Kocatepe Veterinary Journal

Kocatepe Vet J (2019) 12(1):52-61

DOI: 10.30607/kvj.472839

RESEARCH ARTICLE

Effect of Non-Genetic Factors on The Reproductive Performance and Milk Yield Characteristics of Hair Goats

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ABSTRACT

The aim of this study was to determine the potential effect of non-genetic factors on certain production characteristics of Hair goats raised under semi-intensive management and dry- sub humid conditions, and to investigate phenotypic correlations between these traits. A generalized linear model was used to investigate the effect of non-genetic factors on gestation length (GL), number of services per conception (NSPC), lactation length (LL), lactation milk yield (LMY) and daily milk yield (DMY), while the Chi-square method was used to evaluate other fertility parameters. The pregnancy rate, birth rate and single-birth rate in the Traditional Group were higher, while the infertility rate and NSPC were lower, than those in the Artificial Group ($P<0.001$). Furthermore, it was determined that LL, LMY and DMY increased ($P<0.001$), the NSPC decreased ($P<0.001$), and birth and twinning rates fluctuated ($P<0.01$) as age increased. The best fertility and milk yield characteristics were in the ≥5 year-old-goats and live weights of 45.0-49.9 kg. In addition, it was determined that kid yield was increased in the goats synchronized with intravaginal sponges impregnated with fluorogestone acetate and in those bred via the traditional method.

Key words: artificial insemination, estrus synchronization, milk yield, reproductive performance.

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Kıl Keçilerinin Döl ve Süt Verimi Özellikleri Üzerine Genetik Olmayan Faktörlerin Etkisi

ÖZ

Bu çalışmanın amacı, yarı entansif ve kurak az nemli iklim koşullarında yetiştirilen Kıl keçilerinin döl verimi ve süt verimi üzerine genetik olmayan faktörlerin etkisini belirlemek ve bu faktörler arasındaki fenotipik korelasyonu araştırmaktır. Gebelik süresi (GL), gebelik başına düşen tohumlama sayısı (NSPC), laktasyon uzunluğu (LL), laskyason süt verimi (LMY) ve günlük süt verimi (DMY) üzerine genetik olmayan faktörlerin değerlendirilmesinde Genear linear model, diğer döl verim parametrelerinin değerlendirilmesinde ise Chi-square metodu kullanılmıştır. Tabii tohumlama yapılan gruptaki keçilerin gebelik oranı, doğu m oranı ve tek doğum oranı suni tohumlama uygulananlardan daha yüksek iken, NSPC sayısı daha düşüktür. Yaş arttıkça LL, LMY ve DMY artmış ($P<0.001$), NSPC azalmış ($P<0.001$), tek ve ikiz doğum oranları ise dalgalanma göstermiştir ($P<0.01$). En iyi döl verimi ve süt verimi nin 5 ve daha yukarı yaşlı ve 45.0-49.9 kg canlı ağırlığındaki keçilerde olduğu belirlenmiştir. Fluorogestone acetate içeren intravajinal sünger ile senkronizasyon ile tabii tohumlama uygulaması nın keçilerde oğlak verimini arttırdığı sonucuna varılmıştır.

Anahtar Kelimeler: suni tohumlama, östrüs senkronizasyonu, süt verimi, döl verimi.

To cite this article: Bolacalı M. Öztürk Y. Yılmaz O. Küçük M. Karslı M.A. Effect of Non-Genetic Factors on The Reproductive Performance and Milk Yield Characteristics of Hair Goats. Kocatepe Vet J. (2019) 12(1):52-61

Submission: 20.10.2018 **Accepted**: 29.12.2018 **Published Online**: 16.02.2019

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INTRODUCTION

Goats have had important roles throughout the history of Anatolian civilizations, and have been bred for over 1000 years. Goat breeding is widespread in Turkey due to the geographic-economic conditions of the country, the historical accumulation of agricultural experience, and the traditions and customs of the Turkish people. Despite this, the number of goats has decreased by 53% to 10.3 million in the last 5 decades (TUIK, 2017). Among the possible reasons for this decrease are the low yield and income obtained from goat breeding and the lack of sustainable breeding programs and animal husbandry policies. Although Hair goat is generally a low-yield breed in terms of fertility characteristics, milk yield, meat yield and hair yield, it is one of the five indigenous goat breeds of Turkey that has adapted resistance to harsh environmental factors, such as diseases, poor nutrition conditions, and extreme climatic conditions. Hair goat breeding is performed depending on the season and geographical region under semi-intensive and/or extensive management conditions. The population of Hair goats in Turkey is reported to be 10.1 million, accounting for approximately 97% of the total goat population, with the Hair goats commonly raised in the Eastern Anatolian region (TUIK, 2017).

