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Original Paper

Genetic and phenotypic trends for weights of major beef and dual-purpose cattle breeds in the Slovak Republic

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Genetic evaluation of beef cattle in Slovakia started in first years of this century. After the first decade of running the routine evaluations it is important to review the progress made and to discuss the further development. The aim of this paper was to compile and deliver genetic and phenotypic trends in order to review importance of evaluated traits with respect to four major beef (Charolais, Limousine) and dual-purpose breeds (Slovak Pinzgau cattle, Slovak Spotted cattle). The study showed different progress made across the breeds. Higher genetic progress was observed in Charolais purebreds compared to Limousine counterparts. Moreover, almost similar progress to that in Charolais was observed in dual-purpose Slovak Pinzgau cattle. On the other hand no progress was observed in Slovak Spotted purebreds. Results also showed higher progress in bulls compared to cows. Phenotypic trends showed reserves for improvement in Charolais and closing to breed standards in Limousine. In dual-purpose breeds improvement was shown only in Slovak Pinzgau, while no improvement or decrease in actual weights was shown in Slovak Spotted purebreds.

Keywords: beef cattle, dual-purpose cattle, trends, growth, genetic evaluation

1 Introduction

The tradition of beef cattle breeding in the Slovak Republic is rather short. The first animals of specialized beef breeds were imported to former Czechoslovakia in 1970s. After the year 1989 new imports started, which brought animals of several beef breeds to Slovak Republic. Also some of the breeders of combined breeds changed the orientation of their animals towards the beef production. Nowadays, there are two major beef cattle populations (Charolais (CH), Limousine(L)), two large populations of combined breeds with their subpopulations oriented on beef production (Slovak Pinzgau (SP), Slovak Spotted (SS)) and several small beef cattle populations of size up to 1,000 purebred animals (Tomka and Huba, 2019).

In order to assist farmers to select the best animals to become parents of the next generation the system of genetic evaluation was started in the beginning of 2000s. First genetic parameters for the growth traits in beef cattle populations in Slovakia were calculated in 2002 (Krupa et al., 2002). Further analyses led to the use of multi-trait animal model in genetic evaluation of beef cattle in the country (Krupa et al., 2005a; Krupa et al., 2005b). Recent genetic evaluation includes weight characteristics of animals (weight at birth, age of 120 days, age of 210 days and age of 365 days). The most important from these is the weight at the age of 210 days (weaning), because most of the young beef animals in Slovak republic are sold around this period, making the most of the income to farmer. However, thanks to genetic correlations, selection on one trait results in changes of the other correlated traits. Mujibi et al. (2009) reported opposite genetic trends for birth weight and percent of unassisted calvings in Charolais cattle. In case of body weights in different ages Abreu et al. (2018) reported improvement of weights before weaning, while selecting on weights at weaning and post-weaning weight. From the profit point of view it is important to monitor genetic trends in order to change the focus of breeding in order

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to enhance the profitability (Lalman et al., 2019). For this purpose, in some countries breeders` associations publish the genetic trends on regular bases (AICA, 2019).

The recent study was undertaken in order to bring the picture of how the performance and genetics have developed so far in the two major beef breeds (Charolais and Limousine) and two dual-purpose breeds (Slovak Pinzgau, Slovak Spotted) in Slovakia since the beef genetic evaluation was put in place.

