Research

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Abstract

Introduction: dog-mediated rabies kills about 59,000 people annually. Minimising the incidence and fatality associated with rabies disease requires adequate knowledge of dog ecology. Dog rabies vaccination which has proven to be the most effective preventive measures needs to be evaluated while prediction of dog location will be important in planning for intervention. Developing a logical framework for prevention of avoidable human deaths due to dog mediated rabies therefore require adequate information on these factors. This study was carried out to determined demographic characteristics, rabies vaccination coverage and predictor of dog ownership in Osun State. Methods: we conducted a cross-sectional study of households using WHO/WSPA adapted questionnaire. The questionnaire was administered to one person, not younger than 18 years old, per household, asking questions on household characteristics and dog information. Multi-stage sampling technique was used, and data was collected using electronic collection tool. Data were analyzed using descriptive statistics, bivariate and multivariate analyses at 5% significant level to determine predictors of dog ownership in Osun State. Results: total of 320 households sampled, dog-human ratios were 1: 10.7 for owned dogs, overall dog-household ratio was 1: 1.7 with urban area having 1: 1.0 ratio. Female dogs were marginally higher (53.8%) than males and comprised mainly 77.5% local breeds compared to foreign or crossbreeds. Overall rabies coverage was 30.2%, with urban and rural households having 53.2% and 11.1% rabies vaccination coverage. Predictors of dog ownership were the presence of a child in the household (AOR: 8.7; CI 2.2-34.0), the head of household being a hunter (AOR: 4.5; CI 1.4 - 14.6) and living in an urban setting (AOR: 3.5; CI 1.6-7.7). Conclusion: dog population in Osun State was relatively small and rabies vaccination coverage was very poor compared to the recommended safe coverage of 70%. Presence of a child in a household, head of house being a hunter and living in an urban area were predictors of dog ownership in Osun State. We recommended development of comprehensive plan for improved rabies coverage, targeting hunters' association and school communities by the concerned authorities.

Introduction

Domestic dogs are ubiquitously associated with human populations in nearly all parts of the world [1]. The domestic dog, a member of the genus Canis, otherwise referred to as canines, had being a close ally of humans for centuries and are believed to be the closest animal to man [2]. Dogs were used as security guards, as pets, as hunting dogs, for breeding, and herding [3]. They are also used for law enforcement to assist in detecting people that are being smuggled across international borders, detecting drugs, improvised explosive devices (IEDs), and other illegal substances. In the medical field, dogs are used to help people with disabilities. Dogs are being trained to aid in the diagnosis of diseases. The companionship that they provide is believed to foster healthier living in children, the elderly and those isolated by stigmatization due to diseases like AIDS [4]. However, they also serve as vector for several disease agents, chief among them being rabies disease [5]. To maximize the benefit of canine therefore, it is important to understand their ecological distribution and health status, especially as it relates to rabies vaccination.

Reliable estimates of global dog population are not available; however, researchers have reported varying population estimates in different regions and parts of the world. In general, dog-to-human ratio of one to ten (1: 10) to one to six (1: 6) has been reported in the American and European countries [6]. In Mexico, dog-to-human population ratio of 1: 1.7 and 1: 4.6 were reported in different rural communities and 1: 3.4 in a city [7], 35.6% of households in Ireland have one or more pet dogs [7,8]. In Africa, reported dog-to-human population ratios vary widely, ranging from 1: 3.7 to 1: 47. Ratio of 1: 47 in Uganda, 1: 14 in

Tanzania, 1: 7.7 in Machakos District of Kenya, 1: 6.5 in Zimbabwe, 1: 4.5 in Madagascar at different times [1,9-13]. In Nigeria however, reported dog-to-human population range between 1: 3.7 and 1: 25. Researchers reported 1: 11 of owned dog-to-human population and 1: 25 stray dog-to-human in Oyo State, 1: 13 dog-to-household in Kwara State, dog-to-human ratio of 1: 4.1 in Bauchi and Borno States, 1: 4 in Plateau and Benue States and ratio of 1: 3.7 in the Federal Capital Territory [14-20]. In Southwest Nigeria, ratio 1: 11 of owned dog-to-human population and 1: 25 stray dog-to-human in Ibadan, Oyo State was further reported [14].

