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EFFECT OF NON-GENETIC FACTORS ON REPRODUCTIVE TRAITS IN SIMMENTAL COWS REARED IN SUBTROPICAL CLIMATE CONDITION

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ABSTRACT

This study aimed to determine reproductive traits, such as gestation length (GL), service period (SP), calving interval (CI), number of insemination per pregnancy (NIPC), and first calving age (FCA) and to reveal the non-genetic parameters affecting these traits in Simmental cows raised at a private farm in Çorum Province under subtropical climate conditions according to Trewartha climate grading and Csb based on the Köppen–Geiger system. A total of 1904 reproduction performance records of 706 Simmental cows raised between 2001 and 2014 were utilized in this study. The GL, SP, CI, NIPC, and FCA were 283.19 days, 116.41 days, 394.30 days, 1.75, and 847.0 days, respectively, for the Simmental cows in the study. The effects of calving year ($P<0.001$), lactation parity ($P<0.05$), calving age ($P<0.001$), birth type ($P<0.001$) and parity ($P<0.001$) on GL were significant. Among the factors affecting SP, the effects of calving year and calving season were significant ($P<0.01$). Calving year, lactation parity, and calving season were significant at different levels for CI. Among the evaluated factors affecting NIPC, calving year, lactation parity, calving season, calving age, and calving year had significant effects ($P<0.001$, $P<0.05$). Year, calving age, and calving season were significant ($P<0.001$) for FCA. As the values for reproductive traits, namely, GL, SP, CI, NIPC, and FCA, were generally within standard values for the Simmental cows, herd management programs seemed to be properly performed at the farm where the study was conducted. Moreover, Simmental cows were successfully raised under subtropical climate conditions.

Keywords: cattle, fertility traits, non-genetic factors, Simmental.

INTRODUCTION

The total Turkish cattle population is approximately 14.1 million according to the 2016 TUİK data. Although Turkey ranks 22nd in the word in terms of number of cattle owned, it ranks low at 60th and 42nd places in the world in terms of lactation milk yield and carcass weight per cow, respectively (TUİK, 2017; FAO, 2017).

Variation in the reproductive performance of dairy or dual-purpose cattle is dependent on genetic and several environmental factors. The observed performance or yield value of each animal in each trait is the result of the heredity that it receives from both parents and the environment where it is raised. Even when an attempt is made to provide a uniform environment, accidental and unknown environmental differences still exist among animals. Therefore, these random environmental factors cause differences in the expression of economically important traits. To maximize the production level, optimizing the environmental conditions and improving the genetic structure of the cattle are required. Environmental factors can be classified as factors with measurable effects, such as year, lactation number, season, age, birth type, and parity, among others, and factors with non-measurable effects, for example, infectious diseases and parasitic infestations. The determined measurable effects can be profitable in formulating future breeding programs. In these programs, performance and yield records of animals should be adjusted for the environmental sources of variation to reduce known environmental differences among animals. Consequently, genetic differences among animals can be recognized and used for effective breeding plans for improvement (Eyduran *et al.*, 2013; Ali *et al.*, 2015; Dogru, 2015; Khan and Khan, 2016; Olechnowicz *et al*., 2016).

Reproduction is one of the most important animal traits affecting productivity in animal production. The sustainability of animal herd and the effectiveness of the selection process in a herd are mainly dependent on fertility. Decreased performance in fertility is considered one of the most important losses in the animal industry (Alpan and Aksoy, 2009). The fertility level of a herd provides important clues to the proper management of a herd and the presence of fertility problems in the herd (Özbeyaz *et al.*, 1996).

This study aimed to determine reproductive traits, such as calving interval, service period, gestation length, number of insemination per pregnancy, and first calving age, and to reveal some non-genetic parameters affecting these traits in Simmental cows raised in a private farm in Çorum Province. This area is under

subtropical climate conditions according to Trewartha climate grading and Csb based on the Köppen–Geiger system.

MATERIALS AND METHODS

The Simmental cattle herd was kept in a farm where altitude from the sea level was t 810 m. The Simmental cows were raised in a private farm in Çorum Province, which is under subtropical climate conditions according to Trewartha climate grading and Csb (cool winter and hot, drought, and short summer season) based on the Köppen–Geiger system. The reproduction performance records of 706 Simmental cow raised in this private farm between 2001 and 2014 were utilized in this study. Eight age groups beginning from two years and ending in nine years and older for calving age, four groups for calving season, fourteen groups (between 2001 and 2014) for calving year, two groups for birth type, and two groups for parity were formed. Cattles were housed at semi-open barns with free stalls, automated manure sweepers, rubber bedding, and a fan and sprinkler system for cooling. Heifers and cows in the dairy farm were artificially inseminated with the semen of Simmental bulls throughout the year.

