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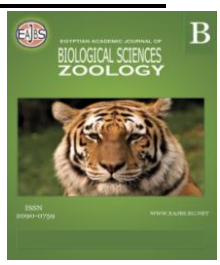

Parasites Diversity and Perceptions of Hunters and Sellers on Some Wild Mammals from Southwestern Nigeria

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ABSTRACT

Wildlife is a major asset and they are very important in ecological balance. Mammals were hunted due to demands for their meats and other parts of the animal. This study was aimed at assessing the prevalence of infection in selected mammals as well as knowledge of hunters and sellers about conservation and zoonotic issues. One hundred mammals were examined, Pangolin, *Phataginus tricuspis* (Pholidonta: Manis), hedgehog, *Atelerix albiventris* (Insectivora: Erinaceidae) and Porcupine, *Atherurus africanus* (Gray, 1842); the overall prevalence is 14% with 15.7% in Epe market and 10% in Odoona market, Ibadan. Hedgehog had the highest prevalence at the markets, 54.5%, and 40% respectively followed by Pangolin, (36.4% and 14.3%)' the least was observed in Porcupine (3.2%) in Epe market only. Single infection was observed in all mammals except in Pangolin and hedgehog where co-infection was observed. Helminthes recovered were Strongyloides sp, Metadavainae sp, Capillaria sp, and Hymenolepis sp. Infectivity was related to seasonal variation which shows no significant relationship; however, more males were infected in wet and dry but no female was infected during the dry season. Assessment of the knowledge of hunters showed that they are predominantly male with little or no knowledge about conservation law. Gun was the most effective method of killing which was used to kill animals indiscriminately because it was believed that game animals keep increasing in the forests hunted. Women are predominately marketers of these game animals; they had little knowledge about zoonotic diseases (3.3%), only a few (36.7%) use deworming drugs, and 22.2% every 3 months. Conservation and health education needs to be intensified for hunters and bushmeat handlers to prevent the re-emerge of some zoonotic infections.

INTRODUCTION

Wildlife is very important for ecological balance and the main asset on earth; however, many fail to realize their importance (Oldfield, 2003). This is due to several human activities such as deforestation, agriculture fragmentation, illegal hunting, and trade (Hansen *et al.*, 2013). Wild animals are being hunted because of the high demand for their meat, fur, tusks, horn, antlers, and other body parts (Arumugam and Annavi, 2018) as well as when they damage crops (Hedges *et al.*, 2005). Wildlife conservation depends mainly on the publics' knowledge, attitude, and practices towards the animals

(Morgan and Gramann, 1989; Milfont and Duckitt, 2010; Tonin and Lucaroni, 2017). Studies have suggested that conservation education is essential and should be cultivated right from an early age (Morgan and Gramann, 1989; Dimopoulos *et al.,* 2008). Environmental education (also compromised wildlife education and conservation) in many countries had shown positive increment in the children's knowledge, awareness, and attitude using pre-test and post-test surveys (Vaughan *et al*., 2003; Dimopoulos *et al*., 2008; Erdogan, 2011; Borchers, *et al*., 2014). Indiscriminate bush meat hunting had led to the decline in some wildlife species (Damania *et al*, 2005; Mfunda and Røskaft, 2010; Wilfred and MacColl, 2010), and may also increase the danger of transmission of zoonotic diseases (Karesh and Noble, 2009). There are laws and regulations which guide hunting in Africa; however, it is difficult to control bushmeat hunting, especially among rural dwellers that depend on it as the source of protein and income (Bowen-Jones *et al*, 2002). Despite existing laws and regulations regarding hunting in Africa, it is difficult to restrict the use of bush meat, as many rural people depend upon it to meet their basic nutritional needs (Bowen-Jones *et al*., 2002).