2 Materials and methods

2.1 Records

Data from the routine beef genetic evaluation were used for this study. The beef genetic evaluation in Slovak Republic is based on the field data; no data from test stations is available. Records from performance recording and pedigree information are regularly provided by the Breeding Services of the Slovak Republic, s. e. Only animals of four sexes (single male, single female, twin male, twin female) and animals with at least one weight record are used in the estimation. In many cases birth weight (HN) is only estimated by the farmer, weights exceeding 50 kg are excluded during data processing. Most of youngsters are reared with mothers on the pasture, where average daily gain greater than 1.8 kg is considered extreme. Also not all animals on the pasture are weighted at the precise age. Therefore weight at age 120 days (H120) represents weightings between 75 and 165 with average daily gain lower than 1.8 kg per day. Similarly, the weight at age 210 days (H210) represents weightings between 166 and 287 days with average daily gain lower than 1.7 kg per day. The weight at age 365 (H365) represents weightings between 288 and 433 days with average daily gain lower than 1.7 kg per day. The total number of animals with data used in the recent genetic evaluation run was 282,130. The study was based on the data from 34,858 animals of Charolais and Limousine breed and 15,104 animals of Slovak Pinzgau and Slovak Spotted breed born between 2006 and 2015. Distribution of animals according to breed and sex, as well as number of records is presented in Table 1. The animals included in the study originated from 1,704 sires (1068 sires from beef breeds) and 26,124 dams (17,352 dams of beef breeds). Average adjusted weights and corresponding estimated breeding values (EBVs) for the whole studied period are summarized in Table 1.

2.2 Genetic evaluation

The multi-trait animal model is routinely used to predict EBVs in the Slovak Republic. EBVs are predicted for the four weights – weight at birth (BW), age of 120 days (W120), age of 210 days (W210) and age of 365 days (W365). Model includes age as linear regression for corresponding weighting, effects of the sex, breed, age of the dam and joint herd-year-season effect treated as fixed and effect of animal treated as random. Recently, software for the multivariate prediction and estimation (Groeneveld, 2006) is used for the estimation of breeding values (EBVs). Calculated EBVs are corrected according to average EBVs of animals born in 2005 (genetic base).

2.3 Genetic and phenotypic trends

The highest selection pressure with regard to weight and daily gain is put on purebred bulls as potential fathers of the next generation and less pressure in this regard is put on dams and crossbred animals. Therefore sixteen groups were created with regard to breed and sex. Genetic trends over time period of 2006–2015 were compiled using average EBVs of animals born in the respective year. Also the corresponding phenotypic trends were compiled. In animals where no birth weight record was available, average birth weight for sex*breed group was used to calculate adjusted weight in age of 120, 210 and 365 days. The phenotypic trends were compiled using averages of adjusted weights of animals born in the respective year. The REG procedure within SAS® software (SAS University Edition) was used to the regress the EBVs/weights on the year of birth and to test difference of the slope from the zero (*F*-test) showing significance of the genetic/phenotypic changes over the studied period.

3 Results and discussion

Regression coefficients for the genetic and phenotypic trends for single breeds are presented in Tables 2–5. Significantly different coefficients from zero were calculated especially for the genetic trends in groups of beef purebred and crossbred animals. Less similar trend was observed in Slovak Pinzgau, where only few coefficients for genetic trends were significantly different from zero. In groups of Slovak Spotted significantly different coefficients were calculated mostly in phenotypic trends.

3.1 Genetic trends

Almost all coefficients for genetic trends in beef breeds were positive indicating the trends were rising, except for the group of Limousine purebred cows, where these trends were negative. Also trend of BW in Limousine crossbred bulls was negative; however, this was very small, nearing the zero value, thus explaining no change over the time. The higher increase was observed in the EBVs for W120, W210 and W365, while very low regression coefficients were calculated for BW indicating almost no genetic improvement of this trait was realized over the studied period. Small genetic changes in BW

Table 1 Distribution of animals, records, average weights and average EBVs according to groups

