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EFFECT OF SOME NON-GENETIC FACTORS ON CHANGE OF SEX RATIO IN THE AWASSI SHEEP BREED

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ABSTRACT

This study investigated the influence of environmental and maternal factors on the sex ratio of Awassi lambs reared at the Ceylanpinar State Production Farm (CSPF) in Türkiye. Lambing data from 2004 to 2011 were analyzed using factorial ANOVA (FANOVA) and chi-square tests to evaluate the effects of lambing year and ewe age. While the effect of lambing year on sex ratio was only marginally significant ($p<0.10$), a statistically significant relationship was found between lamb sex and lambing year ($p<0.01$), indicating temporal variation in sex ratio. In particular, a female sex ratio of 54.41%, 55.58% and 52.21% was observed in the drought years 2006, 2007 and 2008, respectively. These patterns suggest that environmental stressors such as drought and reduced forage availability may exert directional pressure in favor of female offspring under suboptimal conditions. The results are consistent with the Trivers-Willard hypothesis and support the notion that maternal condition may influence sex allocation in a context-dependent manner.

Keywords: Awassi Sheep, Lamb, Sex ratio, Maternal investment, Trivers–Willard hypothesis.

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INTRODUCTION

The sheep, one of the first domesticated animals, holds great value to humanity and was first domesticated in Anatolia (Parmaksız *et al*., 2018). The İvesi (also known as Awassi) is a Middle Eastern fat-tailed sheep breed found mainly in Syria, Israel, Lebanon, Jordan, Iraq, and southeastern Türkiye and known for its adaptation to arid climates and high milk production potential (Porter, 2020). Among the sheep breeds that have been domesticated in this region, the Anatolian Awassi (*Ovis aries*) is particularly noteworthy. This breed is mainly bred in the Southeastern Anatolia region of Türkiye (T.C. Official Gazette, 2004).

However, due to adaptability character of this breed, it is also bred in other regions of Türkiye. It is resistant to hot and dry climates, produces high yields, and, above all, milk. It is medium-sized, robust, and has a thin yet resilient bone structure, making it suitable for milk production. This breed, characterized by its thick tail, is well-suited for a nomadic system due to its strong maternal instinct and high adaptability. It is suitable for keeping breeding sheep in the hot desert and exhibits excellent adaptability to changing environmental conditions. The Anatolian Awassi, which has an advantage over other dairy sheep breeds due to its strong herding instinct and environmental resistance, is also the origin of the Awassi breed bred in Israel (TAGEM, 2025). Additionally, the Awassi sheep breed is the most widespread breed of non-European origin, having been exported from its area of origin in the Mediterranean region to more than 30 countries worldwide (Galal *et al*., 2008). On modern farms, female offspring offer advantages in milk production in terms of herd continuity and milk yield continuity, while male offspring are preferred for meat production due to their faster growth and ability to utilize forage (Blanchard *et al*., 2005).

According to probability theory, the secondary sex ratio (SSR), i.e., the ratio of male to female offspring, is expected to be equal (Roche *et al*., 2006; Kaygisiz and Vanli, 2008). However, the ability to manipulate the sex ratio optionally maximizes genetic progress by intensifying selection in the breeding population (Demiral *et al*., 2007). In the long term, breeders aim to increase the number of female offspring at birth to increase the efficiency and profitability of their operations (Soundararajan and Sivakumar, 2011). The heritability of SSR in sheep is low (0.042, 0.051, and 0.153, respectively) but can be improved through selection programs (Hossein-Zadeh, 2016). Nevertheless, many mammal populations deviate from an equal sex ratio at birth. It is known that this phenomenon exhibits considerable variability. More than one mechanism may influence the sex ratio, and the effects of these mechanisms may depend on environmental conditions (Clutton-Brock and Iason, 1986). In particular, sex ratio in sheep has been reported to be influenced by several factors including location (Tailor *et al*., 2008), maternal age (Skjervold, 1979), season of farrowing (Skjervold, 1979; Kent, 1992), year of farrowing (Balasubramanyam *et al*., 2011). Despite the numerous factors affecting fertility in sheep, genetics, nutrition, and management practices have been identified as key factors in fertility and successful reproduction (Petrović *et al*., 2012).

According to the Trivers-Willard (TW) hypothesis (Trivers and Willard, 1973), mothers exposed to complex conditions, such as inadequate living, nutritional, and health conditions, tend to give birth to more female offspring in order to ensure the continuation of their family line. Conversely, when conditions are favorable, they behave the other way around and give birth to more male offspring. The Trivers-Willard hypothesis has already been the subject of numerous studies (Douhard, 2017; Djedović *et al*., 2021). Indeed, the relationship between the feeding opportunities of red deer and the sex of offspring has been studied, showing that red deer with poor feeding conditions give birth to predominantly female offspring. In contrast, individuals with better feeding conditions tend to have more male offspring (Trivers and Willard, 1973).