Pangolins (Pholidota: Manidae) are toothless, myrmecophagous mammals. They are classified as endangered species (Mohapatra and Panda, 2013; Mahmood *et al.,* 2019) with different species in Asia and Africa; Chinese pangolin (*Manis pentadactyla*), Indian pangolin (*Manis crassicaudata*), Philippine pangolin (*Manis culionensis*), and Malayan pangolin (*Manis javanica*) are native to Asia, whereas, other four pangolin species viz. Temminck's ground pangolin (*Manis temminckii*), giant ground pangolin (*Manis gigantea*), long-tailed pangolin (*Manis tetradactyla*), and tree pangolin (*Manis tricuspis*) occur in Africa (Mohapatra *et al*, 2015). Pangolins harbours both ecto and endoparasites which include protozoan (Esslinger, 1966; Singh, 1976; Else and Colley, 1976), helminthes, ticks, mites, and bacteria (Mohapatra *et al.,* 2015).

Hedgehogs are small, nocturnal, spiny-coated insectivores that have been gaining popularity as exotic pets. There are several species e.g European hedgehog, *Erinaceus europaeus*, and the smaller African pygmy hedgehog, *Atelerix albiventris* (Hoefer, 1994). Hedgehogs live in holes burrowed and are very active at night (Hoefer, 1994). They transmit two species of protozoan which are *Cryptosporidium* and *Toxoplasma gondii* (Riley and Chomel, 2015).

MATERIALS AND METHODS

Study Sites:

Samples were collected from Oluwo Market, Epe, and Odo Ona Kekere in Oluyole Local Government Area Ibadan. Epe is a town and Local Government Area (LGA) in Lagos State, Nigeria located on the north side of the Lekki Lagoon and about 90 km from Ibadan; it has a road connection to Ijebu ode and Ikorodu. It lies between latitude 6°35′ 3N and 3°59' 43′E.

Odo Ona Kekere in Oluyole Local Government Area Ibadan (7.28908; 3.86551) is situated in Ibadan North, Oyo, Nigeria, its geographical coordinates are 7° 14' 1" North, 3° 51' 9" East. Ibadan is the capital city of Oyo State. Samples were collected from May 2018 to December 2020.

Isolation and Preservation of Gastrointestinal Parasites:

The gastrointestinal contents of these mammals were collected from the bushmeat processing sections of the market. The different parts of the gastrointestinal tract (GIT) were dissected and contents emptied inside flat dishes. The linings of each region of the GIT were scraped, washed in saline solution (9gm of salt dissolved in 1 liter of water), and carefully examined for any helminth attaching to it. A hand lens was

used to examine the intestinal content of the mammals for adult parasites. Helminth parasites were recovered with a pair of forceps and fixed in 70% alcohol for parasite identification (Opara and Fagbemi, 2008). The parasites were identified based on standard morphological characteristics and the representative images of the parasites were captured using a super eye cam mini microscope.

Histopathological Assay:

The liver and intestine tissues were preserved in Bouin's fluid for 6 h and then decanted. Afterwards, 10% of phosphate-buffered formalin was added to preserve the tissue. Random selection was made from the preserved tissues for analysis. The selected tissue was routinely dehydrated in an ascending series of alcohol of 1% at 30 min intervals. The liver and intestine tissues were then embedded in molten paraffin wax and allowed to solidify. The blocked tissues were sectioned at 4-5 microns, processed and stained with haematoxylin and eosin (H&E) stains. The stained tissues were washed off in tap water. The tissues were then mounted using DPX mountant dried and examined under the binocular dissecting microscope (American Optical Corporation, Model 570) at the pathology laboratory of the department of veterinary pathology, University of Ibadan, Nigeria where the samples were taken for analysis and recording. Histopathological analysis was done based n the techniques employed by Egonmwan (2007).

Hunters, Sellers, And Meat Processing Workers Assessment:

Structured questionnaires (open and closed-ended questions) were adopted from literature surveys to assess conservation and public health issues among hunters, marketers of bushmeat, and workers who dress the meat at the markets. Hunters in Lagos and Ogun-Oyo boundary were interviewed; this was achieved by a personal interview via a door-door survey and focal group discussion. Marketers were interviewed at Odo-ona kekere, Ibadan, Oyo state, and Oluwo market, Epe, Lagos State. Workers who assist buyers in processing the meat were also interviewed at their various stalls.

