Livestock Science 191 (2016) 108–116

Contents lists available at ScienceDirect

Livestock Science

journal homepage: www.elsevier.com/locate/livsci

Genotype Environment interactions for milk production traits in Holstein and crossbred Holstein-Zebu cattle populations estimated by a character state multibreed model

Alberto Menéndez-Buxadera [a,1], Alejandro Palacios-Espinosa [b,c,*], José Luis Espinosa-Villavicencio [c], Danilo Guerra-Iglesias [b]

[a] National Centre for Animal Recording, Agricultural Ministry, Conill and Boyeros, C. de la Habana, Cuba Agricultural Ministry, Cuba
[b] Centro de Investigaciones para el Mejoramiento Animal de la Ganadería Tropical (CIMAGT), La Habana, Cuba
[c] Universidad Autónoma de Baja California Sur, Departamento de Zootecnia, Carretera al Sur, km. 5.5, C.P. 23080 La Paz, B.C.S., México

ARTICLE INFO

Article history:
Received 20 October 2015
Received in revised form
16 May 2016
Accepted 23 July 2016

Keywords:
Holstein-Zebu animals
Tropical conditions
Genotype Environmental
Interaction-Plasticity-Multi-breed Model

ABSTRACT

A total of 478,555 lactation records from 203,825 cows calving from January 1984 to December 2003 were used to quantify the importance of the genotype-environment interaction (G × E) on milk production in a large population of Holstein and Holstein-Zebu crossbred animals under Cuban tropical conditions. These cows were distributed in a total of 1288 herds, daughters of 1565 Holstein (H) sires and 831 Holstein crossbred sires (HZ) with female Zebu (Z). Due to the dramatic political crisis in eastern countries at the end of the 1980s, all economical activities in Cuba were affected, and particularly the resources available for the dairy sector were marginalize; therefore two contrasted environmental periods of time were created: the first one was the calving from 1984 to 1990 and the second from 1991 to 2003. This division was made to estimate the magnitude of the G × E. Data were analyzed with different character state multi-breed sire models. Accordingly to the genetic correlation between the same traits across the time periods, the G × E was negative and highly significant but with more intensity in H sires with regard to HZ sires. A very important genetic variation was found in plasticity and a group of robust or generalist sires were identified showing a very good performance in the two time-period environmental conditions. The importance of the use of a Character State Multi-breed Model and the plasticity concept for breeding programs in the tropics are highly suggested.

1. Introduction

The use of crossbreeding for dairy cattle has become a renewed topic of great interest during the last decade as a response of the milk production sector, related to decline in fitness traits in those populations with high genetic level for milk production (Heins, 2007). While these concerns are justified in developed countries, the reality in the tropics is different and the use of crossbreeding is an urgent necessity due to the high demand of dairy products in these regions and the lower milk production level of the native local cattle breeds (Thornton, 2010). Much research has been carried out with the introduction of specialized Bos taurus breeds type (TT), as well as some crossbreeding programs with native Bos indicus type (ZZ) animals. In that sense, Cunningham and Syrstad, (1987) and Rutledge (2001) reviewed all papers published during the last century and concluded that the crossbreeding program for obtaining dairy animals adapted to the tropics have failed. The arguments of these two well-known previous articles had been considered as convincing and classical evidence, nonetheless, some elements require some additional comments. First, a great part of the papers reviewed by those authors were based on a relatively small number of lactation records obtained in a long period of time, and in many cases, simple statistics procedures were applied. Second, and probably the most important aspect, in almost all the selection and breeding programs in the tropics, the possible influences of genotype by environment interaction (G × E) were not taken into account.

There are evidences that imported semen continuously, from high genetic level of TT sires from developed countries is not the most economically favorable choice for environmental conditions and production system in the tropics. The results from Holman et al. (1990) showed that the average economic returns from

* Corresponding author at: Universidad Autónoma de Baja California Sur, Departamento de Zootecnia, Carretera al Sur, km. 5.5, C.P. 23080 La Paz, B.C.S., México.
E-mail addresses: palacios@uabcs.mx, paea1122krick@gmail.com (A. Palacios-Espinosa).
[1] Current address: Cordoba University, Genetic Department, Meragen Group, Campus Rabanales, Córdoba 14071, Spain.

http://dx.doi.org/10.1016/j.livsci.2016.07.016
1871-1413/

investing in US semen in Colombia, Mexico, and Venezuela were negative; the same results were reported by Verdugo et al. (2004) for Chile and Argentina; Ramírez-Valverde et al. (2014) with B. Swiss and Jersey sires from US and Mexico; Vargas and Gamboa (2008) with Holstein and Jersey sires from US and Costa Rica; Chagunda et al. (2004) with Holstein Sires from Canada and Malawi; Ojango and Pollott (2002) with Holstein sires from UK and Kenya and Tsiokos et al. (2009) for Holstein sires from different origin and Greek conditions. These evidences are consistent with the existence of G × E as one of the principal affecting factors to explain these results. It is necessary to point out that all these references were related only to TT animals in different countries. Nevertheless, using this source of genetic potential carefully is an option that could be highly important because the demand for animal products have increased continuously in Asia, Africa, and Latin America (Guyomard et al., 2013).

