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Intestinal parasitic fauna and zoonotic potentials of commonly consumed wildlife

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University of Nigeria, Nsukka, E-mail: ikem.okoye@unn.edu.ng**Article info**Received December 30, 2014
Accepted April 28, 2015**Summary**

A study was carried out in Nsukka cultural zone, Nigeria, with the aim of determining the prevalence, intensity and abundance of intestinal endoparasitic fauna of commonly consumed wildlife or bush-meat. From the 143 wild animals sampled, 141 (98.6 %) were found at least infected with one intestinal parasite. *Ascaris lumbricoides* was the overall most prevalent (48.8 %). *Dicrocoelium hospes* differed significantly in age-related prevalence of infection. Significant sex-related difference in infection ($P < 0.05$) was recorded for *Strongyloides papillosus*, *A. lumbricoides*, *Oesophagostomum columbianum* and *Moniliformis moniliformis* while *Taenia saginata* and *Entamoeba histolytica* showed significant seasonal differences in intensity of infection. The results suggest that bush-meats were hosts of various parasites of medical and veterinary importance. There is need for health inspection of bush-meat for trade and consumption.

Keywords: wildlife; zoonosis; intestinal parasites; prevalence; bush-meat**Introduction**

Meat of wild animals widely referred to as bush-meat has the advantage of having less saturated fat, which makes it healthier than other fatty meats, low calories when compared with beef and pork, high level of Eicosapentaenoic acid, an essential omega-3 fatty acid that has several health benefits and because they grow in natural environments, they are rich in vitamins and minerals. Thus, bush-meat is a good source of organic meat (Oboye, 2013). However, despite these benefits, great caution must be taken when handling or consuming bush-meat. The animals are usually caught in traps, killed by hunters and in some cases, found dead in the bush and sold into the market straight away, without any meat inspection procedures carried out on the carcass by a professional to examine and guarantee that their flesh and organs are free of diseases. These meat can be portable sources of food-borne contaminants and pathogens (Oboye, 2013).

The majority of infectious diseases that have emerged worldwide are considered to be zoonotic, and of these emerging diseases, 70 % are believed to have originated among wildlife (WHO, 2012).

The percentage of wild animals that are carriers for zoonotic diseases is increasing, resulting in a growing concern for human safety and control. Commonly consumed wild life serve as food for man and as reservoir hosts of parasites that cause diseases to man. Informal and unregulated bush-meat supply chain offers a realm of opportunities for human exposure to wildlife that potentially harbour a diversity of zoonotic pathogens. Therefore, possibility of transmission of parasites of the bush-meat to human cannot be overlooked.

Quantitative information regarding bush-meat, as hosts of zoonotic pathogens or their vectors is lacking and needful since information about the distribution of these parasites and their hosts speak to the potential of transmission of human infectious diseases and comparisons of parasite burdens between groups of hosts which is central to understanding host-parasite interactions and transmission patterns.

The present research seeks to fill all these information gaps and in addition, to provide baseline data to assist health planners in developing appropriate evidence-based strategies to prevent and control the spread of zoonotic infections.

Material and Methods

Study sites

The study was carried out between September 2013 and August 2014 in Nsukka cultural zone, Nigeria, located in northern part of Enugu State on longitude 7°08' and 7°20' East and latitude 6°46' and 6°49' North. It is made up of seven densely populated Local Council Areas and an estimated population of 1,377,001. The mean temperatures is hottest in the month of February, at about 87.168F (30.648C), while the lowest temperatures occur in the month of November, reaching 60.548F (15.868C). (Okoye et al., 2011) Also, it has tropical relative humidity, with a mean annual range between 40 and 80 %. The daily and annual peaks occur very early in the morning and during the rainy season, respectively. Collection of faecal samples, sexing and ageing of the animals were carried out at the point of collection from the hunters.

Animal samples collections

A total of 143 commonly consumed wildlife were sampled. These included 33 birds (17 bush fowls (*Francolinus bicalcaratus*), 16 guinea fowls (*Numida meleagris*); 77 mammals (16 striped land squirrels (*Xenus erythropus*), 16 Grasscutters (*Thryonomys swin-*

derianus), 15 wild rabbits (*Oryctolagus cuniculus*), 15 Maxwell's Duikers (*Philantomba maxwellii*) and 15 Grimm's duikers (*Sylvicapra grimmia*) and 33 reptiles (17 African savannah monitor lizards (*Varanus exanthematicus*), 16 Ornate monitor lizards (*Varanus ornatus*). The animals were obtained directly from the kills of 60 hunters. Host terminology follows Dekeyser and Derivot (1966, 1967) for birds; Walker (1999) for mammals and Molnar and Pianka (2004), Koch (2010) for Varanoid lizards.

Laboratory analysis

Faeces were taken from the rectum of freshly killed carcasses or from live animals with the aid of long forceps. The faecal samples were examined within 12 hours after collection. Faeces collected were broken up with applicator sticks to check for adult parasites. Adult parasites recovered were preserved in 10 % formalin. The samples were examined by direct smear to establish the presence of intestinal parasites. A combination of modified stoll's dilution technique and faecal sedimentation technique (Soulsby 1982) were used to examine the faecal samples for ova. Egg counts per gram of faeces (EPG) and oocyst counts per gram of faeces (OPG) were evaluated quantitatively using Modified Stoll's Dilution Technique' as described by Soulsby (1982). The parasites were identified at

Table 1. Overall prevalence and mean intensity of intestinal parasites in Nigeria

