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Gross and Histological Studies of the Uterus of Sahel Goat (*Capra hircus*)

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ABSTRACT

Sahel goats are regarded as important breeds of goats widely distributed in West Africa and are easily recognized through their reproductive performance and physical appearance. This study aimed to investigate the gross and histological characteristics of 35 uteri of female Sahel goats. A total of 35 postpartum uteri (days 1, 3, 7, 14, 21, and 28) were collected from female Sahel goats aged 2-4 years and weighing between 30kg - 40kg were used for the study. The uterus was processed for morphological and histological studies at the postgraduate research laboratory, Department of Veterinary Anatomy, University of Maiduguri. The harvested uterus appeared as large hollow organ, pear-shaped and dark red in colour. The shape and conformation of placentomes differed on postpartum days 1, 3, 7, 14, 21, and 28, respectively. The lumen was observed, showing the presence of dark fluid. Histologically, the luminal epithelium in the caruncular area of the endometrium appeared taller and more folded at postpartum days 1, 7, 14, 21, and 28, consisting of simple columnar epithelium. The stroma showed numerous glands that are more tortuous and elongated in shape, with numerous blood vessels and lymphocytes at postpartum days 1, 3, 7, 14, 21, and 28, respectively. This study observed significant changes in the gross morphology and histological structure of the uterus throughout the postpartum period, including reductions in uterine size, epithelial remodeling, and alterations in glandular and muscular layers.

Keywords: Anatomy; Histology; Involution; Sahel goat; Uterus

INTRODUCTION

Sahel goats (*Capra hircus*) are referred to as West Africa desert goats because of their adaptive ability to reproduce and strive well in the sub-Saharan regions compared to humid areas (Igbokwe *et al*., 2009, Habibu *et al*., 2017). They are among the third largest breeds of goat found in Nigeria and are renowned for their ability to breed and reproduce within a short period of time (Igbokwe *et al*., 1998; Maina *et al*., 2006, Waziri *et al*., 2010). The uterus is a major component of the female reproductive tract and it consist of three layers; perimetrium (outermost), myometrium, and endometrium (innermost), respectively (Kelleher *et al*., 2019). It is also known as a hormone-responsive organ that aids in the development of the fetus by providing a healthy environment and it varies among different species (Hanuman *et al*., 2023). These variations are anatomical, which include difference in uterine horn appearance, and endometrial linings (Dutta, 2015). Goats are ruminant with a bicornuate (Y-shaped) uterus, that appears as a highly expandable tubular organ and comprises a short body with a pair of long horns (Dyce *et al*., 2002; Budras and Habel, 2003; Abiaezute *et al*. 2018). The uterus undergoes significant tissue distention and distortion, as well as extensive glandular growth, to accommodate and nourish the developing embryo (Medan, 2015). Physical shrinkage, necrosis, sloughing of the caruncles, and the regrowth of the endometrium with caruncular necrosis occur following the loss of the allantochorion, which is normally sloughed by 12 days after parturition (Noakes *et al*., 2009). During the postpartum phase, significant morphological alterations, along with considerable remodeling and changes in tissue mass and function occur before rebreeding and pregnancy are established (Hunter, 1980; Sanchez *et al*., 2002; Kalender *et al*., 2012; Elsheikh *et al*., 2013). This study was undertaken to evaluate the gross and histological characteristics of the uterus of Sahel goats during uterine involution. Therefore, understanding the gross and histological features of the uterus during uterine involution will enhance our knowledge of the reproductive performance of the Sahel goat.

MATERIALS AND METHODS

The study was conducted at the Postgraduate research laboratory, Department of Veterinary Anatomy, University of Maiduguri, Borno State, Nigeria. A total of 35 postpartum uteri (days 1, 3, 7, 14, 21, and 28) were collected from female Sahel goats aged 2-4 years and weighing between 30kg - 40kg and used for the study. The uteri were collected in a polythene bag, placed in an ice contained before transported to the postgraduate research laboratory, Department of Veterinary Anatomy, for the gross and histological investigations.