The milk yield and reproductive performance of goats has a major impact on the profitability of goat farming. In assessing milk yield, lactation length and lactation milk yield are typically used; in assessing fertility characteristics, the pregnancy, birth, infertility, mortality, abortion, single kidding and twinning rates, along with litter size and kid yields, are used as key parameters. These parameters are considered to be particularly important when regarding economical goat breeding, milk production, goat meat production, goat production and kid sales (Akçapınar and Özbeyaz 1999, Atay and Gokdal 2016).

Both genetic and non-genetic factors affect the milk yield and reproductive parameters of goats. In addition to animal genetics, the effects of non-genetic factors on milk yield and reproductive performance, and the importance of optimum environmental conditions in enhancing goat productivity, have attracted increasing attention in recent years (Rhone et al. 2013, Atay and Gokdal 2016, Keskin et al. 2017). Non-genetic factors include feeding (nutrition), housing, rearing systems and management conditions, climate, (including temperature), kidding year, age, synchronization type, insemination methods, birth type, body weight, number of pregnancies, diseases, LL, and number of lactations (Bolacalı and Küçük 2012, Furstoss et al. 2015).

Knowing the effects of non-genetic parameters on yield properties can provide explanations for variations in milk yield and fertility characteristics, and aids in the assessment of yield parameters when designing prospective breeding programs (Haldar et al. 2014). As a result of these optimized programs, goat productivity may be increased as a direct outcome, while supply of the daily protein needs of individuals living in rural areas and improvement in life standard may be observed as an indirect outcome.

Atay and Gokdal (2016) identified that Hair goats birthing multiple kids at 6 years of age gave the highest milk yield. Meanwhile, Yotov et al. (2016a) reported in their studies that applying synchronization increased the kid yield in goats. However, there is a lack of data on the effects of non-genetic factors on the yield parameters of Hair goats in the Eastern Anatolian region, which is classified to have a dry-sub humid (C1) climate according to the Thornthwaite Climate Classification. Therefore, the aims of this study were (i) to determine the effects of non-genetic factors on certain production characteristics of Hair goats raised in semi-intensive management systems under dry sub-humid conditions; (ii) to investigate phenotypic correlations between milk yield and fertility traits; and (iii) to present data that may be of benefit to goat producers in the region.

MATERIALS and METHODS

All animal protocols were carried out in accordance with the Directive 2010/63/EU of the European Parliament and Council of 22 September 2010 on the protection of animals used for scientific purposes (EUD, 2010). This research was conducted according to the Yuzuncu Yil University Animal Researches Local Ethic Committee on animal use (protocol / decision number 2015/07).

To include flock diversity in our analysis, this research was conducted in two flocks (1st flock located at latitude 38°34'33.0"N and longitude 43°17'15.1"E; 2nd flock located at latitude 38°05'29.1"N and longitude 43°06'46.6"E) from August 2011 to April 2014 in Van Province (altitude, 1600 m) in the Eastern Anatolian region of Turkey. The climate in Van Province is classified as dry-sub humid (C1) according to the Thornthwaite climate grading system (Eken et al. 2008, Şensoy et al. 2012), and rainfall averages at 528.4 mm per annuum (TSMS, 2017).

In this study, the lactation records of 194 Hair goats and reproductive data on 252 Hair goats aged 2, 3, 4, and ≥5 years were collected. The live weight and age of the Hair goat dams were recorded at the beginning of synchronization as fertility parameters, and at kidding as milk yield parameters. Different performance characteristics of the goats were determined under semi-intensive conditions, with the goats given approximately 0.50 kg/head of concentrated feed per day in addition to pasture in the evenings during the experimental period. The nutritional composition of concentrated feed and its estimated nutrient supply is presented in Table 1. The concentrate diets formulated to appropriate the nutrient requirements specified by the National Research Council (NRC, 2007). The kids were suckled by their dams for 60 days after birth.

