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ORIGINAL ARTICLE

Prevalence, seasonal and geographical distribution of parasitic diseases in dogs in Plateau State Nigeria: a 30-year retrospective study (1986–2015)

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Abstract Parasitic diseases of dogs are now major economic and public health issues in Nigeria due to indiscriminate reproduction of dogs, lack of appropriate policies on pet ownership and diseases control as well as inadequate veterinary care. In order to understand the prevalence, seasonal variation and distribution of parasitic diseases of dogs in this region of Nigeria, the present study conducted a 30-year retrospective analysis in the referral veterinary centre, Vom, and analysed data using the Chi square test and the factor analysis. Of the 26,844 dogs handled between January 1986 and December 2015, 17,663 (65.8%) had different parasitic diseases. Yearly distribution of parasitic diseases varied significantly ($p < 0.0001$) and ranged between 52.0 and 85.4%. Age, seasonal and disease specific prevalence rates ranged between 2.8 and 80.5%. Prevalence rates in females 78.2% (95% CI 77.6–78.9) and indigenous breed 70.0% (95% CI 69.2–70.7) were significantly higher ($p < 0.0001$) from those of the males 47.2% (95% CI 46.2–48.1) and exotic breeds of dogs 60.7% (95% CI 59.8–61.6), respectively. Ancylostomosis was the most prevalent (15.9%) disease while Barkin Ladi recorded the highest regional prevalence. It is pertinent to enact appropriate disease control policies and observe control programmes including vector control and improved hygiene to curtail the economic and public health threats associated with these diseases.

Keywords Distribution · Epidemiology · Parasitic diseases · Plateau State-Nigeria · Prevalence · Public health · Retrospective analysis · Seasonal variation

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Introduction

Parasitic diseases of dogs are now major economic and public health issues worldwide due to the relationship between dogs and humans (Coggins 1998). They are caused by parasites grouped into helminths (*Ancylostoma*, *Uncinaria*, *Toxocara*, *Dipylidium*, *Echinococcus, Taenia*), intestinal protozoa (*Cryptosporidium* and *Giardia*), haemoprotozoa (*Babesia* and *Trypanosoma*) as well as ecto-parasites (fleas, lice and ticks). These parasites are transmitted between dogs and humans via vectors or environmental contamination with faeces containing parasitic eggs, larvae, oocysts or cysts (Uga et al. 1996). In humans, these parasites cause clinical diseases referred to as hydatidosis (*Echinococcus*) as well as cutaneous, ocular and visceral larval migrans (Thompson et al. 1986).

Parasitic infections of dogs are acquired either directly via the ingestion of eggs, skin penetration and transplacentally or indirectly through bites of arthropod vectors (Greenland et al. 2015). Factors that influence transmission of these parasites may include environmental contamination through indiscriminate and open defecation (Lee et al. 2010), poor hygiene and sanitation, humidity, temperature and soil moisture. Others include, lack of strategic deworming (WHO 2002), season (Brooker and Michael

2007), poverty and urbanization as well as overcrowding (Brooker et al. 2004).

Seventy five percent of the 700 million dogs distributed across the globe roam freely, reproduce indiscriminately and pose serious public health threats because of lack of veterinary care (Massei and Miller 2013). In Nigeria for instance, dogs are used for several purposes including companionship, hunting, security and protein source. Despite these benefits to man, they are potential risk for the transmission of zoonotic parasites capable of causing morbidity and mortality among all age groups (Azian et al. 2008). The protection of public health requires effective development and implementation of control strategies against these zoonotic parasites of companion animals.

Despite the important roles of dogs in the provision of companionship, security and animal protein in this region of Nigeria and the risk of humans acquiring zoonotic parasites from this species, there are scanty individual reports on the prevalence and distribution of parasitic diseases of dogs in the region. The present study compiled 30-year records (January 1986–December 2015) from a referral veterinary centre in Vom, Nigeria to provide useful epidemiological data including endemic parasitic diseases, their prevalence, seasonal variation and distribution across the state which are envisaged to help in the institution of control programs and enactment of disease control policies in the region.

Materials and methods

Study area

The study was carried out in the referral veterinary centre, Federal College of Animal Health and Production Technology, Vom in Plateau State, north-central Nigeria. The State is located about 1280 m above sea level and between latitudes 9.2422° N and 10.1153° N and longitudes 8.6957° E and 9.5210° E (Fig. 1). The state covers a land mass of 26,899 square kilometres (Ileoje 2001) with a population of 3.2 million (Nigeria Census 2006). Though situated in the tropical zone, the higher altitude gives the state a near temperate climate with average temperature ranging between 18 and 22 °C. The lowest temperatures are observed between December and February while the warmest temperatures usually occur between March and April. It has two distinct seasons namely; rainy which extends from May to October and dry which extends from November to April with average annual precipitations ranging from 1314.8 mm in the southern part to 1465.7 in the northern part and highest rainfall is recorded during July and August. The mean relative humidity is 44% and the major occupation of inhabitants of the state is agriculture (Ileoje 2001).