Intestinal Parasites	Prevalence (%) (95% CI)	Mean intensity (95% CI)
(a) NEMATODES		
<i>Strongyloides papillosus</i>	21.7 (15.61 – 29.31)	235.48 (183.37 – 306.45)
<i>Capillaria bursata</i>	18.2 (12.5 – 25.46)	215.38 (161.54 – 303.85)
<i>Ascaridia galli</i>	21.7 (15.61 – 29.31)	345.16 (267.74 – 461.29)
<i>Trichuris trichiura</i>	23.1 (16.7 – 30.72)	263.64 (209.09 – 333.33)
<i>Ascaris lumbricoides</i>	48.8 (36.69 – 53.15)	259.38 (217.19 – 310.94)
<i>Heligmosomoides polygyrus</i>	1.4 (0.25 – 5.09)	100.00 (0.00 – 0.00)
<i>Trichostrongylus retortaeformis</i>	11.9 (7.25 – 18.44)	288.24 (194.12 – 417.65)
<i>Enterobius vermicularis</i>	4.2 (1.85 – 8.97)	183.33 (116.67 – 216.67)
<i>Ancylostoma sp</i>	2.1 (0.58 – 6.14)	100.00 (0.00 – 0.00)
<i>Metastrongylus elongatus</i>	21.0 (14.96 – 28.61)	196.67 (156.67 – 253.33)
<i>Globocephalus diducta</i>	4.9 (2.32 – 9.70)	257.14 (128.57 – 442.86)
<i>Oesophagostomum columbianum</i>	7.7 (4.03 – 13.20)	154.55 (109.09 – 200.00)
(b) PLATHYHELMINTHES		
<i>Taenia saginata</i>	4.9 (2.32 – 9.7)	185.71 (114.29 – 314.29)
<i>Hymenolepis nana</i>	5.6 (2.63 – 10.7)	300.00 (175.00 – 500.00)
<i>Dicrocoelium hospes</i>	10.5 (6.15 – 16.69)	146.67 (113.33 – 186.69)
(c) ACANTHOCEPHALANS		
<i>Moniliformis moniliformis</i>	12.6 (7.94 – 19.15)	233.33 (166.67 – 322.22)
(d) PROTOZOANS		
<i>Entamoeba histolytica</i>	9.8 (5.85 – 15.98)	171.43 (121.43 – 228.59)
<i>Eimeria tenella</i>	9.1 (5.1 – 14.95)	500.00 (307.69 – 961.54)

Table 2. Prevalence of intestinal parasites in different wildlife species in Nigeria

Bush-meat sampled	Aves			Reptiles			Small mammals			Ungulates			P value
	<i>F. bicaratus</i>	<i>N. meleagris</i>	<i>V. ornatus</i>	<i>V. exanthimaticus</i>	<i>T. swinderianus</i>	<i>X. erythropus</i>	<i>O. cuniculus</i>	<i>P. maxwellii</i>	<i>S. grimmia</i>	<i>P. maxwellii</i>	<i>S. grimmia</i>	<i>P. maxwellii</i>	
Number examined	17	16	16	17	16	16	15	15	15	15	15	15	
(a) NEMATODES													
<i>Strongyloides papillosus</i>	13(76.5)	0(0)	7(43.8)	0(0)	0(0)	0(0)	0(0)	2(13.3)	9(60.0)	0.0001			
<i>Capillaria bursata</i>	4(23.5)	8(50.0)	0(0)	10(58.8)	0(0)	0(0)	0(0)	0(0)	0(0)	0.0001			
<i>Ascaridia galli</i>	15(88.2)	16(100)	0(0)	0(0)	0(0)	0(0)	0(0)	0(0)	0(0)	0.0001			
<i>Trichuris trichiura</i>	0(0)	0(0)	9(56.2)	5(29.4)	8(50.0)	9(56.2)	0(0)	0(0)	0(0)	0.0001			
<i>Ascaris lumbricoides</i>	0(0)	11(68.8)	9(56.2)	10(58.8)	7(43.8)	9(56.2)	0(0)	8(53.3)	7(46.7)	0.0001			
<i>Heligmosomoides polygyrus</i>	0(0)	0(0)	0(0)	0(0)	0(0)	2(12.5)	0(0)	0(0)	0(0)	0.0001			
<i>Trichostrongylus retortaeformis</i>	0(0)	0(0)	0(0)	0(0)	0(0)	0(0)	13(86.7)	0(0)	4(26.7)	0.0001			
<i>Enterobius vermicularis</i>	0(0)	0(0)	0(0)	0(0)	0(0)	0(0)	6(40.0)	0(0)	0(0)	0.0001			
<i>Ancylostoma sp</i>	0(0)	0(0)	0(0)	0(0)	0(0)	0(0)	3(20.0)	0(0)	0(0)	0.0001			
<i>Metastrongylus elongatus</i>	0(0)	0(0)	0(0)	0(0)	9(56.2)	0(0)	0(0)	10(66.7)	9(60.0)	0.0001			
<i>Globocephalus diducta</i>	0(0)	0(0)	0(0)	0(0)	6(37.5)	0(0)	0(0)	0(0)	0(0)	0.0001			
<i>Oesophagostomum columbianum</i>	0(0)	0(0)	0(0)	0(0)	6(37.5)	0(0)	0(0)	0(0)	4(26.7)	0.0001			
(b) PLATHYHELMINTHES													
<i>Taenia saginata</i>	0(0)	0(0)	0(0)	0(0)	0(0)	0(0)	7(46.7)	0(0)	0(0)	0.0001			
<i>Hymenolepis nana</i>	0(0)	0(0)	0(0)	0(0)	0(0)	8(50.0)	0(0)	0(0)	0(0)	0.0001			
<i>Dicrocoelium hospes</i>	0(0)	0(0)	0(0)	6(35.3)	0(0)	0(0)	9(60.0)	0(0)	0(0)	0.0001			
(c) ACANTHOCEPHALANS													
<i>Moniliformis moniliformis</i>	0(0)	0(0)	0(0)	0(0)	5(31.2)	12(75.0)	0(0)	0(0)	0(0)	0.0001			
(d) PROTOZOANS													
<i>Entamoeba histolytica</i>	0(0)	0(0)	6(37.5)	8(47.1)	0(0)	0(0)	0(0)	0(0)	0(0)	0.0001			
<i>Eimeria tenella</i>	6(35.3)	6(37.5)	0(0)	0(0)	0(0)	0(0)	0(0)	0(0)	0(0)	0.0001			

