Yes	12 (41.4)	17 (58.6)	1.50 (0.66; 3.37)	0.33
No	50 (31.6)	108 (68.4)		
Mingle with other dogs				
Yes	16 (57.1)	12 (42.9)	3.22 (1.41, 7.33)	0.01*
No	46 (29.3)	111 (70.7)		
Eat raw meat				
Yes	5 (38.5)	8 (61.5)	1.26 (0.39, 4.03)	0.93
No	57 (33.1)	115 (66.9)		
Abattoir in vicinity				
Yes	1 (33.3)	2 (66.7)	0.99 (0.09, 11.15)	0.54
No	61 (33.5)	121 (66.5)		
For hunting purpose				
Yes	10 (58.8)	7 (41.2)	3.19 (1.15, 8.84)	0.04*
No	52 (31.0)	116 (69.0)		
Dog Fecal disposal				
Unsafe	22 (46.8)	25 (53.2)	2.16 (1.09, 4.26)	0.03*
Safe	40 (29.0)	98 (71.0)		
Type of dog owned				
Local	32 (50.8)	31 (49.2)	3.17 (1.66, 6.02)	< 0.001*
Exotic	30 (24.6)	92 (75.4)		
Sex of dog owned				
Male	33 (32.0)	70 (68.0)	0.86 (0.47, 1.59)	0.75
Female	29 (35.4)	53 (64.6)		
Age of dog owned				
< 24 months	36 (37.1)	61 (62.9)	1.41 (0.76, 2.61)	0.35
≥ 24 months	26 (29.5)	62 (70.5)		
Deworming Status				
Vet-dewormed	29 (24.0)	92 (76.0)	Ref.	
Self-dewormed	15 (45.4)	18 (54.6)	2.64 (1.19, 5.90)	0.03*
Never-dewormed	18 (58.1)	13 (41.9)	4.39 (1.92, 10.04)	0.001*
Type of feed				
Canned food	2 (16.7)	10 (83.3)	Ref.	
Home-made	29 (49.2)	30 (50.8)	4.83 (0.97, 23.98)	0.08
Both	26 (27.1)	70 (72.9)	1.86 (0.38, 9.05)	0.67
Dry food	5 (27.8)	13 (72.2)	1.92 (0.31, 12.05)	0.79

Keeping dogs for hunting (OR: 3.19; 95% CI: 1.15 – 8.84), having dogs mingled with other dogs (OR: 3.22; 95% CI: 1.41–7.33), disposal of dog faeces in the open or outside the compound/bush (OR: 2.16; 95% CI: 1.09 - 4.26) and low educational level of dog owners (OR: 2.77; 95% CI: 1.34, 5.77) were significant factors associated with EG seropositivity. Dogs kept in confinement (OR = 0.37; CI = 0.17 – 0.80) and those dewormed (OR = 0.29; CI = 0.13 – 0.64) were associated with significantly decreased risk of EG seropositivity (Table 2).

Multivariate logistic regression analysis confirmed that belonging to indigenous breeds (AOR: 2.42; 95% CI: 1.19 – 4.93), the practice of self-deworming (AOR: 2.56; 95% CI: 1.14, 5.88) and the absence of any deworming treatment (AOR: 2.86; 95% CI: 1.16, 7.14) are good predictor variables for *E. granulosus* seroprevalence (Table 3).

Discussion

The results of this study show that the overall seroprevalence of EG in dogs in Ibadan was 33.5%. Our findings agree with those observed in Uganda [19] and in northern Chile [1], where a prevalence of 32.4% and 28%, though obtained using different analytical techniques, was found among dogs using the sedimentation and counting technique (SCT) and coproantigen ELISA, respectively. Several diagnostic methods are available for the identification of *Echinococcus* in definitive hosts. SCT is regarded as the reference standard for the diagnosis of *E. multilocularis* in definitive hosts, with high sensitivity and very high specificity. The SCT has the advantage of determining the exact worm burden in the intestine during necropsy; however, it is a limited tool for mass screening. Coproantigen ELISA was used to detect *E. granulosus* antigens in the faeces of infected dogs. This method is suitable for mass screening; however, the positive predictive value of this test may be reduced in areas characterized by low *Echinococcus* prevalence [20-22]. On the contrary, lower values of seroprevalence were reported by other authors in South West Nigeria (12.5%; [7]; similarly, and in comparison, with our results, in Moroto and Bukedea districts of Uganda lower prevalence (12.2%) of *E. granulosus* infection in dogs was also found, but in the study by Oba *et al.* [23], the diagnostic method employed was microscopic and presence of taeniid eggs was confirmed by PCR.

