

GENETIC TREND OF LENGTH OF PRODUCTIVE LIFE IN HOLSTEIN AND SLOVAK SIMMENTAL CATTLE IN SLOVAKIA

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To link to this article: <https://doi.org/10.11118/actaun201967051227>

Received: 8. 8. 2019, Accepted: 24. 9. 2019

To cite this article: STRAPÁKOVÁ EVA, STRAPÁK PETER, CANDRÁK JURAJ. 2019. Genetic Trend of Length of Productive Life in Holstein and Slovak Simmental Cattle in Slovakia. *Acta Universitatis Agriculturae et Silviculturae Mendelianae Brunensis*, 67(5): 1227–1234.

Abstract

National genetic evaluation of length of productive life in Slovakia was carry out from the year 2014 till 2018, three times per year (March, June and October). The survival analysis was performed using Weibull sire model. The heritability obtained from Weibull model was different between populations (0.13 in Holstein and 0.05 in Slovak Simmental, respectively). RBVs of Holstein sires born up to 1999 shows decreasing tendency in all five years. A desirable tendency started from the year 2000. Differences between RBV in particular years are due to descent censored records during the evaluated period. Similar trends showed in Slovak Simmental bulls RBVs. Culled cows reached average 305-day milk yield 6499 kg and 4645 kg in Holstein and Slovak Simmental breeds, respectively. The length of productive life there was 898 days in Holstein and 985 days in Slovak Simmental cows. Age at first calving reached 930 days in Slovak Simmental and 851 days in Holstein heifers. The progress of both traits in the years 2014–2018 was lower in Holstein population, +288 kg milk and +76 productive days than in Slovak Simmental cows.

Keywords: length of productive life, cattle, genetic trends, milk yield

INTRODUCTION

In last years longevity has a important place in genetic evaluation of cattle because affects overall profitability. Breeding values of functional longevity in Holstein and Slovak Simmental breeds are computed for five years. Functional longevity features the capability of cows to delay involuntary culling for infertility or diseases (Ducrocq, 1994; Zavadilová and Štípková, 2012). Longevity is determined also decisions of individual farmers to eliminate cows for low milk production (voluntary culling) (Sewalem *et al.*, 2008).

The length of the productive life (LPL) of the cow determinates of its lifetime yield. Animals culled too early do not reach peak production, which occurs at

3–5 lactations (Juszczak *et al.*, 2003; Dorynek *et al.*, 2005; Canji *et al.*, 2008; Gnyp, 2014; Kvapilík *et al.*, 2016; Najafabadi *et al.*, 2016; Stanojević *et al.*, 2016).

In the past, a decline in many functional traits has been observed (Lucy, 2001), Mészáros *et al.* (2008). The modern dairy cow has a short longevity, although their biological potential is much greater. The negativ genetic trend of longevity can be due to negative response on functional traits (fertility, udder health traits) resulting from intense selection on production. Naturally, both very high and very low-yielding cows are culling earlier than the cows with average milk yield (Imbayarwo-Chikosi *et al.*, 2016).

A milk yield of cows on second parity is approximately 16 to 19% more than a yield of

cows on first parity. A third lactation cow yields approximately 28 to 31% more than a first lactation cow (Walsh *et al.*, 2007). Therefore, good longevity does not only reduce herd replacement cost but supports increase revenue through higher average milk production (due to a higher proportion of older cows) and greater calf price of surplus calves from older cows. In addition, multiparous cows also have increased milk flow, easier calvings and fewer stillbirths (McHugh *et al.*, 2010).

The last twenty years, there has been a stabilization or even increase in genetic trends of functional traits. Strapáková *et al.* (2014), Egger-Danner *et al.* (2015) stated increasing trend of the functional productive life in Holstein population, Morek-Kopeć (2017) in Polish Simmental cattle. An overall increase in genetic trends was observed in Holstein cows in Isfahan province Najafabadi *et al.* (2016), on the contrary, Imbayarwo-Chikosi *et al.* (2017) stated decrease in functional longevity in the South African Holstein cattle.

