RESEARCH ARTICLE

Micrometry of Goat Oviducts during Follicular and Luteal Phases of Estrous Cycle

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Abstract

Present study was carried out to investigate the micrometrical characteristics of oviduct in adult goats during follicular and luteal phases of the estrous cycle. Study revealed that the mucosa of oviduct of goat was highly folded during both the phases. The number, height, and thickness of the primary mucosal folds were more during follicular phase and the values of these parameters were decreased significantly from infundibulum to isthmus. The lining epithelium of all the segments of goat oviduct was pseudostratified columnar, with ciliated and non-ciliated cell, during both phases of the estrous cycle. The average height of the epithelium was higher during the luteal phase and showed a decreasing pattern from the infundibulum to the isthmus during both the phases. The thickness of propria submucosa was higher in luteal phase and difference was significant only in isthmus segment. Thickness of tunica muscularis of all parts of oviduct was significantly higher in luteal phase than the follicular phase. The thickness of propria submucosa, tunica muscularis and tunica serosa increased significantly from infundibulum to isthmus during both the phases.

Key words: Follicular phase, Goat, Luteal phase, Micrometry, Oviduct.

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Introduction

Goat plays an essential role in rural livestock production, particularly in Asia. Goats are the most ecologically diverse species among the farm animals. Since they were domesticated during the Neolithic revolution about 10 millennia ago, they have been the poor people's most consistent source of sustenance. The multi-purpose goat breeds are important to the economy and nutrition of the small, marginal, and landless farmers. India has seen a steady rise in both the demand and the production of goat meat over the past ten years, but despite this rising production trend, the country will need a threefold increase in the number of goats to fulfil the estimated demand for goat meat from a growing human population in the future decades.

Reproduction is a crucial component in maintaining and enhancing the effectiveness of animal production. Reproduction is mainly depending on the functional architecture of female reproductive tract, which is crucial for fertilization, egg transit to the uterus and zygote development (Sharma *et al.*, 2013). The fertility of animals has a direct impact on the profitability of livestock industry. The reproductive processes of both male and female gametes take place in the oviduct, making it a significant organ in mammalian reproduction (Ellington, 1991). The oviduct regulates the success rate of fertilization and the early stages of embryonic development by providing a proper microenvironment for a range of processes to take place (Katare *et al.*, 2015). Understanding the cyclical changes in the oviduct not only aids in comprehending their structure but also aids in correlating the physiological changes with regard to sexual function taking place at the level of the reproductive organs.

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For better understanding the structure and function of goat oviduct, more information is needed on different segments associated with the stages of estrous cycle. Therefore, the present study was conducted to investigate the micrometry of oviduct of goats during the follicular and luteal phases of estrous cycle.

Materials and Methods

The study was conducted on oviduct of 20 adult goats during follicular and luteal phases of estrous cycle. The oviducts were collected fresh from local abattoir, after examining the status of ovaries. Tissue samples were collected from the infundibulum, ampulla and isthmus regions. The tissue

samples were preserved in 10 % neutral buffered formalin (10% NBF) for the histomorphological study. After complete fixation, the tissues were processed using an acetone-benzene schedule to prepare paraffin blocks (Luna, 1968). The paraffin blocks were prepared and sections of 5-6 µm thickness were obtained on glass slide with the help of rotatory microtome. These paraffin sections were used for hematoxylin & eosin and masson's trichrome staining method (Prophets *et al.* 1992). Micrometrical observations were recorded on the stained sections of oviduct of goat during follicular and luteal phases of estrous cycle with the help of Carl Zeiss Zen-2 (blue edition) microscopic image analysis software. The micrometrical observations recorded were: the number of primary mucosal folds in each cross section of oviduct; height and thickness of primary mucosal folds in different regions of oviduct; height of epithelium in different regions of oviduct; and thickness of tunica mucosa-submucosa, tunica muscularis and tunica serosa of different regions of oviduct.

