Improving reproduction and growth characteristics of indegenous goats in smallholding farming system

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ABSTRACT: Goat breeding is an economic activity carried out in the rural areas of the Eastern Mediterranean region of Türkiye. The small ruminants breeding project carried out in extensive farmer conditions was a project which aimed to improve the quality and quantity of meat and milk yields of domestic goat breeds of Anatolia since 2015. The genetic improvement study of indigenous Hair goats was started in 2015 and ended in 2020, using 5985 does and 252 bucks, with the participation of 60 local volunteer farmers in the rural farming system of Eastern Anatolia of Türkiye. At the end of the study, it was found that the birth rate, twinning rate, prolificacy, litter size, and survival rate varied between, 81.88 to 98.18%, 5.26 to 13.54%, 103.00 to 111.00%, 1.11 to 1.27 and 92.67% to 99.06%, by years respectively. As a result of the breeding study, it was determined that the birth weight, weaning weight, and daily body weight gain of the offspring were increased from 2.60 to 3.07 kg, from 8.21 to 10.77 kg, and from 107.74 to 149.15 g, respectively. It was determined that the growth characteristics of kids differed significantly over the years ($P < 0.001$). As a result of this study, it was determined that production based on local gene resources with improved genetic capacity in rural areas is important for sustainability. Simple recording schemes for the objective assessment of performance traits and planned mating schemes will help enhance animals' production performances in traditional farming systems.
Key words: fertility criteria, growth performance, hair goat, indigenous breeds, selection programme.

Melhorando as características reprodutivas e de crescimento em cabras nativas criadas em sistema de pequenas propriedades

RESUMO: A criação de cabras é uma atividade econômica nas zonas rurais da região mediterrânica oriental da Anatólia, na Turquia. O projeto de criação de pequenos ruminantes em condições de exploração extensiva é um projeto destinado a melhorar a qualidade e a quantidade da produção de carne e leite das raças de cabras autóctones da Anatólia desde 2015. Um destes projetos, o melhoramento genético das cabras indígenas da Anatólia, teve início em 2015 e terminou em 2020, utilizando 5985 fêmeas e 252 machos, com a participação de 60 agricultores voluntários locais no sistema agrícola rural da Anatólia Oriental da Turquia. No final do estudo, observou-se que a taxa de natalidade por ano variou entre 81.88 e 98.18%, enquanto a taxa de gemelaridade foi entre 5.26 e 13.54%, a prolificidade foi entre 103.00 e 111.00%, o tamanho da ninhada foi entre 1.11 e 1.27 e a taxa de sobrevivência foi entre 92.67% e 99.06%. Além disso, observou-se que o peso ao nascer dos cabritos variou entre 2.60 kg e 3.07 kg, o peso ao desmame foi entre 8.21 kg e 10.77 kg e o ganho de peso vivo foi entre 107.74 e 149.15 g. As diferenças observadas por anos em termos de características de crescimento dos cabritos foram observadas como significativamente diferentes umas das outras ($P < 0.001$). No final deste estudo, concluiu-se que melhores estratégias de criação de raças locais, esquemas simples de registro para a avaliação objetiva de características de desempenho e esquemas de acasalamento planeados ajudarão a melhorar o desempenho da produção animal em sistemas agrícolas tradicionais.
Palavras-chave: critérios de fertilidade, desempenho de crescimento, cabra peluda, partos indígenas, programa de seleção.

INTRODUCTION

Goats play a key multifunctional role in poverty alleviation of smallholder farmers in particularly the Mediterranean region. Although indigenous goats are considered the most suitable species for harsh environments, they have low productivity levels, cannot meet local demands for meat and have low prices affecting farmers' income. Indigenous breeds have adapted to their marginal environment, but not to increase their level of performance. The goat population in Türkiye has increased over the last 10 years, and it is currently about 12 million heads today (TUIK, 2021). Compared to the increasing human population, the decline in the livestock population in Türkiye has reached very significant levels. This has also been reflected in the recent increase in meat prices. For a better and improved human nutritıon, human beings must obtain the maximum yield (meat, milk, egg, etc) from all kinds of farm animals. The Mediterranean region, including Adana, is the most important goat breeding region in Türkiye due to its mountainous terrain and climate characteristics. Hair goats are the highest goat population in this region along with Kilis goats (GUL et al., 2016; KESKIN et al., 2017;

DAŞKIRAN et al., 2018), which have high milk and reproductive characteristics, and Honamlı goats (AKTAŞ et al., 2015), which are known for their high fattening characteristics.