Goats are seasonally polyestrous animals with peak sexual activity occurring in the fall when day length is decreasing. In the Eastern Anatolian region where the study was conducted, goats typically start their cycle between September and November and give birth from February to April.

The goats were grouped into Sponge and Spontaneous Groups according to estrus synchronization, and into Artificial and Traditional Groups according to the insemination method.

Estrus synchronization in does was performed at the beginning of normal breeding seasons (October and November), and was carried out for the Sponge group using intravaginal progestogen-impregnated sponges containing 20 mg doses of fluorogestone acetate (FGA, Chronogest-CR, Intervet, Turkey), inserted for 11 days. The goats also received an intramuscular injection of 50 mg cloprostenol (Estrumate, Intervet, Turkey) and 400 UI equine chorionic gonadotropin (Chronogest/PMSG, Intervet, Turkey) 48 hours before sponge withdrawal. The Spontaneous Group did not undergo estrus synchronization; instead, the spontaneous estrus principle was adopted.

Estrus detection in does during the normal breeding seasons of the research period was based on the assistance of a teaser buck, and was checked twice daily at approximately 12-hour intervals. Subsequently, according to insemination type, goats in the Artificial Group were inseminated with frozen-thawed buck semen containing 75 × 106 sperm/0.50 ml per straw. The does were first inseminated between 18 and 24 hours after detection of standing estrus symptoms, and the second artificial insemination (AI) was administered between 36 and 48 hours after estrus detection. The AI was administered by means of the transcervical intrauterine insemination method, using an insemination pipette and a speculum with a light source. The semen was deposited as deeply as possible in the genital tract. Meanwhile, the goats in the Traditional Group were hand-mated via a traditional system using 1 buck (3-5 years old) per 30 does (Akçapınar and Özbeyaz 1999).
Blood samples were taken from the jugular vein in 10 ml vacuum tubes (venoject) 21 days after mating or insemination to test for pregnancy. Serum was recovered by centrifugation and analyzed for progesterone concentration using a commercially available ELISA kit. A serum progesterone level of greater than 1.5 ng/ml was taken as evidence of pregnancy (Boscos et al., 2003; Islam et al., 2014),
In this research, the data regarding fertility performance were calculated according to the methods of Akçapınar and Özbeyaz (1999) and Cinar et al. 2017 as follows:

Pregnancy rate: (number of pregnant does / total number of does during mating season) × 100
Infertility rate: (number of does not pregnant / total number of does during mating season) × 100
Birth rate: (number of does giving birth / total number of does during mating season) × 100
Abortion rate: (number of does experiencing abortion / number of pregnant does) × 100
Single kidding rate: (number of does with single kid / number of does giving birth) × 100
Twinning rate: (number of does with twin kids / number of does giving birth) × 100
Litter size: (number of kids born / number of does giving birth) × 100
Kid yield: (number of kids born / total number of does during mating season) × 100

Milk yield controls were collected every month starting 10 days after kidding and were continued until daily milk production was <50 ml. These were collected twice a day in the morning and evening by hand milking. The kids were separated from their mothers approximately 12 hours before collection of the milk controls. The LMY of each goat was estimated with the Fleischmann method according to the ICAR procedure (ICAR, 2016).
Fertility parameters (except for GL and NSCP) were analyzed by the Chi-square test, and phenotypic correlations among fertility (GL and NSPC) and milk yield (LL, LMY and DMY) characteristics were calculated in SPSS software, version 20.0 (SPSS Inc., Chicago, IL, USA). The data points bearing different letters are significantly different at $P<0.05$.

A general linear model in the SAS statistical program (SAS, 2002) was used to determine the effects of flock diversity, kidding year, estrus type, insemination type, birth type, kidding age and doe live weight on fertility (GL and NSCP) and milk yield traits. The Duncan's multiple-range test was used for multiple comparisons of the subgroups.
The following model was used to evaluate factors affecting fertility and milk yield traits: $Y_{ijklmno} = \mu + F_i + Y_j + S_k + I_l + B_m + A_n + W_o +$

eijklmnop, where μ = the mean milk yield of the Hair goat population, Fi = the effect of flock diversity (i = 1, 2), Yj = the effect of kidding year (j = 2012, 2013, 2014), Sk = the effect of estrus type (k = spontaneous, sponge), Il = the effect of insemination type (l = artificial, traditional), Bm = the effect of birth type (m = single, multiple), An = the effect of age at kidding (n = 2, 3, 4, ≥5), Wo = the effect of doe live weight (o = 25.0-29.9, 30.0-34.9, …., ≥50.0 kg).

