Association Between Conformation Traits and Reproductive Traits in Holstein Cows in the Department of Antioquia - Colombia

Asociación entre Características de Conformación y Reproductivas en Vacas Holstein del Departamento de Antioquia - Colombia

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Abstract. *Conformation traits have been related with reproductive parameters and can be used as their indicators. These traits appear earlier in life than reproductive traits and, thus, may allow for faster selection of prolific animals. In order to estimate the phenotypic association between conformation and reproductive traits, 8,037 records from 139 Holstein cow herds were analyzed. The analysis of association was done with a generalized linear model, regression analysis and Pearson correlation coefficient. The results showed that the association between conformation traits tends to be low to medium (0.00 – 0.46); the highest association was for rear udder height and rear udder weight (0.46), while the lowest was for chest width and central ligament (-0.0024). Conformation traits that showed a significant effect on reproductive traits were body and udder compound, angularity, stature and rear udder width. The highest regression coefficient was for calving interval and body compound (-43.13 days); the lowest was for services per conception and rear udder width (-0.063 services). Phenotypic correlations with reproductive traits were low (0.00 to 0.04). The highest correlation was for services per conception and foot angle (0.04); the lowest was for calving interval and rear legs rear view (0.00). These results indicate that there are not phenotypic associations between conformation traits and reproductive parameters. It is important to estimate genetic correlation and determinate their importance and possibilities for use in genetic improvement programs.*

Keywords: Genetic parameters, linear type traits, phenotypic correlation, reproductive efficiency.

Resumen. *Las características de conformación han sido relacionadas con parámetros reproductivos y pueden usarse como indicadores de estos. Estas aparecen más rápido en la vida que las reproductivas, permitiendo una selección rápida de individuos prolíficos. Para estimar la asociación fenotípica entre características de conformación y reproductivas, se analizaron 8.037 registros de vacas Holstein de 139 hatos. El análisis de asociación se realizó mediante el modelo lineal generalizado, análisis de regresión y coeficiente de correlación de Pearson. Los resultados mostraron que la asociación entre características de conformación tiende a ser baja a media (0,00 – 0,46), la asociación más alta fue entre alto y ancho de la ubre posterior (0,46), la más baja fue entre ancho de pecho y ligamento central (-0,0024). Las características de conformación que mostraron un efecto significativo en las reproductivas fueron compuesto de ubre y de cuerpo, angulosidad, estatura, y ancho de la ubre posterior. El mayor coeficiente de regresión fue entre intervalo entre parto y compuesto corporal (-43,13 días), el más bajo entre servicios por concepción y ancho de ubre posterior (-0,063 servicios). Las correlaciones fenotípicas con características reproductivas fueron bajas (0,00 a 0,04). La más alta fue para servicios por concepción y ángulo de pezuña (0,04), la más baja para intervalo entre partos y patas de lado (0,00). Estos resultados indican que las características de conformación no están asociadas con los parámetros reproductivos desde el punto de vista fenotípico. Es importante estimar las correlaciones genéticas y determinar la posible utilización de estas asociaciones en programas de mejoramiento genético.*

Palabras clave: Parámetros genéticos, características lineales, correlación fenotípica, eficiencia reproductiva.

One of the most economically important traits in dairy cattle is female fertility. A low reproductive performance leads to economic losses due to reduction in milk yield as a result of prolonged calving intervals, increased insemination costs and higher replacement costs. Fertility problems are the most common reason for involuntary culling in dairy cattle (Makgahlela *et al.,* 2007).

Worldwide, breeding programs have focused on milk yield traits without considering the negative genetic correlation between fertility and milk production, with consequent negative effects on reproductive efficiency (Makgahlela *et al*., 2009; Royal *et al.* 2002).

Fertility traits have low heritability, whereby it is necessary to implement other characteristics which can enhance genetic improvement (Makgahlela *et al.,* 2007; Makgahlela *et al.,* 2009). Conformation traits (CT) represent an interesting alternative for use within selection indexes because they present a higher co-heritability with reproductive traits than the heritability of the traits of interest (Berry *et al.,* 2004). Little information is available on the genetic relationships between reproductive traits (RT) and CT (Royal *et al.,* 2002).