Group	Number of animals with used data	Birth	120 days	210 days	365 days
		Number of records/Average weight/Average EBV			
CH00b	2079	1,705 36.05 ±5.33 +0.19 ±0.63	1,401 160.94 ±34.78 +4.72 ±9.65	1,120 261.44 ±52.14 +6.85 ±15.91	776 444.72 ±83.59 +5.90 ±16.14
CH00k	2200	1,864 33.93 ±5.70 +0.15 ±0.59	1,547 150.91 ±32.14 +1.67 ±8.99	1,417 237.54 ±46.45 +1.25 ±14.99	1,191 363.41 ±72.09 -0.37 ±15.21
CHxxb	5754	5,136 35.88 ±4.70 +0.12 ±0.45	3,955 141.83 ±28.93 +1.37 ±5.77	2,273 219.41 ±44.78 +1.46 ±9.49	671 370.00 ±93.40 +1.41 ±9.76
CHxxk	7615	6,913 33.63 ±4.89 +0.09 ±0.47	5,088 137.22 ±27.63 +1.73 ±5.89	4,093 210.29 ±42.92 +2.30 ±9.66	2,714 332.13 ±72.00 +2.15 ±9.91
LI00b	920	801 32.03 ±2.96 +0.04 ±0.42	755 159.73 ±29.69 +2.73 ±7.96	631 258.70 ±43.61 +3.92 ±13.36	398 434.58 ±69.20 +3.61 ±13.98
LI00k	783	697 30.52 ±2.80 +0.001 ±0.42	656 146.06 ±27.79 +0.59 ±7.12	615 229.81 ±42.22 +0.04 ±12.16	480 365.17 ±68.62 -0.90 ±12.58
LIxxb	6528	6,329 34.29 ±3.68 +0.04 ±0.38	4,147 128.82 ±24.65 +0.68 ±6.30	2,106 208.93 ±42.67 +0.85 ±10.30	640 312.00 ±76.08 +1.25 ±10.18
LIxxk	8251	7,754 32.21 ±4.01 +0.04 ±0.38	6,118 124.66 ±22.72 +0.55 ±5.96	5,189 196.80 ±38.32 +0.62 ±9.84	4,127 309.40 ±66.23 +0.88 ±10.21
SP00b	903	863 37.05 ±4.28 +0.41 ±0.64	680 147.63 ±24.43 +6.77 ±8.01	517 237.85 ±34.89 +9.76 ±12.74	153 378.04 ±54.27 +6.83 ±13.08
SP00k	1060	985 34.47 ±4.82 +0.23 ±0.64	853 138.72 ±22.27 +4.52 ±7.35	836 221.34 ±31.26 +6.35 ±11.93	668 352.94 ±42.71 +3.39 ±12.22
SPxxb	138	133 36.11 ±3.10 +0.28 ±0.50	99 141.15 ±19.38 +3.87 ±6.32	71 231.01 ±33.84 +5.55 ±10.62	16 353.61 ±55.65 +3.98 ±11.65
SPxxk	209	197 33.16 ±4.27 +0.11 ±0.56	156 136.44 ±21.40 +2.28 ±7.08	165 215.15 ±29.09 +2.82 ±11.30	117 359.18 ±43.18 +1.14 ±11.05
SS00b	2491	2,296 34.40 ±3.60 +0.03 ±0.42	1,449 127.44 ±25.23 -2.24 ±6.73	907 205.35 ±40.06 -3.51 ±11.20	446 334.48 ±73.59 -2.00 ±11.35
SS00k	3033	2,799 32.79 ±3.81 +0.04 ±0.38	2,100 123.71 ±24.03 -1.00 ±6.02	1,864 198.14 ±37.06 -1.58 ±10.12	1,549 309.25 ±62.20 -0.05 ±10.62
SSxxb	3172	2,939 33.33 ±3.40 +0.03 ±0.32	1,780 125.49 ±22.25 -1.61 ±5.90	1,159 198.84 ±40.66 -3.13 ±9.81	561 310.79 ±79.59 -2.38 ±9.87
SSxxk	3986	3,794 31.45 ±3.60 +0.02 ±0.34	2,561 120.90 ±21.54 -0.68 ±5.30	2,300 192.03 ±38.65 -1.12 ±8.98	1,767 296.21 ±61.07 +0.05 ±9.21

CH00b – Charolais purebred bulls, CH00k – Charolais purebred cows, CHxxb – Charolais crossbred bulls, CHxxk – Charolais crossbred cows, LI00b – Limousine purebred bulls, LI00k – Limousine purebred cows, LIxxb – Limousine crossbred bulls, LIxxk – Limousine crossbred cows

