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Estimation of Genetic Parameters and Correlations among Some Body Measurements of Holstein Calves and Effects of These Measurements on Calving Difficulty

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Abstract: In this study, some body measurements (Birth Weight: BW, Withers Height: WH, Body Length: BL and Chest Girth: CG) and Calving Difficulty Scores (CDS) of 202 calves (of which 85 were born from artificial insemination: AI, 45 were born fresh embryo transfer: ET and 62 were born Frozen Embryo Transfer: FET) obtained from Holstein heifers, which were born in the dairy herd of Cukurova Agricultural Research Institute in Adana (Turkey). In the study, it was firstly investigated the effects of producing type (AI, ET and FET) and sex of calf on all of the body measurements and calving difficulty. Then, the effects of these body measurements on calving difficulty scores were investigated. Besides, heritabilities and genetic and phenotypic correlations among the traits were also estimated. Analysis showed that the effect of producing type was significant on all of the traits studied ($p<0.01$). But, the effect of sex was not statistically significant on any of them ($p>0.05$). Heritability estimates were 0.328, 0.287, 0.258, 0.240 and 0.152 for BW, WH, BL, CG and CDS, respectively. Genetic correlations among the body measurements: while, the highest correlation was 0.974 between CG and WH, the lowest correlation was also 0.559 between CG and BL. Genetic correlations between BW and the other measurements and CDS were 0.921, 0.879, 0.829 and 0.804 for WH, BL, CG and CDS, respectively. Genetic correlations between CDS and all of the body measurements studied were 0.804, 0.670, 0.632 and 0.495 for BW, WH, BL and CG, respectively ($p<0.01$). These results showed that BW was more important factor on calving difficulty than the other measurements of calves.

Key words: Holstein, calf, body measurements, genetic parameters and correlations, calving difficulty

INTRODUCTION

Holstein cattle are commonly reared for the milk production in Turkey as dairy cattle farms all over the world. Although, the main breeding aim of this breed is to milk production, male calves are also reared for beef production, either.

In cattle breeding, especially, birth weight and the other body measurements of calves have a great deal of importance for description of breed characteristics Bakir *et al*. (2004) and for the determination of selection and breeding programs of breeders. In addition, calf birth weight is also one of the main criteria for determination of calving difficulty. That is the reason why calving difficulty (or calving ease) is also included as a component in the estimation of breeding value formulas (i.e., in EBV, TPI, PTA for milk production etc.). For example, genetic predictions of merit for calving ease have been available for Holstein AI bulls in the US since, 1978 (Berger, 1994).

Calving difficulty, otherwise known as dystocia, may result in reduced calf performance, delayed estrus and in some cases, loss of the calf and/or dam. Problems during calving result in increased neonatal and postnatal mortality reduced milk production, poor reproductive performance in later parities and increased management, assistance and veterinary costs (Naazie *et al*., 1989; Johanson and Berger, 2003; Lombard *et al*., 2006; Bicalho *et al*., 2007; Lopez de Maturana *et al*., 2007). It is well known that by increasing birth weight of calf, calving difficulty is also increased too. Therefore, it should be estimated the effects of probable factors which may increase birth weight and calving difficulty and so some applicable precautions should be taken in time. The main factors affecting on birth weight are breed of dam and sire, age of dam, pelvic area of dam, parity, sex of calf, hormone profile and feeding program applied to dam during its pregnancy etc. (Naazie *et al*., 1989; Sieber *et al*., 1989). Besides, some differences among birth weights of calves and some reproductive traits (gestation length, pregnancy rate etc.) of dams were born from different reproduction techniques (artificial insemination vs. fresh or frozen embryo transfer) and methods (*in vivo* or *in vitro* fertilization etc.) which were also reported (Behdoodi *et al*., 1995; Hasler *et al*., 1995; Agca *et al*., 1998; Van Wagtendonk-de Leeuw *et al*., 1998;

Jacobsen *et al*., 1999, 2000; Numabe *et al*., 2000). Many of these factors affecting on increasing of birth weight can be controlled by the farmers. If birth weight can be estimated, dystocia can be decreased even if it is impossible to prevent dystocia completely (Takahashi *et al*., 2001).

