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COMMUNICATION

Comparative evaluation of udder and body conformation traits of first lactation ¾ Holstein x ¼ Jersey versus Holstein cows[#]

Comparación de las características de conformación de la ubre y el cuerpo de vacas de primera lactancia ¾ Holstein x ¼ Jersey versus Holstein

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RESUMEN

Con el objetivo de facilitar la selección de razas para cruzamiento se realizó una evaluación comparativa de las características de conformación de vacas cruza ¾ Holstein (HO) x ¼ Jersey (JE) versus vacas HO. Todas las mediciones fueron registradas en vaquillonas de primer parto de 40 a 100 días en lactancia. En relación con la raza HO, para la cruza se registró una menor estatura (-9,62 cm; P = 0,0001), ancho de grupa (–1,55 cm; P = 0,005) y ancho de pecho (–2,18 cm; P = 0,006), más estrechos, profundidad corporal (–6,45 cm; P = 0,04) y perímetro torácico (-10,43 cm; P = 0,0001) menores y menor ángulo de pezuña (–4,61º; P = 0,02). Entre las características de la glándula mamaria, la cruza presentó ubres más profundas (+3,80 cm; P = 0,006) y estrechas (–2,32 cm; P = 0,001), con pezones anteriores más largos (+0,54 cm; P = 0,04) que la raza HO. Se sugiere que ciertos aspectos de la conformación de la glándula mamaria de la cruza ¾ HO x ¼ JE podrían ser factores de riesgo asociados al animal de importancia en el descarte de vacas, principalmente en sistemas lecheros intensificados.

Palabras clave: cruza, conformación, descarte, ubre.

SUMMARY

To facilitate the process of decision-making in selecting specific breeds for crossbreeding, this study aimed to determine the conformation traits of ¾ Holstein (HO) x ¼ Jersey (JE) crossbreds, relative to their pure HO contemporaries during the first lactation. All measurements were objectively recorded on first-calf heifers between 40 and 100 days in milk. Crossbreds had smaller stature (-9.62 cm; P = 0.0001), narrower rump width (–1.55 cm; P = 0.005), shallower body depth (–6.45 cm; P = 0.04), smaller heart girth (-10.43 cm; P = 0.0001), narrower chest width (-2.18 cm; P = 0.006), and lower foot angle (–4.61º; P = 0.02) than HO first-calf heifers. Among udder traits, HO x JE crossbreds had deeper (+3.80 cm; P = 0.006) and narrower (–2.32 cm; P = 0.001) udders with longer front teats (+0.54 cm; P = 0.04) compared with HO. It is suggested that certain aspects of the mammary conformation of ¾ HO x ¼ JE crossbreds, as identified in this study, may be animal-associated risk factors of concern for cow culling, mainly in high input production systems.

Key words: crossbreeding, conformation, culling, udder.

INTRODUCTION

Argentina is ranked in the top 20 largest milk-producing countries in the world (FAO 2013[1]). Holstein (HO) dominates the breed listing of dairy cows in Argentina and its main genetic source corresponds to North American genes (Di Croce 2010). Mainly driven by milk payment schemes based on volume rather than on milk solids content (McCarthy *et al* 2007), dairy farmers of many countries, including Argentina, have focused genetic selection on increasing milk production (Miglior *et al* 2005). In order to achieve this goal, cows have mainly been artificially inseminated with semen from North American HO bulls, which are popularly recognized as a high genetic potential breed for milk yield (Dillon *et al* 2006). However, there is a growing body of evidence to suggest that selection emphases for high milk yield has widely been accompanied by undesirable side effects on fertility, health and longevity of dairy herds around the world (Dillon *et al* 2006, Baudracco *et al* 2010). Similarly, for Argentinean HO herds, it has also been shown that as the genetic ability to produce milk increases, the fertility and the number of lactations decrease (Dutour *et al* 2010).

