

## Indigestible Foreign Materials Impaction of Small Ruminants in Gombe State, Nigeria

Lawal Jallailudeen Rabana<sup>1\*</sup>, Yusuf Zainab Bukola<sup>2</sup>, Muhammad Mustapha<sup>1</sup>, Lawan Adamu<sup>1</sup>

1. Department of Veterinary Medicine, Faculty of Veterinary Medicine, University of Maiduguri, P.M.B. 1069, Maiduguri, Borno State, Nigeria.
2. Department of Veterinary Surgery and Radiography, Faculty of Veterinary Medicine, University of Maiduguri, P.M.B. 1069, Maiduguri, Borno State, Nigeria

### Abstract

**BACKGROUND:** The predisposition of ruminants to indigestible foreign materials is becoming a major global concern in live-stock systems in developing countries making gastrointestinal tract impactions severe veterinary emergencies.

**OBJECTIVES:** This study aimed to investigate the prevalence and types of indigestible foreign material impactions in small ruminants in Gombe state, Nigeria.

**METHODS:** A total of 940 goats and 790 sheep were selected through a systematic random sampling technique and antemortem examinations were completed before slaughter at major abattoirs in Gombe state. The gender, age, and body condition score (BCS) of animals were recorded. Post-mortem examination of the rumen and reticulum was performed and foreign materials in the abdominal cavity were removed, identified, and recorded.

**RESULTS:** Out of 1730 examined small ruminants, 1167 (67.46%) were found to have various types of indigestible foreign materials in their gastrointestinal tracts. The frequency was significantly ( $\chi^2=58.047$ ,  $P<0.0001$ ) higher in goats (38%) than sheep (23.7%). Prevalence rates of 13.6%, 12.9%, 12.1%, 11.8%, and 11.4% were recorded in Gombe, Yamaltu Deba, Akko, Funakaye, and Kwami Local Government Areas, respectively. Prevalence was found to be significantly ( $P<0.0001$ ;  $\chi^2=732.87$ ; OR=47.009) higher in adult (59.6%) than young (2.1%) cases, significantly ( $P<0.0001$ ;  $\chi^2=637.61$ ; OR=31.145) higher in females (42.5%) than males (19.2%), higher in goats ( $\chi^2=177.03$ ,  $P<0.0001$ ) and sheep ( $\chi^2=191.39$ ,  $P<0.0001$ ) with poor BCS than those with medium and good BCS. Significantly higher proportions of indigestible foreign materials were recovered in the rumen of goats and sheep, compared to the reticulum. Plastic was the most commonly encountered indigestible foreign material in goats and sheep, followed by seed/nuts, ropes, and clothes.

**CONCLUSIONS:** The results of the current study revealed a prevalence of 67.46% for indigestible foreign materials in goats and sheep. Predisposing factors to indigestible foreign materials in ruminants in the study area included the lack of adequate plastic waste disposal system and management system, as well as the free grazing of livestock. Therefore, it was recommended that collaborative intervention schemes involving governmental agencies and livestock farmers be incorporated to increase public awareness about the proper disposal of domestic waste.

**KEYWORDS:** Gastrointestinal tracts, Goats, Indigestible foreign materials, Sheep

### Correspondence

Lawal Jallailudeen Rabana, Department of Veterinary Medicine, Faculty of Veterinary Medicine, University of Maiduguri, P.M.B. 1069, Maiduguri, Borno State, Nigeria. Tel: +234 (080) 32886428,

Email: [rabanajallailudeen@yahoo.com](mailto:rabanajallailudeen@yahoo.com)

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## Introduction

Small ruminants, including sheep and goats, are among the popular livestock reared in African developing countries, such as Nigeria (Lawal-Adebowale, 2012; Unigwe *et al.*, 2016). Sheep and goats play an important socio-economic role within conventional animal husbandry systems primarily for providing high-quality animal protein and income (Ukwueze and Kalu, 2015). In most parts of Nigeria, the demand for sheep and goats is quite impressively high due to its common uses for rituals, sacrifices of worship, and cultural festivals. This demand has created good job opportunities for livestock farmers and elevated national income (Anyanwu *et al.*, 2016). Unfortunately, the productivity of ruminants in Nigeria is limited by factors, such as disease risks, unsuitable breeding strategies, insufficient management systems, weak husbandry systems, and poor feeding (Lawal-Adebowale, 2012).

Ruminants are generally considered notorious for ingesting non-dietary foreign bodies (Asrat *et al.*, 2015; Ali and Awoke, 2019). The ingestion of non-dietary metallic and non-metallic materials in ruminants is primarily associated with malnutrition and an unbalanced diet that may result in nutritional deficiencies resulting in pica and the ingestion of non-normal stuff (Ghurashi *et al.*, 2009; Saulawa *et al.*, 2012; Jebessa *et al.*, 2018; Amin and Fentahun, 2020). As a result, various problems may occur in different organs of the affected animal in the long term, primarily in the rumen and reticulum (Mozafari *et al.*, 2009; Teshome *et al.*, 2017).

