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ANIMAL BREEDING AND REPRODUCTION

Estimation of genetic and phenotypic trends for dairy traits of Gyr and Guzerá breeds

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ABSTRACT. Milk production has high economic importance in dairy cattle production systems, which justifies its inclusion in genetic breeding programs. The objective of this study was to evaluate the genetic and phenotypic trends of dairy traits in Gyr (167 lactations) and Guzerá (148 lactations) breeds in the State of Rio Grande do Norte (RN). Milk, fat and protein production obtained from monthly dairy controls were the traits evaluated. The expected differences in progeny (DEPs) for these traits were estimated using an animal model. From the means of phenotypic values and DEPs, we estimated the genetic and phenotypic trends in linear regressions as a function of the year of calving of the animal. Positive genetic and phenotypic trends were observed for Gyr (26.8 and 88.7 kg year^{-1}) and Guzerá (8.44 and 37.68 kg year^{-1}). Gyr breed presented positive genetic trends for fat (1.08 kg year^{-1}) and protein (0.45 kg year^{-1}) production and the Guzerá breed showed positive genetic trends for fat (0.36 kg year^{-1}) and protein (0.25 kg year^{-1}) production. The selection applied in the evaluated herds has produced satisfactory genetic and phenotypic progress for milk, fat and protein production.

Keywords: genetic progress, milk production, selection, zebu.

Estimativa de tendências genéticas e fenotípicas para características leiteiras de animais das raças Gir e Guzerá

RESUMO. A produção de leite tem elevada importância econômica em sistemas de produção de bovinos leiteiros, sendo, portanto, justificada a sua inclusão em programas de melhoramento genético. Objetivou-se avaliar as tendências genética e fenotípica de características leiteiras em animais das raças Gir (167 lactações) e Guzerá (148 lactações) no Estado do Rio Grande do Norte (RN). As características avaliadas foram produção de leite, gordura e proteína, obtida a partir de controles leiteiros mensais. As diferenças esperadas na progênie (DEPs) para estas características foram preditas utilizando-se um modelo animal. Pelas médias dos valores fenotípicos e das DEP's foram estimadas as tendências fenotípicas e genéticas em regressões lineares, em função dos anos de nascimento dos animais. Foram observadas tendências genéticas e fenotípicas positivas para a produção de leite da raça Gir (26,8 e 88,7 kg ano^{-1}) e Guzerá (8,44 e 37,68 kg ano^{-1}). A raça Gir apresentou tendências genéticas positivas para a produção de gordura (1,08 kg ano^{-1}) e proteína (0,45 kg ano^{-1}) e a raça Guzerá apresentou tendências genéticas positivas para produção de gordura (0,36 kg ano^{-1}) e proteína (0,25 kg ano^{-1}). A seleção aplicada nos rebanhos avaliados tem produzido progressos genéticos e fenotípicos satisfatórios para as características leiteiras produção de leite, gordura e proteína.

Palavras-chave: progresso genético, produção de leite, seleção, zebu.

Introduction

As production efficiency becomes fundamentally important to the production system, it is important to assess the genetic progress achieved throughout the selection process. Knowing the genetic progress of a population allows the breeder to analyze the results obtained with the breeding program (Malhado, Carneiro, Pereira, & Martins Filho, 2008), to know the distance between the selection objectives and the gains obtained over the years and to make the necessary adjustments.

Milk production in general is the most economically important trait in dairy cattle breeding programs. In addition, this trait correlates with other important productive and functional traits in the production system, so the direct selection applied to milk production can produce indirect selection for other correlated traits, such as milk fat and protein percentages (Boligon et al., 2005).