Table 2 Charolais

	CH00b		CH00k		CHxxb		CHxxk	
	reg. coeff.	R^2	reg. coeff.	R^2	reg. coeff.	R^2	reg. coeff.	R^2
BW	0.01 ±0.001	0.34	0.02 ±0.01*	0.57	0.01 ±0.01	0.20	0.02 ±0.01*	0.66
W120	0.65 ±0.10*	0.83	0.50 ±0.10*	0.76	0.31 ±0.11*	0.52	0.20 ±0.09	0.37
W210	1.09 ±0.20*	0.78	0.74 ±0.16*	0.72	0.48 ±0.13*	0.64	0.27 ±0.14	0.33
W365	1.27 ±0.24*	0.77	0.65 ±0.18*	0.62	0.51 ±0.13*	0.65	0.33 ±0.13*	0.44
HN	0.34 ±0.13*	0.47	0.43 ±0.12*	0.62	0.03 ±0.14	0.01	0.21 ±0.10	0.35
H120	1.61 ±0.94	0.27	1.58 ±0.82	0.32	-0.54 ±0.95	0.04	-0.82 ±0.55	0.22
H210	2.62 ±1.62	0.24	1.00 ±1.09	0.09	-0.52 ±1.21	0.02	-2.16 ±1.17	0.30
H365	7.42 ±2.71*	0.48	3.74 ±2.02	0.30	-1.64 ±4.47	0.02	-3.18 ±2.45	0.17

*P <0.05

Table 3 Limousine

	LI00b		LI00k		LIxxb		LIxxk	
	reg. coeff.	R^2	reg. coeff.	R^2	reg. coeff.	R^2	reg. coeff.	R^2
BW	0.01 ±0.01	0.15	-0.0003 ±0.01	0.0001	-0.001 ±0.01	0.004	0.01 ±0.01	0.18
W120	0.38 ±0.14*	0.50	-0.25 ±0.09*	0.50	0.20 ±0.09*	0.40	0.20 ±0.08*	0.41
W210	0.69 ±0.22*	0.55	-0.37 ±0.14*	0.46	0.33 ±0.14*	0.40	0.30 ±0.14	0.36
W365	0.79 ±0.25*	0.56	-0.39 ±0.16*	0.42	0.19 ±0.10	0.32	0.25 ±0.13	0.33
HN	-0.11 ±0.06	0.32	-0.19 ±0.05*	0.68	-0.33 ±0.06*	0.77	-0.19 ±0.06*	0.53
H120	0.30 ±1.39	0.01	-0.73 ±1.86	0.02	0.13 ±0.50	0.01	0.42 ±0.40	0.12
H210	0.83 ±1.71	0.03	-3.09 ±2.22	0.20	1.94 ±1.28	0.22	1.12 ±0.86	0.17
H365	4.68 ±2.49	0.31	-8.78 ±4.18	0.36	2.15 ±3.34	0.05	0.78 ±1.64	0.03

*P <0.05

Table 4 Slovak Pinzgau

	SP00b		SP00k		SPxxb		SPxxk	
	reg. coeff.	R^2	reg. coeff.	R^2	reg. coeff.	R^2	reg. coeff.	R^2
BW	0.02 ±0.02	0.09	-0.03 ±0.01*	0.59	-0.02 ±0.02	0.09	-0.04 ±0.02*	0.43
W120	1.00 ±0.29*	0.60	0.21 ±0.13	0.23	0.18 ±0.27	0.05	0.53 ±0.23	0.39
W210	1.67 ±0.55*	0.54	0.36 ±0.24	0.22	0.22 ±0.45	0.03	0.79 ±0.36	0.37
W365	1.85 ±0.49*	0.64	0.67 ±0.27*	0.44	0.10 ±0.51	0.005	0.54 ±0.32	0.27
HN	0.45 ±0.24	0.30	0.15 ±0.24	0.04	0.28 ±0.10*	0.50	-0.20 ±0.14	0.20
H120	0.34 ±2.03	0.003	-0.31 ±1.25	0.01	1.27 ±1.05	0.15	1.73 ±0.91	0.31
H210	6.44 ±4.83	0.18	1.59 ±1.20	0.18	-3.21 ±2.47	0.17	0.74 ±1.27	0.04
H365	3.93 ±3.47	0.15	2.77 ±1.41	0.32	2.72 ±14.78	0.02	0.39 ±2.45	0.003