The comparison is among or between those that have the parasites

Table 3. Mean intensity of intestinal parasites in different wildlife species in Nigeria

Bush-meat sampled	Aves			Reptiles			Small mammals			Ungulates							
	<i>F. bicalcaratus</i>	<i>N. meleagris</i>	<i>V. ornatus</i>	<i>V. exanthimaticus</i>	<i>T. swinderianus</i>	<i>X. erythropus</i>	<i>O. cuniculus</i>	<i>P. maxwellii</i>	<i>S. grimmia</i>	Number examined	17	16	17	16	16	15	15
NEMATODES																	
<i>Strongyloides papillosus</i>	307.69±54.84(13) ^a	0	157.14±29.74(7) ^a	0	0	0	0	0	0	0	0	0	0	0	100.00±0.00(2) ^a	222.22±59.97(9) ^a	0
<i>Capillaria bursata</i>	280.00±86.01(15) ^b	137.05±86.31(8) ^b	0	238.57±63.57(13) ^b	0	0	0	0	0	0	0	0	0	0	0	0	0
<i>Ascaridia galli</i>	366.67±86.01(15) ^b	325.00±56.64(13) ^a	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
<i>Trichuris trichiura</i>	0	0	310±64.03(10) ^a	200.00±51.64(6) ^a	162.80±49.77(8) ^a	344.44±74.74(9) ^a	0	0	0	0	0	0	0	0	0	0	0
<i>Ascaris lumbricoides</i>	277.78±79.54(9) ^a	209.09±39.21(11) ^b	233.33±66.67(9) ^a	241.67±54.29(12) ^a	257.14±75.14(7) ^a	0	0	0	0	0	0	0	0	0	333.33±83.33(9) ^a	285.71±79.96(7) ^a	0
<i>Heligmosomoides polygyrus</i>	0	0	0	0	0	100.00±0.00(2) [*]	0	0	0	0	0	0	0	0	0	0	0
<i>Trichostrongylus retortaeformis</i>	0	0	0	0	0	0	0	0	0	0	0	32.08±73.51(13) ^a	0	0	0	175.00±47.87(4) ^a	0
<i>Enterobius vermicularis</i>	0	0	0	0	0	0	0	0	0	0	0	183.33±75.28(6) [*]	0	0	0	0	0
<i>Ancylostoma sp</i>	0	0	0	0	0	0	0	0	0	0	0	100.00±0.00(3) [*]	0	0	0	0	0
<i>Metastrongylus elongatus</i>	0	0	0	0	144.44±17.50(9) ^a	0	0	0	0	0	0	0	0	0	260±60.00(10) ^a	181.82±32.33(11) ^a	0
<i>Globocephalus dictycta</i>	0	0	0	0	257.14±86.90 [*]	0	0	0	0	0	0	0	0	0	0	0	0
<i>Oesophagostomum columbianum</i>	0	0	0	0	142.86±29.74(8) ^a	0	0	0	0	0	0	0	0	0	0	175.00±47.87(9) ^a	0
PLATHYHELMINTHES																	
<i>Taenia saginata</i>	0	0	0	0	0	0	0	0	0	0	0	185.71±00.00(7) [*]	0	0	0	0	0
<i>Hymenolepis nana</i>	0	0	0	0	0	300.00±84.51(2) [*]	0	0	0	0	0	0	0	0	0	0	0
<i>Dicrocoelium hospes</i>	0	0	0	150.00±34.15(6) ^a	0	0	144.44±24.21(9) ^a	0	0	0	0	0	0	0	0	0	0
ACANTHOCEPHALANS																	
<i>Moniliformis moniliformis</i>	0	0	0	0	250.00±84.65(6) ^a	255.00±47.87(12) ^a	0	0	0	0	0	0	0	0	0	0	0
PROTOZOANS																	
<i>Entamoeba histolytica</i>	0	0	133.33±33.33(6) ^a	200.00±42.25(8) ^a	0	0	0	0	0	0	0	0	0	0	0	0	0
<i>Eimeria tenella</i>	683.33±303.77(6) ^a	342.86±84.11(7) ^a	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

The comparison is among or between those that have the parasites; Results expressed as Mean±S.E.; number in bracket (n) = number infected; Mean values in a row with similar alphabets are not significantly different (P>0.05); *no comparison

least to genus level based on standard morphological characteristics (Sloss *et al.*, 2004; Lynne and David, 2005) and the representative image of the parasites were captured using motif cam.

Statistical analysis

The data was keyed into excel and checked for missing data. Overall prevalence and confidence interval were obtained using Quantitative Parasitology (version 3.0). The prevalence of intestinal parasites were determined using Chi square test from the contingency tables while Fisher's exact test was used to calculate significant difference in prevalence for age, sex and season. One way ANOVA was used to determine significant difference in intensity and abundance for animal species. Independent t-test was used to compare intensity and abundance of parasites by age, sex and season. Analysis was done using SPSS (version 20.0) statistical software. Significant difference was set at $P = 0.05$ and all tests were performed with a 95 % confidence level.