In addition, a study on Macaque species in which social status plays a crucial role showed that non-dominant females have a higher rate of female offspring, while dominant females produce more male offspring (Dittus, 1998). Research in mice also supports the idea that maternal stress has adaptive potential, furthering our understanding of how exposure to different social conditions can influence sex allocation in mammals (Firman, 2020).

This study aims to investigate the changes in the sex ratio of Awassi sheep reared under the same conditions in Ceylanpinar State Production Farm in Türkiye. In the context of sex ratio changes, the Trivers–Willard hypothesis, which posits that natural selection under certain maternal conditions favors unequal parental investment between daughters and sons, was examined.

MATERIALS AND METHOD

Information about the Farm: The present study was conducted at the Ceylanpınar State Production Farm (CSPF), located in the Ceylanpınar district of Şanlıurfa Province in the Southeastern Anatolia Region of Türkiye. The CSPF is geographically located at 36°50′ north latitude and 39°55′ east longitude at an altitude of 398 meters above sea level. The location of the CSPF on the geographical map of Türkiye is shown in Figure 1.

Figure 1. Şanlıurfa province and Ceylanpınar district, where the CSPF is located

Founded in 1943, Ceylanpınar State Production Farm (CSPF) is the largest farm in the world, with an area of 1,635,928 hectares, and is home to the largest population of Awassi sheep. The farm receives an average of 262.9 mm of rainfall per year over a 20-year growing season, with June, July, and August being almost rain-free, resulting in an adjusted annual average of 252.7 mm. The relative humidity fluctuates between a maximum of 82.8% and a minimum of 28%. Initially, the farm had 109,000 decares of irrigated agricultural land. However, to increase efficiency and productivity, an irrigation project was carried out between 2009 and 2011, which expanded the total irrigated area to 612,415 hectares by 2015. This expansion enabled the cultivation of various fodder crops, including alfalfa, vetch, and silage maize as a secondary crop, alongside cereals such as barley, wheat, and grain maize, as well as other plant products. By integrating irrigation, two crops can be harvested per year, improving the sustainability of livestock feeding and overall agricultural productivity (Anonymous, 2025).

Twin births were considered a desirable trait in flocks of sheep. The occurrence of twin births is influenced by both genetic factors and environmental conditions, such as nutrition, pasture quality, and climate, during pregnancy. However, the heritability of twin births in sheep was relatively low, suggesting that environmental factors play an important role in this trait (Notter, 2008; Vatankhah and Talebi, 2009; Cottle *et al*., 2016).

Animal materials: The animal material used in this study consisted of Awassi sheep bred at the Ceylanpınar State Production Farm in Şanlıurfa, in the Southeastern Anatolia Region of Türkiye. This farm manages the world's largest Awassi sheep population, with around 40,000 animals. Lambing and rearing data from 2004 to 2011 was analyzed, including data from 5,454 ewes and 10,835 lambs. Mating takes place in June, and lambing begins on November 15, ending in the same year, so that conception and production years coincide. The dataset includes information on sex, birth year, birth type, and maternal age, which were analyzed to assess their impact on lamb development. Figure 2 shows images of Anatolian Awassi (*Ovis aries*) rams and ewes (TAGEM, 2025).

Figure 2. The Anatolian Awassi (*Ovis aries*) ram and ewe

Environmental conditions: In this study, climatic conditions were considered based on the studies conducted by Gümüş *et al*. (2016) and Akbaş (2014) in Türkiye. The results obtained in these studies are listed in Table 1.

Gümüş *et al*. (2016) conducted a drought analysis using 78 years (1937–2014) of precipitation data from the Şanlıurfa meteorological station in southeastern Türkiye. The Standardized Precipitation Index (SPI) method was used to evaluate drought conditions. According to the results, a drought period of 60 months occurred between February 2004 and January 2009. Additionally, the study identified a period of excessive rainfall (SPI > 2.0) that lasted for ten months, from January 2012 to February 2013.

In another study conducted in Türkiye, temperature and precipitation data from 96 meteorological stations (1929–2009) were analyzed in conjunction with Available Water Holding Capacity (AWHC) data from the ORNL DAAC (United States) to determine the distribution of drought patterns using the Palmer Drought Severity Index (PDSI). Based on these calculations, the severity of the drought was categorized into seven classes according to NOAA standards (Akbaş, 2014).