It is possible to develop a new selection index that includes not only important RT, but also some

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conformational characteristics which may contribute to increased reproductive lives of dairy cows, reduced incidences of certain diseases and improved breeding programs by using more easily measured parameters. The aim of this study was to estimate the association between some conformation features and certain reproductive traits in Holstein dairy cattle in the Antioquia department.

MATERIALS AND METHODS

Data collection. This study was carried out in 139 herds from 19 different municipalities of the Antioquia department. 8,037 records from Holstein cows between 1 and 11 lactations were available for inclusion in the analysis.

Linear evaluation. Four different classifiers scored 16 traits for each cow and 3 compounds were calculated with these traits. The conformation traits evaluated were: stature (STA), chest width (CW), angularity (ANG), rump angle (RA), rump width (RW), foot angle (FA), rear legs side view (RLS), rear legs rear view (RLR), udder depth (UD), central ligament (CL), fore udder attachment (FUA), front teat position (FTP), teat length (TL), rear udder height (RUH), rear udder width (RUW) and rear teat position (RTP). The traits were classified on a scale of 1 to 9 according to biological extremes in agreement with the methodology proposed by the International Committee for Animal Recording (ICAR, 2012).

Compounds were calculated as follows:

Udder compound

$$UC = [(UD \times 0.35) + (FUA \times 0.16) + (RUH \times 0.16) + (RUW \times 0.12) + (CL \times 0.09) + (FTP \times 0.05) - (RTP \times 0.07)] + 0.15$$

Legs compound

$$LC = (FA \times 0.48) + (RLR \times 0.37) - (RLS \times 0.15)$$

Body compound

$$BC = (STA \times 0.5) + (CW \times 0.25) + (ANG \times 0.15) + (RA \times 0.10)$$

Reproductive parameter measurement. 8,037 milk records from 139 herds were analyzed. The most important RT in dairy herds were included in the research calving interval (CI) and services per conception (SPC).

Data analysis. In order to obtain a normal distribution of the data and eliminate outliers, the range of data used for CI was 301 to 650 days and 1 to 8 services for SPC. Finally, 4,792 and 6,198 records were analyzed for CI and SPC, respectively.

The linear conformation trait score was converted into a different qualification scale to perform the descriptive analysis of the population, since the maximum score did not always correspond to the desired optimal for the breed. For STA, CW, ANG, RW, CL, FUA and RUW, the scores 1 and 2 corresponded to bad (B), 3 and 4 to regular (R), 5 and 6 to good (G), 7 and 8 to very good (VG) and 9 to excellent (E). Whereas, for RA, RLS, RLR, UD, FTP, TL, RUH and RTP, the scores 1 and 9 corresponded to bad, 2 and 8 to regular, 3 and 7 to good, 4 and 6 to very good, and 5 to excellent.

To carry out the descriptive analysis of the RT, various measurements of central tendency and dispersion were taken to know their behavior in this population, while the description of the CT was made with contingency tables to identify the population distribution in the proposed qualification scale.

To determine the relationship between CT and RT, three different statistical analyses were carried out. A generalized linear model was used as follow:

$$C_{Iijklmnopqrstuv} = \mu + S_i + D_j + LAC_k + ADMY_l + CM_m + CY_n + IDH_o + EY_p + CM_q + UC_r + LC_s + BC_t + EV_u + Q_{1\ldots v} + e_{ijklmnopqrstuv}$$

Where CI is calving interval, μ is the overall mean for the reproductive trait, S_i and D_j are the fixed effect of sire and dam, respectively; LAC_k is a covariate for lactation number, $ADMY_l$ is a covariate for adjusted milk yield, CM_m is the fixed effect of calving month, CY_n is the fixed effect of calving year, IDH_o is the fixed effect of herd, EY_p and EM_q are the fixed effect of year and month of evaluation, respectively, UC_r, LC_s and BC_t are the covariates for udder, leg and body compound, respectively; EV_u is the fixed effect of the linear type trait evaluator, Q_v is any other conformation trait included in the model depending on the evaluated reproductive trait, and $e_{ijklmnopqrstuv}$ is the residual error.

$$SPC_{ijklmnopqrstuwxy} = S_i + D_j + LAC_k + MY_l + CM_m + CY_n + IDH_o + EY_p + EM_q + UC_r + LC_s + BC_t + EV_u + PP_w + FP_x + DIM_y + Q_{1\ldots v} + e_{ijklmnopqrstuvwxy}$$

Where SPC is services per conception, MY_l is a covariate for milk yield, PP_w is a covariate for protein percentage, FP_x is a covariate for fat percentage, DIM_y is a covariate for days in milk and $e_{ijklmnopqrstuvwxy}$ is the residual error.

