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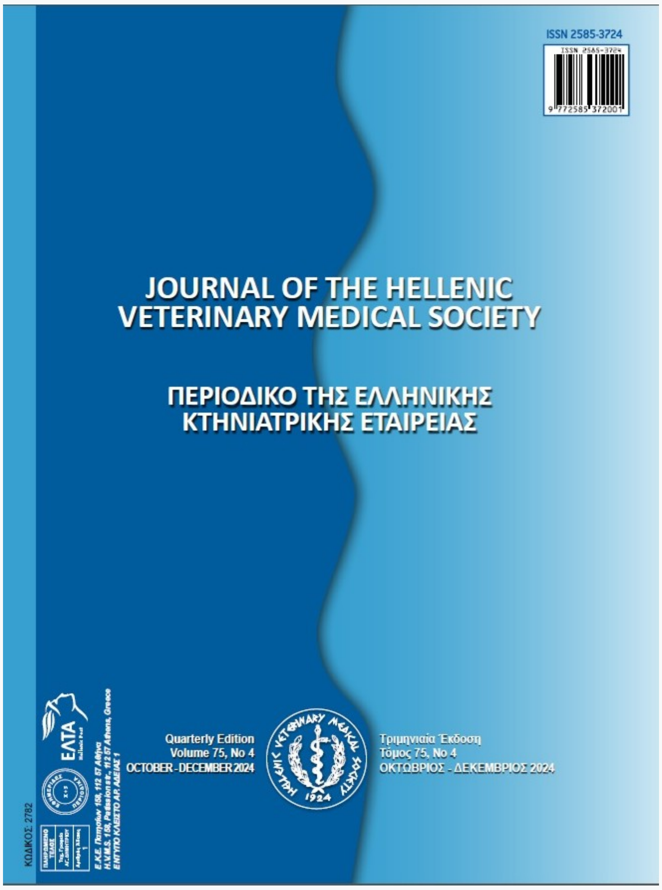

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H Erduran

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Effect of photoperiod, lunar cycle and some environmental factors on gestation and parturition time in purebred and crossbred goats (F1, F2 and B1 generations)

H. Erduran

Bahri Dağdaş International Agricultural Research Institute, Konya, Türkiye

ABSTRACT: The aim of this study was to investigate the effects of photoperiod, lunar cycle and various environmental factors on gestation period and parturition time in 624 kids born to Hair and Saanen × Hair and Alpine × Hair crossbred goats (F1, F2 and B1). The effects of maternal genotype, parity, kid genotype, sex, birth type, flock and year factors on parturition time were found to be significant ($p<0.05$). The majority of births (83.5%) occurred during daylight hours. The effect of lunar cycle and natural light/dark nights on parturition time showed statistically significant differences ($p<0.05$). Only 8% of births were recorded during the new moon phase, while the highest number of births (19%) was recorded during the waning gibbous moon phase ($p<0.05$). In addition, the frequency of goat births was higher on bright nights than on dark nights ($p<0.01$). Moon phase, parental genotype, and birth type affected gestation length in goats ($p<0.01$). Parturition time and lunar cycle were important factors affecting gestation length ($p<0.05$). Goats exposed to higher levels of bright moon phases during parturition had shorter gestation periods than those exposed to dark moon phases. The study showed that environmental factors significantly influence gestation period and parturition time. In addition, the lunar cycle and photoperiod also have a significant effect on these parameters. The results suggest that potential environmental effects should be carefully considered in studies investigating goat reproduction.

Keywords: Crossbreeding; gestation period; goat; lunar cycle; parturition time; photoperiod

Corresponding Author:
Erduran Hakan, Bahri Dağdaş International Agricultural Research Institute, Konya, Türkiye
E-mail address: hakan.erduran@tarim.gov.tr

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INTRODUCTION

Animals rely on reliable and stable environmental cues to synchronise important events in their lives, such as reproduction and growth, or behaviours essential for their survival, such as feeding and protection (Hopper et al., 2019; Nagy and Juhász, 2019; Erduran, 2022).

