

Effects of milking system in suckling period on growth, reproduction traits, and milk yield of East Friesian-cross dairy sheep

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ABSTRACT - The main objective of this study was to determine the effects of milking system on growth, reproduction, and milk yield and composition of East Friesian-cross (Tahirova) dairy sheep that were milked in the evening during the suckling period. A total of 43 Tahirova ewes and 58 lambs were used in the present study. One of the groups was milked in the evening (evening milked; EM) before coming together with their lambs, and the other group was not (not milked in the evening; NEM). Morning milking was performed in both groups during the study. Lambs in both groups were individually weaned at the age of 60 days. There was no statistical difference between the lambs' live weight at weaning in the EM and NEM groups, determined to be 23.46 and 24.11 kg, respectively. Live weight values of lambs were similar in the groups at ages of up to 180 days. The reproductive characteristics of ewe lambs in the EM and NEM groups, having similar growth rates and a similar live weight and body condition in the first estrus stages, were also similar. The return rate and frequency of return were close in both groups of ewe lambs. Milk yield of the NEM group was significantly higher than that of the EM group before and after weaning. However, in groups with similar lactation milk yield and length, the total marketable milk yield was higher in the suckling period of the EM group. The milking system in suckling period of Tahirova ewes does not significantly affect growth, average daily gain, and reproductive characteristics. Milk yield in the NEM group before and after weaning was significantly higher than the EM group, but the total marketable milk yield was higher in the EM group.

Keywords: Tahirova ewes, evening milking, growth rate, first estrus, milk yield, milk composition

1. Introduction

Studies conducted on dairy cattle and dairy goats show that the lactation curve and persistence are different from those obtained from dairy sheep (Tölü et al., 2009; Pollott, 2011). While both dairy cattle and goats reach a peak in 2-3 months of their lactation, dairy sheep having a shorter lactation time starting with a high milk yield during lambing, reach their peak in a short time (30-45 days) and then decline (Cannas et al., 2002; Oravcova et al., 2006; Pulina et al., 2007). Therefore, in the period when the highest yield of the lactation can be observed in dairy ewes, it is important to assess which milking system in suckling period obtains a higher milk yield without adversely affecting the growth performance of lambs. Milking performed only after weaning may adversely affect the milk yield and marketable milk yield in dairy sheep (Gargouri et al., 1993; McKusick et al., 2001).

In dairy goat production in Turkey, evening milking is widely used for does, which are separated from their kids during the day (Keskin, 2002; Uğur et al., 2004; Tölü and Savaş, 2012). Dairy sheep, like dairy goats, can produce more milk for the suckling of their lambs. Yet, milking practice in the suckling period of dairy sheep raised in Turkey is limited (Altın and Çelikyürek, 1996; Dikmen et al., 2007). It has been determined that suckling or partly milking programs significantly affect the growth of lambs and the milk yield characteristics of ewes (Knight et al., 1993; McKusick et al., 2001; Margetín et al., 2020). While there are several studies on the effects of the practices in suckling period on the next reproductive performance of ewes (deNicolo et al., 2006; Godfrey and Weis, 2016; Murphy et al., 2017), studies on the breeding performance of the female lambs are scarce (Gaskins et al., 2005).

Tahirova genotype (75% East Friesian, 25% Kıvrıkcık), developed using the East Friesian sheep breed is a good dairy sheep in terms of milk and growth characteristics among the genotypes bred in Turkey (Kaymakçı and Taşkın, 2001; Sönmez et al., 2009). Therefore, the milking system and lamb rearing programs need to be examined in the Tahirova sheep genotype. The objectives of the present experiment were to study growth, reproduction, survivability of lambs, and milk yield and composition of dairy ewes managed with the evening milking and no-evening milking systems. Additionally, differences between sexes, birth types of growth and survivability of lambs, and birth types of reproduction of ewe lambs were measured.

2. Material and Methods

Research on animals was conducted according to the local Animal Experiments Ethics Committee on animal use (no. 2020/04-09).

2.1. Experimental design

In the study, a total of 43 Tahirova ewes ($88.18 \pm 0.67\%$ East Friesian) and 58 lambs ($89.15 \pm 3.62\%$ East Friesian), born in a three-week period, were divided into two groups by their date of birth, age, parity, and birth weight and type. In this sense, the study was conducted on a factorial design with unbalanced subgroup sample sizes. Mothers and lambs were kept together for one week after birth. Mothers and lambs, which were separated in the morning (08:00 h) after one week, were brought together in the evening (17:00 h), in both groups. While one of the groups was milked in the evening (evening milked; EM) before being together with their lambs, the other group was not milked (not milked in the evening; NEM). Morning milking was performed in both groups during the study.

Lambs in both groups were individually weaned at the age of 60 days. In the EM group, there were 13 single-born and 16 twin (12 males; 17 females) lambs, and 21 sheep with a mean age of 3.09 (1-6 years) and 2.81 parity. In the NEM group there were 15 single-born and 14 twin (12 males; 17 females) lambs and 22 sheep, also with a mean age of 3.09 (1-6 years) and parity of 2.81. Ewes and lambs, housed in separate compartments for 9 h during the day, were gathered in the evening and housed together for 15 h.

