

*Full Length Research Paper*

# Ovarian follicular dynamics during the interovulatory interval in Najdi goats

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The pattern of growth and regression of ovarian follicles was characterized during the estrus cycle in 5 Najdi goats by daily ultrasonographic examination of the ovaries. Follicles  $\geq 2$  mm was measured and their relative locations within the ovary were determined to follow the sequential development of each individual follicle. Results indicated the presence of either four ( $n = 2$  estrus cycles) or five ( $n = 3$  estrus cycles) waves of follicular growth during the interovulatory interval. Each wave was characterized by the development of at least 1 large follicle (dominant) and a variable number of small follicles (subordinate). The mean number of follicular waves in Najdi goats is  $4.6 \pm 0.55$ , the days of wave emergence were on  $-0.8 \pm 1.06$ ,  $3.2 \pm 0.4$ ,  $7.0 \pm 0.6$ ,  $12.3 \pm 1.72$  and  $13.0 \pm 1.63$ , for the first to fifth follicular waves, retrospectively. In goats with four or five follicular waves the dominant follicle in fourth or fifth wave was ovulatory follicle. The mean number of ovulations in Najdi goats is  $1.8 \pm 0.4$ . Means of values were analyzed by repeated measures test using general linear model (GLM).

**Key words:** Goats, estrous, follicles, ultrasonography.

## INTRODUCTION

Real-time ultrasonography scanning permits the study of ovarian structures in large and small animals and the monitoring of their evolution by successive observation (Kohram et al., 1998). Waves or distinct groups of follicles have been shown by transrectal ultrasonography to develop during the estrus cycle in cattle (Pierson and Ginther, 1988) and mares (Ginther, 1990). Maintenance of the day-to-day identity of individual follicles has allowed ultrasonic detection of waves in individual animals; 2 or 3 waves occur during the estrus cycle in cattle (Pierson and Ginther, 1988) and 1 or 2 waves in mares (Ginther, 1999). In these two species, each wave of follicular activity develops into at least 1 follicle that becomes dominant and far exceeds the diameter of other follicles (subordinates) in the wave. In sheep, results of transrectal ultrasound studies indicated that a wave of follicular activity occurred at the beginning and end of the estrus cycle and dominance may have occurred in

association with the development of the ovulatory follicles (Ravindra et al., 1994). In goats, there are a few reports of ovarian follicular dynamics assessed by ultrasonography (Ginther and Kot, 1994; De Castro et al., 1999). The purpose of the present ultrasound study was to characterize follicular dynamics for follicles  $\geq 2$  mm during the interovulatory interval in Najdi goats.

## MATERIALS AND METHODS

Five adult female Najdi goats aged 1.5 - 2.5 years and weighing 25 - 30 kg was used at the experimental laboratory of the Department of Clinical Science, Faculty of Veterinary Medicine, Shahid Chamran University, Ahvaz, Iran. This study was performed during the breeding season (November - February) and included 1 interovulatory interval for each goat. The goats were kept under natural day length and the estrus behavior was checked twice a day with vasectomized buck throughout the experimental period. Before the onset of this study, 5 goats have a regular estrus cycle. The estrous cycle of the animals were synchronized with 2 intramuscular injections of prostaglandin F<sub>2</sub> $\alpha$  (SynchroMate®, 263  $\mu$ g cloprostenol sodium, Bremer pharma GmbH, Germany) given 11 days apart (Estrous = day 0). The operator utilized the period before the onset of the study for practicing the technique of ovarian

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ultrasonic examination. The scanner was a real-time, B-mode instrument with a 7 MHz linear-array transducer (Aloka, Japan). All images on the ultrasonography monitor were recorded by a video apparatus connected to ultrasonography equipment. A slightly arched wooden dowel (diameter, 20 mm; length, 20 cm) was fastened to the transducer with duct tape so that the probe could be manipulated externally into the rectum. Goats were placed in standing position. Fecal pellets were removed digitally, and paraffin oil (50 ml) was inserted with a syringe into the rectum. The transducer was inserted and manipulated in the rectum by external control of the extension. Ovarian follicular development was monitored daily and all follicles observed were recorded. The diameters of individual follicles  $\geq 2$  mm were measured. The ovarian location of follicles was sketched relative to each other and to luteal structure, as described for Saanen goats and heifers (Ginther and Kot, 1994; Pierson and Ginther, 1988). After recording locations, the sketch was compared to that of the previous day. On this basis, each individual follicle that was identifiable from day-to-day was given a letter code, which was maintained for as long as the follicle was identifiable. Identification of the smaller follicles was done retrospectively when they reach a larger diameter.

