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Main Reproductive Indicators and Environmental Factors that Affect *Siboney* and *Mambi de Cuba* Cows at a Breeding Company in Central Cuba

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ABSTRACT

Background: The association of trait heritability with milk production, breeding, and longevity, was thoroughly studied in the past decade. However, the efficiency of productive and reproductive performance is determined by the action of environmental factors and inappropriate husbandry. Therefore, the main reproductive indicators and environmental factors affecting cow genotypes *Cuban Siboney* and *Cuban Mambí* were evaluated at a genetic breeding company in central Cuba.

Methods: The individual records of 618 females were processed between 2007 and 2010 (358 *Mambí de Cuba* from six different herds, and 260 *Siboney de Cuba* from four farms). The calving-first insemination service (CFIS) intervals, the calving-gestation (CG) interval, and the calving interval (CI) were determined. The effects of various factors on the reproductive indicators were estimated using a general linear model.

Results: The farm factor had a significant influence ($P < 0.05$) on CFIS, CG, and CI in both genotypes. Calving years had a significant effect ($P < 0.05$) on CFIS, CG, and CI, with the best results in 2009 and 2010. The best calving quarter for reproductive indicators was the July-August-September period, with a significant influence ($P < 0.05$) on CFIS, CG, and CI, in *Mambi de Cuba*, whereas *Siboney de Cuba* influenced the CFIS.

Conclusions: The two genotypes showed a remarkable deterioration of the reproductive indicators evaluated, particularly influenced by farm, calving year, and calving quarter.

Key words: *dairy bovines, reproductive performance, anestrus, service repetition, reproductive efficiency*

INTRODUCTION

Genotypes *Siboney de Cuba* (5/8 Holstein 3/8 Zebú) and *Mambí de Cuba* (3/4 Holstein 1/4 Zebú) emerged as a result of genetic breeding program for bovines carried out in Cuba (Hernández, Ponce de León, García, Guzmán, Mora, 2011a), which contributed with better adapted crossbred dairy bovines to tropical areas (Portales, González-Peña, Guerra, Évora, Acosta, 2012). Both genotypes are used at the Genetic Livestock Company of Matanzas province, Cuba (Simón, López, Álvarez, 2010).

The genetic parameters are the basis of genetic programs. Trait heritability associated to dairy production, reproduction, and longevity of *Siboney de Cuba* and *Mambí de Cuba* cows was thoroughly studied in the previous decade (Hernández, Ponce de León, de Bien, Mora, Guzmán, 2007; Hernández *et al.*, 2011a). However, environmental factors and malpractice also had a decisive influence on productive and reproductive performance (Álvarez, Hernández, Blanco, 2015; Balarezo, García-Díaz, Hernández-Barreto, García, 2016).

The reproductive indexes are an important tool to evaluate and know the productive efficiency of the herd, as well as the factors affecting it. Accordingly, proper optimization steps can be taken in that direction. These indexes are permanently evolving in relation to time, characteristics of the farm, location, and season, among other factors (González-Stagnaro, 2001, 2002).

In Cuba, several papers on the behavior of the main reproductive indicators of *Mambi de Cuba* bovine females have been published (Sánchez, Lamela, López, 2005; López, Lamela, Sánchez, 2007) and *Siboney de Cuba* (García, Cuesta, García, Quiñones, Figueredo, Faure, Pedroso, Mollineda, 2010; Hernández, Silveira, Molina, Mendoza, Vallejo, 2010; Hernández, Contreras, Pérez, Vallejo, 2011b). However, very few reports have been published on the main environmental factors that affect them, which limit their scientific relevance.

Hence, the aim of this research was to evaluate the main reproductive indicators and environmental factors that affect *Siboney* and *Mambi de Cuba* cows at a breeding company in central Cuba.