*P <0.05

Table 5 Slovak Spotted

	SS00b		SS00k		SSxxb		SSxxk	
	reg. coeff.	R^2	reg. coeff.	R^2	reg. coeff.	R^2	reg. coeff.	R^2
BW	-0.01 ±0.01	0.20	0.004 ±0.01	0.10	-0.01 ±0.01	0.11	-0.002 ±0.01	0.01
W120	-0.14 ±0.13	0.13	-0.03 ±0.08	0.02	-0.31 ±0.10*	0.55	-0.17 ±0.09	0.30
W210	-0.09 ±0.20	0.02	-0.01 ±0.13	0.001	-0.40 ±0.14*	0.50	-0.30 ±0.14	0.38
W365	-0.08 ±0.18	0.02	-0.03 ±0.13	0.01	-0.26 ±0.14	0.32	-0.29 ±0.13	0.38
HN	-0.26 ±0.09	0.54	-0.25 ±0.11	0.41	-0.24 ±0.14	0.26	-0.25 ±0.10*	0.42
H120	-2.70 ±0.67*	0.67	-1.94 ±0.56*	0.60	-2.41 ±0.61*	0.66	-1.60 ±0.35*	0.72
H210	-1.61 ±1.28	0.17	-0.99 ±0.67	0.21	-3.76 ±1.60	0.41	-3.02 ±0.64*	0.74
H365	-9.67 ±3.05*	0.56	-4.02 ±1.18*	0.59	-7.29 ±3.93	0.30	-4.53 ±1.33*	0.59

*$P < 0.05$

can be explained by the fact that the birth weights of newborns are not measured properly, but estimated by the farmers often using the same values over the time. Difference between changes of EBVs for BW and other weights may be due to low genetic correlations found between BW and other weights ranging from 0.16 to 0.26. This situation is favorable for the farmers, who try to keep birth weight in optimal levels, while improving the weights in higher ages, especially weaning weight. In this respect MacNeil (2003) and Rumph et al. (2004) showed that despite higher genetic correlations it is possible to decrease or at least control the increase of birth weight while increasing the weight in higher age (365 days). More recently Parra-Bracamonte et al. (2016) reported different genetic improvement in birth weight compared to yearling weight and Abin et al. (2016) reported low genetic changes in birth weight while observing genetic improvement in weaning and post-weaning weights in African indigenous cattle populations.

Similar situation to that in beef breeds was observed in Slovak Pinzgau breed. Most of the coefficients for the genetic trends were positive. Only coefficients for BW were negative and very low, therefore considered negligible. In Slovak Spotted breed, almost all coefficients were low and negative. In crossbred bulls group negative significant trends were observed for W120, W210. Almost no genetic improvement in SS breed in regard to beef production compared to SP breed may be explained by more intensive selection and transformation of SP herds towards the beef production while only few similar efforts can be found in the SS farms.

Higher genetic correlations between body weights at different ages ranging from 0.77 to 0.93 indicate that improving one weight will also improve the other two. This can be seen in the Figures 1–6, where more detailed genetic trends for purebred groups were more-less similar thanks to their high genetic correlations. The similarity of the genetic trends for the weaning and post-weaning weight was also reported by Teixeira et al. (2018). In general, it can be seen that higher genetic progress was realized in groups of bulls compared to groups of cows. Opposite trend was found in the groups of dual-purpose crossbreds. When comparing differences between breeds, higher changes were observed in the Charolais purebred animals. Interestingly, the coefficients for genetic trends in Pinzgau purebreds were similar to those of Charolais purebreds. This improvement in SP population can be due to import of animals from highly specialized populations from abroad. Differences in genetic trends across the breeds are obvious, because populations have different breeding objectives, selection intensity, generation interval and others (Johnston, 2007). In this respect Sullivan et al. (1999) reported that higher genetic progress was observed in lighter breeds compared to heavier ones leading to decreasing the differences among the breeds. These findings were not observed in this study.