2.2. Lamb and ewe lamb management

The creep feeding system was used in the present study (Tölü and Savaş, 2012). It is presented as *ad libitum* with alfalfa hay (89.80% DM; 17.80% CP), concentrate feed in pellet form (92.74% DM; 18.46% CP), water, and a lick stone to the lambs from the age of one week. Alfalfa hay of 0.8 kg and 0.7 kg of concentrate feed in pellet form per day was given per lamb after 3-4 months of age in group condition. While the amount of alfalfa hay was similar in this feeding system during the breeding season (three months), 0.5 kg concentrate feed and 0.3 kg grain barley (89.72% DM; 11.53% CP) were presented under group conditions.

2.3. Ewe management

Early-, middle-, and late-lactation periods were taken into account in the feeding of ewes (NRC, 2007). While corn silage (32.48% DM; 8.14% CP) and alfalfa hay were the roughage, the concentrate feed was in pellet form (91.77% DM; 18.45% CP) for the ewes. The mothers were given 0.6-0.8 kg of alfalfa hay, 1.5-3.0 kg of corn silage, and 0.4-1.1 kg of concentrate per animal per day, depending on the stage of lactation. Concentrate feed was given to each ewe individually in 2×12 parallel milking units in the morning and evening. In addition, a total of 0.5 kg whole-grain barley was given to each ewe in the morning and evening for 60 days during the breeding period.

2.4. Measurements

Lambs were weaned individually at the age of 60 days and housed in separate compartments from their mothers; live weight controls were followed individually at two-week intervals until the age of 90 days, and at monthly intervals after this age. Estrus synchronization was performed with sponges impregnated with hormones for the mothers, and mating was carried out by the hand-mating method on September 20.

For synchronization, a vaginal sponge containing 60 mg MAP (medroxy-progesterone acetate) was used, and 500 I.U. PMSG (pregnant mare serum gonadotropin) were applied intramuscularly, and the sponge was withdrawn at 14 days. After this date, estrus controls were carried out by ewes and ewe lambs with aproned rams. The ewe lamb in estrus and returning ewe were mated by the hand-mating method. To test the milk, daily checks of the ewes were carried out three times at 20-day intervals before the weaning period and at monthly intervals after weaning, amounting to 10 times in total. The daily milk yield measurement with machine milking before weaning was made after the mother and lamb were separated on consecutive days (Tölü and Arıkan, 2019). Milk yield characteristics of the ewes were calculated from the test-day milk records using the Holland method (Tölü et al., 2010). The interval between lambing and test-day milk yield decreased to 100 mL was calculated as lactation length. An estimate of the lactation milk fat and milk protein yield was obtained from the milk amount and milk composition ratios for the same period. While the yield of milk was made with the mechanical meter of the milking unit, analysis of the milk compositions in the milk samples, taken in 25 mL plastic tubes, was performed in the laboratory with a milk analyzer (Milk-Lab Minor®) (Tölü et al., 2016).

2.5. Statistical analysis

Live weight and average daily gain (ADG) data were analyzed using the PROC MIXED (1) procedure of SAS (Statistical Analysis System, 1999) under the statistical model below:

$$y_{ijklmn} = \mu + \alpha_i + \beta_j + \Gamma_k + \Delta_l + E_{im} + e_{ijklmn}, \quad (1)$$

in which y_{ijklmn} = observed variable, μ = the general constant, α_i = fixed effect of group (i = EM, NEM), β_j = fixed effect of sex (j = ♀, ♂), Γ_k = fixed effect of birth type (k = single, twin), Δ_l = fixed effect of maternal age (l = 1-2, 3-4, 5-6), E_{im} = random repeated effect, and e_{ijklmn} = random error term. Tukey test was used in the *post hoc* analysis.

The survivability of lambs, return rate, and frequency of return were analyzed by the GEE (2) (generalized estimating equations) method (SAS, 1999) under the statistical model below:

$$y_{ijkim} = \Theta (\alpha_i + \beta_j + \Gamma_k + \Delta_{kl}), \quad (2)$$

in which y_{ijkim} = observed variable, Θ = function of standard normal distribution, α_i = fixed effect of group (i = EM, NEM), β_j = fixed effect of birth type (j = single, twin), Γ_k = fixed effect of maternal age (k = 1-2, 3-4, 5-6), and Δ_{kl} = random repeated effect. WALD chi-square test was used in the *post hoc* analysis.

Data of milk yield traits were analyzed using the PROC MIXED (3) procedure of SAS (1999). In the analysis of milk compositions, the amount of milk was added to the statistical model below as a covariant.

$$Y_{ijklmn} = \mu + \alpha_i + \beta_j + \Gamma_k + \Delta_l + E_{im} + b(x_n) e_{ijklmn}, \quad (3)$$

in which y_{ijklmn} = observed variable, μ = general constant, α_i = fixed effect of group (i = EM, NEM), β_j = fixed effect of period (j = evening, morning), Γ_k = fixed effect of maternal age (k = 1-2, 3-4, 5-6), Δ_l = fixed effect of control day (l = 1,...10), E_{im} = random repeated effect, b = regression coefficient, x_n = test-day milk yield, and e_{ijklmn} = random error term. Tukey test was used in *post hoc* analysis. Since the interactions of the effects are not significant for all traits ($P > 0.05$), the interactions were ignored.