MATERIALS AND METHODS

Location of the experimental area and characteristics of animals

This research was done between 2007 and 2010 on farms of the Livestock Breeding Company in Matanzas province. The predominant soils are red ferralitic, according to the FAO-UNESCO soil classification system (Hernández, Ascanio, Morales, Cabrera, 2005).

The topography is slightly wavy. The mean annual temperature is 25.6 ºC, 24.8 ºC and 26.3 ºC in summer and winter, respectively, and the mean annual precipitation value is 1 427.60 mm, averaging 1 096.6 mm in the rainy season, and 330.99 mm in the dry season.

The botanical composition of the grass was determined by the step method (t'Mannetje and Haydocky, 1963). The research location comprises 30.10% of Bermuda grass (*Cynodon nlemfuensis*), 21.30% bahiagrass (*Paspalum notatum*), 27.80% bluestem (*Dichanthium* spp), 6.10% smut grass (*Sporobolus indicus*), 11.30% of other graminaceae, and 3.40% of herbaceous leguminosae.

A time-restricted rotational grazing system was used with a 244.8 cattle/ha^{-1} day^{-1}, with a global stocking rate of 1.5animals/ha^{-1}, grazing 16 h a day. Animal stay and rest in the enclosures was handled depending on grass availability and season.

The mean grass availability per animal and day varied between 8 and 27 kg of dry matter, which was supplemented with dicalcium phosphate and sugar cane, at a rate of 10 kg/animal/day and molasses *ad libitum*. The cows were milked manually once a day between 2 and 5 am, using artificial suckling.

Procedure

The data of Holstein x Zebu genotypes from 618 individual purebred cow records were compared. Of them, 260 belonged to *Siboney de Cuba* (5/8 H x 3/8 Z), from four herds, and 358 were *Mambi de Cuba* (¾ H x ¼ Z), from six herds. The animals were between three and eight years old, bearing one to four calvings, and free from Brucellosis and tuberculosis.

The calving-first insemination service intervals (CFII), calving-gestation interval (CGI), calving-calving interval (CCI), post-calving anestrus (PCA), and service per gestation (S/G) were evaluated, according to the methodologies described by Brito, Blanco, Calderón, Preval, and Campo (2010).

Estrus detection was made by an observed with two teaser bulls (bulls with diverted penis), 1:25 bull/cow ratio, between 6-10 am and 2-6 pm The voluntary waiting period (VWP) was 60 days. Insemination was based on the deep cervical method with 60-65% technical efficiency in the last four years, using frozen semen in straws that had been collected from already fertility-proven bulls.

Statistical analysis

Descriptive statistics were described for all the variables. A general linear model was used following thorough review of all the analysis, linearity, independence, and normality data in the distribution of each indicator. The model was adjusted according to all the first order interactions, which were disregarded due to the lack of statistical significance. Then the model was re-adjusted with the inclusion of the statistically significant factors only (Duarte and Perrotta, 2007). Hence, the following model was adopted:

$$Y_{ijkl} = \mu + U_i + AP_j + TP_k + (UxTP)_{ik} + e_{ijkl}$$

where,

Y_{ijkl} = the lth observation of the ith farm, the jth calving year, and the kth calving quarter, in calving-first service, calving-gestation interval, and calving-calving interval.

μ = general mean

U_i = effect of the i[th] farm (i = 1,2,….., 6)

AP_j = effect of the j[th] calving year (j = 1, 2…, 4)

TP_k = effect of the k[th] calving quarter (k = 1, 2…..,4)

$(UxTP)_{ik}$ = interaction of the i[th] farm with the k[th] calving quarter

e_{ijkl} = random error normally distributed with mean μ and σ^2 variance

The Bonferroni test was performed to the significantly different instances found in order to compare the means.

RESULTS AND DISCUSSION

The reproductive performance of the two cow genotypes on the experimental farms was very deteriorated (Table 1). The CFII, CGI, and CCI values of all the farms were above 100 days, too long, according to the optimum values of this indicator for the two genotypes (Blanco, 2000; Brito *et al.*, 2010). A similar situation was observed in CGI and CCI, where the values were higher than the desired ones, according to the above authors.