Study design and data collation

The study conducted a 30-year retrospective study on parasitic diseases diagnosed in dogs in the referral veterinary centre, Vom, Plateau State, north-central Nigeria. The seasons of the year were grouped into four namely; early rainy (May–July), late rainy (August–October), early dry (November–January) and late dry (February–April). For the purpose of this study, data obtained during the 30 years (1986–2015) were assembled into 10 groups of three years each. Records of diseases diagnosed and confirmed in the laboratory during the 30-years period were reviewed and all parasitic diseases of dogs were recorded. To ensure that data generated from the records were correct, three of the authors checked the records separately and documented their individual findings. Variations in the data recorded by the individual authors were crosschecked for correctness and accuracy. From the records analysed, vector-borne pathogens including *Babesia*, *Ehrlichia* and *Trypanosoma* were diagnosed using direct, thin and thick smears, as well as the buffy coat techniques. Helminthic conditions were diagnosed using the simple saturated sodium chloride floatation and sedimentation techniques (Gupta and Singla 2012). Variables including age, sex breed and sources of dogs presented were also identified. Using the records, dogs were also categorized into four groups namely: 0–12, > 12–24, > 24–36 and > 36 months based on documented ages in months.

All parasitic diseases of dogs confirmed through laboratory investigation were included in the study while unconfirmed parasitic diseases in dogs which were based on history and clinical signs only and those reported in animals other than dogs were all excluded in the study. Diseases were grouped into gastro-intestinal parasitism (ancylostomosis, echinococcosis, taeniosis and toxocariosis), haemo-parasitism (babesiosis, ehrlichiosis and trypanosomosis) and ecto-parasitism (flea, lice, mite and tick infestations).

Data analysis

Data generated were entered into spreadsheet and transferred to Statistical Package for Social Sciences (SPSS version 20.0) and Graph-Pad Prison, Version 4.0. The ratio of the number of dogs positive for parasitic diseases to the total number of dogs examined was multiply by 100 to determine prevalence rates for different variables. The 95% CI was determined using the exact confidence interval internet calculator (https://statpages.info/confint.html). The