To determine the magnitude of the effect a regression analysis was carried out. The models of linear regression used were the following:

$$CI = \beta_0 + LAC\beta_1 + ADMY\beta_2 + Q_n\beta_n$$

Where CI is the dependent variable, β_0 is the intercept, LAC and ADMY are the independent variables, β_1 and β_2 are the regression coefficients between LAC, ADMY and CI, respectively, Q_n is the conformation traits included in the model, shown in Table 1, and β_n is the regression coefficient between the conformation traits and calving interval, and e is the residual error.

$$SPC = \beta_0 + LAC\beta_1 + MY\beta_2 + DIM\beta_3 + Q_n\beta_n + e$$

Where SPC is the dependent variable; LAC, MY and DIM are the independent variables, β_1, β_2 and β_3 are the regression coefficients between LAC, MY, DIM and SPC, respectively; Q_n is the conformation traits included in the model, shown in Table 1, and β_n is the regression coefficient between the conformation traits and services per conception, and e is the residual error.

The association between the CT and RT was done using the Pearson correlation coefficient according to the following formula:

$$r_{X/Y} = \frac{COV_{X,Y}}{\sqrt{var\,X \ x \ var\,Y}}$$

All statistical analyzes were performed with the SAS 9.0 software.

Table 1. Conformation traits included in the regression model for calving interval (CI) and service per conception (SPC) for a Holstein cows population in Antioquia, Colombia.

Conformation trait	STA	ANG	CW	RA	RW	RUW	RTP	UC	LC	BC
CI	X	X	X	X	X			X	X	X
SPC						X	X	X	X	X

RESULTS

Descriptive analysis. The mean, standard deviation, variation coefficient and number of observations for the reproductive traits are given in Table 2.

The description of the Holstein population of the department of Antioquia according to type trait evaluation is presented in Table 3.

The Holstein population in Antioquia (89.41%) had an excellent body conformation. For leg conformation, the majority showed a regular or good qualification (43.46 and 44.85 % respectively). 82.2% of the population had a good or excellent qualification for udder conformation.

Effect of conformation trait score on reproductive traits. ***Calving interval.*** The calving interval was significantly affected by LAC and ANG (P<0.05), as well as by ADMY, CY and IDH (P<0.01). Other variables included in the model had no significant effect (P>0.05). The proposed model had a determination coefficient (r^2) of 0.3330, which means that only 33.30% of the variation found for this parameter was explained by the effects included in the model, the remaining 66.7% was caused by other effects not included. The regression coefficient of the significant variables on the CI is shown in Table 4.

Table 2. Descriptive analysis for calving interval in days (CI) and service per conception (SPC) for a Holstein population in Antioquia, Colombia.

Trait	Mean (X±SD)	Variation Coefficient (VC)	Number of Observation (N)
CI	435 ± 133	30.69	4792
SPC	1.66 ± 1.09	65.69	6198

Standar deviation.

Table 3. Description of Holstein population in Antioquia – Colombia, according to conformation trait score in accordance to the qualification scale proposed; bad (B), regular (R), good (G), very good (VG) or excellent (E).