Results

Overall prevalence, mean abundance and mean intensity

Overall, nineteen genera of intestinal parasites which belong to four phyla; nematode, platyhelminthes, acanthocephalan and protozoa were found infecting commonly consumed bush-meat in the study area (Table 1). Infection with the nematode, *A. lumbricoides* was the most prevalent (48.8 % at 36.69 – 53.15 mean interval (95 %), mean abundance of 116.08 (89.51 – 148.95). The highest mean intensity was recorded for *Eimeria tenella* and recovered from birds only (500.00, 95 % confidence interval 307.65 – 961.54). Nematode parasites *Heligomosomoides polygyrus* had the least prevalence (1.4 %), least mean intensity (100.00) and least mean abundance (1.40) at 95 % confidence interval of (0.25 – 5.09) (0.00 – 0.00) and (0.00 – 3.50) respectively and recovered from one out of nine different phyla of animals sampled. *D. hospes* was the most prevalent platyhelminthes parasites recorded while *H. nana* was highest in intensity and abundance.

Prevalence of intestinal parasites

Prevalence of intestinal parasites in different wild animal species collected is presented in (Table 2). In animals infected with *S. papillosus*, the prevalence was highest in *F. bicalcaratus* (76.5 %) followed by *V. ornatu*s (43.8 %) and least in *P. maxwellii* (13.3 %). In bush-meat infected with *Capillaria bursata*, the prevalence was highest in *V. exanthimaticus* (58.8 %) followed by *N. meleagris* (50 %) and least in *F. bicalcaratus* (23.5 %). In bush-meat infected with *Ascaridia galli*, the prevalence was higher in *N. meleagris* (100 %) than in *F. bicalcaratus*. In bush-meat infected with *Trichuris trichiura* prevalence was highest in *X. erythropus* and *V. exanthimaticus* (56.2 %) and least in (29.4 %). In bush-meat infected with *A. lumbricoides*, prevalence was highest in *N. meleagris* (68.8 %) and least in *T. swinderianus* (43.8 %). In bush-meat infected with *Trichostrongylus retortaeformis*, prevalence was higher in *O. cuniculus* sp (86.7 %) than *S. grimmia*. In bush-meat infected with *Metastrongylus elongatus*, prevalence was highest in *P. Maxwellii* (66.7 %) and least in *T. swinderianus* (56.2 %). In bush-meat infected with *Oesophagostomum columbianum*, prevalence was

higher in *T. swinderianus* (37.5 %) than in *S. grimmia*. In bush-meat infected with *D. hospes*, the prevalence was higher in *O. cuniculus* (60.0 %) than *V. exanthimaticus*. In bush-meat infected with *M. moniliformis*, the prevalence was higher in *X. erythropus* (75.0 %) than in *T. swinderianus*. In bush-meat infected with *E. histolytica*, prevalence was higher in *V. exanthimaticus* (47.1 %) than in *V. ornatu*s. In bush-meat infected with *Eimeria* sp, prevalence was higher in *N. meleagris* (37.5 %) than in *F. bicalcaratus*. The comparison was among or between those that had the parasites and there were significant differences in each of the comparison ($P < 0.05$).

Mean intensity of intestinal parasites

The intensity of intestinal parasites in different wild animal species collected is presented in (Table 3). *F. bicalcaratus* had the highest intensity of *S. papillosus*, highest intensity of *Capillaria bursata* and highest intensity of *A. galli* when compared with the other animals that had any of these parasites. While *X. erythropus* had the highest intensity of *T. trichiura* and *M. moniliformis* when compared with the other animals that had any of these parasites and again *P. maxwellii* had the highest intensity of *A. lumbricoides* and *Metastrongylus elongatus* when compared with the other animals that had any of these parasites. *S. grimmia* had the highest intensity of *Trichostrongylus retortaeformis* and *O. columbianum* when compared with the other animals that had any of these parasites. but *V. exanthimaticus* sp had the highest intensity of *D. hospes* and *E. histolytica*, when compared with the other animals that had any of these parasites. Overall, no significant differences in intensity were observed in comparison between or among the animals that had the same parasites. ($P > 0.05$).

Mean abundance of intestinal parasites

The mean abundance of *S. papillosus* in wild animals showed that *F. bicalcaratus* had significantly ($P < 0.05$) high mean abundance of *S. papillosus* when compared to other wild animals. (Table 4). The mean abundance of *S. papillosus* in *S. grimmia* and *V. ornatu*s were not differed significantly ($P > 0.05$). *P. Maxwellii* had the least mean abundance of *S. papillosus*. The mean abundance of *A. lumbricoides* in wild animals did not differ significantly ($P > 0.05$) while mean abundance of *C. bursata*, *A. galli*, *T. trichiura*, *Trichostrongylus retortaeformis*, *Metastrongylus elongatus*, *Oesophagostomum columbianum*, *M. moniliformis*, *E. histolytica* and *E. tenella* differed significantly ($P < 0.05$).

