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Uterine involution in the post-partum Balady goat

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ABSTRACT

Twenty post-partum Balady goats (primiparous n=10; pluriparous, n=10) were slaughtered at different intervals between the day of parturition and day 37 post-partum (PP). Macroscopic changes included uteri weight and volume, and length of uterine body and horns were measured. Histomorphological changes in the endometrial epithelium cell types and height, glands, stroma and caruncles were recorded. Macroscopic study indicated three phases of uterine regression. A fast involution phase extended from the time of parturition to day 7 PP, a second moderately fast uterine involution phase, which extended until day 13 PP and a slow phase that ended by day 19 PP. By day 19 PP, weight and volume were reduced to less than 5% of the weight recorded on day 1 PP, discharges completely cleared, caruncles completely regressed, horns became symmetrical and the uteri in these animals were not different from uteri of the nulliparous goats. Similarly, microscopic changes were classified into three overlapping phases: disappearance of secretory signs, degenerative and regenerative phases. Microscopic involution and complete regeneration of the caruncular epithelium was evident by day 19. In conclusion, the uterus reassumed normal non-gravid macroscopic and microscopic characteristics by day 19 PP and was unrelated to parity in Balady goats.

Key words: goats, uterus, post-partum, involution

Introduction

The Balady (local) goat is the indigenous goat of Jordan and surrounding countries, including Palestine, Syria, Turkey, Iraqi and Egypt (MASON, 1984). Balady goats belong to the family *Capra hircus*, a horned breed with medium-large ears and reared for meat and milk (DEVENDRA and BURNS, 1983; MASON, 1984). The Balady goat is also known as

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the Mountain, Black, Mountain black, Mamber and Syrian mountain goat. While usually black in colour it is also found in brown, white or grey (ZAITOUN, 2002). Balady goats are being used very effectively because of their ability to survive and thrive on poor ranges in the Jordanian semi-arid environment. Mature Balady goat bucks weigh between 55-65 kg and does between 45-55 kg. A kidding rate not more than 110% is common for this breed. Puberty is usually reached at 10-12 months of age. The Balady goat has a short breeding season starting in late June and ending in October. Thus, out-of- season breeding is a must for accelerated production systems.

The post-partum (PP) period is comprised of a series of integrated anatomic and physiologic re-adjustments of both the uterus and endocrine system, and is a crucial factor for the resumption of reproductive capacity and regular cycling of a breeding goat. Morphological changes or their delay in the PP uterus and ovaries of farm animals exert a limitation on reproductive performance following parturition (GREYLING, 2000). Completion of uterine involution and resumption of sexual activity following parturition in ruminants normally depend on several factors, such as nutrition, nursing of offspring and season of parturition (VAN WYK et al., 1972; DELGADILLO et al., 1998; MWAANGA and JANOWSKI, 2000; YAVAS and WALTON, 2000). Different research reports have shown different intervals to complete uterine involution in goats. While BARU et al. (1983) demonstrated complete macroscopic uterine involution by day 19 PP, GREYLING and VAN NIEKERK (1991) reported day 28 PP as the day of complete uterine involution. Moreover, histochemical study of caprine endometrium indicated complete regression of endometrium and re-epithelialization by day 16 PP (SANCHEZ et al., 2002). With these discrepancies regarding the period necessary for complete uterine involution, and due to lack of information about Balady goats, it was the objective of this investigation to study the process of PP uterine involution and to determine the effect of parity on uterine involution in indigenous Balady goats.

Materials and methods

This study was undertaken at the Veterinary Health Centre at the Jordan University of Science and Technology from June to August 2002. A total of 20 PP Balady goats and 3 nulliparous goats were used in this study. During the study period all goats were kept under uniform standard management practice. The PP animals were categorized into two parity groups as primiparous (age = 1.5-2 years) and pluriparous (age \geq 4 years). One goat of each parity group was slaughtered on days 1, 2, 4, 7, 10, 13, 19, 25, 31 and 37 PP. Immediately following slaughter the reproductive tract was collected and excess superfluous tissues were removed. The weight of the reproductive tract, including uterus, cervix, and ovaries, were separately determined by using a sensitive balance. Volume was measured using volume of displaced water in a graduated cylinder. An incision was made dorsally

on the uterus from os-cervix to utero-tubal junction of both horns to explore the internal surface. Observation of the uterine lumen as a whole and diameter of the largest caruncles in uterine body, and each uterine horn and uterine wall thickness were measured with an outside caliper. Length of uterine bodies was measured from os-uteri to the junction of bases of uterine horns (true bifurcation) and false-bifurcation according to BARU et al. (1983) and GREYLING and VAN NIEKERK (1991). Lengths of horns were measured from point of false bifurcation to utero-tubal junction on the respective long axes (GREYLING and VAN NIEKERK, 1991). Similar measurements were made on normal reproductive tracts of nulliparous cycling control goats.