Gross anatomical studies

On arrival of the 35 uteri to the postgraduate research laboratory, they were immediately placed on the

examination table to observe their shape, colour, texture and content. Thereafter, each of the uteri was cleansed before commencing morphometric studies. The entire weight of the uterus as well as the length, and breadth of the uterine horns were measured using a digital electronic balance (KY electronic balance), rope, and ruler according to the methods described by Rotimi *et al*. (2015) and Majama *et al*. (2018).

Preparation of tissue for histology

Accordingly, to the histological techniques adopted by Luna (1992) and Winsor (1994), about 1cm^2 of tissues samples were taken from the body of each uterus and fixed in a 10% formalin solution for 48-72 hours. The tissues were washed for proper dehydration to remove fixatives and gradually dehydrated through ascending grades of alcohol; 70 %, 80 %, 90 %, and finally passing through absolute alcohol for three times (three changes). This was later cleared with xylene for three times (three changes) and impregnated twice (two changes) with molten paraffin wax. Tissue blocks were placed on wooden chocks, chilled, and then sliced to 5µm thickness with a microtome. The tissue pieces were flattened in a water bath, mounted on glass slides, covered with egg albumin, and dried in a 45-degree oven. The tissue slides were stained with haematoxylin and eosin (H&E) then examined using DB2 - 180 M digital biological light microscopes at various magnifications (×40, ×100, and ×400). Thereafter the appropriate photomicrographs of the histological sections were obtained using scope image version 9.0 (AD 2.0) software.

RESULTS

Gross findings

Grossly, the uterus is bicornuate type, a highly expandable tubular structure with a small body and two long horns that connected the cervix caudally and the uterine tubes cranially. The uterine structure was shown to be a smooth, brightly-shining red organ (Figure 1a). The uterine caruncles were also clearly seen with the presence of Lochia (dark fluid) in the uterine lumen (Figure 1b). On day 3 postpartum, the uterus appeared bright red to pale in colour (Figure 1c), and the caruncles were also seen having a dark fluid in the uterine lumen (Figure 1d). The caruncles were clearly seen with a sticky, dark-brown fluid on their surfaces (Figure. 2b). The uterus on postpartum day 14 was small, while those ob served on day 1, 3, and 7 look reduced in diameter and deficient of luminal fluid (Figure 2c). The uterus on day 21 postpartum was seen small in size and pale in colour along the uterine body and horns, respectively (Figure 3a). The caruncles appeared dark and small in diameter, whereas those observed on 1, 3, and 7 postpartum were short of surface fluid (Figure 3b). At day 28 postpartum, the uterus appeared small and red in color (Figure 3c). Additionally, the caruncles' diameter has decreased fluid surface (Figure 3d).

Histological findings

Histologically, the caruncular and inter-caruncular parts of the endometrium at days 1, 3, 7, 14, 21, and 28 postpartum show that the luminal epithelium was columnar and more folded in the endometrial intercaruncular regions. Under the luminal epithelium, the stroma is densely packed with numerous endometrial glands that have a large, empty lumen (Figure 4a and b). The glandular epithelium was lower than the luminal epithelium, and nuclei were basally located (Figure 4a and b). The muscle layer has an inner circular and outer longitudinal layer with many blood vessels (Figure 4c and d). At this stage, the caruncle was shown to be distended with a concave, dark brown center. The luminal epithelium was ruffled with many folds, showing a regressing endometrial gland. Dead cells were seen near the gland's base, as well as lymphocytic infiltration of the endometrial stroma. The muscle layer has an inner circular and outer longitudinal layer with many blood vessels (Figure 4c and d). The muscular layer was observed to be thin, consisting of blood vessels with inner circular and outer longitudinal layers (Figure 5c and d). The luminal epithelium consists of a tall, simple columnar epithelium that is more folded. The stroma showed glands with narrow lumens that were reduced in cellularity and size (Figure 6a and b). Muscular layer with inner circular and outer longitudinal layer (Figure 6c and d)

The endometrial glands in the stroma have started increasing in cellularity and are tortuous and elongated (Figure 7a and b) with numerous blood vessels in the muscular layer. The muscular layer is thick, consisting of an inner circular and outer longitudinal layer (Figure 7c and d). The caruncles everted and re-epithelized concurrently. The luminal epithelium was tall and folded. The stroma consisted of numerous endometrial glands that were more tortuous and elongated in shape (Figure 8a and b). The muscular layer was observed to be thick at day 21 postpartum and had a reduced number of blood vessels. The muscular layer consists of an inner circular and outer longitudinal layer with numerous blood vessels (Figure 8c and d). At day 28 postpartum, the caruncles have entirely regenerated and epithelized after remodeling from a concave to a convex shape.

