

Effect of Seasonal Changes in Photoperiod on Ovarian Morphometry, Ovarian Follicle Diameter, and Oocyte Diameter in Iraqi Local Goats

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Abstract

Through its impact on ovarian function and follicular growth, photoperiodic seasonal variation is one of the most significant environmental elements in controlling goat reproductive activity. The purpose of this study was to examine how ovarian morphometric traits, ovarian follicle diameter, and oocyte diameter were affected by summer and autumn over two photoperiods in local Iraqi goats. Adult female goats (2–3 years old) were ovarically sampled monthly from June to November, and ovarian weight, length, thickness, volume, along with follicle diameter and oocyte diameter were measured using standard morphometric and histological techniques. A Completely Randomized Design (CRD) was used to evaluate the data, and Duncan's Multiple Range Test at $P < 0.05$ was used to examine the changes across the months. There was a clear seasonal effect for all traits tested, with ovarian weight, length, thickness, volume, and follicle diameter and oocyte diameter being significantly greater in autumn than in summer. The highest values were registered continuously in September and October, while the lowest ones were registered in the summer months. The betterment of these parameters is probably associated with Samane's prolonged photoperiod during autumn, which causes an increase in melatonin, gonadotropin release, follicle development, and steroidogenesis, leading to oocyte quality. In contrast, the short photoperiod in summer, along with heat stress, deleteriously affects ovarian function and its development. In conclusion, seasonal photoperiod is an important factor that influences the ovarian morphology and reproductive performance of Iraqi local goats; autumn provided the most suitable physiological conditions for ovarian changes during summer by increasing follicular maturation and oocyte growth.

Keywords: Iraqi local goats, ovarian dimensions, follicular diameter, oocyte diameter, photoperiod, seasonal reproduction

Introduction

Season plays a fundamental role in regulating reproductive activity in female sheep and goats, as it directly affects ovarian follicular development and intrafollicular steroid hormone levels. In sheep and goats, around 30% of follicular cells were steroidogenic in winter, increasing to 45% in

autumn, which also had higher concentrations of steroid hormones than the other seasons [5]. Seasonal variations, particularly photoperiod or light duration, are crucial in controlling follicular growth and oocyte maturation because they directly affect steroid hormone production, which is necessary for healthy oocyte development. Disturbances in this process may inhibit

follicular development or impair oocyte maturation [20]. In addition, some environmental factors, such as hormonal status, physical stresses, and ambient temperature and photoperiod, regulate the increase of granulosa cells that surround oocytes. In this regard, ovarian follicles larger than 5 mm diameter are more likely to ovulate in autumn vs. other seasons [14,13], and such a response was due to an increase in the growth rate of large follicles at the beginning of the breeding season. By contrast, heat stress is one of the most important environmental factors harming female reproductive efficiency by decreasing oocyte quality [18]. Previous studies have also demonstrated that heat stress suppresses follicular growth and negatively affects preovulatory follicles, resulting in a marked reduction in follicular growth and development during summer compared with winter. In agreement with these findings, [15] reported a significant decrease in the number of ovarian follicles during spring and summer, which was associated with reduced fertility in goats. Furthermore, seasonal variations in ovarian follicle number and size have been documented [18], demonstrating a significant seasonal effect on ovarian follicle size, with follicles exceeding 3 mm in diameter being more abundant during autumn than in other seasons, coinciding with the highest progesterone concentrations. These seasonal changes are also reflected in oocyte growth and quality [2]. Reported significant increases in the number and diameter of developing and mature ovarian follicles, as well as in oocyte number and diameter, during the autumn months compared with summer, leading to improved reproductive efficiency. In addition, previous studies indicated that the proportion of small-diameter oocytes was greater during spring and summer than during autumn and winter. In ewes, [1]