In the figures 1–2 and 5–6 it can be seen that the genetic trends in Charolais and Slovak Pinzgau were rather continual. More evident improvement of EBVs can be observed since the year 2010 in Charolais purebreds. Such development can be also observed in purebred Limousine bulls; however, this is not so continual (Figure 3). These changes can be explained by the progeny born to genetically superior parents imported from abroad (France, Czechia, Hungary) in previous years. Johnston (2007) reported the changes in genetic trends due to enhancements in the evaluation systems (improvement of the performance recording, inclusion of new traits to evaluation process, improvement and inclusion of new fixed and random factors). These factors, however, are affecting the trends in the long term. Changes in Limousine purebred cows and Slovak spotted purebreds were more fluctuant (Figures 4, 7 and 8). Changes in SS

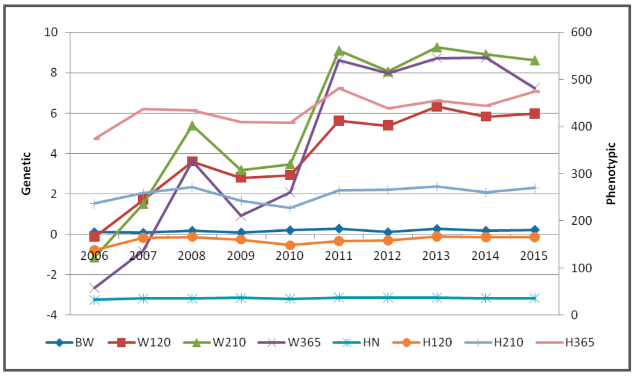

Figure 1 Genetic and phenotypic trends for Charolais purebred bulls

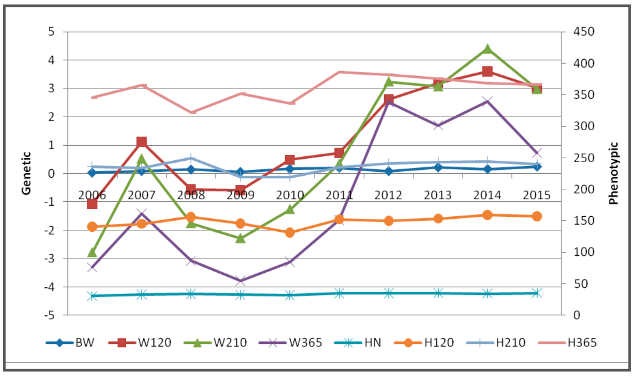

Figure 2 Genetic and phenotypic trends for Charolais purebred cows and heifers

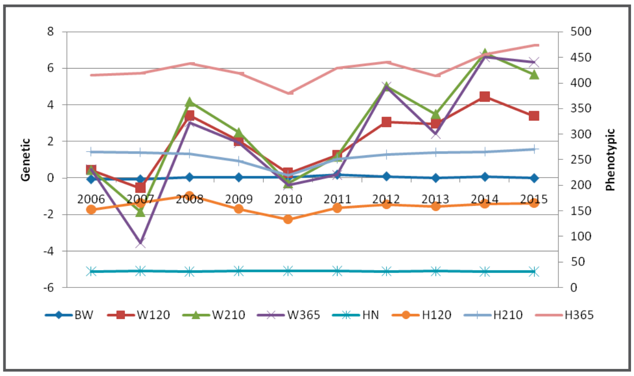

Figure 3 Genetic and phenotypic trends for Limousine purebred bulls

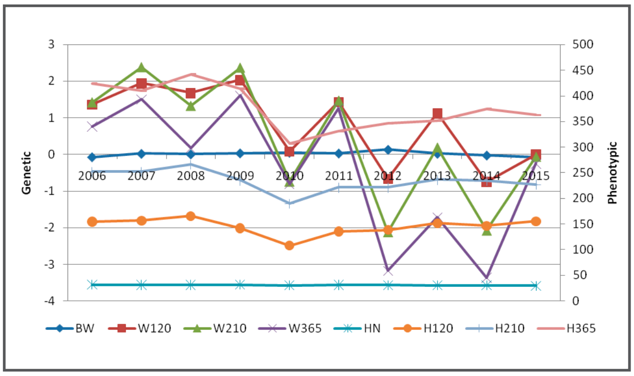

