

Gross and Histo-Pathologic Findings in Goats with Plastic bags in the Rumen

Otsyina, H. R.^{1,3*}, Mbutia, P. G.², Nguhiu-Mwangi, J.³, Mogo, E. G. M.³ and Ogara W. O.⁴

¹School of Veterinary Medicine, College of Basic and Applied Sciences, University of Ghana, Legon.

²Department of Veterinary Pathology, Microbiology and Parasitology, Faculty of Veterinary Medicine, University of Nairobi, Kenya.

³Department of Clinical Studies, Faculty of Veterinary Medicine, University of Nairobi, Kenya.

⁴Department of Public Health, Pharmacology and Toxicology, Faculty of Veterinary Medicine, University of Nairobi, Kenya.

*Corresponding author: rhotsyina@ug.edu.gh /hotsyina64@yahoo.com

ABSTRACT

The objective of this study was to investigate the gross and histo-pathological changes caused by the presence of plastic bags in the rumen of goats. Sixteen castrated one-year old small East African goats were used for the study. The animals were divided into 4 groups, of 4 goats (n=4). Three groups were implanted with 129g, 258g and 387g of plastic bags, respectively, introduced into the rumen through rumenotomy, while the fourth group without implants served as control. All goats with or without plastic bags were observed daily for 6 weeks following implantation. Dead and surviving goats euthanized after the 6-week period were subjected to postmortem and histopathological examination. Gross pathological lesions observed were atrophy of the muscle and body fat, and atrophy and fibrosis of the spleen, liver, kidneys and hydropericardium. Lesions on the rumen epithelium included stunting, atrophy, thinning and loss of ruminal papillae, erosion, ulcerations and nodular formations on the ruminal mucosa. The histopathological examination revealed atrophy, erosion, ulceration, and disruptions of the stratified epithelial layer of the papillae. Other changes included parakeratosis, hyperkeratosis, prominent rete pegs, oedema and severe hydrophic degeneration of different parts of the mucosal layer. There were areas of increased mononuclear cell infiltration, increase in the number of lymphatic vessels and lymphangiectasis in the submucosa, and oedema in the muscularis and serosal layers. The pathological changes observed may interfere with the digestion and absorption of nutrients, resulting in poor animal condition, overall productivity and production.

Keywords: Goats, Pathology, Plastic Bags, Rumen

Introduction

Goats reared under the traditional extensive husbandry systems mainly roam and scavenge for food, and may ingest various indigestible foreign bodies, especially in urban and peri-urban areas (Remi-Adewunmi *et al.*, 2004). These materials, particularly plastic bags, pollute the grazing environment due to indiscriminate disposal of waste in many parts of the developing world (Remi-

Adewunmi *et al.*, 2004; Ghurashi *et al.*, 2009). The risk factors that compel goats to ingest these non-food materials include deficiency of minerals such as calcium, phosphorus and other micronutrients (Radostitis *et al.*, 2009); feed scarcity (Igbokwe *et al.*, 2003); depraved appetite (Reddy and Sasikala, 2012), poor management of animals leading to scavenging at dumping sites;

poverty among animal owners which makes them unable to provide feed; and increased number of animals per given land space (FAO, 1999).

Accumulation of indigestible foreign bodies in the rumen and other parts of the digestive tract may cause complications in the rumen and other organs of the body (Otsyina *et al.*, 2016). The complications caused by ingested foreign bodies may vary with the type of material, the duration of its presence in the body, its location and the degree of obstruction caused by the offending foreign body (Tesgaye and Chanie, 2012). The effect of indigestible materials, particularly plastic bags, in the rumen of goats includes interference with the flow of ingesta, ruminal tympany, anorexia, hypoglycaemia, depression, absence of defaecation, reduced milk production, reduced fattening of the animal, loss of weight and death of the affected animal (Igbokwe *et al.*, 2003; Reddy *et al.*, 2004; Remi-Adewunmi *et al.*, 2004; Debaris and Mousumi, 2010; Vanitha *et al.*, 2010; Otsyina *et al.*, 2014).

Gross and histopathological lesions observed in the rumen and tissues of goats with indigestible foreign bodies in abattoir studies and at postmortem include sloughed and hyperplastic epithelia; atrophy and loss of ruminal papillae; rumenitis; erosion, ulceration and scarred ruminal pillars, and epithelia (Robbins *et al.*, 1984; Hailat *et al.*, 1998; Bakheit, 2008; Pitroda *et al.*, 2010). However, the types of foreign bodies, the quantities and the degree of obstruction, severity of damage caused as well as the duration of their presence in the rumen that produced the reported effects are not known. Gross and histo-pathological changes in goats with indigestible materials experimentally implanted into the rumen have not been previously studied. Since goats have occasionally been found to have plastic bags in their rumen at slaughter and at necropsy (Otsyina *et al.*, 2015), the current study reports the gross and histopathological lesions in goats with specific quantities of plastic bags experimentally implanted into the rumen over a period of 6 weeks.

Material and methods

Experimental animals

Sixteen (16) castrated small East African goats with a mean body weight of 24.5kg and a body condition score of 3.0 ± 0.5 (on a scale of 1-5) were used for the study. The animals were housed in groups of four (4) for the whole period of the experiment and allowed 6 weeks to acclimatize to the environment and the feed. They were fed on chopped Rhodes grass hay supplemented with commercially produced small stock concentrate meal (UNGA AFYA Meal, UNGA Farm Care Ltd, Nairobi, Kenya). Feed and drinking water were provided *ad libitum*. They were treated against endoparasites with 2.5% Albendazole (Alfabas[®] Norbrook, Kenya) administered at a dose rate of 4ml/kg of body weight. They were also treated against ectoparasites with Ivermectin at a dose rate of 1ml/50kg of body weight. All the animals were administered 20% injectable Oxytetracycline HCl (Alamycin LA 20[®], Norbrook, Ireland) at a dose rate of 20mg/10kg of body weight as a prophylactic measure against infection often associated with transportation stress. The animals were subjected to routine physical examination over the acclimatization period.