Ethical Clearance:

Ethical approval was obtained from the University of Lagos College of Medicine, health research ethics committee with reference number CMUL/HREC/05/20/724.

Statistical Analysis:

Data was keyed into a Microsoft Excel spreadsheet, coded, and exported into SPSS. SPSS 26.0 was used to evaluate the relationship between variables. Descriptive statistics were used for the analysis of the questionnaires.

$$\text{Prevalence} = \frac{\text{Number of samples infected}}{\text{Number of samples examined}}$$

$$\text{Parasite Abundance} = \frac{\text{Number of parasites}}{\text{Number of examined host}}$$

$$\text{Mean Intensity} = \frac{\text{Number of parasites}}{\text{Number of Infected hosts}}$$

RESULTS

Prevalence of Gastrointestinal Parasites in The Mammals:

A total of 100 mammals were examined in Oluwo market, Epe and Odo-ona kekere, Ibadan; with Porcupine being the most abundant (68.6%), Hedgehog (15.7%), and Pangolin (15.7%). Table 1 show that the overall prevalence observed is 14% among

the mammals examined. In Epe, 15.7% of the mammals observed had an infection while a 10% prevalence rate was observed in Odo-ona, Ibadan. Of the three mammals sampled, Hedgehog had the highest prevalence of 50%. In Epe, Hedgehog had the highest prevalence (54.5%) followed by pangolin (36.4%) and Porcupine had the least (2.1%). In Ibadan samples, infection was observed only in hedgehog and Pangolin only with a prevalence of 40% and 14.3% respectively; no infection was observed in Porcupine.

Table 1: Prevalence of gastrointestinal parasites in the mammals.

Location	Name of animals	Number Examined	Number Infected	Prevalence of Infection
Epe	Porcupine	48	1	2.1
	Pangolin	11	4	36.4
	Hedgehog	11	6	54.5
	Total	**70**	**11**	**15.7**
Ibadan	Porcupine	18	0	0
	Pangolin	7	1	14.3
	Hedgehog	5	2	40
	Total	**30**	**3**	**10**
Both locations	Porcupine	66	1	1.5
	Pangolin	18	5	33.3
	Hedgehog	16	8	50
	Overall Total	**100**	**14**	**14**

Mean Intensity of Gastrointestinal Parasites in The Mammals:

Table 2 shows a diversity of gastrointestinal parasites which infect the mammals at both locations. Nematodes (*Strongyloides spp, Capillaria spp*) and Cestodes (*Metadavinae spp, Hymenolepis spp*) are the predominant parasites recovered from the gastrointestinal trait of the mammals. The overall mean intensity showed that Hedgehog had the highest in *Hymenolepis spp* (18 parasites/.animal) and *Capillaria spp* (13 parasites/.animal) followed by a porcupine (8 parasites/.animal) and pangolin (6 parasites/.animal). Single infection was observed as well as co-infection of nematodes and cestodes in the mammals.

In Epe, out of the 48 Porcupine examined, only one was infected with *Strongyloides spp* infection. However, co-infection was observed in the other mammals examined. Pangolin had single infections of *Strongyloides spp* (50%), *Metadavainae* spp (25%), and co-infection of *Strongyloides* and *Metadavainae* (25%). 66.7% had *Hymenolepis spp* single infection while 33.3% had co-infection of *Hymenolepis* with *Capillaria spp* in Hedgehog. The highest mean intensity of cestode was observed in Hedgehog - *Hymenolepis spp* (21 parasites /animal), while the highest mean intensity in nematodes was observed in Porcupine - *Strongyloides spp* (8 parasites /animal). Pangolin was infected with *Strongyloides spp* (7 parasites /animal) and *Metadavainae* (4 parasites /animal) (**Table 2**).