Statistical analysis: In this study, gender was considered as a dependent variable, while year of conception and maternal age were treated as independent variables. The factors of year of conception and maternal age, which were hypothesized to influence the mode of delivery, were archived in the farm from which the research dataset originated. Although sex could also be influenced by factors such as the season of conception and the genetic composition of the herd, these variables were not archived. They, therefore, could not be included in the analysis.

Data were analyzed using the chi-square (χ^2) test and factorial ANOVA (FANOVA). Since the dependent (predicted) variable was birth type (Y) and the independent (predictor) factors were year of birth (X_1) and mother's age (X_2), the functional relationship between the dependent and independent variables was expressed in matrix form as follows (Equation 1).

$$Y=X\beta+\varepsilon \quad (1)$$

Where;

In this study, Y represented the vector of the dependent variable, X was the matrix of constant effects,

β denoted the coefficient matrix for the constant effects, and ϵ was the error vector influenced by random factors.
The method examined in this study was formulated based on the general model described above.

In the analysis of variance, the dependent variable (Y) must be continuous, while the independent variables (X) (factors) must be discrete. However, variables that follow a binomial distribution (with two outcomes) can approach normality if the sample size (n) is sufficiently large (Yildiz *et al*., 2020). Under such conditions, data analysis can be performed using the ANOVA approach, assuming that the data are normally distributed.
Accordingly, the biometric model used in this study for data analysis with the FANOVA method is formulated as follows in Equation 2, where a linear biometric model is employed.

$$Yijk = \mu + a_i + b_j + (ab)_{ij} + e_{ijk} \quad (2)$$

Whereby;
Y: observation vector for the sex of the lamb
μ: mean value of the sex of the lamb
ai: constant effects of the levels belonging to the variable of the year of lambing
bj: effects of the levels belonging to the maternal age variable
(ab)ij: interaction effect of year of production X maternal age
eijk: random error
Chi-Square can be written with the following example equations are given (Equation 3):

$$\chi^2 = \sum \frac{(f - f_i)^2}{f_i} \quad (3)$$

Where;
f was the observed frequency and *fi* was the expected frequency. All statistical analyzes were performed with IBM SPSS Statistics for Windows, version 22.0 (SPSS, 2014).

Trivers-Willard (TW) hypothesis: In this study, the Trivers-Willard (TW) hypothesis (Trivers and Willard, 1973) was employed to investigate changes in the sex ratio over time. A comparison was made between years with harsh climatic conditions in the Southeastern Anatolia region of Türkiye, where the study was conducted, and years with more favorable conditions.

To distinguish between good and bad climatic conditions, findings from previous scientific studies on the climate in the Southeastern Anatolia Region of Türkiye were used, as shown in Table 2 (Gümüş *et al*., 2016; Akbaş, 2014). The Ceylanpınar district, where the CSPF is located, was severely affected by droughts, particularly in 2008, 2009, and 2010. As a result, many crops were unable to be harvested due to the drought (Anonymous, 2025).

Gümüş *et al*. (2016) conducted a drought analysis using the Standardized Precipitation Index (SPI) method based on 78 years (1937–2014) of precipitation data from the Şanlıurfa meteorological station in the Southeastern Anatolia region of Türkiye. According to the SPI index, the most prolonged dry period lasted 60 months, occurring between February 2004 and January 2009.

In the study by Akbaş (2014), the temperature and precipitation data from 96 meteorological stations throughout Türkiye (1929–2009) were analyzed. Using these data, the Palmer Drought Severity Index (PDSI) values and classifications for Şanlıurfa province were determined based on the Available Water Holding Capacity (AWHC) of the U.S. ORNL DAAC, PDSI, and National Oceanic and Atmospheric Administration (NOAA) procedures (Table 1). The results of the study show that in 2007 and 2008, the region where Awassi sheep are kept experienced moderate, severe, and extreme drought (Table 2).

Table 1. Palmer drought severity index (PDSI) and standard precipitation index (SPI) classes

Palmer drought severity index (PDSI) (Palmer, 1965)				Standard precipitation index (SPI) (Mckee, 1993 and Vermes, 1998)			
PDSI Values			Drought Category	SPI Values			Drought Category
	≥	4.00	Extremely wet	2.0	> SPI		Extremely wet
3.00	to	3.99	Very wet	1.5	< SPI ≤	2.0	Very wet
2.00	to	2.99	Moderately wet	1.0	< SPI ≤	1.5	Moderately wet
1.00	to	1.99	Slightly wet	0	< SPI ≤	1.0	Slightly wet
0.50	to	0.99	Incipient wet spell	-1.0	< SPI ≤	0	Slightly drought
0.49	to	-0.49	Near normal	-1.5	< SPI ≤	-1.0	Moderate drought
-0.50	to	-0.99	Incipient drought	-2.0	< SPI ≤	-1.5	Severely drought
-1.00	to	-1.99	Mild drought	-2.0	≤ SPI		Extremely drought
-2.00	to	-2.99	Moderate drought				
-3.00	to	-3.99	Severely drought				
	≤	-4.00	Extremely drought				