Table 1. Descriptive statistics ($\bar{X}$ ±SD) of the main reproductive indicators of *Siboney* and *Mambi de Cuba* cows on the farms studied

Genotype	Farm	Reproductive indicators (days)		
		CFII	CGI	CCI
Siboney de Cuba	1	102.30 ± 53.50	181.40 ± 122.00	461.20 ± 110.60
	2	116.20 ± 79.40	161.80 ± 108.30	440.10 ± 108.30
	3	166.40 ± 138.90	215.20 ± 168.00	501.70 ± 170.20
	4	141.40 ± 116.50	192.40 ± 157.40	466.50 ± 157.40
Mambí de Cuba	1	134.20 ± 118.40	235.70 ± 168.57	498 ± 119.12
	2	115.24 ± 75.75	290.20 ± 174.92	542 ± 164.30
	3	91.90 ± 78.50	147.75 ± 105.80	425 ± 109.90
	4	127.70 ± 65.70	201.96 ± 89.35	474 ± 75.56
	5	158.00 ± 105.30	256.10 ± 179.60	527 ± 169.80
	6	125.60 ± 75.47	197.74 ± 115.30	483 ± 118.10

The behavior of reproductive indicators of *Siboney de Cuba* cows is similar to the reports for this genoptype in the genetic breeding companies in the west (Rivas, Gutiérrez, Mora, Évora, González, 2004) and central parts of Cuba (Hernández *et al.*, 2011b). The *Mambi* females coincided with the reports for this genotype in the same scenario, made by other authors (Simón *et al.*, 2010; Hernández *et al.*, 2011a). However, they had longer CFII, CGI, and CCI than animals of the same genotype in Havana (Hernández *et al.*, 2007), possibly due to differences in the production systems.

The variation coefficient of *Siboney de Cuba* ranged between 52.30 and 90.50% (CFII), 67.26-81.79% (CGI), and 23.98-33.92% (CCI), whereas *Mambi de Cuba* underwent fluctuations of 51.42-88.30%, 44.18-71.59%, and 15.92-32.16%, respectively. These values coincided with reports of the two genotypes (Hernández *et al.*, 2007; Hernández *et al.*, 2011a), and indicated the high variability of reproductive indicators in the herds studied, thus confirming the relevance of determinations of environmental and handling factors.

The poor reproductive performance observed in both genotypes was linked to the PCA period in the studied CFII of *Siboney de Cuba*, which varied between 42.30 and 106.40 days on farms one and three, respectively. The CFII of *Mambi de Cuba* varied between 31.90 and 98.00 days on farms three and five, respectively. These values were longer than the optimum values reported in the two genotypes by Blanco (2000) and Brito *et al.* (2010).

The low reproductive efficiency of herds was also caused by the repetition of artificial insemination (AI) services; the S/G of *Siboney de Cuba* fluctuated between 1.83 and 2.28 on farms three and four, respectively, whereas the S/G of *Mambi de Cuba* showed a 2.20-3.36 variation on farms one and two, respectively. These high values were considered optimum for either genotype (Blanco, 2000; Brito *et al.*, 2010), and they corroborated the high frequency of low efficiency occurrence of AI in similar production systems (Santiesteban, Bertot, Vázquez, Loyola, Garay, de Armas, Avilés and Honrach, 2007).

The PCA and service repetition in these herds, and consequently, their low reproductive efficiency could have been motivated by nutritional deficiencies which are frequent in similar production conditions for these genotypes (Simón *et al.*, 2010). Nutritional shortages caused by a negative energy balance lead to loss of body condition (BC) in females, especially after calving (Corea-Guillén, Alvarado, Leyton, 2008; Butler, 2005, 2013).

The analysis of variance of the reproductive indicators of *Siboney de Cuba* is shown in Table 2. Farm, calving year, and calving quarter had a significant influence on CFII, CGI, and CCI, whereas farm-calving quarter interaction had a significant influence on CFII and CCI.