DISCUSSION

The endometrium in this study showed a range of vascular, epithelial, and connective tissue alterations, notably regenerative and degenerative. Eventually, the caruncular and inter-caruncular endometriums were entirely covered in new epithelium. This aligns with the findings of Van Wyk *et al*. (1972b) and Greyling and Van Niekerk (1976). According to earlier findings, three overlapping histological phases were seen in the Sahel goat's involuting uterus (Van Wyk and Van Niekerk, 1972a; Gray *et al*., 2003). These phases include: (1) the disappearance of secretory signs; (2) the degenerative phase; and (3) the regenerative phase. Both the endometrium and myometrium were significantly thinner in conjunction with substantial reductions in uterine mass and horn length. Histological observations revealed an increase and decrease in the extracellular matrix and space of the endometrial stroma respectively. This result is consistent with the findings of Grey *et al*. (2003) and Degefa *et al*. (2006). The luminal epithelium at day 1 postpartum was observed to contain many folds with lymphocytic infiltration. These findings concur with the reports of Degefa *et al*. (2006) on Balady goats, Retinta Extremeña goats (Sanchez *et al*., 2002), Slovak Merino ewes (Krajničáková *et al*., 1999), Suffolk ewes (Gray *et al*., 2003) and as well as in Japanese black cows (Okano

and Tomizuka, 1996), who observed similar characteristics on the endometrial lining. The inter-caruncular luminal epithelium remained intact throughout the postpartum period, whereas the caruncular epithelium sheds. This result is in agreement with the findings of (Gray *et al*., 2003; Degefa *et al*., 2006). The lumen of the endometrial gland at day 3 postpartum revealed dead cells on the base of the glands as well as high concentration of lymphocytes with blood vessels in the lamina propria.

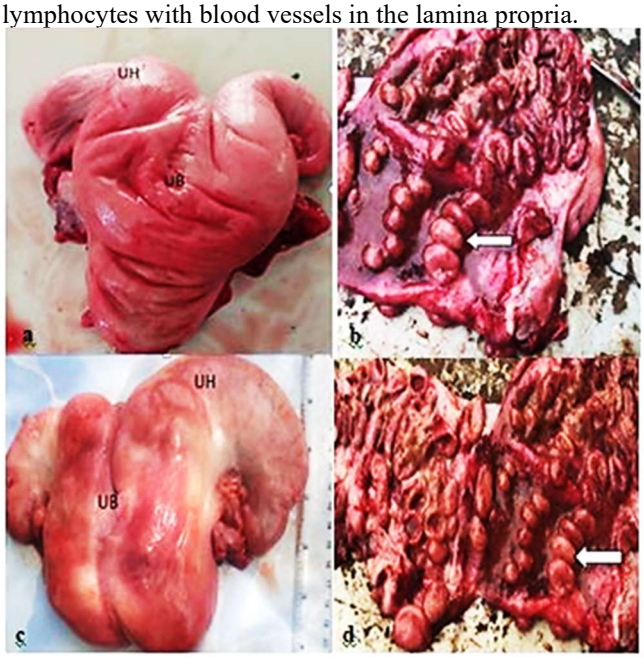

Figure 1: Gross structure of the Sahel reproductive tract at day 1 and 3 postpartum (a and b) and (c and d) respectively. (a) Day 1 postpartum showing the uterine horn (UH), and uterine body (UB), (b) Day 1 postpartum, arrow showing caruncle, (c) Day 3 postpartum showing uterine horn (UH), and uterine body (UB), (d) Day 3 postpartum, arrow showing caruncle. Note the shape and conformation of the caruncles as well as the presence of dark fluid in the uterine lumen.