Results and Discussion

The present study involved micrometrical observations of various parameters in different segments of goat oviducts during the follicular and luteal phases of the estrous cycle. The findings of the statistical analysis are presented in Tables 1.

Number, Height and Thickness of Primary Mucosal Folds of Oviduct

During the follicular phase of estrous cycle, higher numbers of primary mucosal folds in different segments of oviduct of goat, *i.e.* infundibulum, ampulla and isthmus were observed compared to the numbers of folds observed during the luteal phase. Furthermore, there was a significant decrease ($p<0.05$) in the number of primary mucosal folds along the oviduct, from the infundibulum to the isthmus, in both the phases of estrous cycle. In all segments of the oviduct, the average height of primary mucosal folds was found to be higher during the follicular phase compared to the luteal phase. Additionally, there was a significant decrease ($p<0.05$) in the height of primary mucosal folds along the oviduct, from the infundibulum to the isthmus, during both phases of the estrous cycle (Table 1). During the follicular phase of the estrous cycle, there was an increase in the height of folds and the number of ciliated cells within the oviduct (Fig.1, 2, 3). This increase in height and ciliary activity is believed to facilitate the capture of the oocyte. The heightened folds provide a larger surface area for the oocyte to interact with, while the increased number of ciliated cells promotes the movement of the oocyte towards the uterus. These physiological changes work together to enhance the chances of successful

Table 1: Micrometrical values of various parameters of infundibulum, ampulla and isthmus of goat oviduct during follicular and luteal phases of estrous cycle (n=10, Mean ± SE)

Parameter	Oviductal segments	Follicular phase	Luteal phase	'*P*' Value
Number of primary mucosal folds	Infundibulum	56.16 ± 2.27^{c}	$48.83 \pm 3.34^{b*}$	0.099
	Ampulla	43 ± 1.93^{b}	40.83 ± 3.18^{b}	0.573
	Isthmus	11 ± 0.57^{a}	$8.66 \pm 0.55^{a*}$	0.015
Height of primary mucosal folds (µm)	Infundibulum	433.46 ± 14.56^{b}	410.84 ± 30.42^{b}	0.517
	Ampulla	419.63 ± 20.80^{b}	409.53 ± 16.36^{b}	0.710
	Isthmus	267.11 ± 17.32^{a}	253.90 ± 10.07^{a}	0.524
Thickness of primary mucosal folds (µm)	Infundibulum	60.53 ± 1.66^{b}	59.27 ± 1.29^{b}	0.566
	Ampulla	58.18 ± 1.84^{ab}	55.79 ± 2.51^{ab}	0.462
	Isthmus	51.57 ± 3.22^{a}	49.51 ± 2.71^{a}	0.634
Height of Epithelium (µm)	Infundibulum	17.70 ± 0.56^{b}	19.04 ± 0.60^{b}	0.136
	Ampulla	17.36 ± 0.53^{ab}	17.87 ± 0.62^{ab}	0.545
	Isthmus	15.81 ± 0.53^{a}	15.95 ± 1.14^{a}	0.913
Thickness of propria submucosa (µm)	Infundibulum	11.07 ± 1.06^{a}	11.85 ± 0.10^{a}	0.484
	Ampulla	10.59 ± 0.32^{a}	11.14 ± 0.32^{a}	0.255
	Isthmus	16.87 ± 0.69^{b}	$19.62 \pm 0.25^{b**}$	0.004
Thickness of Tunica muscularis (µm)	Infundibulum	29.56 ± 0.63^{a}	$33.08 \pm 1.15^{a*}$	0.023
	Ampulla	45.87 ± 2.12^{b}	$61.25 \pm 1.55^{b**}$	<0.001
	Isthmus	175.62 ± 3.33^{c}	$203.13 \pm 5.50^{c**}$	0.001
Thickness of Tunica serosa (µm)	Infundibulum	54.15 ± 3.13^{a}	62.19 ± 2.21^{a}	0.062
	Ampulla	69.10 ± 2.46^{b}	$82.24 \pm 1.16^{b**}$	<0.001
	Isthmus	77.73 ± 1.66^{c}	83.15 ± 2.23^{b}	0.080

Values with different superscripts within a column of a parameter differ significantly ($P<0.05$). *$p<0.05$, **$p<0.01$ between phases within the segment.

fertilization and implantation during the follicular phase (Shankhapal *et al.*, 2014).

