EFFECT OF AGE OF DAMS ON DAIRY AND FUNCTIONAL TRAITS OF THEIR DAUGHTERS IN CATTLE

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INTRODUCTION

Longevity is an essential part of any breeding goal, reflecting the ability of an animal to cope successfully with the environmental conditions in a given production system. In Austrian Simmental cattle longevity is the economically most important functional trait in the total merit index (Miesenberger *et al*., 1998). However, by trying to increase the productive life span of livestock, the number of offspring born by older mothers also increases. One major effect of parental age, mainly maternal age, on postnatal development in mammals is due to chromosomal abnormalities, especially fetal aneuploidy. The finite ovaria stock of primary follicles and oocytes are produced only before birth in most mammals. Meiosis is resumed in the oocytes of mature follicles just before ovulation (Finch, 1990). Nucleus and mitochondrial DNA damage which is frequently observed (Richter *et al*., 1988) may be the result of the prolonged prophase of meiosis in germ cells. Beside the higher probabilities of chromosomal abnormalities in connection with higher parental age, there is also evidence of transmissible and cumulative effects of parental age on their offspring. In rotifers, clones from older mothers had shorter life spans (Lansing, 1947, 1948). A recent study in drosophila (Hercus and Hoffmann, 2000) showed that females from old mothers and grandmothers showed the lowest viability. The effect of maternal age was also analysed in humans according to the mitochondrial theory of aging. Mitochondrial DNA is assumed to be the major target of oxidative damage and may therefore be responsible for the age-related accumulation of genetic load (Wallace, 1994). Evidence for this theory was found by Gavrilov *et al*. (1996). Daughters of older mothers had a reduced lifespan, while sons did not seem to be affected. The latter might have been caused by a higher pre- or postnatal mortality, though.
However, so far little attention was paid to the maternal age effect on the performance of offspring in livestock. Hence the objective of this study was to investigate the effect of maternal age on production and functional traits of dual-purpose Simmental cows.

MATERIAL AND METHODS

Data of Austrian dual-purpose Simmental cows and their daughters were used. Apart from the usual data checks, the total data set was restricted to dams older than two and younger than 16 years. To avoid a possible bias by dams with short longevity, analysis was additionally carried out for a restricted data set for dams living for at least 10 years. The effect of age of dam at birth on the performance of her daughter was analysed for functional longevity, fertility (non-return-rate), somatic cell score (SCS) and energy corrected milk (ECM) yield. The following age classes for dams were set up: 2 years <= age < 4 years (1), 4 years <= age < 6 years (2), 6 years <= age < 8 years (3), 8 years <= age < 10 years (4), 10 years <= age < 12 years (5), and 12 years <= age < 16 years (6).

Calculations for ECM yield, SCS, and fertility were carried out using the GLM procedure of SAS (Statistical Analysis Systems Institute, 1988). The following statistical models were used for testing the effect of age of dam on performance of her daughter:

ECM yield. $Y_{ijklmn} = \mu + (\alpha_i\beta_j\gamma_k\delta_l) + \lambda_m + \varepsilon_{ijklmn}$ where Y_{ijklmn} = individual observation (kg ECM yield), μ = overall mean, $\alpha_i\beta_j\gamma_k\delta_l$ = interaction effect of region i, herd class j, year k and season l, λ_m = fixed effect of age class m, and ε_{ijklmn} = random residual.

Somatic cell score. $Y_{ijklmno} = \mu + (\alpha\beta)_{ij} + \gamma_k + \delta_l + \lambda_m + \pi_n + \varepsilon_{ijklmno}$ where $Y_{ijklmno}$ = individual observation (SCS), μ = overall mean, $(\alpha\beta)_{ij}$ = interaction effect of herd i and year j, γ_k = fixed effect of month of calving k, δ_l = fixed effect of age at calving l, λ_m = effect of number of samples m, π_n = fixed effect of age class n, and $\varepsilon_{ijklmno}$ = random residual.