Especially, in beef cattle production calf birth weight is one of the main indicator factors on daily gain, survive and subsequent body development of animal (Dawson *et al*., 1947; Lamb and Barker, 1975; Burfening *et al*., 1978; Bennett and Gregory, 1996; MacNeil, 2003; Bakir *et al*., 2004). Selection in beef cattle to decrease calving difficulty is accomplished trough EPDs (expected progeny differences) for birth weight or calving difficulty.

Consequently, with the all information given above was evaluated, birth weights of calves in cattle breeding should be optimized according to the breeding aim and production type of farms. To make this purpose, all probable effects of factors on birth weight should be determined correctly. Moreover, genetic parameters (heritability) and correlations among some related measurements should be estimated in order to take correct decision for the selection of breeding stock (Dawson *et al*., 1947; Burfening *et al*., 1978; Naazie *et al*., 1991; Gregory *et al*., 1995; Eriksson *et al*., 2004).

The aim of the study was to investigate the effects of sex and producing type (Artificial Insemination: AI, fresh Embryo Transfer: ET and Frozen Embryo Transfer: FET) on some body measurements (Birth Weight: BW, Withers Height: WH, Body Length: BL and Chest Girth: CG) of calves and calving difficulty (scores) and to determine the effects of the body measurements on calving difficulty. Besides, it was also aimed to estimate the heritabilities, genetic and phenotypic correlations among the traits studied.

MATERIALS AND METHODS

The data used in this study was collected from Cukurova Agricultural Research Institute's Holstein dairy herd in Adana, located in the East Mediterranean region of Turkey. The herd was established in 2005 by Development of Anatolian Friesian Cattle Type Project started in 2001. The some body measurements (Birth Weight (BW), Withers Height (WH), Body Length (BL) and Chest Girth (CG) and Calving Difficulty Scores (CDS) of 202 Holstein calves (105 males, 98 females) were born at first calving in the herd in 2006 and 2007, which were used. Among them, 85 calves (41 males, 44 females) were born from Artificial Insemination (AI), 55 calves (32 males, 23 females) were born from *in vivo*-derived fresh Embryo Transfer (ET) and 62 calves (32 males, 30 females) were born from Frozen Embryo Transfer (FET).

Donors used in ET had over 10.000 kg first lactation milk yield of which were bought from Bala Agricultural State Farm in Ankara (Turkey), after their first lactation and in their drying off period. Fresh embryos were obtained from these donors artificially inseminated and *in vivo* fertilized. Then usable of them was transferred to the synchronized recipients after the embryo quality evaluation in the Biotechnology Laboratory of Institute within the flushing day. Frozen embryos were imported from USA. Both dams and sires of frozen embryos had high genetic potential, which was at least 10.000 kg first lactation milk yield. All heifers used in both ET and AI programs were almost similar ages and body weights. All strawed bull semen used in AI and ET programs was imported from USA (published in Holstein Association International Top 100 TPI Bull List). Consequently, all animals and genetic materials used in this study belonged to the Holstein breed, which had close genetic superiority and body characteristic.

All pregnant heifers in the herd were kept in the same feeding program and management conditions in semi open barns with ventilation fans under subtropical climate conditions during their pregnancies.

The data used in this study was consisted of some body measurement of calves and calving difficulty scores. Calving performance was scored on a 0-5 scale (0: normal, no assistance, 1: slight assistance, 2: puller used easy, 3: puller used hard, 4: veterinary assistance required and 5: Caesarian). After evaluation of the data, calving difficulty scores 4 and 5 were combined with CDS 3. All body measurements studied were recorded immediately after birth within 24 h.