Conformation trait	Qualification	Frequency	Percent	Conformation trait	Qualification	Frequency	Percent
STA	B	3	0.04	CW	B	10	0.12
	R	243	3.02		R	2120	26.38
	G	4873	60.63		G	5408	67.29
	VG	2871	35.72		VG	491	6.11
	E	47	0.58		E	8	0.10
ANG	B	18	0.22	RW	B	2	0.02
	R	137	1.71		R	2532	31.50
	G	2488	30.96		G	5129	63.82
	VG	5252	65.36		VG	368	4.58
	E	140	1.74		E	6	0.07
CL	B	314	4.35	FUA	B	910	12.61
	R	861	11.94		R	1073	14.87
	G	3396	47.08		G	1665	23.08
	VG	2605	36.12		VG	1979	27.43
	E	37	0.51		E	1588	22.01
RUW	B	15	0.21	RA	B	12	0.15
	R	135	1.87		R	100	1.24
	G	1064	14.74		G	209	2.60
	VG	3741	51.82		VG	3234	40.24
	E	2264	31.36		E	4482	55.77
RLS	B	45	0.56	RLR	B	7	0.09
	R	131	1.63		R	126	1.57
	G	1709	21.26		G	518	6.45
	VG	3569	44.41		VG	2939	36.61
	E	2583	32.14		E	4437	55.28
UD	B	109	1.51	FTP	B	716	9.04
	R	445	6.16		R	1557	19.66
	G	2001	27.71		G	874	11.04
	VG	2936	40.66		VG	1905	24.06
	E	1729	23.95		E	2866	36.20
TL	B	4	0.05	RUH	B	26	0.36
	R	48	0.61		R	202	2.80
	G	361	4.56		G	1574	21.80
	VG	1866	23.55		VG	3892	53.91
	E	5643	71.23		E	1525	21.12
RTP	B	1043	13.24	BC	B	3	0.04
	R	719	9.13		R	0	0
	G	930	11.80		G	20	0.25
	VG	1908	24.22		VG	828	10.30
	E	3279	41.62		E	7184	89.41
LC	B	427	5.32	UC	B	21	0.29
	R	3488	43.46		R	148	2.05
	G	3599	44.85		G	1113	15.45
	VG	458	5.71		VG	3131	43.47
	E	53	0.66		E	2790	38.73

*All frequencies of all traits were significant differences ($P<0.0001$)

Table 4. Regression coefficient ± standard error (β ± SE) and p-value of body compound (BC), angularity (ANG), stature (STA), udder compound (UC) and rear udder width (RUW) for calving interval (CI) and service per conception (SPC) for a Holstein population in Antioquia – Colombia.

Reproductive traits	Conformation trait	β ± SE	P-value
Calving interval	BC	-43.13 ± 20.76	0.0379
	ANG	8.07 ± 3.72	0.0301
	STA	24.28 ± 10.52	0.0211
Service per conception	UC	0.06 ± 0.03	0.0284
	RUW	-0.06 ± 0.02	0.0026

Table 5. Phenotypic correlation between conformation traits for a Holstein population in the Antioquia - Colombia.