Tissue samples for histological evaluation were collected from each goat immediately after obtaining gross morphological data. Sections of approximately 2 cm in length were obtained from six locations for each tract: uterine end of the cervix; middle third of the uterine body, and base and tip of the previously gravid horn (GH) and non-gravid horn (NGH). Tissue samples were fixed in 10% buffered formaldehyde solution for 24 hours (BANCROFT et al., 1990). Fixed tissue were processed for paraffin embedding, sectioned at 5 μ m and stained with hematoxylin-eosin for microscopic examination (BANCROFT et al., 1990). Histologically, the assessment of each samples considered epithelium (cell type and height, nuclear position, and inflammatory condition), sub-mucosal stroma (thickness, inflammatory cells type and density, and presence or absence of lymphocytic foci) and endometrial glands (density, size, content and presence of periglandular fibrosis) (BONNETT et al., 1991). Morphometrical determination of epithelial height and stromal thickness were made from multiple measurements (n=5) of each section using a stage micrometer at 40 x magnification. Additionally, caruncles were evaluated for the extent of regression and epithelialization.

Statistical analysis was performed using Statistical Analysis System (SAS, 1996). Non-linear regression was used to analyze changes in macroscopic parameters in primiparous and pluriparous goats. Repeated measure analysis of variance was used to analyze the effect of parity over time on endometrial epithelial height and stromal thickness.

Results

None of the animals included in the study developed clinical signs of metritis nor of other diseases of pregnancy or the puerperal period. A total number of 24 kids were born with about 20% twinning (4 animals delivered twin kids). Three pluriparous goats and one primiparous goat were pregnant equally in both horns with twin kids; seven goats were pregnant in the left horn, while the remaining nine goats were pregnant in the right horn. New-born kids were separated within 48 hours of birth.

Changes in uterine weight and volume in primiparous and pluriparous goats are presented in Table 1. Overall weight changes revealed a higher rate of reduction during

the first 7 days, and a lower rate up to day 19 PP in both groups. On day 19 PP, uterine weights were 3% and 4% of the weight recorded on day one in primiparous and pluriparous goats, respectively. After day 19 PP, the reduction in weight was non-significant in both groups. Furthermore, regression analyses showed a high positive correlation between weight of the uteri in both primiparous and pluriparous goats and days PP ($r = 0.99$, $P < 0.0001$). Reduction of uterine weight followed the regression equation $Y_1 = 1790.5x^{-1.1266}$, ($r^2 = 0.92$, $P < 0.05$) and $Y_2 = 1901.4x^{-1.0221}$, ($r^2 = 0.91$, $P < 0.05$) where Y_1 and Y_2 = weight of the uterus in grams in primiparous and pluriparous goats, respectively, where as x = post-partum period in days (SAS, 1996).

Table 1. Weight and volume changes in the uteri of primiparous and pluriparous goats on different days post-partum (PP) and nulliparous goats

Days PP	N	Primiparous		Pluriparous		Primiparous		Pluriparous	
		Weight (g)	% of weight on day 1	Weight (g)	% of weight on day 1	Volume (mL)	% of volume on day 1	Volume (mL)	% of volume on day 1
1	1	1200.0*	100.0	1280.0*	100.0	1150*	100.0	1250*	100.0
2	1	650.0	54.0	820.0	64.1	570	49.6	920	73.6
4	1	550.0	45.8	800.0	62.5	470	40.9	785	62.8
7	1	344.3	28.7	318.7	24.9	355	30.9	325	26.0
10	1	148.3	12.4	234.4	18.3	165	14.3	225	18.0
13	1	191.6	16.0	215.3*	16.8	210	18.3	230*	18.4
19	1	37.4	3.1	50.1	3.9	35	3.0	45	3.6
25	1	34.7	2.9	57.5	4.5	30	2.6	42	3.4
31	1	32.9	2.7	42.2	3.3	26	2.3	38	3.0
37	1	29.4	2.5	58.2*	4.5	31	2.7	65*	5.2
Nulliparous goats									
	N	Weight (g)				Volume (mL)			
	1	43.5				40.0			
	1	31.3				29.7			
	1	35.5				37.5			