They were then assigned to 4 experimental groups (4 groups with 4 goats each) using stratified random sampling based on the weight of the animals, such that the mean weight of animals in each of the experimental groups was not statistically different. Three of the groups (GE1, GE2 and GE3) had 129 g, 285 g and 387 g of plastic bags respectively implanted into the rumen through rumenotomy, as previously described by (Hendrickson, 2007). The plastic bags implanted were non-perforated small soft polythene bags (KEBS Industries Ltd, Nairobi, Kenya). Each poly bag measured 167 mm x 290 mm in size and 30 micrometers thick, and a pack of 100 pieces weighed 129 g. These were the most common type of plastic bags found in the rumen of sheep and goats during an abattoir study carried out prior to the experimental study. The fourth group (GC4) served as control on which rumenotomy was done but no plastic bags were implanted. Both test and control animals were monitored daily for a period of 6 weeks (42 days). The duration of

implantation of the plastic bags was informed by a pilot study and an abattoir study conducted at two abattoirs in Nairobi, Kenya. All vital parameters as well as clinical manifestations were noted and recorded.

Euthanasia of experimental animals

After 6 weeks of implantation of plastic bags into the rumen, all were euthanized for postmortem and histopathological examination. Euthanasia was carried out humanely by sedation using Xylazine hydrochloride at a dosage of 0.2mg/kg body weight, followed by stunning with a captive bolt pistol, after which the animals were exsanguinated.

Postmortem examination

Postmortem examination of the euthanized goats was done through inspection of individual carcasses of both test and control groups. The carcasses were weighed, then flayed to examine the state of the musculature and to note any abnormalities. They were opened and the gastrointestinal tract, liver, kidneys, spleen, pancreas, lungs, heart, lymph nodes, adrenal glands, gall bladder and urinary bladder were examined for gross lesions. The rumen was examined while intact with the contents, and then incised to inspect the contents and the nature of the implanted plastic bags. The contents were removed and the rumen thoroughly washed for better inspection of the wall, mucosa, the papillae and the pillars for any abnormalities. The organs of goats implanted with plastic bags were weighed and the weights compared with those of the control. All findings in all tissues and organs were recorded. Photographs of carcasses and body organs were taken using an iPad 4 with retina display application (Apple Computers Inc, USA).

Histopathological examination

Rumen tissues were collected from areas with and without gross pathological lesions. They were immediately preserved in 10% buffered formalin and allowed to fix for a minimum of one week before processing.

The formalin fixed tissue specimens were processed for histological examination as previously described by Smith and Bruton (1977). They were cut into a thickness of 3-5 μ m. Four sections were made from every paraffin wax block, stained with haematoxylin and eosin (H&E) and mounted on microscope slides using Destrene 80, dibutyl Phthalate and xylene (DPX). The slides were examined under the light microscope using x4, x10, x40 and x100 objective lenses. Results were recorded and photomicrographs taken using the photomicroscope (Olympus CXSF1, Olympus Corporation, Tokyo, Japan).

Animal use ethical approval

Animal use ethical clearance was approved by the Biosafety, Animal use and Ethics Committee (BAEC) of the Faculty of Veterinary Medicine, University of Nairobi, Kenya, according to international standards of animal use in research; clearance certificate number: 11250313.

Results

Pathological changes in carcasses and gastrointestinal tract

The gross lesions observed in carcasses and gastrointestinal tract of goats with plastic bags implanted in the rumen are presented in Table 1. The carcasses of the goats in the control group and those with 129g of plastic bags implanted in them appeared normal. However, goats with 258g and 387g of plastic bags implanted in them had atrophy of the muscles and body fat, atrophy and degeneration of the omental fat, hyperemia and oedema of the prescapular lymph nodes.

Table 1: Gross pathological changes observed on carcasses and gastrointestinal tracts of goats with plastic bags implanted in their rumen

Carcass/Organ	Gross Pathological Changes			
	Control (GC4) No plastic bags	Group GE1 129 g	Group GE2 258 g	Group GE3 387 g
Carcass	Good body condition well covered with fat	Fairly good body condition; reduced body fat; lymphadenitis of prescapular lymph nodes	Poor body condition, atrophy of the muscles, body fat and omental fat, lymphadenitis of prescapular lymph nodes	Poor body condition, atrophy of the muscles, body fat, hyperemia and oedema of prescapular lymph nodes, atrophy of omental and mesenteric fat
Rumen	No significant findings	Slightly reduced in size	Eroded patches devoid of papillae, short and stunted papillae, oedema and haemorrhages of the ruminal folds and rumen mucosa	Hyperemia and congestion of the rumen mucosa; eroded patches devoid of papillae; short, stunted and fungoid papillae; oedema and haemorrhages of the ruminal folds and rumen mucosa, ulcers on ruminal folds
Reticulum	No significant findings	No significant findings	Atrophied and empty	Atrophied and empty, no papillae in the combs
Omasum	No significant findings	Slightly reduced in size	Atrophied and empty	Atrophied and empty, hyperemia and oedema of the folds, ulcerations at the reticulo-omasal orifice
Abomasum	No significant findings	Slightly reduced in size.	Empty, atrophied, congested and haemorrhagic. Ulcers at the pyloric region	Atrophied and empty, congested and haemorrhagic, ulcers at the pyloric region
Small intestines	No significant findings	No significant findings	Atrophied, congested and haemorrhagic and filled with fluid	Atrophied, congested, haemorrhagic and filled with blood tinged fluid
Large intestines	No significant findings	No significant findings	Atrophied, congested and haemorrhagic and filled with fluid	Atrophied, congested, haemorrhagic and filled with blood tinged fluid

Key: SE1 - Goats with 129 g of plastic bags implanted in them; **SE2** - Goats with 258 g of plastic bags implanted in them; **SE3** - Goats with 387 g of plastic bags implanted into the rumen; **GC4** (control) - Goats with no plastic bags in the rumen; **n**- number of goats; **g** - grams.

The rumen contents looked normal and the rumen did not show significant pathologic changes in the control goats and those with 129 g of plastic bags implanted in them. However, goats with 258 g and 387 g of plastic implanted in them showed congestion, hyperemia, haemorrhages, erosions, excoriations, scarification and loss of papillae on the walls of the rumen. The rumen papillae were stunted, atrophied and thin. Scars, ulcerations and nodular lesions were found on the ruminal pillars in all

the goats with 258 g and 387 g of plastic bags implanted in them. In the same groups of goats, the walls of the rumen were very thin. Furthermore, in these two groups, the reticulum, omasum and abomasum were atrophied, congested and haemorrhagic. The gastrointestinal tract distal to the rumen was completely devoid of ingesta and the intestines were found to have a blood tinged fluid.