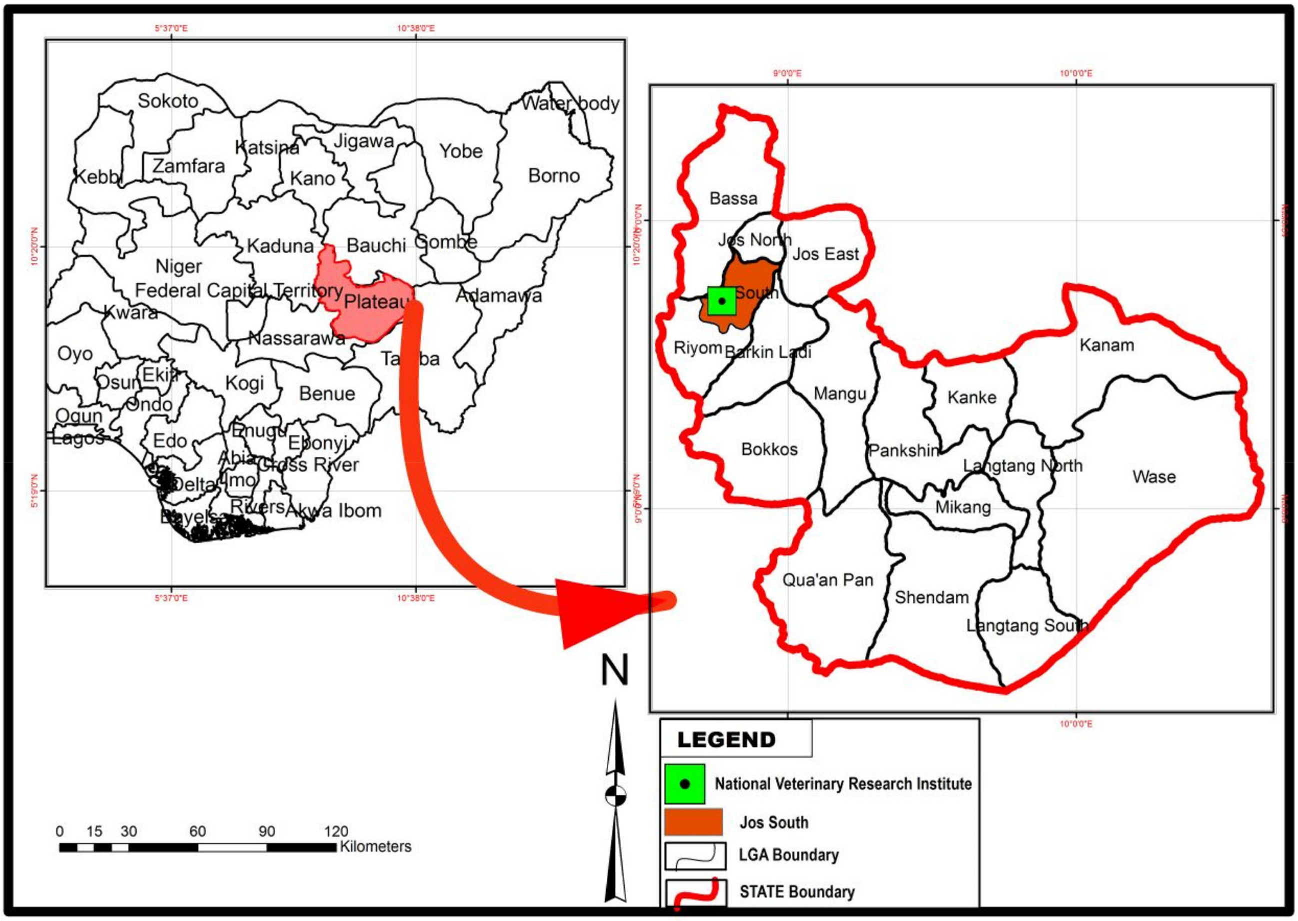

Fig. 1 Map of Nigeria, Plateau State and the location of the veterinary centre where this study was conducted

Chi square (χ^2) test was employed for breed and sex to determine statistical associations.

To have a more precise estimate of the level of variation and more reliable estimates, factor analysis was employed for age groups, years, seasons and disease conditions to transform the bias. The correlation coefficients of the variables were determined. From the correlation matrix, data for the principal component analysis (PCA) were generated which was the primary data required for the PCA. Bartletts test of sphericity was used to test if the correlation matrix was an identity matrix (each variable correlated with itself) or a correlation matrix is full of zero. The Bartlett's sphericity test were used to determine the degree of interrelations between variables and which was sufficient enough to model the multi factor analysis. Factors were rotated using varimax rotation. The factor weights of ≥ 0.80 were considered key markers for decision taking.

Results

Of the 26,844 dogs handled during the period under review, 16,106 (60.0%) were females and 10,738 (40.0%) were males. A total of 17,663 representing 65.8% were positive for one or more parasitic diseases. Yearly prevalence of parasitic diseases varied significantly ($\chi^2 = 1105$, $p < 0.0001$, $df = 9$) and ranged between 52.0 and 85.4% (Table 1). The prevalence of 78.2% (95% CI 77.6–78.9) observed among females was significantly higher ($\chi^2 = 2760$, $p < 0.0001$) than the 47.2% (95% CI 46.2–48.1) observed among males. As in Table 2, the prevalence among indigenous breeds 70.0% (95% CI 69.2–70.7) was also significantly higher ($p < 0.0001$) than that among exotic breeds 60.7% (95% CI 59.8–61.6).

Ancylostomosis, ascariosis, babesiosis, echinococcosis and ecto-parasitism recorded prevalence rates of 15.8, 12.1, 9.4, 9.3 and 8.7%, respectively. Others were 0.4, 4.7, 2.7 and 2.8% for ehrlichiosis, taeniosis, trypanosomosis and mixed infections, respectively (Table 3). The age group 0–12 months recorded the highest prevalence rates of 67.9% while 66.0, 63.1 and 65.4% were observed in dogs

Table 1 Yearly distribution of parasitic diseases reported in dogs between 1986 and 2015

Years	No. of dogs examined (%)	Females (%)	Males (%)	No. positive for parasites	Prev. (%)
1986–1988	1366 (5.1)	820 (3.1)	546 (2.0)	798	58.4
1989–1991	1593 (5.9)	956 (3.6)	637 (2.4)	1085	68.1
1992–1994	1751 (6.5)	1051 (3.9)	700 (2.6)	1140	65.1
1995–1997	2158 (8.0)	1294 (4.8)	864 (3.2)	1297	60.1
1998–2000	2381 (8.9)	1428 (5.3)	953 (3.6)	1238	52.0
2001–2003	2486 (9.3)	1492 (5.6)	994 (3.7)	1723	69.3
2004–2006	3308 (12.3)	1984 (7.4)	1324 (4.9)	2825	85.4
2007–2009	3626 (13.5)	2176 (8.1)	1450 (5.4)	2308	63.7
2010–2012	3819 (14.2)	2291 (8.5)	1528 (5.7)	2784	72.9
2013–2015	4356 (16.2)	2614 (9.7)	1742 (6.5)	2465	56.6
Total	26,844 (100.0)	16,106 (60.0)	10,738 (40.0)	17,663	65.8

$p < 0.0001$, $\chi^2 = 1105$, $df = 9$

Table 2 Breed and sex based prevalence of parasitic diseases reported in dogs between 1986 and 2015