reported seasonal differences in oocyte diameter, recording values of 70.26, 99.37, 103.33, and 117.27 μm during September, October, January, and March, respectively. Another study by the same author also demonstrated seasonal variations in oocyte diameter in local female goats, with values of 185.84, 79.01, 72.85, and 104.43 μm during winter, spring, summer, and autumn, respectively [3] found that most mature follicles in female goats during summer exhibited abnormal arrangements of cumulus and granulosa cells, with degenerated oocytes detached from the surrounding cells, attributing these abnormalities to stress induced by prolonged photoperiod. The same study further showed that photoperiod directly affected the number of recovered oocytes, with 29 oocytes obtained during autumn compared with only 19 during summer. Seasonal effects were not limited to follicular activity and oocyte development but also extended to ovarian morphometric characteristics. In Iraqi local goats, the average ovarian length, weight, and height during summer were 18.41 ± 0.13 mm, 2.28 ± 0.39 g, and 8.90 ± 0.11 mm, respectively, whereas these values increased during autumn to 19.31 ± 0.41 mm, 3.68 ± 0.31 g, and 10.29 ± 0.91 mm, respectively [7]. Similarly, [3] reported seasonal differences in ovarian dimensions in Black Bengal goats, with mean ovarian length, weight, and width of 1.5 ± 0.2 cm, 0.81 ± 0.1 g, and 1.1 ± 0.2 cm during winter, respectively, decreasing to 1.3 ± 0.3 cm, 0.80 ± 0.2 g, and 0.9 ± 0.2 cm during summer. Variations in ovarian dimensions among goat breeds have also been reported. In Turkish goats, the average ovarian length, thickness, and weight were 13.21 ± 1.27 mm, 5.66 ± 0.79 mm, and 0.59 ± 0.17 g, respectively [4]. In Black Bengal goats, ovarian length and width were reported to be 20.70 ± 2.91 mm and 14.90 ± 2.02 mm, respectively [8], whereas another study on

the same breed reported an ovarian length of 1.28 cm, weight of 0.55 ± 0.02 g, and thickness of 0.94 ± 0.21 cm [9]. Further confirmed these findings by reporting significant increases in ovarian weight, length, thickness, and volume during the autumn months (September, October, and November) compared with the summer months (June, July, and August) [2]. Moreover, September recorded the highest value (9.54 ± 0.20), whereas July and August recorded lower values of 7.51 ± 0.20 and 7.87 ± 0.22 , respectively.

Materials and Methods

Ovarian samples were collected from local Iraqi female goats (2–3 years old). The age of the animals was determined according to the dentition immediately after slaughter, combined with the removal of the reproductive tract. Each reproductive organ was examined grossly for normal morphology, as well as the presence of macroscopic abnormalities or pathological alterations. Only ovaries with developing ovarian follicles were taken. Ovarian samples from 6 times (June, July & August, September, October & November) during the summer and autumn months were obtained to yield a total of 18 samples per season. Each ovary was put into a sterile plastic bag with normal physiological saline (0.9% NaCl) and labeled using the Identification number of the animal for sample traceability. Subsequently, samples were transported in an insulated ice container to the laboratory for analysis in order to sustain tissue integrity and avoid postmortem alterations. The morphometry of the ovaries was evaluated by measuring ovarian weight and size (maximum length, maximum width, thickness, and volume) on both sides. Determine ovarian weight using a high-precision electronic balance; Harmonious among the participants who

measured, Ovarian length, Width, and thickness were measured in a vernier caliper. For each individual animal, the values were averaged from both ovaries. The diameter of each ovarian follicle was measured using a Vernier caliper for precise assessment of follicular size. Ovarian tissue sections for histological assessment were prepared following the manual processing of paraffinized tissues in accordance with laboratory procedures and examined under a light microscope equipped with an ocular micrometer at $\times 400$ magnification. Oocytes were measured for longitudinal and transverse diameter by using an ocular micrometer, from which the mean oocyte diameter was calculated as follows:

$$\text{Oocyte diameter } (\mu\text{m}) = (\text{Longitudinal diameter} + \text{Transverse diameter}) \div 2$$