Prevalence of intestinal parasites based on season, sex and age

The prevalence of infection between season, sex and age among the bush-meat are presented in (Table 5). The effect of season on the prevalence of endoparasites of bush-meat showed that all parasites prevalence in bush-meat were higher in rainy season than in the dry season for all parasites examined except *A. galli*, *A. lumbricoides*, *Heligomosomoides polygyrus*, *Trichostrongylus retortaeformis*, *Globocephalus diducta*, *O. columbianum* and *M. moniliformis* that were more in dry season but there was no statistical difference between seasons in the prevalence of any of the parasites ($P > 0.05$). The effect of sex on the prevalence of endoparasites of bush-meat showed that apart from *A. galli* and *T. gag-*

Table 4. Mean abundance of intestinal parasites in different wildlife species in Nigeria

Bush-meat sampled	Aves			Reptiles			Small mammals			Ungulates		
	<i>F. bicalcaratus</i>	<i>N. meleagris</i>	<i>V. ornatus</i>	<i>V. exanthimaticus</i>	<i>T. swinderianus</i>	<i>X. erythropus</i>	<i>O. cuniculus</i>	<i>P. maxwellii</i>	<i>S. grimmia</i>			
	17	16	16	17	16	16	15	15	15			
a) NEMATODES												
<i>Strongyloides papillosus</i>	235.29±52.81 ^a	0	68.75±23.66 ^{bc}	0	0	0	0	13.33±9.08 ^c	133.33±45.40 ^b	0		
<i>Capillaria bursata</i>	82.35±38.57 ^a	68.75±21.83 ^a	0	182.35±54.39 ^b	0	0	0	0	0	0		
<i>Ascaridia galli</i>	323.53±81.13 ^a	325±56.64 ^a	0	0	0	0	0	0	0	0		
<i>Trichuris trichiura</i>	0	0	193.75±55.12 ^a	70.59±29.42 ^b	81.25±31.91 ^b	193.75±60.18 ^a	0	0	0	0		
<i>Ascaris lumbricoides</i>	0	156.25±56.25 ^a	143.75±36.47 ^a	131.25±47.18 ^a	170.59±46.78 ^a	0	200.00±65.46 ^a	112.60±45.52 ^a	133.33±52.25 ^a	0		
<i>Heligmosomoides polygyrus</i>	0	0	0	0	0	12.50±8.53 [*]	0	0	0	0		
<i>Trichostrongylus retortaeformis</i>	0	0	0	0	0	0	280±69.83 ^a	0	46.67±23.63 ^b	0		
<i>Enterobius vermicularis</i>	0	0	0	0	0	0	73.33±26.66 [*]	0	0	0		
<i>Ancylostoma sp</i>	0	0	0	0	0	0	20.00±10.69 [*]	0	0	0		
<i>Metastrongylus elongatus</i>	0	0	0	0	81.25±20.85 ^b	0	0	173.33±51.14 ^a	133.33±31.87 ^c	0		
<i>Globocephalus diducta</i>	0	0	0	0	122.50±49.05 [*]	0	0	0	0	0		
<i>Oesophagostomum columbianum</i>	0	0	0	0	65.50±22.12 ^a	0	0	0	46.67±23.63 ^b	0		
(b) PLATHYHELMINTHES												
<i>Taenia saginata</i>	0	0	0	0	0	0	86.67±35.00 [*]	0	0	0		
<i>Hymenolepis nana</i>	0	0	0	0	0	150.00±52.27 [*]	0	0	0	0		
<i>Dicrocoelium hospes</i>	0	0	0	52.94±21.20 ^a	0	0	86.67±23.63 ^b	0	0	0		
(c) ACANTHOCEPHALANS												
<i>Moniliiformis moniliiformis</i>	0	0	0	0	93.75±43.27 ^b	168.75±43.51 ^a	0	0	0	0		
(d) PROTOZOANS												
<i>Entamoeba histolytica</i>	0	0	50.00±20.41 ^a	94.12±31.47 ^b	0	0	0	0	0	0		
<i>Eimeria tenella</i>	241.18±129.77 ^a	150.00±56.27 ^b	0	0	0	0	0	0	0	0		

The comparison is among or between those that have the parasites; Results expressed as Mean±S.E; Mean values in a row with similar alphabets are not significantly different (P>0.05); *no comparison

Table 5. Prevalence of Intestinal parasites in wildlife based on season, sex and age in Nigeria

Parasites recovered	SEASON			SEX			AGE		
	Dry	Rainy	P value	Male	Female	P value	Juvenile	Adult	P value
(a) NEMATODES									
<i>Strongyloides papillosus</i>	13(16.5)	18(28.1)	0.092	14(20.0)	17(23.3)	0.633	13(19.1)	18(24.0)	0.479
<i>Capillaria bursata</i>	11(13.9)	11(17.2)	0.591	11(15.7)	11(15.1)	0.915	8(11.8)	14(18.7)	0.253
<i>Ascaridia galli</i>	16(20.3)	15(23.4)	0.644	18(25.7)	13(17.8)	0.251	14(20.6)	17(22.7)	0.763
<i>Trichuris trichiura</i>	13(16.5)	18(28.1)	0.092	12(17.1)	19(26.0)	0.197	12(17.6)	19(25.3)	0.265
<i>Ascaris lumbricoides</i>	38(48.1)	23(35.9)	0.144	29(41.4)	32(43.8)	0.771	22(32.4)	39(52.0)	0.018
<i>Heligmosomoides polygyrus</i>	2(2.5)	0(0)	0.2	2(2.9)	0(0)	0.146	1(1.5)	1(1.3)	0.944
<i>Trichostrongylus retortaeformis</i>	9(11.4)	8(12.5)	0.839	8(11.4)	9(12.3)	0.868	7(10.3)	10(13.3)	0.575
<i>Enterobius vermicularis</i>	2(2.5)	4(6.2)	0.27	4(5.7)	2(2.7)	0.375	1(1.5)	5(6.7)	0.122
<i>Ancylostoma sp</i>	1(1.3)	2(3.1)	0.44	1(1.4)	2(2.7)	0.584	1(1.5)	2(2.7)	0.618
<i>Metastrongylus elongatus</i>	14(17.7)	14(21.9)	0.534	14(20.0)	14(19.2)	0.901	14(20.6)	14(18.7)	0.772
<i>Globocephalus diducta</i>	5(6.3)	1(1.6)	0.157	2(2.9)	4(5.5)	0.434	2(2.9)	4(5.3)	0.476
<i>Oesophagostomum columbianum</i>	8(10.1)	2(3.1)	0.103	2(2.9)	8(11.0)	0.058	4(5.9)	6(8.0)	0.62
(b) PLATHYHELMINTHES									
<i>Taenia saginata</i>	3(3.8)	4(6.2)	0.499	3(4.3)	4(5.5)	0.741	1(1.5)	6(8.0)	0.071
<i>Hymenolepis nana</i>	4(5.1)	4(6.2)	0.759	2(2.9)	6(8.2)	0.163	2(2.9)	6(8.0)	0.189
<i>Dicrocoelium hospes</i>	7(8.9)	8(12.5)	0.48	11(15.7)	4(5.5)	0.046	7(10.3)	8(10.7)	0.942
(c) ACANTHOCEPHALANS									
<i>Moniliformis moniliformis</i>	11(13.9)	6(9.4)	0.403	6(8.6)	11(15.1)	0.23	8(11.8)	9(12.0)	0.965
(d) PROTOZOANS									
<i>Entamoeba histolytica</i>	5(6.3)	9(14.1)	0.122	6(8.6)	8(11.0)	8(11.0)	6(8.8)	8(10.7)	0.711
<i>Eimeria tenella</i>	5(6.3)	7(10.9)	0.323	8(11.4)	4(5.5)	4(5.5)	4(5.9)	8(10.7)	0.303

