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Research Article

Environmental and Genetic Effects on Birth Weight and Survival Rate in Holstein Calves

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Abstract: This study was undertaken to investigate the effects of certain factors on birth weight and survival rate, utilizing the records of 8399 Holstein calves maintained at the Ceylanpınar State Farm in southeastern Anatolia. The data were collected from the calf barn sheets, including birth weight, pedigree details, and calf fate. The survival rate was scored as 1 (alive) or 0 (died) in accordance with the records.

Analysis of variance indicated that the effects of year, season, parity, and calf sex on birth weight were significant ($P < 0.01$). Only calf sex had a significant ($P < 0.01$) influence on survival rate. The least squares means of birth weight for all calves averaged 38.79 ± 0.171 kg. The survival rates were 0.95 ± 0.004, 0.94 ± 0.004, and 0.92 ± 0.005 at 3, 6, and 12 months of life, respectively.

Heritabilities were 0.115 ± 0.0023 for birth weight and 0.020 ± 0.009, 0.011 ± 0.008, and 0.011 ± 0.008 for 3-month, 6-month, and 12-month survival rates. Genetic correlations between birth weight and every rate of survival were estimated as -0.113, -0.012, and 0.106. The corresponding phenotypic correlations were 0.022, 0.014, and -0.013.

It was concluded that the birth weight and survival rates of Holstein calves reared at Ceylanpınar State Farm were acceptable. However, further improvements can be accomplished by more effective feeding and management based on the low heritabilities.

Key Words: Birth weight, survival rate, heritability, Holstein

Holştayn Buzağılarda Genetik ve Çevresel Faktörlerin Doğum Ağırlığı ve Yaşama Gücü Üzerine Etkileri

Özet: Bu çalışma ile Güney Doğu Anadolu'da bulunan Ceylanpınar Tarım İşletmesinde yetiştirilen 8399 baş Holştayn buzağıda doğum ağırlığı ve yaşama gücünü etkileyen faktörlerin belirlenmesi amaçlanmıştır. Veriler doğum ağırlıkları, soy kütüğü, ve akıbet bilgilerini içeren buzağı kayıt defterlerinden derlenmiştir. Bu kayıtlara göre yaşama gücü yönünden ölen buzağılar için "0", yaşayanlara ise "1" değeri verilmiştir.

Doğum ağırlığı ile 3, 6 ve 12 aylık yaşlardaki yaşama güçleri genel ortalamaları sırasıyla; 38,79 ± 0,171 kg, 0,95 ± 0,004, 0,94 ± 0,004 ve 0,92 ± 0,005 bulunmuştur. Doğum ağırlığında yıl, mevsim, laktasyon sırası ve cinsiyetin, yaşama gücünde ise sadece cinsiyetin etkisinin önemli ($P < 0,01$) olduğu saptanmıştır.

Söz konusu özelliklerde kalıtım derecesi doğum ağırlığı için 0,115 ± 0,0023 olurken, 3, 6 ve 12 aylık yaşama gücü için sırasıyla; 0,020 ± 0,009, 0,011 ± 0,008 ve 0,011 ± 0,008 bulunmuştur. Doğum ağırlığı ile her bir yaşama gücü ölçüsü arasında fenotipik ve genetik korelasyonlar sırasıyla; 0,022 / -0,113, 0,014 / -0,012 ve 0,013 / 0,106 olarak tahmin edilmiştir.

Sonuç olarak, Ceylanpınar Tarım İşletmesinde yetiştirilen Holştayn buzağılarda doğum ağırlığı ile yaşama gücünün iyi düzeyde olduğu ancak bu özelliklere ait kalıtım derecelerinin düşüklüğü nedeniyle seleksiyon ile ilerlemenin yavaş kalabileceği ve bakım, besleme gibi diğer faktörlerin iyileştirilmesinin daha faydalı olacağı kanaatine varılmıştır.