RESULTS and DISCUSSION

The fertility parameters of the Hair goats are listed in Tables 2, 3 and 4. The pregnancy rate, infertility rate, birth rate, abortion rate, single birth rate, twinning rate, litter size, kid yield, GL and NSPC were 82.94%, 17.06%, 76.97%, 7.18%, 60.71%, 16.27%, 1.23, 94.84, 148.7 days, and 1.65, respectively. Regarding the duration of pregnancy, previous results most similar to those recorded presently were documented by Greyling (2000) in Boer goat to be 148.2 days. In this study, the pregnancy rates of the Spontaneous and Traditional Groups were found to be lower than those recorded in Hair goats lacking synchronization during breeding season (Şimşek et al. 2006, Toplu and Altinel 2008), while litter size and kid yield were higher than those recorded previously (Şengonca et al. 2003, Toplu and Altinel 2008). Additionally, the number of services per conception value of the Traditional Group was found to be similar to that reported by Faruque et al. (2010) for Black Bengal goats bred in semi-intensive conditions.

In terms of flock diversity, it was determined that the pregnancy rate, birth rate and twinning rate of the 1st flock were higher than those of the 2nd flock (P<0.01, P<0.01 and P<0.05, respectively), while the infertility rate of the 1st flock was lower (P<0.01; Table 2). No statistically significant difference between the flocks regarding NSPC was observed (Table 4), which complies with the results reported by Mellado et al. (2008). This variation in fertility parameters due to the diversity of the flocks may have stemmed from differences in the breeders and bioregion (Hoque et al. 2002).

It was observed in the study that fertility performance increased over the subsequent years (Table 2). Most studies (Şengonca et al. 2003, Gül et al. 2016) agree that the variation among yearly results when evaluating the influence of year on fertility traits may be due to differences in total rainfall, which can affect the quantity and quality of foraging, as well as yearly management changes. Thus, variations in the weather, nutrition and farm management from year to year may be responsible for the altered yearly fertility traits in the present study.

The pregnancy rate in the goats synchronized with fluorogestone acetate was 76.43%, which was similar to those reported by Yotov et al. (2016b). More notably, this synchronized pregnancy rate was lower than those observed by Ritar and Solomon (1982) and Susilawati et al. (2014), and higher than those reported in other studies (Arrebola et al. 2012, Yotov et al. 2016a). This variation in pregnancy rate in synchronized goats may be due to interactions between the synchronization method, management strategies, and climatic conditions in the region where the goats were raised. Regarding estrus synchronization among the different estrus-type groups, it was determined that the pregnancy rate, birth rate and single-birth rate in the Spontaneous Group were higher than those in the Sponge Group (P<0.01), while the NSPC of the Spontaneous Group was lower (P<0.05). Therefore, synchronization was determined to decrease the pregnancy rate in this study, which does not comply with the results reported by Yotov et al. (2016b). However, although Sponge application generally decreased fertility performance, it notably increased the twinning rate and kid yield, which are important criteria for goat breeding.

It was determined that the pregnancy rate in the Artificial Group (subjected to transcervical intrauterine insemination application) was 66.67%. This result is similar to that reported by Yotov et al. (2016b), higher than those reported by Arrebola et al. (2012), and lower than that reported by Bhattacharyya et al. (2002). This variation in the pregnancy rate of artificially inseminated goats might have stemmed from differences in the AI method used and in the number of inseminations administered to each animal. In terms of the insemination type, it was determined that the pregnancy rate, birth rate, and single birth rate in the Traditional Group were higher those in the Artificial Group (P<0.001), while the infertility rate and NSPC of the Traditional Group were lower (P<0.001). This reduction in the fertility characteristics of the Artificial Group may have been due to the AI method and/or the frozen-thawed buck semen used.