Pathological changes in other organs and tissues

Gross pathological changes in various organs and tissues in goats with various quantities of plastic bags implanted in them are shown in Table 2. Atrophy and fibrosis of the liver, spleen, kidneys, heart and lungs were observed in all the goats with 258 g and 387g of plastic bags implanted in them. Distension of the gallbladder with thickening of the bile ducts and viscous bile were observed in 3 of the 4 goats in each of the two groups. In all the goats with 258 g and 387 g of plastic bags implanted in them, the heart muscles were thin; the coronary fat was atrophied and there was hydropericardium with straw coloured fluid.

The severity of gross pathological changes in the goats increased with the weight of the implanted plastic bags. Three of the goats with 258 g and all goats with 387 g of plastic bags implanted died before the end of the 6 weeks. The animals that died showed similar lesions as observed in those that were euthanized. The goats with 129 g of plastic bags implanted in them had very minimal changes while those without plastic bags (control) did not have any observable gross pathology upon examination at 6 weeks.

Table 2: Gross pathological changes observed in organs of goats with plastic bags implanted in the rumen

Organs	Gross Pathological Changes			
	Control (GC4) (No plastic bags)	Group GE1 129 g	Group GE2 258 g	Group GE3 387 g
Liver	No significant findings, normal consistency	Slight reduction in size, normal consistency	Firm and fibrotic liver, distended gall bladder, viscous bile	Firm and fibrotic of liver, distended gall bladder with viscous bile
Spleen	No significant findings	Slightly reduced in size, normal consistency	Atrophy of spleen with fibrotic capsule	Atrophy of spleen with fibrotic capsule
Heart	No significant findings	Slightly atrophic with slight degeneration of coronary fat	Hydropericardium (straw coloured fluid), gelatinous coronary fat	Very thin cardiac muscles, no coronary fat, hydropericardium with straw coloured fluid
Kidneys	No significant findings	Slightly atrophied, renal fat atrophy	Atrophy and congestion of the renal fat, fibrotic capsule	Atrophy of the renal fat, fibrotic capsule and congestion of medullary area
Lungs	No significant findings	No gross changes	Presence of froth	Oedematous and congested

Key: **GE1** - Goats with 129 g of plastic bags implanted in the rumen; **GE2** - Goats with 285 g of plastic bags implanted in the rumen; **GE3** - Goats with 387 g of plastic bags implanted in the rumen; **GC4** (control) – Goats with no plastic bags in the rumen; **n** - Number of goats; **g** – grams.

Histopathological findings of the rumen

Histopathological findings of rumen tissues of goats in control and experimental animals are presented in Figures 1-4. The control group showed normal papillae with a thin and continuous stratified epithelium without disruptions or erosions. The long, intermediate and short papillae were all present. The long papillae were about 2-3 microscope fields (x40 Magnification) long from their base to the tip. The mucosa epithelium was 3-5 cells thick with cornified layers and no rete pegs. The submucosa had good connective tissues with few lymphatic ducts and without infiltration of mononuclear or polymorphonuclear cells. The muscular layer and the serosa had no observable gross lesion (Fig 1).

With goats with 129 g of plastic bags in them, the stratified epithelium of the rumen was disrupted with degeneration, necrosis and patchy hyperplasia in many areas (Fig 2). The papillae were shortened, stunted, sometimes broadened, compressed or flattened, atrophied and shredded in some areas. The length of the papillae was about half (1/2) of the field of the microscope at x40 Magnification (Fig 2). There were clefts at the tips of some of the atrophied papillae. Degeneration, necrosis and hyperplasia of the mucosa with prominent rete pegs of variable length projecting into the submucosa were observed. The mucosa had up to 28-32 cells in thickness, with both extracellular and intracellular epithelial cell oedema characterized by hydrophic degeneration, cellular vacuolation and spongiosis (Fig 2). The submucosa appeared widened and oedematous, with dilated lymphatics between the rete pegs. There was degeneration, necrosis and fibrosis of the connective tissue with increased mononuclear cell

infiltration in the submucosa (Fig 2). The muscular layers were atrophied, compressed and shredded in some areas. Muscle fibers were separated by oedema. The serosa was shredded, widened and oedematous (Fig 2).

Goats with 258 g and 387 g of plastic bags implanted showed similar but more severe changes than those with 129 g of plastic bags implanted in them. The severity of the lesions increased with the quantity of plastic bags in the rumen. These changes included degeneration, erosion, necrosis, disruption, sloughing, and segmental hyperplasia of the keratinized epithelia in many areas of the rumen (Figs 3 and 4). In some areas of the rumen, the rumen papillae were atrophied, shortened, compressed, flattened and disrupted.

In goats with 258 g of plastic bags implanted, the papillae were broadened but shortened in length to less than a quarter (1/4) of the microscope field (Magnification 40x) (Fig 3). While in those with 387 g of plastic bags implanted, the length was less than an eighth (1/8) of the microscope field (Magnification 40x) (Fig 4). The mucosa epithelium was 35-37 cells in thickness in those with 258 g and 40-45 cells thick in those with 387 g, with both extracellular and intracellular epithelial cell oedema being characteristic of hydrophic degeneration, cellular vacuolation and spongiosis of the cells (Figs 3 and 4). The submucosa in the two groups was oedematous with dilated lymphatics, increased mononuclear cell infiltration and vascularization (Fig 3). The muscular layers were also atrophic and shredded in some areas while the muscle fibers were separated by oedema. The serosa was also shredded, widened and oedematous (Figs 3 and 4).