When choosing the traits to be included in a selection program, not only the heritability of the trait and its correlations must be taken into account, but also its economic importance in relation to the general economic performance. Thus, the results depend on the environmental, genetic and value relationships between the traits involved. These relationships, if neglected, may result in losses in productivity and response to selection in each trait, and in the remuneration of these by industry (Lôbo, Madalena, & Penna, 2000; Madalena, 2000)

The Gyr breed was a pioneer among the zebu breeds in implanting a genetic breeding program for milk, beginning precisely in 1985. The Guzerá breed, in turn, had the genetic breeding program installed 09 years after the Gyr breed. The selection for milk production of these breeds, since then, has shown results of positive genetic trends (Santos, Leite, & Lôbo, 1990; Balieiro et al., 2000; Peixoto, Verneque, Teodoro, Penna, & Martinez, 2006). Therefore, it is clear that the genetic improvement tools, if correctly used, are effective for changing the productive performance of herds (Santana Junior et al., 2016).

The objective was to verify the genetic and phenotypic trends of Gyr and Guzerá breeds for dairy traits in the state of Rio Grande do Norte.

Material and methods

For the present study, data on the milk, fat and protein (Kg) production traits of the Gyr and Guzerá herds, belonging to the Agricultural Research Company of Rio Grande do Norte (EMPARN), and the genetic merit (DEP in Kg) estimated in the genetic evaluations of Gyr and Guzerá animals conducted by Embrapa Dairy Cattle from information on the growth performance of pure and crossbred animals in the national breeding programs database. The EMPARN herds are reared at the Rockfeller Experimental Station, with an area of 430 ha and located in the municipality of São Gonçalo do Amarante, State of Rio Grande do Norte. The property is located on the coast of the State of Rio Grande do Norte, with average annual rainfall, temperature and relative humidity of 1500 mm, 26ºC and 78%, respectively.

At the experimental station, the animals were kept on grazing, with a forage diet variation according to the time of year. In general, in the rainy season, the forage supply was based on *Brachiaria* sp. pasture and in the dry season, on the remaining pasture of the rainy season and sorghum or corn silage. In both periods, the cows were supplemented with concentrate composed of soybean meal and soybean hull, corn grain, cotton cake, urea, corn meal, salt and mineral supplement.

Milk samples were taken directly from the cooling tank, always after the homogenization of the milk. Each sample was collected in duplicate; one of the samples, containing Bronopol®, was sent to the laboratory accredited by the Brazilian Milk Quality Network (RBQL), in which somatic cell counts and milk composition analysis were performed. Fat, protein, lactose, total solids analyses were performed by the Fourier transform spectroscopy method (Bentley Nexgen®, Bentley Instruments, USA).

Data on milk production and constituents used in the genetic evaluations were obtained in monthly dairy controls, from which the cumulative and corrected yields were calculated for 305 days of lactation. For Gyr, the analysis period was from 1985 to 2010 and for Guzerá from 1994 to 2009. The DEPs for milk, fat and protein production were estimated annually up to 2012.

It is important to point out that the National Breeding Program of Dairy Gyr (PNMGL) began in 1985 with the progeny test; however, only in 1994 the first genetic evaluation was carried out, based on the dairy control data of the heifers of the first batch of the test bulls of ABCGIL and the ABCZ database. In 1999, analyses for protein, lactose and total solids of the milk were started for progeny test animals, although some of this information was already available at the ABCZ database. The phenotypic and genetic trends for milk constituents are, therefore, presented from the year 1994.

The statistical model used in the evaluation of animals for milk traits included the fixed effects of herd, year of calving, calving season, genetic group and the age of the dam at calving; as random effects, in addition to the residual effect, we considered the effect of animal (cow, mother and father) and the permanent effect of environment.

$$Yijklm = \mu + ADi + EPi + GCj + Ek + CGl + b1(Iijklm - I) + b2(Iijklm - I)2 + \varepsilon ijklm$$

where:

Yijklm = observation of the nth cow;

μ = overall mean;

ADi = direct additive random effect;

EPi = permanent environmental random effect;

GCj = fixed effect of contemporary group (herd-year of calving);

Ek = fixed effect of the calving season;

CGl = effect of the genetic group;

Iijkl = effect of cow's age at calving as a covariate;

b1 = linear regression coefficient for cow's age;

b2 = coefficient of quadratic regression for cow's age;

εijkl = random residue associated with each observation.