Hair goats are raised in almost every region of Türkiye due to their high adaptability to all kinds of climate and land conditions, low maintenance and feeding, strong body structure and resistance to diseases. In addition, the ability to climb slopes and rocky lands very well, to make good use of steppe and scrub lands and to have high walking ability are some of the important features of the Hair goat. With the aforementioned characteristics, it can be raised almost at no cost and has a share of approximately 96% in goat breeding in Türkiye. For these reasons, Hair goats are an important goat breed for Türkiye and there is a need for studies to improve their performance. However, there are not enough studies on improving the meat and milk of domestic Hair goats and milk and meat production of this breed is still very low.

This study aims to increased the profitability of the enterprise by increasing the number of indigenous goat populations with high breeding value in the herd raised under extensive conditions.

MATERIALS AND METHODS

This study was initiated in 2015 with the voluntary participation of 60 Hair goat breeders using an extensive production system in the Eastern Mediterranean Region using 5985 does and 252 bucks. The region is located in a hilly and mountainous area with subtropical climatic conditions such as hot and humid summers and mild winters. The animals were kept in an extensive system. The volunteer breeders in the project are registered in the database of Adana Sheep and Goat Breeders Association. Data on the number of breeders and animals according to the settlements where the study was conducted are shown in table 1. Natural mating occurred in the production herds in the farms and the female/male ratio was calculated as 1 bucks for every 25 does.

The study covers Ceyhan (latitude: 37.0286; longitude: 35.8147), Feke (latitude: 37.8182; longitude: 35.9109), Karaisalı (latitude: 37.4528; longitude: 35.8189), Kozan (latitude: 37.4528; longitude: 35.8189), Pozantı (latitude: 37.4256; longitude: 34.8736), Saimbeyli (latitude: 37.9897; longitude: 36.0897), Tufanbeyli (latitude: 38.2612; longitude: 36.2222) and Yumurtalık (latitude: 36.7727; longitude: 35.7900) districts (Figure 1).

Each animal was identified with an ear tag number and each event (e.g., birth, abortion, diseases,

mortality) was recorded. While the does remained in the herd until they lost their breeder qualifications, the bucks were replaced every two years when the first offspring of their sons were old enough to mate. Thus, the bucks were replaced every two years in farms. The surplus male kids and the renewed bucks were sold every year. Each year, about 100 male kids were transferred to other herds as goats born in elite herds and selected based on the fertility of their mothers and sisters. In addition, candidate bucks were tested for semen checks and andrological examinations and transferred to production herds. Breeding males were exchanged between farmers, while the remaining male kids were fattened and sold. Goats were mated at the time determined by the breeders in each herd, but bucks joined females only during the mating period from August to September to benefit from the buck's effect.

Performance data such as birth weight, type of birth and weaning (45-60 days) were recorded by breeders in all herds between 2015 and 2019. The breeding animals were selected according to needs of the farm, considering descriptive characteristics such as morphological traits and some performance data of the kids. According to these criteria, about 10% of males and 50% of females with the best growth and reproduction characteristics were selected as the core herds. In addition, kidding rate (%), twinning rate (%), litter size and prolificacy (%) were calculated to examine the fertility criteria using the following formulas.

Birth rate = (Number of does kidding/Number of mated does) x100

Twinning rate = (Number of twin births/Number of does kidding) x 100

Litter size = Number of born kids/Number of does kidding

Prolificacy = (Number of born kids/Number of mated does) x 100

In all farms where the study was conducted, animals were fed on pasture in spring, summer, and fall. They were fed approximately 500-600 g/day of concentrate feed and approximately 1000-1100 g/day of poor-quality roughage per animal for three months in winter.

