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## Risk factors associated with stillbirth and dystocia in the Murciano-Granadina goat breed

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**Abstract** Perinatal kid loss in the early and later stages of production is a major problem in goat breeding. This study investigates the associated risk factors of stillbirth and dystocia in the Murciano-Granadina goat breed under an intensive production system in the semi-arid tropical region of southern Iran. Data were collected from 2017 to 2024 on a private dairy farm in Ghale-Ganj city, the southern area of Kerman Province, Iran. Data included information from 8,349 kidding records across the first three parities. A multivariate logistic regression model was used to evaluate the influences of independent variables, including kidding year, kidding season, parity, birth type of kid born, sex of kid born, birth weight of kid born, gestation length of doe, and age of doe at kidding. The average incidence rates of stillbirth and dystocia across the first three parities were 2.73% and 3.90%, respectively. The obtained results revealed that stillbirth was significantly influenced by kidding year, sex of the kid born, gestation length of doe, and age of doe at kidding, whereas dystocia was significantly associated with kidding year and sex of the kid born. These findings can inform better management and breeding strategies to reduce perinatal losses and improve reproductive performance in Murciano-Granadina goats raised under intensive conditions.

**Keywords:** goat, logistic regression, logit function, perinatal losses

## Introduction

In most developing countries, goats perform a crucial role in the economy and livelihoods of nomadic farmers (Peacock, 2005). Due to their adaptability to harsh climatic environments, low nutritional requirements, and multi-purpose abilities, including meat, milk, and fiber, goats are considered one of the most resilient livestock species under low-input production systems (Sow et al., 2021). Perinatal kid loss in the early and later stages of production is a major problem in goat breeding (Rattner et al., 1994). Dystocia refers to cases in which the dam requires assistance for delivery due to a prolonged or difficult delivery, while stillbirth includes newborns dying during parturition that are born dead (Robertson et al., 2020). Dystocia and stillbirth are the important causes of death in lambs and kids, being responsible for about 80%

of perinatal deaths (Robertson et al., 2020). Dystocia is associated with fetal-maternal disproportion, abnormal fetal positioning, and uterine inertia, while stillbirths often result from prolonged labor, hypoxia, or infections (Ismail, 2017; Coll-Roman et al., 2023). Robertson et al. (2020) pointed out that the incidence of dystocia and stillbirth can increase neonatal mortality, prolong the postpartum interval, reduce milk production, and ultimately adversely affect the flock's profitability.

Several studies have identified risk factors associated with dystocia and stillbirth in small ruminants (Majeed and Taha, 1989; Jacobson et al., 2020; Robertson et al., 2020). These include maternal age, parity, body condition score, nutritional status during gestation, litter size, and genetic predisposition (Robertson et al., 2020). Breed differences also play an important role in the incidence rate of stillbirth

and dystocia. While local breeds often show lower dystocia incidence due to natural selection, highly productive breeds such as Murciano-Granadina may be more susceptible due to larger fetal size and intensive management systems (Perez-Baena et al., 2021; Ramirez-Gonzalez et al., 2023).

The Murciano-Granadina goat breed is one of the most important dairy goat breeds in Spain and is distributed extensively in various countries (Miranda et al., 2019). In 2015, the private sector imported the Murciano-Granadina goat breed from Spain to the southern region of Iran, which has tropical and harsh climatic conditions. This initiative was intended to increase production efficiency in the native and nomadic goat flocks of the region, primarily maintained under a low-input, low-output production system. The goal was to improve the livelihoods of rural flock holders in the area. To achieve this, purebred Murciano-Granadina does and bucks were either distributed to local flocks or used for crossbreeding with indigenous goat breeds.

Therefore, the current study aims to investigate the incidence rates and risk factors associated with dystocia and stillbirths in the Murciano-Granadina goat breed in the tropical areas of Iran under an intensive production system. Knowledge of this information is crucial for implementing targeted management practices to reduce perinatal losses, enhance reproductive efficiency, and improve the overall profitability of the production system in the region.