The predisposition of sheep and goats to indigestible foreign materials is becoming a major global problem in the production systems of developing countries due to environmental contamination. The rumen and reticulum impactions with indigestible foreign bodies are among the most severe veterinary emergencies (Ghurashi *et al.*, 2009; Suthar *et al.*, 2011; Abu-Seida and Al-Abbadi, 2014; Otsyina *et al.*, 2015). Foreign body impaction has been recorded in small ruminants, specifically in countries lacking adequate domestic and industrial waste recycling facilities (Tsfaye *et al.*, 2012a). In addition,

free ruminant grazing, especially in urban and suburban areas, is an influential factor (Tiruneh and Yesuwork, 2010; Fasil, 2016).

Most of the ingested indigestible materials in the guts of small ruminants generally accumulate in the rumen or reticulum of animals, where they interfere with the normal fermentation process and the mixing of contents that lead to indigestion. These may also block the orifice between the reticulum and omasum and cause various adverse effects on animal health or become fatal if not removed by surgery (Abdelaal and EL-Maghawry, 2014; Olatunji-Akiyoye *et al.*, 2019). Such foreign bodies cannot be digested by the animal or be voided through the feces (Mohammed, 2012; Abdelaal and EL-Maghawry, 2014).

Some of the potential health hazards caused by the ingestion of sharp-edged non-metallic and metallic indigestible foreign materials, such as plastics, nails, and wires, include local or diffuse peritonitis, glossitis, esophagitis, ruminitis, rumen impaction, traumatic pericarditis, and traumatic reticulo-peritonitis. The latter two conditions usually occur when these ingested sharp objects perforate the reticulum or rumen wall to enter other organs (Igbokwe *et al.*, 2003). The presence of foreign bodies in the rumen and reticulum can also interfere with the adequate absorption of volatile fatty acids and hence the rate of weight gain (Igbokwe *et al.*, 2003).

The impaction of rumen and reticulum by indigestible foreign bodies is typically asymptomatic and may cause wasting or progressive emaciation in the affected animals during terminal stages. These animals may also display clinical symptoms with severe impact and damage due to sharp object perforation (Bwala *et al.*, 2016; Alimi *et al.*, 2018). Diagnosis of foreign body impaction in small ruminants is usually based on abdominal palpation, and in most cases, it can be difficult to distinguish between pregnancy and foreign body impaction. Certain methods of diagnosis entail radiography (Semieka, 2010) and ultrasonography (Pitroda *et al.*, 2010; Abdelaal and EL-Maghawry, 2014). However, a major limitation is a complexity of using these techniques under field conditions.

Foreign bodies impaction in small ruminants has been investigated and reported in Kenya (Otsyina *et al.*, 2014 & 2015); Ethiopia (Roman and Hiwot, 2010; Abebe and Nuru, 2011; Tesfaye *et al.*, 2012b), Sudan (Mohammed, 2012), and some parts of Nigeria (Igbokwe *et al.*, 2003; Remi-Adewunmi *et al.*, 2004; Saulawa *et al.*, 2012; Bwala *et al.*, 2016). There is insufficient information about the occurrence of impaction by indigestible foreign materials in small ruminants in Gombe state. Therefore, this study investigated the prevalence and types of indigestible foreign materials impaction in sheep and goats slaughtered at abattoirs in Gombe state, Nigeria.

## Materials and Methods

### Study Setting

The present study was conducted in Gombe state, located in the Northeastern part of Nigeria, sharing common boundaries with Adamawa, Bauchi, Borno, Taraba, and Yobe ([Figure 1](#)). As of 2006, Gombe state has an area of 20,265 km<sup>2</sup> and an estimated human population of about 2,365,000 people (NPC, 2006). The state is between latitude 9° 30' and 12° 3' N and longitude 8° 45' and 11° 45' E. It has an annual rainfall range of 850-1000 mm, with the rainy season beginning from May to October and the dry season starting from November to April (Anonymous, 2009). The average daily temperatures are 34°C in April and 27°C in August and this state has a relative humidity range of 70%-80% in August and falls to around 15%-20% in December with the hottest months of 40°C being between March and May and the coldest time being between December and February (harmattan). Both climatic and edaphic factors favor crops and livestock farming with most of the inhabitants being engaged in trading and agriculture, including village poultry, cattle, sheep, and goats under extensive and semi-intensive animal husbandry management systems. Usually, the natural vegetation is the Sudano-Sahelian Savannah which consists of shrubs, herbs, grasses, and sparsely scattered trees. Gombe state is a multi-ethnic community comprising the dominant Fulani group inhabiting the Northern part of Gombe state, and Tangale, which occupies the southern part of the state. Major abattoirs within five (Akko, Funakaye, Gombe, Kwami,

and Yamaltu Deba) of the eleven (Dukku, Akko, Kaltungo, Nafada, Funakaye, Balanga, Gombe, Billiri, Kwami, Shogom, and Yamaltu Deba) Local Government Areas were visited to investigate indigestible foreign materials in the gastrointestinal tract of small ruminants.