* indicate goats which gave birth to twin kids

Volumes, lengths and wall thicknesses regressed, following the same pattern recorded with the weight of the uterus in both primiparous and pluriparous goats (Tables 1 and 2). By day 19 PP, volume, length of uteri to the false bifurcation and wall thickness represented

3%, 29% and 30% and 4%, 31% and 27% of the values recorded on day 1 in primiparous and pluriparous goats, respectively. Furthermore, there was no effect of parity on the rate of changes, and both uterine horns were approximately of equal size in the respective groups. In addition, gross luminal surface of the previously GH and NGH showed complete involution of caruncles, detached caruncular stalk and absence of any sign of lochia and were comparable to the nulliparous goats. Changes recorded on days 25, 31 and 37 PP for these variables in both groups were not significant. Cervical length, thickness, outer circumference, and weight in primiparous and pluriparous goats are presented in Table 3. Cervical involution preceded uterine involution and the cervix was comparable to the nulliparous goats by day 13 PP.

Table 2. Comparative diameter, length, thickness and outer circumference of uterine body, previously gravid horn (GH) and non-gravid horn (NGH) in primiparous (PR) and pluriparous (PL) goats on different days post-partum (PP), and nulliparous goats

pp days	Uterine body length to true bifurcation (mm)		Uterine body length to false bifurcation (mm)		Uterine wall thickness (mm)		Outer circumference uterine body (mm)		Length of GH (mm)		Length of NGH (mm)	
	PR	PL	PR	PL	PR	PL	PR	PL	PR	PL	PR	PL
1	60	70	190	210	10.0	11.0	240	250	240	280	*	*
2	50	60	150	185	6.0	7.0	130	220	240	290	170	140
4	55	70	150	170	4.0	4.0	140	180	200	340	180	240
7	40	40	110	120	3.0	4.0	100	85	265	270	180	110
10	40	50	90	120	3.5	4.0	80	80	195	220	90	100
13	40	35	90	105	3.0	4.0	83	70	205	205	175	*
19	30	30	55	65	3.0	3.0	45	50	105	80	95	70
25	20	25	45	48	2.5	3.3	50	50	90	105	80	95
31	25	25	50	50	2.5	2.5	40	45	85	82	75	70
37	25	35	60	60	2.5	3.0	40	65	65	105	*	95
Nulliparous goats												
	Uterine body length to true bifurcation (mm)		Uterine body length to false bifurcation (mm)		Uterine wall thickness (mm)		Outer circumference uterine body (mm)		Length of right horn (mm)		Length of left horn (mm)	
	25		65		3.0		40		110		105	
	20		60		3.0		40		105		100	
	20		65		2.5		35		103		100	

Table 3. Cervix lengths, thickness, and weight in primiparous (PR) and pluriparous (PL) between 1 to 37 days post-partum (PP), and nulliparous goats.

PP days	Length (mm)		Outer circumference (mm)		Thickness (mm)		Weight (gm)	
	PR	PL	PR	PL	PR	PL	PR	PL
1	60	70	125	130	11	12	67	79.0
2	50	50	80	85	6	7	25.6	45.9
4	50	60	80	85	4.5	6	38.0	37.0
7	50	55	70	70	5	5	17.8	19.3
10	40	50	70	70	4	6	18.7	22.0
13	50	60	55	58	4	4.5	14.4	20.2
19	40	45	45	55	3.5	4	18.9	19.6
25	35	45	55	50	4.5	4	19.2	19.8
31	40	45	40	45	3.5	4	11.5	14.2
37	40	50	45	65	4	4	17.8	19.1
Nulliparous goats								
	Length (mm)		Outer circumference (mm)		Thickness (mm)		Weight (gm)	
	40		50		4		19.6	
	35		48		4		18.4	
	40		50		5		17.8	

