



Some Environmental Factors Affecting Birth Weight, Weaning Weight and Daily Live Weight Gain of Holstein Calves

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ABSTRACT

The present study was conducted to determine some environmental factors affecting birth weight, weaning weight and daily live weight gain of Holstein calves of a livestock facility in Izmir, Turkey. The data on 2091 calves born between the years 2005-2010 were used to assess the relevant parameters. Effects of calving year, calving month, calf gender and the interaction between calving year and calving month on calves' birth weights were highly significant. The overall mean of birth weights was 39.6±0.15 kg. In addition, effects of calving year, calving month, gender, birth weight, weaning age, calving year x calving month, calving year x gender and calving year x calving month x gender interactions on weaning weight (WW) and daily live weight gain (DLWG) were highly significant. The overall means of WW and DLWG were respectively found to be 79.7±0.20 kg and 525±2.5 g. A one kilogram increase in birth weight resulted in an increase of 0.89 kg in weaning weight and a decrease of 1.26 g in daily live weight gain. Prenatal temperature-humidity index (THI) affected birth weight of calves ($R^2=0.67$). Increasing THI from 50 to 80 resulted in 3.8 kg decrease in birth weight.

Introduction

Growth is defined as the mass increase in animal live weight and divided into two periods as prenatal and postnatal growth. The breeders generally deal with postnatal growth of animals. However, prenatal growth is also as much significant as postnatal growth (Düzgüneş and Eliçin, 1986). Birth weight is an early and easy indicator of prenatal growth. The birth weight is commonly used as an early selection criterion in cattle breeding (Kaygısız et al., 2012). Many researchers reported the medium heritability estimates for birth weight. Heritability estimates for birth weight of Brown Swiss calves given by Kaygısız (1998), Akbulut et al. (2001) and Tilki et al. (2008) were 0.084, 0.36 and 0.15, respectively and for birth weight of Holstein calves given by Unalan (2009) was 0.328. Genetic and environmental factors such as dam age, calving weight of dam, mothering ability, nutritional conditions of dam, litter size, gestation length, calving year, season, insemination bull, gender of calf, type of birth, geographical region and altitude may influence birth weight of calf (Sakhare and Ingle, 1983; Sang et al., 1986; Holland and Odge, 1992; Alpan and Arpacık, 1998; Wattiaux, 1996a). During the nursing period, the growth is significantly affected by calve genetics, birth weight, gender of calf, calving season, duration of nursing period, amount of milk or milk replacer intake, total starter intake, environmental

temperature, and care practices (Akbulut et al., 1993; Greenwood and Cafe, 2007; Bayrıl and Yılmaz, 2010; Bateman et al., 2012). Dairy cattle imports and artificial inseminations in Turkey alter the genetic structures of the herds. There are also various differences between herd management practices of livestock facilities. Therefore, determination of birth and weaning weights of calves at different years and herds may provide significant helps to growers in implementation and assessment of herd management practices. The primary objective of the present study is to determine the environmental factors affecting birth weight, weaning weight and daily live weight gain of Holstein calves of a livestock facility in Izmir, Turkey.

Material and Methods

Research data were supplied from the records of 2091 calves born in a member dairy farm of İzmir Cattle Breeders Association from 2005 to 2010. The data on calving date, birth weight, weaning date and weaning weight were gathered and analyzed. Following the disinfection of umbilical cords and mother's licking, calves were weighed with a scale (± 0.5 kg) and taken into individual pens. Then, 2-3 kg colostrum milked from their mothers was supplied to calves with a plastic milk bottle. The calves were supplied only with colostrum

during the first 3 days. Starting from the 4th day, calves were fed with a total of 4 liters milk replacer in two meals morning and evening. Following the first week, water and a calf starter feed were supplied to the calves. The calf starter feed was only used during the first month. Thereafter, in addition to the starter feed, a vetch and barley dry hay mixed with milk was supplied to the calves. Weaning time was decided by the breeders based on growth nature of the calves. Calves were weaned at an average age of 77 days. They were weighed in the morning of the weaning day. Two linear models were used in data analysis.

Model 1:

$$Y_{ijkl} = \mu + cy_i + cm_j + s_k + (cy*cm)_{ij} + (cy*s)_{ik} + (cm*s)_{jk} + (cy*cm*s)_{ijk} + e_{ijkl}$$

Where, Y_{ijkl} : Birth weight; μ : General mean; cy_i : Effect of calving year; cm_j : Effect of calving month; s_k : Effect of calf gender and interactions $(cy*cm)_{ij}$, $(cy*s)_{ik}$, $(cm*s)_{jk}$, $(cy*cm*s)_{ijk}$ and e_{ijkl} : Randomized error.