The reproductive cycle of animals can be affected by several environmental factors, including geographical latitude, climate, production system, species, genotype, management practices, selection and crossbreeding (Nagy and Juhász, 2019; Tölü et al., 2022; Erduran, 2023). However, recent studies on the reproductive cycle and behaviour of animals have focused on the circadian rhythm controlled by light (Balaro et al., 2019; Hussain et al., 2023). Light is a stimulating environmental factor that regulates circadian rhythms (a 24-hour cycle of day and night), an intrinsic biological timing system in all living organisms that depends on the Earth's light-dark cycle and plays an important role in their reproduction, productivity, adaptation, health and well-being (Sancar et al., 2015; Andreatta and Tessmar-Raible, 2020; Cal-Kayitmazbatir et al., 2021; Erduran, 2022). There is considerable evidence that the movements of the sun and moon affect the birth process in living organisms (Yonezawa et al., 2016; Aguirre et al., 2021; Erduran, 2023). Also, to the best of my knowledge, there are no studies showing the effect of the lunar cycle on gestation and timing of parturition in purebred and crossbred goats. Knowledge of the timing of parturition is essential to reduce the effects of environmental stressors, improve animal performance and ensure the welfare and survival of the offspring. The timing of parturition in animals can vary depending on day and night activity, management routine, physiology and behaviour. In most ruminants, parturition occurs just before or during the sleep/rest period (Edwards, 1979; Erduran and Yaman, 2014; Şahin, 2023).

Saanen and Alpine breeds are widely favoured worldwide for their ability to increase milk production and fertility of native breeds through crossbreeding (Erduran, 2021). Hair goat breed, which is native to Türkiye and adapted to the Mediterranean breeding system, has the largest goat population among the in the Euro-Mediterranean region (Erduran and Dag, 2022).

In this study, the effects of some environmental factors on parturition time and gestation length distribution of pure and crossbred kids born to Hair, Alpine × Hair (F1, F2 and B1) and Saanen × Hair (F1, F2 and B1) crossbred goats in a semi-intensive system were investigated.

MATERIAL AND METHODS

No animals were used in laboratory studies for this study. No animal rights were violated. Data collection and animal husbandry procedures were conducted in accordance with the provisions of Article 9 of Animal Welfare Law No. 5996 of the Republic of Türkiye.

This study was conducted on three different goat farms in the north-western part of Konya province, Türkiye, in 2014 and 2015. Farm 1 is located in Ulumuhsine village (37˚ 55' N, 32˚ 14' E) at an altitude of 1393 m. Farms 2 and 3 are located in different parts of Sızma village (38˚ 04' N, 32˚ 24' E and 38˚ 06' N, 32˚ 27' E) at an altitude of 1404 m and 1524 m respectively. The data consist of 624 purebred and crossbred kids from first and second births of Hair, Alpine × Hair (F1, F2 and B1) and Saanen × Hair (F1, F2 and B1) crossbred goats. The goats were not treated with antibiotics or hormones before birth. Births occurred between February and March in the flocks. Observations in the flocks during the parturition season were carried out throughout the day from January to April 2014 and 2015 until the births were completed. During this period, flocks were observed every hour during the day and every two hours at night. The goats showing signs of imminent parturition were placed in prepared parturition pens. After the kids were allowed to suck milk, ear tags were attached and the data on date, time and type of birth, as well as sex and mother tag number were recorded. The suckling period lasted 12 weeks. During this period, in addition to suckling, the kids were fed dry alfalfa grass and, from the second week, an average of 250 g per day of kid growth feed (16% crude protein and 2500 kcal/kg ME).

The goats were grazed on natural pastures for an average of 6-8 hours per day throughout the year, except in unfavourable weather conditions. During the pre-parturient period (especially the last month and a half) and the post-parturient period, the goats were fed dry alfalfa grass and hay as roughage and concentrates starting at 200 g and gradually increasing to 500 - 600 g. In addition to the pasture, an average of 400 g of concentrates was fed given during the lactation period. It is known that births in farm animals usually occur during daylight hours. Therefore, in order to determine the time period in which births occur more frequently, daylight hours were divided into four periods and dark hours (evening and night) were divided into two periods. The time intervals of births were defined as 24:01-06:00, 06:01-09:00, 09:01-12:00, 12:01-15:00, 15:01-18:00 and 18:01-24:00 (Erduran, 2021). The lunar cycle was analysed using the method described by Hopper et al. (2019). The gestation period was analysed in three periods as early (143-146 days), normal (147-150 days) and late (151-154 days).

