Inbreeding of Polish Holstein-Friesian cattle and its impact on production traits

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Introduction

Modern livestock breeding programs feature accurate breeding value estimation and advanced reproductive technology. Such programs lead to rapid genetic progress, but they also lead to the accumulation of inbreeding via heavy impact of a few selected individuals or families. Routinely performed analysis show positive trends of inbreeding in all investigated dairy cattle populations all over the world. Besides the current level of inbreeding, the growth rate of inbreeding is even more important. It must be underlined that inbreeding growth rates have significantly accelerated in the past two decades and reached an alarming level. Economic losses due to inbreeding depression in production, fertility and health are actually of a serious concern.

The lack of the analysis considering the inbreeding problems of the whole Polish Holstein-Friesian population was a motivation to study the current level of inbreeding and its effect on production in national dairy breed.

Aim

The purpose of this study was to evaluate the level and rate of inbreeding in Polish Holstein-Friesian population and estimate the inbreeding effect on protein and fat yield in first three parities. The amount of pedigree information was considered with special emphasis.

Materials and methods

Pedigree of over 5.5 million cows of Polish Holstein-Friesian breed born in years 1960-2006 was traced back using national pedigree database and information from Canadian, US and Interbull pedigree files. Additionally the alternative numbers stored in national and Interbull database were used.

Inbreeding coefficients were computed using the method of VanRaden (1992), which accounts for missing pedigree information.

The effects of inbreeding on milk, fat and protein yield was examined using first three lactations daily yields recorded between 1995 and 2006. The 5 407 077 observations belonged to over 684 thousands cows with pedigrees >70% complete. The test day model included inbreeding percentage as a covariate.

The model used in this study was the multiple-lactation generalization of the model presented by Strabel et al. (2005).

The model equation was :

$$Y_{ijklmo} = htd_{io} + f_o x_{mo} + \sum_{n=1}^{6} b_{jno} z_{mnlo} + \sum_{n=1}^{4} c_{kno} z_{mnlo} + \sum_{n=1}^{4} a_{mno} z_{mnlo} + \sum_{n=1}^{4} p_{mno} z_{mnlo} + e_{ijklmo}$$

where y_{ijklm} is milk, fat, or protein yield *l* of cow *m* from lactation *o* within herd-test-day effect *i*, belonging to the herd-year of calving *k* and *j*th class of age-season of calving; HTD_i is a random herd-test-day effect; f_o are fixed regression coefficients on inbreeding, b_{jno} are fixed regression coefficients specific to age-season subclass j; c_{kno} are fixed regression coefficients specific to the herd-year *k; a_{mno}* are genetic random regression coefficients specific to animal (AG) m; p_{mno} are random regression coefficients for the permanent environmental (PE) effect; e_{ijklmo} is the residual effect for each observation; x_{mo} is inbreeding of cow o; and z_{mnlo} are covariates. Fixed lactation curves for age-seasons were modeled using Legendre polynomials of order 5 (6 covariates). The same function with 4 parameters was used for all remaining regressions.

The covariance structure of the model was:

$$v\begin{bmatrix} q \\ a \\ p \\ e \end{bmatrix} = \begin{bmatrix} \mathbf{I}\otimes\mathbf{H_0} & \mathbf{0} & \mathbf{0} & \mathbf{0} \\ \mathbf{0} & \mathbf{A}\otimes\mathbf{G_0} & \mathbf{0} & \mathbf{0} \\ \mathbf{0} & \mathbf{0} & \mathbf{I}\otimes\mathbf{P_0} & \mathbf{0} \\ \mathbf{0} & \mathbf{0} & \mathbf{0} & \mathbf{I}\otimes\mathbf{R_0} \end{bmatrix}$$

where **A** is the additive genetic relationship matrix; $\mathbf{H_0}$ and $\mathbf{R_0}$ are diagonal matrices of order 3 × 3, with herd-test-date and residual variances for 3 lactations, respectively; and $\mathbf{P_0}$ and $\mathbf{G_0}$ are covariance matrices for PE and AG random regression coefficients, respectively, each of order 12 × 12.

Results

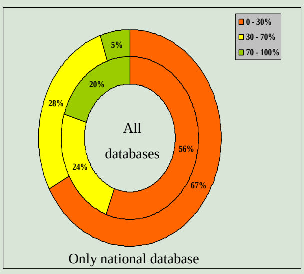

Figure 1. Share of bulls according to pedigree completeness based on national database (outer ring) and after inclusion of foreign sources of pedigree information (inner ring).

