Genetic assessment of the dairy cattle Mambi de Cuba

Arelis Hernández[1], Raquel Ponce de León[1], Sonia M.García[2], Gladys Guzmán[1] and Marta Mora[1]
[1]*Instituto de Ciencia Animal, Apartado Postal 24, San José de Las Lajas, Mayabeque, Cuba.*
[2]*Empresa Pecuaria Genética de Matanzas. Finca San Andrés. Limonar. Matanzas, Cuba*
Email: arelishdez@ica.co.cu

Records, between 1980 and 2006, of dairy females of the Mambi de Cuba breed (3/4 Holstein 1/4 Zebu), from four cattle rearing units were used to estimate the parameters and genetic tendencies of the growth traits up to reproduction (17 434 heifers), milk yield (50 420 lactations of 20 687 cows), reproduction (16 526 reproductive events of 5 881 cows), longevity (11 338 cows), survival and permanence (12 865 cows). A univariate animal model was used for estimating heritability, repeatability and breeding values, including the year-four month period-herd combination and the calving year as linear and quadratic co-variable as fixed effects, and the permanent environment and error as random effects. The heritabilities had values from moderate to low, with higher estimates for the weight per incorporation age (WIA) (0.20), calving interval (CI) (0.06), milk yield up to 244 d (M244) and 305 d (M305) (0.15), fat percentage (FP) (0.19), calving number (CN) (0.06) and 18 months of productive life (S18) (0.05). The highest repeatability estimate was for M244 y M305, with 0.42. The genetic tendencies for WIA, CI, M305, productive life (PL) and P36 were of 0.02 ± 0.01 g/d/year, -1.53 ± 0.16 d/year, -2.52 ± 1.10 kg/year, 0.05 ± 0.03 months/year and 0.0004 ± 0.0002 months/year, respectively. It was concluded that there was no change in the population means because the genetic tendencies had low values (between 0.001 and 0.31 % of the mean), due to the instability of the progeny tests and to the little female selection.

Key words: *longevity, Mambi de Cuba, parameters, genetic tendencies, milk yield, reproduction*.

The development of new breeds is an important via for the genetic improvement in the tropical area (López 1982). In Cuba, the genetic improvement program for milk production began in the 60's. The formation of new breeds was among its objectives, starting from the two most adapted to the country, Zebu and Creole. That's how Siboney de Cuba (5/8 Holstein 3/8 Zebu), Mambi de Cuba (3/4 Holstein 1/4 Zebu), Taino de Cuba (5/8 Holstein 3/8 Creole) and Cuban Dairy Zebu (3/4 Zebu ¼ Holstein) were created (López and Ribas 1993).

The Mambi de Cuba was grown, mainly, in the Genetic Cattle Enterprise of Matanzas, according to the Genetics Direction project. In 2009, there were 5 172 purebred and 7 607 crossbred cows (DG 2009). In the Genetic Cattle Enterprise of Matanzas, 96 % of the cows were allocated.

The genetic parameters are the basis of the genetic programs. The first estimates of heritability, from the animal model, in Mambi de Cuba cows, were obtained in traits of milk yield, reproduction and longevity (Hernández 2005, Hernández *et al*. 2007, Hernández *et al*. 2008 and Palacios-Espinosa *et al*. 2008), considering the herds of the Genetic Cattle Enterprise of Matanzas and the Bacuranao Enterprise. However, there are no previous studies in which the four cattle rearing units with this breed are together.

The objective of this study was to estimate the parameters and genetic tendencies in the growth traits up to the entering to reproduction, milk yield, reproduction, longevity, survival and permanence of Mambi de Cuba dairy cows, considering the four cattle units in which this breed has been grown.

Materials and Methods

The information recorded in the Cattle Control System (SISCOP) was used, as well as that of the master cards of Mambi de Cuba (3/4 Holstein 1/4 Zebu) cows and heifers of the four cattle units where this breed is found (Genetic Cattle Enterprise of Matanzas, Camilo Cienfuegos, Bacuranao and Los Naranjos), located in Matanzas, Pinar del Rio, Havana and Artemisa, respectively. From this information on, data of growth traits up to entering to reproduction was obtained, as well as reproduction, longevity, permanence and survival. The information of milk yield was extracted from the lactation records of the National Center of Cattle Control (CENCOP). Table 1 shows the number of observations, cows, dams, sires and years of study used for estimating the genetic parameters in different traits of the Mambi de Cuba cows.