### Study Design

This cross-sectional study was performed by non-probability sampling techniques used to select five of Gombe State's 11 Local Government Areas (LGAs) to examine the frequency and types of indigestible materials consumed by sheep and goats (Funakaye, Kwami, Gombe, Yamaltu Deba, and Akko Local Government Areas). According to the information acquired, small ruminants (i.e., sheep and goats) transported for slaughter in large abattoirs in the study area were from farms and households that used extensive management strategies.

### Sampling Period and Procedure

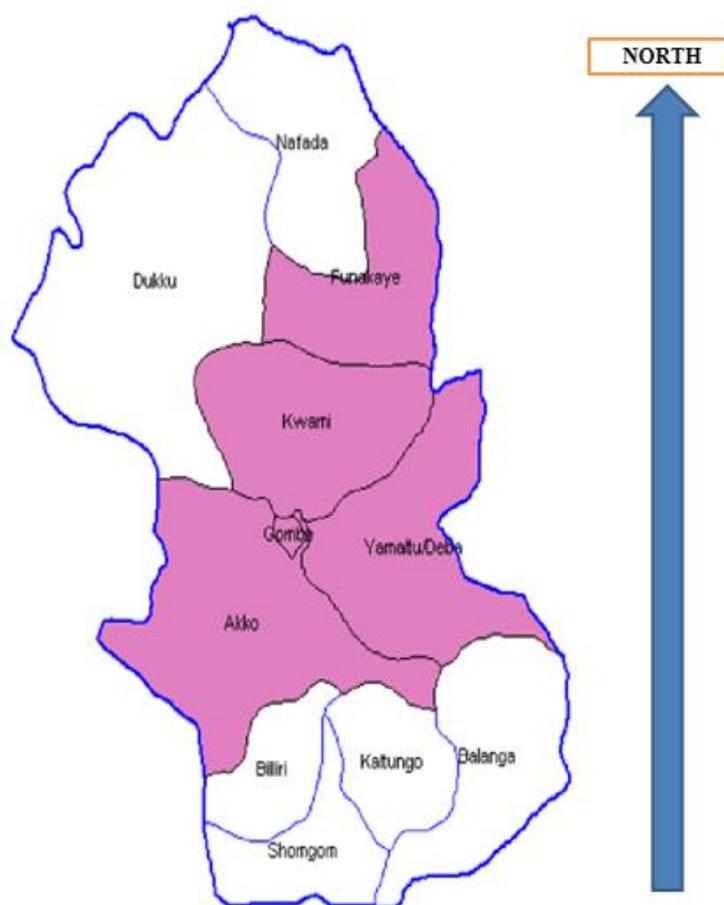
Sampling was carried out during February 2019-January 2020 with sampling involving goats and sheep presented in all the study locations for slaughter at the major abattoirs. The subjects were selected for the study using the systematic random sampling technique. The pre-slaughter antemortem examination, including evaluating body temperature, respiratory rate, heart rate, and rumen motility, was conducted for all animals. In addition, the species of animals, gender, age (broadly grouped into two age groups of young (< 1 year) and adult (> 1 year), and body condition score (BCS) of all animals were observed and recorded. The age of each selected animal was determined according to the animal's teeth based on dental eruption and wear of the incisor teeth as previously described by Pace and Wakeman (2003). The BCS for each selected animal was recorded as poor, medium, and good based on the appearance of the animal, as well as the manual palpation of muscles and fat deposition levels over and around the vertebrae of the lumbar vertebrae and transverse processes as previously described by Thompson and Meyer (1994). During each visit to any of the selected sample collection abattoirs, 20 small ruminants were selected by targeting each animal to be slaughtered regardless of species, gender, or age

until the required number of samples (20) was obtained. With the aid of research assistants in the abattoir, animals selected by this process were labeled and followed throughout the slaughter process. The vital parameters and physical examination, such as body temperature, respiratory rate, heart rate, and rumen motility of each selected animal, were examined. The rumen and reticulum were incised after slaughter, flayed, eviscerated, and physically inspected for the presence or absence of indigestible foreign materials. Next, the recovered foreign materials were carefully removed from the abdominal cavity (rumen, reticulum or both). Types of the materials were identified, washed, dried, and recorded

for each fore-stomach (rumen, reticulum, or both) for each goat or sheep examined.

### Data Analysis

For statistical analysis, all data were imported into the GraphPad Prism software version 6.0 (GraphPad Software Inc., California, USA). The Chi-square ( $\chi^2$ ) test was used to assess the relationships of established categorical variables, including age, gender, BCS, and season with indigestible foreign materials. Significance was determined at  $P$ -value < 0.05. The prevalence of different indigestible foreign materials and types was presented as a percentage.