In the study, the effects of genotype, parity, sex, type of birth, flock, year and lunar phases on the time of birth of kids, as well as the effects of birth time and lunar phases on gestation period were determined using Chi-square test (Keskin et al., 2023). A general linear model was used to compare the gestation length data. Statistical analyses were calculated using RStudio computer software. The following statistical model was used to calculate the gestation length in goats:

$$y_{ijk} = \mu + a_i + b_j + c_k + e_{ijk}$$

where y_{ijk} is the observation, μ the overall mean, a_i the lunar phase effect (i= dark nights, first quarter, bright nights, last quarter) b_j the maternal genotype effect (j= Hair, AHF1, AHF2, AHB1, SHF1, SHF2, SHB1), c_k the birth type effect (k= single, twin), e_{ijk} the random error.

RESULTS

The effects of maternal genotype, kid genotype, parity, sex, birth type, flock and year on the parturition time of kids born at different times of the day showed statistically significant differences ($p<0.001$ and $p<0.05$) (Table 1). The majority of births (83.5%) took place during daytime hours between 06:01 and 18:00. Furthermore, the highest birth rate (38.0%)

Table 1. Distribution of births during the day by some environmental factors of purebred and crossbred kids

Traits	Time period						Total
	06:01-09:00	09:01-12:00	12:01-15:00	15:01-18:00	18:01-24:00	24:01-06:00	
	n (%)	n (%)	n (%)	n (%)	n (%)	n (%)	n (%)
Maternal genotype							
Hair	42 (34.4)	29 (23.8)	15 (12.3)	13 (10.7)	14 (11.5)	9 (7.4)	122 (19.6)
AHF1	62 (40.8)	29 (19.1)	12 (7.9)	24 (15.8)	9 (5.9)	16 (10.5)	152 (24.4)
AHF2	33 (52.4)	12 (19.0)	5 (7.9)	7 (11.1)	1 (1.6)	5 (7.9)	63 (10.1)
AHB1	23 (35.4)	13 (20.0)	6 (9.2)	11 (16.9)	4 (6.2)	8 (12.3)	65 (10.4)
SHF1	35 (29.2)	25 (20.8)	24 (20.0)	18 (15.0)	4 (3.3)	14 (11.7)	120 (19.2)
SHF2	21 (41.2)	5 (9.8)	11 (21.6)	5 (9.8)	7 (13.7)	2 (3.9)	51 (8.2)
SHB1	21 (41.2)	8 (15.7)	5 (9.8)	7 (13.7)	3 (5.9)	7 (13.7)	51 (8.2)
χ2: 44.268; DF: 30; P-value: 0.045							
Kid genotype							
Hair	42 (34.4)	29 (23.8)	15 (12.3)	13 (10.7)	14 (11.5)	9 (7.4)	122 (19.6)
AH	117 (41.8)	56 (20.0)	25 (8.9)	41 (14.6)	12 (4.3)	29 (10.4)	280 (44.9)
SH	78 (35.1)	36 (16.2)	38 (17.1)	31 (14.0)	16 (7.2)	23 (10.4)	222 (35.6)
χ2: 19.564; DF: 10; P-value: 0.034							
Sex							
Male	110 (35.6)	57 (18.4)	48 (15.5)	38 (12.3)	17 (5.5)	39 (12.6)	309 (49.5)
Female	127 (40.3)	64 (20.3)	30 (9.5)	47 (14.9)	25 (7.9)	22 (7.0)	315 (50.5)
χ2: 12.936; DF: 5; P-value: 0.024							
Birth type							
Single	133 (34.1)	77 (19.7)	56 (14.4)	57 (14.6)	32 (8.2)	35 (9.0)	390 (62.5)
Twin	104 (44.4)	44 (18.8)	22 (9.4)	28 (12.0)	10 (4.3)	26 (11.1)	234 (37.5)
χ2: 11.856; DF: 5; P-value: 0.037							
Parity							
1	132 (40)	68 (20.6)	45 (13.6)	47 (14.2)	16 (4.8)	22 (6.7)	330 (52.9)
2	105 (35.7)	53 (18.0)	33 (11.2)	38 (12.9)	26 (8.8)	39 (13.3)	294 (47.1)
χ2: 12.819; DF: 5; P-value: 0.025							
Flock							
1	97 (43.7)	32 (14.4)	18 (8.1)	33 (14.9)	23 (10.4)	19 (8.6)	222 (35.6)
2	83 (38.4)	50 (23.1)	24 (11.1)	23 (10.6)	11 (5.1)	25 (11.6)	216 (34.6)
3	57 (30.6)	39 (21.0)	36 (19.4)	29 (15.6)	8 (4.3)	17 (9.1)	186 (29.8)
χ2: 30.101; DF: 10; P-value: 0.001							
Year							
2014	124 (42.0)	46 (15.6)	35 (11.9)	37 (12.5)	27 (9.2)	26 (8.8)	295 (47.3)
2015	113 (34.3)	75 (22.8)	43 (13.1)	48 (14.6)	15 (4.6)	35 (10.6)	329 (52.7)
χ2: 12.646; DF: 5; P-value: 0.027							
Total	237 (38.0)	121 (19.4)	78 (12.5)	85 (13.6)	42 (6.7)	61 (9.8)	624 (100.0)