	STA	CW	ANG	RA	RW	FA	RLS	RLR	UD	CL	FUA	FTP	TL	RUH	RUW	RTP
STA	1.00000 8037	0.19429a <.0001b 8037c	0.33124 <.0001 8035	-0.01928 0.0839 8037	0.12518 <.0001 8037	-0.02584 0.0205 8037	-0.01133 0.3099 8037	0.05094 <.0001 8027	-0.08616 <.0001 7220	0.08532 <.0001 7213	-0.04796 <.0001 7218	0.03123 0.0055 7918	0.01732 0.1233 7922	0.06564 <.0001 7219	0.09633 <.0001 7219	0.02536 0.0244 7879
CW		1.00000 8037	0.17848 <.0001 8035	0.04343 <.0001 8037	0.17332 <.0001 8037	0.16635 <.0001 8037	-0.11516 <.0001 8037	0.10290 <.0001 8027	-0.15691 <.0001 7220	-0.00240 0.8387 7213	0.04733 <.0001 7218	0.12880 <.0001 7918	0.03928 0.0005 7922	0.06721 <.0001 7219	0.06949 <.0001 7219	-0.01195 0.2890 7879
ANG			1.00000 8035	0.02162 0.0526 8035	0.10341 <.0001 8035	-0.04285 0.0001 8035	-0.04775 <.0001 8035	-0.01578 0.1575 8025	-0.12016 <.0001 7218	0.09383 <.0001 7211	0.01533 0.1929 7216	0.05267 <.0001 7916	0.05750 <.0001 7920	0.04468 0.0001 7217	0.07444 <.0001 7217	-0.01001 0.3743 7877
RA				1.00000 8037	0.03858 0.0005 8037	0.08990 <.0001 8037	-0.11022 <.0001 8037	0.09887 <.0001 8027	-0.02176 0.0645 7220	-0.00982 0.4046 7213	-0.02926 0.0129 7218	0.02262 0.0441 7918	0.04101 0.0003 7922	0.10932 <.0001 7219	0.06758 <.0001 7219	-0.06406 <.0001 7879
RW					1.00000 8037	0.12226 <.0001 8037	-0.06432 <.0001 8037	0.03767 0.0007 8027	-0.02890 0.0141 7220	0.10276 <.0001 7213	0.13652 <.0001 7218	0.12549 <.0001 7918	0.04591 <.0001 7922	0.17303 <.0001 7219	0.14206 <.0001 7219	0.07086 <.0001 7879
FA						1.00000 8037	-0.26595 <.0001 8037	-0.00431 0.6994 8027	-0.00606 0.6068 7220	0.12522 <.0001 7213	0.23753 <.0001 7218	0.14106 <.0001 7918	0.09322 <.0001 7922	0.16298 <.0001 7219	0.11590 <.0001 7219	0.01302 0.2478 7879
RLS							1.00000 8037	0.00924 0.4079 8027	0.04877 <.0001 7220	0.00027 0.9816 7213	-0.09674 <.0001 7218	-0.18629 <.0001 7918	-0.10486 <.0001 7922	-0.14213 <.0001 7219	-0.06233 <.0001 7219	0.06082 <.0001 7879
RLR								1.00000 8027	-0.07845 <.0001 7220	0.08594 <.0001 7213	-0.05635 <.0001 7218	0.01782 0.1130 7910	0.00958 0.3944 7914	0.09054 <.0001 7219	0.17013 <.0001 7219	-0.05778 <.0001 7871
UD									1.00000 7220	0.11132 <.0001 7213	0.40902 <.0001 7218	0.07563 <.0001 7215	-0.01714 0.1454 7219	0.12156 <.0001 7219	-0.06044 <.0001 7219	0.16792 <.0001 7214
CL										1.00000 7213	0.15131 <.0001 7212	0.07327 <.0001 7208	0.01845 0.1171 7212	0.31611 <.0001 7213	0.37595 <.0001 7213	0.13103 <.0001 7207
FUA											1.00000 7218	0.28491 <.0001 7214	0.00411 0.7269 7218	0.23596 <.0001 7218	0.15904 <.0001 7218	0.12222 <.0001 7213
FTP												1.00000 7918	-0.12615 <.0001 7918	0.11909 <.0001 7214	0.15077 <.0001 7214	0.22541 <.0001 7875
TL													1.00000 7922	0.00521 0.6578 7218	-0.02091 0.0757 7218	-0.08554 <.0001 7879
RUH														1.00000 7219	0.46684 <.0001 7219	0.07030 <.0001 7213
RUW															1.00000 7219	0.01853 0.1156 7213
RTP																1.00000 7879

Stature (STA), chest width (CW), angularity (ANG), rump angle (RA), rump width (RW), foot angle (FA), rear legs side view (RLS), rear legs rear view (RLR), udder deep (UD), central ligament (CL), fore udder attachment (FUA), front teat position (FTP), teat length (TL), rear udder height (RUH), rear udder weight (RUW) and rear teat position (RTP). Lines represent the correlation value (a), p-value (b) and number of observations (c).

The CI increased by 8.07 and 24.18 days for each unit increase in the ANG and STA scores, but decreased by 43.13 days when the BC increased one unit.

Services per conception. The number of services per conception was significantly affected by DIM, CY, IDH, BC ($P<0.01$) and also by MY, FP and RUW ($P<0.05$). The model used had a determination coefficient (r^2) of 0.4527, which means that 45.27% of the variation found in SPC was due to the sources of variations included in the model. The regression coefficient of the significant variables for SPC is shown in Table 4. The regression coefficient indicates that, for every unit increase in UC and RUW, the number of services per conception increased and decreased 0.06 days, respectively.