Model2:

It was created for weaning weight and daily live weight gain through adding birth weight (bw) and weaning age (wa) into Model 1 as covariate.

The effects of temperature-humidity index (THI) on birth weight and weaning weight were also investigated. Temperature and relative humidity data of the years 2004-2010 were supplied from İzmir Regional Directorate of Meteorology. To calculate THI values, the formula provided by Kibler (1964) ($THI = 1.8 \times Ta - (1 - RH) \times (Ta - 14.3) + 32$, where THI: Temperature-humidity index, Ta: Atmospheric temperature (°C), RH: Relative humidity (%)) was used. A polynomial relationship was identified between monthly THI averages and birth weights of calves and estimation model of the curve was created. GLM/Univariate procedure of SPSS statistical software was used in data analysis and pairwise comparisons were made based on the estimated marginal means and Bonferroni test was applied for multiple comparisons.

Results and Discussion

Birth Weight

The least square means and standard errors for birth weights of Holstein calves (BW) are provided in Table 1. Calving year, calving month, calf gender and calving year x calving month interaction had significant effects ($P < 0.01$) on birth weights. The overall mean of birth weights was 39.6 ± 0.15 kg. The smallest birth weights (38.1 and 38.4 kg) were observed in the years 2005 and 2010 while the highest value (41.7 kg) was observed in the year 2006. With regard to calving months, the lowest birth weights (38.2 and 38.3 kg) were observed in June and November and the highest values were observed in February and April (41.0 and 41.1 kg). There was a significant variation in birth weights of the calves based on calving year and calving month. Year effect reflects the environmental conditions such as temperature and relative humidity, feeding, hygiene, and management

conditions of dam during gestation (Manzi et al., 2012). Effects of calving year, gender of calf, producing type of calf, feeding conditions through the end of gestation period and climate conditions on birth weight of calves were reported by various studies (Unalan, 2009; Shazzad et al., 2010; Bazzi, 2011; Uzmay et al., 2011; Manzi et al., 2012). The overall mean of birth weights (39.6 ± 0.15 kg) of the present study was lower than the values reported by Bush and Nicholson (1986), Başpınar et al. (1998), Johanson and Berger (2003), Uzmay et al. (2010); similar to value reported by Unalan (2009) and Bayrıl and Yılmaz (2010) and greater than the values reported by Şahiner and Demir (1998), Akbulut et al. (1993), Bardakçioğlu (2001), Bilgiç and Alıç (2005) and Kaygısız et al. (2012). Average birth weight of Holstein-like large-size breeds is commonly reported as 40-45 kg (Wattiaux, 1996b). Birth weights of the calves of the present study complied with the general birth weights of the Holstein breed.

The least-squares means and standard errors for birth weights of male and female calves were respectively 41.1 ± 0.21 and $38.2 \text{ kg} \pm 0.21$ ($P < 0.05$). Birth weights of male calves were about 2.9 kg (7.7%) higher than the birth weights of female calves (Table 1). Previous researchers also reported higher birth weights of male calves (Unalan, 2009; Uzmay et al., 2010; Bazzi, 2011; Manzi et al., 2012). Male calves usually have higher birth weights because of longer gestation periods and higher androgen hormone intensity of fetus serum (Uzmay et al., 2010; Manzi et al., 2012). Thusly, a day prolongation in gestation period result in 0.5 kg increase in birth weights (Wattiaux, 1996a).

To assess the effects of temperature-humidity index (THI) on birth weights, average THI values were calculated for the birth month and before 2 months from the birth month. Variation of birth weights and THI values based on calving months are presented in Figure 1. There was a polynomial relationship between mean THI values and birth weight values of calving month (Figure 2). Degree of accuracy (R^2) of the relationship between THI and birth weight was 0.67. Annual and monthly variations in care, feeding and climate conditions might have resulted in such variations. Considering the polynomial relationship between THI values of calving month and birth weights, it was observed that birth weights initially decreased and then increased with increasing THI values (Figure 2). While birth weights linearly decreased with increasing THI, an increase was observed at THI values of 70 or above (September and October). Birth weights at THI values of 50, 60, 70 and 80 were respectively estimated from equation ($Y = 0.009x^2 - 1.295x + 82.13$; $x = \text{THI}$) as 39.9 kg, 36.8 kg, 35.6 kg and 36.1 kg. There was 3.8 kg difference in birth weights of calves born at THI values of 50 and 80. Decrease in birth weights at high THI values was mainly because of negative impacts of heat stress on fetus development through the end of gestation period. Thusly, Collier et al. (1982) reported that calves of Holstein cows exposed to heat stress during the last 1/3 of gestation period had 3 kg less birth weights than the cows stayed at shade. Since