The DEPs for milk, fat and protein production are estimated annually from equations of the mixed models, with inclusion of the kinship matrix, using the derivative-free restricted maximum likelihood method, allowing to obtain BLUP estimates (Peixoto et al., 2013; Verneque et al., 2013). The statistical model used in the genetic evaluation of animals for milk traits included the fixed effects of herd, year of calving, calving season, genetic composition and age of the dam at calving; and, as random effects, in addition to the residue, the effect of animal (cow, mother and father) and the permanent effect of environment. For the traits of fat and protein production, a bitrait analysis was applied to milk production. For this, the MTDFReML software was used (Boldman, Kriese, & Van Vleck, 1995).

Results and discussion

During the execution period of breeding programs of the breeds, there was a significant difference in the means of fat and lactose between Gyr (1985 to 2010) and Guzerá (1994 to 2009) breeds (Table 1).

Table 1. Means and standard deviations in milk composition for Gyr and Guzerá breeds belonging to the herds of EMPARN.

Breed	Milk composition (%)			
	Fat	Protein	Lactose	Dry extract
Gyr	3.56 ± 0.79a	2.91 ± 0.34a	4.14 ± 0.25a	11.77 ± 1.00a
Guzerá	3.92 ± 0.92b	2.95 ± 0.35a	3.75 ± 0.30b	11.07 ± 0.99a

Significance level $p < 0.05$ by Tukey's test.

These results were presented to characterize the milk level of the breeds of the EMPARN population and to illustrate the advances. The results are below those reported in the literature (Rangel, Guedes, Albuquerque, Novaes, & Lima Júnior, 2009; Ribeiro, Tinoco, Lima,., Guilhermino, & Rangel, 2009; Galvão Junior et al., 2010; Rompa & Cavalari, 2012) for the breeds in question, which can be attributed mainly to environmental differences.

Figures 1, 2 and 3 illustrate the trends for milk production at 305 days of lactation (PL305), fat production (PG305) and protein production (PP305) accumulated in 305 days of lactation of the Gyr herd of EMPARN participating in the National Breeding Program of Dairy Gyr (PNMGL).

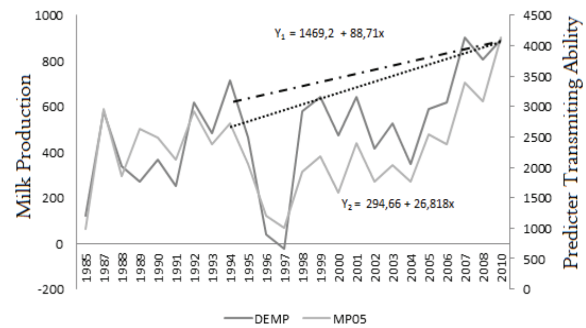

Figure 1. Phenotypic and genetic trends of 305-d milk production for the Gyr herd.

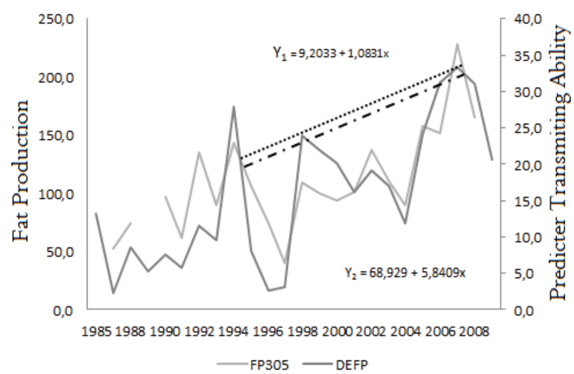

Figure 2. Phenotypic (Pfat) and genetic (DEFP) trends for fat production of the Gyr herd.