The following six reproductive traits were analyzed: gestation length is the time in which a fetus develops, beginning with fertilization and ending at birth; service period is the interval from calving to conception, (i.e., the number of days between parturition and the insemination that resulted in pregnancy); calving interval is the number of days occurring between two successive parturitions; number of inseminations per conception is the number of inseminations per gestation; and age at first calving is the number of months between date of birth and date of the first parturition of a cow.

To determine the non-genetic effects of reproductive traits, a general linear model was run using the SAS program (SAS, 2009). Duncan's multiple range tests were used for multiple comparisons in important subgroups (Duncan 1955).

The following model was used for gestation length, duration of service period, calving interval, and number of insemination per pregnancy parameter: $Y_{ijklmno}= \mu+ Y_i + L_j+ S_k + A_l+ B_m+D_n+e_{ijklmno}$, where μ= mean calving interval, duration of service period, gestation length, and number of insemination per pregnancy traits of the Simmental cow population, Y_i = effect of calving years (i= 2001, 2002,…,2014), L_j = effect of lactation number (j= 1, 2, ….,8), S_k = effect of calving season (k= winter, spring, summer, autumn), A_l = effect of calving age (l= 2, 3, 4…9>), B_m = effect of birth type (m= single, twin), D_n = effect of parity (n= heifer, cow), and $e_{ijklmno}$ = error term.

The following model was used for age at first calving: $Y_{ijklmn}= \mu+ Y_i+ L_j+ S_k + A_l+ B_m+e_{ijklmn}$, where μ= mean age at first calving of the Simmental cow population, Y_i = effect of calving years (i= 2001, 2002,…,2014), G_j = effect of lactation number (j= 1, 2, ….,8), S_k = effect of calving season (k= winter, spring, summer, autumn), A_l = effect of calving age (l= 2, 3, 4…9>), B_m = effect of birth type (m= single, twin), and e_{ijklmn} = error term. No significant interaction was found among the evaluated factors, and the total impact of factors on their sub-group was zero (Düzgüneş and Akman, 1995).

RESULTS

The least square means, significance, and multiple comparison test results for gestation length, duration of service period, calving interval, number of insemination per pregnancy, and age at first calving of the Simmental cows are presented in Tables 1 and 2. Average gestation length, duration of service period, calving interval, number of insemination per pregnancy, and calving age were 283.19±0.14 days, 116.41±1.43 days, 394.30±1.38 days, 1.75±0.03, and 847.0±30.84 days, respectively, for the Simmental cows.

The shortest gestation lengths were observed in 2005 (283.42 days) among years, eighth lactation (279.11 days) among lactations, autumn (281.14 days) among seasons, and age two (276.60 days) among ages, whereas the longest gestation lengths were observed in 2003 (283.42 days) among years, first lactation (284.64 days) among lactations, winter (281.81 days) among seasons, and age nine (284.81 days) among calving ages.

The longest service period was observed in 2002 (74.94 days) among years, eighth lactation (92.32 days) among lactations, spring (118.01 days) among seasons, and cows calving at age nine (132.41 days) among calving ages, whereas the shortest service period was observed in 2002 (129.66 days) among years, third lactation (118.30 days) among lactations, winter (103.99 days) among season, and cows calving at age two (100.09 days) among calving ages.

In terms of calving intervals, the shortest calving interval was determined in 2003 (345.85 days) among years, second lactation (386.81 days) among lactations, spring (386.56 days) among seasons, and cow calving at age two (374.22 days). The longest calving interval was determined in 2005 (408.18 days) among years, sixth lactation (363.46 days) among lactations, winter (375.12 days) among seasons, and cow calving at age nine (404.23 days).

The number of insemination per pregnancy for the Simmental cows in the was the lowest in 2001 (1.15) and the highest in 2010 (2.14); the lowest during first lactation (1.54) and the highest during fifth lactation (2.22); the lowest in spring and summer (1.68) and the highest in autumn (1.84); and the lowest at the calving

age of two (1.46) and the highest at the calving age of five (2.04).