χ2, chi-square result; DF, degree of freedom; n, number of animals; P, significance level; AHF1, Alpine × Hair F1; AHF2, (Alpine × Hair F1) × (Alpine × Hair F1); AHB1, Alpine × (Alpine × Hair F1); SHF1, Saanen × Hair F1; SHF2, (Saanen × Hair F1) × (Saanen × Hair F1); SHB1, Saanen × (Saanen × Hair F1); AH, Alpine × Hair crossbreds; SH, Saanen × Hair crossbreds was recorded between 06:01-09:00 and the lowest birth rate (6.7%) was recorded between 18:01-24:00. Furthermore, maternal genotype had a significant effect on the distribution of births at different times of day, with the highest variability observed in AHF2 and SHF2 crossbred goats. It was observed that 85.1% of female kids and 81.9% of male kids were born during daylight hours. However, 62.5% of the kids were born as singletons and 37.5% as twins. Moreover, 17.2% of singletons and 15.1% of twins were born during dark hours. Goats with primiparous births gave birth more often during daylight hours compared to goats with second births. Differences in the distribution of births according to the time of day were observed in flock and year factors. The distribution of eight different lunar phases and the distribution of lunar bright and

Table 2: Distribution of births during the day in relation to lunar phases for kids

Moon phases	Time period						Total
	06:01-09:00	09:01-12:00	12:01-15:00	15:01-18:00	18:01-24:00	24:01-06:00	
	n (%)	n (%)	n (%)	n (%)	n (%)	n (%)	n (%)
New moon	23 (47.9)	10 (20.8)	5 (10.4)	7 (14.6)	2 (4.2)	1 (2.1)	48 (7.7)
Waxing crescent	26 (35.6)	17 (23.3)	13 (17.8)	9 (12.3)	5 (6.8)	3 (4.1)	73 (11.7)
First quarter	26 (38.8)	8 (11.9)	11 (16.4)	10 (14.9)	4 (6.0)	1 (11.9)	67 (10.7)
Waxing gibbous	19 (30.2)	14 (22.2)	12 (19.0)	8 (12.7)	4 (6.3)	6 (9.5)	63 (10.1)
Full moon	43 (40.2)	22 (20.6)	6 (5.6)	12 (11,2)	8 (7.5)	16 (15.0)	107 (17.1)
Waning gibbous	48 (40.7)	18 (15.3)	9 (7.6)	23 (19.5)	9 (7.6)	11 (9.3)	118 (18.9)
Last quarter	39 (42.4)	12 (13.0)	10 (10.9)	11(12.0)	8 (8.7)	12 (13.0)	92 (14.7)
Waning crescent	13 (23.2)	20 (35.7)	12 (21.4)	5 (8.9)	2 (3.6)	4 (7.1)	56 (9.0)
$\chi2$: 51.723; DF: 35; P-value: 0.034							
Dark nights	60 (35.0)	47 (26.6)	30 (16.9)	21 (11.9)	9 (5.1)	12 (4.5)	179 (28.4)
Bright nights	108 (38.2)	57 (18.8)	26 (9.4)	45 (14.9)	23 (7.3)	35 (11.5)	286 (46.2)
$\chi2$: 16.063; DF: 5; P-value: 0.007							
Total	237 (38.0)	121 (19.4)	78 (12.5)	85 (13.6)	42 (6.7)	61 (9.8)	624 (100.0)

