Individual Increases in Inbreeding on a highly inbred Guzerat Dairy Herd in Brazil

J.C.C. Panetto[*], J.P. Gutiérrez[†], J.B.S. Ferraz[‡], D.G. Cunha[*] and B.L. Golden[§]

Introduction

Benefits from the development of evaluation and artificial reproductive techniques are expected to the genetic improvement of livestock populations. On the other hand, intensive use of small numbers of sires and dams may lead to reduced genetic variability within and among livestock populations, increasing levels of inbreeding as a consequence. Decreased performances in traits related to production, reproduction and health in dairy cattle have been reported by many authors to be caused by inbreeding (Hudson and Van Vleck, 1984; González-Recio et al., 2007; Maiwashe et al, 2008). Because of their small numbers of founders and applied selection practices, zebu breeds in Brazil have tended to lose genetic variability. Investigations on the impact of inbreeding in these breeds would be needed to help overcome possible problems in the future (Faria et al. (2009).

Increase in the traditional inbreeding coefficient (F) (Wright, 1931) is not linear across generations, and may lead to different conclusions concerning inbreeding depression depending on the pedigree depth (González-Recio et al., 2007).

The objective of the present study was to characterize the influence of inbreeding on daily milk yields (DMY), ages at first calving (AFC) and calving intervals (CI) of females from a highly inbred elite zebu dairy herd of the Guzerat breed. The inclusion of individual increases in inbreeding on the statistical models was applied as an alternative to the usual individual inbreeding coefficients to access inbreeding depression.

Material and methods

Data. Totals of 1419 records of Daily Milk Yields (DMY), calculated as the average daily production during the best 305-d milk yield recorded for each cow, 745 records of Ages at First Calving (AFC) and 4420 records of Calving Intervals (CI) from a zebu elite dairy herd of the Guzerat breed in Brazil have been used.

Inbreeding. Inbreeding coefficients (F_i) (Wright, 1931) were computed following Meuwissen and Luo (1992). Numbers of equivalent complete generations (t_i) were calculated

[*] Curso de Veterinária, Universidade de Uberaba, Av. Nenê Sabino, 1801, 38050-501, Uberaba, MG, Brazil
[†] Departamento de Producción Animal, Faculdad de Veterinaria, Universidad Complutense de Madrid, Avda. Puerta de Hierro s/n, 28040 Madrid, Spain
[‡] Faculdade de Zootecnia e Engenharia de Alimentos, Universidade de São Paulo, Cx. P. 23, 13635-900, Pirassununga, SP, Brazil
[§] Dairy Science Department, California Polytechnic State University, San Luis Obispo, CA 93407-0257

as the sum over all known ancestors of the term $(1/2)^n$, where n is the number of generations separating the individual to each known ancestor (Maignel et al., 1996, cited by Gutiérrez and Goyache, 2005). Individual increases in inbreeding, or inbreeding rates (ΔF_i), were calculated according to the methodology described by González-Recio et al. (2007) and modified by Gutiérrez et al. (2009). Accordingly, individual increases in inbreeding were computed as: $\Delta F_i = 1 - \sqrt[ti-1]{1 - F_i}$. Individual inbreeding coefficients, numbers of equivalent complete generations and individual increases in inbreeding were computed using the ENDOG program (Gutiérrez and Goyache, 2005).

Variance Components and Effects of Inbreeding. Single trait analyses were conducted under animal models. At one moment the effect of inbreeding was included through individual inbreeding coefficients (F_i). At another moment, this effect was included through individual increases in inbreeding (ΔF_i). Calving intervals was treated as a longitudinal trait and the analysis was conducted by fitting a random regression model with Legendre polynomials of order 3 fitted for the fixed effect of age at calving and for both random animal and permanent environment effects. All mixed model analyses were conducted by restricted maximum likelihood using the program Wombat - version 1.0 (Meyer, 2007).

