Impact of Milk Production Breeding Program on the Guzerat (*Bos indicus*) Population Parameters in Brazil

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Abstract

Guzerat breed has strongly fitted to the tropical conditions of Brazil. Since 1940, the use of Guzerat animals for crossing has been reducing its population size. In 1994, a selection program for milk production traits was initiated in some purebred herds. This study was undertaken to evaluate the genetic status of the Guzerat population under milk selection in order to estimate population parameters. Genealogical data of 10,051 animals were used. Averages F for all and for the inbred animals were, respectively, 0.009 and 0.025. Average relatedness was 0.011. The linear increase in F by generation was 0.0051. There is not a clear trend of reduction in the effective population size and it was equal to 98 at the last generation evaluated. Average F and relatedness values are still low, despite the non-random mating. However, reduced effective population size indicate risks of increasing inbreeding coefficient and genetic drift and, consequently, losing of variability.

Keywords: inbreeding coefficient, Effective population size, Animal Breeding, Zebu Cattle

1. Introduction

Guzerat breed is originated from a semi-arid region in India. It was introduced in Brazil at the end of the XIX century where it was prevalent until 1939 due to its adaptation to several Brazilian tropical conditions. The broad utilization of this breed for crossing resulted in an expressive reduction in the purebred population size (Faria *et al.,* 2004). Considering this and their productive potential, parasites resistance, ability to consume gross forage and thermal tolerance, FAO included this breed in the list of the domestic genetic resources to be conserved by management (FAO, 1995).

Regarded as dual purpose cattle, Guzerat has been selected within herds for meat, milk or both production traits in Brazil. In 1994, a nation-wide breeding program based on progeny test and on an open MOET selection nucleus was implemented for Guzerat breed for the improvement of milk production traits (Penna *et al.,* 1998). The interest for this breed increased since the beginning of the Program. Semen market reflects this trend. Today the number of registered animals is 164.228, being Guzerat among the three largest populations of Zebu breed in Brazil.

In addition to genetic improvement, genetic diversity of a population is an important aspect of any breeding program since it allows species to face future challenges and long-term response to selection (Frankham *et al.,* 2002). Concerning on the reduction of effective population size and inbreeding coefficient over cattle genetic diversity have been raised up mainly after the utilization of new reproductive technologies (Vieira *et al.,* 2005). Besides the loss of genetic variability, inbreeding depression can reduce yield and reproductive traits performance.

Estimates of parameters to assess and monitor genetic variability have been frequently obtained for many breeds using genealogical or molecular data. Studies using pedigree data of all Brazilian registered Guzerat animals found a small effective population size (117) and an average inbreeding coefficient (F) ranging from 0.04 (Weigel *et al.,* 2001) to 0.03 (Vieira *et al.,* 2005). (Faria *et al.,* 2002). These statistics made evident the narrow genetic basis of the current Guzerat population.

To our knowledge, this is the first study on genetic diversity of Guzerat breed selected for milk production - a subpopulation of the whole

Brazilian Guzerat cattle. The objectives of the present study were to calculate inbreeding coefficients and average relatedness in order to evaluate and, as a reference, to monitor genetic variability in the Guzerat population selected for milk purposes.

2. Material and Methods

Pedigree data were obtained from the Brazilian Program for the Improvement Guzerat Dairy Cattle. Lactation records came from 31 herds distributed in the Northeastern (6 states), Central-western (1 state) and Southeastern (4 states) Brazil. The complete data set included 10,051 animals being 2,379 with unknown parents, 116 with at least a known parent and 7,556 with both known parents. These animals were registered since the end of 19^{th} century in the beginning of the official Guzerat breed importation.

The population parameters were calculated by means of the algorithms available in the free software ENDOG v 4.0 (Gutiérrez *et al.,* 2005). This software uses the probability that an individual has two identical alleles by descent to calculate inbreeding coefficients (F). The inbreeding rate (ΔF) per generation is calculated by means of the formula $\Delta F=(F_t-F_{t-1}/(1-F_{t-1})$. Using ΔF, ENDOG computes the effective population size (N_e), as Ne=1/2ΔF. The program also calculated the average relatedness coefficient (AR) of each animal, using the vector $c'=(1/n)1'\mathbf{A}$, where **A** is the numerator relationship matrix (NRM) of size n x n. The NRM included 10,051 individuals - 1,955 males and 8,096 females.