3. Results

3.1. Growth, reproduction, and survivability

The live weight values of Tahirova sheep lambs, which were subjected to different milking programs during the suckling period, were similar in the groups at ages up to 180 days (Table 1).

Male lambs had a significantly higher weight than female lambs; similarly, single-born lambs had a higher weight than twin lambs at all ages (Table 1). The live weight of the lambs on the 30th and 45th days differed significantly according to the maternal age ($P \leq 0.05$; data not shown). While the difference between milking system \times sex was not significant in weaning on day 60, the live weight of the 120 males was significantly higher than that of females (Figure 1). It can be said that evening milking of Tahirova sheep does not cause a significant difference of lamb live weight in weaning and on the 120th day. In the present study, while no significant effect was observed in the birth type of the EM and NEM groups in weaning ($P > 0.05$), there was a significant difference in these groups according to the birth type on the 120th day ($P \leq 0.05$). Single lambs in the NEM group had a higher live weight than single lambs in the EM group and twin lambs in both groups ($P \leq 0.05$).

Male lambs showed higher ADG (kg) than females at birth-15th day, and at 61-75th days, 76-90th days, 61-120th days, and 0-120th days (Table 2). Single lambs had higher values than twin lambs at 0-15th days, 16-30th days, 31-45th days, 0-60th days, and 0-180th days ($P \leq 0.05$). The mother age significantly affected the ADG at 16-30th and 31-45th days ($P \leq 0.05$; data not shown).

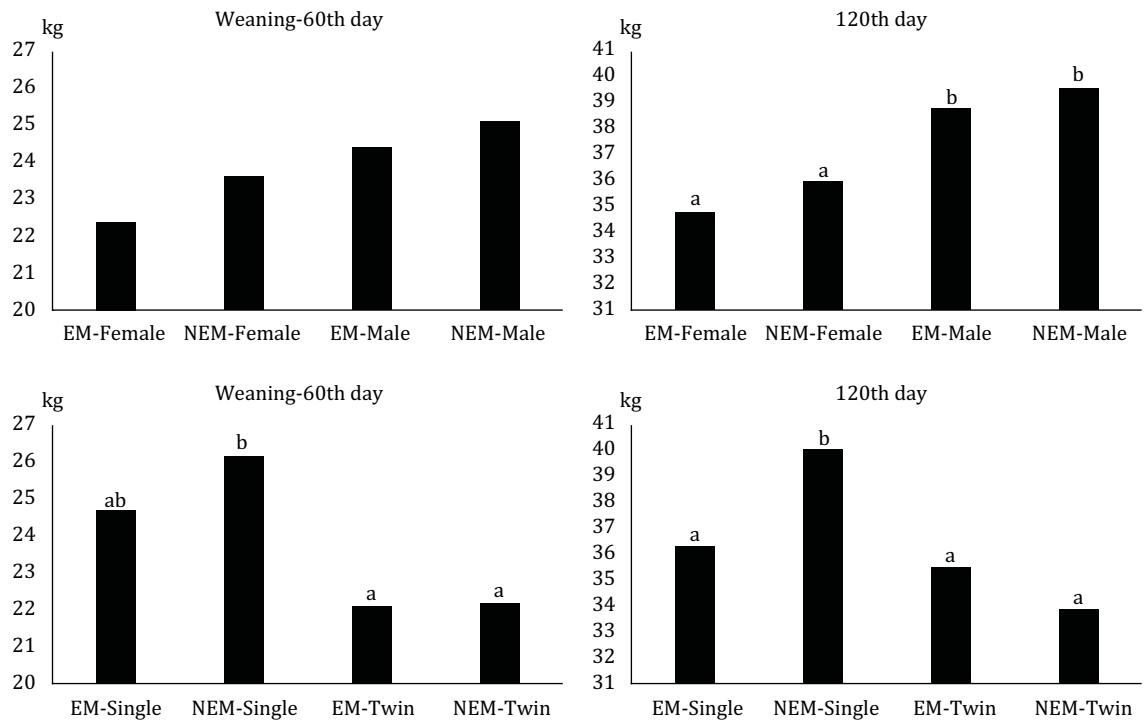
Table 1 - Least squares means (LSM), standard error of the mean (SEM), and P-values of live weight (LW) of lambs at different ages by milking system, sex, and birth type

Period	Milking system			Sex			Birth type			SEM
	EM	NEM	P-value	Female	Male	P-value	Single	Twin	P-value	
	LSM	LSM		LSM	LSM		LSM	LSM		
Birth	4.84	4.79	0.7374	4.63	5.01	0.0468	5.23	4.40	0.0023	0.21
15th day	9.62	9.33	0.4583	8.81	10.14	0.0015	10.27	8.68	<0.0001	0.38
30th day	14.19	13.71	0.4699	13.18	14.72	0.0157	15.18	12.72	<0.0001	0.61
45th day	18.92	19.14	0.5630	18.02	20.04	0.0138	20.76	17.29	<0.0001	0.73
60th day ¹	23.46	24.11	0.5076	22.88	24.69	0.0459	25.55	22.02	0.0006	1.04
75th day	28.27	28.80	0.5972	26.94	30.12	0.0199	30.35	26.72	0.0030	1.29
90th day	31.91	32.97	0.3360	30.42	34.45	0.0063	34.32	30.56	0.0097	1.38
120th day	36.91	37.59	0.5789	35.21	39.28	0.0067	39.10	35.39	0.0305	1.47
180th day ²	40.95	41.36	0.2389	-	-	-	44.20	38.12	0.0201	2.05

EM - evening milked; NEM - not-milked in the evening.