Because of their hybrid vigor potential to improve fertility, health and survival (Funk 2006) and the fact that Argentinean milk prices are currently based on concentration of milk fat and protein solids rather than fluid milk, the use of HO x Jersey (JE) crossbreds is a topic of

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1 http://faostat3.fao.org/home/index.html

growing interest among Argentinean dairy producers. More recently, empirical evidence suggests that HO x JE cows, particularly the second-generation (F_2) crossing, are more prone to premature culling than pure HO cows. Heins *et al* (2008) pointed out the need of recording conformation traits of HO crossbreds to compare them with pure HO populations to facilitate the process of decision-making in selecting a specific breed for crossbreeding. The objective of this study was to compare udder and body conformation traits between ¾ HO x ¼ JE crossbreds and pure HO contemporaries during first lactation.

MATERIAL AND METHODS

EXPERIMENTAL ANIMALS AND DIET

Data were collected from two research dairy farms of the National Institute of Agricultural Technology, Rafaela, Province of Santa Fe, Argentina (31º 12’ S; 61º 30’ W). One of the research farms has a herd made up exclusively of Argentinean HO cows whereas the other one has a herd comprised of HO x JE crossbreds.

Both farms are separated from each other by 1,000 m. In both herds, virgin heifers were reared and bred by artificial insemination. The second generation ¾ HO x ¼ JE cross heifers were mated to JE sires, and pure HO heifers were mated to HO sires. Because udder clearance is the most import conformation trait regarding longevity (Morek-Kopéc and Zarnecki 2012), it was considered as the critical variable to determine the sample size. Assuming a mean udder clearance difference between breeds of at least 3 cm and a probability value of 0.05, the minimum number of animals required to achieve the desired statistical properties was 12 (Montgomery and Runger 2003). Before calving, 19 pure HO and 15 ¾ HO x ¼ JE heifers were randomly selected from each herd and they were assigned to each experimental group. Heifers were fed according to NRC (2001) dairy cattle nutrient requirements. Previous to calving, all heifers were offered a total mixed ration (TMR) containing corn silage (490 g/kg), alfalfa hay (180 g/kg), ground corn (150 g/kg), soybean expeller (100 g/kg) and cotton seed (80 g/kg) on dry matter (DM) basis, excluding the mineral salts. The TMR was delivered once daily in the morning. Animals had free access to drinking water.

The calving period extends from July to September 2010. Following calving, first-calf heifers were milked twice daily commencing at approximately 5:00 h and 15:30 h. All heifers were fed a partial mixed ration (PMR) with access to alfalfa pasture. In addition, heifers were individually fed corn-based concentrate pellets at rate of 5.5 kg DM/heifer/day split into two equal amounts allocated in the milking parlour during milking. The total diet consisted of 470 g of pasture/kg DM, 280 g of PMR/kg DM and 250 g of pelleted concentrate/kg DM. Cattle had access to pasture after morning milking. Following the afternoon milking, the PMR was group-fed once a day. Thereafter, cows were returned to pasture. The PMR consisted of corn silage (720 g/kg), cotton seed (140 g/kg) and ground corn (140 g/kg) on DM basis. Drinking water was provided at all times.

RECORDING CONFORMATION TRAITS

All body and udder measurements were recorded on first-calf heifers between 40 and 100 days in milk (DIM). Except for body condition score (BCS), all conformation measurements were objectively recorded. Body measurements were BCS, hip height, rump width, body depth, heart girth, chest width, foot angle and foot length. Udder measurements were udder clearance, central ligament, rear udder height (RUH), rear udder width (RUW), fore udder attachment (FUA), width between teats (WBT) and teat length.

The BCS was recorded by a single evaluator, using the scoring system based on a five-point scale (1 = excessively thin to 5 = excessively fat) with increments of 0.25 (Wildman *et al* 1982). Hip height was measured from the top of the spine between hips to ground, rump width was the distance between the inner walls of the two ischial tuberosities (i.e. pin bones), and body depth was the distance between the top of spine and the bottom floor of the abdomen at last rib. Heart girth was measured behind the front legs and shoulder blades, and chest width was the inside surface distance between the top of the front legs. Foot angle was measured at the front of the hoof from the floor to the hairline, whereas foot length was measured from the hairline to the tip of the hoof. Both foot measurements were recorded on the right-rear hoof.