Variable	No. examined	No. positive	Prevalence (%)	95% CI	*p*-value
Sex					
Female	16,106	12,598	78.2	77.6–78.9	
Male	10,738	5065	47.2	46.2–48.1	< 0.0001
Breed					
Exotic	12,080	7331	60.7	59.8–61.6	
Indigenous	14,764	10,332	70.0	69.2–70.7	< 0.0001
Total	26,844	17,663	65.8	65.2–66.4	

Table 3 Age-based prevalence of parasitic diseases reported in dogs between 1986 and 2015

Age (months)	0–12		> 12–24		> 24–36		> 36		All ages
Parasitoses	Cases (%)	95% CI	Cases (%)	95% CI	Cases (%)	95% CI	Cases (%)	95% CI	Overall (%)
N	8067		5815		5409		7553		26,844
Ancylostomosis	1019 (12.6)	11.9–13.4	919 (12.0)	14.9–16.8	922 (17.1)	16.1–18.1	1372 (18.2)	17.3–19.1	4232 (15.8)
Ascariosis	1104 (13.7)	12.9–14.5	699 (12.0)	11.2–12.9	625 (11.6)	10.7–12.4	810 (10.7)	10.0–11.4	3238 (12.1)
Babesiosis	882 (10.9)	10.3–11.6	545 (9.4)	8.6–10.2	388 (7.2)	6.5–7.9	709 (9.4)	8.7–10.1	2524 (9.4)
Echinococcosis	771 (9.6)	8.9–10.2	537 (9.2)	8.5–10.0	480 (8.9)	8.1–9.7	698 (9.2)	8.6–9.9	2486 (9.3)
Ectoparasitism	720 (8.9)	8.3–9.6	502 (8.6)	7.9–9.4	448 (8.3)	7.6–9.1	654 (8.7)	8.0–9.3	2324 (8.7)
Erhlichiosis	36 (0.5)	0.3–0.6	25 (0.4)	0.3–0.6	22 (0.4)	0.3–0.6	33 (0.4)	0.3–0.6	116 (0.4)
Taeniosis	489 (6.1)	5.6–6.6	271 (4.7)	4.1–5.2	242 (4.5)	3.9–5.1	254 (3.4)	3.0–3.8	1256 (4.7)
Trypanosomosis	220 (2.7)	2.4–3.1	154 (2.7)	2.3–3.1	138 (2.6)	2.2–3.0	220 (2.9)	2.6–3.3	732 (2.7)
Mixed infections	234 (2.9)	2.6–3.3	163 (2.8)	2.4–3.3	146 (2.7)	2.3–3.2	212 (2.8)	2.5–3.2	755 (2.8)
Overall (%)	5475 (67.9)	66.8–68.9	3835 (66.0)	64.7–67.2	3411 (63.1)	61.8–64.4	4942 (65.4)	64.4–66.5	17,663 (65.8)

within the age groups > 12–24, > 24–36 and > 36 months, respectively (Table 3).

Seasonal prevalence of parasitic diseases were 65.8, 49.3, 80.5 and 61.4% for early dry, late dry, early rainy and late rainy seasons, respectively (Table 4). Regional distribution of parasitic diseases showed highest (88.0%) and lowest (38.0%) prevalence rates in Barkin Ladi and Riyom, respectively. The highest prevalence rates of

Table 4 Seasonal prevalence of parasitic diseases reported in dogs between 1986 and 2015

Season	Early dry		Late dry		Early rainy		Late rainy		Yearly total	
Year	Cases (%)	95% CI	Cases (%)	95% CI	Cases (%)	95% CI	Cases (%)	95% CI	Cases (%)	95% CI
N	6711		4563		7516		8054		26,844	
1986–1988	117 (1.7)	1.4–2.1	134 (2.9)	2.5–3.5	342 (4.6)	4.1–5.1	205 (2.6)	2.2–2.9	1366 (5.1)	4.8–5.4
1989–1991	196 (2.9)	2.5–3.4	207 (4.5)	4.0–5.2	410 (5.5)	5.0–6.0	272 (3.4)	3.0–3.8	1593 (5.9)	5.7–6.2
1992–1994	285 (4.3)	3.8–4.8	246 (5.4)	4.8–6.1	231 (3.1)	2.7–3.5	378 (4.7)	4.2–5.2	1751 (6.5)	6.2–6.8
1995–1997	324 (4.8)	4.3–5.4	226 (5.0)	4.3–5.6	379 (5.0)	4.6–5.6	368 (4.6)	4.1–5.1	2158 (8.0)	7.7–8.4
1998–2000	309 (4.6)	4.1–5.1	189 (4.1)	3.6–4.8	334 (4.4)	4.0–4.9	406 (5.0)	4.6–5.5	2381 (8.9)	8.5–9.2
2001–2003	430 (6.4)	5.8–7.0	216 (4.7)	4.1–5.4	646 (8.6)	8.0–9.3	431 (5.4)	4.9–5.9	2486 (9.3)	8.9–9.6
2004–2006	709 (10.6)	9.8–11.3	321 (7.0)	6.3–7.8	986 (13.1)	12.4–13.9	812 (10.1)	9.4–10.8	3308 (12.3)	11.9–12.7
2007–2009	577 (8.6)	7.9–9.3	224 (4.9)	4.3–5.6	845 (11.2)	10.5–12.0	662 (8.2)	7.6–8.8	3626 (13.5)	13.1–13.9
2010–2012	850 (12.7)	11.9–13.5	246 (5.4)	4.8–6.1	1001 (13.3)	12.6–14.1	687 (8.5)	7.9–9.2	3819 (14.2)	13.8–14.7
2013–2015	622 (9.3)	8.6–10.0	241 (5.3)	4.7–6.0	878 (11.7)	11.0–12.4	724 (9.0)	8.4–9.6	4356 (16.2)	15.8–16.7
Seasonal total	4416 (65.8)	64.7–66.9	2250 (49.3)	47.9–50.8	6052 (80.5)	79.6–81.4	4945 (61.4)	60.3–62.5	17,663 (65.8)	65.2–66.4