The first calving ages of cows calving in 2014 (1097.28 days) and in autumn were the highest, whereas the first calving ages of cows calving in 2001 (966.00 days) and in summer (1002.88 days) were the lowest.

Table 1. Least square means, significance, and multiple comparison test results for calving interval, duration of service period, gestation length, and number of insemination per pregnancy of the Simmental cows.

Factors	N	GL (day)	SP (day)	CI (day)	NIPC
		$\overline{X}_{\pm S}\,\overline{x}$	$\overline{X}_{\pm S}\,\overline{x}$	$\overline{X}_{\pm S}\,\overline{x}$	$\overline{X}_{\pm S}\,\overline{x}$
Overall Mean	1904	283.19±0.14	116.41±1.43	394.30±1.38	1.75±0.03
Year of calving		***	**	***	***
2001	13	283.12±1.58^{abc}	97.13±17.60^{abc}	347.37±16.59^{cd}	1.15±0.15^{a}
2002	14	282.17±1.53^{abc}	74.97±17.02^{c}	347.36±16.04^{d}	1.36±0.17^{e}
2003	29	283.42±1.09^{a}	92.84±12.12^{bc}	345.85±11.42^{cd}	1.41±0.13^{de}
2004	37	280.94±0.97^{abcd}	126.54±10.79^{a}	354.64±10.17^{cd}	1.57±0.17^{cde}
2005	168	278.93±0.52^{d}	129.66±5.82^{a}	408.18±5.49^{a}	1.94±0.12^{bcde}
2006	180	281.44±0.50^{abc}	108.78±5.61^{ab}	386.92±5.28^{ab}	1.66±0.07^{ab}
2007	185	279.97±0.49^{cd}	114.55±5.41^{ab}	393.78±5.10^{ab}	1.74±0.08^{bcd}
2008	156	280.93±0.52^{abcd}	114.59±5.74^{ab}	394.32±5.41^{ab}	1.68±0.09^{abcd}
2009	177	280.69±0.51^{abcd}	117.63±5.64^{ab}	395.79±5.32^{ab}	1.75±0.09^{abcd}
2010	153	282.73±0.53^{ab}	116.08±5.95^{ab}	401.37±5.61^{a}	2.14±0.13^{abcd}
2011	219	280.83±0.49^{bcd}	113.71±5.44^{ab}	395.51±5.13^{a}	1.48±0.06^{bcde}
2012	187	282.00±0.52^{abc}	127.67±5.76^{a}	407.70±5.43^{a}	1.74±0.08^{abcd}
2013	237	281.14±0.46^{abcd}	119.45±5.15^{a}	401.46±4.86^{a}	1.84±0.08^{abc}
2014	149	281.27±0.56^{abc}	111.98±6.24^{ab}	372.52±5.88^{bc}	1.75±0.09^{abcd}
Lactation Number[#]		*	NS	*	***
1st	607	284.64±1.08^{b}	127.98±12.01	393.75±11.32^{ab}	1.54±0.04^{c}
2nd	484	284.05±0.83^{ab}	117.52±9.25	386.81±8.72^{ab}	1.94±0.06^{ab}
3rd	334	282.42±0.72^{ab}	118.30±7.99	392.88±7.54^{ab}	1.66±0.05^{bc}
4th	179	282.45±0.68^{a}	117.55±7.61	392.34±7.17^{ab}	1.77±0.09^{bc}
5th	125	280.36±0.77^{ab}	110.84±8.56	381.21±8.07^{ab}	2.22±0.14^{a}
6th	101	279.72±0.92^{ab}	97.85±10.25	363.46±9.67^{b}	1.79±0.11^{bc}
7th	47	278.36±1.24^{ab}	112.26±13.78	380.53±12.99^{a}	1.62±0.13^{bc}
8th	27	279.17±1.73^{a}	92.32±19.24	367.71±18.14^{a}	1.82±0.19^{bc}
Season of calving		NS	**	*	*
Spring	536	281.42±0.41	111.83±4.56^{a}	385.39±4.30^{a}	1.68±0.05^{b}
Summer	515	281.22±0.42	113.48±4.63^{a}	382.30±4.37^{a}	1.68±0.05^{b}
Autumn	438	281.14±0.42	118.01±4.65^{a}	386.56±4.38^{a}	1.84±0.06^{a}
Winter	415	281.81±0.42	103.99±4.69^{b}	375.12±4.42^{b}	1.82±0.05^{a}
Age at calving		***	NS	NS	***
2	575	276.60±1.12^{c}	100.09±12.51	374.22±11.79	1.46±0.04^{c}
3	439	278.96±0.91^{ab}	109.16±10.13	376.92±9.55	1.77±0.05^{ab}
4	310	280.06±0.82^{abc}	110.35±9.10	375.39±8.57	1.9±0.08^{ab}
5	202	281.05±0.76^{ab}	109.17±8.48	375.40±7.99	1.69±0.07^{bc}
6	142	281.34±0.74^{bc}	106.11±8.21	375.84±7.74	2.04±0.12^{a}
7	122	284.34±0.83^{ab}	114.66±9.25	386.16±8.72	2.02±0.11^{a}
8	70	284.02±1.06^{ab}	112.66±11.75	390.55±11.08	2.01±0.18^{a}
9	44	284.81±1.36^{a}	132.41±15.17	404.23±14.30	1.96±0.16^{ab}
Birth Type		***	NS	NS	NS
Single	1765	284.15±0.29^{a}	107.88±3.18	381.02±2,99	1.75±0.03
Twin	139	278.65±0.53^{b}	115.78±5.95	383.66±5,61	1.72±0.09
Parity[#]		***	NS	NS	***
Heifers	607	282.27±0.24	117.93±2.54	396.74±2.44	1.54±0.05
Cows	1297	283.63±0.16	115.70±1.74	393.16±1.67	1.84±0.03