Growth traits up to entering to reproduction. Incorporation age (IA, months), incorporation weight (IW, kg) and weight per incorporation age (WIA= IW/IA, g/d).

Reproductive traits. Calving-first service interval (CFSI, d), calving-gestation interval (CGI, d), calving interval (CI, d) and services per gestation (S/G, number).

Milk yield traits. Lactation length (LL, d), milk yiled up to 244 d (M244, kg), milk yield up to 305 d (M305, kg), daily milk yield (DMY, calculated as the fraction of the total milk/LL, kg/d), fat percentage up to 244 d (FP244, %) and fat percentage up to 305 d (FP305, %).

Longevity traits. The information of the culled animals was used to study the productive life (PL,

Table 1. Number of observations (N), cows (or heifers), dams, sires and years in the study of the different traits in Mambi de Cuba females

Type of trait	N	Cows or heifers	Dams	Sires	Years
Growth	17 434.0	17 434.0	13 635.0	260.0	1978 - 2006[a]
Reproduction	16 526.0	5 881.0	5 137.0	218.0	1981 - 2006[b]
Milk production	50 420.0	20 687.0	8 843.0	264.0	1981 - 2006[b]
Longevity	11 338.0	11 338.0	9 381.0	233.0	1980 - 2004[c]
Survival and permanence	12 865.0	12 865.0	10 411.0	239.0	1981 - 2004[c]

[a]Birth year, [b]Calving year, [c]Year of first calving

months), determined as the months of the first calving to the culling, age at culling (AC, months) and calving number during lifetime (CN, number).

Survival and permanence traits. The data of the culled animals were used to study the permanence and those of the animals that were alive during the analysis. The permanence included the life months, from the first calving to the census, at 18, 24 and 36 months of productive life (P18, P24 and P36).

The survival was established according to the cows that were alive at the time of the census, and at 18, 24 and 36 months of productive life (S18, S24 y S36), with value = 100, and the culling = 0. Four data groups were created for the statistical processing, with those cows of 18, 24 and 36 months of productive life.

The files with reproduction and milk yield data were cleaned, eliminating calving ages inferior to 24 months (0.09 % of the data), values over and below three standard deviations of the means and the contemporaneous groups with less than three animals. Besides, lactations inferior to 100 d (5.35 % of the data) and milk yield with less than 300 kg (4.22 % of the data) were eliminated from the milk yield file.

The ASREML software was used (Gilmour *et al*. 2003), with an animal univariate model for estimating heritability, repeatability and breeding values. Only one pedigree file was used, formed by 47 284 individuals. The pedigree data included the grandparents from the dam and the sire line.

The models used for each data group were the following:

Growth traits up to entering to reproduction: y = Xb+Za+e

Where,

y = vector of the heifer observations

b = vector of fixed effects (herd-year-four month period of birth)

a = vector of random effects of the animal

e = vector random residual effects

X and Z are the design or incidence matrixes relating the fixed effects and those of the animal with the data, respectively.

Reproductive and milk yield traits: y = Xb + Za + Wp + e

where,

y = vector of the cows observations

b = vector of fixed effects with the effect of herd-year-four month period of calving and age at calving as linear and quadratic covariable

a = vector of random effects of the animal

p = vector of the permanent environmental effect of the cow

X, Z and W are the design or incidence matrixes relating the fixed effects and those of the animal with the data, respectively.

Longevity, survival and permanence traits: y = Xb + Za + e

where:

b = vector of fixed effects (herd-year-four month period of calving) and age at first calving as linear and quadratic covariable

The genetic tendencies were estimated by the linear regression of the mean breeding values in the birth years of the Mambi de Cuba cows with productive information.

Results and Discussion

Table 2 shows the statistics, heritability (h^2) and repeatability (r) of the traits.

The average of incorporation age surpassed the results of Torrano *et al*. (1986), Suárez *et al*. (2005) and Portales *et al*. (2007) in Brown Swiss and Siboney de Cuba heifers, where values between 18.3 and 22.1 months were obtained. The calving interval was inferior to 514.7 d reported by Ribas *et al*. (2001) in Siboney de Cuba under the conditions of other Cuban enterprise. The milk yield up to 244 d was inferior to the results of Ribas *et al*. (1999) and Plasse and Salomón (2003) in Siboney de Cuba and Carora, with 2 323 and 2 141 kg, respectively.