Figure 2: Gross structure of the Sahel reproductive tract at day 7 and 14 postpartum (a) Day 7 postpartum, showing the uterine horn (UH), and uterine body (UB), (b) Day 7 postpartum arrow showing caruncle. (c) Day 14 postpartum showing uterine horn (UH) and uterine body (UB), (b) Day 14 postpartum, arrow showing caruncle. Note the changes in shape and conformation of caruncle as well as the absence of dark fluid in the uterine lumen.

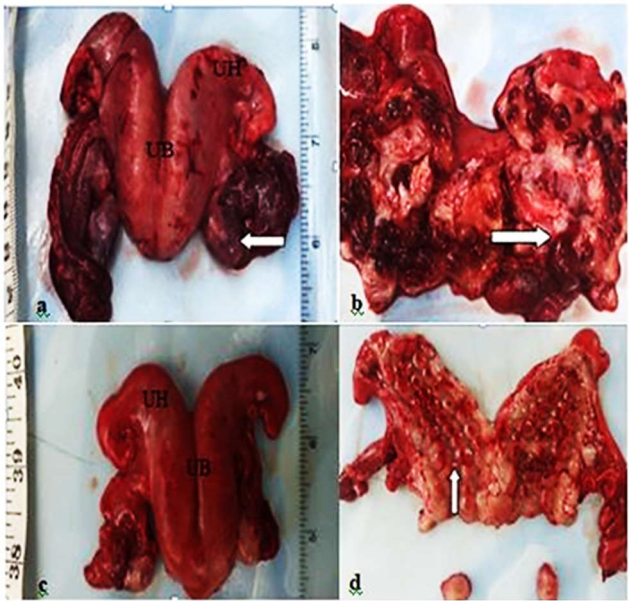

Figure 3: Gross structure of the Sahel reproductive tract at day 21 and 28 postpartum. (a) Day 21 postpartum, showing uterine horn (UH), and uterine body (UB), (b) Day 21 postpartum, arrow showing caruncle, (c) Day 28 postpartum, showing the uterine horn (UH), and uterine body (UB) and (d) Day 28 postpartum, arrow showing caruncle. Note the changes in shape and conformation of caruncles as well as the absence of the dark fluid (Lochia) in the uterine lumen.

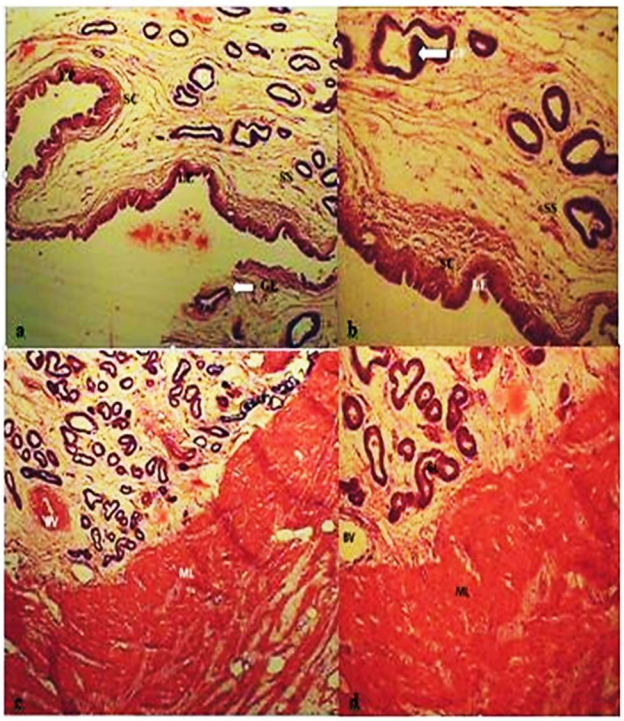

Figure 4: Photomicrograph of the uterine tissue of the Sahel goat at day 1 postpartum uterine involution: (a) Uterus consisting of tall columnar epithelium (LE) that is more folded, Stratum compactum (SC), Stratum spongiosum (SS) ×40 (b) Lamina propria of the uterus showing numerous glands with dilated lumen, Glandular epithelium (GE)× 100 (c) Muscular Layer (ML) showing minimal thickness with inner circular and outer longitudinal layer ×40 (d) Muscular layer with blood vessel and endometrial glands in the lamina propria (BV) ×100 H&E