The analysis of average thickness of primary mucosal folds of infundibulum, ampulla and isthmus revealed that the thickness of folds exhibited a significant decrease ($p<0.05$) from the infundibulum to the isthmus in both the follicular and luteal phases of the estrous cycle. Additionally, the folds were found to be thicker in the follicular phase compared to the luteal phase in all segments of the oviduct (Table 1, Fig. 1, 2). Similar trends were observed by Sharma *et al.* (2015) in the goats, Natarajan *et al.* (2003) in the buffalo, Ayen *et al.* (2012) in the Azarbaijan buffaloes and Mokhtar (2015) in cow.

Height of Surface Epithelium

The data on average height of surface epithelium of infundibulum, ampulla and isthmus was higher during the luteal phase compared to the follicular phase. Additionally, there was a significant decrease ($p<0.05$) in the height of the surface epithelium along the oviduct, from the infundibulum to the isthmus, during both phases of the estrous cycle (Table 1, Fig. 4, 5). These findings align with the observations made by Saleem *et al.* (2016) in Bakerwali goats. However, Shankhapal (2013) in goat and Natarajan *et al.* (2003) in buffalo found contrasting results, where the maximum cell height was observed in the infundibulum during the follicular phase and the minimum cell height was observed in the isthmus during pregnancy. Kumar (2018) also found that the average height of epithelium in infundibulum, ampulla and isthmus was higher during follicular phase than the luteal phase.

Thickness of Different Layers of Oviduct

The oviductal wall thickness, *i.e.* of propria-submucosa in infundibulum, ampulla and isthmus was higher during the luteal phase compared to the follicular phase. The thickness of the propria-submucosa increased significantly ($p<0.05$) from infundibulum to the isthmus in both phases (Table 1, Fig. 6, 7). These observations were consistent with findings by Saleem *et al.* (2016) in goats, Tienthai *et al.* (2009) in Thai buffalo, and Kumar (2018) in Jaffarabadi buffalo, while Sharma *et al.* (2015) found a significant increase in the submucosa thickness specifically in the ampullary region of the goat oviduct.

The average thickness of the tunica muscularis in the infundibulum, ampulla, and isthmus was significantly ($p<0.05$) higher during the luteal phase compared to the follicular phase. The average thickness of the tunica muscularis increased significantly ($p<0.05$) from infundibulum to isthmus during both phases of the estrous cycle (Table 1, Fig. 6, 7). Similar trends were observed in previous studies conducted by Saleem *et al.* (2016) in goats, and Natarajan *et al.* (2003), Ayen *et al.* (2012), Tienthai *et al.* (2009) and Kumar (2018) in buffaloes. These findings highlight the consistency of thicker tunica muscularis in the oviduct during the luteal phase compared to the follicular phase, as well as the significant increase in tunica muscularis thickness along the oviduct. The increased thickness of the tunica muscularis in the isthmus plays a crucial role in facilitating the transport of sperm cells from the isthmus to the ampulla. This histological feature of the oviduct, observed in Azarbaijan buffalo and other species, is part of a precisely regulated mechanism where the oocyte and spermatozoa are transported in opposite directions simultaneously during estrus. The ultimate goal of this transport is to bring the spermatozoa to the ampulla, where fertilization can take place (Ayen *et al.*, 2012).