Table 2. Main sources of variation of reproductive indicators in *Siboney de Cuba*

Sources of variation	LG	Mean squares (MS)					
		CFII		CGI		CCI	
		MS	C	MS	C	MS	C
Farm (F)	3	28 510.20	0.0038	26 168.21	0.0501	45 885.15	0.0010
Calving year (CY)	3	164 954.10	0.0000	323 491.30	0.0000	286 347.24	0.0000
Calving quarter (CQ)	3	37 234.45	0.0006	100 218.168	0.0000	97 664.70	0.0000
F x CQ	9	10 339.26	0.0461	12 093.90	0.2805	13 786.25	0.0419
Exp. error	155	6 124.55		9 830.08		8 075.14	

Table 3 shows the values of reproductive indicators studied in *Siboney de Cuba*. The best CFII-CCI were observed on farms 1, 2, and 4, which differed significantly (P<0.05) from the ones on farm three, with a better reproductive performance. Farm was critical, which demonstrated the effects of changes in the production system on reproductive performance among herds (Rivas *et al.*, 2004; García-Díaz, Scull, Sarria, Pérez-Bello, Hernández-Barreto, 2018).

Table 3. Effect of farm, calving year, and calving quarter on indicators of reproductive performance, in Siboney de Cuba

Factor		CFII		CGI		CCI	
		$\bar{X}$	SE±	$\bar{X}$	SE±	$\bar{X}$	SE±
Farm	1	106.06b	19.52	170.07a	24.80	437.20b	22.48
	2	135.10ab	21.23	173.80a	27.00	444.46b	24.57
	3	176.04a	18.27	228.50a	23.25	514.92a	21.08
	4	138.00ab	19.73	179.55a	25.15	448.30b	22.80
CY	2007	318.33a	23.25	414.30a	30.10	665.50a	27.29
	2008	148.31b	13.17	253.25b	16.97	535.43b	15.41
	2009	96.30c	8.376	127.60c	10.82	407.00c	9.90
	2010	108.77bc	57.87	143.20c	73.34	437.00c	66.47
CQ	J-F-M	167.10a	17.76	238.30a	22.62	511.25a	20.53

A-M-J	154.80a	22.58	203.82a	28.70	478.90a	26.01
J-A-S	97.19b	18.59	119.03b	23.66	392.44b	21.57
O-N-D	136.00ab	19.38	190.60a	24.62	462.30a	22.32

ab: unequal letters on the same column within the same variation source differ for P<0.05, Bonferroni. CY: calving year. CQ: calving quarter. J-F-M: January, February, March. A-M-J: April, May, June. J-A-S: July, August, September O-N-D: October, November, December

The calving years with the best reproductive performance were 2009 and 2010, which differed significantly (P<0.05) from 2007, when the three indicators were excessively delayed. Regarding calving quarter, significant differences (P<0.05) were observed in the July-August-September quarter in relation to the other quarters.

Table 4 shows the calving quarter-farm interaction in terms of CFII and CCI. Significant differences were observed on all the farms (P<0.05) in terms of the effect of calving quarter on CFII and CCI, except on farm three.

Table 4. Calving quarter-farm interaction on CFII and CCI in *Siboney de Cuba*

	Calving quarters							
Farm	J-F-M		A-M-J		J-A-S		O-N-D	
	$\overline{X}$	±SE	$\overline{X}$	±SE	$\overline{X}$	±SE	$\overline{X}$	±SE
				CFII				
1	120.60a	62.94	137.30a	92.27	168.82b	113.49	101.90a	64.07
2	86.85ab	34.89	127.45a	75.61	143.96b	107.37	97.50a	44.37
3	50.75b	20.75	63.775a	38.48	313.50a	171.47	215.71a	236.41
4	116.10a	57.50	84.80a	53.59	76.70b	51.66	172.90a	148.23
				CCI				
1	516.90a	123.27	482.1a	126.57	499.30b	108.98	424.93a	88.58
2	414.03a	84.88	452.5a	94.02	461.85b	109.11	451.15a	103.05
3	411.70a	137.32	362.5a	59.94	729.60a	172.44	494.43a	154.41
4	458.55a	102.27	380.2a	56.55	391.55b	114.59	502.10a	187.02