## Materials and methods

### Data collection and traits

The dataset contained information regarding the type of kidding, including normal kidding, stillbirth, and dystocia, in the first three parities of Murciano-Granadina does. Data was collected from 2017 to 2024 at a private dairy farm in Ghale-Ganj city, in the southern region of Kerman province, Iran. The data set is partitioned into two distinct sets, while the kidding status, as a dependent variable, is defined as a binary variable. In the first data set, the dependent variable is defined as a binary with 1 for normal kidding and 0 for stillbirth, and in the second with 1 for normal kidding and 0 for dystocia. A veterinarian diagnosed dystocia and stillbirth. Dystocia is characterized by prolonged parturition without progress, visible fetal parts without delivery, restlessness, and frequent lying down and getting up of the doe before parturition. Stillbirth is regarded as the death of a fetus during labor or shortly before birth and is characterized by no movement or breathing after delivery, rigor mortis, or foul odor if retained, and absence of heartbeat or reflexes in the fetus.

### Statistical analysis

The following multivariate logistic regression model was used to investigate the effect of the predictor variables on the response variable:

$$\log(\pi) = \beta_0 + \beta_1 X_{i1} + \beta_2 X_{i2} + \beta_3 X_{i3} + \beta_4 X_{i4} + \beta_5 X_{i5} + \beta_6 X_{i6} + \beta_7 X_{i7} + \beta_8 X_{i8}$$

where  $\pi$  was the probability of stillbirth and/or dystocia;  $\beta_0$  was the intercept, parameters of  $\beta_1$  to  $\beta_8$  the logistic regression coefficients (parameter estimates) for the explanatory effects of  $X_1$  to  $X_8$  were included in the statistical model. The eight explanatory variables ( $X_1$  to  $X_8$ ) were kidding year with seven levels (2018 to 2024), kidding season with two levels (the first season from March to September, and the second from October to February), the birth type of the kids with two levels (single-born and twin or higher kidding born), sex of the kids with two levels (male and female), parity with three levels (first, second, and third), birth weight of the kid with five categories (< 1.80 kg, 1.80-2.19 kg, 2.20-2.59 kg, 2.60-3.0 kg, > 3kg), gestation length of does with five categories (< 135 days, 136-141 days, 142-147 days, 148-154 days, and >154 days), and age at kidding with three levels (1-3 years old). Multivariable logistic regression models were used to analyze stillbirth and dystocia separately using the maximum likelihood method of the LOGISTIC procedure of SAS 9.4 software (SAS, 2010).

## Results and discussion

### General considerations

In the present study, the average incidence rates of stillbirth and dystocia in the first three parities of the Murciano-Granadina goat breed were 2.73% and 3.90%, respectively. Within-parity incidence rates of stillbirth were 3.95%, 2.21%, and 1.32% in the first, second, and third parities, respectively. The corresponding incidence rates of dystocia were 5.51%, 3.54%, and 3.20% in the first, second, and third parities, respectively. The reported incidence of dystocia in small ruminants ranges from 2.5% to 3.1% (Thomas, 1990). In general, dystocia in small ruminants is considered to have a low incidence worldwide (<5%) (Purohit, 2006). The rate of stillbirth in ibex crossbred goats was reported as 6.03% by Rattner et al. (1994). Balasopoulou et al. (2022) also reported a mean stillbirth rate of 6.4% in German dairy goats, which is higher than the corresponding value obtained in the present study. Delgado et al. (2018) noted that genetic selection programs in the Murciano-Granadina goat breed prioritize traits such as milk yield, udder health, and reproductive efficiency, which indirectly reduce complications like dystocia and stillbirth during parturition.

### The influencing factors on stillbirth

The estimated odds ratios (OR) with their 95% confidence intervals (CI) for risk factors associated with stillbirth are presented in Table 1. In the present study, kidding year, sex of the kid, gestation length, and age of doe at kidding were significant factors associated with stillbirth in the Murciano-Granadina goat breed ( $P < 0.01$ ). The effects of kidding season, parity of does, birth type

of kids, and birth weight of the kids were not statistically significant on the stillbirth rate ( $P>0.05$ ).