The data were transferred to figures showing the diameter profile for each follicle. A diameter profile began and ended at 2 mm. The total number of follicles  $\geq 2$  mm in diameter was assessed on each day. Each wave was characterized by the development of one large follicle (dominant) and a variable number of small (subordinate) follicles. Appearance day of follicular wave was the day of emergence of the largest follicle of that wave, and more than 1 day was allowed for all the follicles of a wave to emerge (Ginther and Kot, 1994). The day of emergence of a follicle was the day that a follicle was 3 mm in diameter followed by an increase in diameter to  $\geq 4$  mm on the following day. The occurrence of ovulation was detected as described for Saanen goats and heifers (Ginther and Kot, 1994; Pierson and Ginther, 1988) by the collapse of a large follicle. Means of values were analyzed by the general linear model (GLM) procedure of the statistical analysis system (SAS, 1989) that examined effect of goat.

## RESULTS

The mean ( $\pm$  SEM) interovulatory interval for the five Najdi goats was  $20.6 \pm 0.89$  days. Follicular turnover was characterized by the presence of waves of follicular growth beginning at different times during the estrus cycle (Figure 1). In terms of number of waves per cycle, two different patterns were observed in five goats. These patterns included either four ( $n = 2$ ) or five ( $n = 3$ ) follicular waves per cycle and the mean number of follicular waves in Najdi goats was  $4.6 \pm 0.55$  (Table 1).

The mean ( $\pm$  SEM) diameter of largest follicle in the five follicular waves was  $5.6 \pm 0.8$ ;  $5.6 \pm 0.49$ ;  $6.0 \pm 1.72$ ;  $7.0 \pm 1.79$  and  $5.25 \pm 0.43$  for first to fifth follicular waves, respectively (Table 2). The mean ( $\pm$  SEM) appearance day of follicular wave was  $-0.8 \pm 1.06$  ( $n = 5$ );  $3.2 \pm 0.4$  ( $n = 5$ );  $7.0 \pm 0.6$  ( $n = 5$ );  $12.3 \pm 1.72$  ( $n = 5$ ); and  $13.0 \pm 1.63$  ( $n = 3$ ) for first to fifth follicular waves, respectively ( $n =$  follicular wave number; Table 2). The day of dominant follicle appearance with its largest diameter was  $2.9 \pm 1.49$ ;  $7.6 \pm 0.58$ ;  $12.2 \pm 1.36$ ;  $16.7 \pm 2.08$  and  $18.6 \pm 0.47$  for first to fifth follicular waves, respectively (Table 2). The mean ( $\pm$  SEM) period (days) of follicular wave appearance until dominant follicle reached its

largest diameter was  $4.3 \pm 1.6$ ;  $4.18 \pm 1.3$ ;  $4.3 \pm 1.4$ ;  $4.3 \pm 1.4$  and  $4.4 \pm 1.4$  for first to fifth follicular waves, respectively (Table 2). The mean ( $\pm$  SEM) period (days) of dominant follicle appearance until its disappearance was  $6.6 \pm 0.4$ ;  $7.8 \pm 1.16$ ;  $8.8 \pm 1.16$ ;  $7.2 \pm 1.93$  and  $6.5 \pm 1.7$  for first to fifth follicular waves, respectively (Table 2). The mean ( $\pm$  SEM) maximal diameter reached the ovulatory follicles in fourth follicular wave and in fifth follicular wave was  $7.75 \pm 0.83$  and  $5.2 \pm 0.4$ , respectively (Table 2).

In the 23 follicular development waves observed in the five Najdi goats, 14 follicular waves had second largest follicle (60.8%), which was growing during dominant follicle on the same wave but with lower size than the dominant follicle (Figure 1). The mean ( $\pm$  SEM) second largest follicles diameter for 14 follicular waves was  $4.6 \pm 0.7$ . The mean ( $\pm$  SEM) number of ovulations in the five Najdi goats was  $1.8 \pm 0.4$ .