¹ Weaning.

² Only females.



EM - evening milked; NEM - not-milked in the evening.

The difference between means shown by different letters within each graph is statistically significant ($P \leq 0.05$).

Figure 1 - Live weight (kg) of lambs and significant levels of milking system for 60th (weaning) and 120th days according to sex and birth type.

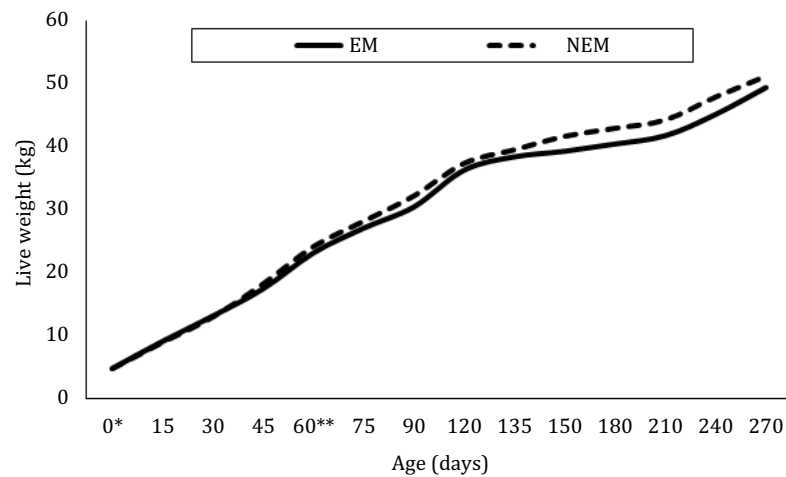
Table 2 - Least squares means (LSM), standard error of the mean (SEM), and P-values of average daily gain (ADG, kg) of lambs at different ages by milking system, sex, and birth type

Period	Milking system			Sex			Birth type			SEM
	EM	NEM	P-value	Female	Male	P-value	Single	Twin	P-value	
	LSM	LSM		LSM	LSM		LSM	LSM		
0-15th days	0.308	0.302	0.8478	0.277	0.333	0.0149	0.325	0.285	0.0049	0.02
16-30th days	0.306	0.292	0.6555	0.292	0.306	0.1241	0.329	0.268	0.0001	0.03
31-45th days	0.327	0.354	0.6109	0.325	0.355	0.4977	0.376	0.304	0.0007	0.03
46-60th days	0.302	0.331	0.2917	0.324	0.310	0.5893	0.318	0.315	0.2253	0.04
61-75th days	0.320	0.312	0.7486	0.271	0.362	0.1590	0.319	0.313	0.8568	0.04
76-90th days	0.243	0.278	0.3523	0.232	0.288	0.0024	0.264	0.256	0.9869	0.03
91-120th days	0.190	0.174	0.4879	0.178	0.185	0.1876	0.175	0.188	0.4535	0.01
0-60th days	0.311	0.321	0.6453	0.304	0.328	0.2345	0.339	0.293	0.0026	0.01
61-120th days	0.224	0.224	0.5558	0.205	0.243	0.0504	0.226	0.223	0.8156	0.01
0-120th days	0.265	0.270	0.4816	0.256	0.285	0.0112	0.278	0.258	0.0492	0.01
0-180th days	0.206	0.206	0.4904	-	-	-	0.224	0.188	0.0471	0.01

EM - evening milked; NEM - not-milked in the evening.

The lambs in the EM and NEM groups had very close live weight values from birth until the 120th day, especially after the male lambs left the herd, but showed little difference after this age ($P > 0.05$) (Figure 2). Female lambs in the NEM group followed a slightly higher live weight curve than female lambs in the EM group between 120-270th days.

The survival rate was 96.5% in the EM group and 93.1% in the NEM group until 120 days in males and 270 days in females (Table 3). After estrus synchronization was performed in the mothers, the return



EM - evening milked; NEM - not-milked in the evening.
* Birth; ** Weaning.

Figure 2 - Live weight (kg) of Tahirova sheep lambs of different ages by milking system.

Table 3 - Least squares means \pm standard errors (LSM \pm SE) and significance levels of survival rate and reproductive characteristics by milking system and birth type

Trait	Milking system			Birth type ¹		
	EM	NEM	P-value	Single	Twin	P-value
	LSM \pm SE	LSM \pm SE		LSM \pm SE	LSM \pm SE	
Lamb yield/ewe	1.38 \pm 0.10	1.32 \pm 0.10	0.5991	-	-	-
Survival rate (%)	96.5 \pm 3.44	93.1 \pm 4.78	0.5778	92.8 \pm 4.95	96.7 \pm 3.33	0.5342
Return rate in ewe (%)	4.7 \pm 0.04	13.6 \pm 0.07	0.3418	14.3 \pm 6.73	0.00	0.0516
First estrus age (days)	252.1 \pm 2.63	246.8 \pm 2.76	0.1720	253.6 \pm 3.16	251.0 \pm 3.12	0.2913
Last mating age (days)	269.6 \pm 7.89	260.9 \pm 7.32	0.3004	275.1 \pm 6.80	255.3 \pm 5.46	0.0347
Return rate in ewe lamb (%)	42.8 \pm 13.72	25.0 \pm 13.05	0.2736	44.4 \pm 17.56	29.4 \pm 11.39	0.3555
Return frequency in ewe (times)	2.0 \pm 0.51	3.0 \pm 0.57	0.4154	3.0 \pm 0.70	1.8 \pm 0.37	0.2224
Live weight at first estrus (kg)	45.5 \pm 2.32	47.4 \pm 2.16	0.4063	48.5 \pm 2.26	44.5 \pm 2.29	0.3329
BCS at first estrus (1-5)	3.00 \pm 0.06	2.91 \pm 0.06	0.1202	2.97 \pm 0.06	2.94 \pm 0.06	0.9313