PDSI: Palmer drought severity index, SPI: standard precipitation index

In this study, the results of Akbaş (2014) and Gümüş *et al*. (2016) were utilized to classify the challenging conditions hypothesized to influence the shaping of the sex ratio in Awassi sheep kept in CSPF (Table 2).

Table 2. PDSI and SPI values determined for Şanlıurfa province

PDSI value and classes determined for Şanlıurfa Province (Akbaş, 2014)					SPI value and classes determined for Sanlıurfa Province (Gümüş *et al*., 2016)			
Years	PDSI Values (February/July)			Drought Category	SPI Values			Drought Category
2004		-		-	-1.0	<SPI≤	0	Mild drought
2005		-		-	-1.0	<SPI≤	0	Mild drought
2006	1.9/-2	to	-1.9/-2.9	Normal/Moderate drought	-1.5	<SPI≤	-1	Moderate Drought
2007	-2/-3	to	-2.9/-3.9	Moderate/Severely drought	-2.0	≤ SPI		Extremely Drought
2008		≤	-4/-4	Extremely/Extremely drought	-2.0	<SPI≤	-1.5	Severe drought
2009		-		-	0	≤SPI≤	1.0	Slightly wet
2010					-1.0	≤ SPI	0	Mild drought
2011								

PDSI: Palmer drought severity index, SPI: Standardized Precipitation Index.

As this study was conducted in the context of non-experimental agricultural practices (Anonymous, 2011), it was not necessary to obtain an "ethics committee certificate".

RESULTS AND DISCUSSION

According to the GLM procedure (Table 3), there was a marginal difference between the groups by year ($p<0.10$). Duncan's comparison test was used to show the differences between years. Maternal age had no direct effect on the sex ratio (Table 4).

The significance of the change in sex ratio by year was analyzed using the chi-square independence test ($\chi 2$). Table 4 shows the significance of these differences by year, and the results were significant. Another factor hypothesized to influence the change in the sex ratio is the mother's age. In this study, maternal age was found not to affect the sex ratio, as indicated by both the GLM procedure (Table 3) and the results of the chi-square independence test (Table 4).

Table 3. GLM analysis results of factors affecting sex ratio

Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Model	2882.058[a]	30	96.069	385.100	0.000
Year	3.084	7	0.441	1.766	0.089[+]
Maternal age	0.470	3	0.157	0.628	0.597[ns]
Year x Maternal age	5.393	19	0.284	1.138	0.304
Error	2702.942	10835	0.249		
Total	5585.000	10865			

+: $p<0.10$ (marginal important); **ns:** non-significant; **a:** Coefficient of determination ($R^2 = 0.516$; Adjusted $R^2 = 0.515$).

When Table 3 was examined, it was found that the significant differences causing the change in sex ratio (for the increase in female sex) were due to the factor of the year of birth of the offspring ($p < 0.10$: marginally significant). It could be considered significant that the change in sex ratio by year was found to be marginally significant ($p<0.10$), as the sex ratio in mammals was expected to be the same under normal conditions (Cheryl *et al*., 2004; Rosenfeld and Roberts, 2004; Abecia *et al*., 2017). Additionally, a drought category was created based on years, according to the standardized precipitation index (SPI). The results showed that this factor influences the change in the sex ratio in Awassi sheep (Table 3).

The drought category shown in Table 4 was created according to the SPI to test the TW hypothesis. The TW hypothesis states that "natural selection under certain maternal conditions favors unequal parental investment between daughters and sons." In this study, the number of newborn female and male offspring, as well as their sex ratio, was determined by year and under the environmental conditions in which the sheep lived. The changes in sex ratio from year to year were determined to be statistically significant ($P < 0.01$) using the $\chi 2$ test, and the results of the statistical analysis are presented in Table 4.