A study on knowledge, attitude and practice about rabies prevention and control conducted in Tanzania revealed that only 51% of respondents vaccinated their dogs against rabies while rabies vaccination coverage survey in six selected villages in Tanzania as at 2012 was estimated at 25% [21,22]. In Uganda as at 2003, rabies vaccination coverage of 36.1% was reported [9]. In a study conducted in Benue State, Nigeria, dog owners reported 26.4% rabies vaccination coverage [16]. This level is grossly insufficient to prevent rabies transmission compared to the recommended minimum herd coverage of 70% [15,23,24]. In Osun State however, no published or unpublished document on dog population, demography or ecology was found. We, therefore, determined demographic characteristics, rabies vaccination coverage and predictor of dog ownership in Osun State to provide information for the development of effective dog management and rabies vaccination measures as well as providing baseline for future researches.

Methods

Study area: the study was carried out between March and May 2019 in Osun State, Nigeria. The State is an inland state in south-western Nigeria, situated within the tropical rain forest zone of Nigeria with patches of savannah in the northern part of the state. Politically, the state is divided into three Senatorial Districts with 30 Local Government Areas (LGAs), Osogbo being the state capital. The estimated population of the state as at 2019, using the reported annual growth rate of 3.25%, is 5,178,578 [25]. The state comprises one main ethnic group, Yoruba, with major sub-ethnic groups being, Ijesha, Oyo, Ibolo, and Igbomina. Religions practiced were Islam, Christianity and traditional faith. Animal health services in the state are under the Ministry of Agriculture and Food Security which among other roles is saddled with the development and implementation of government policies regarding animal health. The ministry has veterinary clinics in about 16 LGAs manned by qualified veterinary doctors or at least an animal health technologist as zonal veterinary Officers. Most of the clinics are organized to provide veterinary services to a neighboring LGA either through ambulatory posts or outreaches. Complementing the services are the private veterinary practitioners providing preventive, control and curative veterinary services in the state.

Study design and eligibility criteria: a cross-sectional study design was conducted to determine demographic characteristics, rabies vaccination coverage and dog ownership predictors using an adapted standard questionnaire [6]. The survey was conducted between March and April, 2019.

Inclusion criteria: any persons above the age of 18 years residing in the selected household were included as respondents in the study.

Exclusion criteria: any persons in the inclusion criteria with visual or auditory impairment(s), mental illness or who had not resided in the household for more than six months were excluded.

Sampling technique: multi-stage sampling technique was adopted. Household sample size was determined by the formula described by Thrusfield [26]. Eleven LGAs were randomly

selected using a simple random technique. Thereafter, three wards per LGA selected using simple random sampling technique. At the Ward stage, three streets per ward were selected using systematic random sampling technique followed by three to four households´ selection per selected street using simple random sampling technique to make the required households sample size. At the final stage, one occupant per household, residing in the selected households not younger than 18 years old, was randomly selected as respondent.

Sample size determination: the sample size was calculated using the formula as described by Thrusfield [26]. Using 24% proportion (P) as reported in a similar study conducted in Tanzania on dog ownership [1] and precision (d) of 5%, the effective sample size (ne) was calculated to be 281 households using the single proportion population formula, given as;

$$n_e = \frac{Z^2_{(1-\alpha/2)}pq}{d^2}$$

Adjusting for a non-response rate (f), assumed to be 10%, using the formula for adjusting for non-response rate;

$$n = \frac{n_e}{1 - f}$$

Required minimum sample size (n) was calculated to be 312 households.