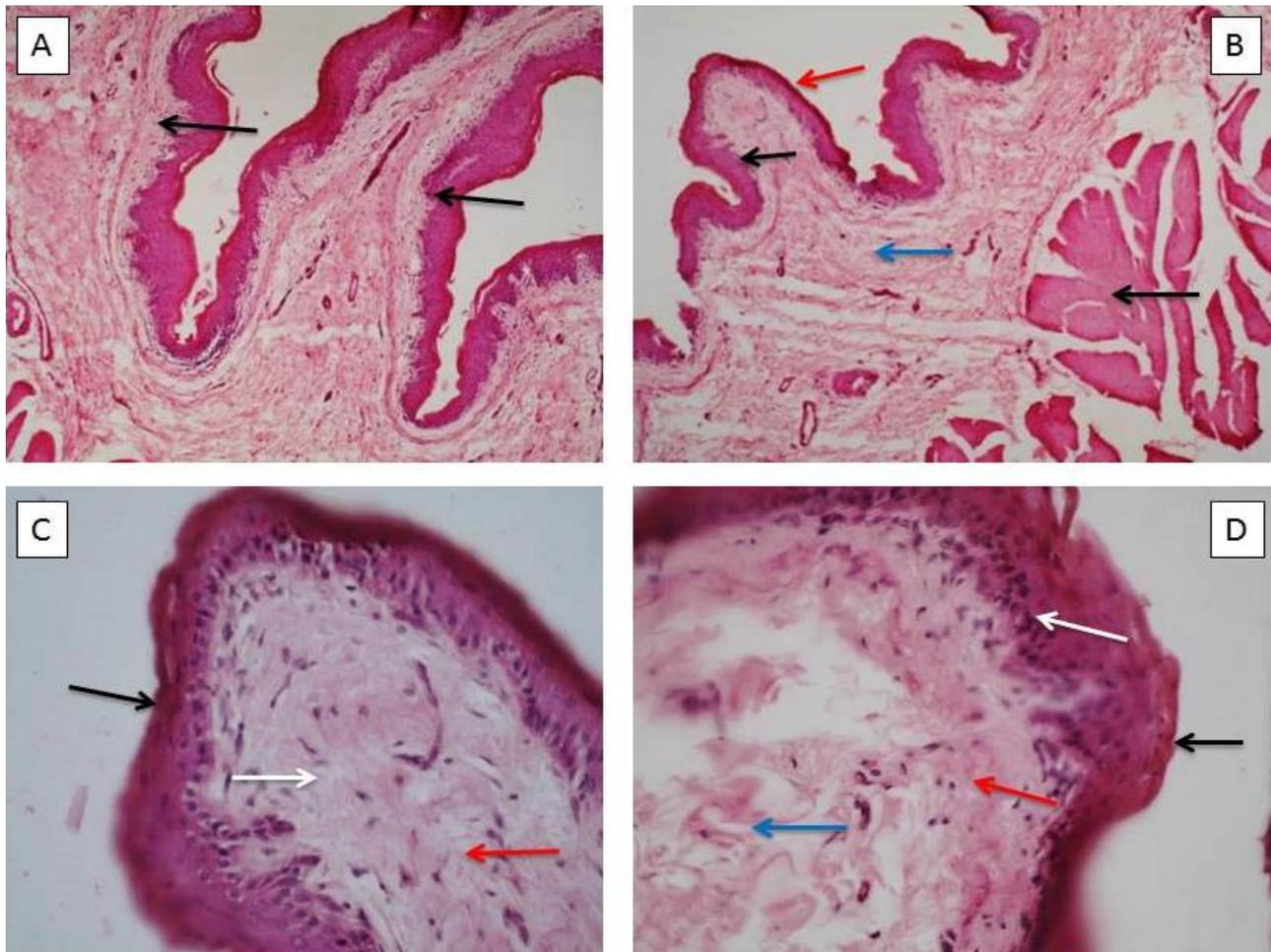


Fig. 1: Rumen of goats without plastic bags (control): (A) showing normal ruminal papillae (arrows) with normal keratinized epithelium, mucosa and submucosa (Magnification 40x); (B) showing normal papilla (red arrow), normal mucosa (white arrow), submucosa (blue arrow), muscular (black arrow) (Magnification 40x); (C) higher magnification of the tip of ruminal papilla showing its 3-4 cell epithelium with a thick keratinized layer (black arrow), submucosa (white arrow), and muscularis parts (red arrow) (Magnification 100x); (D) higher magnification of the tip of the papilla showing epithelium with keratinized layer (black arrow), mucosa (white arrow), submucosa (red arrow) and muscularis layer (blue arrow) (Magnification 400x) (H & E stain).