Fertility. $Y_{ijklmno} = \mu + (\alpha\beta)_{ij} + \gamma_k + (\delta\lambda)_{lm} + \pi_n + \varepsilon_{ijklmno}$ where $Y_{ijklmno}$ = individual observation (non-return-rate), μ = the overall mean, $(\alpha\beta)_{ij}$ = interaction effect of herd i and year j, γ_k = fixed effect of the k^{th} month of service, $(\delta\lambda)_{lm}$ = interaction effect of number of lactation l and service period or age at first service m, respectively, π_n = fixed effect of age class n, and $\varepsilon_{ijklmno}$ = the random residual.

To account for additive genetic effects, the ECM, SCS and fertility data sets were also analysed using the computer program PEST (Groeneveld, 1990). The same models, including the random animal effect were used. However, hypothesis tests were only carried out with SAS.

Table 1. Number of daughter records, means and standard deviations for both datasets (total and restricted to dams living for at least 10 years)

	Total data set		Restricted data set	
Trait	N	$\bar{x} \pm s$	N	$\bar{x} \pm s$
ECM (1^{st} lactation, kg)	118,847	4,702±1153	38,647	4591±1108
ECM (2^{nd} lactation, kg)	86,370	5342±1314	30,126	5273±1285
ECM (3^{rd} lactation, kg)	63,312	5,520±1329	23,302	5490±1317
SCS (1^{st} lactation)	15,948	1.64±1.01	4,112	1.64±1.10
SCS (2^{nd} lactation)	13,359	2.07±1.19	4,063	2.04±1.18
SCS (3^{rd} lactation)	11,068	2.35±1.25	3,884	2.32±1.22
Non-Return-Rate (%)	88,026	65.4±47.6	28,538	65.3±47.9
Funct. Longevity (Hazard rate)	-	-	167,878	1^A

^{A} no standard deviation available

The computer program SURVIVAL KIT (Ducrocq and Sölkner, 1999) was used for analysis and hypothesis test of the functional longevity data set. The following model was applied:

Functional Longevity. $h(t, z) = h_0(t) * \exp[(\alpha\beta\gamma)_{ijk} + (\beta\gamma\delta)_{jkl} + \zeta_m + \lambda_n + \pi_o + \sigma_p + \tau_q + \varpi_r]$ where h(t, z) = the hazard of a cow t days after her first calving, $h_0(t)$ = the Weibull baseline hazard function, $(\alpha\beta\gamma)_{ijk}$ = interaction effect of region i, year j and season k, $(\beta\gamma\delta)_{jkl}$ = interaction effect of year j, season k and herd l, ζ_m = fixed effect of age at first calving m, λ_n = time-dependent fixed effect of stage of lactation in lactation n, π_o = time-dependent fixed effect of milk yield o, σ_p = time-dependent fixed effect of fat and protein % p, τ_q = time-dependent fixed effect of herd size q and ϖ_r = fixed effect of age class r.

Only the restricted data set was investigated on basis of a sire-maternal grandsire model. Number of total daughter records per trait, means and standard deviations (results from PEST and SURVIVAL KIT, respectively) are shown in Table 1.

RESULTS AND DISCUSSION

Table 2. Deviations from age class 1 for all traits and both data sets (Total and restricted)

Traits	Age classes				
Total data set	2	3	4	5	6
ECM (1st lactation, kg)	-30	-56	-83	-113	-144
ECM (2nd lactation, kg)	-35	-57	-89	-104	-170
ECM (3rd lactation, kg)	-31	-73	-90	-111	-148
SCS (1st lactation)	+0.01	±0	+0.05	-0.08	-0.02
SCS (2nd lactation)	-0.01	-0.03	-0.08	-0.13	-0.16
SCS (3rd lactation)	+0.01	-0.02	-0.08	-0.05	+0.08
Non-Return-Rate (%)	-0.5	±0.0	+0.7	-0.4	+1.2
Restricted data set					
ECM (1st lactation, kg)	-35	-81	-118	-152	-188
ECM (2nd lactation, kg)	-27	-83	-122	-144	-212
ECM (3rd lactation, kg)	-1	-71	-106	-136	-178
SCS (1st lactation)	+0.03	+0.05	+0.07	±0	+0.09
SCS (2nd lactation)	-0.09	-0.02	-0.10	-0.04	-0.19
SCS (3rd lactation)	+0.02	+0.07	+0.02	+0.03	+0.14
Non-Return-Rate (%)	-2.1	-1.1	-0.2	-1.4	-0.2
Funct. Longevity (Hazard rate)	+0.02	+0.03	+0.04	+0.03	-0.08