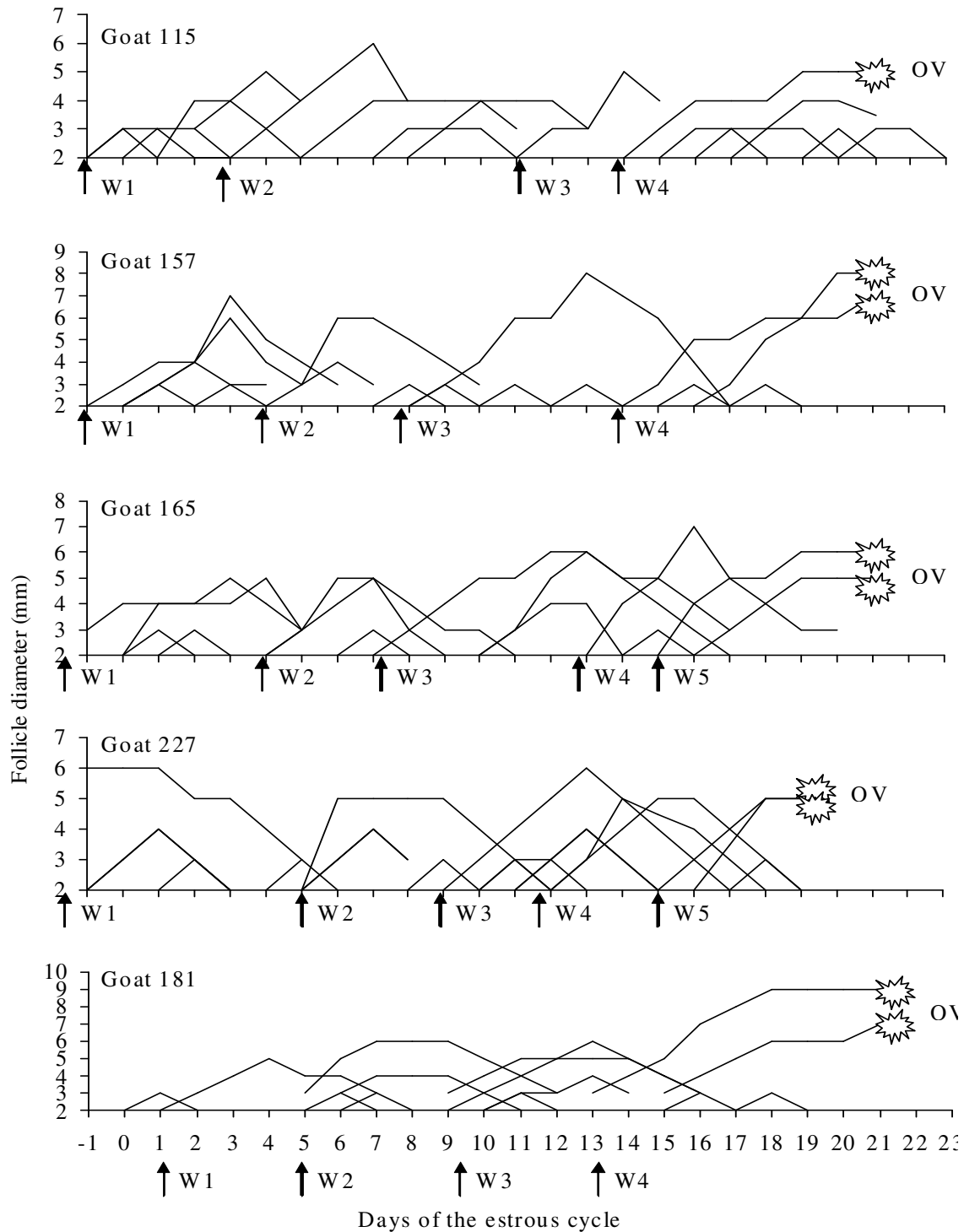
## DISCUSSION

The results of ovarian daily ultrasonography in this study confirms the previous finding that the wave-like pattern of follicular development occurs in goats (De Castro et al., 1999; Ginther and Kot, 1994) and it is similar to other ruminant species (cattle: Pierson and Ginther, 1988; sheep: Ginther et al., 1995). The mean ( $\pm$  SEM) interovulatory interval for Najdi goats ( $20.6 \pm 0.89$  days), was similar to White Polish goats ( $20.4 \pm 1.1$  days; 22), and Saanen goats ( $20.8 \pm 0.89$ ) (Menchaca and Rubianes, 2002), but not comparable to that West African dwarf goats (23.89 days) (Akusu et al., 1986).

However, in this study predominant number of follicular wave was 5, but generally in goats that show regular interovulatory period (19-21 days), there were 4 follicular waves (Ginther and Kot, 1994; De Castro et al., 1999). Probably a part of this variation refers to genetic and environmental difference. The mean ( $\pm$  SEM) time of the five follicular waves emergence of Najdi goats as determined by ultrasonography of the ovaries (Table 2) was similar to White Polish goats (the days -1, 4, 7, 11 and 15 of the estrous cycle; Schwarz and Wierzchos, 1999) and Saanen goats (the days -1, 4, 8 and 15 of the estrous cycle; Ginther and Kot, 1994).