$\chi2$, chi-square result; DF, degree of freedom; n, number of animals; P, significance level; “Dark” (waning crescent, new moon, waxing crescent) and “bright” (waxing gibbous, full moon, waning gibbous)

Table 3. Least squares and standard errors for gestation length of goats

Traits	n	Gestation length (days)
Lunar cycle		
Bright nights	228	148.2 ± 0.15^{c}
Dark nights	147	149 ± 0.18^{ab}
First quarter	53	149.4 ± 0.29^{a}
Last quarter	79	148.4 ± 0.23^{bc}
Significance		P<0.001
Maternal genotype		
Hair	110	149.6 ± 0.28^{a}
AHF1	129	148.4 ± 0.27^{b}
AHF2	51	149.1 ± 0.32^{ab}
AHB1	47	148.3 ± 0.19^{b}
SHF1	94	149.2 ± 0.29^{ab}
SHF2	40	148.9 ± 0.28^{ab}
SHB1	36	148.2 ± 0.19^{b}
Significance		P<0.001
Birth type		
1	390	149.3 ± 0.13^{a}
2	117	148.2 ± 0.18^{b}
Significance		P<0.001
Overall	507	148.8±0.12

AHF1, Alpine × Hair F1; AHF2, (Alpine × Hair F1) × (Alpine × Hair F1); AHB1, Alpine × (Alpine × Hair F1); SHF1, Saanen × Hair F1; SHF2, (Saanen × Hair F1) × (Saanen × Hair F1); SHB1, Saanen × (Saanen × Hair F1): “Dark” (waning crescent, new moon, waxing crescent) and “bright” (waxing gibbous, full moon, waning gibbous)

Table 4. Effect of parturition time and lunar phases on gestational age at birth of kids

Traits	Gestation period			Total
	143-146 days n (%)	147-150 days n (%)	151-154 days n (%)	n (%)
Time period				
06:01-09:00	48 (20.3)	133 (56.1)	56 (23.6)	237 (38.0)
09:01-12:00	22 (18.2)	85 (70.2)	14 (11.6)	121 (19.4)
12:01-15:00	12 (15.4)	53 (67.9)	13 (16.7)	78 (12.5)
15:01-18:00	14 (16.5)	54 (63.5)	17 (20.0)	85 (13.6)
18:01-24:00	4 (9.5)	32 (76.2)	6 (14.3)	42 (6.7)
24:01-06:00	13 (21.3)	43 (70.5)	5 (8.2)	61 (9.8)
$\chi2$: 18.611; DF: 10; P-value: 0.045				
Moon Phases				
New moon	5 (10.2)	30 (61.2)	14 (28.6)	49 (7.9)
Waxing crescent	14 (19.7)	48 (67.6)	9 (12.7)	71 (11.4)
First quarter	16 (18.8)	57(67.1)	12 (14.1)	85 (13.6)
Waxing gibbous	21 (18.6)	69 (61.1)	23 (20.4)	113 (18.1)
Full moon	26 (24.8)	64 (61.0)	15 (14.3)	105 (16.8)
Waning gibbous	15 (22.1)	46 (67.6)	7 (10.3)	68 (10.9)
Last quarter	12 (16.2)	41 (55.4)	21 (28.4)	74 (11.9)
Waning crescent	4 (6.8)	45 (76.3)	10 (16.9)	59 (9.5)
$\chi2$: 25.189; DF: 14; P-value: 0.033				
Total	113 (18.1)	400 (64.1)	111 (17.8)	624 (100.0)

$\chi2$, chi-square result; DF, degree of freedom; n, number of animals; P, significance level

dark nights according to the birth times of the kids (Table 2). The variation was significant for both lunar phases and bright/dark nights. The lowest proportion of births occurred during the new moon phase (8%) and the highest proportion occurred during the waning gibbous phase (19%). In general, births occurred during the brighter phases of the moon.