Table 5 Prevalence and geographical distribution of parasitic diseases reported in dogs between 1986 and 2015

Parasitoses	BL	BK	BS	JE	JN	JS	KK	KN	LN	LS	MG	MK	PK	QP	RY	SD	WS
N	1007	921	618	4118	7277	11,142	891	782	406	1122	2461	516	884	821	978	1174	674
Ancylostomosis	19.7	12.1	13.1	21.2	19.6	20.4	6.3	16.1	10.6	10.1	9.1	11.2	10.9	7.4	3.7	10.8	9.9
Ascariosis	11.3	6.8	12.3	14.3	12.5	14.7	9.3	6.0	6.4	6.0	7.8	5.2	15.1	10.0	2.9	13.9	12.3
Babesiosis	17.5	10.4	17.5	11.9	7.0	5.8	8.3	11.3	15.0	12.4	10.6	8.9	8.1	6.9	3.5	8.2	16.5
Echinococcosis	7.2	8.6	7.4	7.8	5.8	12.6	25.9	4.6	9.6	7.3	7.7	3.2	16.0	2.8	2.8	10.7	8.3
Ecto-parasitism	15.7	16.5	7.1	5.2	3.1	12.9	8.1	13.0	23.9	17.3	3.6	2.3	9.6	8.3	1.8	7.5	6.5
Erhlichiosis	0.3	0.9	0.0	1.1	0.4	0.3	0.2	0.0	0.0	1.0	0.2	0.0	0.1	0.6	0.1	0.3	0.6
Taeniosis	8.4	5.7	14.2	5.9	3.9	3.3	4.2	10.1	4.4	5.4	4.8	4.5	4.4	3.8	2.4	8.6	5.2
Trypanosomosis	5.6	1.4	2.8	1.9	1.9	1.7	0.7	1.2	3.7	4.3	0.9	2.5	3.7	6.6	20.7	1.9	5.5
Mixed infections	2.3	4.1	7.6	4.1	2.5	1.8	3.7	3.1	4.2	5.7	2.3	6.2	1.1	5.7	0.3	2.9	3.1
Overall parasitoses	88.0	66.5	82.0	73.3	56.7	73.4	66.7	65.4	77.8	69.4	47.1	44.2	69.0	52.1	38.0	64.7	68.0

BL (Barkin Ladi), BK (Bokkos), BS (Bassa), JE (Jos East), JN (Jos North), JS (Jos South), KK (Kanke), KN (Kanam), LN (Langtang North), LS (Langtang South), MG (Mangu), MK (Mikang), PK (Pankshin), QP (Quanpan), RY (Riyom), SD (Shendam), WS (Wase)

ancylostomosis (20.4%), ascariosis (15.1%) babesiosis (17.5%) erhlichiosis (0.9%), taeniosis (14.2%) and trypanosomosis (20.7%) were observed in Jos South, Pankshin, Barkin Ladi, Bokkos, Bassa and Riyom, respectively (Table 5 and Fig. 2).

Co-infections of haemo and gastrointestinal parasites involving *Ancylostoma caninum* and *Babesia canis* (0.36%), *Ancylostoma caninum* and *Ehrlichia canis* (0.06%), *Ancylostoma caninum* and *Trypanosoma brucei* (0.23%), *Toxocara canis* and *Babesia canis* (0.15%), *Toxocara canis* and *Ehrlichia canis* (0.05%), *Toxocara canis* and *Trypanosoma brucei* (0.26%), *Echinococcus granulosus* and *Babesia canis* (0.33%), *Echinococcus granulosus* and *Trypanosoma brucei* (0.13%), *Taenia hydatigena* and *Babesia canis* (0.41%), *Taenia hydatigena* and *Ehrlichia canis* (0.03%) as well as *Taenia hydatigena* and *Trypanosoma brucei* (0.07%) were observed among 367 of the 17,663 dogs with parasitic infections (Fig. 3). In addition, co-infections of cestodes and nematodes involving *Ancylostoma caninum* and *Echinococcus granulosus* (0.14%), *Ancylostoma caninum* and *Taenia hydatigena* (0.17%), *Toxocara canis* and *Echinococcus granulosus* (0.1%) as well as *Toxocara canis* and *Taenia hydatigena* (0.29%) were among 127 of the 17,663 positive dogs (Fig. 4).