For udder measurements, udder clearance was measured from the ground to the bottom of the udder. Central ligament was measured as the depth of cleft at the base of the rear udder, RUH was the distance from the bottom of the vulva to the top of the rear udder, and RUW was measured as the udder width at the point where the rear udder is attached to the body. The FUA was measured as the angle formed between the abdominal wall and the front surface of udder, WBT was the distance between the base of the front teats, and teat length was measured as the distance from base to tip of the front teat.

STATISTICAL ANALYSIS

All data were assessed by a single-factor experiment with one covariate (Montgomery 2001). For all body and udder conformation traits, DIM at time of measurement was used as a covariate in the statistical model (Heins *et al* 2008, 2011). The following model equation was used:

$$y_{ij} = \quad + \tau_i + \beta * \left(x_{ij} - \overline{x}_{..} \right) + \varepsilon_{ij}$$

$i = 1, 2$

$j = 1, \ldots, n_i$

Where: y_{ij} represents an observation in the i^{th} breed of the j^{th} heifer, μ is the overall mean, τ_i is the breed effect, β is a linear regression coefficient indicating the dependency of y_{ij} on x_{ij}, x_{ij} is the measurement made on the covariate corresponding to y_{ij}, ε_{ij} is a random error component and n_i is equal to 15 for crossbreds and 19 for pure HO.

Statistical analyses were performed using the PROC GLM procedure of SAS (2004). The experimental unit was the heifer and a 5% significance level was used.

RESULTS AND DISCUSSION

To correctly compare conformation traits of crossbreds, relative to their pure HO contemporaries, chronological ages of individuals must be comparable. In this experiment, calving age was not different between both breed groups (Table 1). Additionally, the observations herein presented were recorded from 40 to 100 DIM. Consistent with the statistical analysis performed by Heins *et al* (2008, 2011), the effect of DIM on the response variable was accounted for by using it as a covariate in the statistical model (Montgomery, 2001). In this regard, the covariate was significant (P = 0.01; table 1) only for chest width (β coefficient = -0.063) and teat length (β coefficient = -0.022).

Conformation traits are reported in table 1. Body condition scoring system is a tool to assess body fat reserves and energy status of dairy cows (Roche *et al* 2009). The intensity and extent of changes in energy balance could be a risk factor contributing to health disorders, infertility and shorter lifespan (Coffey *et al* 2001). The fact that HO x JE and HO did not differ significantly (P = 0.24) for BCS, suggests that energy balance, under the feeding system provided herein, was similar for both breed groups.

Crossbreds had less hip height (-9.62 cm; P = 0.0001), rump width (-1.55 cm; P = 0.005) and heart girth (-10.43 cm; P = 0.0001) than did HO counterparts. These findings are consistent with those published by Heins *et al* (2008) for the first-generation (F_1) of HO x JE. Relative to HO, body depth was shallower (-6.45 cm; P = 0.04) and chest width narrower (–2.18 cm; P = 0.006) for HO x JE.

Crossbreds had lower foot angle (–4.61°; P = 0.02) than HO. This result is consistent with Heins *et al* (2008), who found a lower foot angle for F_1 HO x JE, relative to HO. A steeper foot angle, like that found in HO, is generally desirable because it allows keeping the heel and pastern

Table 1. Comparison of conformation traits and calving ages between ¾ Holstein x ¼ Jersey and Holstein first-calf dairy heifers.
Comparación de las características de conformación y de la edad al parto entre vaquillonas de primer parto ¾ Holstein x ¼ Jersey y Holstein.