The average of longevity traits highlighted, with values higher than those reported by Ponce de León *et al*. (2002), Orrego *et al*. (2003), Cedeño and Vargas (2004) and Suárez *et al*. (2005) in other dairy breeds (Siboney de Cuba, Holstein, Jersey, Brown Swiss and the crossing Holstein x Brown Swiss) under tropical conditions.

The highest heritability estimates, within the growth traits up to entering to reproduction, were obtained for the weight per incorporation age (0.20). Ribas *et al*. (2001) and Suárez *et al*. (2003) also achieved the highest results for this trait (0.20-0.23) in Siboney de Cuba.

Table 2. Means, standard deviations (SD), coefficients of variation (CV), heritability (h^2) and repeatability (r) of different traits in Mambi de Cuba

Traits	Mean	SD	CV	$h^2 \pm$ SE	r ± SE
Age at incorporation (months)	26.8	4.8	17.8	0.11 ± 0.03	
Weight at incorporation (kg)	291.3	21.2	7.3	0.03 ± 0.01	
Weight per age at incorporation (g/d)	382.8	62.2	16.2	0.20 ± 0.03	
Calving-first service interval (d)	116.7	100.6	86.2	0.01 ± 0.01	0.10 ± 0.01
Calving-gestation interval (d)	204.9	143.9	70.2	0.03 ± 0.03	0.05 ± 0.05
Calving interval (d)	482.4	114.5	29.9	0.06 ± 0.01	0.20 ± 0.01
Services per gestation (number)	2.27	1.46	64.2	0.01 ± 0.01	0.07 ± 0.01
Lactation length (d)	287.8	76.5	26.5	0.05 ± 0.01	0.16 ± 0.01
Milk yield up to 244 d (kg)	1 944.5	795.3	40.9	0.15 ± 0.01	0.42 ± 0.01
Milk yield up to 305 d (kg)	2 097.1	893.3	42.5	0.15 ± 0.01	0.42 ± 0.01
Fat up to 244 d (%)	3.40	0.44	12.9	0.18 ± 0.02	0.31 ± 0.01
Fat up to 305 d (%)	3.35	0.40	13.0	0.19 ± 0.02	0.33 ± 0.01
Daily milk yield (kg/d)	7.4	3.1	41.9	0.13 ± 0.01	0.35 ± 0.01
Age at first calving (months)	38.9	3.8	10.5		
Productive life (months)	56.2	32.5	58.0	0.05 ± 0.02	
Age at culling (months)	98.8	32.7	33.1	0.05 ± 0.02	
Number of calvings (number)	3.9	2.1	55.1	0.06 ± 0.02	
Permanence up to 18 months of productive life (months)	16.4	3.4	21.1	0.009 ± 0.018	
Permanence up to 24 months of productive life (months)	21.2	5.4	25.5	0.02 ± 0.01	
Permanence up to 36 months of productive life (months)	29.8	9.5	31.8	0.002 ± 0.01	
Survival up to 18 months of productive life (%)	81.7	35.6	43.6	0.05 ± 0.00	
Survival up to 24 months of productive life (%)	77.2	38.7	50.2	0.03 ± 0.00	
Survival up to 36 months of productive life (%)	66.2	43.2	65.2	0.03 ± 0.00	

There were low heritability values for the reproductive traits, mainly for the gestation services and the calving first service interval. The heritability for the calving intervals was within the range reported by Kardamideen *et al*. (2000), Brotherstone *et al*. (2002), Pereira *et al*. (2006), Facó *et al*. (2008) and Pérez and Gómez (2009) in Holstein cattle in the United Kingdom, the dairy cattle of Portugal, in crossings of Holstein x Gir in Brazil and in the Brown Swiss in Venezuela. The repeatability value for the CI was low, although it surpassed the 0.049 ± 0.008 obtained by Kardamideen *et al*. (2000), and the 0.120 ± 0.004 referred by Pereira *et al*. (2006).

The heritability estimates for the dairy traits were also low and inferior to that referred in the literature (Wall *et al*. 2003, Boligon *et al*. 2005 and Silvestre *et al*. 2005) for breeds specialized in milk yield, with values from 0.22 to 0.32.

Estimates varying from 0.22 in Carora breed in Venezuela (Cerutti *et al*. 1994) were obtained in new breed in tropical areas. There were estimates of 0.17 and 0.18 in cattle units of Artemisa and Pinar del Rio provinces in Siboney de Cuba breed (Ribas *et al*. 2004). Values from 0.16 to 0.19 were reported in Mambi de Cuba in Matanzas (Hernández *et al*. 2005) and Havana (Hernández *et al*. 2007).

