GENETIC VARIATION IN RESPONSE TO SUPEROVULATION IN CATTLE

Torkild Liboriussen
National Institute of Animal Science,
Research Centre Foulum, DK-8830 Tjele, Denmark

SUMMARY

Response to superovulation was expressed as number of ova and number of transferable embryos per flush. Red Danish and Danish Red & White had significantly higher values than Danish Jersey and Danish Friesian. Higher heritability (0.25 ±0.06) was found when response was expressed as number of ova, but number of transferable embryos was also heritable (h^2=0.15 ±0.05). It is argued that systematic use of superovulation in cattle breeding programs might increase ovarian sensitivity to gonadotropins and hence increase twinning frequency in non-superovulated cows.

INTRODUCTION

Few attempts have been made to estimate heritability of response to superovulation in cattle (Lohuis et al., 1990; Preisinger et al., 1990; Preisinger & Kalm, 1992). This paper presents some new results on this matter.

MATERIALS AND METHODS

The superovulations were performed in the FY-BI project (the Danish MOET breeding experiment, Liboriussen & Christensen, 1990). Data were obtained from 542 flushings of 474 donors. The donors were Red Danish (n=95), Danish Friesian (n=294), Danish Jersey (n=66) or Danish Red and White (n=19). We distinguished donors according to origin; *Internal* donors were from the three experimental herds which form the nucleus stock of a MOET scheme, *external* donors were selected from many herds of Danish milk-recorded cows. All cows that were treated with gonadotropic hormones (either FSH or PMSG) were included in the data set, although the flushing procedure were omitted if rectal palpation of the ovaries indicated that the donor had not responded to the superovulatory treatment. In these instances the two dependent variables OVA (number of ova per flush) and EMB (number of transferable embryos per flush) were set to zero.

Breed effects were quantified as least-squares means, derived from a model which included other significant fixed effects. Repeatability and heritability were calculated from variance components estimated by a derivative-free REML algorithm (Jensen & Madsen, 1992), assuming an animal model with repeated measurements. The model included fixed effects of breed, origin, age group x time from calving, year x season, treatment, and induction time. The random effects were service sire, permanent environment associated with the donor, additive genotype of the donor, and residual. Ancestors were traced back four generations if possible. Phenotypic and genetic correlations were calculated from variance and covariance components estimated from bivariate analyses. The model was the same as the one described above, except that the random effect of permanent environment was excluded. Phenotypic variance was calculated as the sum of the four variance components. Heritability (h^2) was computed as the ratio of variance due to additive genotype to phenotypic variance. Standard errors of variance components were estimated using a quadratic approximation to the restricted likelihood function based on evaluations around the maximum in a response surface design. Standard errors of repeatabilities and heritabilities were computed from standard errors of the variance components using a Taylor series expansion (Jensen & Madsen, 1992).

RESULTS

Descriptive statistics are presented in Table 1 and breed effects in Table 2. Red Danish and Danish Red & White responded better to superovulation than Danish Friesian and Danish Jersey. Jersey donors generally had a smaller proportion of transferable ova.

Table 1. Descriptive statics for superovulation response

Trait [1]	n	mean	s.d.	min.	max.	c.v.%
OVA	542	8.57	7.10	0	39	82.8
EMB	542	5.43	5.38	0	33	99.0

1) OVA: Number of ova per flush
EMB: Number of transferable embryos per flush

Table 2. Response of breeds to superovulation (least-squares means ± s.e.)

	Red Danish	Danish Friesian	Danish Jersey	Danish Red & White
OVA	10.6 ± 0.8	7.8 ± 0.5	8.6 ± 0.9	11.7 ± 1.5
EMB	6.6 ± 0.6	4.9 ± 0.4	4.7 ± 0.7	6.9 ± 1.1

The Bull used for insemination was not an important source of variation for either dependant variable. The effect of permanent environment was also small and insignificant for both traits, and the estimates of heritability are consequently also estimates of repeatability.

Estimates of heritability were 0.25 ±.06 and 0.15 ±.05 for OVA and EMB, respectively. The genetic and phenotypic correlations between OVA and EMB were 0.90 and 0.78, respectively.

