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Research Article

Environmental Factors Affecting Milk Yield and Fertility Traits of Simmental Cows Raised at the Kazova State Farm and Phenotypic Correlations between These Traits

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Abstract: The aim of this study was to investigate environmental factors affecting milk yield and fertility traits of Simmental cows raised at the Kazova state farm and the phenotypic correlation between these traits from 1473 records between 1992 and 2001. The least square means of 305-days milk yield, lactation duration, dry period, service period, calving interval, gestation length and number of inseminations per conception (NIPC) were 4700 kg, 300 days, 81 days, 94 days, 379 days, 283.6 days and 1.76, respectively. The effect of calving year on milk yield and fertility traits was statistically significant ($P < 0.001$). The effect of calving age on gestation length and milk yield was also statistically significant ($P < 0.001$-$P < 0.05$). The effect of calving season on gestation length, 305-days milk yield and NIPC was also statistically significant ($P < 0.001$-$P < 0.05$). Birth type did not significantly affect any traits, except for gestation length.

The phenotypic correlations between 305-days milk yield and lactation duration (0.39), between NIPC and service period (0.81), between NIPC and calving interval (0.77), between calving interval and service period (0.96) and between calving interval and gestation length (0.12) were statistically significant ($P < 0.001$). Correlations between milk yield and fertility traits (0.09-0.77) were statistically significant ($P < 0.001$-$P < 0.05$), except for gestation length.
These results are acceptable and it can be concluded that Simmental cattle are raised successfully on this farm and under Turkish conditions.

Key Words: Cattle, Simmental, environmental factors, correlation, milk yield, fertility traits

Kazova Tarım İşletmesinde Yetiştirilen Simental Irkı Sığırların Süt ve Döl Verim Özelliklerine Etkili Çevresel Faktörler ve Bu Özellikler Arasındaki Fenotipik Korelasyonlar

Özet: Bu Çalışma, Kazova Tarım İşletmesinde yetiştirilen Simental ırk ineklerin 1992 - 2001 yılları arasında süt ve döl verimi özelliklerine etkili çevre faktörlerinin ve bu özellikler arası fenotipik korelasyonların incelenmesi amacıyla yapılmıştır. En küçük kareler ortalamaları, süt verimi için 4700 kg, laktasyon süresi için 300 gün, kuru dönem için 81 gün, servis periyodu için 94 gün, buzağılama aralığı için 379 gün, gebelik süresi için 283,6 gün ve her gebelik başına tohumlama sayısı (GBTS) için 1,76 adet bulunmuştur. Buzağılama yılının, süt ve döl verim özelliklerine etkisi ($P < 0,001$) ve buzağılama yaşının, gebelik süresi ve süt verimine etkisi önemli ($P < 0,001$- $P < 0,05$) bulunmuştur. Mevsimin, gebelik süresine, 305 günlük süt verimine ve GBTS'na etkisi önemli ($P < 0,001$- $P < 0,05$) bulunmuştur. Doğum tipinin, gebelik süresi dışındaki diğer özelliklere etkisi önemsiz bulunmuştur.

Süt verimi ile laktasyon süresi (0,39), GBTS ile servis periyodu (0,81) ve buzağılama aralığı (0,77), buzağılama aralığı ile servis periyodu (0,96) ve gebelik süresi arasındaki (0,12) fenotipik korelasyonlar istatistiki olarak önemli ($P < 0,001$) bulunmuştur. Süt ve döl verimi özellikleri arasında (0,09-0,77) gebelik süresi dışında önemli korelasyonlar bulunmuştur ($P < 0,001$- $P < 0,05$).
Sonuç olarak, bulgular beklentilere uygun olup Simental'in bu işletmede ve Türkiye şartlarında başarıyla yetiştirilebileceği söylenebilir.

Anahtar Sözcükler: Sığır, Simental, çevresel faktörler, korelasyon, süt verimi, döl verimi

Introduction

The yields of farm animals are the result of the combined effects of genotype and environmental conditions. In order to increase the yield level, it is necessary to optimise the environmental conditions and to improve the genetic structure of the animals. Environmental factors can be classified as factors with measurable effects (age, year, season, milking frequency, etc.) and factors with unmeasurable effects (infectious diseases, parasitic infestations, etc.). The measurable

effects can be determined and used in the management of the farm.