In the present study, the mean ( $\pm$  SEM) period that one follicular wave emerged until dominant follicle of the same wave reached its largest diameter ( $4.3 \pm 1.4$  days; Table 2) was comparable to that obtained on White Polish goats ( $4.1 \pm 0.65$  days) (Schwarz and Wierzchos, 1999) and Saanen goats (De Castro et al., 1999) which suggested that growth rates of the largest follicles of the successive waves were not different.

The mean ( $\pm$  SEM) diameter of ovulatory follicles of the fourth follicular waves ( $n = 4$ ) was larger than the fifth follicular waves ( $n = 5$ ). Whereas duration of the interovulatory interval in goats with 4 or 5 follicular waves was the same, the larger diameter of ovulatory follicle was



**Figure 1.** Growth and regression profile of individual follicles. Parts of regressive phases have been removed to minimize obscurement of the growth phase. Arrows indicate the emergence of waves at 2 mm as defined by the development of 5 mm follicles. OV = Ovulation. W = follicular wave.

**Table 1.** Number of follicular waves in the ovaries of Najdi goats.

Najdi goats' ear tag number	115	157	165	181	227	Mean $\pm$ SEM
Number of follicular waves	5	4	5	4	5	4.6 $\pm$ 0.55

**Table 2.** Characteristics of follicular dynamics during the interovulatory interval in Najdi goats.

Follicular wave number	First wave	Second wave	Third wave	Fourth wave	Fifth wave	Mean $\pm$ SEM
Largest follicle diameter (mm)	5.6 $\pm$ 0.8	5.6 $\pm$ 0.49	6.0 $\pm$ 1.72	7.0 $\pm$ 1.79	5.25 $\pm$ 0.43	5.91 $\pm$ 1.17
Appearance day of follicular wave	-0.8 $\pm$ 1.06 (N = 5)	3.2 $\pm$ 0.4 (N = 5)	7.0 $\pm$ 0.6 (N = 5)	12.3 $\pm$ 1.72 (N = 5)	13.0 $\pm$ 1.63 (N = 3)	—
Day of dominant follicle appearance with largest diameter	2.9 $\pm$ 1.49	7.6 $\pm$ 0.58	12.2 $\pm$ 1.36	16.7 $\pm$ 2.08	18.6 $\pm$ 0.47	—
Period (days) of follicular wave appearance until dominant follicle reached its largest diameter	4.3 $\pm$ 1.6	4.18 $\pm$ 1.3	4.3 $\pm$ 1.4	4.3 $\pm$ 1.4	4.4 $\pm$ 1.4	4.3 $\pm$ 1.4
Period (days) of dominant follicle appearance and its disappearance	6.6 $\pm$ 0.4	7.8 $\pm$ 1.16	8.8 $\pm$ 1.16	7.2 $\pm$ 1.93	6.5 $\pm$ 1.7	—
Ovulatory follicle diameter (mm)	-	-	-	7.75 $\pm$ 0.83 (n = 4)	5.2 $\pm$ 0.4(n = 5)	6.3 $\pm$ 0.13

N = Number of goats; n = number of ovulatory follicles.

attributed to longer presence of the follicles in the fourth follicular waves. The mean ( $\pm$  SEM) maximum diameter of ovulatory follicles in Najdi goats (6.3  $\pm$  0.13 mm; Table 2), was similar to that obtained for Saanen goats (6 and 7 mm; De Castro et al., 1999), White Polish goats (7 mm; Schwarz and Wierzchos, 1999), and Serrana goats (6.3  $\pm$  1.0 mm; Simoes et al., 2005). For Najdi goats the mean ( $\pm$  SEM) number of ovulations (1.8  $\pm$  0.4) was similar to West African dwarf (1.57 CL; Akusu et al., 1986) and Maradi (1.55 CL; Akusu et al., 1986) goats.

In conclusion although our work involved the study of follicular dynamics on morphological basis alone, the results suggest that during breeding season, Najdi goats showed a pattern of 4 or 5 follicular wave per cycle. Moreover, follicular growth in Najdi goats is a dynamic process, and the development of follicles  $\geq$ 2 mm occurs in waves. Follicular dynamics during the estrous cycle of Najdi goats is characterized by 4.6  $\pm$  0.55 waves; however, during each wave a single follicle becomes dominant whereas other follicles in the same wave regress. The follicular growth patterns as observed in the present study support

the model hypothesized by Ginther and Kot (1994).

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