Microscopically during the early PP period (1-7 days) the luminal epithelium in the intercaruncular areas was tall, columnar and with centrally located nuclei (Fig. 1, Table 4). The lamina propria (stroma) immediately beneath the luminal epithelium was markedly hypercellular while the deeper stroma was relatively acellular with varying degrees of oedema up to day 13 PP (Fig. 1). Stromal thickness of pluriparous goats was significantly thicker than that of primiparous goats (Table 4). Endometrial glands were abundant with wide and apparently empty lumen (Fig. 1). There was evidence of cellular death and degeneration of glandular epithelium mostly confined to basal regions of the epithelium (Fig. 2). Despite the absence of acute or chronic forms of metritis, the stroma was infiltrated with varying degree of leukocytes, mainly polymorphonuclear cells (PMN), during the first week PP (Fig. 2). Significant changes occurred in the caruncular area during this period. The interfacing foetal placentomes were totally dissolved and denuded with marked leukocytic infiltration in the caruncular crypts (Fig. 3). During the second week PP epithelial height was reduced and the surface epithelium was much more regular in height, and the nucleus assumed the basal position (Table 4), endometrial

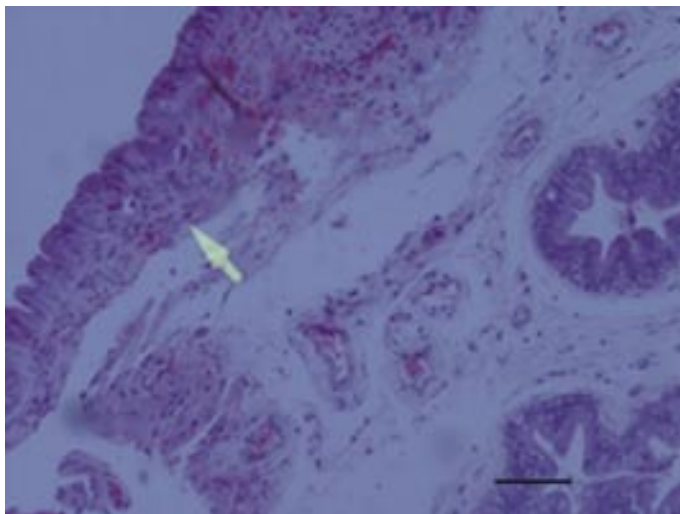


Fig. 1. Histology of the inter-caruncular endometrium on the day following parturition, showing high columnar epithelium, polymorphonuclear cells (arrow), empty and dilated glandular lumen and stromal oedema. H&E; scale bar = 100 μ m.

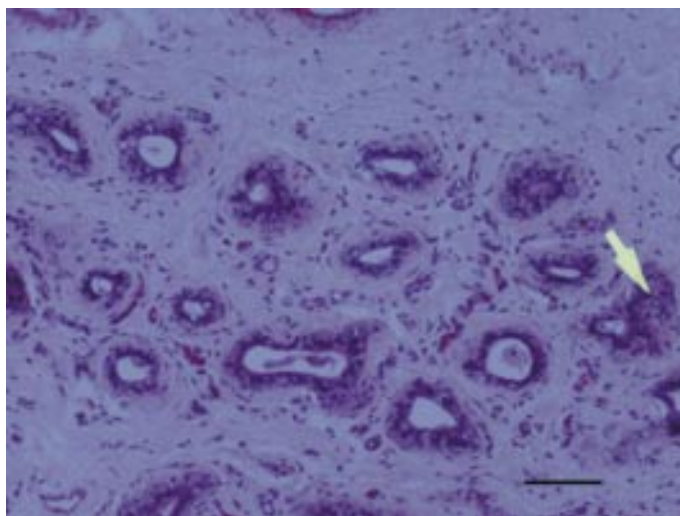


Fig. 2. Histology of the inter-caruncular endometrium on day 4 post-partum, showing degenerating dead cells on the base of the gland (arrow). H&E; scale bar = 100 μ m.