The 305-days milk yield of Simmental cows was between 2683 and 3227 kg in different studies in Turkey (1,2). Milk yields of Simmental cows were 3371 kg in Russia (3) and 5325 kg in Germany (4). Effects of calving age or parity on milk yield have been varyingly reported as significant (1,2) and as non-significant (5). The effect of season on lactation duration was reported as non-significant (6,7). However, the effect of calving age on lactation duration was reported as significant (7,8).

The gestation length of Simmental cattle has been reported as between 283 and 288 days (9,10). Although Oğan (11) stated that gestation length increased parallel to calving age, İnal and Alpan (12) stated that gestation length increases until 6 years of age and then begins to decrease.

Phenotypic correlation between 305-days milk yield and lactation duration has been determined at between 0.38 and 0.41 (13,14). Phenotypic correlations between NIPC and service period and between NIPC and calving interval were reported as 0.66-0.73 (15,16). Phenotypic correlations between milk yield and NIPC, between milk yield and service period, and between milk yield and calving interval have been reported as 0.09-0.17 and as statistically significant (14,17,18). The correlation between lactation duration and service period has been reported as 0.32-0.66 and as statistically significant (13,14).

This study was conducted to investigate the environmental factors affecting milk yield and fertility traits of Simmental cows raised at the Kazova state farm and the phenotypic correlation between these traits.

Materials and Methods

A total of 1473 lactations and fertility records of Simmental cows raised at the Kazova state farm between 1992 and 2001 were used. Seven age groups were formed beginning from 2 years and ending at 8 years and older for calving age; 4 groups for calving season, and 10 groups for calving year, between 1992 and 2001. The 305-days milk yield was estimated from test milk yields collected once a month during all lactation periods using the Holland method (19). Environmental factors which influenced lactation milk yield, lactation duration, dry period, service period, NIPC, calving interval and gestation length were investigated. The general linear model was used for variance analyses of fertility and milk yield traits. Duncan's multiple range test was used for multiple comparisons. Pearson's phenotypic correlations between milk yield and fertility traits were estimated (20).

Results

Least square means for milk yield traits are presented in Table 1. The average 305-days milk yield was estimated as 4700 kg; 305-days milk yields were lowest in 1993 at 3268 kg, and highest in 2001 at 6236 kg. The highest level in cattle calving in winter was 4819 kg, and the lowest level in cattle calving in summer was 4477 kg.

Average lactation duration was estimated as 300.4 days. The effects of birth type, calving age and season on lactation duration were statistically non-significant ($P > 0.05$). However, the effect of calving year was significant ($P < 0.001$). Lactation duration was shortest in 1997 at 286.3 days and longest in 1992 at 309.7 days.

Average dry period was estimated as 80.93 days. Effects of birth type, calving age and calving season on dry period were statistically non-significant ($P > 0.05$), but the effect of calving year was significant ($P < 0.001$). The dry period was lowest in 1996 at 63.6 days, and highest in 2000 at 103.7 days.

The least square means for gestation length are presented in Table 2. Average gestation length was 283.6 days. Effects of birth type, sex of calf, calving age, year, and season on gestation length were statistically significant ($P < 0.05$-$P < 0.001$). The least square means for service period, calving interval and NIPC are presented in Table 3. The effects of calving age and calving season on service period and calving interval were non-significant ($P > 0.05$), but the effect of calving year was significant ($P < 0.001$). Average service period and calving interval were estimated as 93.87 and 379.1 days, respectively.

Phenotypic correlations between fertility traits and milk yield traits are presented in Table 4. Phenotypic correlation between milk yield and lactation duration was 0.39 and significant. Phenotypic correlations between service period and NIPC and calving interval and NIPC and

Table 1. Least square means of 305-days milk yield, lactation duration and dry period (ϕ).