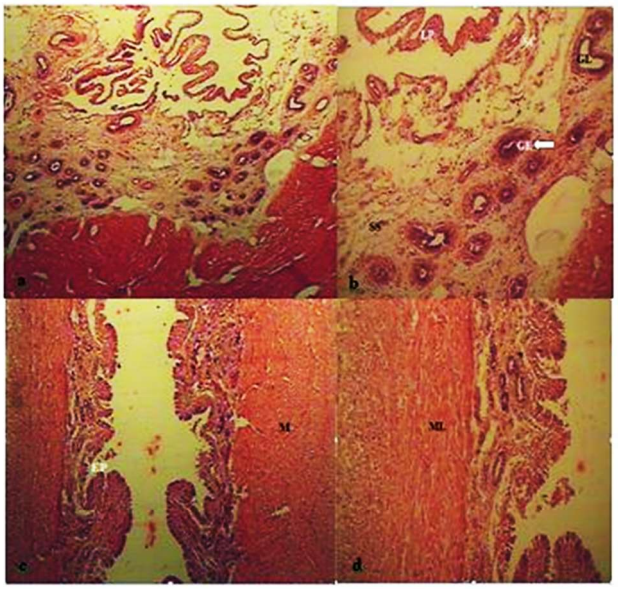

Figure 5: Photomicrograph of the uterine tissue of the Sahel goat at day 3 postpartum uterine involution: (a) Uterus consisting of tall columnar epithelium (LE) that is thin and more folded, Stratum spongiosum (SS) ×40 (b) Lamina propria of the uterus showing numerous glands (GL), with dilated lumen, regressing endometrial gland with dead cells on the base of the gland, Glandular epithelium (GE)×100 (c) Muscular Layer showing minimal thickness with inner circular and outer longitudinal layer ×40) (d) Muscular layer (ML) with blood vessel and endometrial glands in the lamina propria (BV) ×100 H&E

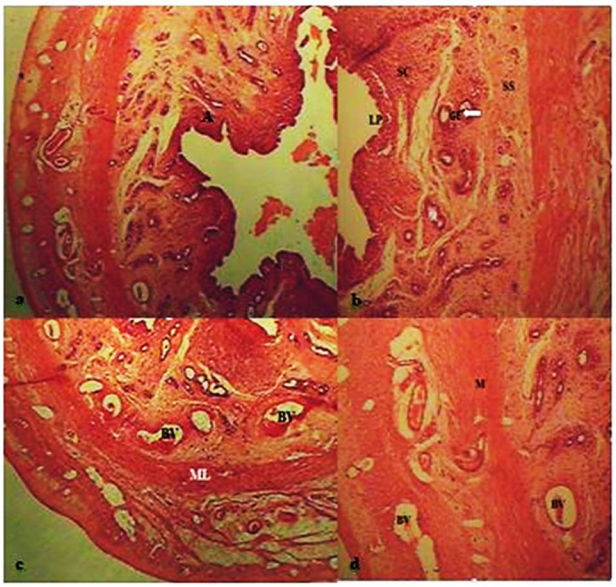

Figure 6: Photomicrograph of the uterine tissue of the Sahel goat at day 7 postpartum uterine involution: (a) Uterus consisting of tall columnar epithelium (LE) , Stratum spongiosum (SS)×40 (b) Lamina propria of the uterus showing reduced number of glands (GL) with regressing endometrial gland and dead cells on the base of the gland, Glandular epithelium (GE)×100 (c) Muscular Layer (m) showing minimal thickness with inner circular and outer longitudinal layer × 40 (d) Muscular layer with large blood vessel (BV) towards the myometrium and endometrial glands in the lamina propria×100 H&E

This is in line with the findings of (O'shea and Wright, 1984; Sanchez *et al*., 2002; Ababneh and Degefa, 2005; Degefa *et al*., 2006) whom observed similar characteristics on the endometrial lining in Balady and Retinta Extremeña goats. The luminal epithelium was less consistent in height and less ruffled than that of day 3 postpartum, and revealed no change.