Figure 4 Genetic and phenotypic trends for Limousine purebred cows and heifers

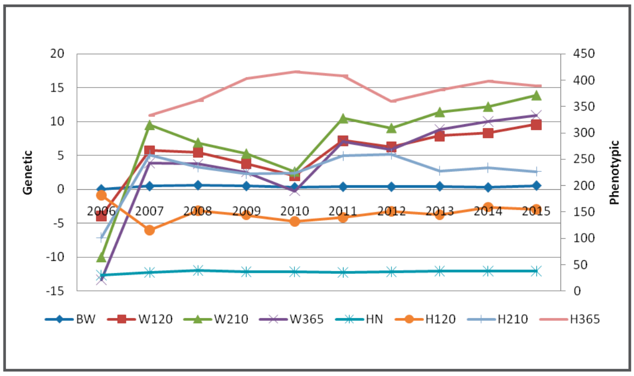

Figure 5 Genetic and phenotypic trends for Slovak Pinzgau purebred bulls

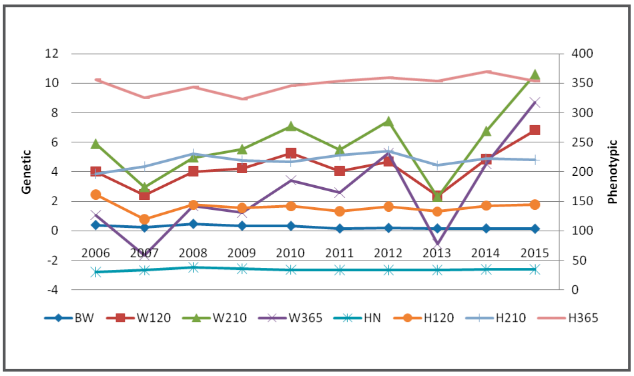

Figure 6 Genetic and phenotypic trends for Slovak Pinzgau purebred cows and heifers

could be caused by continuous income of new animals from dairy herds.

3.2 Phenotypic trends

Not all phenotypic trends were positive. Slightly negative trends were observed in Charolais crossbreds. In the group of purebred Limousine cows negative trends in actual weights (H120, H210 and H3650) were calculated indicating that the weights of the cows were decreasing over the studied period. These phenotypic trends were in accordance with corresponding genetic trends and can be due to selecting for lighter cows in order to maintain the easy levels of calvings. However, some authors (Phocas and Sapa, 2004) reported there is none or only slight correlations between weight characteristics, reproduction characteristics and calving ease in beef breeds. Thus, selecting for higher weights is not expected to negatively affect reproduction traits. Moreover, phenotypic correlations between birth weight and weights in higher age are lower than genetic ones