**Figure 1.** Map of Gombe State showing the study area in pink color

## Results

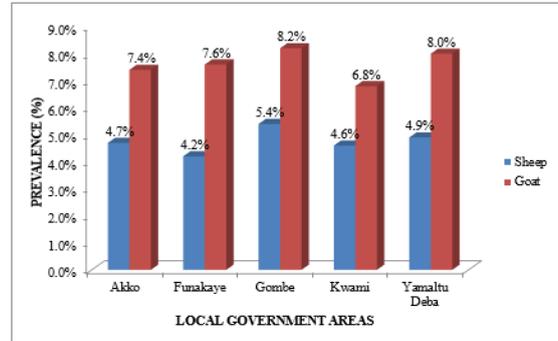
[Table 1](#) summarizes the prevalence of indigestible foreign materials in small ruminants in Gombe state, Nigeria. A total of 1730 small ruminants comprising 940 goats and 790 sheep in Gombe state, Nigeria

were examined for indigestible foreign materials, and 1067 (61.7%) cases were found to have indigestible foreign materials in their fore-stomach. Our findings revealed that 657 (69.9%) goats and 410

(51.9%) sheep were found with indigestible foreign materials with the frequency of 38% and 23.7%, respectively. There was a significant ( $P<0.0001$ ) correlation between the ruminants (sheep and goats) and the prevalence of indigestible foreign materials.

The prevalence of indigestible foreign materials in small ruminants based on LGAs in Gombe state, Nigeria is graphically presented in [Figure 2](#). The frequency was found to be higher in goats than sheep in all the study LGAs. The overall prevalence of indigestible foreign materials in sheep and goats based on LGA was reported to be higher in Gombe (13.6%) followed by Yamaltu Deba (12.9%), Akko (12.1%), Funakaye (11.8%), and Kwami (11.4%) LGAs. However, the indigestible foreign materials were more prevalent in goats (8.2%) than sheep (5.4%) from Gombe LGA. Furthermore, our study revealed the prevalence to be higher in goats (8%) than sheep (4.9%) from Yamaltu Deba LGA, higher

in goats (7.4%) than sheep (4.7%) from Akko LGA, higher in goats (7.6%) than sheep (4.2%) from Funakaye LGA, and finally higher in goats (6.8%) than sheep (4.6%) from Kwami LGA.



**Figure 2.** Prevalence of Indigestible Foreign Materials in Small Ruminants based on Local Government Areas in Gombe State, Nigeri

**Table 1.** Prevalence of Indigestible Foreign Materials in Small Ruminants in Gombe State, Nigeria

Type of ruminant	No. Examined	No. affected (%)	Prevalence (%) (95% CI; LL – UL)	$\chi^2$	P-value	Odd Ratio
Goats	940	657 (69.9)	38.0 <sup>a</sup> (35.7 – 40.3)	58.047	<0.0001	0.4648
Sheep	790	410 (51.9)	23.7 <sup>b</sup> (21.8 – 25.8)			
<b>Total</b>	1730	1067 (61.7)	61.7 (59.4 – 63.9)			

Key: <sup>a,b</sup> Different superscripts indicate significant ( $P < 0.05$ ) difference in prevalence;  $\chi^2$  = Chi-square; CI = Confidence Interval; LL = Lower limit; UL = Upper limit

[Table 2](#) summarizes the anatomical sites of the detected cases of indigestible foreign materials in small ruminants in Gombe state. Out of 1067 positive cases of indigestible foreign materials in goats and sheep in Gombe state, the prevalence rate in the rumen of the affected goats and sheep was 30.4% and 18.5%, respectively. The likelihood of consuming foreign materials in the rumen of goats was significantly higher (OR = 0.5359;  $P<0.0001$ ) than that of the sheep. Moreover, the frequency of indigestible foreign materials in the affected goats and sheep reticulum was 5.5% and 3.9%, respectively. The likelihood for the occurrence of foreign materials in

the reticulum was not significantly higher (OR=0.8377;  $P=0.3269$ ) compared to other anatomical sites of the digestive organs. However, the frequency of indigestible foreign materials accumulated in both rumen and reticulum of the affected goats and sheep was found to be 2.1% and 1.3%, respectively. The likelihood for the occurrence of foreign materials in the rumen was not significantly higher (OR=0.7193;  $P=0.2852$ ) compared to other anatomical sites of the digestive organs.