The aim of this study was to evaluate genetic trends of length of productive life in Slovak Simmental and Holstein dairy cows and found phenotypic progress of milk production and true longevity of culled cows in the period 2014–2018.

MATERIALS AND METHODS

Data

National genetic evaluation in Slovakia was carry out from the year 2014 till 2018, three times

per year (March, June and October). The data was provided by the Slovak Breeding Services. There was included information about the length of productive life and milk yield of Holstein and Slovak Simmental cows with the first calving between the years 1996–2015. Only cows with age at first calving between 600 and 1200 days were filed into the evaluation. Length of productive life (LPL) was measured as the number of days from the first calving to culling (uncensored records) or last test day (censored data). The cows with unknown culling day, with less than 1700 kg milk production, with more than 6 lactation, and cows sold for other purpose or remove from a milk recording system were considered as censored. Censored data in Holstein breed were 19.3% in March 2014, so then gradually fall to 7.7% in October 2018. Similar tendency was observed in Slovak Simmental Breed, from 32.6% to 16.9% in the last season. Number of cows and their sires is referred to Tab. I.

Estimate of Breeding Values of Longevity

The analysis was performed using Weibull sire model:

$$\Lambda(t) = \Lambda_0(t) \exp(p + m + h + a + \text{hys} + s), \quad (1)$$

where: $\Lambda(t)$ – hazard function of a cow t days after calving; $\Lambda_0(t)$ – Weibull hazard function; p – fixed time dependent effect of the parity (6 classes); m – fixed time-dependent effect of milk yield classes expressed as a standard deviation (SD) from within-herd-year average: (1) +1 SD from herd-

I: The structure of the data sets used for genetic evaluation of longevity in Holstein and Slovak Simmental breeds

Year	Season (month)	Holstein				Slovak Simmental			
		Number of cows	Number of culled cows	Number of sires	Censored data (%)	Number of cows	Number of culled cows	Number of sires	Censored data (%)
2014	3	524960	447566	4779	19.3	155990	123295	1952	32.6
2014	6	528449	459303	4790	18.1	157372	125404	1961	32.3
2014	9	528720	467683	4795	16.8	158229	128042	1960	31.0
2015	3	528359	474658	4799	15.3	158436	130757	1967	29.4
2015	6	527968	480882	4802	14.1	158185	133452	1962	27.6
2015	9	527686	485200	4799	13.3	158055	134857	1961	26.7
2016	3	527137	491587	4797	12.2	157761	137600	1585	25.0
2016	6	526720	497048	4797	11.1	157521	139957	1958	23.5
2016	9	526347	500985	4796	10.4	157324	141867	1955	22.4
2017	3	526099	504830	4798	9.7	157163	143418	1957	21.3
2017	6	525894	507253	4797	9.2	157015	144887	1964	20.4
2017	9	525735	509605	4794	8.7	156846	146123	1963	19.6
2018	3	525556	511760	4795	8.3	156657	147432	1962	20.1
2018	6	525444	513022	4794	8.0	156553	148285	1961	18.1
2018	9	529438	518459	4856	7.7	158793	151687	1961	16.9

year average, (2) -1 SD from herd-year average, (3) more than +1 SD, (4) less than -1 SD, (5) non-standard or uncompleted lactations; h – time-dependent effect of annual change in herd size with 5 classes: (1) decrease > 30%, (2) decrease of 0–30%, (3) unchanged state, (4) increase of 0–30%, (5) increase > 30%; a – fixed time-independent effect of age at first calving with 5 age classes: (1) 600–690 days, (2) 691–780 days, (3) 781–870 days, (4) 871–960 days, (5) 961–1200 days; hys – random time-dependent effect of the herd \times year \times season interaction, following a normal distribution with change points at April 1st and October 1st of each year; s – random time-independent effect of the sire assuming to follow a multinormal distribution.