Factors	305-days Milk Yield (kg)		Lactation Duration (day)		Dry Period (day)	
	n	Mean ± SEM	n	Mean ± SEM	n	Mean ± SEM
Calving Age	***		ns		ns	
2	371	3789 ± 83.1 d	371	297.2 ± 4.22	291	79.6 ± 6.41
3	255	4491 ± 88.3 c	255	299.4 ± 4.48	197	72.5 ± 6.89
4	299	4824 ± 86.6 b	299	299.6 ± 4.39	232	77.2 ± 6.84
5	202	4830 ± 92.8 b	202	303.6 ± 4.71	141	92.7 ± 7.41
6	122	4981 ± 109.4 ab	122	304.0 ± 5.55	98	82.6 ± 8.45
7	99	5128 ± 119.9 a	99	296.1 ± 6.08	80	84.8 ± 9.26
8 and older	125	4859 ± 110.9 b	125	302.6 ± 5.62	71	77.2 ± 9.69
Calving Season	***		ns		ns	
Spring	395	4737 ± 81.9 a	395	301.7 ± 4.15	312	82.4 ± 6.33
Summer	353	4477 ± 80.8 b	353	301.1 ± 4.10	259	87.3 ± 6.44
Autumn	358	4768 ± 83.7 a	358	295.1 ± 4.24	255	76.0 ± 6.60
Winter	367	4819 ± 82.0 a	367	303.4 ± 4.16	284	78.0 ± 6.35
Calving Year	***		***		***	
1992	171	3805 ± 101.8 e	171	309.7 ± 5.16 a	143	85.4 ± 7.74 bcd
1993	155	3268 ± 106.1 f	55	306.0 ± 5.38 ab	111	82.5 ± 8.44 bcde
1994	127	3457 ± 105.8 f	127	304.1 ± 5.36 abc	104	64.9 ± 8.22 e
1995	148	4594 ± 104.8 d	148	307.1 ± 5.32 ab	136	76.4 ± 7.77 cde
1996	158	4681 ± 102.6 d	158	302.6 ± 5.21 abc	133	63.6 ± 7.73 e
1997	169	5146 ± 98.1 c	169	286.3 ± 4.98 d	104	68.6 ± 8.24 de
1998	142	5221 ± 102.9 bc	142	294.0 ± 5.22 cd	103	74.6 ± 8.18 de
1999	148	5163 ± 104.1 c	148	296.7 ± 5.28 bcd	110	95.6 ± 8.30 ab
2000	114	5432 ± 113.2 b	114	307.3 ± 5.74 ab	92	103.7 ± 8.77 a
2001	141	6236 ± 104.3 a	141	289.8 ± 5.29 d	74	94.1 ± 9.24 abc
Birth Type	ns		ns		ns	
Single	1340	4743 ± 28.4	1340	296.6 ± 1.44	1012	84.9 ± 2.34
Twin	49	4658 ± 134.7	49	304.1 ± 6.83	39	77.0 ±10.38
Overall mean	1473	4700 ± 69.2	1473	300.4 ± 3.51	1110	80.9 ± 5.37

ϕ: in Tables, *: P < 0.05; **: P < 0.01; ***: P < 0.001; ns: non-significant; SEM: standard error of the mean. a,b,c: means without a common superscript within each variable and each factor differ (P < 0.05).

service period were positive and statistically significant (P < 0.001). Phenotypic correlations between gestation length and NIPC and service period were not significant (Table 4).

Discussion

Milk yields of Simmental cows are quite different in different countries, and even in different districts in the same country. In this study, average 305-days milk yield

Table 2. Least square means of gestation length (day).

Factors	n	Mean ± SEM
Calving Age	*	
2	328	282.5 ± 0.63 c
3	228	283.2 ± 0.66 bc
4	275	283.9 ± 0.66 ab
5	182	284.0 ± 0.67 ab
6	115	284.6 ± 0.78 a
7	87	284.5 ± 0.82 a
8 and older	116	282.5 ± 0.78 c
Calving Season	***	
Spring	362	284.1 ± 0.62 a
Summer	308	282.3 ± 0.62 b
Autumn	328	283.1 ± 0.63 b
Winter	333	284.9 ± 0.63 a
Calving Year	***	
1992	159	283.9 ± 0.74 a
1993	137	284.5 ± 0.75 a
1994	111	285.4 ± 0.78 a
1995	129	284.8 ± 0.75 a
1996	136	285.4 ± 0.73 a
1997	150	284.7 ± 0.71 a
1998	138	282.2 ± 0.73 bc
1999	138	281.6 ± 0.74 bc
2000	107	281.0 ± 0.79 c
2001	126	282.5 ± 0.75 b
Birth Type	***	
Single	1282	286.7 ± 0.18
Twin	49	280.6 ± 1.10
Sex of Calf	*	
Male	680	284.1 ± 0.58
Female	628	283.1 ± 0.58
Overall mean	1331	283.6 ± 0.56

was 4700 kg. This yield is close to that estimated in Germany (4).