Results and Discussion

The influence of season by month on ovarian weight was detected, which was significant ($P \leq 0.05$). Abstract: The mean value of ovarian weight was substantially lower in the summer season 2.89 ± 0.12 g, while autumn, marked by the high mean values (autumn means = 3.80 ± 0.10 g), also indicated significant differences at the monthly level within each season. For summer, July had the lowest ovarian weight (mean 2.72 ± 0.19 g), while August had a higher value (mean 3.14 ± 0.20 g); for autumn, October had the highest ovarian weight (4.15 ± 0.08 g) and then September (3.99 ± 0.40 g), followed by significant declines in November (3.28 ± 0.11 g). Such results suggest that, at some level, reproductive activity was greater in the autumn than in the summer. A high ovarian weight in the seventh month (September) and eighth month (October) of treatment may be due to the increased melatonin secretion caused by shortening the

photoperiod and lengthening the photoperiod of darkness. This seasonally variable information regulates the secretion of follicle-stimulating hormone (FSH) and luteinizing hormone (LH), which, in turn, enhances ovarian function and promotes ovarian growth. In addition, melatonin acts as a potent antioxidant by maintaining mitochondrial function, improving cellular energy utilization, and reducing oxidative stress in reproductive tissues, which ultimately enhances ovarian viability and contributes to increased ovarian weight [10]. A significant seasonal effect ($P \leq 0.05$) was also observed for ovarian thickness. In summer, the lowest mean ovarian thickness (5.60 ± 0.11 mm) was maintained, while a significantly higher value (8.29 ± 0.14 mm) was observed during autumn. In the summer, thickness was lowest in June (5.27 ± 0.14 mm) and highest in August (5.99 ± 0.17 mm), with July (5.54 ± 0.18 mm) not differing from either month significantly. Ovarian thickness was highest in October (8.82 ± 0.19 mm), followed by September (8.15 ± 0.27 mm) and November (7.88 ± 0.15 mm) during the fall, and these were significantly different from each other ($P < 0.001$). Autumn ovarian thinning corresponds to follicular activity due to improved endocrine status and increased estradiol levels. Increased estradiol levels promote granulosa cell proliferation and greater thickness of the granulosa layer, which together lead to ovarian enlargement. On the other hand, during summer heat stress inhibits cellular proliferation and follicular development, leading to thinner ovaries, which is in agreement with [6,17]. The effects of season were also significant ($P \leq 0.05$) on ovarian volume, which averaged 9.17 ± 0.21 cm³ during fall (autumn), compared with 7.01 ± 0.17 cm³ during summer months. On the monthly scale, no significant differences were found between June (6.59 ± 0.17 cm³) and July

(6.68 ± 0.14 cm³), while a significant increase was observed in August (7.77 ± 0.31 cm³). Within autumn, October recorded the greatest ovarian volume (9.84 ± 0.22 cm³), followed by September (8.87 ± 0.16 cm³), while November exhibited a slight but significant reduction (8.81 ± 0.21 cm³). The increase in ovarian volume during autumn is associated with a greater number of growing and mature follicles together with enhanced stromal tissue development, increased vascularization, and continued follicular growth, all of which contribute to enlargement of the ovary. In contrast, reduced feed intake and heat stress during summer suppress follicular development, leading to decreased ovarian volume, in agreement with the findings of [12]. Similarly, a large seasonal effect ($P \leq 0.05$) was detected for ovarian length, whereby the average size was 16.22 ± 0.18 mm in autumn versus 13.89 ± 0.13 mm in summer. However, no major monthly differences were found in either season, and ovarian length exhibited modest variation for summer (13.66–14.27 mm) and autumn (16.11–16.31 mm). Longer ovaries one year in autumn are due to a shorter photoperiod that prolongs melatonin secretion and increases reproductive activity, generating more growth of the follicles and surrounding ovarian tissue. Elevated estradiol concentrations may also contribute to ovarian growth during this period. The absence of significant monthly differences within each season is likely due to the similarity in environmental conditions and photoperiod among the months within each season, resulting in relatively stable ovarian activity [19]. A significant seasonal effect ($P \leq 0.05$) was also found for follicular diameter. Autumn recorded a significantly higher mean follicular diameter (6.12 ± 0.19 mm) than summer (2.74 ± 0.14 mm). No significant differences were detected among the months within either season; however,