**Table 2.** Anatomical Site of Detected Cases of Indigestible Foreign Materials in Small Ruminants in Gombe State, Nigeria

Site of im-paction	Type of rumi-nant	No. examined N = 1730	No. af-fected (%)	Prevalence % (95% CI; LL – UL)	$\chi^2$	P-value	Odds Ratio
<b>Rumen (%)</b>	Goats	940	526 (56.0)	30.4 <sup>a</sup> (28.3 – 32.4)	40.395	< 0.0001	0.5359
	Sheep	790	320 (40.5)	18.5 <sup>b</sup> (16.7 – 20.4)			
<b>Reticulum (%)</b>	Goats	940	95 (10.1)	5.5 <sup>a</sup> (4.5 – 6.7)	0.9611	0.3269	0.8377
	Sheep	790	68 (8.6)	3.9 <sup>a</sup> (3.1 – 5.0)			
<b>Rumen and Reticulum (%)</b>	Goats	940	36 (3.8)	2.1 <sup>a</sup> (1.5 – 2.9)	1.142	0.2852	0.7193
	Sheep	790	22 (2.8)	1.3 <sup>a</sup> (0.8 – 1.9)			

Key: N = Total number of small ruminants examined and sampled during study period;

<sup>a,b</sup> Different superscripts indicate significant ( $P < 0.05$ ) difference in prevalence;

$\chi^2$  = Chi-square; CI = Confidence Interval; LL = Lower limit; UL = Upper limit

[Table 3](#) summarizes the results of some risk factors associated with the occurrence of indigestible foreign materials in small ruminants in Gombe state. From 448 young and 1282 small adult ruminants examined for indigestible foreign materials, the affected cases were more frequently adults (N=1031, 80.4%) than young (N=36, 8%) small ruminants with prevalence rates of 59.6% and 2.1%, respectively. There was a significant ( $P < 0.0001$ ) relationship between the age of small ruminants and the prevalence of indigestible foreign materials with an OR of 47.009, indicating that the consumption of indigestible materials is significantly less likely to occur in young goats and sheep than adults. In addition, out of 951 male and 779 female small ruminants examined for indigestible foreign materials in Gombe state, cases were more frequently encountered in female 735 (94.4%), compared to male 332 (34.9%) small ruminants with prevalence rates of 42.5% and 19.2%, respectively. There was a significant ( $P < 0.0001$ ) correlation between the gender of small ruminants and the frequency of indigestible foreign materials with an OR of 31.145, demonstrating that the consumption of indigestible materials is

significantly less likely to occur in male goats and sheep than females.

[Table 4](#) shows the prevalence of indigestible foreign materials in small ruminants in Gombe state based on BCS. Out of 413, 370, and 157 goats examined with poor, medium, and good BCS, 352 (85.2%), 261 (70.5%), and 44 (28%) cases were found to have indigestible foreign materials with prevalence rates of 20.3%, 15.1%, and 2.5% respectively. BCS was significantly ( $P < 0.0001$ ) correlated with the frequency of indigestible foreign materials in goats in Gombe state. Moreover, out of 357, 285, and 148 sheep examined with poor, medium, and good BCS, 279 (78.2%), 103 (36.1%), and 28 (18.9%) animals were found to have indigestible foreign materials with prevalence rates of 16.1%, 6%, and 1.6%, respectively. BCS had a significant ( $P < 0.0001$ ) correlation with the prevalence of indigestible foreign materials in sheep in Gombe state.

The type of indigestible foreign materials found in slaughtered small ruminants in Gombe state entailed clothes, rope/thread, stone/sand, seed/nuts, plastic/leather/nylon bags, wire/metals, and a mixture of materials. Among all cases of indigestible foreign

materials found in the affected small ruminants, plastic/leather/nylon bags were the most common as observed in 556 (52.1%) followed by seed/nuts in 178 (16.7%), a mixture of materials in 95 (8.9%), rope/thread in 81 (7.6%), stone/sand in 59 (5.5%),

clothes in 55 (5.2%), and wire/metals in 43 of the affected small ruminants (4). However, the results revealed that the different types of indigestible foreign materials in the affected small ruminants are more frequent in goats than sheep, as shown in [Table 5](#).



**Figure 3.** Ingested indigestible foreign materials (mixture of plastic/nylon, ropes, clothes, stone and nuts) retrieved from the rumen of an adult female (doe) goat

**Table 3.** Some Risk Factors Associated with the Occurrence and Prevalence of Materials in Small Ruminants in Gombe State, Nigeria

Risk factors	Parameters	No. examined N = 1730	No. affected (%)	Prevalence (%) (95% CI; LL – UL)	$\chi^2$	P-value	Odd Ratio
Age	Young (< 1 year)	448	36 (8.0)	2.1 <sup>a</sup> (1.5 – 2.9)	732.87	< 0.0001	47.009
	Adult (> 1 year)	1282	1031 (80.4)	59.6 <sup>b</sup> (57.3 – 61.9)			
Sex	Male	951	332 (34.9)	19.2 <sup>a</sup> (17.4 – 21.1)	637.61	< 0.0001	31.145
	Female	779	735 (94.4)	42.5 <sup>b</sup> (40.2 – 44.8)			

Key: N = Total number of small ruminants examined and sampled during study period;

<sup>a,b</sup> Different superscripts indicate significant ( $P < 0.05$ ) difference in prevalence;

$\chi^2$  = Chi-square

**Table 4.** Occurrence of Indigestible Foreign Material in Small Ruminants based on Body Condition Score (BSC) Levels in Gombe State, Nigeria