The inbreeding trend was obtained from the regression coefficient of inbreeding coefficients over generations. In the former analysis, for individuals with unknown birth date in the first generation, it was assumed the birth date equal to 01/01/1940. For that in the second generation, it was assumed the birth date of 01/01/1950. The analysis were carried out using the REG procedure available in the computational package SAS® (SAS, 2003).

3. Results

The overall population means were 0.009 for inbreeding coefficient (F) and 0.011 for average relatedness (AR). F was the same for male and female individuals. F was 0.025 among the 3,471 inbred individuals. Estimates of F by the known birth year periods used for estimate trends are shown in table 1. There were 5,593 individuals with F equals to 0 and the second most frequent class of F was $0<F\leq0.01$ including 1,631 individuals (Tab. 2). Both classes comprised almost 80% of the population. The least frequent classes of inbreeding were in $0.10<F\leq0.12$ interval. There were only 213 individuals with F>0.12. The maximum value found for individual F was 0,317.

The value calculated for the effective population size (N_e), mean inbreeding coefficient (F) and mean average relatedness (AR) at each generation are shown in Table 3. The results show an evident trend of increasing in F and AR and a fluctuating N_e at succeeding generations.

Figure 1 shows the trend in F per generation. There was an increase of F until the fifth generation followed by a slight decrease in the last generation. The inbreeding rate per generation was estimated in 0.0051.

3. Discussion

Average inbreeding coefficients (F) were calculated for some Zebu breeds in Brazil (Faria *et al.,* 2002). In the Guzerat population, average F values for inbred animals were calculated using different data sets. Values of 0.04 (Weigel *et al.,* 2001) and 0.03 (Vieira *et al.,* 2005) were found. It has been considered harmless levels for populations under selection.

Despite constituting a subpopulation of the Guzerat cattle, the level of inbreeding coefficient (F) and the inbreeding rate (ΔF) calculated for the dairy Guzerat were below the ones found in other dairy breeds in all over the world (Faria *et al.,* 2002; Weigel *et al.,* 2001). Many aspects can be related to these findings. Among them, the different founders used to start each herd, somehow the geographic distances among the regions they are bred in Brazil, beyond the increasing concern of breeders on inbreeding depression are regarded.

The emphasis given to double purpose in most of the herds under milk selection, which uses also bulls from the beef Guzerat cattle, besides the increase in the number of participating herds and females in the program can be pointed out as further contributing factors. The F and ΔF values found can be considered low mainly when compared to the levels reached for other dairy Zebu breeds (SAS, 2003) and specifically for Guzerat breed (Faria *et al.,* 2002).

The decrease in F values at the 6th generation, after the beginning of the breeding program at the 5th generation, has coincided also to the publication of the first sire summary for milk production traits. Despite the breeding program being recently initiated (1994) and the sex ratio is increasing (Tab. I), these results could be considered a consequence of the introduction of new lines into the herds through artificial insemination, in detriment of those from the own herd. Beyond that, the practice of mating planning carried out in most herds since the beginning of the program must also be regarded (Colleau *et al.,* 2004).

The impact of assessing a more precise pedigree on the estimates was stand out by comparing our F values for inbred individuals (0.025) to those obtained in a previous study with the same population (0.04) (Peixoto *et al.,* 2006). Besides leading to underestimation of inbreeding levels the precision of the pedigree data is relevant to the accuracy of the animal genetic evaluations and the rate of genetic progress (Cassel *et al.,* 2003; Weigel *et al.,* 2001).

The mean average relatedness (1.06%) corroborated with the results for F and gave an idea about how much an individual was represented in the pedigree data of this population. It was considered low mainly when compared to the value of 2.10% (SAS, 2003) found in the Dairy Gyr cattle another Zebu breed also under milk selection in Brazil.

According to the values showed in tables 2 and 3, the trends of F and AR have increased over generation. Many factors have contributed to this scenario however most of these results can be attributed to a larger use of related bulls since the beginning of the breeding program and previously to the founder effect and bottlenecks, as well (Nei *et al.,* 1975). No clear trend has occurred with N_e, despite revealing fluctuations in the process of narrowing of the genetic variability in this population, probably due to bottlenecks.