all autumn months exhibited significantly larger follicular diameters than those observed during summer. Follicular depth during autumn is presumably higher as a result of the photoperiod, which enhances pineal melatonin secretion and consequently increases FSH and LH release from the anterior pituitary gland. These endocrine changes facilitate follicular growth and maturation, leading to larger ovarian follicles [11]. Oocyte diameter in the high-temperature regions was also significantly influenced ($P \leq 0.05$) by both season and month. The average oocyte diameter was significantly higher in autumn ($95.38 \pm 0.99 \mu\text{m}$) than in summer ($58.27 \pm 2.97 \mu\text{m}$). Among the summer months, July has had the lowest value ($40.82 \pm 2.20 \mu\text{m}$), then June ($58.05 \pm 2.06 \mu\text{m}$), and August has had the largest value ($75.93 \pm 2.15 \mu\text{m}$). On the

contrary, September, October, and November did not differ significantly from one another (all being equally high statistical groups). An increase in oocyte diameter during autumn indicates the completion of ovogenesis in anthropogenic optimal physiological conditions with high estradiol levels and a better function of granulosa cells. These modifications contributed to oocyte growth and quality concomitant with follicular diameter increase. In contrast, heat stress in a peak summer month leads to impairment of oocyte development and an increase in follicular atresia due to diet-activated decreases in granulosa cell aromatase activity, limiting estrogen synthesis and follicular growth, which may be associated with reduced oocyte diameter [16].

Oocyte Diameter (μm)	Follicular Diameter (mm)	Ovarian Length (mm)	Ovarian Volume (cm^3)	Ovarian Thickness (mm)	Ovarian Weight (g)	Studied Traits Study Months
2.06 ± 58.05 c	0.09 ± 2.40 b	± 13.66 0.24 b	± 6.59 0.17 d	0.14 ± 5.27 d	± 2.81 0.23 bc	June
2.20 ± 40.82 d	0.20 ± 2.83 b	± 13.75 0.22 b	± 6.68 0.14 d	0.18 ± 5.54 cd	± 2.72 0.19 c	July
2.15 ± 75.93 b	0.34 ± 2.98 b	± 14.27 0.14 b	± 7.77 0.31 c	0.17 ± 5.99 c	± 3.14 0.20 bc	August
1.21 ± 96.30 a	0.25 ± 6.02 a	± 16.24 0.11 a	± 8.87 0.16 b	0.27 ± 8.15 b	0.4 ± 3.99 a	September
1.64 ± 97.04	0.37 ± 6.56	± 16.31 0.24	± 9.84 0.22	0.19 ± 8.82	± 4.15 0.08	October

a	a	a	a	a	a	
1.96 ±92.80	0.33 ±5.78	±16.11 0.50	±8.81 0.21	0.15 ±7.88	±3.28 0.11	November
a	a	a	b	b	b	

According to Duncan's Multiple Range Test, means with different capital letters in the same column show significant differences between the two experimental seasons, while means with different lowercase letters in the same column show significant differences between the study months at the probability level of ($P \leq 0.05$).

Conclusions

The results of the present study demonstrated a significant effect of season on the ovarian morphological characteristics. For ovarian weight, length, thickness, and volume; follicular diameter and oocyte diameter, the autumn months were significantly greater than the summer months. Additionally, autumn (October) exhibited the greatest values for follicular and oocyte diameters, reflecting significant advancement in follicular development and oocyte maturation. These results were attributed to the superiority of local Iraqi goats in reproductive performance during the fall season.

Statistical Analysis

A Completely Randomized Design (CRD) with a single factor, the study month (June, July, August, September, October, and November), was used to analyze the data using the Statistical Analysis System (SAS, 2010). Significant differences in mean comparisons were conducted by Duncan's Multiple Range Test ($\alpha \leq 0.05$) among the six months of the study.

This statistical model was employed:

$$Y_{ij} = \mu + a_i + \varepsilon_{ij}$$

Where:

Y_{ij} = the observed value of the j th observation in the i th month.

μ = the overall mean of the experiment.

a_i = the effect of the i th month.

ε_{ij} = the random error associated with each observation

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