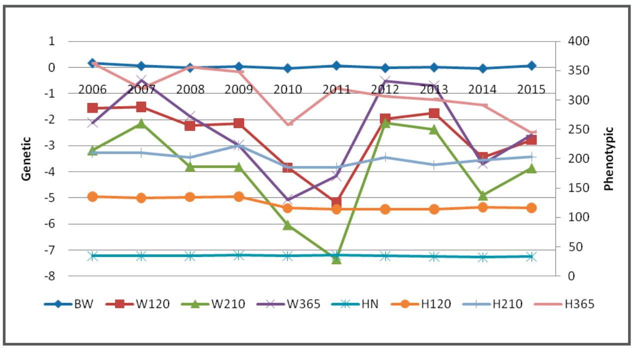

Figure 7 Genetic and phenotypic trends for Slovak Spotted purebred bulls

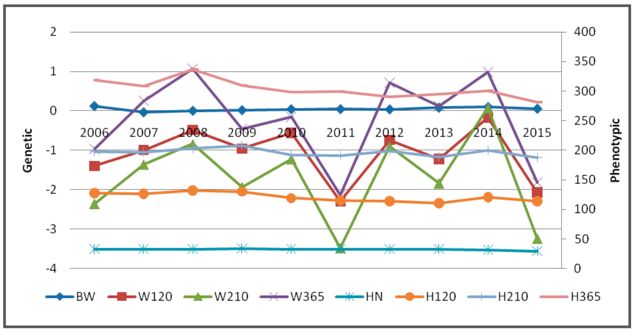

Figure 8 Genetic and phenotypic trends for Slovak Spotted purebred cows and heifers

(Čepon et al., 2008) suggesting the environmental factors have effect on relation between these traits. Although the genetic trends for BW in Charolais purebreds were almost negligible, phenotypic trends showed increase of HN in both groups by more than 1% compared to HN in 2006. Opposite situation was observed in Limousine purebreds with decrease of HN by up to 0.5% compared to HN in 2006.

In dual-purpose breeds more favorable trends were observed in Slovak Pinzgau purebreds compared to Slovak Spotted purebreds. Significantly negative trends were observed in Slovak Spotted groups for H120 and H365, while in Slovak Pinzgau crossbreds only trends for H210 (bulls) and H120 (cows) were negative. These findings also showed changed direction of part of Slovak Pinzgau population towards the beef production. Indeed, import of bulls from countries with beef-oriented Pinzgau populations is in place in Slovakia and dedicated part of the herd book was created for these animals. Two separate populations of Slovak Pinzgau (dual-purpose and beef) were previously reported by Šidlová et al. (2015). On the other hand, in population of Slovak Spotted breed the orientation towards beef production is not so significant. This can also be due to fact, that Slovak Spotted and Beef Simmental are closely related breeds of the same origin and in the case of beef production Beef Simmental breed is reported instead of Slovak Spotted breed. In many cases of Slovak spotted cattle, cows are just removed from milking herd to the herd without milk production without intention of improving beef production.

The phenotypic progress achieved in Charolais purebreds (expressed in absolute numbers) was higher compared to progress achieved in Limousine purebreds. Nevertheless, it has to be noted that during the studied period the Limousine purebreds were on average closing to the published breed standards for weights at 120 and 210days (ZCHMD, 2009a,b), while there was still reserve for improvement in Charolais breed. In fact average weights of Charolais purebreds during the studied period were slightly lower than those presented for the year 2006 (Darnadiova and Debrecéni, 2009). In dual-purpose breeds more favorable trends are observed in Slovak Pinzgau purebreds. These trends result in meeting their published breeding standards (ZCHPD, 2016), while SS purebreds still have reserves (ZCHSSD, 2016).

4 Conclusion

Positive trends in studied beef breeds and Slovak Pinzgau breed show the improvement of weight characteristics of these breeds in Slovakia. Although the overall trends are more-less similar, detailed look showed differences in development of studied traits. On the other hand there are only slight improvements in weight characteristics in Slovak Spotted breed. These results suggest transformation towards beef production is more visible in Slovak Pinzgau cattle while Slovak Spotted breed keeps it status of purely dual-purpose breed. In this regard the discussion should follow whether the inclusion of Slovak Spotted breed in national beef genetic evaluation is necessary. In practice discussions on possible updates of breeding standards could be undertaken in breeds which are meeting their standards or the breeding goals could be updated to include other traits.

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