In Ibadan, out of the 2 infected hedgehogs; 1 had a single infection – *Capillaria spp* (50%) and the other co-infection of *Capillaria spp* and *Hymenolepis spp* (50%). Pangolin had only 1 infected with *Strongyloides* and *Metadavainae.* Mean intensity varies with *Capillaria spp* (19 parasites /animal) and *Hymenolepis* (1 parasite /animal) in Hedgehog; *Metadavainae spp* (10 parasites /animal) and *Strongyloides* (4 parasites /animal) in Pangolin (Table 2). No Porcupine observed was infected in Ibadan.

Table 2: Mean intensity of gastrointestinal parasites in the mammals.

Location	Name of animals	Number Infected	*Strongyloides* spp	*Metadavinae* spp	*Strongy n Meta*	*Capillaria* spp	*Hymenolepis* spp	*Cap n Hym*
Epe	Porcupine	1	8	-	-	-	-	-
	Pangolin	4	7	4	1 *	-	-	-
	Hedgehog	6	-	-	-	6	21	2 *
Ibadan	Porcupine	0	-	-	-	-	-	-
	Pangolin	1	4	10	1 *	-	-	-
	Hedgehog	2	-	-	-	19	1	1 *
Overall	Porcupine	**1**	**8**	-	-	-	-	-
	Pangolin	**5**	**6**	**6**	2 *	-	-	-
	Hedgehog	**8**	-	-	-	**13**	**18**	3 *

Strongy n *Meta* means Strongyloides and Metadavinae; Cap n Hym means Capillaria and Hymenolepis; * shows the number with co-infection

Parasites Abundance of Gastrointestinal Parasites in The Mammals:

The abundance of gastrointestinal parasites was observed in the mammals as shown in Table 3. At both markets, Hymenolepis spp was the most abundant parasite (7.1) followed by Capillaria spp (2.8) and Strongyloides spp (1.4). At Epe, Hymenolepis spp was more abundant in the hedgehog (11.5), *Strongyloides spp* in Pangolin (1.9), and *Capillaria spp* in Hedgehog (1.1) while in Ibadan the most abundant parasites were Capillaria in Hedgehog (7.6), Metadavinae in pangolin (1.4) and the least were *Strongyloides spp* (0.6) and *Hymenolepis* (0.2). Porcupine had the lowest parasites abundance in Epe (0.2) and no parasite was observed in Ibadan.

Table 3: Parasite Abundance of gastrointestinal parasites in mammals.

Location	Name of animals	Number Examined	*Strongyloides* spp	*Metadavinae* spp	*Capillaria* spp	*Hymenolepis* spp
Epe	Porcupine	48	0.2	-	-	-
	Pangolin	11	1.9	0.6	-	-
	Hedgehog	11	-	-	1.1	11.5
Ibadan	Porcupine	18	-	-	-	-
	Pangolin	7	0.6	1.4	-	-
	Hedgehog	5	-	-	7.6	0.2
Overall	Porcupine	**66**	**0.1**	-	-	-
	Pangolin	**18**	**1.4**	**0.9**	-	-
	Hedgehog	**18**	-	-	**2.8**	**7.1**

Seasonal and Sex Influence on The Prevalence of Parasites in Selected Bushmeat:

Prevalence of infection was related to sex and seasons in **Table 4,** infection was observed in both seasons (50% respectively); however, it was observed that males had more infection (78.6%) than females (21.4%) in both seasons. In the dry season, all the males had infections (100%) while female mammals had no infection. In contrast, males had 57.1% and females (42.9%) during the wet season (**Table 4**).

Hedgehog had infection more infection (50%) than Pangolin (27.8%) and Porcupine (1.5%). During the wet season, the hedgehog had the highest prevalence in Epe (80%) and Ibadan (50%); while Pangolin had the highest during the dry season in Epe (50%) and hedgehog in Ibadan (50%) (Table 4). Table 4 also showed that during the wet season in Epe, 50% of the infected hedgehogs were male while 16.7% were female; in Ibadan, no male was infected while 50% of the infected were females. Pangolin had 25% in males; no infection in females in Epe, a contrasting case was observed in Ibadan where females had 100% prevalence.