calve weights increase from 4 to 45 kg during the last 1/3 of the gestation period, such a prenatal period is highly critical for birth weights of the calves (Wattiaux, 1996a). Due to the fact that the heat stress had negative impact on the fetus development, the pregnant cows should be subjected to cooling treatment during the dry period.

Weaning weight

The least square means and standard errors for weaning weights (WW) are presented in Table 1. Calving year, calving month, calf gender, birth weight, weaning age, calving year x calving month, calving year x calf gender and calving year x calving month x calf gender interactions had highly significant effects (P<0.01) on weaning weight. The overall mean of weaning weight was 79.7±0.20 kg. With regard to calving year, the lightest weaning weights (76.8 and 77.1 kg) were observed in the years 2006 and 2007 and the heaviest weaning weight (84.3 kg) was observed in the year 2008. With regard to weaning months, the lowest weaning weight (77.8 kg) was observed in April and the highest value (82.0 kg) in February. The overall mean of weaning weight of the present study was smaller than the value reported by

Başpınar et al. (1998) and higher than the values reported by Akbulut et al. (1993), Bayrıl and Yılmaz (2010) and Uzmay et al. (2011). With regard to weaning weight of calves, Başpınar et al. (1998) reported the highest value in winter and the lowest in summer and Akbulut et al. (1993) reported the highest values in summer and fall seasons. In the present study, weaning weight was low in spring and high in winter months.

The least square means for weaning weight was 81.6±0.28 kg in males and 77.9±0.28 kg in females (P<0.05). While birth weights of male calves of the present study were 7.7% higher than the female calves, the ratio receded to 4.7% in weaning. Weight gain until weaning was in favor of females. Although male calves were not able to exhibit their birth weight advantage at weaning, they still have higher weaning weights than the female calves just because of longer gestational period or higher androgen level (Manzi et al., 2012). Similar to findings of the present study, Yanar et al. (1993) also reported higher weaning weights for males than females, but Bayrıl and Yılmaz (2010) was not able to identify any significant differences in weaning weights of genders.

Table 1 Least square means, significance and multiple comparison test results for birth weight (kg), weaning weight (kg) and daily weight gain (g) of Holstein calves

Factors	Birth weight (kg)			Weaning weight (kg)			Daily weight gain (g)		
	n	Mean	SE	n	Mean	SE	n	Mean	SE
Overall Mean	2091	39.6	0.15	1853	79.7	0.20	1853	525	2.5
Birth year		***			***			***	
2005	268	38.1 ^c	0.38	258	79.5 ^c	0.48	258	513 ^{cd}	6.1
2006	224	41.7 ^a	0.42	221	77.1 ^d	0.53	221	490 ^d	6.8
2007	232	40.1 ^{ab}	0.43	214	76.8 ^d	0.55	214	490 ^d	7.0
2008	280	40.4 ^{ab}	0.42	276	84.3 ^a	0.52	276	587 ^a	6.6
2009	596	39.2 ^{bc}	0.24	563	79.3 ^c	0.32	563	523 ^c	4.1
2010	491	38.4 ^c	0.26	321	81.5 ^b	0.46	321	550 ^b	5.9
Birth month		***			**			**	
January	182	40.2 ^{a-c}	0.46	169	79.1 ^{ab}	0.59	169	517 ^{ab}	7.6
February	144	41.0 ^a	0.51	117	82.0 ^a	0.74	117	549 ^a	9.5
March	132	40.2 ^{a-c}	0.68	119	80.2 ^{ab}	0.86	119	529 ^{ab}	11.1
April	146	41.1 ^a	0.54	127	77.8 ^b	0.71	127	499 ^b	9.2
May	160	39.5 ^{a-c}	0.69	153	78.0 ^b	0.84	153	505 ^{ab}	10.8
June	192	38.2 ^c	0.45	178	80.2 ^{ab}	0.56	178	530 ^{ab}	7.3
July	188	38.6 ^{bc}	0.49	157	80.4 ^{ab}	0.62	157	535 ^{ab}	8.0
August	187	38.9 ^{a-c}	0.48	169	80.5 ^{ab}	0.61	169	532 ^{ab}	7.9
September	153	40.7 ^{ab}	0.52	144	79.9 ^{ab}	0.66	144	529 ^{ab}	8.4
October	187	39.8 ^{a-c}	0.46	169	80.3 ^{ab}	0.57	169	536 ^{ab}	7.3
November	202	38.3 ^c	0.43	177	79.7 ^{ab}	0.56	177	524 ^{ab}	7.2
December	218	39.2 ^{a-c}	0.45	174	78.7 ^b	0.61	174	516 ^{ab}	7.8
Gender of calf		***			***			***	
Female	1039	38.2	0.21	935	77.9	0.28	935	500	3.5
Male	1052	41.1	0.21	918	81.6	0.28	918	551	3.6
Birth year x Birth month		***			***			***	
Birth year x Gender		NS			***			***	
Birth month x Gender		NS			NS			NS	
Birth year x Birth month x Gender		NS			***			***	
Birth weight		-			0.89***			-1.26**	
Weaning age		-			0.41***			-1.08***	
R ²		0.21			0.60			0.43	