Item	¾ Holstein x ¼ Jersey (n = 15)			Holstein (n = 19)		Significance ANOVA	Significance Covariable*
	Direction of trait**	Mean	SEM	Mean	SEM	P-value	P-value
Age at calving (year)	–	2.34	0.08	2.32	0.07	0.8841	–
Body measurement							
Body condition score (1-5)	–	2.83	0.08	2.96	0.07	0.2435	0.89
Hip height (cm)	shorter	135.01	1.01	144.63	0.90	0.0001	0.22
Rump width (cm)	narrower	16.84	0.38	18.39	0.34	0.0052	0.56
Body depth (cm)	shallower	219.10	2.29	225.55	2.03	0.0455	0.07
Heart girth (cm)	smaller	184.91	1.26	195.34	1.11	0.0001	0.25
Chest width (cm)	narrower	20.43	0.55	22.61	0.49	0.0066	0.01
Foot angle (degree)	lower	41.60	1.44	46.21	1.28	0.0247	0.27
Foot length (cm)	–	7.75	0.17	8.17	0.15	0.0769	0.62
Udder measurement							
Udder clearence (cm)	deeper	56.26	0.96	60.06	0.85	0.0062	0.95
Central ligament (cm)	–	3.38	0.35	3.28	0.31	0.8203	0.77
Rear udder height (cm)	–	21.86	0.70	21.95	0.62	0.9260	0.97
Rear udder width (cm)	narrower	15.32	0.48	17.64	0.43	0.0012	0.84
Fore udder attachment (degree)	–	138.14	4.35	141.26	3.85	0.6000	0.51
Width between teats (cm)	–	13.69	0.52	13.73	0.59	0.9650	0.54
Teat length (cm)	longer	5.58	0.19	5.04	0.17	0.0440	0.01

* Except for age at calving, DIM at time of measurement was used as a covariable in the statistical model.
** When ANOVA P-value < 0.05.

off the ground, enabling cows to better cope with muddy, unlevel and/or rocky ground. As compared to a steep foot angle, a low one increases the risk of culling by about 30% (Morek-Kopéc and Zarnecki 2012). Furthermore, crossbreds had longer teat length (+0.54 cm; P = 0.04) than HO counterparts. In contrast to our findings, teat length was not modified by F_1 HO x JE, relative to pure HO (Heins *et al* 2008).

Longevity has an important influence on dairy cattle profitability because multiple lactations are required to pay for replacement costs (VanRaden and Sanders 2003). To increase longevity (survival), it has been recommended, as a breeding strategy, to reduce causes of involuntary culling (Essl 1998). Among other conformations traits, udder clearance and RUW were significantly associated with involuntary culling. In this regard, it has been demonstrated that as udders are deeper (i.e. less udder clearance) and narrower (i.e. less RUW), the risk of involuntary culling of dairy cows increases (Morek-Kopéc and Zarnecki 2012). This study showed that, relative to HO, crossbreds of HO x JE had deeper (+3.80 cm; P = 0.006) and narrower (–2.32 cm; P = 0.001) udders. Because of their position relative to the ground, deeper udders are more prone to injury and infections (Zavadilová *et al* 2009), especially in herds with high milk production levels. Generally, injury of the distal end of teats compromises the defense mechanisms of quarters against infections making cows more susceptible to mastitis (Nichols 2008). Deeper udders have been associated with high somatic cell counts (Kadarmideen 2004).

Heins *et al* (2012) have suggested that the benefits of HO x JE crosses depend greatly on production environments in reference to low- vs. high- input production systems. According to this, these authors suggested that relative to HO cows, in high-input production systems, the proportionally larger udders of HO x JE crossbreds in relation to their body size may be of great concern. In Argentina, dairy farms are slowly moving towards more complex feeding systems. Mostly, this could be explained by the fact that Argentinean dairy producers are looking for ways to release land for grain crop production (mainly soybean, *Glycine max*), which is considered a more profitable and simpler activity than dairy. In the long run, individual component feeding systems based on the use of grazed pasture are gradually being replaced by confinement or semi-confinement feeding systems, in which conserved forages and concentrates are fed to dairy cattle as a total mixed ration or PMR, respectively. In the present study, it was demonstrated that ¾ HO x ¼ JE crossbreeds had significantly narrower RUW (i.e. less mammary capacity), less udder clearance (i.e. deeper udder) and longer front teat length than pure HO cows did. Overall, these findings, in the actual context of Argentinean dairy production systems, may partially explain the perception among dairy farmers that ¾ HO x ¼ JE crossbreeds are more prone to premature culling.

To reduce the premature culling of cows from dairy herds, it is essential to identify and eliminate risk factors associated with the environment, herd management and cow conformation. In this regard, it is suggested that certain aspects of the mammary conformation of ¾ HO x ¼ JE crossbreds, as identified in this study, may be animal-associated risk factors of concern for cow culling, mainly in high input production systems (i.e. high milk yield systems).

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