Similar results to those of this study were obtained in Holstein herds in Brazil (Barbosa and Dórenles 2000 and Ferreira *et al*. 2001), in Brown Swiss cattle in Venezuela (Pérez and Gómez 2005) and in Siboney de Cuba herds (Guerra *et al*. 2002) in cattle units of Artemisa and Havana provinces.

The heritability estimates for longevity, survival and permanence traits were also low. For the longevity traits, the estimates obtained were lower than those reported for this breed in the conditions of the Genetic Cattle Enterprise of Matanzas (Hernández *et al*. 2008), with values from 0.13 to 0.17. There was low variability in the permanence and survival traits up to a certain time.

The highest repeatability estimate was for M244 and M305. Its value (0.42) coincides with the reports of Vargas and Solano Patiño (1995), Gómez and Tewolde (1999), De Almeida *et al*. (2000), Pérez and Gómez

(2005) and Facó *et al*. (2009) in tropical climate. The estimate obtained indicated high correlation between successive records of the same animal. Thus, it is possible to make decisions related to the elimination of cows, after their first records of milk yield.

The genetic tendency for WIA in the Mambi de Cuba heifers, born between 1978 and 2004, was increased in 0.02 ± 0.01 g/d/year. That for the CI was favorable, because it decreased in -1.53 ± 0.16 d/year. This decrease in the genetic tendency for the CI was, probably, due to there was strong pressure in the selection by milk yield. These outcomes are not in correspondence with those of authors that obtained a genetic tendency to the increment of the CI, such as Hare *et al*. (2006) in five dairy breeds (Jersey, Ayrshire, Brown Swiss, Holstein, and Guernsey) in the United States (0.49 a 1.07 d/year, according to the breed) and Carolino *et al*. (2006), with 0.192 ± 0.004 d/year in dairy cows from Portugal. The lack of correspondence is explained because, contrary to Mambi de Cuba, in these breeds there was an intense selection due to milk yield.

The genetic tendency of the M305 for the cows born between 1976 and 2003 diminished in -2.52 ± 1.10 kg/year. These results were due to the progeny tests of the bulls of this breed were not conducted in the period from 1992 to 1995, having impairment in the rearing conditions of the animals, due to the prevailing economic crisis in Cuba at those times. Since 1996, the progeny tests were started again, with capacity to test few bulls per year. Besides, little selection was conducted through the females, by not having enough heifers for the replacement.

In Cuba, in cows from other breeds, such as Siboney de Cuba, genetic tendencies were reported for milk yield of 2.70 kg/year, 2.49 kg/year, and 4.50 kg/year (Guerra *et al*. 2002 y González-Peña 2006). They represented only between 0.14 and 0.30 % of the milk yield mean of the herd, thereby being far from the 1% of the milk yield mean expected by genetic improvement.

The genetic tendencies of the productive life and the permanence up to 36 months of productive life were low, thus, there was no change in them from the genetic point of view. They had values of 0.05 ± 0.03 months/year and of 0.0004 ± 0.0002 months/year, respectively.

In general, the genetic tendencies for the different traits under study were low. They represented 0.005 % of the mean for the WIA, 0.001% for the CI and 0.31 % for PL. The genetic tendency of M305 was at 0.12 % below the milk yield mean.

The results of this work showed that during the years of the study there was no change in the population means for the traits under study, because the genetic tendencies were low, with values between 0.001 and 0.31 % of the mean. This was due to the instability in the conduction of the progeny tests, and the little selection through the females, by not having enough heifers for the replacement.

Alternatives of simultaneous selection for several traits are recommended to be studied with the aim of enhancing the performance of the genetic tendencies. Due to the difficult environmental conditions in the tropics, it is necessary to have animals that may be high milk producers and that, at the same time, can survive and adapt to the environment. Therefore, the most adequate selection would be that involving several traits.

Acknowledgements

Thanks are due to the technicians and workers from the genetic enterprises and from the National Center of Cattle Control (CENCOP) for facilitating the data to conduct this work.