Genetic parameters obtained from the Weibull model were estimated from the dataset of sires which had minimum 10 daughters in the analysis and subsequently were used to estimate of the breeding values of sires.

Heritability on the original scale was calculated by Back and Lidauer (2007):

$$h^2 = 4\sigma_s^2 / [\sigma_s^2 + \sigma_{hys}^2 + (1/p)], \quad (2)$$

where: σ_s^2 – sire variance; σ_{hys}^2 – herd-year-season variance; p – proportion of culled cows.

The formula for relative breeding value (RBV) expression:

$$RBV = [(eval - a)/sd] \times 12 + 100, \quad (3)$$

where: RBV – sire's relative breeding value; eval – sire's breeding value; a – mean of the base adjustment; sd – standard deviation of the base.

Reliability of the breeding value estimation was calculated by Ducrocq (2005) as:

$$R = Nh^2 / [(N - 1)h^2 + 4], \quad (4)$$

where: N – number of all daughter; h^2 – heritability.

Genetic trends of RBV by birth year of sire were calculated as moving average of 4 previous years and the dataset included only sires with more than 30% reliability of RBV.

Phenotypic Trends

True length of productive life and 305-d milk yield were computed from the dataset of both Holstein and Slovak Simmental culled cows.

SAS 9.3 was used for the preparation of the data and calculation of the basic statistical parameters (SAS, 2008). The estimate of breeding values of the length of productive life was carried out by Survival Kit v6.1 (2012).

RESULTS

Genetic Parameters

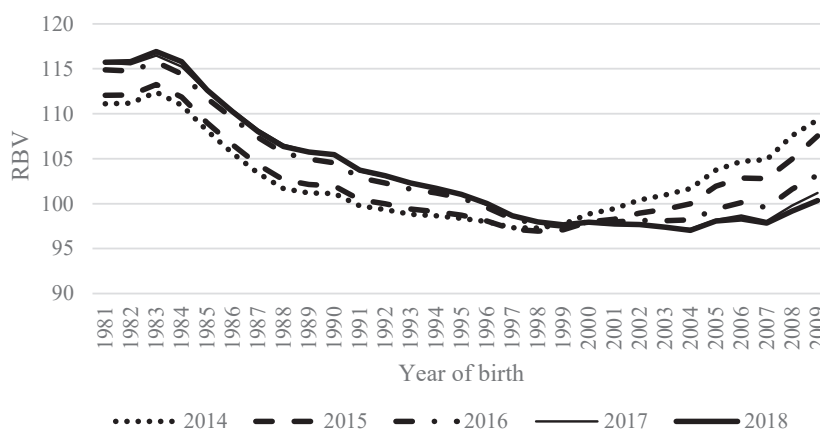
The estimates of sire and herd-year-season (HYS) variances and heritabilities are presented in Tab. II. The sire variances obtained in this study ranged from 0.02 to 0.05 across the 2 breeds. HYS variance was similar for both breeds (0.3 and 0.38). The heritability achieved considerable difference between breeds (0.13 and 0.05 in Holstein and Slovak Simmental populations, respectively).

The comparison of genetic trends RBV of LPL between breeds in various years is shows in Figs. 1, 2. RBV for functional longevity of Holstein sires born in period 1981 to 1999 shows decreasing tendency in all five years. Countertendency started from the year 2000. Average RBVs for older sires achieved higher values in the 2018 than 2014 year, vice versa, the young bulls born in the year 2009 reached the highest RBV in the year 2014. Differences between RBV are due to descending censored records during the evaluated years. Estimates of