During the dry season, only male mammals were infected; Porcupine had only 1

of its mammals infected (100%), Pangolin (75%), and Hedgehog (33.3%) in Epe. In Ibadan, only 1 male Hedgehog was infected (50%) during the dry season (**Table 4**).

Table 4: Seasonal and sex influence on the prevalence of parasites in selected bushmeat.

Location	Name of Animals	Number examined (NE)	Number Infected (%)	WET SEASON (April to September)			DRY SEASON (October to March)		
				NE (%)	PINM (%)	PINF (%)	NE	PINM (%)	PINF (%)
Epe market	Porcupine	48	1 (2.08)	29 (60.4)	0	0	19 (39.6)	1 (100)	0
	Pangolin	11	4 (36.4)	5 (45.5)	1 (25)	0	6 (54.5)	3 (75)	0
	Hedgehog	11	6 (54.5)	5 (45.5)	3 (50)	1 (16.7)	6 (54.5)	2 (33.3)	0
Ibadan market	Porcupine	18	0	13 (72.2)	0	0	5 (27.8)	0	0
	Pangolin	7	1 (14.3)	2 (28.6)	0	1 (100)	5 (71.4)	0	0
	Hedgehog	5	2 (40)	3 (60)	0	1 (50)	2 (40)	1 (50)	0
Overall	**Porcupine**	**66**	**1 (1.5)**	**42 (63.6)**	**0**	**0**	**24 (36.4)**	**1**	**0**
	Pangolin	**18**	**5 (27.8)**	**7 (38.9)**	**1 (20)**	**1 (20)**	**11(61.1)**	**3 (60)**	**0**
	Hedgehog	**16**	**8 (50)**	**8 (50)**	**3 (37.5)**	**2 (25)**	**8 (50)**	**3 (37.5)**	**0**
Overall TOTAL		**100**	**14**	**57 (57)**	**4**	**3**	**43 (43%)**	**7**	

PINM – Prevalence in male mammals examined; PINF – Prevalence in female mammals examined

Knowledge Attitude and Practices of Hunters Towards Conservation Issues

Table 5 shows the hunting practices of the hunters. It shows that 57% of them kill their animals with guns only, 38% hunt with guns/ traps, only 1% hunt with traps only, and 4% hunt with other materials. Also, on the effective methods of killing animals, 96% reported guns, 2% reported traps and 2% reported other methods. On the number of animals, they are permitted to kill within a period, 92% said they can kill unlimited animals, 3% can kill only adult animals while 5% can kill only animals that are not endangered species (**Table 5**).

In addition, 75% stated that the number of animals they killed over the years has increased, 21% said it has decreased and 4% said it is somewhat the same. Also, 58% of the hunters hunt in Ogun state, 15% hunt in Lagos state, another 155 hunts in Southwest Nigeria, and 12% hunt in other places. Lastly, on the specific areas they do their hunting activity, 7% reported they hunt in forest areas, 23% in forests/ arable/ farm areas, 14% in forests/ plantations, only 3% in arable/ farm area, and another 3% hunt everywhere (**Table 5**).

Only 12% of the hunters said they have a boundary limit/ area they must hunt, 78% said they cross boundaries of these areas, and only 8% said there are particular seasons you are permitted to cross the boundaries (inter-state). Among those that cross boundaries, 28% do for more animals, 42% do as a team, and 6% cross the boundaries because of limited animals. In addition, all the hunters enjoy their work, only 9.0% are aware of animal conservation policies, and 13.0% will comply when asked not to kill these animals again (**Table 5**).