As the age of the Hair goats increased (2 to ≥5 years old), the birth rate increased (P<0.01), the twinning rate increased (P<0.01), and the NSPC decreased (P<0.001), and the best fertility performance was observed in ≥5-year-old goats. Interestingly, all of the 2-year-old goats produced single births. The result that the 5 year-old-goats had the highest pregnancy rate is consistent with that reported by Bolacalı and Küçük (2012); and the increase in litter size with age is consistent with the result reported by Rhone et al. (2013). Synman (2010) documented that the fertility traits of goats increased until the age of 7 and started to decrease thereafter. Conversely, the highest litter size was observed in 3-year-old goats by Hoque et al. (2002), and in ≥4-year-old goats by Ibnelbachyr et al. (2014). Unlike these results, Dadi et al. (2008) found that litter size was not affected by age.

In this study, it was determined that the pregnancy rate ($P<0.01$) and birth rate ($P<0.001$) increased from 25.0-29.9 kg to 45.0-49.9 kg doe live weight, and that twinning rate ($P<0.05$) increased from 25.0-29.9 kg to 40.0-44.9 kg doe live weight, all of which started to decrease at subsequent higher weights. Meanwhile, the infertility rate ($P<0.01$) and NSPC ($P<0.05$) decreased from 25.0-29.9 kg to 45.0-49.9 kg doe live weight, after which the parameters started to increase. Hoque et al. (2002) reported that litter size increased until 19-20 kg doe live weight and decreased at subsequent higher weights.

The effects of flock diversity, year, estrus type, insemination type, birth type, doe age, and doe live weight on the milk yield characteristics of the Hair goats are shown in Table 5. The LL, LMY, and daily milk yield (DMY) were found to be 170.93 days, 145.58 kg, and 0.835 kg, respectively. The LL measured in the present study was found to be similar to that reported by Şimşek et al. (2006); longer than that reported by Olfaz et al. (2011); and shorter than those reported by Toplu and Altinel (2008) and Atay and Gokdal (2016). Although the LMY and DMY were similar to those reported by Şimşek et al. (2006), they were higher than those reported for Hair goats in previous studies (Toplu and Altinel 2008, Olfaz et al. 2011, Atay and Gokdal 2016). This variation may be due to differences in the management and climatic conditions.

In the present study, it was also determined that the LMY and DMY increased over the subsequent years, 2012 data vs. 2013/14 data ($P<0.05$). The increases in the LMY and DMY over subsequent years were expected, and reflect the regional effects on grazing incurred from the variability in climatic conditions and flock composition, and from fluctuations in the availability of nutrients over time (Ishag et al. 2012), which are beyond the influence of management alterations (Lôbo et al. 2017).

This study found that does that nursed multiple kids produced more milk (higher LMY) than those with single kids ($P<0.05$). Does birthing multiple kids produce more milk due to greater hormonal stimuli deriving from the multiple fetuses, as indicated from measurements of the levels of the hormones placental lactogen, progesterone and prolactin during gestation, which are mammary gland stimulants (Lôbo et al. 2017). In addition, there is a greater tendency for does rearing multiple kids to produce more milk due to the suckling reflex and the physiological mechanism during pregnancy that prepares the udder to produce more milk for does carrying multiple fetuses (Idowu and Adewumi 2017).

With increasing age of doe (2 to ≥5 years old), the LL, LMY and DMY significantly increased ($P<0.001$), and the highest LL, LMY and DMY were detected in the goats that were ≥5 years old. These results are consistent with those reported by Toplu and Altinel (2008). Similarly, Atay and Gokdal (2016) found that 6-year-old goats gave the highest milk yield. Conversely, the highest milk yield performance was reported by Sam et al. (2017) in 3-year-old goats, by Ibnelbachyr et al. (2015) in 3-4-year-old goats, and by Keskin et al. (2017) in ≥4 year-old-goats. The milk yield of animals increases with age due to age-dependent increases in hormonal levels, metabolic activity, secretory cells and nutrient intake, all of which are used in milk synthesis. Additionally, the significant effect of age on milk yield in the present study suggests that milk production tends to increase with age, possibly due to the accumulation of mammary alveoli from previous lactation periods, until this process is interrupted by further advances in age (Idowu and Adewumi 2017).

It was also determined that the live weight of does had significant effects on LL, LMY and DMY ($P<0.05$); there were increases in the milk yield performances as the doe live weights increased, and the best performances were observed in goats between 45.0-49.9 kg live weight.

