Relationship Between Fertility and Functional Longevity in Polish HF Cows

M. Morek-Kopec[*], W. Jagusiak[*] and A. Zarnecki[†]

Introduction

Functional longevity, reflecting the ability of a cow to avoid involuntary culling, is a complex trait that depends on a number of factors, among them reproductive performance. In the Polish HF population, fertility and reproductive problems are responsible for 30 percent of all registered culling reasons, and they show an increasing trend (Morek-Kopec and Zarnecki 2009). Declining fertility of Holstein cows is also observed in other populations (Van Raden 2006). Both longevity and fertility traits are important components of selection indices (Miglior *et al.* 2005). Knowledge of the relationship between fertility and longevity could be helpful in establishing the relative weights of these traits in a total merit index.

In this study survival analysis (Ducrocq and Sölkner 1998) was applied to evaluate the contribution of female fertility traits to the functional longevity of Polish Holstein cows.

Material and methods

Data. Test-day and lactational production, culling and fertility data were extracted from the Polish National Recording System, SYMLEK (provided by the Polish Federation of Cattle Breeders and Dairy Farmers). Length of productive life (LPL) was measured by the number of days from first calving to culling (uncensored records) or last test day (censored data). Functional longevity (FLPL) was defined following Ducrocq (1988) as LPL corrected for within-herd-year-season phenotypic production of a cow. Four female fertility traits were examined. Two binary traits used to measure the ability to conceive were non-return rate at 56 days for heifers (NRh), and non-return rate at 56 days for cows (NRc). Two interval fertility measures for first parity cows were days from calving to first insemination (CTFI), representing a cow's ability to recycle, and days open (DO) as combined trait. Cows included in the analyses were required to have longevity information and non-missing data for at least one of the fertility traits. After editing, records were available for 1,171,353 cows from 16,987 herds, which calved for the first time between 1995 and 2009. Characteristics of longevity data are presented in Table 1. Classes of fertility traits are shown in Table 2.

[*] University of Agriculture in Cracow, Mickiewicza 24/28, 30-059 Cracow, Poland
[†] National Research Institute of Animal Production, Balice, 32-083 Cracow, Poland

Table 1: Characteristics of productive life data

	Number of cows (%)	Length of productive life (days)		
		Mean	Min	Max
Uncensored records	540954 (46.2%)	1115	1	4897
Right censored records	630399 (53.8%)	985	1	5061
Total	1171353 (100%)			

Table 2: Classes of fertility traits

Class	NRh		NRc		Class (days)	CTFI		DO	
	N	%	N	%		N	%	N	%
missing	259096	22,1	309504	26,4	missing	570341	48,7	642616	54,9
0=no	221947	18,9	314370	26,8	1: ≤ 30	6067	0,5	1761	0,2
1=yes*	690310	58,9	547479	46,7	2: 31 to 60	137148	11,7	56682	4,8
					3: 61 to 90	206360	17,6	118475	10,1
					4: 91 to 120	118316	10,1	100122	8,5
					5: 121 to 150	56532	4,8	72009	6,1
					6: >150	76589	6,5	179688	15,3
ALL	1171353	100,0	1171353	100,0	ALL	1171353	100,0	1171353	100,0

** yes = cow did not return to oestrus at 56 day after insemination*

Statistical Model. Following Weibull proportional hazard model was used:

$$h(t) = h_0(t)\exp\left[hys(t) + age + ys(t) + ls(t) + hsize(t) + fat(t) + prot(t) + \right.$$
$$\left. + NRh + NRc + CTFI + DO\right]$$

where: t is time from first calving to culling or censoring, $h(t)$ is the hazard function for a cow at time t, $h_0(t)$ is the Weibull baseline hazard function with scale parameter λ and shape parameter ρ. The random effect included was hys – time-dependent effect of herd-year-season, assumed to be independently distributed, following a log–gamma distribution. Fixed effects included in the model were age – time-independent effect of age at first calving with 22 classes including the age<20 months class, 20 one-month classes of age between 20 and 40 months, and age≥ 40 months as 22nd class; ys – time-dependent fixed effect of year-season (years from 1995 to 2009; 2 seasons, April – September and October – March); ls – time-dependent combined effect of lactation number from 1 to 6 (lactations 6 and later were pooled) and 4 stages of lactation designated by 30, 180 and 305 day of each lactation; and $hsize$ – time-dependent effect of yearly herd size variation with classes reflecting relative change of herd size from the current year to the next year (< -50%, -50% to -30%, -30% to -10%, -10% to 10%, 10% to 30%, 30% to 50% and > 50% change). fat and $prot$ are time-dependent fixed effects of classes of 305-day fat and protein production levels relative to herd mean. Classes, defined separately for first and later lactations, were class 1 – production more than 50% below herd mean; 10 classes of production falling within the ranges set by border points at -50%, -40%, -30%, -20%, -10%, 0%, 10%, 20%, 30%, 40%, 50% of herd mean; and class 12 representing production more than 50% above herd mean. NRh, NRc, $CTFI$, and DO are time independent fixed effects of fertility traits.

Estimation. Computations were carried out using The Survival Kit version 3.12 (Ducrocq and Solkner 1998). Weibull distribution shape parameter ρ was assumed to be 2.0. Random HYS effect was algebraically integrated out, and the γ parameter of the HYS distribution was estimated jointly with other effects. The significance of each effect was determined based on the likelihood ratio test. The influence of different fertility traits on longevity was analyzed by comparing their contribution to the log-likelihood function. Solutions for fixed class effects, including fertility traits, were expressed as relative risks of culling (RRC).