Type of ruminant	Body Condition Score (BCS) Level	No. examined (N = 1730)	No. affected (%) n = 1067	Prevalence (%) (95% CI; LL – UL)	$\chi^2$	P-value	Degree of freedom
Goat	Poor	413	352 (85.2)	20.3 <sup>a</sup> (18.5 – 22.3)	177.03	< 0.0001	2
	Medium	370	261 (70.5)	15.1 <sup>b</sup> (13.5 – 16.9)			
	Good	157	44 (28.0)	2.5 <sup>c</sup> (1.9 – 3.4)			
Sheep	Poor	357	279 (78.2)	16.1 <sup>a</sup> (14.5 – 17.9)	191.39	< 0.0001	2
	Medium	285	103 (36.1)	6.0 <sup>b</sup> (4.9 – 7.2)			
	Good	148	28 (18.9)	1.6 <sup>c</sup> (1.1 – 2.3)			

Key: <sup>a,b,c</sup> Different superscripts indicate significant ( $P < 0.05$ ) difference in prevalence;  $\chi^2$  = Chi-square; CI = Confidence Interval; LL = Lower limit; UL = Upper limit  
 N = Total number of small ruminants examined and sampled during study period;  
 n = Total number of small ruminants found with indigestible foreign materials

## Discussion

The present study showed an overall prevalence of 61.7% for indigestible foreign materials in the abdominal cavity of small ruminants comprising of goats and sheep slaughtered at major abattoirs in Gombe State, Nigeria. The result of the current study is higher than 19.3% and 11% reported by Igbokwe *et al.* (2003) and Saulawa *et al.* (2012) from Maiduguri and Kastina states, Nigeria, respectively. Our findings are also higher than 10.8% reported by Otsyina *et al.* (2015) from Kenya and 30.7% and 23.4% reported by Fasil (2016) and Mekuanint *et al.* (2017), respectively from Ethiopia. On the other hand, our result was lower than 97% and 87% prevalence rates previously reported in small ruminants from Nigeria and South Darfur by Remi-Adewunmi *et al.* (2004) and Ghurashi *et al.* (2009), respectively.

It has been reported that the ingestion of indigestible foreign materials is associated with a shortage of forage and increased pollution of the grazing land with the indigestible materials (Negash *et al.*, 2015). Moreover, in Nigeria, feed shortage is predominant, particularly during the long dry season and most of the small ruminant owners practice mainly extensive management and do not supply supplementary feed

to their animals. The current study's findings revealed that goats are significantly more likely to consume indigestible foreign materials than sheep in the studied area, which is evidenced by the prevalence rate being higher in goats (38%) than sheep (23.7%) in Gombe state. This finding was in line with the results of Mohammed (2012) and Negash *et al.* (2015), who also reported a higher frequency of indigestible foreign bodies in goats than sheep. The findings of the current study contrast the reports from Remi-Adewunmi *et al.* (2004), Roman and Hiwot (2010), Akinrinmade and Akinrinde (2012; 2013), Fasil (2016), and Mekuanint *et al.* (2017) who previously reported significantly higher prevalence rates of indigestible rumen foreign bodies in sheep, compared to goats. However, Abebe and Nuru (2011), Tesfaye *et al.* (2012b), Saulawa *et al.* (2012), and Otsyina *et al.* (2015) have reported no significant difference in the prevalence of indigestible rumen foreign bodies between sheep and goats. The differences in the frequency of indigestible foreign materials reported between goats and sheep might be associated with the variable origins of the small ruminants sampled. Furthermore, it could be attributed

**Table 5.** Types and Frequency of Indigestible Foreign Materials based on Small Ruminant affected in Gombe State, Nigeria

Type of ruminant	No. affected (N = 1730)	Types and Frequency of Indigestible Foreign Materials (n = 1067)						
		Cloth (%)	Rope (%)	Stone/Sand (%)	Seed/Nuts (%)	Plastics/Leather/Nylon bags (%)	Wire/Metals (%)	Mixture of materials (%)
Goats	657	31 (2.9)	48 (4.5)	34 (3.2)	95 (8.9)	367 (34.7)	27 (2.5)	55 (5.2)
Sheep	410	24 (2.2)	33 (3.1)	25 (2.3)	83 (7.8)	189 (17.7)	16 (1.5)	40 (3.7)
<b>Total</b>	1067	55 (5.2)	81 (7.6)	59 (5.5)	178 (16.7)	556 (52.1)	43 (4.0)	95 (8.9)

Key: N = Total number of small ruminants examined and sampled during study period;  
n = Total number of small ruminants found with indigestible foreign materials

to the variations in the access of animals to indigestible foreign materials from domestic leftover and industrial waste materials, as we all the husbandry and management systems employed in the rearing of the animals waste management system of the study areas.