As reported previously (5,6), the effect of calving season on milk yield was significant and milk yield was high in cows calving in winter. Cows calving in winter have high milk yields, due probably to good feeding levels in the first 3 or 4 months of lactation, and increase milk yield due to feed containing alfalfa being given during the period when milk yield begins to decrease. On the other hand, cows calving in summer have low milk yields due to their being subject to high environmental temperatures in the first 3 or 4 months of lactation.

The lowest milk yield was obtained from cows calving at 2 years of age, and the highest from those calving at 7 years of age. Milk yield decreases after 7 years of age. As eported in the literature (5-7), this confirms that milk yield increases with age up to maturity, and decreases thereafter. In this farm, the lowest milk yield was obtained in 1993. After 1993, milk yield increased up to 2001. The reasons for this increase could be the use of bulls with high genetic capacity, selection for milk yield and culling in the herd, and especially improvement in management and feeding conditions. Additionally, adaptation factors may have affected these results. Uniform feeding was started with the importation of silage machine in 1995. This caused the cattle to reflect their genetic capability better. In 2001, that feeding level was improved and stress factors prior to milking decreased (cleaning was done at night), which could also have caused increase in milk yield.

In this study, average lactation duration was 300 days. This was very close to the ideal value (305 days). Lactation duration increased until 6 years of age, and decreased thereafter. The shorter lactation duration in 7-year-old cows may be related to incomplete lactations because of culling.

The average dry period was 81 days. Although lactation duration was at the ideal value, the dry period grew longer as a result of longer calving intervals. The dry period decreased in animals older than 6, a result of keeping old animals with good fertility in the herd. The dry period was above the ideal value in all years. In order to make animals more profitable, it is essential they be made pregnant as soon as possible during the service period in order to shorten the dry period.

Average gestation length was 283.6 days. This is between the limits reported in the literature (9,10). The longest gestation length was in winter, when daylight is short, and the shortest was in summer, when daylight is long. Similarly, it was reported that length of gestation increased by 1.3 days for every 1 h decrease in day length from September to December (21). As reported in the literature (12), gestation length increased up to 6 years of age, and decreased thereafter. The gestation length for single and male births was longer than that for twins and female births, and this result agrees with those of a previous study (8).

Table 3. The least square means of NIPC, service period and calving interval.

Factors		Service period, day	Calving Interval, day	NIPC, number
	n	Mean ± SEM	Mean ± SEM	Mean ± SEM
Calving Age	ns	ns	ns	ns
2	255	96.6 ± 3.53	381.4 ± 3.62	1.80 ± 0.07
3	283	84.4 ± 3.81	369.4 ± 3.90	1.52 ± 0.07
4	209	91.0 ± 4.01	375.8 ± 4.20	1.71 ± 0.08
5	126	98.0 ± 5.25	383.5 ± 5.37	1.84 ± 0.10
6	89	98.0 ± 6.24	384.1 ± 6.39	1.89 ± 0.12
7	65	92.9 ± 7.20	379.6 ± 7.37	1.78 ± 0.14
8 and older	59	92.2 ± 7.48	380.1 ± 7.65	1.78 ± 0.15
Calving Season		ns	ns	*
Spring	323	92.2 ± 3.45	377.4 ± 3.53	1.71 ± 0.07 ab
Summer	238	101.6 ± 3.84	386.0 ± 3.93	1.86 ± 0.08 a
Autumn	246	93.0 ± 3.66	377.9 ± 3.75	1.85 ± 0.07 a
Winter	279	88.7 ± 3.48	375.1 ± 3.56	1.62 ± 0.07 b
Calving Year		***	***	***
1992	128	106.0 ± 6.04 a	392.6 ± 6.18 ab	2.17 ± 0.12 a
1993	119	97.8 ± 5.83 ab	382.0 ± 5.97 abc	2.07 ± 0.11 ab
1994	112	112.1 ± 5.69 a	396.5 ± 5.83 a	2.17 ± 0.11 a
1995	95	89.8 ± 5.99 b	377.9 ± 6.14 bc	1.74 ± 0.12 cd
1996	122	78.9 ± 5.14 c	366.0 ± 5.26 cd	1.55 ± 0.10 cd
1997	123	83.1 ± 5.10 bc	369.9 ± 5.52 cd	1.55 ± 0.10 cd
1998	103	72.5 ± 5.48 c	356.9 ± 5.61 d	1.46 ± 0.11 d
1999	106	88.8 ± 5.44 bc	372.7 ± 5.57 cd	1.79 ± 0.11 bc
2000	100	97.6 ± 5.89 ab	380.9 ± 6.03 abc	1.56 ± 0.12 cd
2001	78	112.2 ± 6.41 a	395.6 ± 6.56 a	1.54 ± 0.13 cd
Overall mean	1086	93.9 ± 2.03	379.1 ± 2.08	1.76 ± 0.04