Study instruments and data collection methods: a pretested standard structured questionnaire by WHO/WSPA was adapted for the study [6], using electronic data management tool (Kobotool) for data collection to estimate owned dog population. Household and dog-level data was obtained from selected member of the household. The data included the number of people in the household, household demographic characteristics, number of dogs per household and individual dog demographic information and vaccination history. Dependent variable being dog ownership with all other variables as independent. Fifteen (15)

interviewers were recruited from Osun State Ministry of Agriculture and Food Security, comprising mainly university graduates with experience in data collection. They were trained on interview techniques to minimize bias and the use of electronic data collection tool (Kobo Collect Application) for data collection. Location of the selected households was also captured using GPS.

Data analysis: data collected were analyzed using Microsoft Excel 2013 and Epi Info 7. Univariate analyses to determine means, range, frequencies, and proportions of all the variables generated to describe dog ecology and vaccination coverage. Bivariate analyses using Chi square and Fisher exact tests were carried out to determine association between owning a dog as the dependent variable and all others as independent variables. Confidence limit was set at 95% and p-value <0.05 was considered significant. Variables that were significant at bivariate analyses were fitted into multivariate logistic regression analyses model using backward stepwise approach. Any p-value less than 0.05 were considered statistically significant. We estimated owned dog population by multiplying dog to human ratio by 2019 projected human population in the state based on National Population Commission Census figures. The number of dogs found during the household survey was divided by the corresponding human population obtained during the survey; dog to human ratio was calculated [6,27,28]. Dog-to-household ratio was calculated by dividing the number of dogs found during the survey by the total number of households that responded to the questionnaire.

Ethical approval: this study was approved by the Animal research ethics committee of Osun State Ministry of Agriculture and Food Security (Ref. no: VD.19/597/76). Informed consent was obtained from all participants before proceeding to questionnaire administration.

Study limitations: this study was subject to recall bias, and social desirability bias and misinformation bias. Recall bias was minimized by

the use of pretested standard structured questionnaire adapted for the study. Social desirability and misinformation bias which is also associated with surveys was minimized by training the interviewers on questioning techniques and evidence-based conclusions.

Results

A total of 320 households were visited for the survey, 18 declined consents, giving a non-response rate of 5.6%. The selected households with approved consent spread across 11 LGAs giving a good spread (Figure 1). An aggregate of 57 (18.9%) of 302 sampled households owned at least a dog. Household setting comprised mostly 71.5% rural while traditional single-family type of home constituted 50.3% of homes surveyed. There was no perimeter fencing in 254 (84.1%) households. More than 75% of dogs were local breeds with 53.8% of all dogs being female. Age range 13 to 24 months old accounted for the highest (30.2%) proportion, canine rabies vaccination coverage in the state was 30.2% (55 of 182), with 53.2% in the urban and 11.1% in the rural households (Table 1). Dog-to-human population ratio in the state was 1: 10.7 while dog-to-household ratio was calculated to be 1: 1.7 as presented in Table 2. A total of 486,076 domestic dogs were estimated to be the total domestic dog population in Osun State, Nigeria (Table 2).

More than two-thirds (70.8%) of the respondents mentioned religion as a reason for not owning a dog (Table 3). At bivariate analyses, urban home setting (OR=3.1; CI 1.7- 5.7), presence of children in the household (OR=5; CI 1.5 - 16.5), sex of the head of household being male (OR=2.8; CI 1.3 - 5.8), home enclosure with the presence of a fence (OR=5.3; CI 2.7 - 10.3), complete restriction of dog movement with fence (OR=4; CI 1.8 - 8.7) and occupation of the head of household being hunting (OR=3.5; CI 1.2 - 10.5) were all statistically significant (Table 4). However, multivariate analysis revealed that urban home setting (AOR=3.5; CI 1.6-7.7), presence of children in the

household (AOR=8.7; CI 2.2 - 34.0) and the head of household being a hunter (AOR=4.5; CI 1.4 - 14.6) were the independent predictors of dog ownership (Table 5).