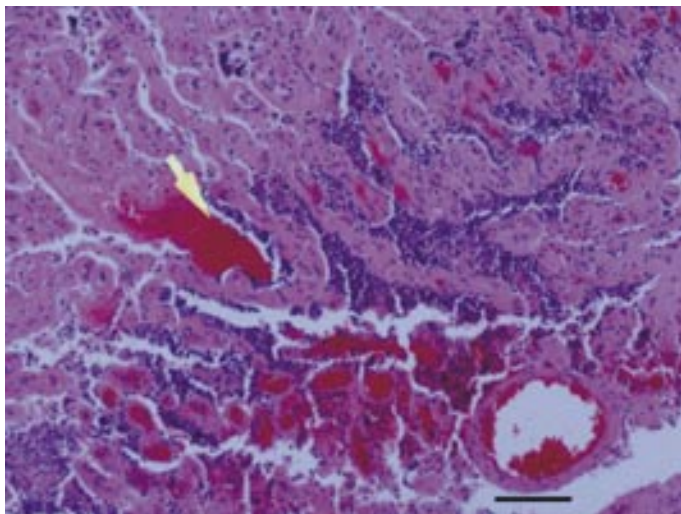


Fig. 3. Histology of the interfacing foetal and maternal placentome on day 2 post-partum. Note excessive haemorrhage (arrow) in between the thin caruncular stalks. H&E; scale bar = 100 μ m.

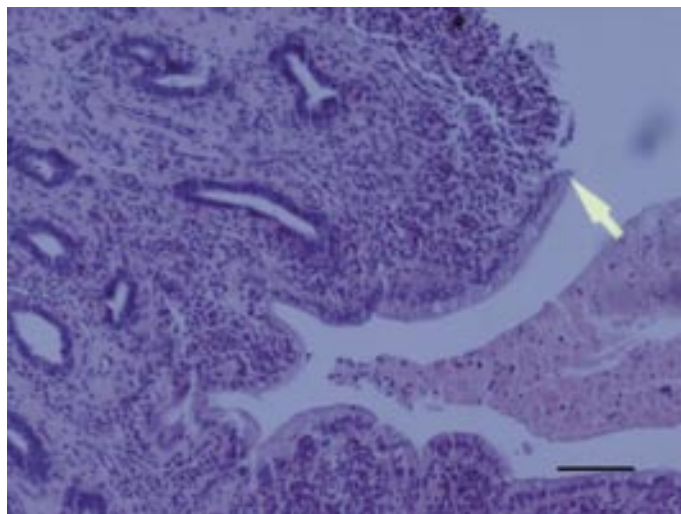


Fig. 4. Caruncular - inter-caruncular endometrium on day 13 post-partum showing columnar epithelium (arrow) creeping over the sloughed caruncular epithelium. H&E; scale bar = 100 μ m.

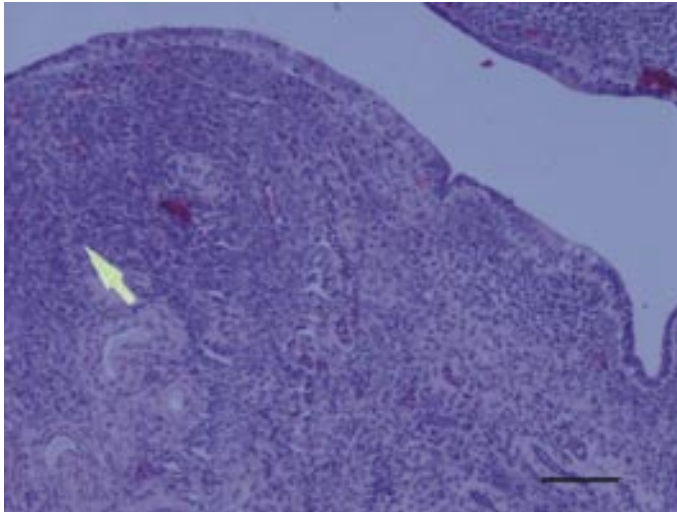


Fig. 5. Histology of caruncular endometrium on day 19 post-partum, showing complete re-epithelialization of the involuted caruncles (arrow). H&E; scale bar = 100 μ m.