The comparison is between season (dry and rainy), sex(male and female), age(juvenile and adult)

inata that had non significant higher prevalence in male animals than in female animals, all other parasites gave higher prevalence in the female animals and were also non significant ($P > 0.05$) except *D. hospes* ($P < 0.05$). The effect of age on the prevalence of endoparasites of bush-meat showed that all the parasites were not significant in difference between age class in animals except *A. lumbricoides* ($P < 0.05$) that was statistically higher in adult animals than in the juvenile animals.

Intensity of intestinal parasites based on season, sex and age

The intensity of infection between season, sex and age among the bush-meat are presented in (Table 6). Among the eggs and oocysts recovered, *A. galli* had highest mean intensity in dry season and in male while *H. nana* had the highest in rainy season and in female, *Globocephalus diducta* had highest intensity in juvenile while the highest intensity was recorded for *Trichostrongylus retortaeformis* in adult. *Heligmosomoides polygyrus* and *A. duodenale* were the

least in intensity in two seasons, for both sexes and in age class. The difference in seasons did not show statistical difference except in *T. saginata* and *E. histolytica* where ($p < 0.05$) and differed more in rainy season. The effect of age on the intensity did not differ between juvenile and adult animals ($P > 0.05$) and did not differ in male and in female animals except for *S. papillosus*, *A. lumbricoides*, *O. columbianum* and *M. moniliformis* that showed significant difference ($P < 0.05$).

Abundance of intestinal parasites based on season, sex and age

The abundance of infection between season, sex and age among the bush-meat are presented in (Table 7). Among the parasites recovered, *A. lumbricoides* had highest mean abundance in the two seasons, for both sexes and in juvenile and adult while *Heligmosomoides sp* had the least. The difference in all parameters (season, sex and age) did not show statistical difference in variation ($P > 0.05$) except in season effect on *E. histolytica*, which differed

Table 6. Intensity of intestinal parasites in wildlife based on season, sex and age in Nigeria