Table 5: Knowledge Attitude and Practices of Hunters Towards Conservation Issues

Hunting practices		Frequency	Percent
How do you kill these animals	Guns	57	57.0
	Trap	1	1.0
	Trap/ Gun	38	38.0
	Others	4	4.0
	Total	100	100.0
Effective methods of killing animals	Gun	96	96.0
	Trap	2	2.0
	Others	2	2.0
	Total	100	100.0
Number of animals you are permitted to kill within a period	Unlimited	92	92.0
	Only adults	3	3.0
	Only not endangered	5	5.0
	Total	100	100.0
The number of animals killed over the years has	Increased	75	75.0
	Decreased	21	21.0
	Somewhat the same	4	4.0
	Total	100	100.0
State of hunting	Lagos	15	15.0
	Ogun	58	58.0
	South West	15	15.0
	Others	12	12.0
	Total	100	100.0
The specific area you do your hunting activity	Forest area	57	57.0
	Arable/ farm area	3	3.0
	Forest/ Arable - farm area	23	23.0
	Everywhere	3	3.0
	Forest/ Plantations	14	14.0
	Total	100	100.0
You cross boundaries of these areas	No	22	22.0
	Yes	78	78.0
	Total	100	100.0
Why cross-boundary	For more animals	28	28.0
	As a team	42	42.0
	Limited animals	6	6.0
	Non - response	24	24.0
Do you enjoy this work?	Yes	100	100.0
Are you aware of conservation policies	No	91	91.0
	Yes	9	9.0
	Total	100	100.0
If you are asked not to kill these animals again you will comply	No	87	87.0
	Yes	13	13.0
	Total	100	100.0

Perception of Bushmeat Marketers to Conservation and Zoonotic Diseases

Table 6 shows that 45.6% of the meat sellers preserve their unsold animals by freezing, 30% by smoking, and 23.3% using both freezing and smoking while 1.1% did not respond. Also, none of the meat sellers is involved in hunting of the animals, 14.4% of them do other work apart from bush meat sales, 37.8% are aware of government conservation laws, and 36.7% deworm themselves. Among those that deworm, 22.2% do it in 3 months, 7.8% do it in 6 months and 11.1% do it once a year. In addition, only 3.3% know the diseases humans are likely to contract from contact with wild animals, and among the disease(s) humans get from animals are Taeniasis, *Trachinesis, Salmonella* (1.1%), ebola (1.1%0, cholera (1.1%) and 96.7% have no idea. Lastly, only 2.2% of the meat sellers know that there is/are animal(s) government prevents them from selling.

Table 6: Perception Of Bushmeat Marketers To Conservation And Zoonotic Diseases.

Meat sellers' practices		Frequency	Percent
How do you preserve unsold animals	Freezing	41	45.6
	Smoking	27	30.0
	Both	21	23.3
	Non – response	1	1.1
	Total	90	100.0
Are you involved in the hunting of animals as well	No	90	100.0
You do other work apart from bush meat sales	No	77	85.6
	Yes	13	14.4
	Total	90	100.0
Are you aware of government conservation laws	No	56	62.2
	Yes	34	37.8
	Total	90	100.0
Do you deworm yourself?	No	57	63.3
	Yes	33	36.7
	Total	90	100.0
Frequency of deworming	3 Months	20	22.2
	6 months	7	7.8
	Once a year	10	11.1
	NA	53	58.9
	Total	90	100.0
Do you know diseases humans are likely to contract from contact with wild animals	No	87	96.7
	Yes	3	3.3
	Total	90	100.0
Mention disease(s) humans can get from wild animals	Taeniasis, Trachinesis, Salmonella,	1	1.1
	No idea	87	96.7
	Ebola	1	1.1
	Cholera	1	1.1
	Total	90	100.0
There is/are animal(s) government prevents you from selling	No	88	97.8
	Yes	2	2.2
	Total	90	100.0

Histopathological Alterations in The Selected Mammals:

Tissue alterations observed in infected mammals ranged from mild to total loss; this includes a mild increase in the connective tissue of the submucosa, loss of villous structure, mild stunting of villi, thickening of the muscularis mucosa, mild presence of detritus within the lumen, and loss of intestinal glands in mammal tissues.