DISCUSSION

Lohuis (1993) reported mean values of 8.00 and 6.62 for viable embryos per flush from Ayrshire and Holstein donors, respectively, but these means were not significantly different.

Heritabilities for OVA and EMB were similar to those reported by Preisinger et al. (1990), but higher than those found by Preisinger & Kalm (1992) who reported values close to zero. A very low estimate of heritability of "embryo yield" was also reported by Lohuis et al. (1990). Van Vleck et al. (1991) reported a heritability of 0.16 for spontaneous ovulation rate in heifers.

To our knowledge, estimates of genetic correlations among quantitative measures of superovulatory response in cattle have not previously been reported. The very high genetic correlation among OVA and EMB indicates that genetic changes in one of these measures will be associated with almost parallel change in the other, and that the development of ova to transferable embryos is not influenced by the donors genotype.

Our results indicates that Red Danish and Danish Red & White are more sensitive to treatment with exogenous gonadotropic hormones than Danish Friesian and Danish Jersey. Pedersen (1991) found that Red Danish and Danish Red & White had higher twinning frequency than Danish Friesian and Danish Jersey. Bindon et al. (1986) observed that the daughters of sires whose dams had high phenotypic merit for twinning were more sensitive to superovulatory treatment than daughters of sires from unselected commercial cattle. They suggest that this difference in superovulatory response could be due to increased ovarian sensitivity to gonadotropins. Snyder (1986) confirmed that selection of cows for multiple births is associated with an increased ovarian response to gonadotropins. Van Vleck et al.

1991 reported genetic correlations ranging from 0.62 and 1.00 between the occurrence of twin births in beef cows and average ovulation rates based on 3 to 8 estrous cycles of the same animals as pubertal heifers.

If superovulation is systematically used in cattle breeding programs without restrictions to standardize family size an indirect selection for increased ovarian responsiveness to gonadotropins will occur. This will result in an increased number of ova and transferable embryos per flushing. Another consequence with a direct impact on the cattle industry could be an increased frequency of multiple births after natural spontaneous ovulations.

Since in dairy cattle twinning is generally considered undesirable, family size in dairy MOET schemes should be standardized in order to avoid indirect selection for increased ovarian sensitivity. Selection programs for beef- and dual purpose breeds could, however, take advantage of the genetic variation in sensitivity to superovulatory treatment to increase the frequency of multiple births.

In conclusion, our investigation confirmed that breeds differed significantly in the numbers of ova and transferable embryos per flush. Within-breed genetic variation exists, and the heritability is in the order of 0.15 to 0.25.

REFERENCES

BINDON, B.M., PIPER, L.R., CAHILL, L.P., DRIANCOURT, M.A. and O'SHEA, T.O. (1986) Theriogenology, 25 : 53-70.

JENSEN, J. and MADSEN, P. (1992) Natl. Inst. Anim. Sci., Denmark. Mimeo. 17 pp.

LIBORIUSSEN, T. and CHRISTENSEN, L.G. (1990) Proc. 4th World Congr. Genet. Appl. Livestock Prod., 13 : 66-69.

LOHUIS, M. (1993) In "Strategies to improve efficiency and genetic response of progeny test programs in dairy cattle". PhD-thesis at The University of Guelph, Canada. 34-59.

LOHUIS, M., SMITH, C. and BURNSIDE, E.B. (1990) Proc. 4th World Congr. Genet. Appl. Livestock Prod., 13 : 221-224.

PEDERSEN, J. (1991) The Danish Agricultural Advisory Centre, Denmark. LK-report no. 55.

PREISINGER, R., KALM, E., WICHMANN, U. and HAHN, J. (1990) Tierzuchter, 12 : 534-535.

PREISINGER, R. and KALM, E. (1992) Proc. 43rd Annual Meeting EAAP, 13-17.

SNYDER, D.A. (1986) Theriogenology, 25 : 200.

VAN VLECK, L.D., GREGORY, K.E. and ECHTERNKAMP, S.E. (1991) J. Anim. Sci., 69 : 3213-3219.