Discussion

Traditional single-family type of home constituted about half of all the homes surveyed and there were perimeters fencing in only about a-fifth of all the households. These type of homes suggest a rural to semi-urban community which describes Osun State [29]. Heads of households were about 70% males as expected in a rural to semi-urban communities like Osun. The finding that trading and farming were the most frequent occupation of the respondents may still be pointing towards a rural to semi-urban community settings with little formal employment characteristics. Domestic dog sex ratio of almost 50% found in this study contrasts a study conducted in urban and rural areas of Borno State that reported male dog to female ratio of about 1 to 2 and 4 to 1 [17]. The variation may have been influenced by the different technique adopted, or that true demographic variation exists in these states due to differences in cultural and traditional practices. The finding that the age-range 13 to 24 months old accounted the highest (30%) proportion of dogs in the state may suggest puppyhood death due to vaccine-preventable diseases as vaccination coverage is low. Local breeds of dogs were about three-quarter of all dogs in the state which may suggest that most dog owners in the state were not willing to invest huge amount which is required for the purchase and maintenance of foreign breeds. We estimated 2019 owned dog population in Osun State to be a little less than half a million with higher proportion of unrestricted or stray dogs reported in urban home settings which suggests that the dogs were drawn to urban settings due to availability of consumable wastes compared to rural settings with the low chances of finding food. World Organization for Animal Health (OIE) proposed identifying source of unrestricted or stray dog as one important

consideration for effective dog population management [30].

The dog-to-human ratios of about 10% gotten is lower compared to about 25% estimates in Federal Capital Territory, Bauchi, and Borno States [16,17,20]. However, the study in Bauchi State estimated both street and household counts while the study in Borno State and Federal Capital Territory estimated the ratio for urban/semi-urban areas only. Also, local attitudinal and cultural practices of these other states vary from that in Osun State. These may have accounted for the varied ratio as revealed in this study coupled with temporal and spatial differences of the studies. Also, about 8% household owning at least a dogs reported in Kwara State [15] is much lower compared to ratio gotten in this study, which may be as a result of different techniques adopted or that a real difference actually exist. While we adopted questionnaire survey, the other study adopted aerial photograph enhanced dog census. Only about one-third of the dogs were vaccinated against rabies in the state with about 50% coverage in the urban areas. This is similar to what was reported in Abuja, Nigeria [20].

In this study, living in urban home setting, presence of children in the household and head of household being a hunter were independently associated with owning a dog. A study found sex of the head of the household being male; if they owned a cat; or if they owned poultry to be associated with dog ownership [1], but this study showed that, though sex of the head of the household had association with dog ownership, it was most likely a confounder. However, the findings of our study is in tandem with the study that found that "presence of children in the household" had true association with dog ownership [31].

Conclusion

An estimate of 486,076 owned dogs' lives in Osun State as at the time of study with a ratio of one

dog per about eleven persons. Rabies vaccination coverage in Osun State was very low (30%) compared to recommended minimum coverage for herd immunity. Households situated in the urban areas or with a hunter as household head or having children in the household are independently likely to own at least a dog in the state. We recommend that Veterinary authorities in Osun State Ministry of Agriculture and Food Security develops a comprehensive plan to improve dog rabies vaccination coverage, as stipulated by WHO, GARC and OIE to promote responsible dog ownership. To achieve the minimum recommended rabies vaccination coverage of 70% by 2030 [23], increased awareness and sensitization needs to be heightened, especially targeting hunters' associations, schools and rural area dwellers.

What is known about this topic

- *Rabies is a highly fatal viral disease whose spread is majorly mediated by domestic dogs;*
- *Dog rabies vaccination with a minimum of 70% coverage is an effective preventive measure in the control of the disease;*
- *Dog population and ecology is important in the development, design and implementation of effective intervention programs.*

What this study adds

- *Domestic dog population and their demographic distribution in Osun State, Nigeria between March and May, 2019;*
- *Rabies vaccination coverage in Osun State, Nigeria;*
- *Predictors of dog ownership in Osun State, Nigeria.*

Competing interests

The authors declare no competing interests.