References

Barbosa, G.B. & Dórenles, H. 2000. Parâmetros genéticos para características produtivas em bovinos da raça holandesa no Estado de Goiás. Rev. Brasil. Zoot. 2:421

Boligon, A.A., Rorato, P.R.N. & Ferreira, G.B.B. 2005. Heritability and genetic trend for milk and fat yields in Holstein herds raised in the state of Rio Grande do Sul. Rev. Bras. Zootec. 34:1512

Brotherstone, S., Banos, G. & Coffey, M.P. 2002. Evaluation of yield traits for the development of a UK fertility index for dairy cattle. Proc. 7th World Congress on Genetics Applied to Livestock Production. Montpellier, France. pp. 155 -158

Carolino, M.I., Pereira, C.M., Carolino, N., Machado, J. & Gama, L.T. 2006. Calving interval in Portuguese dairy cattle. 1. Estimates of genetic parameters and trends. 8th WCGALP.

Cedeño, D.A. & Vargas, B. 2004. Effect of management and breed type on herd-life of dairy cattle from Costa Rica. Arch. Zootec. 53:129

Cerutti, F.M., Caroli, A., Crimella, C., Bagnato, A. & López, E. 1994. Heredabilidad y repetibilidad de la producción de leche en la raza Carora. XIV Congreso Panamericano de Ciencias Veterinarias. Acapulco. México

De Almeida, R., Vieira, C., Napolis, C., García, J.A., De Almeida, R. & Silva, C. 2000. Ajustamento da produção de leite para os efeitos simultâneos de ordem, idade e estação de parto. Rev. Brasil. Zoot. 8:2253

DG. 2009. Resumen de la información estadística de las empresas y granjas genéticas del año 2009. La Habana. 93 pp.

Facó, O., Martins, R., Nonato, R., Lobo, B., Danielle Maria Machado, D.M. & Pinheiro, S.M. 2008. Additive and non-additive genetic effects on productive and reproductive traits in Holstein × Gir crossbred cows. Rev. Bras. Zootec. 37:48

Facó, O., Martins, R., Nonato, R., Lobo, B., Danielle Maria Machado, D. M. & Pinheiro, S. M. 2009. Efeito da redução da variação da duração de lactação na avaliação genética de bovinos leiteiros mestiços. Rev. Ciênc. Agron. 40:287

Ferreira, A., Cordeiro, M., Valente, J., Milagres, N., Martinez, M.L. & Magalhaes, M.N. 2001. Parâmetros genéticos para produções de leite e gordura nas três primeiras lactações de vacas holandesas. Rev. Brasil. Zoot. 3: 709

Gilmour, A.R., Gogel, B.J., Cullis, B.R., Welham, S.J. & Thompson, R. 2003. ASREML. User's Guide Release 1.10.

Gómez, H. & Tewolde, A. 1999. Parámetros genéticos para producción de leche, evaluación de sementales y caracterización de fincas lecheras en el trópico húmedo de Costa Rica. Archiv. Latinoam. Prod. Anim. 7:19

González-Peña, D. 2006. Evaluación genética del ganado Siboney de Cuba empleando la producción del día de control bajo un modelo de regresión aleatoria. PhD Thesis. Ciudad de La Habana. 118 pp.

Guerra, D., Évora, J.C., de Bien, R. & Prada, N. 2002. Evaluación genética de la raza Siboney de Cuba. II Congreso Internacional de Mejoramiento Animal. XVIII Congreso Panamericano Ciencias Veterinarias. Palacio de las Convenciones de La Habana, Cuba

Hare, E., Norman, H.D. & Wright, J. R. 2006. Trends in calving ages and calving intervals for dairy cattle breeds in the United States. J. Dairy Sci. 89:365

Hernández, A. 2005. Comportamiento productivo y reproductivo de la raza lechera Mambi de Cuba. Master's Thesis in Veterinary Sciences. Universidad Agraria de La Habana "Fructuoso Rodríguez Pérez". 66 pp.

Hernández, A., Ponce de León, R., de Bien, R., Mora, M. & Guzmán, G. 2007. Genetic analysis of the milk yield and the reproduction of the Mambi de Cuba (3/4 Holstein ¼ Zebu) in a farm of Havana City. Cuban J. Agric. Sci. 41:13

Hernández, A., Ponce de León, R., Gutiérrez, M., García, R., García, S.M., Mora, M. & Guzmán, G. 2008. Heritabilities in longevity traits of Mambi de Cuba cows. Cuban J. Agric. Sci. 42:139

Kadarmideen, H.N., Thompson, R. & Simm, G. 2000. Linear and threshold model genetic parameters for disease, fertility and milk production in dairy cattle. Anim. Sci. 71:411

López, D. 1982. Caracterización de la población base de un nuevo genotipo lechero tropical: El Siboney de Cuba. PhD Thesis. Universidad Agraria de La Habana "Fructuoso Rodríguez Pérez"- Instituto de Ciencia Animal. La Habana, Cuba