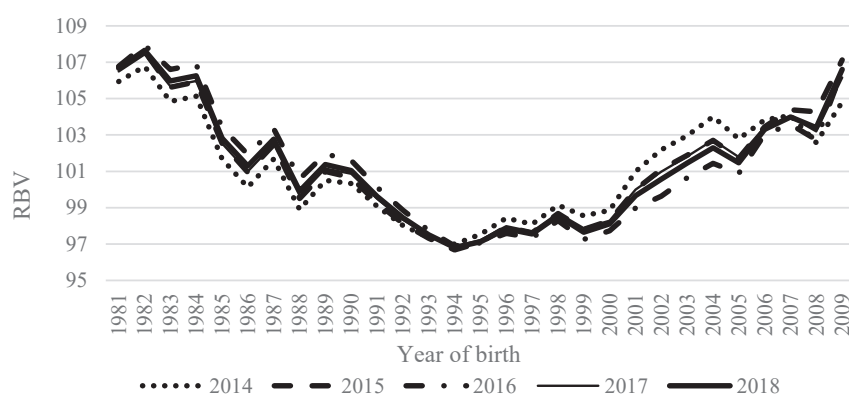
II: Genetic parameters of longevity in Holstein and Slovak Simmental breeds

Genetic parameter	Holstein	Slovak Simmental
Sire variance	0.05	0.02
HYS variance	0.3	0.38
Heritability	0.13	0.05

HYS variance – herd-year-season variance



1: Genetic trends of the length of productive life in Holstein bulls by years of evaluation



2: Genetic trends of the length of productive life in Simmental bulls by years of evaluation

III: Average milk yield and LPL of culled Holstein and Slovak Simmental cows

	Holstein			Slovak Simmental		
	\bar{x}	s.d.	Variance	\bar{x}	s.d.	Variance
305-day milk yield (kg)	6499	96.15	9244.4	4645	115.77	13402.5
LPL (days)	898	21.78	474.6	985	36.42	1327
Age at first calving (days)	851	0.26	0.07	930	0.59	0.35

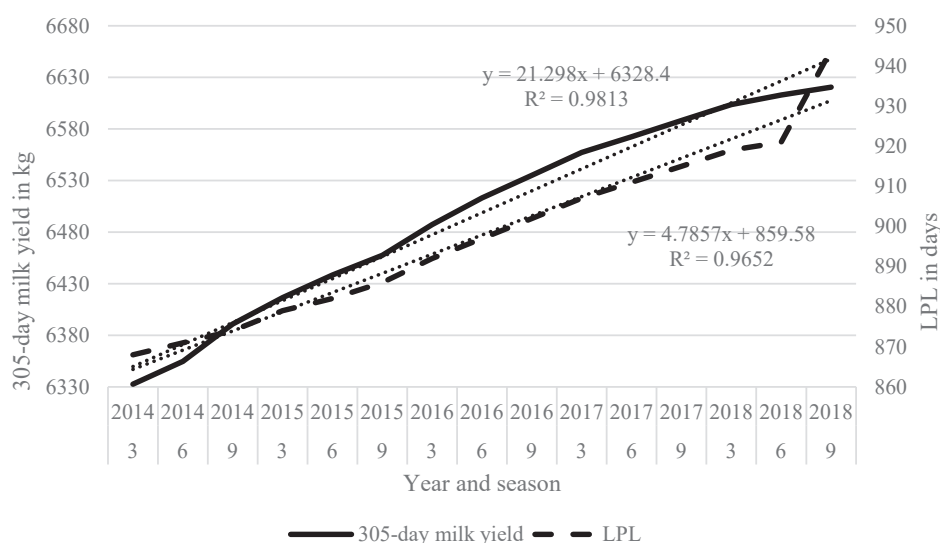
LPL – length of productive life

reliability increased with the number of uncensored daughters per sire, this implies that the most reliable are RPH estimated in the year 2018 (Fig. 1).