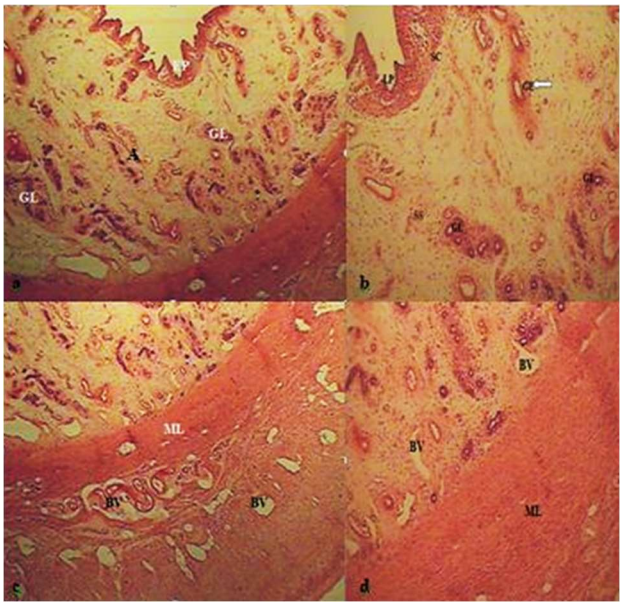

Figure 7: Photomicrograph of the uterine tissue of the Sahel goat at day 14 postpartum uterine involution: (a) Uterus consisting of tall columnar epithelium (GE) , Stratum spongiosum (SS)×40 (b) Lamina propria of the uterus showing reduced number of glands (GL) with regressing endometrial gland and dead cells on the base of the gland, Glandular epithelium (GE) ×100 (c) Muscular Layer (M) showing minimal thickness with inner circular and outer longitudinal layer ×40 (d) Muscular layer (M) with large blood vessel (BV) towards the myometrium and endometrial glands in the lamina propria×100 H&E

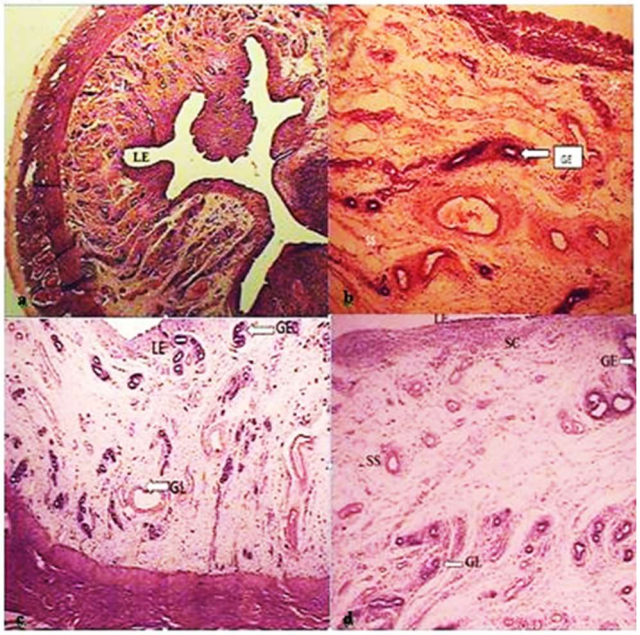

Figure 8: Photomicrograph of the uterine tissue of the Sahel goat at day 21 and 28 postpartum uterine involution: (a) Postpartum day 21 showing uterus consisting of tall columnar epithelium (LE) , Stratum spongiosum (SS)×40 (b) Lamina propria of the uterus showing reduced number of glands (GL) with regressing endometrial gland and dead cells on the base of the gland, Glandular epithelium (GE)×100 (c) Postpartum day 28 showing uterus consisting of tall columnar epithelium (LE) , Stratum spongiosum (SS)×40 (d) Lamina propria of the uterus showing reduced number of glands (GL) with regressing endometrial gland and dead cells on the base of the gland, Glandular epithelium (GE)×100 H&E

At this stage, the number of endometrial glands appeared sparse, with decreasing lumen and blood vessels in the lamina propria were observed. Additionally, less lymphocytic infiltration was observed in the stroma than that of day 1 and 3 postpartum. These findings were in agreement with Degefa *et al*. (2006) in Balady Goats (Gray *et al*., 2003) in Suffolk ewes and (Sheldon *et al*., 2008) in ewes but disagree with the reports of Sanchez *et al*. (2002) and Van Wyk *et al*. (1972b), whom observed histological degenerative changes at day 10 postpartum in the endometrium respectively.