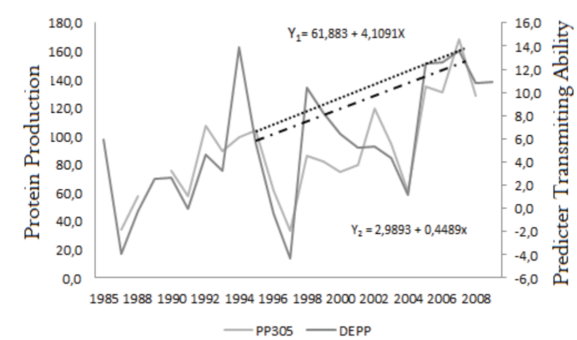

Figure 3. Phenotypic (Pro) and genetic (DEPP) trends for protein production of the Gyr herd.

The annual genetic and phenotypic gains for PL305 in the Gyr herd were 26.8 and 88.7 kg year^{-1}, respectively. Although positive and expressive, the genetic gain (1.8%) of the Gyr herd still falls short of the possible annual genetic gains with selection for milk production traits of up to 3% of the population mean (Smith, 1985). This result suggests that the selection pressure on the herd cows and the bulls that will be progenitors of the next generation can be increased in order to allow the animals of greater genetic merit for dairy traits to have a greater chance of remaining in the herd and to maximize genetic changes. Phenotypic gain, sum of the effects of genetic and environmental factors, reveals that in addition to the genetic changes, favorable changes in milk production occurred in the environmental conditions. Balieiro et al. (2000), obtained annual genetic and phenotypic gains of 10.46 and 66.93 kg $year^{-1}$, respectively, for the population of Gyr cows selected for milk in 19 herds, which were lower than those achieved by the EMPARN herd for the milk production trait. The highest genetic gain for PL305 was verified in the period from 2001 to 2007.

In the trend curve for fat (Figure 2), there was a positive trend for both the mean DEP and the phenotypic mean for fat production, that is, both presented growth, despite annual fluctuations. The phenotypic gain for fat production was 5.85 kg $year^{-1}$ and the genetic gain was 1.08 kg $year^{-1}$. These values of selection for production, by selection pressure, promote changes in the production of milk components. The genetic improvements in the direct selection for milk production advance much more than the improvements in the production of the constituents and, therefore, when we deal with the production of constituents as a percentage, we have a reduction. Boligon et al. (2005) report a negative genetic correlation between milk yield and fat percentage, that is, the increase in milk production is not accompanied by an increase in milk fat content.

In the same way, the production of protein had an expressive increase, with a positive genetic trend. Annually, the phenotypic and genetic gains were respectively 4.10 and 0.45 kg. The phenotypic gains for protein production were greater than the genetic gains due to favorable environmental conditions in which the animals were bred.

Despite the annual fluctuations, our findings showed that, during the last decades, there was a positive trend for genetic progress for PL305, PG305 and PP305 in the EMPARN Gyr breeding herd (Figures 1, 2 and 3). This scenario is similar to that occurring throughout Brazil, where the Gyr breed has undergone vigorous selection for productive traits (Santana Junior et al., 2014).

Figures 4, 5 and 6 show, respectively, trends for milk production (PL305), fat production (PG305) and protein production (PP305) accumulated in 305 days of lactation of the EMPARN Guzerá herd participant in the National Breeding Program of Guzerá (PNMGul), since its inception in 1994. It should be noted that the first bulls summary of the progeny test was published in 2000. Therefore, this year is used as the highlight for the beginning of the trend curve presented in the figures below.