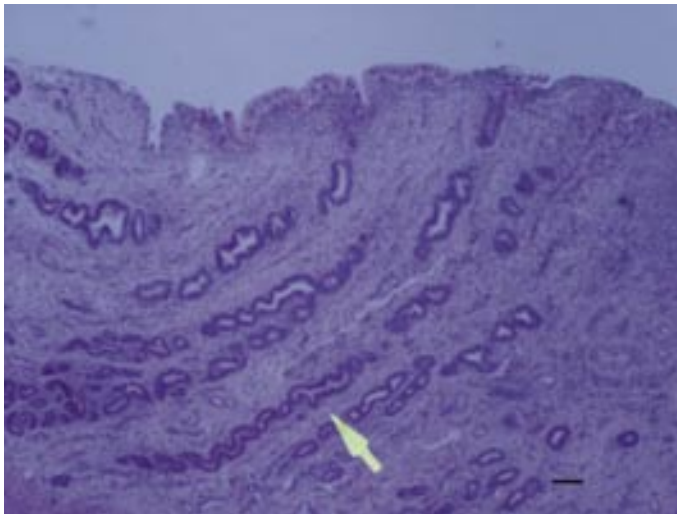


Fig. 6. Histology of the intercaruncular area on day 25 post-partum. Note that the stroma is cleared of oedema and leukocytic infiltration. Glands are increasing in number and becoming tortuous with obliterated lumen (arrow). H&E; scale bar = 100 μ m.

glands were moderately sparse, their lumen collapsed and glandular epithelial cells were regenerated. In addition, there was a trend of a gradual decrease in stromal thickness and PMN infiltration with respect to PP days starting on day 13 (Table 4). Furthermore, the caruncular stalk was regenerating and the epithelium creeping to cover the denuded service of the caruncles (Fig. 4). In the third week PP, the surface endometrial epithelium was composed of low columnar or high cuboidal cells with scanty cytoplasm and basally situated nucleus (Fig. 5; Table 4). The stroma was cleared of oedema and leukocytic infiltration and the glands were increasing in number and getting tortuous and obliterated lumen (Fig. 6). On day 19 PP, re-epithelialization of the caruncles was completed in both groups (Fig. 5). No further significant histological changes were recorded after the third week PP (Table 4).

Table 4. Mean (\pm SEM) for epithelial height and stromal thickness in primiparous (PR) and pluriparous (PL) goats from 1 to 37 days post-partum

Days PP	Epithelial height - μm		Stromal thickness - μm	
	PR	PL	PR	PL
1	50.9 \pm 8.1 ^{ab}	52.4 \pm 7.8 ^a	1260.7 \pm 285.8 ^a	1510.7 \pm 4504.1 ^{ab}
2	49.6 \pm 8.1 ^{ab}	51.2 \pm 7.8 ^a	1225.6 \pm 610.9 ^a	1495.5 \pm 360.7 ^{ab}
4	52.5 \pm 4.7 ^a	49.9 \pm 5.4 ^{ab}	702.5 \pm 376.7 ^c	1315.4 \pm 466.1 ^{abc}
7	39.6 \pm 7.1 ^{abc}	47.6 \pm 3.8 ^{ab}	1314.2 \pm 361.8 ^a	1588.7 \pm 628.2 ^a
10	35.6 \pm 6.7 ^{cd}	40.3 \pm 5.8 ^{bc}	1101.4 \pm 149.6 ^{ab}	1240.9 \pm 284.2 ^{abc}
13	35.3 \pm 12. ^{cd}	34.8 \pm 7.3 ^{cd}	662.5 \pm 292.8 ^c	1238.6 \pm 314.9 ^{abc}
19	32.1 \pm 4.3 ^{cd}	33.3 \pm 8.7 ^{cd}	886.6 \pm 187.2 ^{bc}	868.3 \pm 218.3 ^c
25	23.7 \pm 2.5 ^{de}	25.2 \pm 3.6 ^{de}	666.7 \pm 186.7 ^c	1235.1 \pm 330.2 ^{abc}
31	35.9 \pm 6.2 ^{bcd}	17.9 \pm 2.2 ^e	1130.4 \pm 298.8 ^{ab}	1021.1 \pm 267.5 ^{bc}
37	12.9 \pm 6.2 ^e	14.5 \pm 3.6 ^e	848.6 \pm 200.8 ^{bc}	1214.5 \pm 461.8 ^{abc}

different letters in the same column differ significantly ($P < .0001$)