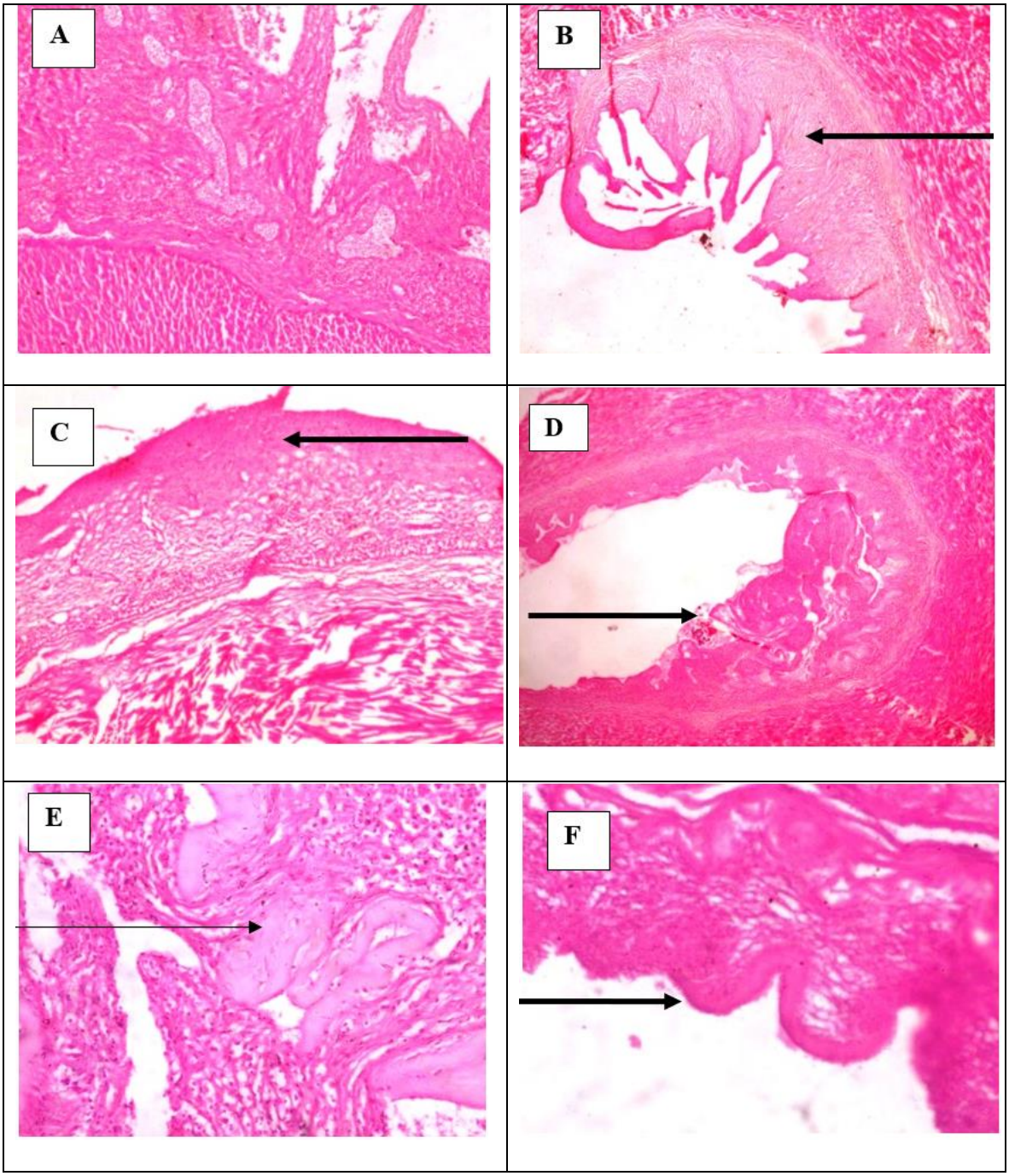

Plate 1: A. Normal B. mild increase in the connective tissue of the submucosa C. focal area of loss of villous structure D. mild stunting of villi and loss of intestinal glands E. thickening of the muscularis mucosa (slender arrow) and mild presence of detritus within the lumen F. mild stunting of villi and loss of intestinal glands in mammal tissues