NS: P>0.05; *: P<0.05; **: P<0.01; ***: P<0.001

a, b, c, d, e – values in columns with different letters differ significantly (P<0.05).

[#]Heifers (parity 1) or cows (parity ≥2); for example, a gestation that produced a second calving is parity 2.

[#]*: Lactation number = Number of Gestation = Number of Calving.*

Table 2. Least square means, significance, and multiple comparison test results for age at first calving of the Simmental cows.

Factors	n	Age at fist calving (days)
		$\overline{X}$ ±S $\overline{x}$
Overall Mean	607	847.0±30.84
Year of calving		***
2001	10	836.3±35.99^{ef}
2002	3	884.0±63.78^{cdef}
2003	18	900.4±29.28^{cde}
2004	12	929.7±34.19^{bcd}
2005	53	992.6±20.05^{ab}
2006	50	962.8±20.63^{bc}
2007	42	834.6±21.30^{ef}
2008	40	802.9±21.26^{f}
2009	58	817.8±20.26^{ef}
2010	55	850.3±19.58^{def}
2011	129	831.8±16.81^{ef}
2012	35	837.4±23.21^{def}
2013	84	899.1±18.01^{cde}
2014	18	1031.6±29.18^{a}
Season of calving		*
Spring	197	896.2±16.66^{a}
Summer	145	862.8±17.56^{b}
Autumn	112	890.1±17.25^{a}
Winter	153	897.1±17.43^{a}
Birth Type		NS
Single	592	893.7±6.92
Twin	15	879.4±28.57

NS: P>0.05; *: P<0.05; ***: P<0.001
a, b, c, d, e, f – values in columns with different letters differ significantly (P<0.05).

DISCUSSION

The average gestation length was 283.19 days for the Simmental cows in this study, similar to those in Vlačić *et al*. (2015) and Fedorovych *et al*. (2016), longer than that in Özkan and Güneş (2007), and shorter than that in Miciński *et al.* (2014).

Among the factors affecting gestation length, the effects of calving year (P<0.001), lactation parity (P<0.05), calving age (P<0.001), birth type (P<0.001), and parity (P<0.001) were significant, but the effect of calving season was not significant (P>0.05).

Similar to the findings of the current study, the significant effects of year (Çilek and Tekin, 2005), lactation parity (Koçak *et al.*, 2008), calving age, and birth type (Petrović *et al.*, 2010) on gestation length and the non-significant effect of season on gestation length (Pantelić *et al.*, 2005; Koçak *et al.*, 2008) were reported in the literature. However, no significant effects of year (Özkan and Güneş, 2007; Koçak *et al.*, 2008) and lactation parity (Vlačić *et al*., 2015 and Fedorovych *et al*., 2016) were noted.