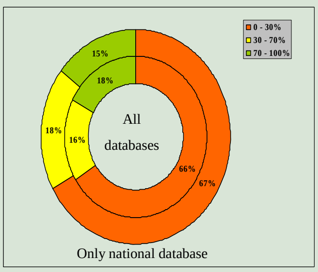

Figure 2. Share of cows according to pedigree completeness based on national database (outer ring) and after inclusion of foreign sources of pedigree information (inner ring).

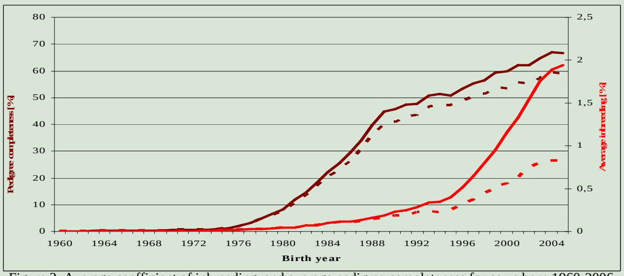

Figure 3. Average coefficient of inbreeding, and average pedigree completeness for cows born 1960-2006. The dashed lines show values calculated based on national database only, solid lines based on all databases.

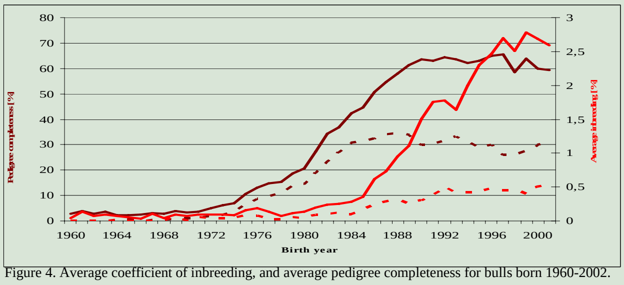

Figure 4. Average coefficient of inbreeding, and average pedigree completeness for bulls born 1960-2002. The dashed line show values calculated based on national database only, solid line based on all databases.

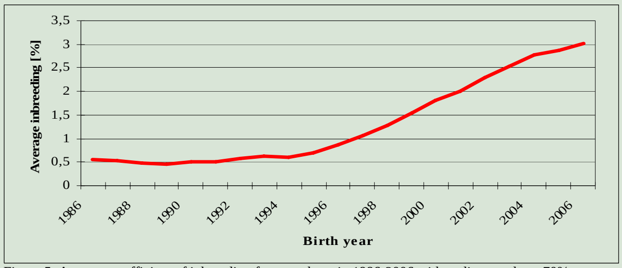

Figure 5. Average coefficient of inbreeding for cows born in 1986-2006 with pedigree at least 70% complete

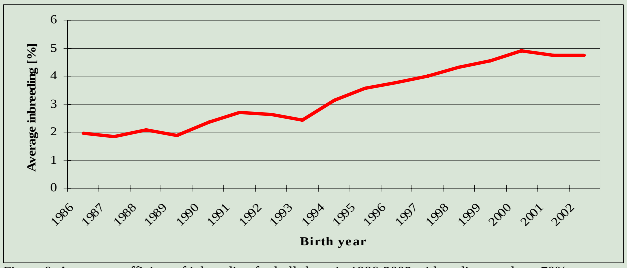

Figure 6. Average coefficient of inbreeding for bulls born in 1986-2002 with pedigree at least 70% complete

Table 1. Inbreeding depression on lactation milk, protein and fat yield per 1% increase in inbreeding

Lactation	Milk yield	Protein yield	Fat yield
1	15.6	0.48	0.65
2	18.0	0.59	0.79
3	22.8	0.69	0.96

Conclusions

1. Pedigree information stored in national database should be extended with foreign pedigrees when calculating inbreeding.
2. The level of inbreeding of Polish Holstein-Friesian cows is lower than in other Holstein populations and for animals born in 2006 with pedigree completeness of minimum 70% is equal 3%.
3. The trend of inbreeding is similar to that observed in foreign populations - has accelerated in past two decades and reached 0.14% per year.
3. The relatively low level of homozigosity has already shown negative effect on milk, fat and protein yield which increases with parity number.

References

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3. VanRaden P.M. (1992) J. Dairy Sci. 75: 3136-3144