Phenotypic correlation between conformation traits. The phenotypic correlation between the conformation traits is shown in Table 5. The association between the CT tended to be low to medium (0.00 – 0.46). The highest correlation was for RUH and RUW (0.46), while the lowest was for CW and CL (-0.0024). UD and FUA also showed a high association (0.40).

FUA had a low association with other udder characteristics, such as FTP (0.28) and RUH (0.23). The correlation between the position of front and rear teat was low (0.22). The CL showed a positive and medium association with RUH and RUW (0.31 and 0.37, respectively).

Association between the conformation traits and reproductive traits. Table 6 shows the phenotypic

Table 6. Phenotypic correlations between conformation traits and calving interval (CI) and service per conception (SPC) for a Holstein population in Antioquia - Colombia.

Type trait	Reproductive characteristics		Type trait	Reproductive characteristics	
	CI	**SPC**		**CI**	**SPC**
STA	0.02981 a 0.0471 b 4436 c	0.03139 0.0135 6194	FUA	0.03315 0.0370 3958	0.03421 0.0107 5566
CW	-0.01438 0.3383 4436	0.01796 0.1576 6194	FTP	-0.00055 0.9711 4369	0.03398 0.0080 6092
ANG	0.00296 0.8440 4435	-0.01467 0.2483 6192	TL	-0.00179 0.9059 4372	0.00892 0.4862 6096
RA	-0.01340 0.3722 4436	-0.00687 0.5887 6194	RUH	0.02266 0.1541 3958	0.01036 0.4398 5566
RW	0.02560 0.0883 4436	0.04073 0.0013 6194	RUW	-0.01307 0.4109 3958	-0.01306 0.3298 5566
FA	-0.00804 0.5922 4436	0.04476 0.0004 6194	RTP	0.02486 0.1014 4343	0.01261 0.3265 6061
RLS	0.02764 0.0657 4436	-0.00177 0.8893 6194	BC	0.01631 0.2774 4435	0.02543 0.0454 6192
RLR	0.00110 0.9419 4429	0.00213 0.8667 6185	UC	0.03368 0.0344 3948	0.02612 0.0516 5552
UD	0.03183 0.0453 3958	0.01820 0.1745 5567	LC	-0.01286 0.3922 4429	0.03817 0.0027 6185
CL	0.01467 0.3564 3954	0.00168 0.9002 5560			

Lines represent correlation value (a), P-value (b) and number of observations (c).

correlations between the conformation traits and reproductive traits. The association between CT and RT was low, from 0.00 for FTP and CI; to 0.04 for FA and SPC. STA had a significant association with CI and SPC (0.02 and 0.03, respectively), while RW was only significantly associated with SPC. For the udder characteristics, FUA was significantly associated (0.03) with both of the RT evaluated, but UD and UC had a significantly association with CI (0.03), while FTP showed a significant association with SPC (0.03). BC and LC were significantly associated with SPC (0.02 and 0.03, respectively).

DISCUSSION

The mean value found for CI in this research agrees with the value reported by Salazar *et al.* (2009), who found, for a Holstein population in Antioquia, that the CI was 437 days. Echeverri *et al.* (2011) reported for the Holstein breed an average of 417 days for CI, a value lower than the value reported here, but found that the mean SPC was higher (2.0) than here. Moreover, Lopez *et al.* (2011) reported, for Holstein cattle in Antioquia, a CI of 394 days, whilst other authors reported, for a Holsteins herd in Antioquia - Colombia, an average of 2.4 ± 1.5 services calving/life (Quiroz *et al*., 2011).

The association between STA and ANG found in this paper was similar to that found by Corrales *et al.* (2011) (0.35), also in Antioquia Holstein cows. These authors found lower association between UD and FUA (0.17), CL and RUH (0.12), FUA and RTP (0.18), FUA and RUH (0.13), RUH and RUW (0.20) and between CL and RUW (0.09), than what is shown in this report, but these have the same direction. For FTP and RTP, they found a higher association than what we found (0.31). The correlation between CL, RUH and RUW could indicate that a more definite central ligament is associated with more desirable udders and, therefore, with greater permanence of the cow in the herd, as these animals would be less prone to involuntary culling due to undesirable physical characteristics.