The data of the study were evaluated using the SPSS package program and t test was used to compare the means of two groups. The comparison of the means of more than two groups was performed using One-way ANOVA test. The mathematical model of One-Way ANOVA is as follows.

$$Y_{ij} = \mu + \alpha_i + e_{ij} \; i = 1, 2, \ldots, t \; j = 1, 2, \ldots, r$$

Where μ is the mean effect, α_i is the ith year effect, t is number of treatment, r is the

Table 1 - Number of breeders and animals according to the settlements.

Adana districts	-------Number of breeder-------	---------Number of does---------	--------Number of bucks--------
Ceyhan (Hamidiye)	6	603	30
Feke (Bahçecik)	6	549	22
Feke (Göbelli)	1	100	4
Feke (Gürümze)	1	83	6
Feke (Güzpınarı)	3	289	13
Feke (Kırıkuşağı)	2	194	8
Feke (Kovukçınar)	1	90	4
Feke (Mansurlu)	1	160	6
Feke (Paşalı)	2	291	7
Feke (Tenkerli)	1	139	3
Karahisalı (Ömerli)	1	150	7
Kozan (Oruçlu)	3	275	12
Pozantı (Yukarı belemedik)	3	311	13
Pozantı (Yağlıtaş)	1	106	5
Pozantı (Yenikonacık)	2	200	10
Pozantı (Kamışlı)	2	249	12
Pozantı (Dağdibi)	4	394	18
Saimbeyli (Himmetli)	6	517	19
Saimbeyli (Ayvacık)	2	176	5
Saimbeyli (Beypınarı)	3	308	12
Saimbeyli (Çeralan)	3	288	14
Saimbeyli (Yeşilbağlar)	1	83	4
Tufanbeyli (Şar)	1	80	3
Yumurtalık (Yeniköy)	4	350	15
Total	60	5985	252

number of replications, eij is the error term (MONTGOMERY, 2001).

Comparison of differences between groups was made using Duncan's test. The data were summarized as mean and standard error. The statistical significance level was taken as 0.05 in all tests.

RESULTS AND DISCUSSION

Reproduction traits of hair goat according to years

The reproduction characteristics of Hair goats are shown in table 2. When the reproductive characteristics of the goats were examined according to the years, it was seen that the birth rate varied between 81.88 and 98.18%, the twinning rate between 5.26 and 13.54%, the fertility rate between 103.00 and 111.00%, prolificacy between 1.11 and 1.27 and survival rate between 92.67 and 99.06%.

Within the fertility criteria, the twin birth rate increased in all years compared to the first year, and continuous improvement was observed except in 2019. It was also observed that litter size was the highest in 2018, and the first-year data were similar or lower than the other years. When the survival data of the kids were analyzed, the highest value was observed in 2017, and it was observed that it increased in all other years compared to the first year.

In similar studies, birth rates of Hair goats were reported as 85.90, 80.00, 79.00, 82.90 and 90.00%, respectively (ERTEN & YILMAZ, 2013; ERIŞIR & GÜRDOĞAN, 2004; ŞENGOCA et al. 2003; TOZLU 2006; ŞIMŞEK et al 2006). The birth rate in the first three years of this study was found to be higher than the results of some of the other studies mentioned above; however, the results reported in our study in 2018 and 2019 were lower than the results reported by ŞIMŞEK et al (2006). The twinning rate was reported as 17.90% by ERTEN & YILMAZ (2013), 32.60% by ERIŞIR & GÜRDOĞAN (2004) as well as 17.70% by TOZLU (2006). The results of the present study are lower in terms of twinning rate compared to the aforementioned literature. Fertility of hair goats was reported as 101.30% by ERTEN & YILMAZ (2013), 100.00% by ÇAM et al. (2003), 96.30% by ORAL & ALTINEL (2006), 79.00% by ŞENGONCA et al. (2003), 116.00% by ERIŞIR &