Anahtar Sözcükler: Doğum ağırlığı, yaşama gücü, kalıtım derecesi, Holştayn

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Introduction

Animal husbandry contributes significantly to the agricultural economy of southeastern Anatolia. The choice of the right type of animal to be raised in the area where it is best adapted would result in higher productivity. Holsteins maintained at Ceylanpınar State Farm in the southeastern city of Şanlıurfa are used for milk production in a semiarid continental climate. An understanding of the genetic and non-genetic aspects of adaptation traits of this high-yielding breed under local environmental conditions is essential to the success of sustainable agricultural development in the region. Traits considered in this investigation were birth weight and survival rate of Holstein calves.

Numerous authors (1-22) have reported that both birth weight and survival rate can be affected by various environmental factors like farm, period, parity, and calving season. Heritability estimates range from 0.007 to 0.24 and from 0.04 to 0.09 for these 2 traits, respectively (2,7,10,11,14,15,18,20,23,24).

The information on these traits of Holsteins in Turkey is relatively limited. Therefore, an attempt was made in this study to investigate the birth weight and survival rate, factors influencing them, and their inheritance in southeastern Anatolia.

Materials and Methods

Records of 8399 Holstein calves maintained at Ceylanpınar State Farm, Turkey, from 1993 to 2003 were used in this study. The geographical coordinates for the Ceylanpınar State Farm are 36° 37° 20´ E and 36° 36´ 40° 10´ N. The average annual rainfall is around 267.8 mm (25). Cows were inseminated artificially with semen imported from the USA and EU and produced in Turkey. Stillborns were not included in the study and the birth weights of live-born calves were measured within 24 h of birth. One day later, the calves were removed from their dams. They were placed in single pens for 72 h and then moved into pens where several calves may be kept together until weaning at about 3 months of age. Six-month-old male and female calves were separated. All of the calves were vaccinated against the common diseases in the area.

Calf survival was evaluated as a binary trait. Calves that survived were assigned "1" and those that did not were assigned "0" as described by Haile-Mariam (14) and Riley et al. (26). Survival rates for male and female calves were determined at 3, 6, and 12 months of age.

Data were analyzed using Harvey's linear mixed model least squares and maximum likelihood (LSMLMW) computer program (27). Birth weight and survival rate were analyzed with a model that included 1 random (sire) effect, 5 fixed effects (calving year and season, parity, calf sex, age of dam) and all 2-way interactions among fixed effects. The years were grouped into 2 periods: (1) 1993-1998, and (2) 1999-2003. The calving months were grouped into 4 seasons: (1) winter, December-February, (2) spring, March-May, (3) summer, June-August, (4) fall, September-November. Parity and age of dam were listed numerically, 1 through 5 and 6; the fifth lactation and sixth age represented 5 or more parities and 6 or more ages. Only 88 sires with greater than or equal to 10 calves were included in the analysis. Heritabilities (h^2), genetic (r_G), and phenotypic (r_P) correlations by paternal half-sib method were computed by LSMLMW program (27).

Results

Mean squares from the analysis of variance are presented in Table 1. All factors had significant main effects ($P < 0.01$) on birth weight except the age of dam. Only calf sex was significant ($P < 0.01$) for survival rates at 6 and 12 months of age. Significant interactions of year × season, year × calf sex, calf sex × age of dam for birth weight, and year × parity for 12-month survival rate were observed ($P < 0.05$).

Estimates of least-squares means and standard errors by year, season, parity, calf sex, and age of dam, genetic, and phenotypic correlations among different traits and heritabilities are shown in Tables 2 and 3.

Table 1. Analysis of variances for birth weight and survival rate.