DISCUSSION

This study established the presence of parasites in bushmeat and they are predominantly infected by helminths. The overall prevalence was low (14%) compared to findings of Mohapatra *et al* (2020) which had an overall prevalence of 4.4% observed in wild mammals. Nematodes and cestodes co-infected *Phataginus sp* and *Atelerix sp* which indicates they are a susceptible host for infective microorganisms. The high prevalence observed in hedgehogs was similar to the findings of Youssefi *et al*. (2013)

which observed 100% parasitic infection in eastern European hedgehogs. Infectivity was higher in Pangolin in this study but contrast the findings of Okonkwo and Okaka (2018), Ugiagbe and Awharitoma (2018) which observed 100% prevalence in Anambra and Edo states respectively in Nigeria. Okonkwo and Okaka (2018) also observed the presence of cestode (Metadavainae) and nematode (*Parastrongyloides)* in pangolin, however, this study observed *Strongyloides* as nematode found which supports the findings of Heath and Vanderlip (1988).

Youssefi *et al.* (2013) observed *Nephridiacanthus major* and *Hymenolepis erinacei* from the small intestine in Iran while *Hymenolepis sp* and *Capillaria sp* was observed in hedgehog in this study This study was the first to report helminth *Strongyloides sp* infection in Porcupine.

A parasite is ever-present in the environment; this may be responsible for the reason why there are equal percentages of infection at both seasons. Higher prevalence was observed in males than females in both seasons, this may be due to the lifestyle of males and hormones that debilitate immune functions (Apio *et al,* 2006). The higher infection rate found in Hedgehog in the study may be attributed to their burrowing lifestyle. During the wet season, burrowing will be easier for the animal than in the dry season.

The myrrphagous state of pangolin made them more prone to infection during the wet and dry season.

The presence of tissue alterations in infected mammals may be due to other factors but parasitized tissues showed marked tissue alterations. This agreed with the findings of Opara and Fagbemi (2010) who reported alterations in vital organs of grasscutter infected with Trypanosomiasis. Parasitic infestations result in altered tissue structure, which may result in mild, moderate, or severe cases.

Gun and trap remain the most used means of hunting by rural dwellers due to their educational level and exposure. This is the reason why the belief that hunted mammals increases over the years. Most of the hunters hunt in forests, arable, or plantations within their communities unless they are searching for more animals or as a team. Means of transporting the killed animals control or regulate the areas where they hunt if they are going alone. All the interviewed hunters enjoy hunting thus the reason why most of them responded they will not comply if requested to leave the job. Poor knowledge of conservation laws made the hunters kill an unlimited number of mammals irrespective of their age. The study of Bitanyi *et al*, (2012) reported that Districts in the western part of Seregenti National Park in Tanzania had a fair knowledge of modalities of existing conservation laws and illegal hunting.

This study showed that bushmeat marketers are not involved in hunting activities; this is because most sellers are female which could not withstand the rigours of hunting. The response by a few of the marketers and those processing killed games involved in other jobs shows the potentiality of contact with non-bushmeat eaters and may transmit animal-borne diseases if precautions were not taken.

Different methods were adopted by bushmeat marketers to preserve unsold games to inhibit microbial growths which can cause decaying, however, zoonotic microbes may be thermophilic.

Knowledge of conservation laws is dependent on the educational level of the marketers, thus their poor knowledge about zoonotic diseases. Despite Government efforts in educating their citizens towards disease control, less than 50% of the marketers deworm regularly and fewer numbers every three months. This is affected by educational level and cultural norms. Bowitta *et al* . (2018) study on unintended consequences of the 'bushmeat ban' in West Africa during the 2013–2016 Ebola virus disease epidemic

showed that skepticism, misconception, misinterpretation, and so on affect governmental efforts.

More awareness is required by the appropriate ministry to control imbalance in the ecosystem, educate citizens on conservation laws, hygiene, and disease control measures. Mass media should be utilized often for the campaign on human-animal contacts, the potentiality of harbouring zoonotic pathogens. Information should be made simple, concise, and clear for different people based on their educational levels.

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