Results and discussion

The pedigree file included 9,915 animals, from which 9,055 were inbred, with an average inbreeding coefficient of 15.2%. The maximum inbreeding coefficient observed was 49.45%. Among the females contributing with data to the daily milk yield analysis, which were still alive in 2009, 100% were inbred, with a minimum inbreeding coefficient of 19.75%, a maximum of 40.13%, and an average of 26.42%. Various previous studies have been published about inbreeding values in dairy cattle populations (Peixoto et al., 2006, Sewalem et al., 2006, González-Recio et al., 2007), but none with values as high as the average and maximum found for the Guzerat herd analyzed in the present study.

Heritability estimates were 0.27 for daily milk yield and 0.38 for age at first calving. The genetic variance ratio estimated with the random regression model for calving intervals ranged around 0.10. Similar estimates were obtained with both approaches, whether individual inbreeding coefficients or individual increases in inbreeding. Since both approaches have resulted in similar heritabilities for the studied traits, it would be advisable to use increases in inbreeding in future analyses because it accounts for the number of equivalent generations available in the pedigree, keeping the about the same additive genetic variance estimates. Another reason to choose increases in inbreeding is because inbreeding coefficients generally grow with time and may be confused with the effect accounting for the time, the contemporary groups, whilst increases in inbreeding do not grow with time.

For the creation of figure 1, increases in inbreeding (ΔF) have been converted to equivalent F (%), considering 7.37, 7.02 or 7.15 equivalent generations, respectively, according to averages for the animals included on each analysis. Increased inbreeding generally caused poorer performances in terms of daily milk yield, age at first calving and calving intervals. However, selection on milk yield was able to overcome the negative effects of moderate inbreeding on this trait, which can be realized through an inspection of the curves on figure 1a. One possible speculation could be that individuals surviving to high levels of inbreeding would be free from most deleterious alleles, allowing additive genetics to perform better.

Another fact to be considered is that inbreeding depression affects in more extent to traits related to fitness such as reproductive traits.
It can also be recognized that average milk yields were positively related to individual increases in inbreeding only until a certain level, corresponding to values around 20%. When the effect of selection is excluded, as shown with the predicted lines on figures 1a, 1b and 1c, the general effect of inbreeding on the herd was to cause diminished daily milk yield and increased ages at first calving and calving intervals, meaning that indeed inbreeding depression have occurred.

a)

b)

c)