Gestation length of purebred and crossbred goats was affected by lunar phase, maternal genotype and parturition type ($p<0.001$) and presented in Table 3. The mean gestation length of purebred and crossbred goats was 148.8 days. Gestation length in goats was the longest in the first lunar quarter and the shortest in the bright lunar days. As the level of crossbreeding increased backwards, the gestation period shortened. The gestation period of goats with singletons was longer than that of goats with twins. The study found that the time of birth and eight different lunar phases had a significant effect on the gestational age at birth of the kids (Table 4). It was found that kids born during bright moon phases had a lower gestational age at birth.

DISCUSSION

The study found that births coincided with daylight hours, which is consistent with previous studies in ruminants. Although the timing of parturition in mammals has a binomial distribution, births in primates and humans typically occur late at night or early in the morning (McCarthy et al., 2019; Çobanoğlu and Şendir, 2020). In nocturnal rodents, birth usually occurs in the afternoon or late in the day (Takayama et al., 2003; Amano et al., 2020). In diurnal ruminants, births usually occur in the early morning or late afternoon (Erduran and Yaman, 2014; Şahin, 2023). However, there is evidence suggests that ruminants have evolved and regulated a circadian pattern that prevents nocturnal births as a protective measure against predators (Edwards, 1979; Erduran, 2023). Furthermore, differences in the diurnal distribution of births in ruminants, circadian rhythms, geographical structure, production system, feeding, climatic conditions, type of crossbreeding and different methodological approaches, as well as differences between species and breeds, can obviously lead to conflicting results (Mushap et al., 2017; Pan et al., 2020; Erduran, 2022; Tölü et al., 2022), and simple comparisons between different studies without taking these factors into account may be erroneous. In addition, the bio-molecular mechanisms underlying the circadian and stress systems that trigger the onset of labour remain unclear.

The evidence underlying the 24-hour periodicity of the onset and timing of parturition in mammals suggests that the hormone melatonin, under the control of the circadian system, may alter the timing of parturition by controlling the neuroendocrine system that regulates reproduction through photoperiod (Takayama et al., 2003; Pan et al., 2020). Melatonin levels in goats are lowest during the day and highest at night. High melatonin levels are a factor that delays parturition and may be the reason why more births occur during daylight hours (McCarthy et al., 2019; Amano et al., 2020). There is evidence that goats giving birth in the dark have higher milk yield and udder size and lower somatic cell counts than those giving birth during the day, and this is explained as a physiological, hormonal and behavioural response of the goat's circadian rhythm to photoperiod (Erduran, 2022). Therefore, the effect of light on the timing of parturition in goats should be studied not only during the reproductive period but also during the lactation period. With this information, parturition timing can be used in breeding programmes as an indirect selection criterion for milk yield, udder characteristics, health and quality products in dairy animals. There is considerable evidence to suggest that circadian rhythms influence not only the birth process, but also embryo implantation, pregnancy rate and foetal development (Xu et al., 2016; Bektaş, 2020). Therefore, daylight and moonlight, which regulate circadian rhythms, can be used as an ideal tool to increase the success rate of reproductive biotechnology applications. However, this issue needs to be further investigated.

The difference in the timing of births between day and night may be related to mammalian adaptations to their habitat. There is evidence that the timing of parturition is controlled by environmental conditions, particularly light, in many species, including ruminants, camels, primates, laboratory animals and alpacas (Edwards, 1979; Xu et al., 2016; Nagy and Juhász, 2019; Erduran, 2023; Miranda-de la Lama and Villarroel, 2023). Furthermore, these studies showed that there is a relationship between the circadian rhythm of parturition and management practices in ruminants, with the highest proportion of births occurring during periods of rest or sleep, or before or after feeding periods. In this study, the lowest birth rates were observed during daily routine cleaning, grazing and feeding periods. This phenomenon can be explained by the increased noise and activity in the environment during these periods, as well as the delay of nearby births due to various stress factors (Erduran, 2022; Miranda-de la Lama and Villarroel, 2023). Furthermore, the negative association between the timing of parturition and management routine suggests that high stress levels and internal hormonal rhythms during lactation preparation in late pregnancy regulate parturition patterns in goats (Balaro et al., 2019; Kalyesubula et al., 2021; Erduran, 2023).