The average service period for Simmental cows was 116.41 days in this study. Although this value was slightly more than the target value of 85–115 days for Simmental cows, it was similar to that in Leka *et al.* (2014). The average service period observed in this study was longer than those in Erdem *et al*. (2015), Fedorovych *et al*. (2016), and the average of the breeding database for Simmental cows in Turkey (Şahin, 2016) and shorter than those in Vlačić *et al*. (2015) and Cziszter *et al*. (2016). The service period was generally consistent with the literature, thus indicating that the estrus cycles of cows were well followed up and that management strategies of the farm seemed proper.

Among the factors affecting the duration of service period in this study, the effects of calving year and calving season were significant (P<0.01), but the effects of lactation parity, calving age, birth type, and parity were not statistically significant (P>0.05).

Note that the effects of year (Nguyen-Kien *et al*., 2017) and calving season (Pantelić *et al.*, 2005; Hammoud *et al.*, 2010; Özkan and Güneş, 2011) on the duration of service period were significant, but the effect of birth type was not significant (Nguyen-Kien *et al*., 2017), consistent with the results of the current study. By contrast, no significant effects of year and calving season were reported in the literature (Pantelić *et al.*, 2014). Similar to the results of this study, no significant effects of lactation parity and calving age on the duration of service were found in Fedorovych *et al*. (2016) and Çilek and Tekin (2005), respectively.

The calving interval for the Simmental cows in this study was 394.30 days. This number was similar to those in Neja *et al.* (2013), Fedorovych *et al*. (2016), and the average of the breeding database for the Simmental cows in Turkey (Şahin, 2016); shorter than those in Bacila *et al*. (2014), Vlačić *et al*. (2015), and Cziszter *et al*. (2016); and longer than that in Erdem *et al*. (2015).

Calving year, lactation parity, and calving season had a significant effect (P<0.05), but calving age, birth type, and parity had no significant effect (P>0.05) on calving interval in the current study.

Similar to the results of this study, the significant effects of year (Çilek and Tekin, 2005; Hammoud *et al.*, 2010), lactation parity (Vlačić *et al*., 2015; Fedorovych *et al*., 2016), and calving season (Hammoud *et al.*, 2010) and the non-significant effect of calving age on calving interval (Çilek and Tekin, 2005) were reported in the literature. However, no significant effects of year (Koçak *et al.*, 2008), lactation parity (Pantelić *et al.*, 2013; Bacila *et al*., 2014), and calving season (Pantelić *et al.*, 2005; Çilek and Tekin, 2005; Koçak *et al.*, 2008) were noted, inconsistent with the results of the current study.

The average number of insemination per pregnancy for the Simmental cows in this study was 1.75. Although this number was similar to that in Cziszter *et al*. (2016), it was less than that in Erdem *et al*. (2015) and higher than those in Deliömeroğlu *et al.* (1996) and the average of the breeding database for Simmental cows in Turkey (Şahin, 2016).

Among the evaluated factors affecting the number of insemination per pregnancy, calving year, lactation parity, calving season, calving age, and parity had a significant effect ($P<0.05$) but not birth type ($P>0.05$).

Calving year (Nguyen-Kien *et al*., 2017), lactation parity (Özkan and Güneş, 2007), and calving season (El-Wishy, 2013) were reported to have significant effects on the number of insemination per pregnancy, consistent with the findings of the current study. However, Özkan and Güneş, (2011) found that the effects of calving year, lactation parity, and calving season on the number of insemination per pregnancy were not significant.

The first calving age for the Simmental cows in this study was 847.0 days, which was similar to those in Bacila *et al*. (2014) and Szewczuk *et al*. (2015). It was less than the values reported by Neja *et al.* (2013), Fedorovych *et al*. (2016), and the average of the breeding database for Simmental cows in Turkey (Şahin, 2016) but longer than those in Pantelić *et al.* (2013) and Pantelić *et al.* (2014).

Year and calving season had a significant effect ($P<0.05$), but birth type had no significant effect ($P>0.05$) on the first calving age of the Simmental cows in this study, consistent with the results of Hammoud *et al.* (2010).

Conclusion: As the values of reproduction traits, such as gestation length, service period, calving interval, number of insemination per pregnancy, and first calving age, were generally within standard values, herd management programs seemed to be properly performed in the farm where the study was conducted. Moreover, Simmental cows were successfully raised in Turkey under subtropical climate conditions.

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