ab: unequal letters on the same column within the same variation source differ for P<0.05, Bonferroni. CY: calving year. Calving quarter: J-F-M: January, February, March. A-M-J: April, May, June. J-A-S: July, August, September O-N-D: October, November, December

The influence of farm on CFII and CGI of *Siboney de Cuba* was significant. However, calving year and calving quarter had the same influence on all the indicators. The influence of calving quarter on CFII was not significant, though farm interaction was influenced (Table 5).

Table 5. Main sources of variation of reproductive indicators in *Mambi de Cuba*

Sources of variation	LG	Mean squares					
		CFII		CGI		CCI	
		MS	C	MS	C	MS	C
Farm (F)	5	18 954.65	0.0244	31 758.85	0.0439	18 691.23	0.1503
Calving year	3	52 987.50	0.0001	520 658.10	0.0000	439 882.00	0.0000
Calving quarter	3	8 490.98	0.3162	52 444.00	0.0105	33 095.00	0.0358
F x CQ	15	15 113.40	0.0111	16 210.9	0.2813	12 071.20	0.3944
Exp. error	207	84.58	-	116.61	-	106.57	

Table 6 shows the values of reproductive indicators; the best results were observed on farm No. 1, with significant differences (P<0.05) from farms No. 2 and 5 (the worst reproductive performance). Farm was critical, since it demonstrated the effects of changes in the production system on reproductive performance.

Table 6. Effect of farm, calving year, and calving quarter on reproductive performance indicators in *Mambi de Cuba*

Factor		CFII		CGI		CCI	
		$\overline{X}$	SE±	$\overline{X}$	SE±	$\overline{X}$	SE±
Farm	1	127.05ab	16.99	306.10b	23.71	569.90a	21.69
	2	93.17b	19.93	397.62a	27.48	632.50a	27.33
	3	112.90ab	20.29	320.15ab	27.97	584.62a	25.66
	4	126.30ab	22.75	327.30ab	31.37	590.70a	28.71
	5	160.90a	16.45	363.06ab	22.67	628.35a	20.80
	6	135.55ab	22.66	334.25ab	31.24	607.10a	28.56
CY	2007	96.40b	45.95	588.20a	63.35	807.42a	57.92
	2008	178.35a	20.34	400.25b	28.04	684.65a	26.02
	2009	144.33a	9.32	259.32c	12.90	519.33b	12.05
	2010	84.90b	10.94	117.81d	15.09	397.40c	14.31
CQ	J-F-M	147.02a	17.77	371.00a	24.49	631.10a	22.51
	A-M-J	123.65a	18.58	376.34a	25.62	627.33a	23.94
	J-A-S	115.64a	18.57	318.45ab	25.72	580.15a	23.64
	O-N-D	117.63a	15.91	299.90b	21.93	570.23a	20.51

ab: unequal letters on the same column within the same variation source differ for P<0.05, Bonferroni. CY: calving year. CQ: calving quarter. J-F-M: January, February, March. A-M-J: April, May, June. J-A-S: July, August, September O-N-D: October, November, December

The calving years with the best reproductive performance were 2009 and 2010, which differed significantly (P<0.05) from 2007, when the three indicators were excessively delayed. Regarding calving quarter, significant differences (P<0.05) were observed in the July-August-September quarter in relation to the other quarters.

Table 7 shows the calving quarter-farm interaction of CFII. All the farms showed significant differences (P<0.05) in the calving quarter effect.