In terms of LGAs, the prevalence of indigestible foreign materials in small ruminants is higher in Gombe (8.2%) followed by Yamaltu Deba (8%), Funakaye (7.6%), Akko (7.4%), and Kwami (6.8%) LGAs. The prevalence is higher in goats than sheep in all the study locations. The relatively higher prevalence recorded in Gombe, Yamaltu Deba, and Funakaye LGAs might not be surprising as they are the most urban regions among the five study locations. This result might be associated with higher strewing of the environment with indigestible materials from domestic and industrial waste dumped into the environment where grazing animals habitually have unrestricted access, such as the garbage dumps.

It was observed that most of the small ruminants at all the abattoirs in the present study were from the urban, rural, and semi-arid areas within or those that shared boundaries with Gombe state. Small ruminants in Gombe state are reared extensively in the rural areas, where they are allowed to graze freely on natural pastures and the leftover of farms, which are much less contaminated with indigestible materials. On the other hand, the urban areas of Gombe state have less forage for grazing, and animals feed on any

ingestible materials during grazing, especially in the dry season. The current study's findings concur with Otsyina *et al.* (2015) who have also reported the higher prevalence of indigestible foreign bodies in small ruminants examined from urban areas compared to rural areas.

Furthermore, probably not all the small ruminants brought for sales in the current study are destined for the abattoirs. Many might be sold to people who slaughter them at home during sacrifices, ceremonies, and festivals. The present study results are limited to animals slaughtered at abattoirs, which might have also contributed to the relatively lower prevalence rate of indigestible foreign materials in sheep and goats. Our findings are consistent with the results of Ghurashi *et al.* (2009) in Sudan and Tesfaye *et al.* (2012b) in Ethiopia, who considered insufficient forage land obtainable for grazing in urban and peri-urban areas as one of the major factors exposing sheep and goats to the high risk of ingesting indigestible foreign materials.

In the present study, the prevalence of indigestible foreign materials in sheep and goats was correlated with age. The latter finding revealed that the consumption of indigestible foreign materials is significantly less likely to occur in young goats and sheep than in the adults of these small ruminants in the study area. This might partly be due to the gradual ingestion of indigestible foreign materials over

sustained periods as the animal grows older. Moreover, older animals meet trace minerals demands by feed, compared to young cases who comparatively acquires their nutrient requirements from milk. This result is in line with similar studies performed by Remi-Adewunmi *et al.* (2004), Roman and Hiwot (2010), Abebe and Nuru (2011), Saulawa *et al.* (2012), Tesfaye *et al.* (2012b), Fasil (2016), and Mekuanint *et al.* (2017), who reported a higher prevalence of indigestible foreign bodies in adults than small young ruminants. On the other hand, these findings contradict Otsyina *et al.* (2015), who has recovered a significantly higher prevalence of foreign bodies in young sheep and goats than the adults of these species. However, Akinrinmade and Akinrinde (2013) have stated that sheep and goats are usually exposed to the consumption of indigestible materials at an early age and accumulation occurs over time due to increased environmental pollution.

Furthermore, we found a relationship between the prevalence of indigestible foreign materials in small ruminants in the study area and their gender. Even though more males were slaughtered and sampled in the present study, our results revealed that the consumption of indigestible foreign materials is significantly higher in females than in male small ruminants. This finding might be associated with the fact that ewes and does are kept longer for breeding purposes leading to a higher chance of gradual consumption and accumulation of indigestible foreign bodies over time than rams and bucks. Moreover, several hormonal changes result in elevated appetite to meet nutritional demands during estrus, pregnancy, and lactation in female ewes. In this study, female animals without indigestible foreign materials could be associated with the intensive management of such animals from birth till salvage age. This finding of the present study is in line with the report of Igbokwe *et al.* (2003), Adewunmi *et al.* (2004), Roman and Hiwot (2010), Negash *et al.* (2015), Otsyina *et al.* (2015), and Bwala *et al.* (2016) who also reported a higher prevalence of indigestible foreign bodies in female sheep and goats, compared to males. However, our result was not consistent with the findings of Abebe and Nuru (2011), Saulawa *et al.* (2012), and Otsyina *et al.* (2015) who reported the lack of a significant difference in the prevalence of indigestible foreign bodies between different genders.

In addition, it was shown in the present study that the occurrences of indigestible foreign materials in sheep and goats were correlated with BCS. This present study revealed a significantly higher prevalence rate of indigestible foreign materials in sheep and goats in poor BCS compared to those with medium and good BCS. The finding of indigestible foreign bodies in small ruminants with poor BCS in the present study might be attributed to foreign bodies occupying most parts of the stomach, triggering the rumen's impaction. As a result, abdominal distention and significant interference with the adequate absorption of volatile fatty acids in the rumen occurs, which in turn, leads to reduced weight gain, progressive loss of flesh, and emaciation. These findings concur with previous studies by Igbokwe *et al.* (2003), Remi-Adewunmi *et al.* (2004), Roman and Hiwot (2010), Abebe and Nuru (2011), Saulawa *et al.* (2012), Tesfaye *et al.* (2012b), Negash *et al.* (2015), and Fasil (2016) who have also reported a higher prevalence of indigestible foreign bodies in sheep and goats with poor BCS, compared to those with medium and good BCS. The present study's findings disagree with Otsyina *et al.* (2015) who have previously reported a significantly higher prevalence of indigestible foreign bodies in sheep and goats with good BCS.