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Authors' contributions

Acknowledgments

Tables and figure

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Table 4: association of socio-demographic characteristics with dog ownership in Osun State, Nigeria

Table 5: predictors of dog ownership in Osun State, Nigeria

Figure 1: selected LGAs and households for dog ecology study in Osun State, Nigeria

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Table 1: ecology and demographic characteristics of owned-dogs and rabies vaccination coverage in Osun State			
Variables		**Total**	**Percent (%)**
Household survey response (n=320)	Yes	302	94.4
	No	18	5.6
Households ownership of dogs (n=302)	Owned no dog	245	18.9
	Owed at least a dog	57	81.1
Household home settings (n=302)	Rural	216	71.5
	Urban	86	28.5
Household type of home (n=302)	Modern single family	58	19.2
	Traditional single family	152	50.3
	Home in multi-apartment building	27	8.9
	Mud house	65	21.5
Households enclosure (n=302)	No fence	254	84.1
	Fence that cannot restrain dog	18	6.0
	Fence that can completely restrain dogs	30	9.9
Sex of dogs (n=182)	Female	98	53.8
	Male	84	46.2
Age of dogs in months (n=182)	<6	14	7.7
	6 - 12	32	17.6
	13 - 24	55	30.2
	25 - 36	25	13.7
	>36	3	1.6
	Unknown	53	29.1
Dog breed classification (n=182)	Local	141	77.5
	Cross breed	9	4.9
	Foreign breed	32	17.6
Foreign dog breed classification (n=32)	Boerboel	6	18.8
	German shepherd	13	40.6
	Caucasian	7	21.9
	Rottweiler	6	18.8
Rabies vaccination in the State	Yes	55	30.2
	No	127	69.8
Rabies vaccination (urban settings)	Yes	44	53.2
	No	39	46.8
Rabies vaccination (rural settings)	Yes	11	11.1
	No	88	88.9

Table 2: estimates of dogs; households and dogs; human-population ratios in Osun State, Nigeria

Area	# Household surveyed	Number of people	Percent (%)	Number of dogs	Percent (%)	Ratio	
						Dog to household	Dog to human
Total	302	1939	100.0	182	100.0	1 : 1.7	1 : 10.7
Rural	216	1624	83.8	99	54.4	1 : 2.1	1 : 16.4
Urban	86	315	16.2	83	45.6	1 : 1.0	1 : 3.8

Table 3: factors associated with non-owning a dog in Osun state, Nigeria (n=245)

			95% Conf. Limits	
	Frequency	Percent (%)	Lower	Upper
Religion				
No	71	29.2	22.8	36.1
Yes	174	70.8	63.9	**77.2**
I don't like dogs				
No	184	75.0	68.3	81.0
Yes	61	25.0	19.0	31.7
It is expensive to keep				
No	244	99.5	97.1	100.0
Yes	1	0.5	2.2	8.7
They are not useful in the house				
No	234	95.3	61.3	97.8
Yes	11	4.7	2.2	8.7
Fear of disease transmission				
No	244	99.5	97.1	100.0
Yes	1	0.5	0.0	2.9
Fear of dog bite				
No	242	99.0	96.3	99.9
Yes	3	1.0	10.0	3.7
Allergies				
No	239	97.4	94.0	99.2
Yes	6	2.6	90.0	6.0

Table 4: association between socio-demographic characteristics and dog ownership in Osun State (n=302)

Category	Total	Yes	No	OR	95% CI	P-value
Home setting						
Urban	86	28	58	3.1	1.7 - 5.7	0.0001*
Rural	216	29	187			
Total	302	57	245			
Type of home						
Non-multiple home	270	55	215	3.8	0.9 - 16.6	0.05
Multi apartments home	32	2	30			
Total	302	57	245			
Presence of children in the household						
Children	246	54	192	5	1.5 - 16.5	0.004*
No child	56	3	53			
Total	302	57	245			
Sex of head of household						
Male	201	47	154	2.8	1.3 - 5.8	0.005*
Female	101	10	91			
Total	302	57	245			
Home enclosure						
Fence	48	22	26	5.3	2.7 - 10.3	<0.0001*
No-fence	245	35	219			
Total	302	57	245			
Dog restriction home						
Fence restriction	30	13	17	4	1.8 - 8.7	0.0003*
No Restriction	272	44	228			
Total	302	57	245			
Occupation of the head of household						
Hunter	14	6	8	3.5	1.2 - 10.5	0.02*
Non-hunter	288	51	237			
Total	302	57	245			
Occupation of the head of household						
Farmer	88	12	76	0.6	0.3 - 1.2	0.1
Non-farmer	214	45	169			
Total	302	57	245			