Table 7. Calving quarter-farm interaction on CFII and CCI in Mambi de Cuba

Farm	Calving quarters							
	J-F-M		A-M-J		J-A-S		O-N-D	
	$\overline{X}$	±SE	$\overline{X}$	±SE	$\overline{X}$	±SE	$\overline{X}$	±SE
	66.22a	25.07	172.50a	180.59	92.08a	24.02	178.50a	66.54
2	161.00ab	95.81	87.50a	41.06	100.47a	21.63	72.70a	46.58
3	60.80a	46.75	61.66a	28.80	138.11a	101.67	112.66a	100.07
4	142.23ab	62.91	102.62a	20.59	130.32a	70.75	105.24a	93.14
5	206.65b	103.17	152.90a	106.56	112.21a	77.89	180.88a	120.06
6	125.33ab	63.31	104.82a	16.66	180.07a	113.13	127.15a	95.85

ab: unequal letters on the same column within the same variation source differ for P<0.05, Bonferroni. CY: calving year. Calving quarter: J-F-M: January, February, March. A-M-J: April, May, June. J-A-S: July, August, September O-N-D: October, November, December

Previous studies reported the influence of environmental factors similar to farm on various bovine breeds and genotypes under different management conditions (Rivas *et al*., 2004; Simón *et al*., 2010; García-Díaz *et al*., 2018). Several differences in the reproductive performance on farms of the same location were attributed to parasitic infestation, nutritional problems, metabolic disorders, estrus detection problems, and lack of timely cow dryness (Bertot, Madruga, Álvarez, Avilés, 2005).

The effects of calving year and calving quarter can be explained by the tendency of bovines to have season-dependent estrus and greater fertility due to variations in nutrient availability and handling practices. This effect has been observed in other genotypes (De la Torre, Bertot, Collantes, and Vázquez, 2006; Santiesteban *et al*., 2007; Viamonte, 2010; García-Díaz *et al.*, 2018).

The effects of calving year and calving quarter were possibly influenced by differences in climatic conditions, herd arrangement and handling, as well as transformations in production systems (Viamonte, 2010). This paper has demonstrated a sensitive reduction in the sources of nutrition due to climatic variations in different years. Furthermore, nutrient deficiency was the main cause of delayed CFII and CGI.

The unfavorable climatic conditions that generate nutritional deficiencies and reproductive problems encourage the adoption of proper handling (Roche, 2006) and organizational measures (Loyola, Bertot, Guevara, 2012), which can significantly increase the reproductive efficiency of bovine herds when properly implemented.

In that sense, Pérez and Moreno (2009) explained that the effect of year on the reproductive activity of bovines is conditioned by environmental changes from year to year. They have a direct effect on grass availability and quality, and the cow husbandry conditions.

The reproductive performance and productive aspects were influenced by the effects of year and season. Accordingly, *Mambi*´s dairy production varied in relation to calving bimester and dairy production (Sánchez *et al*., 2005).

The differences found between calving quarters with the lowest CFII, CGI, and CCI values in cows to calve by the July-August-September quarter, possibly occurred because the last gestation quarter takes place in the months with the highest grass availability, thus ensuring better nutrition for the gestating female, and improved BC for calving.

The ready-to-calve animals with favorable BC (below three in the five-point scale), lost more weight, underwent a sharper negative energy balance, and showed a longer time to restart ovarian activity, with higher empty day average and a higher number of females in that state than the ones calving with a favorable BC (Viamonte (2010). In this study, the calving quarter alone or in interaction with calving year period and parity, had a significant influence on the reproductive indicators of the Cuban-creole cows.

CONCLUSIONS

The two genotypes underwent a marked deterioration of the main reproductive indicators evaluated, with a significant influence of the farm on CFII and CGI; calving year on CFII, CGI, and CCI; calving quarter on CFII of *Siboney de Cuba*, and CGI and CCI in the two breeds; farm-calving quarter on CFII in the two genotypes; and CCI on 5/8 Holstein 3/8 Zebú.

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