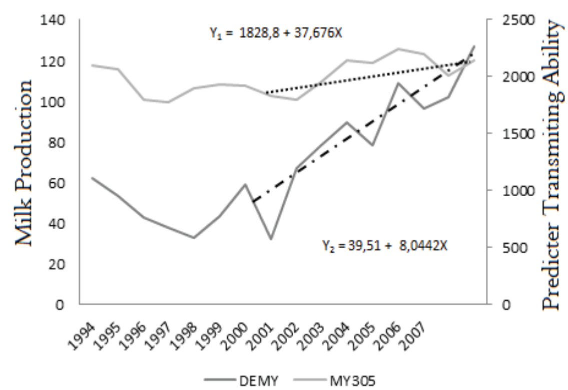

Figure 4. Phenotypic and genetic trends of 305-d milk production for the Guzera herd.

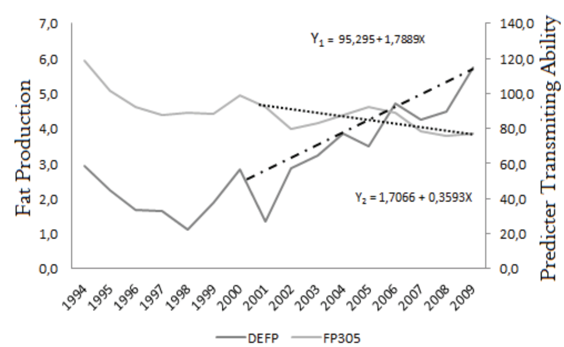

Figure 5. Phenotypic trend (Pfat) and genetic (DEFP) for fat production of the Guzera herd.

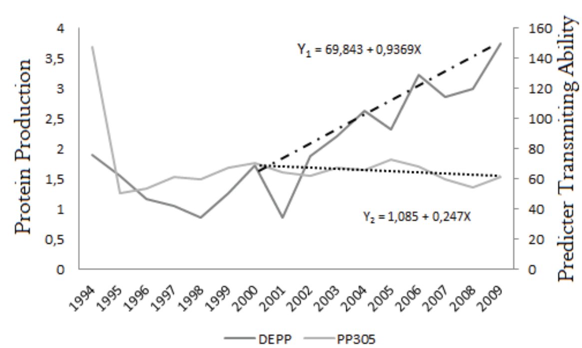

Figure 6. Phenotypic trend (Pro) and genetic (DEPP) for protein production of the Guzera herd.

A positive genetic and phenotypic gain was observed for milk production from the year 2000, which has been maintained over the years. The annual phenotypic gain was 37.68 kg and the genetic gain was 8.44 kg per year. Although lower than in the Gyr breed, the genetic and phenotypic gains are positive for the Guzerá breed. These results also suggest that the selection pressure on the progenitors can be increased.

In the trend curve for fat (Figure 5), a positive trend line was verified for the mean of DEP, but for the phenotypic mean it was negative. The genetic gain was 0.36 kg year and the phenotype gain was -1.79 kg year.

The protein production (Figure 6) also showed an expressive increase for the genetic trend, since the phenotypic trend remained low and constant, the phenotypic and genetic gains were respectively -0.94 kg year^{-1} and 0.25 kg.

The positive response registered in the genetic gain for the production of milk constituents resulted from the high genetic correlation with milk production, the focus of the selection. The same was not verified for the negative phenotypic trend (fat: -2.3 kg year^{-1} and protein: -1.1 kg year^{-1}). For Peixoto et al. (2010), the intensive use of some breeding bulls has led to an increase in inbreeding coefficient and genetic drift in the population, a fact that may be associated with a negative phenotypic trend.

Nevertheless, the progress of the herd occurred under harsh conditions, representative of the Northeast region and, therefore, the EMPARN herd constitutes an important genetic resource for the improvement of commercial dairy herds in the state of Rio Grande do Norte.

Conclusion

The selection applied in the last decades to the herds of the Gyr and Guzerá breeds in the EMPARN, RN, herds under adverse environmental conditions and with low input use, has resulted in satisfactory genetic and phenotypic advances for dairy traits, milk, fat and protein production.

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