EM - evening milked; NEM - not-milked in the evening; BCS - body condition score.

¹ Lamb number for ewe in birth.

rate in the milking system groups was 4.7% in the EM group and 13.6% in the NEM group. While no return was observed in mothers that gave birth to twins, the rate of return was 14.3% in those that gave birth to single lambs ($P \leq 0.05$).

The live weight and body condition in the first estrus ages of ewe lambs in EM and NEM groups were similar (Table 3). Ewe lamb twins showed their first estrus at a significantly earlier age than ewe lamb singles ($P \leq 0.05$). Ewe lamb twins also had a slightly lower frequency of return ($P > 0.05$).

3.2. Milk yield and composition

It was determined that evening milking applied during the suckling period significantly affects the amount of milk per milking in the EM and NEM groups before weaning (Table 4). A higher milk yield was obtained in the NEM group than in the EM group ($P \leq 0.05$). Milk composition was similar in the EM and NEM groups ($P > 0.05$). Milk yield was higher in the morning milking than in the evening milking, and milk fat ratio was higher in the evening milking than in the morning milking ($P \leq 0.05$). The amount

Table 4 - Least squares means (LSM), standard error of the mean (SEM), and P-values of milk yield (L) and milk composition (%) by milking system and milking periods in pre- and post-weaning

Trait	Pre-weaning						SEM
	Milking system			Milking period			
	EM	NEM	P-value	Evening	Morning	P-value	
	LSM	LSM		LSM	LSM		
Milk yield (L)	0.70	0.78	0.0170	0.51	0.98	<0.0001	0.02
Milk fat (%)	4.01	4.21	0.5213	5.30	2.93	<0.0001	0.26
Milk protein (%)	4.54	4.55	0.7671	4.52	4.58	0.2393	0.03
SNF (%)	9.54	9.48	0.4546	9.46	9.56	0.3314	0.06
Lactose (%)	4.36	4.33	0.4344	4.29	4.34	0.3358	0.03
Trait	Post-weaning						SEM
	Milking system			Milking period			
	EM	NEM	P-value	Evening	Morning	P-value	
	LSM	LSM		LSM	LSM		
Milk yield (L)	0.40	0.46	0.0002	0.37	0.48	<0.0001	0.02
Milk fat ¹ (%)	7.36	7.50	0.2741	8.35	6.51	<0.0001	0.09
Milk protein (%)	4.57	4.55	0.7524	4.52	4.60	0.0930	0.03
SNF ¹ (%)	9.54	9.48	0.4858	9.46	9.56	0.1394	0.06
Lactose (%)	4.36	4.33	0.4097	4.32	4.37	0.2742	0.03

EM - evening milked; NEM - not-milked in the evening; SNF - solids not-fat.

¹ Milk yield is included in the model of milk fat (P = 0.0227) and SNF (P = 0.0372).

of milk varied significantly according to maternal age and milk compositions according to the control days ($P \leq 0.05$; data not shown).

After weaning, a higher milk yield was obtained in the NEM group compared with the EM group (Table 4). Milk compositions were similar in the EM and NEM groups ($P > 0.05$). Similar to pre-weaning, milk yield was higher in the morning milking than in the evening milking, and there was a higher milk fat ratio in the evening milking than in the morning milking ($P \leq 0.05$). While milk yield varied significantly according to maternal age, milk yield and milk compositions differed significantly according to the control days ($P \leq 0.05$; data not shown).