Furthermore, as presented in Table 6, litter size was identified to be positively correlated with LL, LMY and DMY ($P<0.05$). This association between litter size and milk yield may be due to the stimulus provided by suckling, which increases milk production.

Table 1. Ingredient composition and analyzed content of nutrients in the feed used in the study (2012, 2013, 2014).

Ingredients (%)	2012	2013	2014	Nutritional content, DM basis (%)	2012	2013	2014
Yellow corn	50.00	50.00	38.40	Dry matter	89.62	89.48	89.51
Barley	17.00	15.00	33.00	Metabolic energy			
Wheat		5.00		kcal/kg	2699	2701	2693
Vetch seed	10.00	5.00		MJ/kg	11.30	11.31	11.27
Vegetable oil			0.50	Crude protein	16.20	16.11	16.18
Soybean meal (44% CP)	8.00	10.00	14.00	Crude fat	2.71	2.74	3.01
Sunflower meal (28% HP)	12.20	12.20	10.50	Crude fibre	6.06	5.91	5.99
Limestone	1.75	1.75	2.00	Crude ash	5.16	5.15	6.16
Salt	0.50	0.50	0.80	Calcium	0.92	0.92	1.02
DCP	0.25	0.25	0.50	P	0.40	0.40	0.49
Vit. min. prem.*	0.30	0.30	0.30	Na	0.22	0.22	0.34

*Supplied per kilogram of diet: 3.000 mg Vitamin D3, 15.000 mg Vitamin A, 30 mg Vitamin E, 5 mg Vitamin B1, 0.3 mg Selenium, 50 mg Manganese, 0.15 mg Cobalt, 50 mg Ferrum, 300 mg Niacin, 0.8 Iodine, 10 mg Copper.

Table 2. Effect of flock diversity, year, estrus type and insemination type on reproductive traits in Hair goats.

Variation Sources	Pregnancy rate	Infertility rate	Birth rate	Abortion rate	Single birth rate	Twinning rate	Litter size	Kid yield
Flock								
1	90.68	9.32	86.44	4.67	74.51	25.49	1.16	79.85
2	76.12	23.88	68.66	9.80	83.70	16.30	1.29	111.86
Chi-square	9.397	9.397	11.200	1.166	1.269	5.412	0.303	3.467
P	0.002	0.002	0.001	0.209	0.159	0.015	0.582	0.063
Year								
2012	71.70^{b}	27.36^{a}	63.21^{b}	11.84	85.07	14.93^{b}	1.15	72.64
2013	91.07^{a}	8.93^{b}	87.50^{a}	5.88	81.63	18.37^{ab}	1.18	103.57
2014	91.11^{a}	10.00^{b}	86.67^{a}	3.66	71.79	28.21^{a}	1.33	115.56
Chi-square	14.194	14.194	19.611	2.358	4.922	8.052	0.494	5.301
P	0.001	0.001	0.0001	0.308	0.085	0.018	0.781	0.071
Estrus type								
Sponge	76.43	23.57	69.29	9.35	75.26	24.74	1.18	101.79
Spontaneous	91.07	8.93	86.61	4.90	82.47	17.53	1.29	89.29
Chi-square	8.421	8.421	10.536	0.391	9.703	0.062	0.227	0.523
P	0.004	0.004	0.001	0.532	0.002	0.804	0.634	0.470
Insemination type								
Artificial	66.67	33.33	63.41	4.88	75.64	24.36	1.29	82.11
Traditional	98.45	1.55	89.92	8.66	81.03	18.97	1.19	106.98
Chi-square	42.726	42.726	24.970	2.258	16.368	0.031	0.186	2.121
P	0.000	0.000	0.000	0.133	0.000	0.861	0.666	0.145
Overall	82.94	17.06	76.97	7.18	60.71	16.27	1.23	94.84

P: Statistical significance value,

$^{a, b, c}$: Means with different superscripts in the same column significantly differ ($P<0.05$).

Table 3. Effect of doe age and live weight on reproductive traits in Hair goats.