The deviations from age class 1 for age classes 2-6, all traits and both data sets are shown in Table 2 (Results from PEST and SURVIVAL KIT). Generally, means for age classes were similar with or without genetic effect in the model. In both data sets the ECM milk yield of daughters decreased with age of dam. The effect of age of dam was significant with $P<0.001$ for all lactations and both data sets. This is in accordance with the work of Alakhverdov and Maslennikov (1973) who observed the highest milk yield of daughters resulting from 1st and 2nd calvings in Russian Simmental. In another Russian study (Polyakov, 1979), parity of dams did not affect the milk yield of their daughters. The results for SCS were inconsistent. For the total data set, the age of dam was significant in the first lactation ($P<0.01$). In the second lactation, a trend of decreasing SCS with increasing age of dam could be observed ($P=0.052$). However, the effect of age of dam was not significant in the third lactation and for all lactations of the reduced data set. The same was found for the non-return-rate. The age of dam had a significant effect on the hazard rate of their daughters ($P<0.001$). The result for functional longevity was surprising, though. Following the studies in rotifers and Drosophila (Lansing, 1947, 1948; Hercus and Hoffmann, 2000) the hazard rate slightly increased for the first four age classes of dams. However, the risk of being culled was lowest for daughters of oldest dams. A reason for that could be that the genetic effect still interferes with the results, especially, since the model is not an animal model but a sire-maternal grandsire model.

CONCLUSION

From the results of studies in other species, an effect of maternal age on functional traits of their daughters could be expected. Hence it was rather surprising that an effect on a dairy trait (ECM yield) was found whilst functional traits seemed to be more or less unaffected by maternal age. However, even though the additive genetic effect was included in the model, the result for ECM might still be biased by the fact that younger mothers were genetically superior for this trait. If the genetic effect did not exist, the restricted data set should have avoided this problem, though. For functional longevity the sire-maternal grandsire model could be sub-optimal. Additionally, paternal age might have influenced the performance of offspring. Because of the use of artificial insemination it is not possible to record the age of sire at conception. The semen straw might have been produced long before the actual insemination. Check of the joint effects of paternal and maternal age based on a data set including only cows sired by natural service bulls is planned.

REFERENCES

Alakhverdov, A.S. and Maslennikov, V.N. (1973) *Nauchnye-Trudy, Voronezhskii Selskokhozyaistvennyi Institut* **8** : 3, 120-125.

Ducrocq, V. and Sölkner, J. (1999) Survival Kit, Version 3.12.

Finch, C.E. (1990) Longevity, Senescence, and the Genome. Univ. Chicago Pr.: 449pp.

Gavrilov, L.A., Gavrilova, N.S., Semenova, V.G., Evdokushkina, G.N., Krut'ko, V.N., Gavrilova, A..L., Evdokushkina, N.N. and Lapshin, E.V. (1997) *Doklady Biol. Sci*: **354** : 287-289.

Groeneveld, E. (1990) PEST User's Manual.

Hercus, M.J. and Hoffmann, A.A. (2000) *Proc. R. Soc. Lond. B* **267** : 2105-2110.

Lansing, A..I. (1947) *J. Gerontol*. **2** : 228-239.

Lansing, A..I. (1948) *Proc. Natl. Acad. Sci. USA* **34** : 304-310.

Miesenberger, J., Sölkner, J. and Essl, A.. (1998) *Interbull Bull*. **18** : 78-84.

Polyakov, P.E. (1979) Puti intensifik. kormoprva i zhivotnovod. v tsentr. r-ne nechernozemn. zony: 38-42.

Richter, C., Park, J.W. and Ames, B.N. (1988) *Proc. Natl. Acad. Sci. USA* **90** : 7255-7259.

SAS Institute Inc. (1988) Sas/Stat^{TM} User`s Guide, 6.03 Ed., SAS Inst. Inc., Cary, NC.

Wallace, D.C. (1994) *Proc. Natl. Acad. Sci. USA* **91** : 8739-8746.