Table 4. Duncan and χ^2 test of the effect on sex ratio of maternal age and years

Factors	Drought category by SPI	Abbreviations	Lamb Number Female (Male)]	Sex Ratio (%) [Female (Male)]
General			n= 5585(5280)	51.40 (48.60)
Years				+ (**)
2004	Mild drought	MID	640(657)	49.38 (50.62)^{a}
2005	Mild drought	MID	706(671)	51.27 (48.73)^{ab}
2006	Moderate drought	MD	734(614)	54.41 (45.59)^{bc}
2007	Extremely drought	ED	687(548)	55.58 (44.42)^{c}
2008	Severe drought	SD	721(660)	52.21 (47.79)^{abc}
2009	Slightly wet	SW	579(574)	50.26 (49.74)^{a}
2010	Mild drought	MID	818(841)	49.31 (50.69)^{a}
2011	Mild drought	MID	700 (715)	49.47(50.53)^{a}
Maternal Age				ns
3			2476(2312)	51.23 (48.77)
4			1782(1740)	50.74 (49.26)
5			994(915)	52.08 (47.92)
6			333(313)	51.38 (48.62)

+: $p<0.10$ (marginal important); ns: non-significant; a, b, c**:** The differences between the sex ratios shown with different letters in the same column are statistically significant ($p<0.10$).
**: $p<0.01$ (Pearson Chi-Square (df=7)= 22.089, p= 0.002), NS: (Pearson Chi-Square (df=3)= 1.446; p= 0.695)

The analysis of Table 4 shows that, out of the total 10,865 lambs born, the sex ratio was 51.40% for females and 48.60% for males.

Studies on the sex ratio of sheep offspring have shown that the ratio of female offspring is generally higher than that of male offspring (Reddy and Naidu, 2008; Balasubramanyam *et al*., 2011; Tariq *et al*., 2013). In this study, it was shown that the lowest ratio of female lambs (49.38%) occurred under moderate drought conditions (2004), while the highest ratio of female lambs (55.58%) occurred under conditions where there was a transition from severe drought to extreme drought (2007).

The sex ratio determined in the study was compared with sex ratios from studies conducted with the same and different sheep breeds in various regions of the world. At the end of this comparison, it was found that the sex ratio (female: male) obtained was quite similar to the values reported by Nawaz *et al*. (1985) of 50.74:49.26% and 51.12:48.88% in Awassi and Kachhi sheep, respectively. The value of sex ratio in the study was also similar to Tailor *et al*. (2008), Reddy and Naidu (2008), Tariq *et al*. (2013), who studied Sonadi sheep (50:50%), Nelore sheep (50.74:49.26%), Mengali sheep (50.63:49.37%) and Mandya sheep (48.7:51.3%) respectively.

Numerous researchers have also documented similar results. On the other hand, the sex ratio (female: male) found in this study was relatively high compared to that of Nawaz *et al*. (1985) in Awassi x Kachhi sheep (49.13:50.87%); Babar *et al*. (2004) in Lohi sheep (48.47:51.53%); Thiruvenkadan *et al*. (2008) in Mecheri sheep (49.22:50.78%); Soundararajan and Sivakumar (2011) in Madras Red sheep (49.07:50.93%); Jahan *et al*. (2013) in Balochi sheep (49.67:50.33%); and Javed *et al*. (2013) in Lohi sheep (49.51:49.51%). In addition, the sex ratio values (female: male) were higher in some studies than in our study, e.g. Balasubramanyam *et al*. (2011) in Madras Red sheep (52.18:47.82 %).

The graph of the change in sex ratio over the years under the specified conditions of drought category (MID: Mild Drought, MD: Moderate Drought, ED: Extreme Drought, SD: Severe Drought, SW: Slightly Wet), assigned by SPI, is shown in Figure 3.

The TW hypothesis could explain the change in the gender ratio from 2005 to 2009. According to this hypothesis, the mother tends to give birth to male individuals when the environmental conditions (climate, care, feeding, stress, etc.) in which she lives provide good opportunities; when the environmental conditions in which the mother lives do not provide good opportunities, she tends to give birth to female individuals (Triver and Willard, 1973).

In this study, when examining the sex ratio of lambs born to Awassi sheep between 2004 and 2011, in parallel with environmental factors, it was found that mothers gave birth to mainly female offspring in extreme and severe drought years, as well as in years with extreme rainfall, as shown in Figure 3. Analyzing the results in light of this information leads to the conclusion that the sex ratio has changed in line with the TW hypothesis.

The distribution of the sex ratio by age is shown in Table 4. It was found that maternal age made no statistically significant difference in the variation of the sex ratio ($p > 0.05$).

Although maternal age (the age of the ewe) did not affect the sex ratio in this study, the female sex ratio (female/male) was consistently higher than the male sex ratio at all ages (Table 5). The lowest female offspring ratio of 50.74% was found in the 4-year-old breeding ewes, and the highest female offspring ratio of 52.08% in the 5-year-old breeding ewes (Table 4). The changes in the sex ratio as a function of the age of the ewes were not statistically significant. The result that the age of the ewes has no influence on the sex ratio is consistent with the reports of Skjervold (1979).