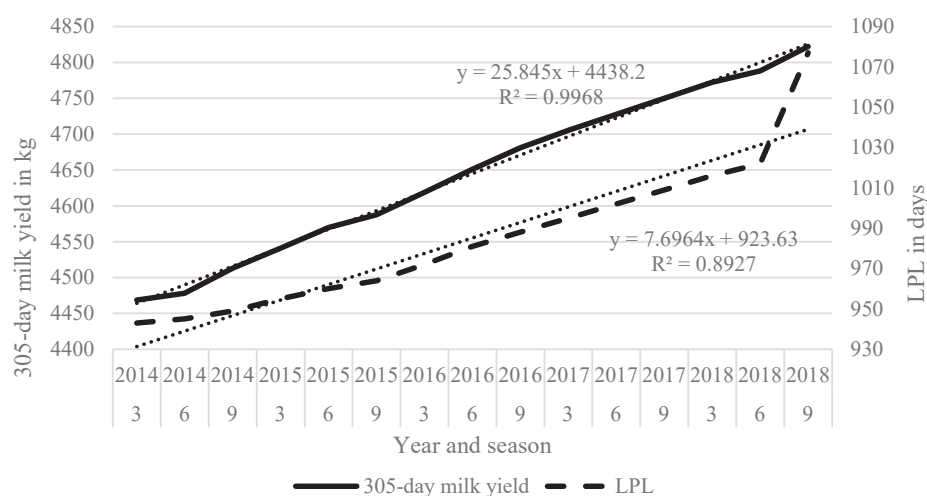
In Simmental breed, genetic trends in particular years were different. In general, trends showed a decrease in Slovak Simmental bulls RBVs in the period 1981–1994. Since 1994 are visible positive genetic trends in all years due to include functional traits as longevity, fertility and udder health into a selection criteria (Fig. 2).

Phenotypic Trends

Milk yield and LPL were evaluated within the years 2014–2018 in culled Holstein and Slovak Simmental cows. Average 305-day milk production was 6499 kg and 4645 kg in Holstein and Slovak Simmental breeds, respectively. The length of productive life reached 898 days in Holstein and 985 days in Slovak Simmental culled cows. Age at first calving was higher in Slovak Simmental breed compared with Holstein heifers about +79 days (Tab. III).



3: Phenotypic trends of milk yields and the length of productive life of culled Holstein cows



4: Phenotypic trends of milk yields and the length of productive life of culled Slovak Simmental cows

Phenotypic trends of 305 day milk yields in culled Holstein cows increased from 6333 kg to 6621 kg and LPL from 868 to 944 days within period 2014–2018. The most increase of LPL (23 days) was between second and third seasons of the year 2018 (Fig. 3).

Milk yield and LPL in Slovak Simmental breed showed the same trends as Holstein (Fig. 4). Milk production was lower than in Holstein population (from 4469 to 4822 kg), but the increase in this period was higher (+353 kg). Slovak Simmental cows reached also more productive days (943–1077) than Holstein cows (Fig. 4). The progress for both traits in Holstein population was lower, +288 kg and +76 days for the five years (Fig. 3).

DISCUSSION

Longevity is a trait with very low heritability. Heritability estimated with Weibull model can be expressed on a logarithmic or original scale. Heritability on a logarithmic scale cannot be compared directly with heritability obtained from linear models (Ducrocq, 1994). Dürr *et al.* (1999), Vukasinovic (1999), Sasaki *et al.* (2012) stated lower heritability in Holstein in compare with our results (0.075, 0.072 and 0.056, respectively). Identical heritability found Caraviello *et al.* (1999). Raguž *et al.* (2014) and Morek-Kopeć and Zarnecki (2017) computed similar heritability in Simmental population (0.075, 0.09, respectively).

The holstein sire variance obtained in Weibull model was similar as stated Sewalem *et al.* (2005) (0.046) and Imbayarwo-Chikosi *et al.* (2017) (0.047). Raguž *et al.* (2014) and Morek-Kopeć and Zarnecki (2017) found higher Simmental sire variance in compare with our results (0.03 and 0.069).