Factor analysis showed that the year group 1986–1988 (96.0%), the age group 0–12 months (97.0%), late rainy season (91.7%) and trypanosomosis (83.6%) had the most significant influence on the prevalence of parasitic diseases of dogs in Plateau State at factor weights of ≥ 80% key markers for decision making.

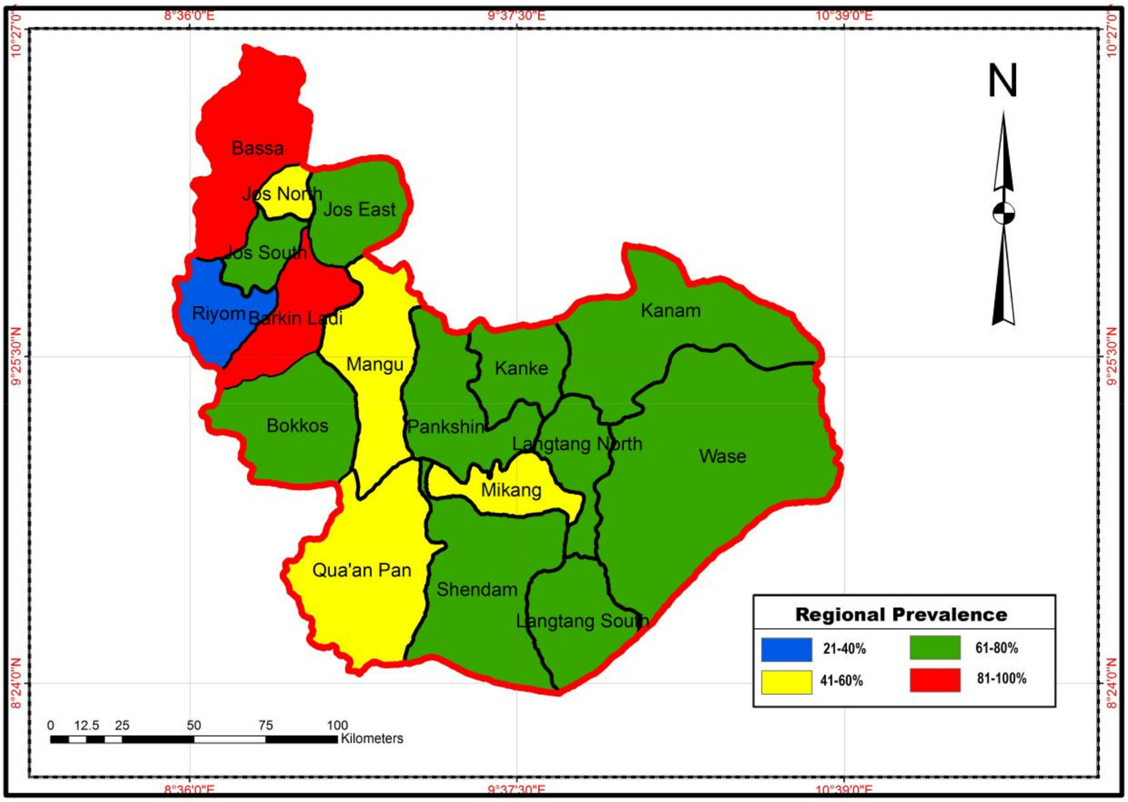

Fig. 2 Regional distribution of parasitic diseases in dogs in Plateau State

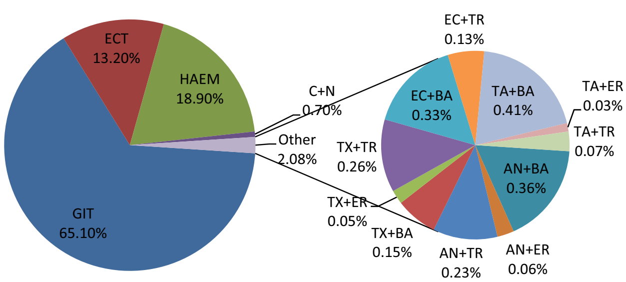

Fig. 3 Distribution of co-infections of haemo and gastrointestinal parasites among the positive dogs. ECT (ecto-parasitism), GIT (gastrointestinal parasitism), HAEM (haemo-parasitism), C + N (co-infections of cestodes and nematodes), AN + BA (co-infections of *Ancylostoma* and *Babesia*), AN + ER (co-infections of *Ancylostoma* and *Ehrlichia*), AN + TR (co-infections of *Ancylostoma* and *Trypanosoma*), TX + BA (co-infections of *Toxocara* and *Babesia*), TX + ER (co-infections of *Toxocara* and *Ehrlichia*), TX + TR (co-infections of *Toxocara* and *Trypanosoma*), EC + BA (co-infections of *Echinococcus* and *Babesia*), EC + TR (co-infections of *Echinococcus* and *Trypanosoma*), TA + BA (co-infections of *Taenia* and *Babesia*), TA + ER (co-infections of *Taenia* and *Ehrlichia*) and TA + TR (co-infections of *Taenia* and *Trypanosoma*)