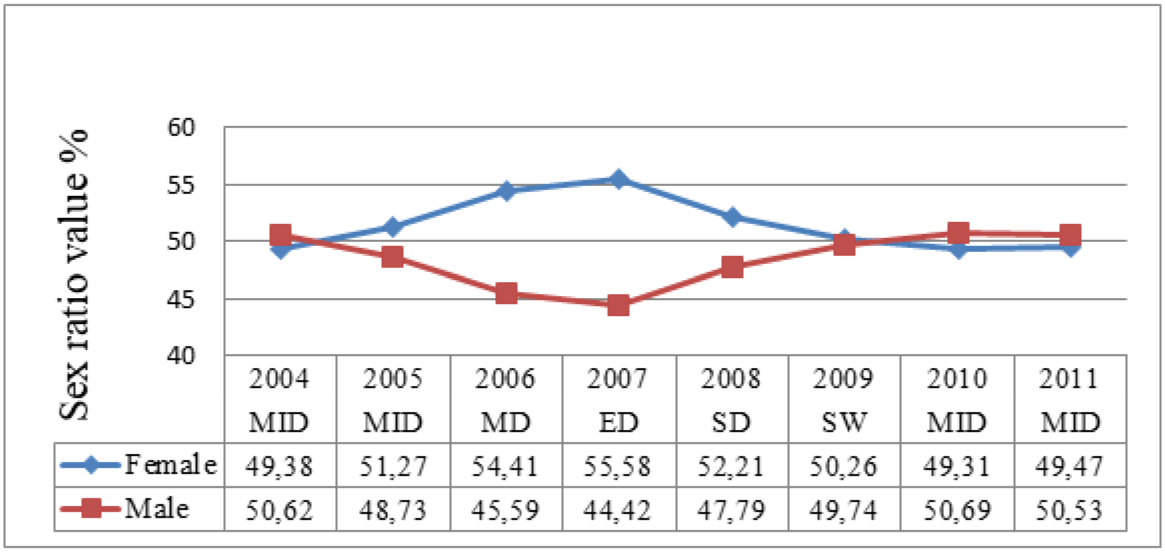

Figure 3. Change of sex ratio by drought category and by years

Conclusion: The study analyzed the sex ratio of 10,835 Awassi lambs and found a significant correlation between lambing year and sex ratio. An increase in the proportion of female lambs was observed when environmental stress factors such as drought and feed shortage were severe and the proportion of female lambs reached the highest value of 55.58%. On the other hand, the proportion of male lambs increased relatively in years with more favorable nutritional and environmental conditions.

Conflict of interest: The authors declare that no competing interests exist.

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Authors' contribution: Ali Kaygısız (AK) and Isa Yılmaz (IY) designed the study and collected the data. AK and IY analyzed the data and wrote the article—critical review by Mehmet Sarı (MS) and Kadir Önk (KÖ).

REFERENCES

Abecia, J. A., F. Arrébola and C. Palacios (2017). Offspring sex ratio in sheep, cattle, goats and pigs: influence of season and lunar phase at conception. Biol. Rhythm Res. 48(3): 417-424. http://dx.doi.org/10.1080/09291016.2016.1268325

Akbaş, A. (2014). Important drought years over Türkiye. Turkish J. Geographical Sci. 12(2): 101-118. http://dx.doi.org/10.2139/ssrn.3417309

Anonymous (2025). Republic of Türkiye Ceylanpinar District Governorship. Ceylanpinar Agriculture Directorate. http://www.ceylanpinar.gov.tr/ceylanpinar-tarim-isletmesi-mudurlugu Accessed 15 March 2025.

Anonymous (2011). Republic of Türkiye Official Gazette. Regulation on the welfare and protection of animals used for experimental and other scientific purposes. https://www.resmigazete.gov.tr/eskiler/2011/12/20111213-4.htm Accessed 15 March 2025.

Babar, M.E., Z. Ahmad, A. Nadeem and M. Yaqoob (2004). Environmental factors affecting birth weight in Lohi sheep. Pakistan Vet. J. 24(1): 5-8.

Balasubramanyam, D., S. Jaishankar, P. Kathiravan and S.N. Sivaselvam (2011). Sex ratio and reproductive performance of Madras Red sheep under field conditions. Indian J. Field Vet. 6(3): 63-65.