Variation Sources	Pregnancy rate	Infertility rate	Birth rate	Abortion rate	Single Birth rate	Twinning rate	Litter size	Kid yield
Age of doe								
2	73.68	26.32	68.42[ab]	7.14	100.00	0.00[b]	1.00	68.42
3	75.36	24.64	63.77[b]	15.38	81.82	18.18[ab]	1.18	75.36
4	82.61	17.39	73.91[ab]	7.89	88.24	11.76[b]	1.12	82.61
≥5	88.98	11.02	87.29[a]	2.86	71.84	28.16[a]	1.32	115.25
Chi-square	6.998	6.998	14.904	6.417	3.172	12.713	0.777	5.210
P	0.072	0.072	0.002	0.093	0.366	0.005	0.855	0.157
Live weight of doe								
25.0-29.9	62.50[b]	37.50[a]	46.88[b]	25.00	100.00	0.00[b]	1.00	46.88
30.0-34.9	75.00[ab]	25.00[a]	69.44[ab]	7.41	92.00	8.00[a]	1.08	75.00
35.0-39.9	80.95[ab]	19.05[a]	73.81[a]	8.82	77.42	22.58[a]	1.23	90.48
40.0-44.9	89.58[a]	10.42[ab]	87.50[a]	2.33	71.43	28.57[a]	1.29	112.50
45.0-49.9	91.18[a]	8.82[b]	88.24[a]	3.23	73.33	26.67[a]	1.33	117.65
≥50.0	90.00[a]	10.00[ab]	85.00[a]	5.56	76.47	23.53[a]	1.27	108.33
Chi-square	16.408	16.408	25.367	7.396	3.700	13.870	0.737	8.336
P	0.006	0.006	0.000	0.193	0.593	0.016	0.981	0.139
Overall	82.94	17.06	76.97	7.18	60.71	16.27	1.23	94.84

P: Statistical significance value.
[a, b]: Means with different superscripts in the same column significantly differ ($P<0.05$).

Table 4. Effect of flock diversity, year, estrus type, insemination type, birth type, doe age, and doe live weight on gestation length and number of services per conception in Hair goats.

Variation Sources	n	GL (day)	NSPC
Flock		**NS**	**NS**
1	102	148.4±0.38	1.67±0.13
2	92	149.0±0.36	1.70±0.12
Year		NS	NS
2012	67	148.8±0.42	1.76±0.14
2013	49	148.0±0.43	1.69±0.15
2014	78	149.4±0.40	1.62±0.15
Estrus type		NS	*
Sponge	97	148.7±0.34	1.80±0.12
Spontaneous	97	148.8±0.40	1.58±0.14
Insemination type		NS	***
Artificial	78	148.6±0.38	2.20±0.13
Traditional	116	148.8±0.37	1.18±0.13
Birth type		NS	NS
Single	153	148.8±0.25	1.66±0.18
Multiple	41	147.7±0.53	1.72±0.09
Age of doe		NS	*
2	13	149.1±0.78	1.74±0.27[a]
3	44	148.5±0.45	1.74±0.21[a]
4	34	149.0±0.60	1.69±0.16[ab]
≥5	103	148.3±0.30	1.58±0.11[b]
Live weight of doe		NS	*
25.0-29.9	15	147.9±0.67	1.80±0.23[a]
30.0-34.9	25	148.6±0.56	1.75±0.18[ab]
35.0-39.9	31	148.3±0.54	1.70±0.19[bc]
40.0-44.9	42	148.7±0.53	1.63±0.17[cd]
45.0-49.9	51	149.1±0.52	1.55±0.19[d]
≥50.0	30	149.8±0.48	1.70±0.18[bc]
Overall	194	148.7±0.19	1.65±0.08

NS: Not significant ($P>0.05$); *: $P<0.05$; **: $P<0.01$; ***: $P<0.001$.
[a, b, c, d]: Means with different superscripts in the same column significantly differ ($P<0.05$).
GL: Gestation length; NSPC: Number of services per conception.
Values (except overall) represent the least square mean ± standard error.

Table 5. Effects of flock diversity, year, estrus type, insemination type, birth type, doe age, and doe live weight on milk yield characteristics in Hair goats.