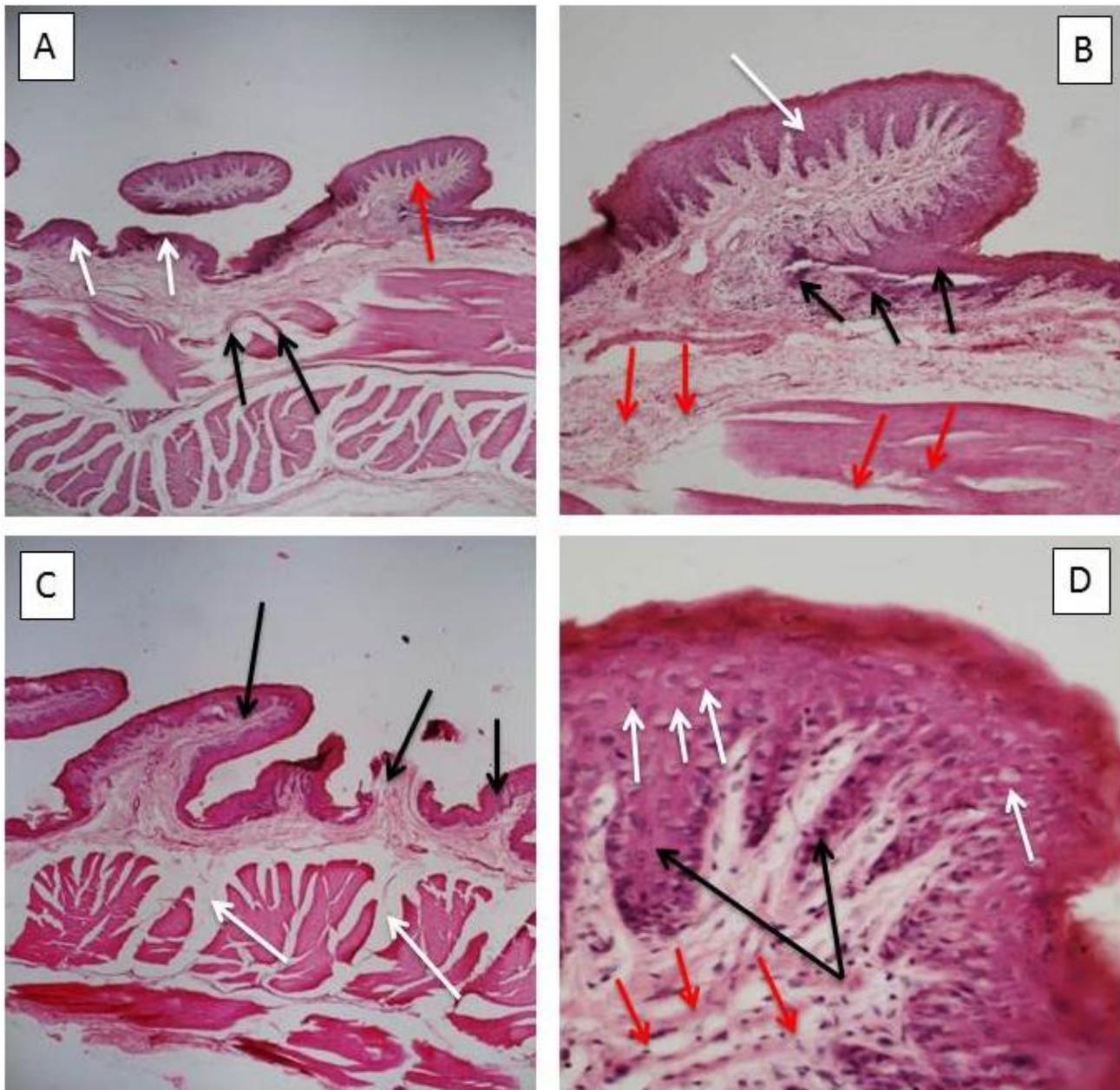


Fig. 2: Rumen of goats with 129 g of plastic bags implanted in them: (A) showing atrophied (*white arrows*), flattened (*red arrow*) ruminal papillae and shredded submucosa and muscle layers (*black arrows*) (Magnification 40x); (B) showing atrophied and flattened papilla (*white arrow*) with regenerated epithelium (*black arrows*), and compacted muscle layers (*red arrows*) (Magnification 100x); (C) showing atrophied and destroyed papillae (*black arrows*) and separated bundles of the muscle layer (*white arrows*) (Magnification 40x); (D) showing tip of the papilla with hyperplasia of the mucosa and prominent rete pegs (*black arrows*), oedema and spongiosis of the cells (*white arrows*) and oedema of the submucosa (*red arrows*) (Magnification 400x) (H & E stain).

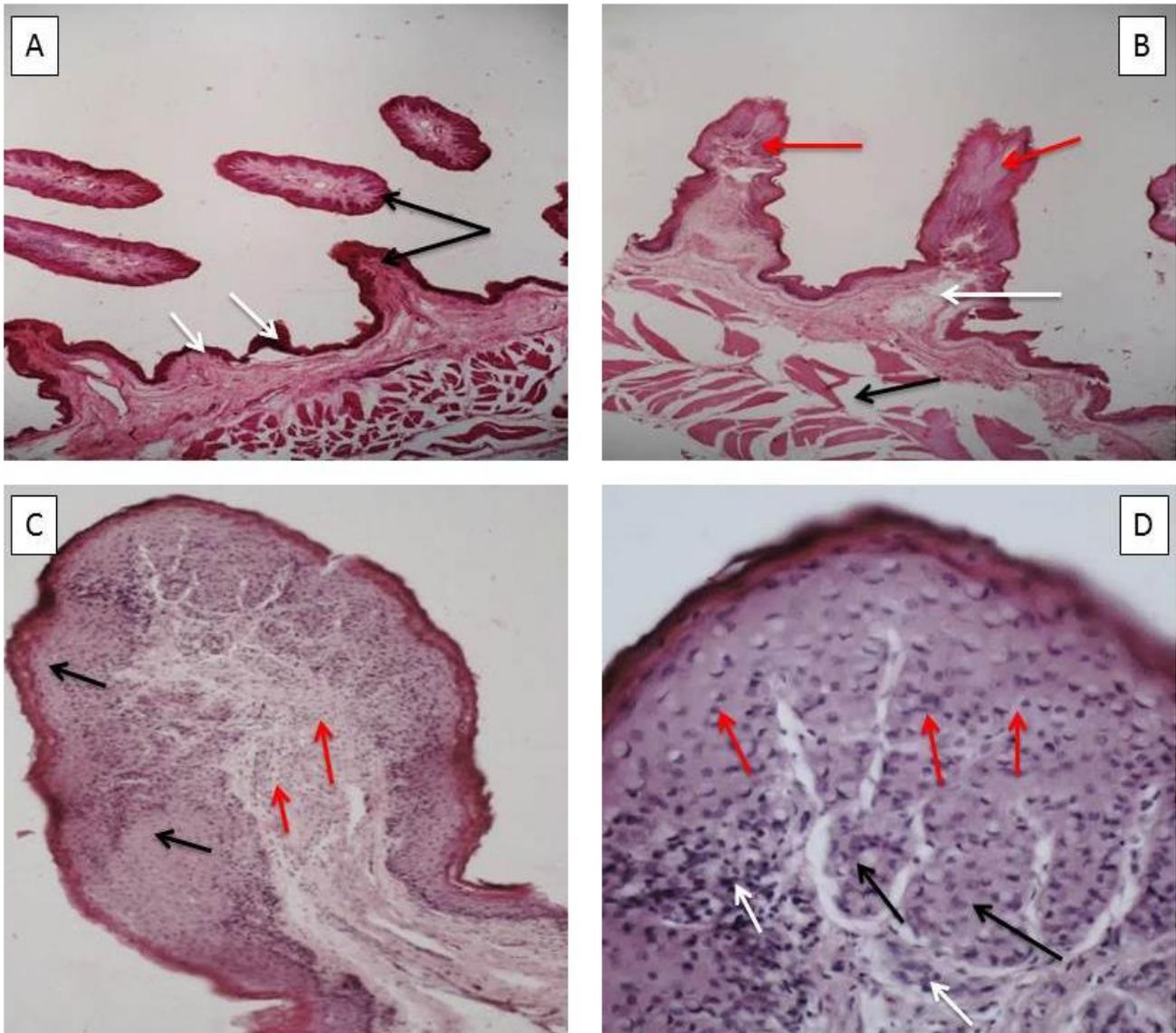


Fig. 3: Rumen of goats with 258 g of plastic bags implanted in the rumen: (A) showing disrupted (*black arrows*) and atrophied (*white arrow*) papillae (Magnification 40x); (B) showing destroyed ruminal papillae (*red arrows*), submucosa (*white arrow*) and atrophic separated muscle layer (*black arrow*) (Magnification 40x); (C) showing atrophied and fungoid papilla with hyperplastic mucosa (*black arrows*), compaction and vascularization of the submucosa (*red arrows*) (Magnification 100x); (D) showing tip of an atrophic papilla with hyperplastic epithelium with prominent rete pegs (*black arrows*), vacuolation and spongiosis of the cells (*red arrows*) and massive infiltration of mononuclear and polymorphonuclear cells (*white arrows*) (Magnification 400x) (H & E stain).