**Table 1.** Risk factors associated with stillbirth in the Murciano-Granadina goat breed

Variable	Level (n) <sup>a</sup>	Odd Ratio	95% CI <sup>b</sup>	P-value
Kidding year	-	-	-	0.0001
	2018 (1662)	Reference	-	-
	2019 (1739)	1.20	0.77-1.89	-
	2020 (1715)	0.41	0.22-0.75	-
	2021 (850)	0.72	0.44-1.20	-
	2022 (816)	1.06	0.67-1.69	-
	2023 (931)	0.48	0.25-0.89	-
Kidding season	-	-	-	0.1266
	First (2935)	Reference	-	-
The birth type of the kid	Autumn (5414)	0.79	0.58-1.07	-
	-	-	-	0.6799
Sex of the kid	Single (3311)	Reference	-	-
	Twin (5038)	0.94	0.71-1.25	-
Parity	-	Reference	-	0.0001
	Male (4053)	-	-	-
The birth weight of the kid	Female (4296)	0.56	0.42-0.74	-
	-	-	-	0.8116
	First (3545)	Reference	-	-
	Second (2754)	1.22	0.67-2.22	-
Gestation length	Third (2050)	1.23	0.51-2.99	-
	-	-	-	0.7350
	< 1.80 kg (337)	1.09	0.58-2.06	-
	1.80-2.19 kg (1704)	0.89	0.62-1.27	-
	2.20-2.59 kg (3092)	Reference	-	-
	2.60-3.0 kg (2281)	0.85	0.59-1.20	-
Age at kidding	> 3kg (935)	0.75	0.45-1.24	-
	-	-	-	0.0041
	< 135 days (606)	0.48	0.24-0.97	-
	136-141 days (1250)	1.02	0.69-1.53	-
	142-147 days (3341)	Reference	-	-
The birth weight of the kid	148-154 days (2289)	1.15	0.82-1.62	-
	>154 days (863)	2.14	1.36-3.37	-
	-	-	-	0.0010
	1-yr (2615)	Reference	-	-
Gestation length	2-yr (3060)	0.41	0.24-0.70	-
	3-yr (2674)	0.36	0.15-0.81	-

<sup>a</sup> n: the number of observations in each level

<sup>b</sup> CI: confidence interval

The significant effect of kidding year on stillbirth was possibly due to variation in management practices or environmental conditions. As shown in Table 1, the OR of stillbirth significantly decreased in 2020 (0.41), 2023 (0.48), and 2024 (0.25) but not in other kidding years.

The OR of stillbirth decreased with the birth of female kids (OR=0.56). In other words, male kids showed a higher probability of stillbirth than female kids, which is in agreement with Margatho et al. (2019). They reported that male fetuses generally have higher birth weights, potentially leading to dystocia and disrupted oxygen supply. Hormonal differences in the development of male and female fetuses may also contribute to differing levels of resilience to the stressors of parturition (Giussani et al., 2011).

The incidence rates of stillbirth in does with gestation lengths of shorter than 135 days (OR=0.48) and those longer than 154 days (OR=2.14) were significantly different from other does. In other livestock species such as cattle and sheep, both very short and long lengths of gestation have been associated with an increased risk of fetal death (Mellado et al., 2000). Short gestations may result in underdeveloped organs, while prolonged

gestations can stem from placental dysfunction or fetal oversize, both increasing the risk of prenatal death (Mellado et al., 2000). In the present study, both shortened and prolonged gestations showed a significant relationship with stillbirth rates.

The age of does at kidding had a significant effect on the incidence rate of stillbirth in the Murciano-Granadina goat breed. As shown in Table 1, the incidence rate of stillbirth in 2 (OR=0.41) and 3 year (OR=0.36) of does was significantly lower than that in one-year-old young does. Similarly, Simoes and Pires (2018) pointed out that primiparous goats were at a higher risk of experiencing stillbirth. These findings can be explained by underdeveloped birth canals in young goats and metabolic weakness or deranged placental function in older animals. In contrast to the findings obtained in the present study, Mellado et al. (2006) reported that older does were approximately 90% more likely to experience stillbirths compared to younger does. Hamed (2010) also reported that the oldest Zaraibi does were 70% more likely to have stillbirths than the youngest does.

### *The influencing factors on dystocia*

The OR and their CI for risk factors associated with dystocia are shown in Table 2. Kidding year and sex of the kid were significant factors associated with dystocia

( $P < 0.01$ ) but the effects of kidding season, parity, birth weight of kid, birth type of kid, gestation length and age of does at kidding were not significant.