Moro and Ruiz (1999) found a positive and low association for CW and CL (0.16), different from those found in this research, where this association was very low and negative (-0.0024). On the other hand, they found a similar association between FA and FUA (0.25), UD and FUA (0.44), and CL and RUH (0.36), not only in magnitude but also in direction. For CL and RUW, they found a higher association (0.61); also for FUA and FTP (0.37) and for FUA and RUH (0.41). Between RUH and RUW, Moro and Ruiz (1999), also found a high association (0.55).

Berry *et al.* (2004) reported on the association between some CT in Holstein-Friesian cows from the south of Ireland. In agreement with the results presented here, they reported a similar association for STA and ANG (0.30), but found a low association between FA and FUA (0.06); while, for UD and FUA these authors reported a higher association (0.50).

Other authors have reported similar values for these associations in Holstein cows in Turkey. For CL and CW, a non-existent association has also been reported (0.00), but, for FA and FUA, some authors have reported a negative association (-0.20), which is similar in magnitude to the value reported here but different in direction. For UD and FUA and CL and RUH, a high association has also been reported (0.55 and 0.51, respectively) that is higher than what we found (Duru *et al.,* 2012). These authors reported a lower association between FUA and FTP and RUH (0.00 and 0.09, respectively). They also found a similar association for rear and front teat position to that reported here (0.21).

The strong phenotypic correlation between FUA and UD indicated the possibility of reducing the number of CT assessed on each animal with the loss of very little information (Berry *et al.,* 2004).

Nouman and Abrar (2013) evaluated the association between conformation traits as reproductive efficiency, measured in terms of calving interval in Sahiwal cows in Pakistan. They found that the association between STA and CI was -0.31, much greater than found here, but in a negative sense. They also reported a negative and low association for FUA and CI (-0.08). Unlike the positive and low association that is reported here for UD and CI, these same authors found a negative but slightly association (-0.12). They found higher associations than reported here, for chest and body they reported a phenotypic correlation of -0.27 with reproductive efficiency, and -0.16 with pelvic angle. These authors also carried out multiple and stepwise regression techniques to study the effect of conformation traits on reproductive efficiency (calving interval) and to find out important conformation traits for the prediction of reproductive efficiency. The highest regression coefficient that they found for conformation traits and calving interval was for STA (-11.13), which differs not only in direction but also in magnitude compared to the coefficient of regression encountered here. For pelvic angle, they found a regression coefficient of 2.88, -0.38 for rump width and -1.75 for chest and body (Nouman and Abrar, 2013).

Perez *et al.* (2006) evaluated the association between locomotion traits and fertility in Holstein cattle from the Basque and Navarra Autonomous Regions (Spain). They found that only the high foot and leg score affected cow fertility, but this effect disappeared when the CI was adjusted by production. Also, the average CI was shorter for low-score cows. They found that the feet and leg score was not statistically significant for the insemination per lactation, although their results showed a slightly positive trend that could agree with the low but positive association that we found between LC and SPC. For calving interval and insemination per lactation, they didn't find a significant effect of foot angle or rear leg set.

In Holstein cattle from the United Kingdom, an association of -0.03 for RA and CI has been found, which is higher than the association we reported and in a negative sense. For RW and CI, the association reported in the literature was 0.00 but we found a slightly higher value (0.02); however, but this association wasn't significant (Wall *et al.,* 2005). These authors also reported the same association that is reported here for CI and RUH (0.02). For legs and feet, a negative and higher association was found in comparison to what they reported (0.00), but, regarding the association between mammary system and CI, they reported a slightly higher value (0.04) (Wall *et al.,* 2005).

Some authors reported fertility deterioration among animals with good locomotion scores because of higher yields that could drive energetic disorders that affect the reproductive ability (McDaniel, 1997).

CONCLUSIONS

The phenotypic correlation between the analyzed conformation traits generally showed a large variation; specifically, the udder traits showed high and positive values for the phenotypic correlation.

Conformation traits are not associated with reproductive parameters from the phenotypic standpoint. However, it is necessary to analyze the genetic correlations to determine whether some of these conformation traits are suitable for inclusion in breeding programs, based on the selection of superior individuals in order to improve some of the most important reproductive parameters of dairy production systems.

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