The data was analyzed using the mathematical model given below in SPSS 12.0 statistical program. Multivariate analysis in General Linear Model (GLM) procedure was performed for least squares analysis of variance. Sex and producing type (AI, ET and FET) of calf were assumed as main fixed effect factors in the model:

$$Y_{tijk} = \mu_t + S_{ti} + P_{tj} + e_{tijk}$$

where:

- Y_{tijk} = Observation of k^{th} calf for t^{th} trait (t = 1, .., 5; birth weight, wither height, body length, chest girth and calving difficulty score)
- μ_t = The overall mean for t^{th} trait
- S_{ti} = i^{th} sex effect for t^{th} trait (i = 1, 2)
- P_{tj} = j^{th} Calf producing type effect for t^{th} trait (j = 1, ..., 3)
- e_{tijk} = Random error for t^{th} trait

Heritabilities, genetic and phenotypic correlations among all of the body measurements and CDS were estimated using by DXMUX sub-program that was developed in order to multi-trait analysis in DFREML Ver. 3.0 β program (Meyer, 2000). Animal Model (AM) given below, which was used for the estimation of heritabilities, genetic and phenotypic correlations.

$$Y_{tijk} = \mu_t + S_{ti} + P_{tj} + a_{tk} + e_{tijk}$$

In the equation given above, a_{tk} referred to additive genetic effect of k^{th} calf for t^{th} trait and the other components of model were also defined in the first model given before.

RESULTS AND DISCUSSION

Variance analysis results (summarized for p-values) of fixed effects for the traits studied according to sex of calf and producing type of calf were given in Table 1.

P-values in Table 1 showed that producing type of calf was statistically significant effect on all of the body measurements and calving difficulty scores ($p<0.01$). But, sex of calves was not significant effect on any traits studied ($p>0.05$). In parallel with this result Bakir *et al.* (2004) also reported that sex of calf was not significant effect on birth weights of Holstein calves. On the other hand, sex of calf was found a significant effect on birth weights of Holstein calves (Kocak *et al.*, 2007).

Descriptive statistics of data set and least-square means for the body measurements and calving difficulty scores according to sex and producing type of calf were given in Table 2.

When all means of the body measurements between male and females were evaluated, although male calves had higher means than females as expected, these differences were not statistically significant ($p>0.05$). In addition, sex of calf was not significant effect on CDS ($p>0.05$). Agca *et al.* (1998) reported that mean birth weights of single-born Holstein calves derived from fresh, frozen and vitrified embryos did not differ between sexes ($p>0.05$). Legault and Touchberry (1962) found that the mean birth weight of 207 Holstein calves at first calving was 40.82 kg (90.0 lb) and there was statistically significant differences for mean birth weights between sexes in the whole data set (587 records) ($p<0.01$). Bakir *et al.* (2004) informed that the mean birth weight of 885 Holstein calves in first parity was 35.40 kg and there was no significant differences for mean birth weight between sexes in the whole data set (2583 records) ($p>0.05$). Kocak *et al.* (2007) reported that the mean birth weight of 1830 Holstein calves in first parity was 38.47 kg

Table 1: Variance analysis results (p-values) for all of the traits studied according to sex and producing type of calf

Fixed effect factors	p-values for the traits				
	BW	WH	BL	CG	CDS
Sex	0.154	0.331	0.110	0.101	0.391
Producing type	0.000	0.000	0.001	0.000	0.002

BW: Birth Weight, WH: Withers Height, BL: Body Length, CG: Chest Girth, CDS: Calving Difficulty Score

and there was statistically significant differences for mean birth weight between sexes in the whole data set (8399 records) ($p<0.05$).