In the second phase of this study, the degenerative phase, the endometrial epithelium and the glands lose their secretory activity, and the degenerative phase commences as a result of a complete decline in progesterone prior to parturition. The difference observed in the present study could be due to breed differences and the stage of physiology during which the sample was taken. The stroma showed oedema, but less so than at day 7 postpartum; lymphocytes were still moderately numerous in the stroma, with an intact endometrial lining and thick myometrium characterized by an inner circular and outer longitudinal layer. The endometrial characteristics observed in this study agree with the report of O'shea and Wright (1984). The endometrium at day 14 postpartum was characterized by simple columnar epithelium with more numerous glands than at day 7 postpartum, but their lumen was still relatively small and distributed in the lamina propria with prominent blood vessels. The endometrial characteristics observed in this study agree with the report of O'shea and Wright (1984). The third regenerative phase was observed to begin at day 21 and be completed at day 28 postpartum in the present study. This finding is in disagreement with the report of Sanchez *et al*. (2002), who reported that day 10 postpartum is the beginning of endometrial caruncular and inter-caruncular regeneration in goats. The differences observed could probably be a result of the slaughter animals used by Sanchez *et al*. (2002). The endometrium is characterized by a simple columnar epithelium with little increase in endometrial glands, basal location of nuclei, and a reduction in the size of the cytoplasm of endometrial epithelial cells. This finding was consistent with the reports of O'shea and Wright (1984) and Degefa *et al*. (2006). They observed similar characteristics on the endometrial lining in ewes and goats. The muscular layer was thick and edematous, with distinct collagen fibers showing inner circular and outer longitudinal layers at day 1, 3, 21, and 28 postpartum respectively.

The histology of both the caruncular and inter-caruncular areas at day 28 postpartum was similar to that of the non-pregnant uterus of the Sahel goat. From day 28 postpartum, the histology of the endometrium was uniformly low columnar or high cuboidal surface epithelium; glandular epithelial cells were fully regenerated; the glands were more tortuous, tubular, increased in size and number; the caruncles were fully re-epithelialized and completely covered with cuboidal epithelium; and leucocytes were completely cleared, indicating the completion of the regeneration phase of the postpartum period. The observations in the present study were similar to previous reports in non-pregnant goats (Greyling and Van Niekerk, 1991; Greyling, 2000; Gray *et al*., 2003), although the reports did not consider the variation in the physiological status of the animals. It is also in agreement with the reports of O'shea and Wright, (1984) and Krajničáková *et al*., (1999) in sheep, which indicate commencement of the uterine involution in the first week and completion in the third and fourth weeks postpartum, indicating certain similarity between these two species but contrary to previous reports on Balady goats and post parturient ewes (Krajničáková *et al*., 1999; Sanchez *et al*., 2002; Degefa *et al*., 2006). The differences could probably be due to differences in breeds. The regeneration phase was completed between days 21 and 28 postpartum at a slow rate. Numerous substances are involved in these postpartum degenerative and regenerative events, which include ovarian steroid hormones, various growth factors, cytokines and metalloproteinases as previously reported by Woessner, (1991), Klauke and Hoffmann, (1992) and Tasende *et al*., (1996). However, the differences encountered in this study could be attributed to breed or ecotype peculiarities among other factors not controlled in this study, especially the differences in the reproductive performance and the physiological status of the animals.

Conclusion

This study observed significant changes in the gross morphology and histological structure of the uterus throughout the postpartum period, including reductions in uterine size, epithelial remodeling, and alterations in glandular and muscular layers. However, the differences encountered could be attributed to breed or ecotype peculiarities as well as differences in the reproductive performance and the physiological status of the animals.

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Conflict of Interest

The authors have no conflict of interest to declare.

Author's Contributions

YBM conceptualized and interpreted the result, HDK, and MBM supervise and reviewed the manuscript, SB data collection and literature review, AMW write and critical review.

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