5. Conclusion

Despite the low values found for F and AR, as well as the low frequency of high inbred individuals, the values for N_e are on the threshold for the risk of losses in the genetic variability. The National Program for the Improvement of Guzerat Cattle for Milk Production must encourage the broad use of proven bulls from different lines in order to avoid increasing in the inbreeding coefficient to avoid losses of genetic variability by means of population structure parameters. Results found in this study suggest, therefore, the necessity of further studies to evaluate the effects of inbreeding on production and reproduction traits. Even the Guzerat dairy cattle breeding program is keeping inbreeding in a low rate.

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Table 1. Average inbreeding coefficient (F) and respective standard deviation (SD), minimum (Min) and maximum (Max) F values according to the birth year period of the individuals' (N).

Period	N	F ± SD	Min	Max
1940-1949	49	0.005 ± 0.036	0	0.250
1950-1959	335	0.000 ± 0.000	0	0.001
1960-1969	461	0.002 ± 0.019	0	0.250
1970-1979	758	0.004 ± 0.021	0	0.250
1980-1989	1,383	0.012 ± 0.035	0	0.266
1990-1999	2,649	0.015 ± 0.034	0	0.313
2000-2007	3,355	0.012 ± 0.027	0	0.317

Table 2. Number (N) and percent (%) of individuals, average inbreeding coefficient (F) and respective standard deviation (SD), minimum and maximum F values according to the F class.

F classes	N	%	F ± SD	Min	Max
0 (F=0)	5,593	62.21	0 ± 0	0	0
1 (0<F≤0.01)	1,631	18.14	0.0040 ± 0.0028	0.001	0.010
2 (0.01<F≤0.02)	493	5.48	0.0155 ± 0.0029	0.011	0.020
3 (0.02<F≤0.03)	208	2.31	0.0246 ± 0.0025	0.021	0.030
4 (0.03<F≤0.04)	295	3.28	0.0344 ± 0.0029	0.031	0.040
5 (0.04<F≤0.05)	118	1.31	0.0452 ± 0.0027	0.041	0.050
6 (0.05<F≤0.06)	80	0.89	0.0552 ± 0.0026	0.051	0.060
7 (0.06<F≤0.07)	179	1.99	0.0648 ± 0.0028	0.061	0.070
8 (0.07<F≤0.08)	64	0.71	0.0759 ± 0.0029	0.071	0.080
9 (0.08<F≤0.09)	61	0.68	0.0832 ± 0.0022	0.081	0.090
10 (0.09<F≤0.10)	24	0.27	0.0951 ± 0.0021	0.091	0.100
11 (0.10<F≤0.11)	19	0.21	0.1053 ± 0.0025	0.101	0.109
12 (0.11<F≤0.12)	12	0.13	0.1157 ± 0.0013	0.113	0.117
13 (F>0.12)	213	2.37	0.1573 ± 0.0504	0.121	0.317

Table 3. Average inbreeding coefficient (F), average relatedness (AR) and effective population size (N_e) per complete generations.

Generation	N	F (%)	Inbred Individuals (%)	F[1] (%)	AR (%)	N_e
0	2,495	0.00	-	-	0.07	-
1	2,803	0.13	8.03	1.62	0.64	384.1
2	1,830	1.16	50.93	2.27	1.44	48.6
3	1,597	1.96	72.39	2.71	1.89	61.2
4	1,138	2.34	85.41	2.74	2.26	131.2
5	183	2.83	100.00	2.83	2.63	98.0
6	5	2.54	100.00	2.54	2.78	-

[1]For inbred individuals.

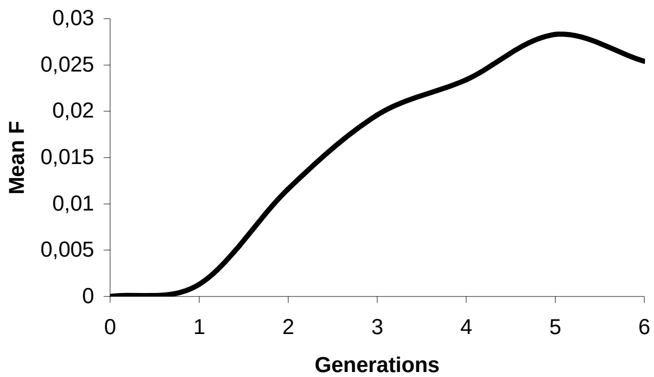

Figure 1. Trend of inbreeding coefficients averages ($\overline{F}$) and per generation.