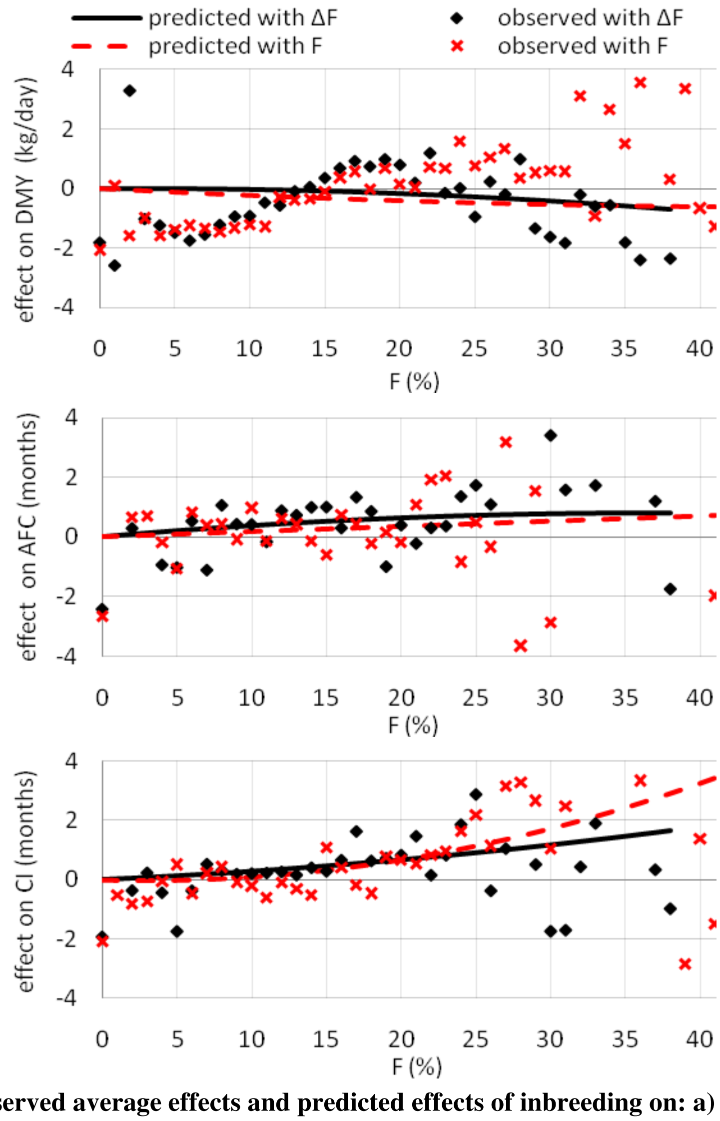

Figure 1: Observed average effects and predicted effects of inbreeding on: a) daily milk yields (DMY); b) ages at first calving (AFC); and c) calving intervals (CI).

Even if the directions of the effects of inbreeding were the same for both approaches, the shape of the curves predicted with them resulted different from each other (figure 1a). For example, mating between half-sibs with no previous inbreeding (F=12.5%) would lead to reductions of 84.61 kg or 15.25 kg for 305 day lactations, according to the estimates from the models with inbreeding coefficients or with increases in inbreeding, respectively. Ages at first calving and calving intervals have both been affected by inbreeding depression also in the same direction but with different shapes for each statistical model (figures 1b and 1c). A manuscript with a complete version of the present study has been previously submitted to publication (Panetto et al., 2010).

The authors acknowledge CAPES, a foundation affiliated with the Ministry of Education of Brazil and FAPEMIG for the financial support, and the J.A. breeders for kindly providing the data for this study.

Conclusion

Inbreeding resulted in poorer performances in terms of daily milk yields, ages at first calving and calving intervals. However, selection on milk yield was able to overcome the inbreeding depression on this trait. Individual increases in inbreeding used as a covariate in the statistical models accounted for the inbreeding depression avoiding potential overestimation of this effect on more recent generations due to increased numbers of known generations.

References

Faria, F.J.C., Vercesi Filho, A.E., Madalena, F.E., et al. (2009). *J. Anim. Breed. Genet.*, 126: 148-153.

González-Recio, O., Lópes de Maturana, E., and Gutiérrez, J.P. (2007). *J. Dairy Sci.*, 90: 5744-5752.

Gutiérrez, J.P. and Goyache, F. (2005). *J. Anim. Breed. Gen.*, 122: 172-176.

Gutiérrez, J.P., Cervantez, I, and Goyache, F. (2009). *J. Anim. Breed. Genet.*, 126: 327-332.

Hudson, G.F.S. and Van Vleck, L.D. (1984). *J. Dairy Sci.*, 67: 171-179.

Maiwashe, A., Nephawe, K.A., and Theron, H.E. (2008). *S. Afr. J. Anim. Sci.*, 38(2)119-125.

Meuwissen, T. and Luo, Z. (1992). *Genet. Sel. Evol.*, 24: 305-313.

Meyer, K. (2007). *J. Zhejiang Univ. Sci. B*, 8(11): 815-821.

Panetto, J.C.C., Gutiérrez, J.P., Ferraz, J.B.S. et al. (2010) *J. Dairy Sci.*, doi:10.3168/jds.2010-3197

Peixoto, M.G.C.D., Verneque, R.S., Teodoro, R.L. et al. (2006). *Genet. Mol. Res.*, 5: 454-465.

Sewalem, A., Kistemaker, G.S., Miglior, F. et al. (2006). *J. Dairy Sci.*, 89: 2210-2216.

Wright, S. (1931). *Genetics*, 16: 97-159.