Parasites recovered	SEASON			SEX		AGE		
	Dry	Rainy		Male	Female	Juvenile	Adult	
(a) NEMATODES								
<i>Strongyloides papillosus</i>	230.77±45.83(13) ^a	238.89±43.64(18) ^a		271.43±58.76(14) ^c	271.43±58.76(17) ^d	223.08±37.81(13) ^e	244.44±47.29(18) ^e	
<i>Capillaria bursata</i>	200.00±33.80(15) ^a	236.36±75.40(11) ^a		191.67±65.66(12) ^c	235.71±40.06(14) ^c	218.18±42.25(11) ^e	213.33±56.79(15) ^e	
<i>Ascaridia galli</i>	341.18±84.47(17) ^a	350.00±46.58(14) ^a		347.06±52.94(17) ^c	342.86±93.00(14) ^c	335.71±91.15(14) ^e	352.94±54.98(17) ^e	
<i>Trichuris trichiura</i>	268.75±49.76(16) ^a	258.82±46.22(16) ^a		190.00±34.80(10) ^c	295.65±44.22(23) ^c	216.67±42.34(12) ^e	290.48±46.24(21) ^e	
<i>Ascaris lumbricoides</i>	263.41±32.33(41) ^a	252.17±37.65(23) ^a		300.00±41.73(31) ^c	221.21±26.02(33) ^d	233.33±29.23(27) ^e	278.38±36.788(37) ^e	
<i>Heligmosomoides polygyrus</i>	100.00±00.00*	00.00±00.00*		100.00±00.00*	00.00±00.00*	100.00±00.00*	100.00±00.00*	
<i>Trichostrongylus retortaeformis</i>	262.50±90.50(8) ^a	311.11±80.69(9) ^a		300.00±280(7) ^c	280.00±89.19(10) ^c	214.29±98.63(7) ^e	340.00±71.80(10) ^e	
<i>Enterobius vermicularis</i>	150.00±50.00(2) ^a	200.00±40.82(4) ^a		200.00±40.82(4) ^c	150.00±50.00(2) ^c	200.00±00.00(1) ^e	180.00±37.41(5) ^e	
<i>Ancylostoma sp</i>	100.00±00.00*	100.00±00.00*		100.00±00.00*	100.00±00.00*	100.00±00.00*	100.00±00.00*	
<i>Metastrongylus elongatus</i>	225.00±4031(16) ^a	164.29±24.82(14) ^a		207.14±43.80(14) ^c	187.50±27.195(16) ^c	164.29±26.94(14) ^e	225.00±39.26(16) ^e	
<i>Globocephalus diducta</i>	283.33±98.03(6) ^a	100.00±00.00(1) ^a		200.00±100.00(2) ^c	280.00±120.00(5) ^c	366.67±176.38(3) ^e	175.00±75.00(4) ^e	
<i>Oesophagostomum columbianum</i>	150.00±34.15(6) ^a	160.00±40.00(5) ^a		100.00±00.00(4) ^c	185.71±34.00(d)	157.14±29.73(7) ^e	150.00±50.00(4) ^e	
(b) PLATHYHELMINTHES								
<i>Taenia saginata</i>	266.67±120.18(3) ^a	125.00±25.00(4) ^b		133.33±33.33(3) ^c	225.00±94.64(4) ^c	100.00±00.00(1) ^e	200.00±63.24(6) ^e	
<i>Hymenolepis nana</i>	175.00±47.87(4) ^a	425.00±143.61(4) ^a		150.00±50.00(2) ^c	350.00±105.67(6) ^c	250.00±50.00(2) ^e	316.67±113.77(6) ^e	
<i>Dicrocoelium hospes</i>	142.86±29.73(7) ^a	150.00±26.72(8) ^a		145.45±20.73(11) ^c	150.00±50.00(4) ^c	171.43±35.95(7) ^e	125.00±16.36(8) ^e	
(c) ACANTHOCEPHALANS								
<i>Moniliformis moniliformis</i>	245.45±54.54(11) ^a	214.29±67.00(7) ^a		312.50±78.91(8) ^c	170.00±30.00(10) ^d	250.00±70.71(8) ^e	220.00±51.20(10) ^e	
(d) PROTOZOANS								
<i>Entamoeba histolytica</i>	100.00±00.00(5) ^a	211.11±38.88(9) ^b		200.00±44.72(6) ^c	150.00±37.79(8) ^c	166.67±42.16(6) ^e	175.00±41.18(8) ^e	
<i>Eimeria tenella</i>	750.00±288.38(6) ^a	285.71±76.93(7) ^a		571.43±264.318(7) ^c	416.67±119.49(6) ^c	666.67±304.40(6) ^e	357.14±81.23(7) ^e	

The comparison is between season (dry and rainy), sex (male and female), age (juvenile and adult); Results expressed as Mean±S.E; number in bracket (n)= number infected; Mean values in a row with similar alphabets are not significantly different (P>0.05); *no comparison

Table 7. Abundance of Intestinal parasites in wildlife based on season, sex and age in Nigeria

Parasites recovered	SEASON		SEX		AGE	
	Dry	Rainy	Male	Female	Juvenile	Adult
(a) NEMATODES						
<i>Strongyloides papillosus</i>	43.04±13.32 ^a	60.94±16.9 ^a	54.29±17.34 ^c	47.95±12.35 ^c	42.65±12.79 ^e	58.69±16.45 ^e
<i>Capillaria bursata</i>	27.85±8.43 ^a	53.13±18.63 ^a	38.57±15.40 ^c	39.73±11.66 ^c	26.47±10.39 ^e	50.67±15.58 ^e
<i>Ascaridia galli</i>	63.29±17.76 ^a	89.06±28.44 ^a	82.86±21.33 ^c	67.12±23.97 ^c	42.65±12.62 ^e	104±28.05 ^e
<i>Trichuris trichiura</i>	48.10±14.62 ^a	76.56±19.88 ^a	35.71±11.51 ^c	84.93±20.52 ^d	35.29±10.63 ^e	84.00±20.53 ^f
<i>Ascaris lumbricoides</i>	129.11±21.02 ^a	100.00±22.60 ^a	132.86±26.03 ^c	100.00±16.8 ^c	66.18±14.90 ^e	161.33±25.03 ^f
<i>Heligmosomoides polygyrus</i>	2.53±1.77 [*]	0.00±0.00 [*]	2.86±2.00 [*]	0.00±0.00 [*]	1.47±1.47 ^e	1.33±1.33 ^e
<i>Trichostrongylus retortaeformis</i>	26.58±43.75 ^a	43.75±17.51 ^a	31.43±12.79 ^c	36.99±16.26 ^c	23.53±12.59 ^e	44.00±16.13 ^e
<i>Enterobius vermicularis</i>	3.80±2.81 ^a	12.50±6.49 ^a	11.43±5.94 ^c	4.11±3.04 ^c	2.94±2.94 ^e	12.00±5.68 ^e
<i>Ancylostoma sp</i>	1.27±1.26 ^a	3.13±2.19 ^a	1.43±1.42 ^c	2.74±1.92 ^c	1.47±1.47 ^e	2.67±1.87 ^e
<i>Metastrongylus elongatus</i>	45.57±12.58 ^a	35.94±10.76 ^a	42.86±13.43 ^c	39.73±10.45 ^c	33.82±9.27 ^e	48.00±13.73 ^e
<i>Globocephalus diducta</i>	13.92±6.67 ^a	10.94±10.93 ^a	2.86±2.00 ^c	21.92±11.74 ^c	5.88±4.63 ^e	18.67±4.63 ^e
<i>Oesophagostomum columbianum</i>	15.19±5.72 ^a	7.81±5.13 ^a	8.57±6.01 ^c	15.07±5.03 ^c	7.35±3.81 ^e	16.00±6.58 ^e
(b) PLATHYHELMINTHES						
<i>Taenia saginata</i>	10.13±6.88 ^a	7.81±4.04 ^a	5.71±3.45 ^c	12.33±7.54 ^c	1.47±1.47 ^e	16.00±7.83 ^e
<i>Hymenolepis nana</i>	8.86±4.83 ^a	26.56±15.14 ^a	4.29±3.17 ^c	28.77±13.85 ^c	7.35±5.26 ^e	25.33±13.02 ^e
<i>Dicrocoelium hospes</i>	12.66±5.21 ^a	18.75±6.99 ^a	22.86±7.09 ^c	8.22±4.67 ^c	17.65±7.24 ^e	13.33±4.77 ^e
(c) ACANTHOCEPHALANS						
<i>Moniliformis moniliformis</i>	34.18±12.07 ^a	23.44±10.85 ^a	34.29±14.65 ^c	24.66±7.99 ^c	29.41±12.58 ^e	29.33±10.86 ^e
(d) PROTOZOANS						
<i>Entamoeba histolytica</i>	6.33±2.75 ^a	29.69±10.60 ^b	17.14±7.60 ^c	16.44±6.76 ^c	14.71±6.71 ^e	18.67±7.52 ^e
<i>Eimeria tenella</i>	22.78±10.18 ^a	73.44±37.48 ^a	71.43±33.38 ^c	20.55±13.22 ^c	13.24±6.91 ^e	74.67±32.99 ^e