^{a,b,c,d}P<0.05 differences among means of the same column are significant **P<0.01, ***P<0.001 NS: Non-significant

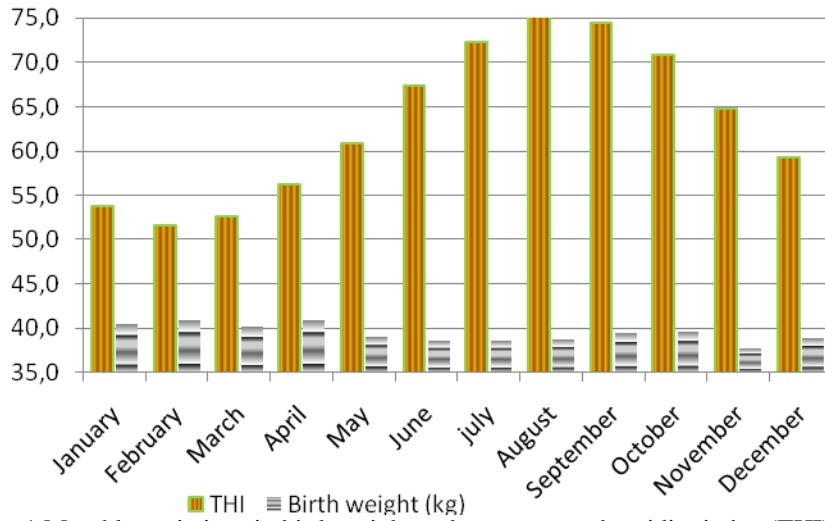


Figure1 Monthly variations in birth weight and temperature-humidity index (THI) values.