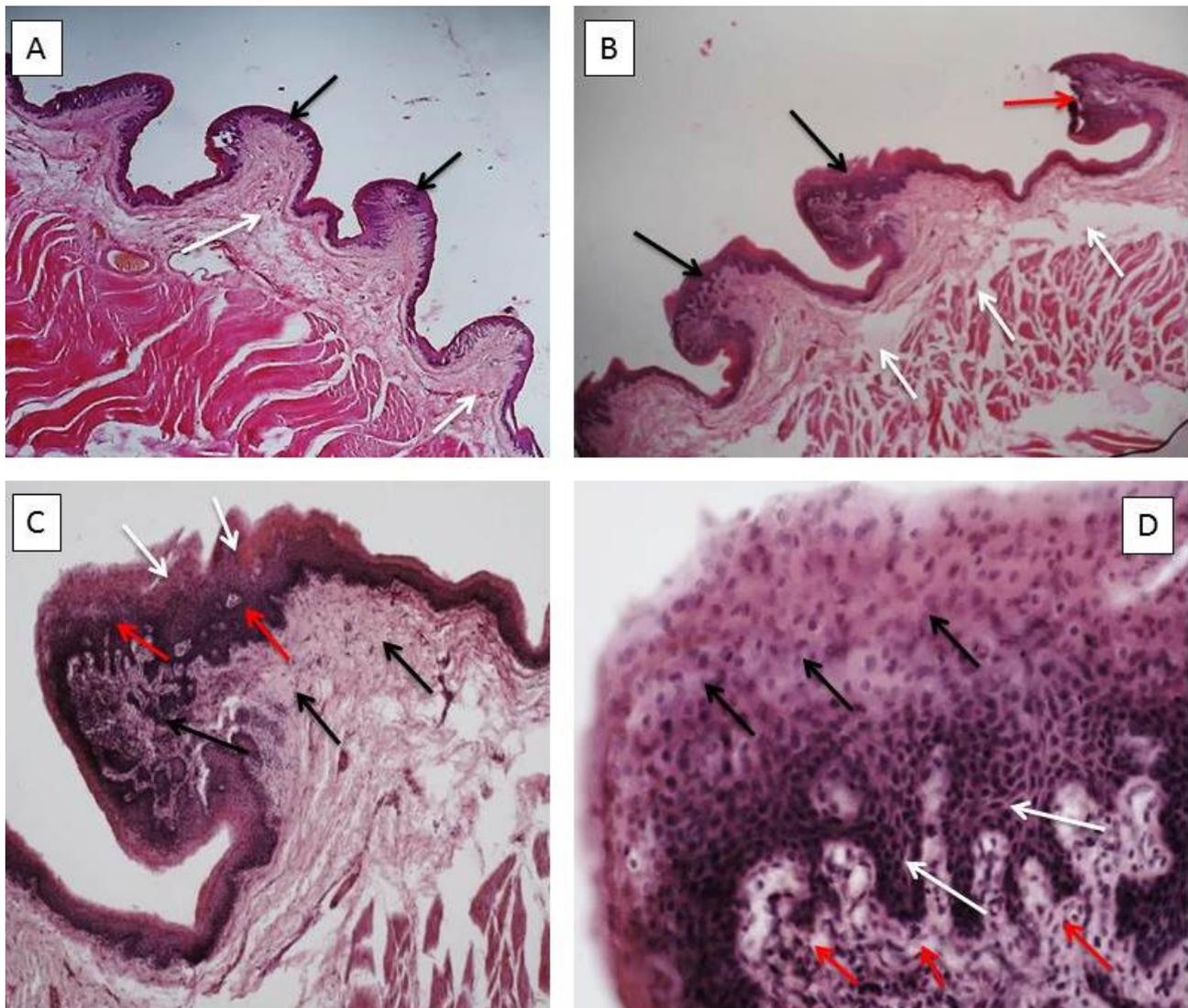


Fig. 4: Rumen of goats with 387 g of plastic bags implanted in the rumen: (A) showing stunted, clubbed atrophied and broadened (*black arrows*) ruminal papillae, widened and disrupted submucosa (*white arrows*) (Magnification 40x); (B) showing atrophied and bent papillae (*black arrows*), ruptured papilla (*red arrow*), disrupted, degenerated submucosa, and atrophic degenerated muscularis (*white arrows*) (Magnification 40x); (C) showing atrophied papilla with disrupted stratified epithelium (*white arrows*), degenerated and hyperplastic epithelium (*red arrows*) and degenerated submucosa (*black arrows*) (Magnification 100x); (D) showing tip of the atrophied papilla with hyperplastic epithelium (*black arrows*) and interlocking rete pegs (*white arrows*), compressed and degenerated submucosa with massive infiltration of mononuclear and polymorphonuclear cells (*red arrows*) (Magnification 400x) (H & E stain).

Discussion

This study described the gross and histopathological changes associated with accumulation of plastic bags in the rumen of goats. The severity of the gross and histopathological changes varied with the quantity of plastic bags present in the rumen. This confirms what was previously suggested, that the severity of pathological changes depends on the type of foreign body, the duration in the rumen and the degree of obstruction (Calfee and Manning, 2002; Tesgaye and Chanie, 2012). However, quantitative damage by the same type of foreign body as evaluated in this study has not been previously reported.

Generalized muscle and organ atrophy; degeneration of body; omental, mesenteric and pericardial fat observed in the goats may be due to anorexia and physiological nutrient imbalances. The extent of stretching of the ruminal wall and reduced ruminal motility due to the presence of plastic bags in the rumen may have stimulated the hypothalamus and satiety centre, leading to anorexia, emaciation and dehydration (Ghurashi *et al.*, 2009; Mozaffari *et al.*, 2009; Otsyina *et al.*, 2016). In addition, the plastic bags may have produced toxicants, while the damage to the ruminal mucosa may allow these toxic substances from the rumen into the body to cause toxemia and anorexia. Chronic wasting diseases, malnutrition and cachexia result in mobilization of fat deposits (Jubb *et al.*, 1985), hence the degeneration and atrophy (Abdalla *et al.*, 2010). The selected organs in the body showed a reduction in size and weight due to atrophy. Radostitis *et al.* (2009) reported that atrophy of the liver is related to chronic distension of adjacent structures of the alimentary canal such as the rumen or colon, which exerts pressure on the organ, and this could explain the observation in the current study.