The seroprevalence of *E. granulosus* determined in the study area showed that the infection had attained an endemic status in the dog population. High infection rates in dogs have been associated with a significant risk of human exposure to EG [24]. This is particularly concerning to public health in a country such as Nigeria with no official control program for echinococcosis.

In our study, male dogs were found to be 1.2 times more likely to be EG seropositive than female dogs, however, the sex difference was not statistically significant; this is consistent with the findings of Adediran *et al.* [7] and Wang *et al.* [25] who found no significant association between sex and prevalence of dog Echinococcosis in South West Nigeria and North West China, respectively. Male dogs are more prone to roaming in response to territorialism and hunting, as postulated by Budke *et al.* [26], which may account for the higher prevalence.

Dogs younger than 24 months of age accounted for approximately two-thirds of the overall prevalence (19.5% out of 33.5%). Previous studies have reported a higher prevalence of EG in younger dogs than in adult dogs (26–30 months), which is possibly attributable to multiple exposures to parasite antigens determining a more effective protective immunity [27]. Consistent with the findings of Adediran *et al.* [7], we found no association between age and EG seropositivity. However, Buishi *et al.* [28] reported a positive association between young dogs and EG seropositivity in Turkana District, Kenya.

Our findings revealed that the indigenous breeds of dogs examined in this study were approximately four times more likely to be EG-seropositive than their exotic counterparts, similar to a report by Adediran *et al.* [7]. Dogs of local breeds are considered less valuable than exotic breeds, which are perceived as status symbols. This implies that dogs are treated differently by their owners depending on the intrinsic value given

Table 3. Predictors of *Echinococcus granulosus* seropositivity among owned dogs in Ibadan, 2018 (n = 185).

Variables	Positive (%)	Negative (%)	AOR (95% CI)	*p* value
Type of dog owned				
Local	32 (50.8)	31 (49.2)	2.42 (1.19, 4.93)	0.01*
Exotic	30 (24.6)	92 (75.4)		
Deworming Status				
Vet-dewormed	29 (24.0)	92 (76.0)	Ref	
Self-dewormed	15 (45.4)	18 (54.6)	2.56 (1.14; 5.88)	0.02*
Never-dewormed	18 (58.1)	13 (41.9)	2.86 (1.16; 7.14)	0.02*

to them. Generally, dogs of exotic breeds are likely to live in a domestic environment with humans and receive proper nutrition and veterinary healthcare. Conversely, local breeds are more comparable with stray dogs, which are often underfed and forced to scavenge for survival. It should also be noted that the local dogs are more likely to be used as hunting dogs due to their superior stamina and ruggedness. Based on the findings of this study, 93% of the exotic breeds were treated for helminthiasis, of which, 80% were treated by veterinarians. Only one-third of the local breeds received any form of anthelmintic treatment. The free-roaming status of the local breed, coupled with a lack of veterinary care, predisposes local breeds to echinococcosis [19].

Finally, it is worth noting a potential limitation of this study was that the sensitivity and specificity of the ELISA kit were not specified by the manufacturer. This lack of information did not allow calculation of the true prevalence of EG. The present study demonstrated that a high proportion of dogs in the Ibadan area have been exposed to *E. granulosus*, which constitutes a significant risk of infection in humans. Moreover, the main factors associated with the parasite cycle perpetuation were identified as belonging to a local breed of dog that very often do not receive any anthelmintic treatment or are dewormed by the owners themselves. The practice of self-deworming of dogs, might easily lead to administration of incorrect and inappropriate anthelmintic dose resulting in ineffectiveness against infecting parasites. The authors would like to stress the importance of seeking veterinary advice for effective deworming practices, thus reducing risk of *E. granulosus* and other zoonotic parasites transmission to humans.

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