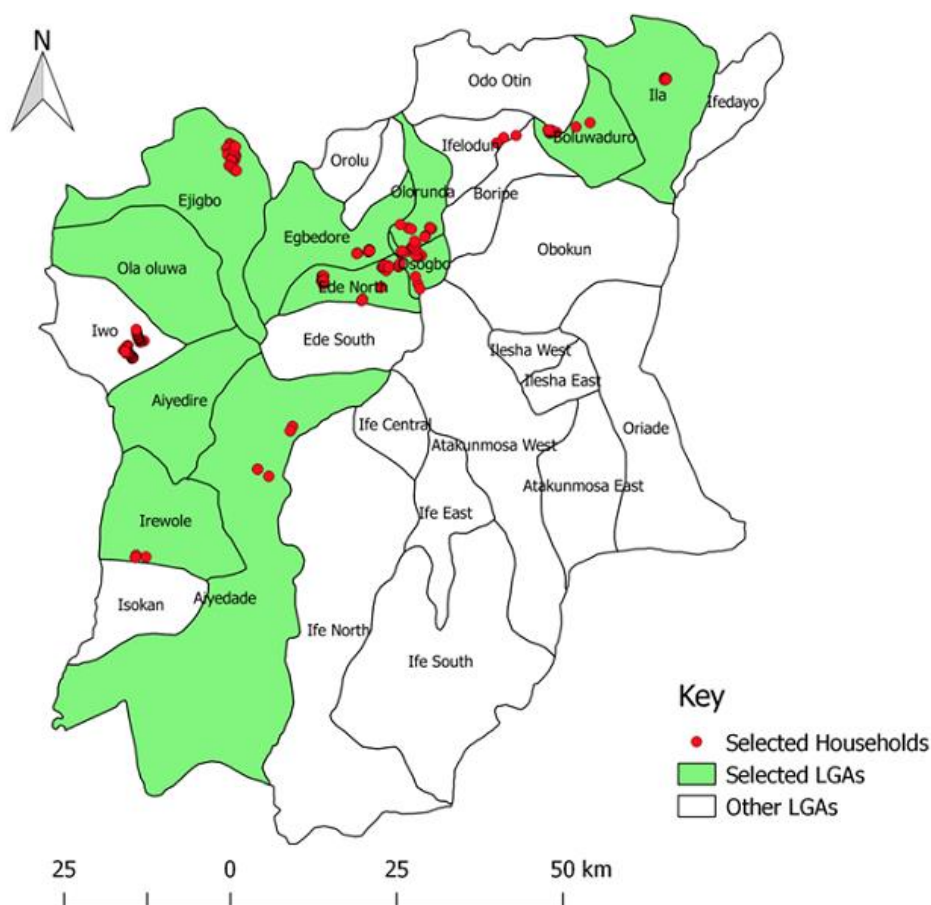| Table 5: predictors of dog ownership in Osun State, Nigeria			
Variables	**AOR**	**95% CI**	**P-value**
Home setting (urban/rural)	3.5	1.6 - 7.7	0.001*
Household occupants (children/no-child)	8.7	2.2 - 34.0	0.002*
Sex of head of household (male/female)	2.0	0.9 - 4.6	0.08
Home enclosure (fence/no fence)	2.1	0.7 - 6.2	0.16
Home enclosure (full restricted wall/no restriction)	1.1	0.3 - 3.6	0.91
Occupation of the head of household (hunter/others)	4.5	1.4 - 14.6	0.01*

Figure 1: selected LGAs and households for dog ecology study in Osun State, Nigeria