Figure 1 - Districts of Adana province.
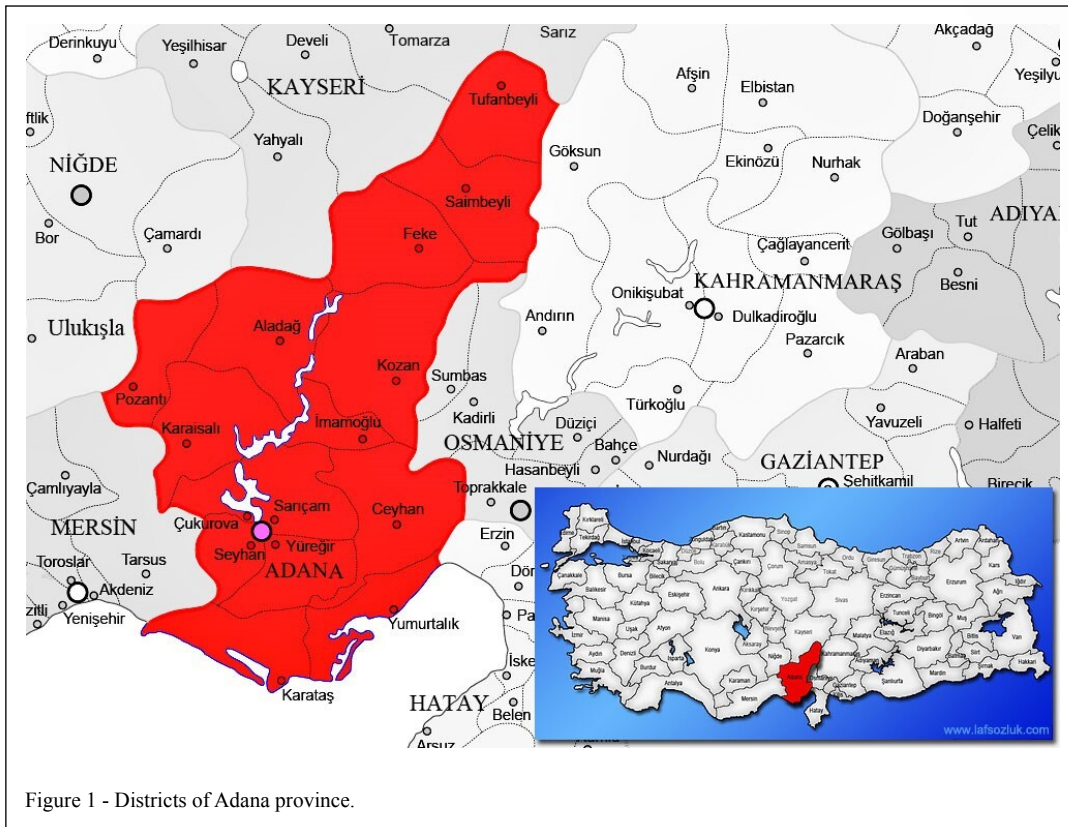
GÜRDOĞAN (2004) and 118.00% by ŞIMŞEK et al. (2006). It was determined that the prolificacy findings of the present study were lower than those reported by ERIŞIR & GÜRDOĞAN (2004) and Şimsek et al. (2006), but higher than those of the other researchers mentioned above.

The litter size reported by ERTEN & YILMAZ (2013) was 1.20, by TOZLU (2006) was 1.20 and by ŞIMŞEK et al. (2006) was 1.40. The litter size in the present study was lower than those reported by

ŞIMŞEK et al. (2006), but higher than those reported by ERTEN & YILMAZ (2013) and TOZLU (2006), except for the findings we reported in 2015 and 2016.

These herds have been in the genetic breeding program since 2015. Within the framework of the genetic breeding program implemented, tested male individuals performing above the herd average in terms of fertility and milk yield were transferred from elite herds to production herds. Since the female offspring born from the mating of tested bucks with

Table 2 - Reproduction characteristics of hair goats according to years.