In most countries, there was a negativ genetic trend of longevity for sires born up to 2000. The upward genetic trends for bulls born after 2000 is a reflection of increased attention placed on

longevity for the selection of sires of sons by artificial insemination organizations globally and in national selection indexes (van Doormaal, 2009). Increase in sire breeding values is distinguished. Genetic trends of LPL sires of two breeds in Slovakia were similar in compare with many authors (van Doormaal, 2009; Raguž *et al.*, 2014; Egger-Danner *et al.*, 2015; Stanojević *et al.*, 2018; Morek-Kopeć *et al.*, 2017). The negative genetic trends in functional longevity found Imbayarwo-Chikosi *et al.* (2017) in South Africa Holstein cattle and Jenko *et al.* (2013) in Slovenian Brown cattle, which could have been resulting from intense selection on high milk production. Genetic trends of length of productive life from a Weibull survival model may be overestimated for young sires because they have few culled daughters and its reliability of the RBV estimate is very low (Sewalem *et al.*, 2005).

Phenotypic Trends

The level of milk yield is one of the principal reason for voluntary culling of cows (Sewalem *et al.*, 2005; Meszaros *et al.*, 2008). Economic milk production should combine high milk yield and longevity. Pritchard *et al.* (2013) and many other authors found negative genetic correlations between functional longevity and 305-day milk in first-lactation cows, which suggests that lower milk and fat yield in the first lactation was associated with an increased lifespan of dairy cows at the same production level. In this study were evaluated 305-day milk production and length of productive life in culled dairy cows. Phenotypic trends showed a increase both traits, milk production and LPL in the period 2014–2018. Average milk production in Holstein cows was higher than stated M'hamdi *et al.* (2012) (5807.83), Rahayu (2018) 4386 kg, in Simmental cows was lower than declared Bolacali and Öztürk (2018) (6060.30 kg).

Length of productive life of culled Holstein cows in this study was lower than introduced Martens

and Bange (2013) 3.5 lactations, Van Pelt *et al.* (2015) 41.2 months, Stanojević *et al.* (2018) (1251, 1300 days). Hultgren and Svensson (2009) stated lower LPL of culled Swedish Red and Swedish Holstein cows about 118 days in comparison with our results. LPL in Simmental cattle was low, many authors declared higher number of reproductive days (Raguž *et al.*, 2014; Morek-Kopeć *et al.*, 2017) (1076, 1198 days, respectively).

A negative relationship is between age at first calving and functional longevity. The late calvings are related to poor fertility which also influences longevity (Sewalem *et al.*, 2005). From the economic point of view, age at first calving at 24 months or less is recommended (Pirlo *et al.*, 2000), because

increase the efficiency of production by reducing input costs. In compare with other authors Holstein heifers reached higher age at first calving (Hultgren and Svensson, 2009 (28.2 month); Gnyp, 2014 (848) days; Coffey *et al.*, 2016 (736 days); Stanojević *et al.*, 2018 (809 days)). Raguž *et al.* (2014) stated about -120 days lower age at first calving in Simmental than was result from our study.

Most of the emphasis in the selection of dairy cattle has been based on milk production, but efficiency of production is also determined by longevity, fertility, and health. Many cows never have the opportunity to express their full genetic potential because they don't live in an environment that maximizes the non-genetic factors.

CONSLUSION

The Weibull proportional hazard model was used for estimate of RBV of length of productive life. Heritability of LPL reached of 0.13 in Holstein and 0.05 in Slovak Simmental population.

Genetic trends of LPL shown decrease for sires born up to 1999 and 1994 (Holstein and Slovak Simmental breed), but increasing trends afterwards.

Average 305-day milk production of culled cows achieved 6499 and 4645 kg (Holstein and Slovak Simmental).

Phenotypic trends of milk yield in Holstein in the years 2014–2018 were positive (+288 kg) however lower than in Slovak Simmental breed (+353 kg).

LPL of culled Holstein cows increased from 868 to 944 days, in Slovak Simmental cows was range within 943–1077 days.

Age at first calving was higher in Slovak Simmental population in comparison with Holstein heifers about +79 days.

Acknowledgements

This paper was supported by Grant Agency of The Ministry of Education, Science, Research and Sport of the Slovak Republic KEGA - 012SPU-4/2019 and VEGA 1/0724/16.

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