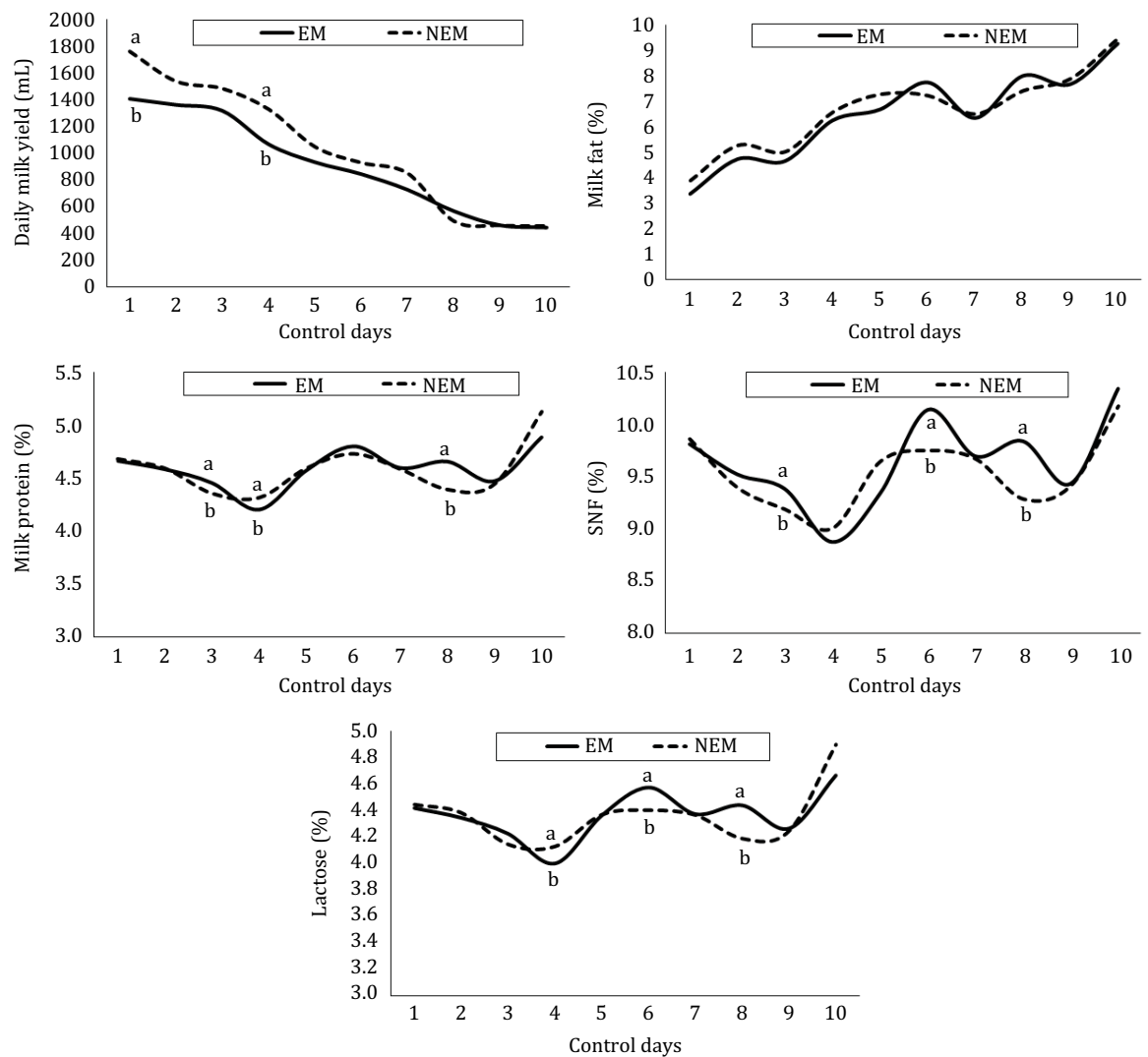
The total milk yield during the suckling period varied significantly according to the two groups (Table 5). Lactation period, milk yield, and milk content were similar in the groups. While milk was obtained only in the EM group during the evening milking in the suckling period, slightly more milk was obtained in the NEM group compared with the EM group during the morning milking ($P = 0.3467$).

Daily milk yield and milk composition changes were observed in the EM and NEM groups and control days (Figure 3). The average daily milk yield in the NEM group was slightly higher than in the EM group until the eighth control day, after which it was at a similar level. The daily milk yield of the EM and NEM groups differed significantly on the first and fourth control days ($P \leq 0.05$). While the milk fat content was at similar levels in the groups during the control days, similar trends were observed in the proportions of the groups throughout the study. The trends of milk protein content were similar in the groups compared with the control days, although the protein content between the groups differed significantly on the third, fourth, and eighth control days ($P \leq 0.05$). While solids-not-fat (SNF) content differed significantly between the groups on the third, sixth, and eighth control days, it followed a slightly more volatile curve, especially in the EM group ($P \leq 0.05$). Lactose content varied between the groups on the third, sixth, and eighth control days, similar to the SNF ($P \leq 0.05$).

Table 5 - Least squares means \pm standard errors (LSM \pm SE) and P-values for lactation traits by milking system

Trait	Milking system		P-value
	EM	NEM	
	LSM \pm SE	LSM \pm SE	
Lactation length (days)	207.75 \pm 12.67	213.89 \pm 12.31	0.7290
Milking period (days)	147.75 \pm 12.67	153.89 \pm 12.31	0.7290
Milking milk yield (L/ewe)	127.18 \pm 11.82	144.18 \pm 14.25	0.3069
Totally milk yield in suckling period (L/ewe)	78.62 \pm 4.26	93.07 \pm 4.20	0.0192
Milk fat (%)	6.58 \pm 0.10	6.74 \pm 0.09	0.2424
Milk fat (kg/ewe)	11.72 \pm 1.09	13.65 \pm 1.08	0.2140
Milk protein (%)	4.57 \pm 0.02	4.57 \pm 0.02	0.8371
Milk protein (kg/ewe)	9.29 \pm 0.65	10.60 \pm 0.65	0.1618
Totally milk yield of evening in suckling period (L/ewe)	24.15 \pm 1.45	-	-
Totally milk yield of morning in suckling period (L/ewe)	2.34 \pm 0.83	3.47 \pm 0.83	0.3467

EM - evening milked; NEM - not-milked in the evening.