Shortening, stunting and atrophy of the papillae; erosion, excoriation of the papillae as well as oedema of the ruminal pillars, ulcerations, scars, nodules, hyperemia and haemorrhages of the rumen mucosa and thinning of the ruminal wall, were consistent findings in previous reports in clinical and abattoir studies involving different types of foreign bodies (Bakhiet, 2008; Ghurashi *et al.*,

2009). Similarly, Raoofi *et al.* (2012) found a significant reduction in the thickness of the rumen in goats with a nylon rope implanted in them. However, these changes varied with the quantity of plastic bags present in the rumen. The degree of papillae and pillar atrophy was also dependent on the quantity of plastic bags. The degree of shortness of the papillae has not been evaluated and graded as in this study. These pathological changes may be attributed to the pressure exerted against the ruminal walls by the plastic bags (Bakhiet, 2008) and perhaps toxicants from the plastic bags and the ruminal contents. Furthermore, constant irritation of the wall of the rumen by continuous movement of the plastic bags may have led to erosion and excoriations of the rumen papillae, ruminal pillars and mucosa, resulting in inflammation and hyperplasia of the epithelial mucosa (Bakhiet, 2008). It is also possible that some of the lesions may have resulted from poisonous substances released from the plastic bags and toxicants absorbed from the rumen. Hyperemia, haemorrhages and oedema observed in the reticulum, omasum, abomasum and intestines could be due to irritation, circulatory disturbances and inflammation as a result of toxic substances released from the plastic bags and absorbed from the gastrointestinal tract.

Fibrosis and atrophy of the liver observed in the current study could be due to hepatocyte damage from absorbed toxic substances from the rumen after severe ruminal mucosa damage by the plastic bags. It has been reported previously that fibrosis and necrosis of the liver could occur as a result of toxic injury to the liver parenchyma, and the degree and pattern of the damage is determined by the duration of injury and the metabolic reactions triggered by the intoxication (Jubb *et al.*, 1985). This could mean that the animals with 387 g of plastic bags implanted in them had more injury to the liver, hence the variegated discolourations of the liver associated with the fibrosis. This could have contributed to the early deaths observed in the goats in this study. The distended gall bladder, viscous bile and thick bile ducts observed in goats implanted with plastic bags could be due to anorexia and starvation (Radostitis *et al.*, 2009).

The changes in the spleen and kidneys including atrophy and capsular fibrosis observed in the goats with plastic bags implanted in them may be associated with the anorexia, malnutrition and cachexia in these animals as a compensatory body mechanism during stressful conditions such as chronic wasting diseases (Jubb *et al.*, 1985). Similar compensatory body mechanisms may also be responsible for the gross pathological changes on the heart including atrophy and thin atrial and ventricular musculature, the absence of pericardial fat and hydropericardium observed in most of the goats with 285 g and 387 g of plastic bags implanted in them. Oedema and congestion of lungs could be due to starvation resulting in hypoproteinaemia and difficulty in breathing due to pressure exerted on the diaphragm by the distended rumen. Impaired function of the heart could be due to myocardial atrophy, degeneration and hydropericardium. Pulmonary congestion due to cardiac insufficiency resulting in interstitial pulmonary oedema has been reported in some heart conditions (Jubb *et al.*, 1985). Such findings have not been previously associated with foreign bodies in the rumen.

Histopathological changes observed in the rumen involving the papillae, pillars and the epithelia can be attributed to excessive pressure exerted on the ruminal walls by the plastic bags. Similar findings have been reported in abattoir studies by other authors (Bakhiet, 2008; Hailat, 1998), although the time span and quantities of foreign bodies were not evaluated as in this study. The degree of atrophy and estimation of cell numbers, and thickness in hyperplastic tissue have not been previously reported in goat rumen with indigestible foreign bodies. These changes may have been due to mechanical irritation induced by the plastic bags or chemical substances released by these bags as suggested previously (Bakhiet, 2008).

The hyperplasia, degeneration, oedema, cellular vacuolation and karyolysis observed in the mucosa of the rumen could be the effects of plastic bags (Raofi *et al.*, 2012; Bakhiet, 2008). According to Robbins *et al.* (1984), pathologic hyperplasia constitutes precursors from which cancerous proliferation may eventually arise.

Hence the papilloma-like hyperplasia of the mucosa of the rumen with prominent interlocking rete pegs projecting into the underlying submucosa and nodules observed grossly in this study could be an indication of an early process. Further investigations are however needed to elucidate this assertion. The prominent mucosal and submucosal oedema, cellular oedema and spongiosis observed in this study may be due to fluid seeping through the ruminal walls into the tissues because of the physical damage caused by the plastic bags or generalized oedema resulting from the severe starvation and cachexia (Jubb *et al.*, 1985).

The degeneration, necrosis and fibrosis of the connective tissue with increased mononuclear and polymorphonuclear cell infiltrations into the submucosa could be due to progressive cellular change attracting phagocytic cells to remove destroyed ruminal tissue and provide stimuli for tissue repair after irritation and cellular damage by the plastic bags. Dowan *et al.* (1995) previously reported similar inflammatory response after intra-arterial injection of plastic particles into the brain parenchyma of a sheep. The exostosis of the polymorphonuclear cells and increased vascularization with congestion of the blood capillaries in the submucosa can occur in the early stages of regeneration of the epithelia in response to chronic irritation by the plastic bags. Hyperplasia, oedema and separation of the muscular layer and serosa observed could be due to the pressure exerted on the ruminal wall by the plastic bags as previously suggested (Bakhiet, 2008).

Conclusion

The presence of plastic bags in the rumen of goats, depending on the quantity and duration, caused significant damage to the ruminal wall and the ruminal papillae as well as major body organs. This could adversely affect digestion leading to impaired nutrient absorption, ill-health and death of the animal. Goats should therefore not be left to roam freely if they are to be prevented from ingesting plastic bags and suffering the effects on their overall well-being, productivity and production.