Source of variation	df	MEAN SQUARES			
		Birth weight	Survival rates		
			3-month	6-month	12-month
Year (Y)	1	147.749920**	0.007378	0.054779	0.058442
Season (S)	3	177.941181**	0.077723	0.043801	0.000886
Parity (P)	4	22.559318**	0.031144	0.025955	0.014206
Calf sex (CS)	1	8734.033017**	0.022790	0.352527**	0.515906**
Age of dam (A)	4	59.055942	0.018733	0.023427	0.051247
Y × S	3	90.954109**	0.146450	0.108166	0.112272
Y × P	4	12.935962	0.024321	0.026161	0.154080*
Y × CS	1	101.480262**	0.009116	0.020239	0.046155
Y × A	4	20.115581	0.012676	0.007296	0.104045
S × P	12	23.750134	0.047100	0.063108	0.067339
S × CS	3	4.441392	0.069900	0.128163	0.148079
S × A	12	20.280049	0.044365	0.039656	0.067231
P × CS	4	33.258390	0.053235	0.099319	0.139525
P × A	16	25.549028	0.058055	0.080697	0.101594
CS × A	4	42.531649*	0.038681	0.073532	0.101162
Error	8235	15.850829	0.038659	0.050984	0.062162

* $P < 0.05$, ** $P < 0.01$.

Discussion

In general, calves born during 1999-2003 were significantly ($P < 0.05$) heavier than those born during 1993-1998. Similar results for the effect of years have been reported in earlier research (6,8,18,20). In the present study, this result may be explained by the advances in feeding and other administrative conditions over the years. Sehar and Özbeyaz (21) reported that the year also had a significant effect on survival rate. This result seems to contradict our findings. The difference may be too small to detect in our data for this trait.

The least-squares means in Table 2 showed that the spring born calves had the highest birth weight, in accordance with previous studies (8,13,18). This may result from low temperatures and the availability of high quality fodder to spring calvers during the last one-third of gestation. Sehar and Özbeyaz (21) and Başpınar et al. (16) reported that winter born calves had the lowest survival rate. In this study, survival rates were not affected by season, whereas summer born calves tended to have lower survival rates.

Calves born in early parities were lighter in weight than those born to late-parity dams. This finding is in accord with the literature (12,19,22). One explanation of these results is that earlier-parity cows continue to grow until reaching adult size and compete with the fetus for available nutrients during pregnancy. Contrary to our findings, parity was reported to be a significant source of variation by Haile-Mariam (14) for survival rate. The difference might have arisen from the survival rate measures used.

The age of dam was not observed to affect the birth weight or survival rate. These results seem to contradict the findings reported by Başpınar et al. (16) and Akbulut et al. (18) for birth weight and by Özcan (9) and Auran (1) for survival rate, while being in accordance with those reported by Bardakçıoğlu (13), Sehar and Özbeyaz (21), and Başpınar et al. (16) for the latter trait. Inconsistencies among various studies may result from the use of different statistical models and methods. In addition, variation caused by age of dam may be too small to detect in these data.

Table 2. Least squares means and standard errors for birth weight and survival rate.