Variation Sources	n	LL	LMY	DMY
Flock		NS	NS	NS
1	102	161.42±4.35	131.18±6.40	0.797±0.028
2	92	158.66±3.99	127.40±5.88	0.790±0.026
Year		NS	*	*
2012	67	156.54±4.35	121.54±6.40^{b}	0.755±0.028^{b}
2013	49	159.56±4.70	126.89±6.92^{b}	0.784±0.030^{b}
2014	78	164.02±4.95	139.44±7.29^{a}	0.841±0.032^{a}
Estrus type		NS	NS	NS
Sponge	97	160.06±3.96	126.25±5.83	0.778±0.026
Spontaneous	97	160.02±4.46	132.33±6.57	0.808±0.029
Insemination type		NS	NS	NS
Artificial	78	161.63±4.18	129.92±6.15	0.794±0.027
Traditional	116	158.45±4.26	128.66±6.28	0.792±0.027
Birth type		NS	*	NS
Single	153	156.34±5.87	124.25±8.65	0.788±0.038
Multiple	41	161.74±3.02	133.33±4.45	0.809±0.019
Age of doe		***	***	***
2	13	142.92±9.48^{c}	102.97±13.96^{c}	0.714±0.061^{b}
3	44	145.64±4.73^{c}	109.79±6.97^{c}	0.734±0.031^{b}
4	34	168.20±6.41^{b}	140.73±9.43^{b}	0.843±0.041^{a}
≥5	103	183.40±3.15^{a}	163.66±4.64^{a}	0.882±0.020^{a}
Live weight of doe		*	*	*
25.0-29.9	13	149.34±5.56^{bc}	121.13±8.18^{cd}	0.778±0.036^{bcd}
30.0-34.9	26	152.43±5.82^{c}	119.67±8.58^{d}	0.766±0.038^{cd}
35.0-39.9	29	160.48±7.33^{bc}	114.09±10.79^{d}	0.721±0.047^{d}
40.0-44.9	41	165.05±5.84^{a}	135.40±8.60^{bc}	0.806±0.038^{ab}
45.0-49.9	53	169.73±5.23^{a}	148.27±7.69^{a}	0.862±0.034^{a}
≥50.0	32	163.21±6.02^{ab}	137.18±8.86^{ab}	0.828±0.039^{abc}
Overall	194	170.93±2.51	145.58±3.80	0.835±0.014

NS: Not significant (P>0.05); *: P<0.05; ***: P<0.001.
[a, b, c, d]: Means with different superscripts in the same column significantly differ (P<0.05).
Values (except overall) represent the least square mean ± standard error.
LL: Lactation length, LMY: Lactation milk yield, DMY: Daily milk yield

Table 6. Phenotypic correlations among reproductive traits and milk yield characteristics of Hair goats.

	LMY	LL	DMY	GL	NSPC
LL	0.864**				
DMY	0.903**	0.587**			
GL	0.070	0.104	0.020		
NSPC	-0.062	-0.019	-0.080	0.080	
Litter Size	0.211*	0.187*	0.176*	0.045	0.090

*: P<0.05; ***: P<0.001; LL: lactation length; LMY: lactation milk yield; DMY: daily milk yield; GL: gestation length; NSPC: number of services per conception.

CONCLUSION

In this study, it was determined that the majority of fertility parameters in Hair goats were influenced by flock diversity, year, estrus synchronization type, insemination type, doe age and doe live weight. It was also determined that milk yield parameters were influenced by estrus synchronization type, birth type, and doe age and live weight. The highest performances in the Hair goats regarding fertility traits and milk yield were determined in 5-year-old goats, and in goats between 45.0-49.9 kg live weight. In addition, it was observed that kid yield was increased by synchronization with the fluorogestone acetate intravaginal sponge and in goats bred via the traditional method, and a positive correlation was identified between litter size and milk yield parameters. The results further indicated that increased performance can be attained by minimizing the effects of environmental factors. While environmental effects cannot be eliminated completely, taking precautions, such as providing better nutrition regimes during extreme climatic conditions, providing green feeds and better management in farms, and providing multivitamin and mineral supplements during pregnancy, may contribute to better performance.

ACKNOWLEDGEMENTS

This study was partially supported financially by the Office of Scientific Research Projects of Van Yuzuncu Yil University (YYUBAP) [grant number 2011-VF-B035]. The authors thank to YYUBAP. This study was partially presented as an abstract and oral presentation at the 6th National Veterinary Animal Science Congress, June 1-4, 2016, in Kapodakya, Turkey. Research was conducted according to the Yuzuncu Yil University Animal Researches LocalEthic committee on animal use (protocol/file number 2015/07). The authors give special thanks Spandidos Language Editing Service for English language and grammar.

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