However, in tropical countries the problematic of G × E is even more complex because of the existence of a mixed TT × ZZ dairy cattle population; therefore, it is necessary to estimate the genetic components of G × E, particularly the importance of this effect connected with TT and TT × ZZ, a subject with scarce references available, except for the preliminary results reported by de Almeida Teixeira et al. (2006) and Arboleda et al. (2010) working with TT × ZZ crossbreed beef cattle. Therefore, some results in dairy cattle will be very useful and welcome for breeding programs in these regions.

From a practical point of view it will be necessary to obtain more information about the genetic base of G × E, which can be done by using the biological property of each organism to show a given phenotype in function of the environmental conditions (Via et al., 1995). The phenomenon previously mentioned is called plasticity, a concept established at the beginning of the last century by evolutionary biology experts, but only recently has been introduced in the field of animal breeding (de Jong and Bijma, 2002). In statistical terms, it is possible to estimate the genetic variability in plasticity by applying a character state model or a random regression model and the results can be used to classify the animals as robust or generalist (those animals showing the lower variation in performance in different environmental conditions) or otherwise plastic/specialists. However, it is a difficult task because very large data sets are necessary and unfortunately the milk recording systems are, in general, not very well developed in the tropics.

In Cuba, a national breeding program has been established since 1964 with thousands of cows and many Holstein (H) sires imported from Canada. At the same time an extensive individual milk production recording system was developed by the National Recording Centre (CENCOP) that belongs to the Agricultural Ministry with the information of milk production, breed composition, and animal pedigree. A crossbreeding program was established with H sires using artificial insemination on native Zebu (Z) cows (see Prada, 1984 for a completely description of the program). The priority of the breeding program was to increase the influence of Holstein blood in the Cuban cattle population and create two new dairy breeds more adapted to tropical conditions, in particular, animals with a proportion of 5/8H:3/8Z and 3/4H:1/4Z, known as Siboney de Cuba (SC) and Mambi de Cuba (MC), respectively.

As a first result from the crossbreeding program, a remarkable improvement of the total milk production level of the country was obtained. However, the economic and political crisis in eastern countries at the end of the 1980s affected all the productive activity in Cuba dramatically, and the animal sector was not an exception. In the period after 1990, the economic resources available for animal production systems were completely marginal and not sufficient to meet the requirements of highly productive breeds; consequently, in the dairy sector the number of animals, fertility, and level of milk production of the herds decreased practically by 50% with respect to the results obtained in the last previous 10 years. Pérez (1999) reported a detailed description of the impact of that crisis for all livestock industries in Cuba. In fact, these two periods of time, before and after 1990 could be considered as two contrasting and very different macro-environmental conditions that can be used for G × E studies.

As a consequence of the breeding programs, an historical data base has been available at CENCOP central office and can be used in a detailed study of G × E. The objective of our study was to quantify the genetic (co)variance components and the importance of G × E on the milk production in a large Holstein and Holstein-Zebu populations under Cuban tropical environment.

2. Materials and methods

2.1. Data

A copy of the historical dairy record files existing at CENCOP was available, from which a total of 579312 lactations from H cows and different crossings between H sires and Z females were taken. The depuration of this database was made sequentially. Firstly, all records with paternity doubts were culled, as well as those animals without a correct classification of their breed composition and without birth dates. From all these processes, a total of 478555 lactation records of calving occurring from January 1984 to December 2003 were finally used. This new data base contained the multiple lactations of cumulative milk production at 244 (MY244) and at 305 (MY305) days of lactations and lactation length (LL) of the 203,825 cows from 1288 state owner herds (90% of them with more than 20 records and the remaining with 10–19 records). The animals whose LL was lower than the previous point limits were not discarded, considering their milk production until drying as equivalent to the previous corresponding standard points. This particularity is necessary in the case of crossbreed cows as it was reported by Madalena et al. (1992) who showed that results will be biased when abnormal lactations are not considered.

The SC and MC are two types of dairy crossbred animals very closely connected to the H breed, reared and managed in similar conditions, both have been subjected to a similar breeding program with very low selection intensity for more than 30 years. With these elements, and considering that Acosta et al. (2013) based on the use of 30 microsatellite loci showed there were no differences between SC and MC, therefore were considered as a 'gene pool' of HZ mixed population, and their records together with H were used. The final data base consisted on n=141041H cows and n=62,784 crossbred HZ cows, daughters of 1565H and 831 Hz sires, respectively. A total of 693H sires were represented in the crossbred HZ sires and a total of 230H paternal grand sires were common in H and HZ sires, and 1515 sires were represented in both time periods. The pedigree of sires of the cows with records was constructed, and a total of 2577 sires were represented. This information was available from the herd book files kept at CENCOP central office.

For more than 50 years all the Cuban activity was highly affected by the strict blockade by the United States government. In order to overcome that situation, the Cuban economy was very closely connected to the East European countries. However, after the structural and economic crisis in 1989, all economical activities were affected in Cuba, particularly in the Cuban livestock sector with a decrease of nearly 50% in all the productive levels. Therefore, two time periods were created according to the calving year of the cows (1984 to 1990 and 1991 to 2003). Table 1 shows a general descriptive statistical information of the data analyzed.

Please cite this article as: Menéndez-Buxadera, A., et al., Genotype Environment interactions for milk production traits in Holstein and crossbred Holstein-Zebu cattle populations estimated by a.... Livestock Science (2016), http://dx.doi.org/10.1016/j.livsci.2016.07.016