In this study, producing type of calf was significant effects on CDS ($p<0.05$). The means of the body measurements given in Table 2 showed that calves born from FET had higher mean than both ET and AI calves. Mean birth weight of FET calves was 42.36 kg and higher 9-15% than mean birth weights of AI and ET calves (38.85 and 36.90 kg, respectively). According to the producing type of calf, all of the means for traits of FET calves were in the first statistical group (in group a), both of the means of AI and ET calves were also in the same group (in group b). Behboodi *et al.* (1995) informed that calves that developed from IVM/IVF-derived embryos co-cultured *in vitro* were larger at birth than calves born from IVM/IFV-derived embryos that developed into blastocysts in the sheep oviduct and calves born from AI. Jacobsen *et al.* (2000) reported that BW higher for IVPserum (46.9 kg) and IVPops (50.6 kg) than for AI control calves (41.8 kg).

Heritabilities, genetic and phenotypic correlations of the body measurements of calves and calving difficulty scores were given in Table 3.

Table 3 showed that from the highest to lower, heritabilities of the body measurements and calving difficulty scores were 0.328, 0.287, 0.258, 0.240 and 0.152 for BW, WH, BL, CG and CDS, respectively. Legault and Touchberry (1962) informed that estimates of heritability ranges for birth weight of Holstein calves were as 0.12 and 0.39. Bakir *et al.* (2004) and Kocak *et al.* (2007) reported that estimates of heritability for birth weight of Holstein calves were 0.13 and 0.115, respectively.

Eriksson *et al.* (2004) reported direct heritabilities on the observable scale for calving difficulty score at first parity ranged from 0.11-0.16 for two beef breeds. Luo *et al.* (1999) informed the specific heritabilities for direct and maternal calving ease in Canadian Holsteins were 0.05 and 0.03, respectively. Steinbock *et al.* (2003) reported when using a threshold model, the heritabilities for calving difficulty at first calving of Swedish Holsteins were 0.17 and 0.12 for direct and maternal effects, respectively. When using the linear model, they were also 0.06 and 0.05 for the corresponding traits, respectively.

Table 2: Descriptive statistics of data set and least-square means all of the body measurements studied and calving difficulty scores

Traits	BW	WH	BL	CG	CDS
Sex					
Female (n = 97)	38.67	75.65	72.40	75.94	0.462
Male (n = 105)	40.07	76.23	73.51	76.95	0.571
Producing type					
AI (n = 85)	38.85b	75.55b	72.62b	75.60b	0.471b
ET (n = 55)	36.90b	74.42b	71.64b	74.73b	0.236b
FET (n = 62)	42.36a	77.87a	74.65a	79.19a	0.823a
Overall					
Means±SD	39.39±6.23	75.96±4.11	72.98±4.63	76.47±4.43	0.517±0.063
CV (%)	15.81	5.41	6.34	5.79	12.18
No. records	202				
Measurement time	At birth				
No. fixed effect	2				
1st effect and its level	Sex-2 (female, male)				
2nd effect and its level	Producing type-3 (AI, ET, FET)				

Means for each effect within columns bearing different letters differ ($p<0.05$), *kg for BW, cm for the other body measurements, raw scores for CDS

Table 3: Heritabilities, genetic and phenotypic correlations among the body measurements and calving difficulty scores

Traits	BW	WH	BL	CG	CDS
BW	0.328±0.05	0.921	0.879	0.829	0.804
WH	0.745	0.287±0.04	0.712	0.974	0.670
BL	0.704	0.678	0.258±0.03	0.559	0.632
CG	0.752	0.729	0.610	0.240±0.04	0.495
CDS	0.765	0.566	0.548	0.481	0.152±0.05

Heritabilities±standard error on main diagonal, genetic correlations above main diagonal ($p<0.01$) and phenotypic correlations below main diagonal ($p<0.01$)

Table 4: Descriptive statistics of calving difficulty scores

	CDS*	0		1		2		3+	
Factors	N	n	(%)	n	(%)	n	(%)	n	(%)
Producing type									
AI	85	60	70.6	14	16.5	7	8.2	4	4.7
ET	55	48	87.3	3	5.5	2	3.6	2	3.6
FET	62	35	56.5	10	16.1	10	16.1	7	11.3
Sex									
Female	97	73	75.3	10	10.3	9	9.3	5	5.1
Male	105	70	66.7	17	16.2	10	9.5	8	7.6
Overall	202	143	70.8	27	13.4	19	9.4	13	6.4

*Calving difficulty score (0: Normal, 1: Slight assistance 2: Puller used easy, 3+: Puller used hard or veterinary assistance required or Caesarian)

In comparison with estimates of BW and CDS from previous studies given above, the heritabilities in this study were similar, somewhat lower or higher.