Table 4. The phenotypic correlations between fertility traits and milk yield traits.

Milk Yield Traits	305-days Milk Yield	Lactation Duration	Dry Period	NIPC	Service period	Calving Interval
Lactation Duration	0.39 ***					
Dry Period	0.02 ns	0.05 ns				
NIPC	0.09 *	0.48 ***	0.61 ***			
Service Period	0.17 ***	0.61 ***	0.75 ***	0.81 ***		
Calving Interval	0.18 ***	0.62 ***	0.77 ***	0.77 ***	0.96 ***	
Gestation Length	-0.06 ns	0.10 *	0.06 ns	0.04 ns	0.001 ns	0.12 ***

The average service period was 93.9 days. This is very close to the ideal value (60-90 days). Therefore, it may be said that accurate oestrus detection and artificial insemination took place at the right time and manner. The fact that the service period and NIPC were shorter in cattle calving in winter may result from the effects of temperature and humidity and the availability of green fodder during the spring, which might favour the physiological functioning of different systems. The rapid increase in milk yield in 2001 may be the reason for the extension of the service period.

Although service period and calving interval decreased up to 4 years of age and then increases thereafter in the literature (11,12), these time periods increased up to 6 years of age, and then decreased thereafter in this study. Decreases in service period in animals older than 7, may result from keeping old animals with good fertility in the herd. The longer service period in 2-year-old cows may result from giving more opportunities for gestation to young animals with infertility. The average calving interval was 379 days. This is near the ideal value (365 days) and acceptable.

Average NIPC was 1.76. That the shortest value was found in cows calving in winter can be related to the inseminations performed in spring. Although NIPC was high between 1992 and 1995, NIPC decreased with accurate oestrus detection and insemination being performed at the right time after 1995.

Phenotypic correlation between milk yield and lactation duration is similar to the value given in the literature (13,14). As lactation duration increases, milk yield increases. The correlation between lactation duration and dry period was positive and statistically insignificant, as reported by Özçelik and Doğan (14).

The correlation between NIPC and service period was high and statistically significant. Based on this result, an increase in NIPC could cause an increase in service period. As reported in the literature (13,14), the highest correlation among fertility traits was between service period and calving interval, and this correlation indicates that service period is the most significant factor affecting calving interval.

In agreement with the literature (14,17,18), the correlations between milk yield and service period, and between milk yield and calving interval were positive and statistically significant. In this study, the increase in milk yield could have caused an increase in NIPC, service period and calving interval. It may also be related to the endocrinal system.

As reported in the literature (13,14), correlations between lactation duration and NIPC, between lactation duration and service period, and between lactation duration and calving interval were positive and statistically significant. As service period and calving interval increase in animals with fertility problems, lactation duration grows longer. In agreement with the literature (14), correlations between dry period and service period and between dry period and calving interval were positive and at high levels in this study. These correlations show that animals with fertility problems could have longer service periods and calving intervals, and consequently, the dry period could increase.

In conclusion, it can be said that Simmental cattle are raised successfully on this farm and under Turkish conditions. Obtaining high fertility and milk yield could be achieved by reducing the factors affecting these traits. Therefore, profitable breeding could be achieved by keeping service period and calving interval between optimal limits.

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