In this study, births were found to be highest during the waning gibbous moon and then the full moon, and lowest around the new moon. This finding is consistent with the studies conducted in humans, domestic animals and wildlife (Yonezawa et al., 2016; Raible et al., 2017; Hopper et al., 2019; Matsumoto and Shirahashi, 2020). Differences in the availability, intensity and variability of moonlight are therefore likely to have a significant influence on the delay or acceleration of parturition and the moon phases on natural birth dates. However, some studies have shown that the effect of the full moon on parturition in humans and cows varies with oestrus period, temperature, season of birth, feeding habits, latitude and longitude (Marco-Gracia, 2019; Aguirre et al., 2021). In addition, the highest proportion of dark births occurred during the full moon phase and the lowest during the new moon phase. This finding may indicate that births are influenced by moonlight. Thus, even if there is a consistent biological mechanism, the question of the moon's effect on life requires more in-depth research.

This study found that the gestation period of goats giving birth on bright moon nights (148.2 days) was shorter than that of goats giving birth on dark moon nights (149.0 days). This is probably due to the fact that moonlight suppresses the production of the hormone melatonin, which is involved in the regulating of the reproductive cycle, and increases the levels of the hormones prolactin and oxytocin, which trigger parturition. This also suggests that light can be used to ensure that goats give birth at a specific time. In addition, the available data showed that births in goats vary throughout the lunar cycle and are not randomly distributed.

In the present study, 64% of the births occurred between days 147-150, 18% between days 143-146 and 18% between days 151-154. Therefore, it can be said that most of the goats had a good feeding period and a normal gestation and parturition period. In addition, early births may be due to environmental stressors and late births may be due to circadian rhythm disruption and malnutrition (Amano et al., 2020; Çobanoğlu and Şendir, 2020; Erduran, 2021).

Dystocia is a major reproductive problem associated with parturition and the incidence of dystocia ranges from 3% to 32% of goat populations depending on parity, genotype, season, gestation length and health, foetal sex and number of foetuses (Prajapati and Chauhan, 2024). Furthermore, dystocia causes hypoxia and hypercapnia in kids and oxidative stress in both goats and kids (Akkuş et al, 2022). On the other hand, the earlier the kids are fed colostrum after birth, the higher the growth of their vital organs and the development of their passive immune system (Erduran, 2021; Akkuş et al, 2022; Prajapati and Chauhan, 2024). Therefore, knowing the timing of goat parturition and following births according to lunar phases can be an effective management tool for dairy goat farms to save pregnant goats, and reduce kid losses and increase productivity. The results of this study provide important information for goat farmers. Knowing that light has an effect on the duration and timing of parturition may help to better control births. It also allows for better care and nutrition and early intervention against stressors and various complications that may arise during parturition (Erduran, 2021; Erduran, 2023). In addition, the provision of a safe and quiet environment away from environmental and social stressors such as predators and anthropogenic noise during the parturition period provides favourable conditions for the rapid establishment of the maternal-offspring relationship (Erduran, 2022; Miranda-de la Lama and Villarroel, 2023).

CONCLUSION

It was concluded that lunar cycle, photoperiod and environmental factors have a strong influence on gestation and timing of birth. It was observed that births tended to occur during daylight hours and during the bright phases of the moon.

These findings suggest that light signals influence the birthing process in goats. It is possible that the effects of daylight and moonlight on gestation period and parturition time are independent or synergistic. It can be used as a parameter in breeding models to assess how parturition time affects growth, development and yield characteristics of goats. The result of this study shows that understanding the complexity of biological rhythms driven by both solar and lunar cycles is a topic that requires much more effort to be studied in depth in all its dimensions, as it represents productivity and efficiency for all living organisms. More research is needed to understand the hormonal and physiological effects of light on the birthing process.

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CONFLICT OF INTEREST

The author declared that there is no conflict of interest.

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