EM - evening milked; NEM - not-milked in the evening; SNF - solids-not-fat.

The difference between means within each trait shown with different letters on the same control day is statistically significant ($P \leq 0.05$).

Figure 3 - Change of daily milk yield (mL) and milk compositions (%) by milking system and control days.

4. Discussion

4.1. Growth, reproduction, and survivability

The live weight values of Tahirova sheep lambs, which were subjected to different milking programs during the suckling period, were similar in the groups. In a study on dairy sheep in Slovakia, it was determined that the live weight of lambs was similar among the groups in artificially raised, once-daily milked, and not-milked groups (Margetín et al., 2020). In East Friesian sheep, it was found that the live weight and ADG on the 30th day were similar among the groups, which artificially reared lambs; after the morning milking of the suckled lambs and continuously suckled lambs, the live weight mean on the 120th day was determined as 43.7, 45.9, and 47.3 kg in the groups, respectively (McKusick et al., 2001). In another study, comparing East Friesian and Lacaune sheep raised in USA, the live weights on the 30th day were reported as 14.3 kg in East Friesian lambs and 13.3 kg in Lacaune lambs, then 48.4 and 48.9 kg in the genotypes on the 150th day, respectively (Thomas et al., 2014).

The higher values of male lambs compared with female lambs on the 120th day were similar in both groups. In a study conducted on the crosses of East Friesian × Wallachian sheep, there was a significant change among birth types on the 30th, 70th and 100th days; live weight was determined to be higher only in males on the 100th day (Kuchtik and Dobes, 2006). In East Friesian sheep, significantly higher live weight was found in males than in females (McKusick et al., 2001).

Average daily gain determined in different age ranges of the Tahirova lambs were similar in all ages according to the milking groups (Table 2). In East Friesian ewes, regarding the three groups of lambs that were examined (artificially raised, those whose mothers were milked and suckled, and those continuously suckled), the ADG were 350.9, 321.8, and 338.1 g, respectively, during the 0-30th days. For the same groups, the ADG were 314.4, 348.0, and 358.2 g respectively, for the 0-120th days (McKusick et al., 2001). Margetín et al. (2020) reported that ADG was similar in groups from birth to weaning periods. In the present study, it can be said that the live weight and growth values determined in Tahirova sheep lambs are similar to the values determined in East Friesians and their crosses, especially until the age of 2-3 months, then they are slightly lower for the following periods. However, the Tahirova sheep genotype has a higher live weight and growth rate than many sheep genotypes raised in Turkey (Kaymakçı and Taşkın, 2001; Dikmen et al., 2007; Sönmez et al., 2009; Ceyhan et al., 2011). In addition, there are no adverse circumstances in terms of growth and development from the live weight and body condition values in the first breeding stage (Table 3). The growth and development of the Tahirova ewe lamb is at an appropriate level corresponding to the mature body size of ewes. It must be noted that growth in farm animals continues to a remarkable age (Tölü et al., 2009).

In the groups with similar lamb yields per ewe at the beginning of this experiment, the survival rates of lambs were similar (Table 3). The survival rate was 96.5% in the EM group and 93.1% in the NEM group. This value can be considered acceptable for Tahirova sheep lambs with a high proportion of East Friesian genotype. While the survival rates were determined as 82.6 and 86.9% in the Awassi and Awassi × East Friesian crossbreed genotypes up to the 105th day, the survival rates of genotypes up to one year old were determined as 76.9 and 69.2%, respectively (Kul and Akcan, 2002). On the other hand, the survival rate from birth to weaning has been reported as between 83.4 and 97.1% in crossbred lambs with different rates of the East Friesian genotype in USA (Thomas et al., 2014).

The return rate in the milking system groups was similar and 14.3% in those that gave birth to single lambs (Table 3). It was reported that number of corpora lutea present and pregnancy rates of the mothers of the early (69 days) and late (91) lambs weaned did not significantly affect Romney sheep (deNicolo et al., 2006). Also, the effect of time of weaning on subsequent reproductive performance of ewes was similar in Barbados Blackbelly sheep (Knights et al., 2012) and St. Croix White and Dorper sheep (Godfrey and Weis, 2016). With the available data set and findings of the effect of milking during suckling in Tahirova ewe, it is not possible to give any conclusions on the reproductive performance

of the ewes in the present study. This issue needs to be addressed with a greater number of animals and more research.

In the study, the rate of estrus in ewe and ewe lambs in the EM and NEM groups was 100%. The return rate in the milking system groups was similar. Ewe lamb twins showed their first estrus at a significantly earlier age than ewe lamb singles. Osuhor et al. (1997), evaluating eight years of data in Yankasa sheep, determined the average age of first lambing of 533.1 ± 10.3 days and reported that it had no effect on birth weight, birth type, weaning age, and weaning weight. However, it was illustrated that birth season had a significant effect on the first lambing age. In our study, the application of evening milking during the suckling period did not have a significant effect on the use of first breeding in Tahirova ewe lambs. It can be said that Tahirova ewe lambs are in a healthy state in terms of growth rhythm and body condition during the first breeding period. Kenyon et al. (2014) advised that ewe lambs should be at least 35-40 kg, depending on breed, and with a body condition score of 3.0.