All genetic correlations among the body measurements of calves and calving difficulty scores were high and positive. The highest genetic correlation among the body measurements was 0.974 between CG and WH and the lowest genetic correlation was also 0.559 between CG and BL.

Genetic correlations, from the highest to the lowest, between BW and the other body measurements were 0.921, 0.879 and 0.829 for WH, BL and CG, respectively.

Genetic correlations, from the highest to the lowest, between CDS and the other body measurements of calves were 0.804, 0.670, 0.632 and 0.495 for BW, WH, BL and CG, respectively ($p<0.01$). These results showed that BW was more indicator factor on calving difficulty than the other body measurements of calves. Naazie *et al.* (1991) informed that genetic correlation between CDS and BW in beef heifers was 0.65 and 0.78 for raw CDS and binary CDS, respectively.

Multiple regression model equation was also estimated as CDS = 0.136 BW + 0.014 WH-0.030 BL-0.028 CG-1.595 ($p<0.01$ for BW, $p<0.05$ for BL and $p>0.05$ for the other regression coefficients) ($R^2 = 0.603$). This equation showed that the regression coefficient of calving difficulty on BW was also significant and higher indicator factor than the other body measurements.

Some descriptive statistics about calving difficulty scores were given in Table 4.

The total of 202 calvings given in Table 4 were evaluated; of which 143 (70.8%) were as normal (CDS = 0), 27 (13.4%) as slight assistance (CDS = 1), 19 (9.4%) as puller used easy (CDS = 2) and 13 (6.4%) as puller used hard or veterinary assistance required (CDS = 3+). The rates of CDSs were very similar to the results for three breed heifer groups (68.9, 12.6, 11.3 and 7.2% for CDS = 0, 1, 2 and 3+, respectively) informed by Naazie *et al.* (1989). In this study, if both CDS = 2 and 3+ scores were assumed as the availability of calving difficulty, calving difficulty rate would be 15.8%. This rate was higher than average calving difficulty rate (9.3%) at first calving of Holstein informed by Berger (1994). On the other hand, the rates of CDSs were also similar to the results (of which 63.4, 25.8 and 10.8% were born unassisted, mild dystocia and severe dystocia, respectively for Holstein calves) reported by Lombard *et al.* (2006).

CONCLUSION

In this study, sex of calves was not significant effect on birth weight and some body measurements of calves and calving difficulty. But, producing type of calves (were born from AI, ET or FET) was statistically significant effect on all of the traits studied. Means birth weight and body measurements of calves were born from AI and ET which were similar values statistically. On the other hand, especially, frozen embryo transfer reasoned to increase of calving difficulty and birth weight of calves statistically significant. Therefore, the probably effects of this kind factor on calving difficulty should be estimated correctly in order to reduce some problems related to calving difficulty before using these kind of reproductive techniques and applications in the herds.

Heritability estimates in this study showed that birth weight (h^2 = 0.328) and the other body measurements (ranges of h^2 were from 0.240-0.287) of calves were more determined by genetic factors than for calving difficulty (h^2 = 0.152). In other words, calving difficulty is more controlled by some environmental factors than genetic effects. Genetic correlation estimates showed that all correlations among birth weight and the other body measurements of calves were high and positive. In addition genetic correlations were higher than phenotypic correlations. These results can be also used in selection programs in the herds.

Consequently, birth weight of calves among the other body measurements was found as a main indicator factor on calving difficulty. In addition, because of heritability estimates of birth weight is also high so the selection against calving difficulty (as calf trait) through selection for low birth weight should be effective similarly suggested by Naazie *et al.* (1991).

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