Results and discussion

All fertility traits showed a highly significant ($P < 0.001$) association with functional longevity. As presented in Figure 1, the highest impact on longevity was found for non-return rate for cows. A lower but still high effect was shown by days open. Much smaller contributions to the likelihood function came from the other two traits: days from calving to first insemination and non-return rate for heifers.

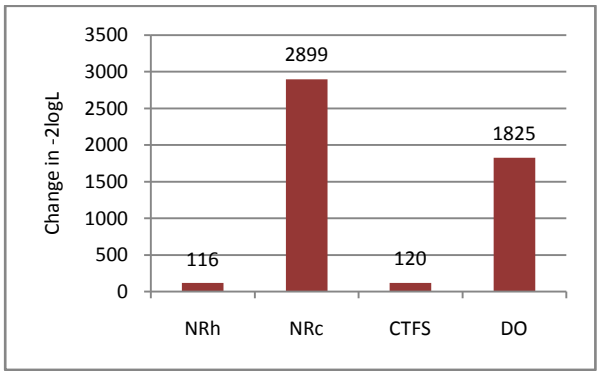

Figure 1: Contribution of fertility effects to -2logLikelihood function

Figure 2 presents the relative risks of culling related to the classes of all fertility traits studied. Both non-return traits showed similar characteristics, manifested in increased risk of culling of cows returning to service within 56 days after first insemination. The increase was small, amounting to 4% for NRh and only 1% for NRc, but still displayed a positive relationship between ability to conceive and longevity. A longer interval from calving to first insemination had a negative influence on longevity. Cows classified in a CTFI interval of less than 30 days had the lowest risk of culling, which increased by 9% for cows with an interval of 90 days or longer. RRCs associated with DO were characterized by small variation, except for DO below 30 days which showed 6% lower risk of culling. The "missing" class includes cows too young to have NRc, CTFI and DO recorded, or which were culled early in life. Consequently, the missing class for NRc is characterized by high RRC.

The results presented here are consistent with findings from Sewalem *et al.* (2008), who for Canadian Holstein reported an increased risk of culling associated with longer CTFI, longer DO, and increasing number of services per conception.

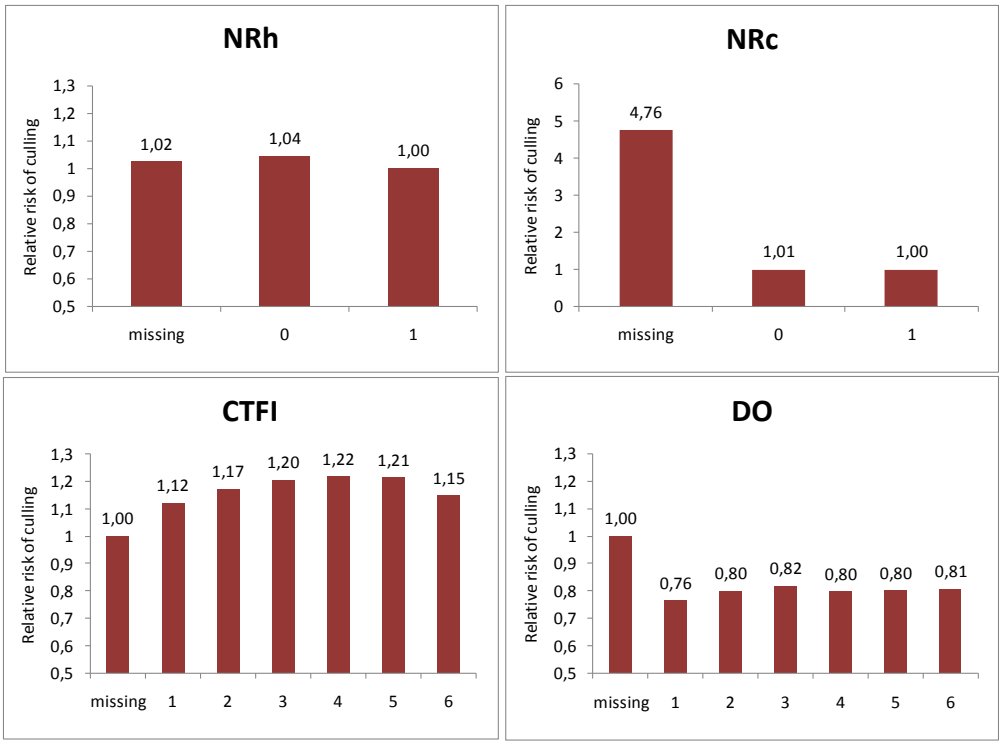

Figure 2: Relative risk of culling by classes of fertility traits

Conclusion

This study showed significant impacts of all analyzed fertility traits on the functional survival of Polish Holstein cows but the differences between RRCs were small. A lower risk of culling, which could result in longer length of productive life, was found for heifers and cows not returning to oestrus at 56 days after first insemination, and cows with a shorter interval of calving to first insemination. RRCs were similar for all lengths of DO, except that the risk was lower for extremely short open period.

References

Ducrocq, V., Quaas R. L., Pollak E. J. *et al*. (1988). *J. Dairy Sci*. 71:3061.
Ducrocq, V. and Solkner J. (1998). *Proc. 6th WCCGALP* 27:447–448.
Miglior, F., Muir B. L., and Van Doormaal B. J. (2005). *J. Dairy Sci*. 88:1255–1263.
Morek-Kopec M. and Zarnecki A. (2009). *Roczn. PTZ* t.5 No 3:9-17.
Sewalem, A., Miglior, F., Kistemaker G. J. *et al.* (2008). *J. Dairy Sci.* 91:1660-1668.
Van Raden, P.M. (2006). *Interbull Annual Meeting Proceedings. Interbull Bull.* 34:53-56.

Acknowledgment. This research was supported by the Ministry of Science and Higher Education, grant No. N311 046 32/2756.