Parameters	Years					
	2015	2016	2017	2018	2019	Mean
Number of mated does	4661	4878	5742	5574	5378	5246.60
Number of given birth does	4576	4721	5255	4564	4790	4781.20
Number of twin births	241	343	416	618	365	396.60
Number of born kids	5058	5407	6087	5800	5520	5574.40
Birth rate (%)	98.18	96.78	91.50	81.88	89.06	87.48
Twinning rate (%)	5.26	7.27	7.92	13.54	7.62	9.69
Prolificacy (%)	109.00	111.00	106.00	104.00	103.00	106.60
Litter size	1.11	1.15	1.16	1.27	1.15	1.19

selected goats were also selected, performance increases occurred in these herds as well. Along with the breeding program, nutrition has also been improved and has been the main focus of efforts to increase goat reproduction rates in recent years. However, nutrition was only improved in the 700 head of does in the elite herds. The rest of the herds were not under intensive conditions and nutrition was based on natural pastures only. Therefore; although, the reproductive performance of these goats seems to be low compared to intensive farms, it seems to be higher than the production herds reported in the literature due to the effect of the breeding program implemented. This can be considered a result of the research carried out in such a large area. When compared to all other studies, it is seen that the goats in this study perform0ed better, especially in terms of reproductive efficiency.

Growth characteristics and survival rate of Hair goat kids according to years

In terms of growth characteristics and survival rate (up to 45-60 days of age), birth weights, weaning weights and daily live weight gain until weaning were recorded for five years. The performance values and survival rates of mixed sex kids according to years are shown in table 3.

Accordingly, the birth weight of the kids varied between 2.60 kg and 3.07 kg, weaning weight (until 45-60 days of age) varied between 8.21 kg and 10.77 kg, and daily body weight gain until weaning age varied between 107.74 and 149.15 g. It was observed that the differences in birth weight, weaning weight, and daily body weight gain were significant ($P < 0.001$). When table 3 was analyzed, it was observed that the birth weight, weaning weight, and live weight gain of kids were higher in the other years compared to the first year and this observation was in a general increasing trend except for 2018.

In different studies on the growth characteristics of hair goats, it was reported that

the birth weight of kids varied between 2.20 kg and 3.90 kg (DAŞ & SAVAŞ, 2002; ÇAM et al., 2003; ŞENGONCA et al., 2003; ŞIMŞEK, 2005; ORAL & ALTINEL 2006; ŞIMŞEK & BAYRAKTAR, 2007; TOZLU, 2006; ŞIMŞEK et al., 2007; ATAY et al, 2010; ERTEN & YILMAZ, 2013; GÖKDAL et al., 2013; ÇELIK & OFLAZ, 2018; ALŞAHAN & ÖZTÜRK, 2019). In the present study, while the birth weight of Hair goat kids was 2.60 kg in 2015, this value increased to 3.02 kg in 2019. The birth weight of Hair goat kids was lower than the values reported by DAŞ & SAVAŞ (2002), ÇELIK & OFLAZ (2018), ALŞAHAN & ÖZTÜRK (2019), ATAY et al (2010) and TOZLU (2006), but higher than the other studies mentioned above.

Weaning weights of three-month-old kids were reported as 12.30 kg by ERTEN & YILMAZ (2013), 13.70 kg by ÇAM et al (2003), 11.80 kg by CENGİZ et al (1995), 13.60 kg by ORAL & ALTINEL (2006), 17.80 kg by ŞIMŞEK (2005), 16.10 kg by ŞIMŞEK & BAYRAKTAR (2007) and 16.00 kg by TOZLU (2006). Since the kids in our study were weaned at 1.5-2 months of age, weaning weight was determined lower compared to the above mentioned studies.

The survival rate was stated as 89.80% by ERTEN & YILMAZ (2013), 78.20% by ODABAŞIOĞLU & ALTIN (1992), 78.60% by ŞENGONCA et al (2003), 88.10% by TOZLU (2006), 80.00% by YAMAN (2012), 90.60% by ŞIMŞEK & BAYRAKTAR (2007), 93.30% by ÇAM et al (2003) and 95.40% by ORAL & ALTINEL (2006). As mentioned before, the findings of the present study were higher than the previous studies in terms of the survival rate of kids until weaning age.