We also evaluated the types and frequency of indigestible foreign materials in sheep and goats in the study area. The higher prevalence of plastic/nylon bags found in sheep and goats compared with other types of indigestible foreign materials is because plastics or nylon are non-biodegradable and have been observed to contaminate grazing fields in the study area. The high prevalence of these materials indicates the free grazing management practice, widespread use of plastic/nylon bags in the studied area, and environmental pollution due to their improper disposal. This finding buttresses the previous studies that have also reported plastic as the most commonly encountered foreign material in the gastrointestinal tract of small ruminants (Igbokwe *et al.*, 2003; Remi-Adewunmi *et al.*, 2004; Roman and Hiwot, 2010; Abebe and Nuru, 2011; Saulawa *et al.*, 2012; Tesfaye *et al.*, 2012b; Negash *et al.*, 2015; Otsyina *et al.*, 2015; Fasil, 2016; Mekuanint *et al.*, 2017). In Nigeria, plastic/nylon bags are the most dominant component of household waste (Igbokwe

*et al.*, 2003) accounting for the observations in this study.

In terms of the anatomical sites, the present study revealed the rumen in sheep and goats to be significantly the most likely site for the dislodgement of indigestible foreign materials in the affected goats (30.4%) and sheep (18.5%). The difference between diverse types of ruminants in this regard was statistically significant ( $P < 0.0001$ ). This finding may be because digestible and indigestible ingested materials are first swallowed into the rumen. Therefore, all foreign bodies lodge in the rumen when there is an interruption in the flow of the ingested materials through the digestive tract. However, 95 (10.1%) and 68 (8.6%) of the cases occurred in the reticulum of the affected goats and sheep with a prevalence of 5.5% and 3.9%, respectively. However, different ruminants were not significantly different ( $P = 0.3269$ ) with an OR of 0.8377. The findings of the present study buttress the report of Negash *et al.* (2015) who also reported more foreign bodies in the rumen (87.9%) than in the reticulum (5%). However, 36 (9.4%) and 75 (9.5%) of the cases occurred in the rumen and reticulum of the affected goats and sheep with a prevalence of 2.1% and 1.3%, respectively. The likelihood for the occurrence of foreign materials in the rumen was not significantly higher (OR = 0.7193;  $P = 0.2852$ ) compared to other anatomical sites of the digestive organs. This finding of the current study is in line with the results of Roman and Hiwot (2010), Abebe and Nuru (2011), Tesfaye *et al.* (2012b), Saulawa *et al.* (2012), Negash *et al.* (2015), and Fasil (2016) who also reported more foreign bodies in the rumen, compared to other anatomical sites of the digestive organs. This finding may be attributed to the larger rumen volume, the cumulative size, composition of the foreign bodies, and the type of materials with metals and sharp objects tending to localize preferentially in the reticulum. Finding foreign indigestible materials in the reticulum might be due to the withholding of these indigestible foreign bodies by the honeycomb structure of the reticular mucosa.

## Conclusion

The extensive management system employed in rearing small ruminants in Gombe state can be incriminated as a major predisposing factor for acquiring indigestible foreign materials. Scarcity of forage during the dry season and nutritional deficiency also lead animals to find their feed from grazing lands potentially polluted with various indigestible foreign materials, including plastics, clothes, rope, leather, and metals. Extensive usage and inappropriate disposal of plastic bags, lack of adequate and proper legislation on waste disposal, or awareness campaigns regarding small ruminant health led to the high prevalence of rumen impaction with indigestible foreign materials in small ruminants. The present investigation revealed that the most common indigestible foreign materials in small ruminants are plastic/nylon (polyethylene) bags. This observational study showed the importance of foreign bodies as a risk for health and productivity causing weight loss by interfering with the absorption of volatile fatty acids, death, and premature culling. This study could help environmental activists, livestock owners, veterinarians, and policymakers to recognize the impact of indigestible foreign materials on ruminants' health and productivity in Gombe state, Nigeria. It could be recommended that government and private companies devise policies on handling waste management in these areas or the grazing sector.

## Recommendations

It is recommended that livestock extension service providers raise awareness among ruminant owners concerning the health consequences and risk factors associated with indigestible foreign materials in small ruminants. Small ruminant owners should be recommended to rear their animals under a semi-intensive management scheme to monitor their animal access to foreign bodies easily. Public awareness about the proper disposal of domestic waste, such as plastic bags, ropes, metals, and clothes, as well as the periodic cleaning of such waste in the grazing areas should be improved. The government and private companies need to devise policies on handling waste management in the area or the grazing sector. There is no previous research in this area on indigestible

foreign materials in sheep and goats. Therefore, further evaluations should be carried out to illustrate the issue's relevance in other species and discuss prevention and control measures.

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## Conflict of Interest

The authors declared no conflict of interest.

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