The data also showed that the average thickness of the tunica serosa in the infundibulum, ampulla, and isthmus was higher during the luteal phase compared to the follicular phase, but with significant ($p<0.05$) difference only in ampullary region. Additionally, there was a significant increase ($p<0.05$) in the average thickness of the tunica muscularis along the oviduct, from the infundibulum to the isthmus, during both the follicular and luteal phases of the estrous cycle (Table 1, Fig. 6, 7). Saleem *et al.* (2016) in goat oviduct and Tienthai *et al.* (2009) in Thai buffalo oviduct observed similar trend of increase thickness of tunica serosa in luteal phase.

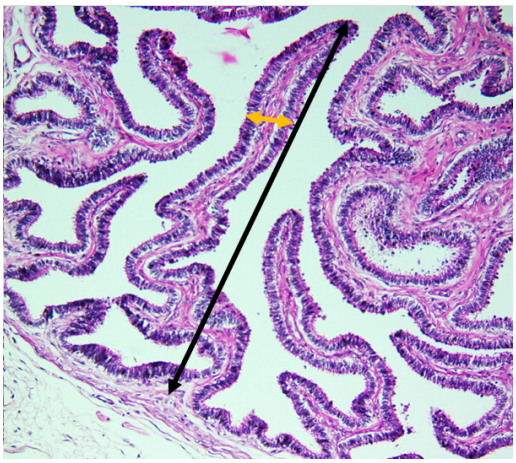

Fig. 1: Photomicrograph of oviduct showing height (black arrow) and thickness (yellow arrow) of primary mucosal fold during follicular phase. H & E x 100.

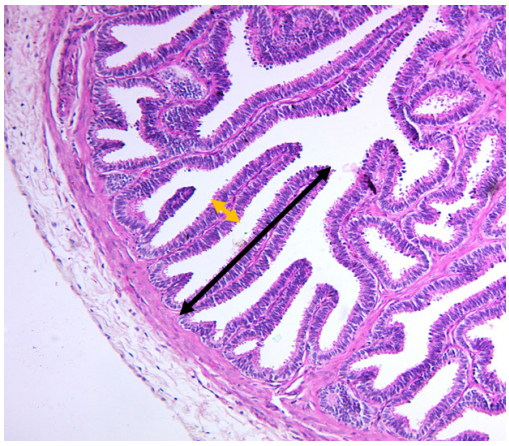

Fig. 2: Photomicrograph of oviduct showing height (black arrow) and thickness (yellow arrow) of primary mucosal fold during luteal phase. H & E x 100.

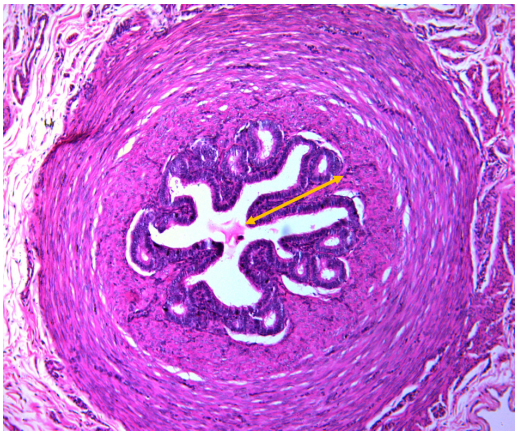

Fig. 3: Photomicrograph of isthmus showing height (yellow arrow) of primary mucosal fold during follicular phase. H & E x 100.

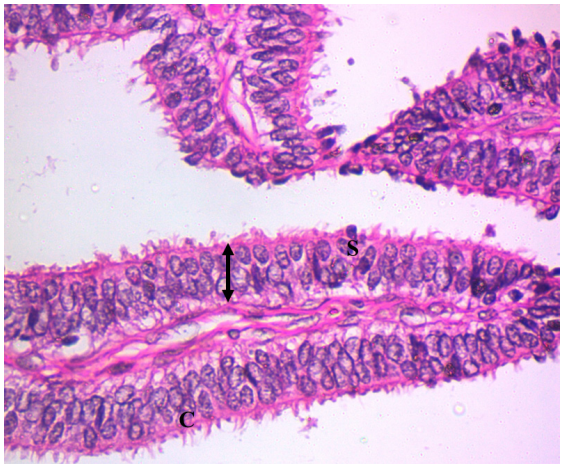

Fig. 4: Photomicrograph of oviduct showing C. ciliated cells, S. secretory cell and height of epithelium (arrow) during follicular phase. H & E x 400.