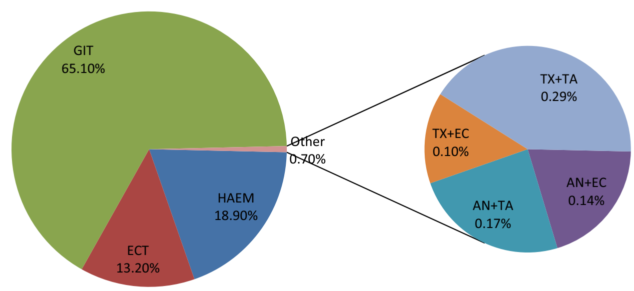

Fig. 4 Distribution of co-infections of cestodes and nematodes among the positive dogs. ECT (ecto-parasitism), GIT (gastrointestinal parasitism), HAEM (haemo-parasitism), AN + EC (co-infections of *Ancylostoma* and *Echinococcus*), AN + TA (co-infections of *Ancylostoma* and *Taenia*), TX + EC (co-infections of *Toxocara* and *Echinococcus*) and TX + TA (co-infections of *Toxocara* and *Taenia*)

Discussion

Epidemiological data are vital for the institution of disease control strategies. The present study provided information on endemic parasitic diseases, their prevalence, seasonal variation and regional distribution in the study area. It is envisaged that this information will provide a good understanding of the prevalence and distribution patterns of parasitic infections in dogs in the region as well as the successes of the present control programmes against these infections. This will in turn direct possible policy review so as to reduce the regional economic and public health problems associated with these infections.

The overall prevalence of 65.8% observed by the present study is high. This might be attributed to the fact that this was a hospital based study that considered dogs that were presented for ill health. The overall prevalence observed is within the range (52.6–73.3%) documented in other resource limited countries (Katagiri and Oliveira-Sequeira 2008; Gugsa et al. 2015; Amissah-Reynolds et al. 2016), but is however higher than the range (16.6–33.3%) reported in industrialized countries (Zanzani et al. 2014; Villeneuve et al. 2015; Rehbein et al. 2016). These variations may be due to differences in levels of hygiene and sanitation as well as control strategies. Due to the wide range of data studied, data from three consecutive years were pulled together for analysis.

The inconsistency in the distribution patterns of parasitic diseases across years may be attributable to factors including environmental conditions such as temperature, humidity, soil moisture, rainfall and human activities which usually influence the occurrence of parasitic diseases. Others may include variations in management practices, prophylactic use of anthelmintics and antiprotozoans, vector control as well as sanitation. The high yearly prevalence observed between 2004 and 2006 may be explained by the average higher precipitation and lower temperature reported by the National Bureau for Statistics in Plateau State during the same period. These factors are known to improve vector breeding and increase environmental survivability of eggs, larvae and oocysts of parasites capable of initiating infections.

The predominance of ancylostomosis over other parasitoses is in line with reports of Mbaya et al. (2008) and Kutdang et al. (2010) in Northern Nigeria, suggesting that this disease may be the commonest parasitic disease of dogs in Nigeria. This predominance may not be unconnected with the multiple modes of infection (faeco-oral, percutaneous, transplacental and trasmammary) utilised by the hookworm responsible for the disease as compared to the others which are transmitted only via the faeco-oral route or requiring arthropod vectors or vertebrate intermediate hosts. Contrary to this finding, Coggins (1998) and Villeneuve et al. (2015) reported predominance of ascariosis in dogs from South-eastern Wisconsin and Canada, respectively. The low rate of co-infections observed might be due to regular strategic deworming by dog owners, host immune system and parasite competition within the host (Uric and Schmid-Hempel 2012).

Though trypanosomosis is well documented in Nigeria (Dede et al. 2005; Shamaki et al. 2009; Majekodunmi et al. 2013; Karshima et al. 2016a), its control strategies concentrates on livestock population and tsetse vectors. Reports of canine trypanosomosis in Nigeria are very scanty; therefore, the present finding suggests the need for the inclusion of canine species also as targets for trypanosomosis control in the region and Nigeria at large. The highest prevalence of trypanosomosis observed in dogs from Riyom was not surprising considering the fact that the region is the most endemic for tsetse flies in the State (Dede et al. 2005). *Trypanosoma brucei* infections in companion dogs is also of great concern especially with unpublished speculations of *T. brucei* infections in humans in Nigeria and substantive evidence of atypical human infections with trypanosomes of animal origin in different parts of the world (Truc et al. 1998; 2007; Joshi et al. 2006; Deborggrave et al. 2008; Parashar et al. 2016). In addition, the identification of *T. brucei* in dogs in this region without further characterization to sub-species levels may also be a concern especially with reports of animal reservoirs of *Trypanosoma brucei gambiense* around the region (Karshima et al. 2012, 2016b) and elsewhere (Njiokou et al. 2010; Simo et al. 2010; Hamill et al. 2013).