**Table 2.** Risk factors associated with dystocia in the Murciano-Granadina goat breed

Variable	Level (n) <sup>a</sup>	Odd Ratio	95% CI <sup>b</sup>	P-value
Kidding year	-	-	-	0.0001
	2018 (1593)	Reference	-	-
	2019 (1685)	0.49	0.11-2.10	-
	2020 (1753)	9.13	3.54-23.57	-
	2021 (928)	35.35	14.12-88.50	-
	2022 (852)	26.09	10.30-66.10	-
	2023 (970)	16.59	6.47-42.51	-
Kidding season	-	-	-	0.1287
	First (2989)	Reference	-	-
The birth type of the kid	Second (5462)	1.20	0.95-1.52	-
	-	-	-	0.3868
Sex of the kid	Single (3370)	Reference	-	-
	Twin (5081)	0.90	0.72-1.14	-
Parity	-	-	-	0.0001
	Male (4122)	Reference	-	-
The birth weight of the kid	Female (4329)	0.49	0.39-0.62	-
	-	-	-	0.8318
	First (3518)	Reference	-	-
Gestation length	Second (2792)	1.14	0.73-1.77	-
	Third (2141)	1.18	0.66-2.10	-
	-	-	-	0.5845
	< 1.80 kg (344)	1.19	0.71-1.99	-
	1.80-2.19 kg (1726)	0.99	0.73-1.34	-
	2.20-2.59 kg (3130)	Reference	-	-
Age at kidding	2.60-3.0 kg (2309)	0.88	0.66-1.18	-
	> 3kg (942)	0.74	0.48-1.15	-
	-	Reference	-	0.1944
	< 135 days (624)	1.51	0.97-2.34	-
	136-141 days (1547)	1.26	0.92-1.73	-
The birth weight of the kid	142-147 days (3391)	Reference	-	-
	148-154 days (2294)	1.09	0.81-1.45	-
	>154 days (595)	1.45	0.96-2.15	-
	-	-	-	0.7992
Age at kidding	1-yr (2572)	Reference	-	-
	2-yr (3092)	1.12	0.73-1.73	-
	3-yr (2814)	1.22	0.68-2.22	-

<sup>a</sup> n: the number of observations in each level

<sup>b</sup> CI: confidence interval

The significant effect of kidding year on dystocia was possibly due to variations in management or environmental conditions (Dadi et al., 2008). The OR of dystocia significantly increased after 2019, implying a reduction in dystocia incidence in recent years, which was accompanied by improvement in the health status of the flock and implementation of a breeding strategy for not joining the does with previous dystocia. The kidding year is considered a general indicator of the specific management, nutritional, sanitary, and environmental conditions over the years. Jacobson et al. (2020) reported that environmental stress can disrupt the normal parturition process by affecting the secretion of hormones such as cortisol and adrenaline, ultimately leading to dystocia.

The OR of dystocia decreased with the birth of female kids (OR=0.49). In other work, Majeed et al. (1992) found that about 70% of cesarean sections in local Iraqi goats were associated with male kids. Bhattacharyya et al. (2015) also reported a higher frequency of dystocia for male Kashmiri kids. Giussiani et al. (2011) pointed out

that hormonal differences in the development of male and female fetuses may also contribute to differing levels of resilience to the stressors of parturition. The most likely mechanism for this association is the higher birth weight of male kids, which leads to fetal pelvic disproportion interfering with the birth process.

### Conclusion

The incidence rates of stillbirth and dystocia in the Murciano-Granadina goat breed under an intensive production system in the semi-arid tropical region of southern Iran were low. Stillbirth was significantly influenced by kidding year, sex of kid, gestation length, and age of doe at kidding, whereas dystocia was primarily associated with kidding year and sex of kid. Male kids and extreme gestation lengths (either very short or very long) were identified as risk factors for both outcomes. These findings highlighted the importance of precise reproductive management strategies in reducing perinatal losses and improving reproductive efficiency. Incorporating these results into herd management

programs could enhance reproductive performance and animal welfare in similar goat production systems.

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## Conflict of interest

The authors certify that there are no conflicts of interest among authors and between authors and other people and organizations.

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