Discussion

The uterus experiences considerable distension and distortion of tissues and intensive glandular development to accommodate and nourish the developing foetus to term (HUNTER, 1980; SANCHEZ et al., 2002). The uterus must undergo gross anatomical changes together with extensive remodelling and changes in tissue mass and function during the PP period before rebreeding and pregnancy can be established (HUNTER, 1980; MIETTINEN, 1990; OGAWA et al., 2001; SANCHEZ et al., 2002). After parturition the complete

withdrawal of hormonal effects and the removal of mechanical distension of the uterus would result in contraction and regression of the uterus through loss of rich blood supply, degradation of extra-cellular matrix, finally ending in reduction of thickness and length of the uterus (WRAY, 1982; HULBOY et al., 1997). The initial fast rates of reduction in length and circumference observed in the current study indicated relief of myometrium from high tension from the growing foetus. This is supported by the fact that uterine body length to the false bifurcation involuted at a faster rate than that of the uterine body to the true bifurcation. This is in agreement with the findings of WRAY (1982), who demonstrated the importance of mechanical factors and emptiness of the uterus in the involution process. The pattern of macroscopic changes took place in power scale fashion, with rapid involution phase occurring during the first 7 days PP and at a slower rate until day 13 to 19 after parturition. Weight changes ceased by day 19 PP and resembled those of nulliparous control goats. Change in uterine volume and diameter of the uterine horns and lengths of uterine body followed the same trend as changes in weight. Regression of caruncles was significantly apparent by day 13 PP. However, complete regression of the caruncles was not completed until day 19 PP. In addition, lochia was cleared as early as day 7 PP in primiparous goats and as late as day 13 PP in pluriparous goats. By day 19 PP gross luminal surfaces of GH and NGH showed complete involution of caruncles and were devoid of any sign of discharges in both groups, the caruncles resembling those of non-pregnant nulliparous goats. The progressive changes in the aforementioned criteria (weight, volume, length and diameter of the uterine horns) and uterine horns symmetry coinciding with the complete dissolution of the caruncles and absence of lochia signified complete macroscopic involution of the uteri in both primiparous and pluriparous goats on day 19 PP. Although uterine weight, volume and diameter of the horns were consistently larger in the pluriparous goats, which might be the result of the residual effect of the preceding pregnancies, gross macroscopic involution was completed on the same day as the primiparous group. The findings of the current study are in complete agreement with previous reports on goats (BARU et al., 1983; SANCHEZ et al., 2002) and contrary to previous reports on Boer goats, which indicated day 28 as a landmark (GREYLING, 2000; GREYLING and VAN NIEKERK, 1991). However, similar trends for the changes recorded herein were reported in these earlier studies, in which the fast reduction phase during the first period of uterine involution levelled off later during the course of PP involution. Differences encountered in this study might have been due to breed effect, especially with the difference in the reproductive performances between the two breeds and larger genital tract and body weight recorded in Boer goats (GREYLING, 2000; GREYLING and VAN NIEKERK, 1991).

The close association between cervical involution and uterine involution, especially over the first 7 days, may be related to the vaginal longitudinal smooth muscle, which is contiguous with that of the uterus. However, after the fast reduction phase during the first week cervical involution was completed earlier, which is in agreement with reports on

Boar goats (GREYLING and VAN NIEKERK, 1991) and the cervix resembled nulliparous goat cervix by day 13 PP.