Cheryl, S., R. Rosenfeld and R. Michael (2004). Maternal Diet and Other Factors Affecting Offspring Sex Ratio: A Review. Biol. Reprod. 71(4): 1063–

1070. https://doi.org/10.1095/biolreprod.104.030890
Clutton-Brock, T. H. and G.R. Iason (1986). Sex ratio variation in mammals. The Quarterly Rev. Biol. 61(3): 339-374. https://doi.org/10.1086/415033
Cottle, D.J. and A.L. Cowie (2016). Allocation of greenhouse gas production between wool and meat in the life cycle assessment of Australian sheep production. Int. J. Life Cycle Assess. 21(6): 820-830. https://doi.org/10.1007/s11367-016-1054-4
Demiral, O., M. UN, M. Abay and T. Bekyurek (2007). The effect of artificial insemination timing on the sex ratio of offspring and fertility in dairy cows. Turkish J. Vet. Anim. Sci. 31(1): 21-24.
Dittus, W.P. (1998). Birth sex ratios in toque macaques and other mammals: integrating the effects of maternal condition and competition. Behav. Ecol. Sociobiol. 44(3): 149-160. https://doi.org/10.1007/s002650050527
Djedović, R., D. Stanojevi´c, V. Bogdanovi´c, D.O. Andri´c, L. Samolova'c and T. Stameni´c (2021). Bias of Calf Sex on Milk Yield and Fat Yield in Holstein Crossbreed Cows. Animals. 11(9): 2536. https://doi.org/10.3390/ani11092536
Douhard, M. (2017). Offspring sex ratio in mammals and the Trivers-Willard hypothesis: In pursuit of unambiguous evidence. Bioessays. 39(9): 1700043. https://doi.org/10.1002/bies.201700043
Blanchard, P., M. Festa-Bianchet, J.M. Gaillard and J.T. Jorgenson (2005). Maternal condition and offspring sex ratio in polygynous ungulates: A case study of bighorn sheep. Behavioral Ecology 16(1): 274-279. https://doi.org/10.1093/beheco/arh153
Firman, R.C. (2020). Exposure to high male density causes maternal stress and female-biased sex ratios in a mammal. Proc. R. Soc. B. 287: 20192909. http://dx.doi.org/10.1098/rspb.2019.2909
Galal, S., O. Gürsoy, and I. Shaat (2008). Awassi sheep as a genetic resource and efforts for their genetic improvement—A review. Small Rumin. Res. 79(2): 99-108. https://doi.org/10.1016/j.smallrumres.2008.07.018
Gümüş, V., A. Başak and N. Oruç (2016). Drought Analysis of Şanlıurfa Station with Standard Precipitation Index (SPI), Harran Univ. J. Eng. 1(1): 36-44. https://dergipark.org.tr/en/download/article-file/298757
Hossein-Zadeh, N.G. (2016). Threshold analysis of genetic effects for secondary sex ratio in domestic sheep using Bayesian approach via Gibbs sampling. Small Rumin. Res. 144: 197-204. https://doi.org/10.1016/j.smallrumres.2016.09.019
Jahan, M., M.M. Tariq, M.A. Kakar and A. Waheed (2013). Reproductive performance of Balochi sheep differ ecological zones of Balochistan. Pakistan Vet. J. 33(1): 37-40.
Javed, K., A. Iram, M. Abdullah, M.A. Sattar and M. Akhtar (2013). Genetic trends for some productive traits of Lohi sheep in Pakistan. Pakistan J. Sci. 65(4): 492-495.
Kaygisiz, A. and Y. Vanli (2008). Factor influencing sex ration in Brown Swiss cattle. Indian J. Anim. Sci. 78(6): 656-657.
Kent, J.P. (1992). Birth sex ratios in sheep over six lambing seasons. Behav. Ecol. Sociobiol. 30(3): 151-155. https://doi.org/10.1007/BF00166697
Mckee, T.B., N.J. Doesken and J. Kleist (1993). The relationship of drought frequency and duration to time scales. Proc. 8th Conf. Appl. Climatol., Anaheim, California (USA), pp. 179-184.
Nawaz, M., M.D. Ahmad, Z. Ahmad and G.R. Khan (1985). Comparative performance of Awassi, Kachhi and crossbred (Kachhi x Awassi) lambs. Pakistan J. Agri. Sci. 22(3): 181-186.
Notter, D.R. (2008). Genetic aspects of reproduction in sheep. Reprod. Domest. Anim. 43(2): 122-128. https://doi.org/10.1111/j.1439-0531.2008.01151.x
Palmer, W.C. (1965). Meteorological Drought, Weather Bureau Research Paper No. 45, U.S. Department of Commerce, Washington, D.C. (USA).
Parmaksiz, A., Oymak, A., Yüncü, E., Demirci, S., Koban Baştanlar E., Özkan Ünal, E., Togan, İ., Özer, F. (2018). Y-chromosome polymorphisms in 12 native, Karagül, Karacabey Merino breeds from Türkiye and Anatolian Mouflon (*Ovis gmelinii anatolica*). Kafkas Univ. Vet. Fac. J. 24(6): 821-828. http://dx.doi.org/10.9775/kvfd.2018.19962
Petrović, M.P., V. Caro Petrović, D. Ružić-Muslić, N. Maksimović, Z.Z. Ilić, B. Milošević and J. Stojković (2012). Some important factors affecting fertility in sheep. Biotechnology in Animal Husbandry. 28(3): 517-528. http://dx.doi.org/10.2298/BAH1203517P
Porter, V. (2020). Mason's world dictionary of livestock breeds, types and varieties. CABI; Wallingford (UK). 456 p.
Reddy, Y.R. and P.T. Naidu (2008). Twinning and sex ratio in Nellore sheep. Indian J. Small Rumin. 14(1): 118-120.
Roche, J.R., J.M. Lee and D.P. Berry (2006). Climatic factors and secondary sex ratio in dairy cows. J. dairy sci. 89(8): 3221-3227.