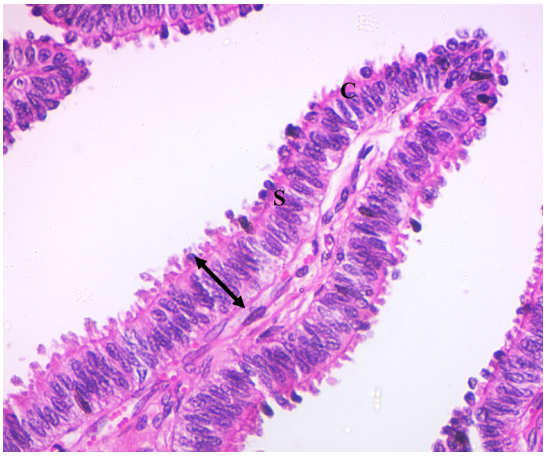

Fig. 5: Photomicrograph of oviduct showing C. ciliated cells, S. secretory cell and height of epithelium (arrow) during luteal phase. H & E x 400.

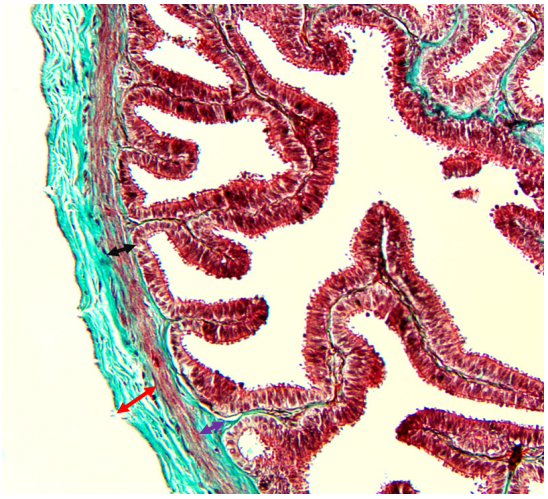

Fig. 6: Photomicrograph of ampulla showing thickness of propria submucosa (purple arrow), tunica muscularis (black arrow) and tunica serosa (red arrow). Masson's trichrome x 100.

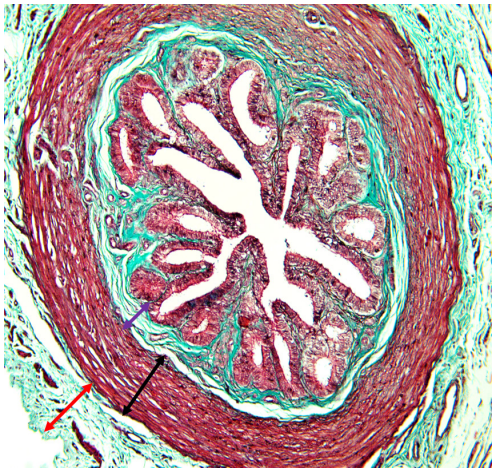

Fig. 7: Photomicrograph of isthmus showing thickness of propria submucosa (purple arrow), tunica muscularis (black arrow) and tunica serosa (red arrow). Masson's trichrome x 100.

Conclusions

Study revealed that the mucosa of oviduct of goat was highly folded during both the phases. The number, height, and thickness of the primary mucosal folds were more during follicular phase, and decreased significantly from infundibulum to isthmus. The lining epithelium of all the segments of goat oviduct was pseudostratified columnar, with ciliated and non-ciliated cell, during both phases of the estrous cycle. Average height of the epithelium, and thickness of propria submucosa and tunica muscularis were higher during the luteal phase. The thickness of propria submucosa, tunica muscularis and tunica serosa was increased significantly from infundibulum to isthmus during both the phases.

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