Classification	n	Birth weight (kg)	Survival rate		
			3-month	6-month	12-month
μ	8399	38.79 ± 0.17	0.95 ± 0.004	0.94 ± 0.004	0.92 ± 0.005
Year					
1993-1998	4719	38.28 ± 0.249[b]	0.95 ± 0.010[a]	0.93 ± 0.011	0.91 ± 0.012[a]
1999-2003	3680	39.30 ± 0.227[a]	0.96 ± 0.008[a]	0.95 ± 0.009	0.93 ± 0.010[a]
Calving Season					
Winter	2232	38.80 ± 0.189[a]	0.96 ± 0.006[a]	0.94 ± 0.006	0.92 ± 0.007[a]
Spring	2106	39.23 ± 0.189[a]	0.96 ± 0.006[a]	0.94 ± 0.006	0.92 ± 0.007[a]
Summer	2105	38.55 ± 0.190[b]	0.95 ± 0.006[a]	0.93 ± 0.006	0.92 ± 0.007[a]
Autumn	1956	38.59 ± 0.189[b]	0.96 ± 0.006[a]	0.94 ± 0.006	0.93 ± 0.007[a]
Parity					
1	1843	38.43 ± 0.267[b]	0.95 ± 0.011[a]	0.93 ± 0.012	0.93 ± 0.014[a]
2	1991	38.12 ± 0.254[b]	0.96 ± 0.010[a]	0.95 ± 0.011	0.93 ± 0.012[a]
3	1621	39.29 ± 0.296[a]	0.95 ± 0.012[a]	0.93 ± 0.014	0.93 ± 0.016[a]
4	1089	38.77 ± 0.301[a]	0.96 ± 0.013[a]	0.93 ± 0.015	0.92 ± 0.016[a]
5+	1855	39.34 ± 0.277[a]	0.97 ± 0.011[a]	0.95 ± 0.013	0.92 ± 0.012[a]
Calf Sex					
Male	4342	39.86 ± 0.177[a]	0.95 ± 0.005[a]	0.93 ± 0.005	0.92 ± 0.006[a]
Female	4057	37.72 ± 0.177[b]	0.96 ± 0.005[a]	0.95 ± 0.005[b]	0.93 ± 0.006[b]
Age of dam					
2	1830	38.47 ± 0.267[a]	0.97 ± 0.011[a]	0.94 ± 0.012	0.93 ± 0.013[a]
3	1997	38.91 ± 0.255[a]	0.95 ± 0.010[a]	0.93 ± 0.011	0.92 ± 0.013[a]
4	1623	38.62 ± 0.293[a]	0.96 ± 0.012[a]	0.93 ± 0.014	0.90 ± 0.015[a]
5	1087	39.27 ± 0.304[a]	0.96 ± 0.013[a]	0.95 ± 0.015	0.94 ± 0.016[a]
6+	1862	38.69 ± 0.275[a]	0.95 ± 0.011[a]	0.93 ± 0.013	0.94 ± 0.014[a]

[a,b]: Subclass means followed by different superscripts are significantly different ($P < 0.05$).

Table 3. Heritabilities, genetic, and phenotypic correlations for birth weight and survival rate[1].

	Trait	Birth weight	Survival Rate		
			3-month	6-month	12-month
Survival rate	Birth weight	0.115 ± 0.0023	-0.113	-0.012	0.106
	3-month	0.022	0.020 ± 0.009	>1[†]	>1[†]
	6-month	0.014	0.858	0.011 ± 0.008	0.990
	12-month	0.013	0.767	0.892	0.011 ± 0.008

[1]: Diagonals are heritabilities; upper-off diagonals are genetic correlations; lower-off diagonals are phenotypic correlations.
[†]: The estimates of these genetic correlations are outside the parameter limits of -1 and +1 in our data.

Male calves had higher birth weight and lower survival rates than females. This was in unison with the findings of previous research (2-9,12,13,17,18). These findings suggested that the female calves show more resistance than males to the subtropical environment of Ceylanpınar. In addition, the significant difference ($P < 0.05$) between calf sexes in 6- and 12-month survival rates indicated that increasing activity of hormones such as estrogen may have influenced the differences between sexes. In addition, more attention is given to female calves on the farm due to their breeding value.

The low heritabilities for both traits were in accordance with other studies (2,7,11,14,15,20,24). These poor estimates could be due to the influence of some non-tangible individual and environmental factors that were not included in the model. However, birth weight was more heritable than survival rate. Low genetic and phenotypic correlations among these traits suggested that the selection of animals based on birth weight would not result in an improvement in survival rate. High correlations (genetic and phenotypic) between different survival rate measures implied that calves resistant to the environment in early life could also maintain this ability in later life.

In conclusion, Holstein calves appear to be raised successfully at Ceylanpınar State Farm under subtropical conditions. Some environmental factors such as calving year, season, parity, and sex should be considered when calves are evaluated. Further studies are required to understand the complex nature of parity, age of dam, and calf sex effects on birth weight and survival rate. The low heritabilities found in this investigation suggested that improvements in these traits could be achieved through better feeding and management.

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