López, D. & Ribas, M. 1993. New dairy cattle breeds. Results in Cuba. Cuban J. Agric. Sci. 27:1

Orrego, J., Delgado, A. & Echevarría, L. 2003. Vida productiva y principales causas de descarte de vacas Holstein en la Cuenca de Lima. Rev. Investig. Vet. Perú. 14:68

Palacios-Espinosa, A., Espinoza-Villavicencio, J. L., González-Peña, D., Guerra-Iglesias, D., Mellado-Bosque, M. & Rodríguez-Almeida, F. 2008. Parámetros genéticos para la producción de leche del día de control en vacas Mambí. Agrociencia. 42:157

Pereira, C.M., Carolino, M.I., Carolino, N., Machado, J. & Gama, L.T. 2006. Calving interval in Portuguese dairy cattle. 2. Relationships with production traits. 8th WCGALP

Pérez, G.A. & Gómez, M.G. 2005. Factores genéticos y ambientales que afectan el comportamiento productivo de un rebaño Pardo Suizo en el trópico. 1. Producción de leche. Rev. Cient. 15:141

Pérez, G.A. & Gómez, M.G. 2009. Factores genéticos y ambientales que afectan el comportamiento productivo de un rebaño Pardo Suizo en el trópico. 2. Intervalo entre partos y su relación con la producción de leche. Rev. Cient. 19:30

Plasse, D. & Salomón, J. 2003. Investigación en genética animal en Venezuela 1953 – 2003. I Congreso Venezolano de Mejoramiento Genético y Biotecnología Agrícola. UCV-Maracay

Ponce de León, R., Ribas, M., Guzmán, G., Gutiérrez, M. & Mora, M. 2002. Longevidad, supervivencia y producción por vida de la nueva raza Siboney de Cuba. II Congreso Internacional de Mejoramiento Animal. Palacio de las Convenciones de La Habana, Cuba

Portales, A., González-Peña, D., Guerra, D. & Ortiz, J. 2007. Parámetros genéticos para rasgos reproductivos de primer parto en el genotipo Siboney de Cuba. Ciencia y Tecnología Ganadera. 1: 143

Ribas, M., Gutiérrez, M., Évora, J. C. & García, R. 1999. The environmental effects and genetic parameters affecting milk production in Siboney de Cuba. Cuban J. Agric. Sci. 33:235

Ribas, M., Gutiérrez, M., Mora, M., Evora, J.C. & Gonzáles, S. 2004. Productive and reproductive performance of Siboney de Cuba in two regions. Cuban J. Agric. Sci. 38:119

Ribas, M., Ponce de León, R., Ajete, A., Mederos, R.E., Gutiérrez, M. & Sosa, E. 2001. Mejoramiento genético de la producción de leche bovina bajo las condiciones actuales de producción. Technical report. Instituto de Ciencia Animal, Cuba. 71 pp.

Silvestre, A. M., Petim-Batista, F. & Colaco, J. 2005. Genetic parameter estimates of Portuguese dairy cows for milk, fat and protein using a Spline Test-Day-Model. J. Dairy Sci. 88:1225

Suárez, M.A., Fernández, L., Pérez, T., Quincosa, J., Álvarez, A., Pérez, E., Évora, J.C., Menéndez Buxadera, A., González, M.T. & Marrero, A. 2005. Siboney de Cuba: nuevo genotipo lechero para la producción de leche y carne. Technical report. 198 pp.

Suárez, M.A., Pérez, T. & Marrero, A. 2003. La novilla de reemplazo: piedra angular de la eficiencia en el rebaño "Siboney de Cuba". Revista ACPA. 22:55

Torrano, C.J., Rosete, J., Lagunes, H. Castillo, H. & Román-Ponce.1986. Eficiencia reproductiva de ganado Suizo Pardo en el Módulo lechero "Santa Elena" en clima sub-tropical húmedo. Proc. X Reunión Latioamericana de Producción Animal. Acapulco, México. 83 pp.

Vargas, L.B. & Solano Patiño, C. 1995. Tendencias genéticas y ambientales en producción de leche en vacas lecheras de Costa Rica. Arch. Latinoam. Prod. Anim. 3:165

Wall, E., Brotherstone, S., Woolliams, J. A., Banos, G. & Coffey, M. P. 2003. Genetic Evaluation of fertility using direct and correlated traits. J. Dairy Sci. 86: 4093

Received: April 27, 2011