Acknowledgment

The authors are grateful to Transdisciplinary Training for Resource Efficiency and Climate Change Adaptation in Africa (TRECCAfrica) Project funded by the EU/Intra ACP and the University of Ghana for providing the funds for this work, the research assistants who assisted in data collection and the University of Nairobi for providing equipment and facilities for the work.

References

- Abdalla, M. A., Salwa, A. E, and Yahia, M. H. (2010). Effect of state of hydration on body weight, blood constituents and urine excretion in Nubian goats (*Capra hircus*). *World Journal of Agricultural Sciences*, 6 (2), 178-188.
- Bakhiet, O. M. (2008). Studies on the rumen pathology of Sudanese desert sheep in slaughter house. *Scientific Research and Essay*, 3 (7), 294-298.
- Debaris, J. and Mousami, J. (2010). Non Metallic Foreign Body Syndrome in a Garole ewe. *Intas Polivet*, 2 (II), 253-255.
- Dowan, P. A., Owen, A. J. and Byard, R. W. (1995). Histological response to injection of polyethylene and bioplastique in the sheep brain. *Journal of Urology* 75, 666-669.
- FAO. (1999). Spotlight issues in urban agriculture studies suggest that up to two-thirds of city and peri-urban households are involved in farming. <http://www.fao.org/ag/magazine/9901sp2.htm> (05/06/2012).
- Ghurashi, M. A. H., Seri, H. I., Bakheit, A. H. and Ashwag, E. A. M. (2009). Effect of surgical removal of foreign body from goat's rumen with special reference to the prevalence of foreign body in goats in Southern Dafur. *Australian Journal of Basic and Applied Science*, 3(2), 664-668.
- Grunberg, W. and Constable, P. D. (2009). Function and Dysfunction of the ruminal forestomach. In *Food Animal Practice*. Anderson D.E and Rings D.M (eds) Saunders Elsevier, St Louis, Missouri, USA, pp 12- 19.
- Hailat, N., Al-Darraj, A., Lafi, S., Barakat, S. A. F., Al-Ani, F., El-Magraby, H., Al-Qudah K., Gharaibeh, S., Rousan, M. and Al-Smadi, M. (1998). Pathology of the rumen in goats caused by plastic foreign bodies with reference to its prevalence in Jordan. *Small Ruminant Research*, 30, 77-83.
- Hendrickson, D. A. (2007). *Techniques in large animal surgery*. Third edition, Blackwell Publishing Ltd, Oxford, England, pp 223-226.
- Igbokwe, I. O., Kolo, M. Y., and Egwu, G. O. (2003). Rumen impaction in sheep with indigestible foreign body in the semi-arid region of Nigeria. *Small Ruminant Research*, 49, 141-147.
- Jubb, K. V. F., Kennedy, P. C. and Palmer, N. (1985). *Pathology of Domestic Animals*. Vol 2 and Vol 3, 3rd edition, Academy Press Inc, London pp 5, 241- 289, 306- 364, 448.
- Mozaffari, A. A., Olomi, M. M and Vosouh, D. 2009. Unusual and severe ruminal impaction in a goat-kid: clinical and radiographic findings. *Iranian Journal of Veterinary Surgery*, 4 (1, 2), 115-118.
- Otsyina, H. R., J. Nguhiu-Mwangi., E. G. M. Mogoa, P. G. Mbuthia and W. O. Ogara (2014). A Retrospective Study on the Prevalence of Plastic Materials in the Rumen of Sheep and Goats in Nairobi, Kenya. *Bulletin of Animal Health and production in Africa*, 62 (3), 197- 205.
- Otsyina, H. R., Nguhiu-Mwangi, J., Mogoa, E. G. M., Mbuthia, P. G and Ogara W. O (2015). Prevalence of Indigestible Rumen Foreign Bodies in Sheep and Goats at Dagoretti and Kiserian Abattoirs, Kenya. *International Journal of Veterinary Medicine* 3 (2), 75-80.
- Otsyina, H. R., Nguhiu-Mwangi, J., Mogoa, E. G. M., Mbuthia, P. G. and Ogara, W. O. (2016). Clinical manifestations in sheep with plastic bags in the rumen. *Ghana Journal of Agricultural Science*. Vol. 62 (In press).
- Pitroda, A. H., Tiwari, D. K., Mehraj-u-din Dar and Parikh, P. V. (2010). Ultrasonographic diagnosis and treatment of rumen impaction in a goat. *Intas Polivet*, 2 (2), 251-252.
- Radostitis, O. M., Gray, C. C., Blood, D. C. and Hincheliff, K. W. (2009). *Veterinary Medicine: A Textbook of the diseases of cattle, sheep, pig, goats and horses*, 10th ed. New York, USA: Saunders Elsevier. pp 189-382, 296 and 313.

- Raofi A., Namjoo A, Karimi AH and Esfahani, M. A. (2012). A study of clinical signs, hematological changes and pathological findings of experimental ingestion of soft foreign body (plastic rope) in goats. *Small Ruminant Research*, 105, 351-354.
- Reddy, Y. R., Rao, S. T. V., Naidu, P. T. and Sunder, N. S. (2004). Foreign bodies in rumen and reticulum of Punganur cattle. *Indian Veterinary Journal*, 81(9), 1063.
- Remi-Adewunmi, B. D., Gyang, E. O., and Osinowo, A. O. (2004). Abattoir survey of foreign body rumen impaction in small ruminants. *Nigerian Veterinary Journal*, 25, 32-38.
- Robbins, S. L, Cotran, S. and Kuma, V. (1984). *Pathologic Basis of Disease*, 3rd Ed. W.S. Saimders. Philadelphia, USA. pp. 32.
- Smith, A. and Bruton, J. (1977). *Histopathological staining techniques*, Wolfe Medical Publications Ltd., London, England. pp 192.
- Tesgaye, D. and Chanie, M. (2012). Study on rumen and reticulum foreign bodies in cattle slaughtered at Jimma Municipal abattoir, South west Ethiopia. *American-Eurasian Journal of Scientific Research* 7 (4), 160 – 167.
- Vanitha, V, Nambi, A. P., Gowri, P. and Kavitha, S. (2010). Rumen impaction of cattle with indigestible foreign bodies. *Tamilnadi Journal of Veterinary and Animal sciences*, 6, 138-140.
- Reddy, M. V. B. and Sasikala, P. (2012). A review of foreign bodies with special reference to plastic pollution threat to livestock and environment in Tirupati rural areas. *International journal of Scientific and Research Publications*, 2 (12), 1-8.