Rainy season has been shown to influence the prevalence of parasitic diseases through the provision of favourable environmental conditions such as reduced temperature and increased soil moisture which usually increase vector population and survivability of parasitic eggs, oocysts and larvae in the environment (Odongo-Aginya et al. 2005; Medlock et al. 2006; Andresiuk et al. 2007). These factors might have contributed to the higher prevalence observed during the rainy season. Factors including hormonal differences, genetic makeup and management practices may be possible explanations for the significant variations in the prevalence observed in relation to sex and breed of dogs. The higher prevalence of parasitosis observed in females agrees with earlier reports (Karshima et al. 2010; Kutdang et al. 2010).

The variations in the overall distribution of parasitic diseases across study locations may be attributable to factors including differences in temperature, humidity, altitudes as well as encroachment into wildlife habitats especially through hunting and human settlements arising from increasing population. More so, the differences in the distribution of individual parasitic diseases may be as a result of differences in the levels of sanitation and hygiene as well as abundance of vectors such as ticks and tsetse flies that are required for the transmission of *Babesia*, *Ehrlichia* and *Trypanosoma* species.

The implications of the co-infections of haemo and gastrointestinal parasites especially those of the genus *Ancylostoma* is the risk of severe anaemia in infected dogs. The co-infections of cestodes and nematodes may influence diarrhoea thus increasing environmental contamination by the dogs. It is important to note at this point that the parasitic diseases reported in this study were earlier reported in dogs in Nigeria (Ugochukwu and Ejimadu 1985; Mbaya et al. 2008; Karshima et al. 2010), other parts of Africa (Davoust et al. 2008; Gugsa et al. 2015; Amissah-Reynolds et al. 2016) and elsewhere in the world (Villeneuve et al.

2015; De et al. 2017; Randhawa et al. 2017; Sumbria and Singla 2017) suggesting they are global problems.

The public health implications of the zoonotic parasites identified in this study is the risk of dogs serving as reservoirs of human infections with these parasitic diseases, especially with the fact that dogs are the closest companion animals to man. The association of these parasites with intellectual and cognitive retardation, malnutrition and stunted growth as seen in *Ancylostoma caninum* (Drake et al. 2000; Hotez et al. 2004) and hydatidosis or cystic echinococcosis (*Echinococcus granulosus*) in humans is also of great public health importance since transmission between these dogs and humans is possible. Documented reports in the United States (Conrad 1989), Venezuela (Perez et al. 2006) and Montenegro (Andric 2014) have also shown that *Ehrlichia canis* in companion animals may also be a serious threat to human health. The epidemiological implication of this finding is the risk of environmental contamination which may arise from indiscriminate defecation by these dogs, thereby exposing other animals and humans to these infections.

Factor analysis showed that the year group 1986–1988, the age group 0–12 months, late rainy season and trypanosomosis significantly influenced the prevalence of parasitic diseases of dogs in Plateau State. This suggests that for any control policy and decision to make an impact in the control of parasitic diseases in the region it must target the late rainy season as well as the age group 0–12 months.

Though this study presents vital epidemiological information such as endemic parasites in this region of Nigeria, their prevalence as well as regional, seasonal and yearly variations which are important in disease control decisions, it has a number of limitations. First, data were strictly from animals that were presented for veterinary care. Second, the study relied on the accuracy of the people that diagnosed the parasitic infections and third, the blood films and faecal floatation and sedimentation which were used for the diagnosis of the parasites reported in the study have low sensitivity and specificity. These suggest that this finding might not be the absolute situation in the region and the need for employing molecular techniques in present research in the region to understand the current status of these parasites in the region.

Conclusion

The study revealed high prevalence of parasitic infections during the 30-year period under review. Ancylostomosis recorded the highest prevalence while Barkin Ladi had the highest regional prevalence in the State. Factor analysis showed that dogs aging 0–12 months, the year group 1986–1988, late rainy season and trypanosomosis have the greatest influence on the prevalence of parasitic diseases in Plateau State. It is hoped that this information will help stakeholders and policy makers in understanding the patterns and distribution of parasites in this region which will be useful in discerning disease control strategies in the State.

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Compliance with ethical standards

Conflict of interest The authors declare that there is no conflict of interest.

Ethical approval Approval from the management of the Referral Veterinary Centre following an application to access their records was received before the commencement of the study.

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