Tahirova ewe lambs can be used for first breeding at the age of 4-5 months or at the latest six months, due to their live weight at the age of 4-6 months (Table 1; Figure 1). Sezenler et al. (2014) indicated that for Kivırcık, Chios, and Gökçeada sheep breeds, the live weight and age at first estrus was 37.9, 33.3, and 29.7 kg and 315, 320, and 337 days, respectively. The fact that only mothers that gave birth to singles returned (ewe lambs born to twins had a lesser return rate and frequency of return) draws our attention to multiplicity, which may be an important criterion for the reproductive performance of Tahirova sheep.

4.2. Milk yield and composition

In our study, (suckling to lamb rather than milking), especially during the milking period, milk yield increases in Tahirova sheep. In fact, the total milk yield in the NEM group during the suckling period was significantly higher than the milk yield in the EM group (Table 5). Similar to the results of the present study, in a study with East Friesian sheep (McKusick et al., 2002), the daily milk yield in the 2-4-week suckling period was 2.31 and 3.28 kg for continuously and partly milked groups, respectively. The same study found that the milk yields in the sixth week after weaning was 1.77 kg in continuously milked group and 1.95 kg in partly milked group. In another study conducted on East Friesian sheep, while the length of lactation (179.2-183.4 days) was similar among the groups, the daily milk yields of the groups, whose lambs were artificially raised and suckled after milking by machine in the morning and continuously suckled without milking at all, were found to be 1.42, 1.32, and 1.11 kg, respectively (McKusick et al., 2001). In a study examining the effect of milking during the suckling period in Awassi sheep, the lactation length was found to be similar in the groups, while the daily milk yield was 634 g in the milking group and 568 g in the continuously suckled group (Dikmen et al., 2007). Regarding Poll Dorset sheep, while the total milk yield was highest in the group milked twice, the lowest milked once group, similar milk yields were found in the groups whose lambs suckled after milking in the morning and evening (Knight et al., 1993). Lower milk yield was determined in a group of Chios sheep that were suckled after morning milking, compared with the group whose lambs were artificially raised and milked by a machine twice a day (Tzamaloukas et al., 2015). In a study using data collected over eight years evaluated under farm conditions in Çanakkale, the marketable milk yield per sheep was reported for the sheep breeds of Kivırcık, Chios, and Tahirova as 37.0, 47.4, and 67.5 kg, respectively (Ayağ et al. 2018). In the present study, when the milk yield (127.18 L/ewe) and suckling period total milk yield (78.62 L) were calculated, total milk yield was 205.8 L in the EM group and 237.2 L in the NEM group. The marketable milk yield was 153.67 L (milking milk yield per ewe, 127.18 L + totally milk yield of evening in suckling period per ewe 24.15 L + totally milk yield of morning in suckling period per ewe, 2.34 L) in the EM group and 147.65 L (milking milk yield per ewe, 144.18 L + totally milk yield of morning in suckling period per ewe, 3.47 L) in the NEM group. Hence, the differences between the groups should be evaluated together, including the milk yield, milk composition yield, lamb growth rate, and labor and costs required for evening milking.

The milk composition, lactation milk composition, and composition yield were similar in the EM and NEM groups (Tables 4 and 5). Milk composition in the EM and NEM groups changed significantly on some control days (Figure 3). In East Friesian sheep, the milk fat ratio was determined to be 5.06% and milk protein 5.27% in the group milked by continuous machine, 4.53% fat and 5.14% protein in the group suckled after milking, and 4.81% fat and 5.21% protein in the group suckled continuously. The fat ratios differed significantly according to the groups (McKusick et al., 2001). In the groups that were continuously milked and suckled after milking, the milk fat was 5.48 and 4.77% and milk protein 4.45 and 4.44%, respectively. In the suckling period (2-4 weeks), while milk fat was 5.23 and 5.50%, milk protein was 4.25 and 4.38%, respectively, in the groups in the post-weaning (sixth week) period (McKusick et al., 2002).

While the milk composition determined before suckling in the present study was similar to the milk composition in the suckling period of previous studies, it was observed that the milk composition was found to have higher values after weaning periods, especially after the fourth control day (Figure 3). Thomas et al. (2014) reported milk fat and milk protein as 6.3 and 5.2%, respectively, for East Friesian sheep, while 6.5% milk fat and 5.3% milk protein for Lacaune sheep. In a group that was suckled after the morning milking, the milk fat ratio was significantly lower than the other groups during the suckling period in Chios sheep, while similar milk fat and milk protein ratios were determined in the following periods (Tzamaloukas et al., 2015).

5. Conclusions

The milking system in suckling period of East Friesian-Cross (Tahirova) sheep does not significantly affect the growth and average daily gain of Tahirova lambs. Ewe lambs, which had similar growth rates in the EM and NEM groups, had similar live weight and body condition in the first estrus years and other reproductive characteristics.

In the group in which evening milking was not applied during the suckling period, the milk yield before and after weaning was significantly higher than the EM group. However, in groups with similar lactation milk yield and length, the total marketable milk yield was higher in the EM group.

Conflict of Interest

The authors declare no conflict of interest.

Author Contributions

Conceptualization: C. Tölü. Investigation: C. Tölü and N. Yazgan. Methodology: C. Tölü and N. Yazgan. Writing – original draft: C. Tölü. Writing – review & editing: C. Tölü.

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