https://doi.org/10.3168/jds.S0022-0302(06)72597-8
Rosenfeld, C. S. and R.M. Roberts (2004). Maternal diet and other factors affecting offspring sex ratio: a review. Biol. Reprod. 71(4): 1063-1070. https://doi.org/10.1095/biolreprod.104.030890
Skjervold, H. (1979). Causes of variation in sex ratio and sex combination in multiple births in sheep. Livestock Production Sci. 6(4): 387-396. https://doi.org/10.1016/0301-6226(79)90006-X
Soundararajan, C., T. and Sivakumar (2011). Factors affecting sex ratio in Madras red sheep. Tamil Nadu J. Vet. Anim. Sci. 7(1): 12-15.
SPSS (2014). IBM SPSS Statistics for Windows, Version 22.0 (Computer software). IBM Corp.; Armonk, New York (USA)
T.C. Official Gazette (2004). Official Gazette of The Presidency of The Republic of Türkiye. Communiqué on the Registration of Native Animal Breeds and Lines (No: 2004/39, issue: 25668). ANNEX-7 Anatolian Ivesisi.doc
TAGEM (2009). Republic of Türkiye Ministry of Agriculture and Rural Affairs General Directorate of Agricultural Research, General Directorate of Agricultural Research (TAGEM), Türkiye Domestic Animal Genetic Resources Presentation Catalogue. Ankara (Türkiye) https://www.tarimorman.gov.tr/TAGEM/Belgeler/yayin/Katalog%20T%C3%BCrk%C3%A7e.pdf Accessed 16 March 2025.
Tailor, S.P., L. Gupta and R.K. Nagda (2008). Lambing pattern and sex ratio in Sonadi sheep reared by the farmers in semi-arid conditions of Rajasthan. Indian J. Small Rumin. 14(2): 279-282.
Tariq, M. M., M. A. Bajwa, K. Javed, A. Waheed, M. A. Awan, M. Rafeeq and M. Shafee (2013). Identification of environmental factors affecting pre weaning performance of Mengali sheep of Balochistan. J. Anim. Plant. Sci. 23(2): 340-344.
Thiruvenkadan, A.K., K. Chinnamani, J. Muralidharan, K. Karunanithi (2008). Effect of non-genetic factors on birth weight of Mecheri sheep of India. Livestock Res. Rural Development. 20(6): 1-4. http://www.lrrd.org/lrrd20/6/thir20096.htm
Trivers, R.L. and D.E. Willard (1973). Natural selection of parental ability to vary the sex ratio of offspring. Science, 179 (4068): 90-92. https://www.science.org/doi/10.1126/science.179.4068.90
Vatankhah, M. and M.A. Talebi (2009). Genetic and non-genetic factors affecting mortality in Lori-Bakhtiari lambs. Asian-Australasian J. Anim. Sci. 22(4): 459-464. https://doi.org/10.5713/ajas.2009.80318
Vermes, L. (1998). Irrigation, Drainage, How to Work Out a Drought Mitigation Strategy: An ICID Guide: Wirtschafts-und Verlagsgesellschaft, Gas und Wasser mbH; Bonn (Germany). 29 p. ISBN: 3895540927, 9783895540929
Yildiz, N., O. Akbulut and B. Bircan (2020): Introduction to Statistics (14th Edition). Culture and Education Foundation Publishing House (in Turkish), ISBN: 9786058034136, Erzurum (Türkiye). 326 p.