In general, breeding programs aim to achieve genetic gains in the population, which are also monitored in reproductive traits. These results provide good assumptions for the accuracy of the breeding process. The growth and survival rates of kids increased from 2015 to 2019. However, the

Table 3 - Growth characteristics of Hair goat kids according to years.

Years	------Birth weight (kg)------	---Weaning weight (kg)---	-Daily live weight gain (g)-	------Survival rate (%)------
2015	2.60[d]±0.01	8.21[e]±0.01	107.74[e]±0.20	92.67
2016	2.65[c]±0.01	9.54[d]±0.01	132.55[d]±0.80	97.48
2017	3.07[a]±0.01	10.24[b]±0.01	137.85[b]±0.13	99.06
2018	3.02[b]±0.01	10.12[c]±0.02	136.48[c]±0.25	96.90
2019	3.02[b]±0.01	10.77[a]±0.03	149.15[a]±0.58	95.29
P	< 0.001	< 0.001	< 0.001	-

response of breeding programs, expressed by genetic trends in the population, primarily indicates whether breeders select animals based on their reproductive value. But, this method does not directly reflect the relationship between the genetic predisposition of parents to growth and performance traits and their manifestation in offspring.

Growth characteristics and survival rate of Hair goat kids according to maternal age, gender, and birth type

Table 4 shows the growth characteristics and survival rates of hair goat kids according to maternal age, sex and birth type.

Depending on the age of the maternal, the birth weight of the kids was between 2.85 kg and 2.90 kg, weaning weight between 9.74 kg and 9.85 kg, daily body weight gain between 131.43 g and 133.96 g, and survival rate between 92.28% and 97.66%. According to sex, the birth weight of kids ranged between 2.75 and 2.99 kg, weaning weight between 9.43 and 10.13 kg, daily live weight gain between 128.18 and 137.32 g, and survival rate between 96.05 and 96.51%. According to single and twin birth types, the birth weight of kids ranged between 2.76 and 2.98 kg, weaning weight between 9.72 and 9.83 kg, daily live weight gain between 131.82 and 133.67 g, and survival rate between 94.65 and 97.90%. Birth types and sex had a significant effect on performance ($P < 0.001$). In addition, weaning weight and live weight gain of kids were significantly affected by maternal age ($P < 0.05$). The birth weight for Hair goat kids with maternal age of 2, 3 and 4 and above in the study conducted by ERTEN & YILMAZ (2013) was

reported as 2.80, 3.10 and 3.10 kg, respectively, 60th-day live weight was 9.20, 10.00 and 10.20 kg, daily body weight gain until weaning was 96.00, 105.70 and 105.90 g and survival rate was 82.80%, 100.00 and 88.00%. According to singe and twin births, the birth weight of kids were 2.97 and 3.05 kg, live weight on the 60th day was 9.90 and 9.70 kg, daily body weight gain until weaning was 105.80 and 99.30 g and the survival rate was 89.10% and 91.70%, respectively. In the same study, birth weight for male and female kids was reported as 3.00, 60-day live weight was 9.90 and 9.80 kg, daily body weight gain until weaning was 104.60 and 100.50 g, and survival rate was 90.90% and 88.60%, respectively. In the present study, the results obtained in terms of birth weight and 60th-day live weight values of kids depending on maternal age, birth type, and sex were similar to the results reported by ERTEN & YILMAZ (2013), but higher values were observed in terms of live weight gain and survival rate until weaning in the present study.