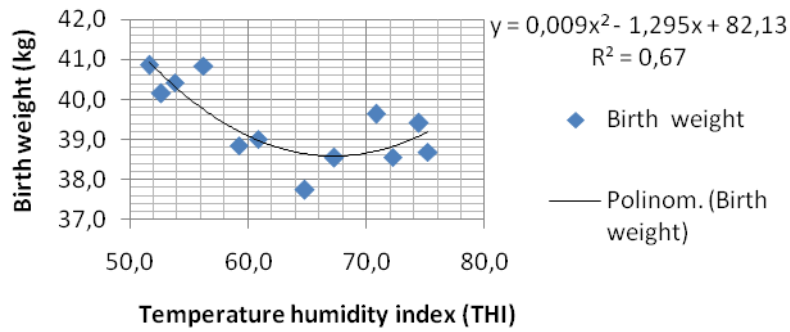


Figure 2 Variation of birth weights based on temperature-humidity index

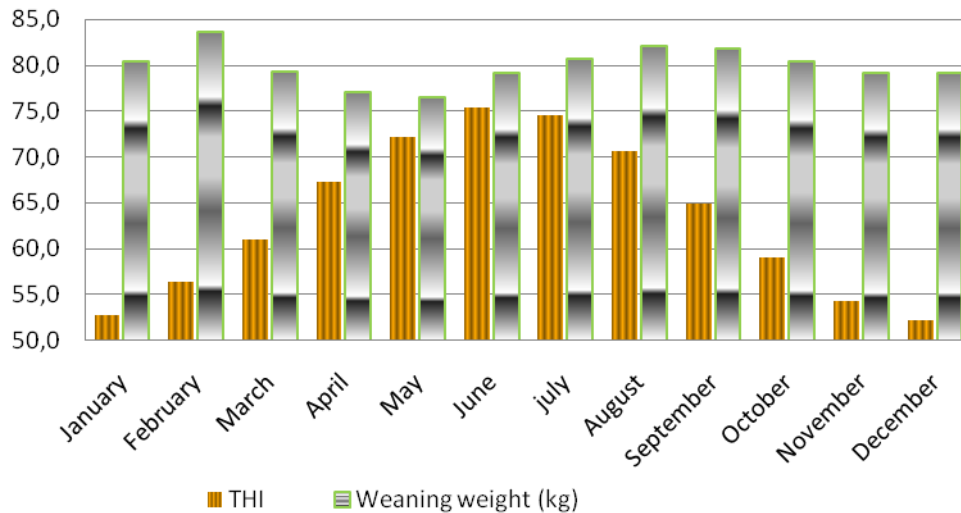


Figure 3 Monthly variations in weaning weight and temperature humidity index (THI) values

Weaning weight was influenced by birth weight and weaning age (Table 1). A one kilogram increase in birth weight resulted in 0.89 kg increase in weaning weight and a day prolongation in weaning age resulted in 0.41 kg increase in weaning weight. Bayrıl and Yılmaz (2010) reported 0.93 kg increase in weaning weight of Holstein calves with a one kg increase in birth weight and Yaylak et al. (2013) reported 1.09 kg increase in Brown Swiss and Simmental calves. Besides increasing weaning weights and higher birth weights also increase calf mortality within 48 hours of birth and dystocia risk (Johanson and Berger, 2003; Uzmay et al., 2010). Therefore, ideal birth weights should be aimed in selection.

Again, average THI values were calculated for the birth month and after 2 months from the birth month to assess the effects of THI on weaning weights. Monthly variations in temperature-humidity index values and weaning weights are presented in Figure 3. Weaning weights decreased with increasing temperature-humidity index values and vice versa. However, as it was between birth weight and THI, a relationship was not observed also between weaning weights and THI. Lower weaning weights in spring were mainly because of increasing disease-causing microorganisms and disease carrying flies together with increasing temperatures. Thusly, diseases are mostly observed in spring months at this region (Yaylak et al., 2010). High temperature also decreases feed consumption of calves. This suggests that the variation in temperature and other environmental conditions among birth years and birth months had significant effect on the calves at weaning.

Daily live weight gain

The least square means and standard errors for daily live weight gain (DLWG) of calves are provided in Table 1. Effects of calving year, calving month, calf gender, birth weight, weaning age, calving year x calving month, calving year x calf gender and calving year x calving month x calf gender interactions on daily live weight gain were found to be highly significant ($P<0.01$). The overall mean DLWG of calves was 525 ± 2.5 g with the lowest value (490 g) in the years 2006 and 2007 and the highest value (587 g) in the year 2008 ($P<0.05$). With regard to calving months, the lowest DLWG value (499 g) was observed in April, the highest value (549 g) was observed in February. The least square mean DLWG values of male and female calves were respectively observed as 551 and 500 g. A one kilogram increase in birth weight resulted in 1.26 g and a day prolongation in weaning age resulted in 1.08 g decrease in DLWG of calves ($P<0.01$). The present mean DLWG was higher than the value reported by Uzmay et al., 2011. Daily live weight gains of the calves to weaning age should be 550-600 g (Kumlu, 1999). Thus, current values were found to be sufficient.

Conclusions

Current findings revealed that birth weight, weaning weight and daily live weight gains of Holstein calves were significantly affected by birth year, birth month, calf gender and some interactions between these variables.

However, birth weight, weaning weight and daily live weight gains complied with Holstein breed in general. Prenatal temperature-humidity index (THI) affected birth weight of calves. Birth weights of calves with low THI values during the last trimester of gestation period were higher than the calves with high THI values throughout the same period. Variations in birth weight, weaning weight and daily live weight gain of calves were mainly because of climate conditions, housing conditions, feeding and herd management practices of the dams during gestations and suckling period of calves. In a selection to be made, such effects of environmental factors should be tried to be eliminated. Determination of birth weights and weaning weights of calves may also provide various supports in practical implementations of livestock facilities. Prevention of heat stress exerted over cows in housing systems, therefore the provision of proper care and feeding practices may also improve birth weights which could negatively affected by the heat stress.

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