Three overlapping histological phases were demonstrated in the PP period in goats. These phases are: 1) disappearance of secretory signs phase, 2) degenerative phase, and 3) regenerative phase. The first phase starts as a direct continuation of pregnancy and characterized by centrally located nuclei in the tall columnar epithelial lining of the endometrium and wide dilated glands. Unlike the caruncular epithelia, which sloughed, the luminal epithelia of the inter-caruncular region remained intact throughout the PP period. The displacement of the nucleus from the basal location to the centre of the cell indicates mainly glycogen deposit during pregnancy (CROSS and MERCER, 1993). Due to a complete decline of progesterone shortly before parturition the endometrial epithelium and glands lose their secretory activity and demonstrated the degenerative signs of the second phase. The degenerative phase was characterized by vacuolation of the cytoplasm, reduction in luminal epithelial height and resumption of the nucleus to its basal position. In addition, degeneration of glandular epithelial cells, denuding caruncular crypts and heavy infiltration of leukocytes, were the main signs of this phase. These two phases of change took place very rapidly and were completed by day 7 PP. These findings are in line with a previous report on goats (SANCHEZ et al., 2002). Cellular death and degeneration during this period coincided with the rapid decline in uterine weight and volume, and possibly accounted for complete withdrawal of steroid hormones and concomitant massive and extended release of prostaglandin (DEGEFA, 2003). The mechanism of clearance of these dying cells was suggested to be apoptosis in which individual cells die and are rapidly engulfed by neighbouring viable cells without the need of involvement of macrophages (O'SHEA and WRIGHT, 1984). During the first week the deeper stroma was composed of a loose and relatively acellular fibrous connective tissue, which was the extension of the excessive extracellular tissue matrix and collagen fibres. However, as involution proceeds, collagen fibres and extracellular matrix are degraded and tissue fluid is lost by day 13 PP, which explain macroscopic involution to be a reflection of the histological involution. The heavy leukocytic infiltration is the first line of defence, rendering the uterus resistant to bacterial infection during the early PP period. The absence of any evidence of inflammation during this period supports the current view that bacterial isolates from the PP uteri are merely contaminants residing in the genitalia (LEWIS, 1997; DEGEFA, 2003). The third regenerative phase was characterized by basal location of nuclei and reduction in size of the cytoplasm of endometrial epithelial cells, regeneration of glandular epithelial cells, collapsing of lumen of endometrial glands, decreasing leukocytic infiltration and initiation of re-epithelialization of caruncular stalk. This phase was completed between day 13 PP and day 19 PP at a moderately fast rate. From day 19 PP, histology of endometrium was a more uniformly low columnar or high cuboidal surface epithelium, glandular epithelial cells were fully regenerated, glands increased in number and size, caruncles completely

covered with cuboidal epithelium, and leukocytes completely cleared, indicating completion of the regenerative phase of the PP period. These results are in line with previous reports on goats (SANCHEZ et al., 2002) and in partial agreement with reports on sheep (O'SHEA and WRIGHT, 1984; KRAJNICKAKOVA et al., 1999), which indicated commencement of the process in the first week, and completion in the third and fourth weeks PP, indicating a certain similarity between these two species. Completion of changes in endometrial epithelium, regeneration of glandular epithelial cells, re-epithelialization of caruncles and return to nearly original size by day 19 PP indicate completion of microscopic involution and preparedness for initiation of cycling.

In conclusion, macroscopic uterine involution under normal non-pathological conditions was completed and the uterus assumed the size of non-pregnant uterus by day 19 PP in Balady goats. Microscopically, endometrial epithelium, glands, stromal tissue and caruncles assumed a non-pregnant state by day 19 PP. Despite the persistence of the greater values of measured parameters in pluriparous goats, the rate and pattern of uterine involution recorded was unrelated to parity.

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SAŽETAK

Dvadeset Balady koza (10 primiparnih i 10 pluriparnih) bilo je zaklano u postpartalnom razdoblju. Mjerene su makroskopske promjene uključujući volumen i težinu maternice te dužinu tijela i rogova maternice. Prikazane su histomorfološke promjene u visini i tipu epitelnih stanica endometrija, žlijezda, strome i karunkula. Makroskopska istraživanja pokazala su da postoje 3 faze regresije maternice. Brza faza involucije traje od jarenja do 7 dana poslije jarenja. Druga faza srednje brze involucije traje do 13. dana poslije jarenja, a spora faza završava 19. dana poslije jarenja. Težina i volumen bili su do 19. dana smanjeni na 5% vrijednosti izmjerenih 1. dana postpartum. Iscjedak je prestao, došlo je do regresije karunkula, simetričnost rogova se vratila, a maternica u ovih životinja nije se razlikovala od maternica u nuliparnih koza. Slično su i mikroskopske promjene bile klasificirane u 3 faze koje su se preklapale: nestanak sekretornih znakova, degenerativna i regenerativna faza. Mikroskopska involucija i potpuna regeneracija epitela karunkula zabilježena je 19. dana. Zaključuje se da su maternice poprimile normalne makroskopske i mikroskopske značajke 19. dana poslije jarenja i nisu bile povezane sa sposobnošću za rađanje Balady koza.

Ključne riječi: koze, maternica, jarenje, involucija