In a similar study, The birth weight of the Hair goat kids with maternal ages of 3, 4, 5, 6 and 7 years was stated as 4.00, 3.70, 4.10, 3.70 and 3.40 kg, respectively, 75th-day live weight was 15.90, 16.60, 17.10, 16.20 and 15.20 kg, daily live weight gain until weaning was 158.30, 169.40, 176.00, 165.20 and 157.90 g (TOZLU, 2006). In the same study, according to single and twin birth types, the birth weight of the kids were 3.90 and 3.30 kg, 75th-day live weight (weaning weight) was 17.00 and 13.90 kg, and the daily body weight gain until weaning was 173.60 and 141.60 g, respectively. In addition, the birth weight of male and female kids was reported as

Table 4 - Growth characteristics of Hair goat kids according to maternal age, gender and birth type.

Maternal age	----Birth weight (kg)----	--Weaning weight (kg)--	Daily live weight gain (g)	----Survival rate (%)----
2nd age	2.85±0.01	9.75[b]±0.02	132.64[b]±0.28	97.66
3rd age	2.90±0.01	9.74[b]±0.02	131.43[c]±0.24	97.05
4th age	2.88±0.01	9.79[ab]±0.02	132.92[b]±0.46	96.89
5th age	2.86±0.01	9.78[b]±0.02	132.82[b]±0.34	97.26
6th age	2.85±0.02	9.76[b]±0.03	132.75[b]±0.52	96.51
7th age and above	2.88±0.02	9.85[a]±0.03	133.96[a]±0.44	92.28
P	0.064	0.023	0.035	-
--Gender--				
Male	2.99[a]±0.01	10.13[a]±0.01	137.32[a]±0.17	96.51
Female	2.75[b]±0.01	9.43[b]±0.01	128.18[b]±0.25	96.05
P	< 0.001	< 0.001	< 0.001	-
--Birth type--				
Single	2.98±0.01	9.83±0.01	131.82±0.16	97.90
Twin	2.76±0.01	9.72±0.02	133.67±0.24	94.65
P	< 0.001	< 0.001	< 0.001	-

3.80 and 3.70 kg, 75th-day live weight was 16.40 and 15.20 kg, and daily live weight gain until weaning was 168.70 and 153.50 g, respectively.

The results reported by TOZLU (2006) were higher than those observed in the current study. Birth weight, which was below the values reported in some of the other studies, was lower due to the high rate of prolificacy. Kids compensated for the decreased birth weight by the increase in twinning rate at weaning and showed similar values to previous reports. When birth weights and twinning rates are taken into account in terms of gender and age of does, they showed similar characteristics with other reports. A significant situation here is that the weaning live weight of kids from 2015 to 2019 increase 10.77 kg from 8.21 kg. This means an increase of approximately 30.00%. Similar results were obtained in terms of survivability and daily weight gain. With the applied breeding program, both the viability of the born offspring and the live weight gains has increased.

CONCLUSION

Domestic hair goats will be an indispensable gene source in the scenarios to be made in terms of goat breeding for rural areas of Türkiye, which is under the pressure of climate change. This will be possible only if the yield characteristics of this breed are at an economic level. This is the main purpose of this project. The importance of this goat is that it is an indigenous gene source, its productivity continues under all kinds of harsh conditions and it can adapt to these conditions better than other gene sources in scenarios developed under the negative effects of changing climatic conditions. With these existing characteristics, domestic Hair goats are preferred more by small-scale family businesses because they are satisfactory in animal production systems carried out under harsh conditions as in the whole world. Considering the data obtained as a result of this breeding study carried out in a very large population under farmer conditions, it can be said that the program applied to the local Hair goat population has been successful. The data obtained from the first five years of this study, the second five-year period of which is still ongoing, meet the expectations that the desired progress can be achieved. It is expected to increase the widespread effect of the breeding work carried out by the people. With the effect of selection, a significant improvement of 30.00% has been achieved, especially in the fertility of females. Therefore, the effects of the breeding program are expected to increase further.

DECLARATION OF CONFLICT OF INTEREST

The authors declare no conflict of interest.

AUTHORS' CONTRIBUTIONS

All authors contributed equally for the conception and writing of the manuscript. The authors critically revised the manuscript and approved of the final.

BIOETHICS AND BIOSSECURITY COMMITTEE APPROVAL

Ethics committee certificate is not required for the current study.

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