The comparison is between season (dry and rainy), sex (male and female), age (juvenile and adult); Results expressed as Mean±S.E; Mean values in a row with similar alphabets are not

more in rainy season, sex effect on *T. trichiura* that differed more in female and effect of age on the abundance of *T. trichiura* and *A. lumbricoides* which differed more in adult where $P < 0.05$.

Discussion

This study has provided for the first time detailed quantitative data on intestinal endoparasitic fauna of commonly consumed wildlife (bush-meat) hosts, which are relatively poorly studied and documented. The results revealed that animals from the wild are heavily infected with parasites that can be transmitted to their offspring and other mammals, including humans that may be exposed to them. This poses health problems to humans. The fact that most of the animals examined have lived together in same ecological zone for a long time may explain the finding of similar parasites in

different animal types. Many of these animals share many things in common and thus could easily have shared infection among themselves.

Apart from hookworm, which is well known to be transmitted through soil-contaminated hands, all the other species of intestinal parasites found are transmitted through contaminated food and water, and mostly cause diseases with symptoms of anaemia, diarrhoea and weight loss (Roberts *et al.*, 2010). Only one trematode, *D. hospes* (10.5 %) was recovered during this study. This might be due to the fact that most of the animals sampled do not normally feed on aquatic vegetation.

This study recorded the presence of *S. papillosus*, *A. lumbricoides*, *T. trichiura*, *Capillaria bursata*, and *A. galli* in birds contrary to the report by Ajibade *et al.*, (2010) which recorded no infection of birds in Obafemi Awolowo University, Ile-Ife and University of Ibadan

Zoology gardens in Nigeria. Animals whose movement are restricted by fences are not likely to pick up accidental parasites. Wild birds are known to migrate over long distances and wide areas of land and could therefore, acquire more parasites or introduce parasites to new areas in the process (Mbaya *et al.*, 2007).

Seasonal differences were observed in parasite intensities, which is in line with the report of Devos and Lambrechts, (2003) that most parasites tend to reach their highest biotic potentials during the rainy season. Meanwhile, *A. lumbricoides* was statistically higher in the dry season, which might be the survivors from infections acquired during the late rainy season, in line with the report by Keyyu *et al.*, (2003), that peak contamination of the pastures in which most of these animals feed on occur just at the end of the rainy season.

Sex difference in parasitism was observed in the prevalence of *D. hospes* and also in the intensity of *S. papillosus*, *A. lumbricoides* and *M. moniliformis* which agree with the report of Poulin (1996) that sex differences in parasite prevalence or intensity are commonly observed with male of many species exhibiting higher parasitism than females. There was no definite pattern observed in the mean intensity and abundance of some of the parasites by sex, which might be attributed to different factors influencing a host at the same time. Apio *et al.*, (2006) attributed the sex related differences to hormones that debilitate immune functions. During this survey, it was observed that hunters used raw offal and intestinal organs from this wildlife including those from wild monkeys, to feed their hunting dogs. This could be suitable avenue for transmission of zoonotic parasites to humans as in many tropical communities, dogs roam the streets untended, defecate indiscriminately and contaminate the environment with helminth eggs and larvae, protozoan cysts and other infective agents in areas where children play outdoors and adults walk the streets barefoot, picking up infections from contaminated soils (Sowemimo and Asaolu, 2008; Okoye *et al.*; 2011).

Conclusion and Recommendations

The result of this study suggests that bush-meats are reservoirs of various parasites of medical and veterinary importance. We recommend that animal health planners should design zoonotic awareness interventions targeted at bush-meat hunters and traders. There is the need for legislation requiring authorization for hunting including hunting-area permit, animals allowed to be hunted at particular areas (giving cultural and conservation considerations), period of hunting, etc. Also, professional health or veterinary inspection and approval of bush-meat meant for trade and consumption. The feeding of hunting dogs with raw offal and intestinal organs as observed should be discouraged and wild animal carcasses should be handled with care.

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