Breeding Objectives of Dam Pig Breeds of the Czech National Breeding Program Based on Reproduction Traits

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Summary

Reproduction traits as total number of piglets born (TNB), piglets alive born (PBA), piglets weaned (NW) and farrowing interval (FI) play important role in dam pig breeds. Main aim of the study was to calculate economic weights and consequently to estimate the genetic and economic selection response on PBA and FI within the Czech dam population of pigs. PBA and FI were defined in the aggregate genotype and the estimated breeding values (EBV) of four traits (TNB, PBA, NW and FI) were assumed as the candidate traits for construction of the index. Four variants of reproduction selection index A) based on PBA and FI, index B - based on PBA, NW, FI and the indices C) and D) based on four reproduction traits with different proportion of traits were taken into account. Economic weight of traits calculated by the bio-economic model were 23.57 € and -3.52 € for PBA and FI, respectively. The highest genetic (0.180 piglet born alive and 0.00 days of FI per year, respectively) and economic (10.05 € and 0.00 € per year for PBA and FI, respectively) response on selection was calculated in index C. The Spearman's rank correlation coefficients between indices A to D and for top 1%, 2%, 5% and 10% of animals were close to one (0.978 – 0.994) and significant.

Key words

total number of piglets born, piglets born alive, piglets weaned, farrowing interval, selection response

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Received: April 30, 2017 | Accepted: August 11, 2017

ACKNOWLEDGEMENTS
Thanks are due to the Czech Pig Breeders Association for helpful comments and providing the data. This study was financially supported by the project QJ1310109 and the project MZERO0717 of the Ministry of Agriculture of the Czech Republic.

Introduction

The selection of dam pig breeds should be oriented on traits directly and indirectly connected with reproduction ability of sows. The total number of piglets born is a measure for the biological potential of the sow and is directly connected with the feeding costs for sow. From the farmers point of view the number of piglets weaned is the most important litter trait. This trait expresses milk ability of sows together with survival of piglets. Therefore, it has the highest impact on efficiency of the whole production system.

The genetic evaluation of pigs based on multi-trait animal model is routinely used in the Czech Republic from beginning of 1998 (Wolf et al., 1999). Shortly after that, the total merit index (TMI) was defined for dam pig breeds where average daily gain from the birth to the end of the test (ADG), lean meat content (LMC) and number of born piglets alive at the second and higher farrowings of sows (PBA) were applied. The percentage ratio of traits in MTI of dam breeds is 40%, 5%, 55% for ADG, LMC and PBA, respectively. In spite of the fact that proportion of the reproduction trait in MTI index is the highest, the positive phenotypic and genetic trend is slightly slowing down within the last few generations (Krupa et al., 2016). Moreover, the routine genetic evaluation on farrowing interval (which started in 2012; Wolf, 2012) shows slightly positive (not favorable) genetic relationship of this trait with the litter size traits. Therefore, omitting the farrowing interval from the selection process will probably have negative impact on the turnover rate and overall production of piglets per year in the future.

The aim of the study was to estimate the economic weights by the bio-economic model, and the genetic and economic response in two reproduction traits included into the new reproduction index of the Czech dam pigs population.

Material and methods

Number of piglets born alive per reproduction cycle and farrowing interval of sow were defined as the breeding objective to improve the reproduction performance of the local dam pig breed populations (Czech Large White and Czech Landrace). In total, genetic parameters of reproduction traits PBA, FI, the total number of piglets born and piglets weaned were assumed as candidate traits for construction of reproduction selection index.

Calculation of economic weights

Marginal economic values of traits (expressed in € per sow and year) were calculated as the partial derivative of the profit function with respect to the trait keeping the level of other traits constant (to avoid double counting). The marginal economic values of traits were then expressed per farrowing interval (2.36 farrowings per year) to unifying the units of traits for which the genetic parameters and the economic values are calculated. The bio-economic model of the program EWPIG 1.1.0 (Wolf et al., 2016) and program GFPIG 1.0.0 were used for calculation of economic weights of traits and to consider the gene flow in pigs. Detailed description of principles used to calculate economic values of traits can be found in Wolfová et al. (2017). The investment period for calculation of gene flow was set to 16 (8) and 10 (5) reproduction cycles (years) for boars and sows, respectively. In presented study, marginal economic value of each trait calculated for two dam breeds were averaged to reflect the overall trait importance in the pig population. Basic parameters to calculate economic values of traits are summarized in Table 1.

Estimation of genetic parameters

The data used for genetic evaluation were provided by the Pig Breeders Association of the Czech Republic. Detailed pedigree information about the analyzed breeds and factors affecting the production and reproduction traits of the local pig population has been reported in previous studies (Krupa et al., 2015; Krupa and Wolf, 2013). Variance and covariance components of evaluated traits were estimated by restricted maximum likelihood (REML) and optimization using a quasi-Newton algorithm with analytical gradients as implemented in VCE 6.0 program (Groeneveld et al., 2008). The four trait animal model with: quadratic regression on covariate (age at first farrowing or farrowing interval) within parity, fixed effects of parity class, breed, mating type, random effects of herd-year-season, permanent effect of the sow and random animal effect were used for traits. The breeding values were estimated by the PEST 4.2 (Groeneveld et al., 1990) and they accuracy was derived from estimated PEVs (Prediction Error Variances of BV) as it was described by Mrode (2014). The correlation between the estimated breeding values of traits were computed by using the SAS (2016) procedure Corr. Estimated breeding values for the traits were used as the information sources in the constructed reproduction index. The genetic parameters of traits used to calculate selection response in the Czech dam pig breeds are given in Table 2.

Calculation of selection response

The coefficients for traits in selection index and the appropriate selection response were calculated using the general principles of selection index theory. The genetic selection response in the traits of breeding goal was calculated per year assuming the standardized selection intensity of 1.0. The economic response

Table 1. Basic parameters to calculate economic values

Parameter (unit)	Value
Maximal number of reproduction cycles of sows/boars	10/6
Average productive lifetime of sows (years)	4.98
Average farrowing interval of sows (days)	155.25
Average total number of born piglets from all litters	13.94
Average number of born piglets alive from all litters	12.53
Average number of weaned piglets from all litters	10.99
Average number of died piglets till weaning from all litters	1.54
Average conception rate of sows/gilts (%)	92.00/88.48
Total nutrition costs in breeding unit (€/farrowed sow and reprod. cycle)	152.46
Total health care costs in breeding unit (€/farrowed sow and reprod. cycle)	14.66
Total mating costs in breeding unit (€/farrowed sow and reprod. cycle)	23.36
Total non-specific non-feed costs (€/farrowed sow and reprod. cycle)	167.89
Total average costs in breeding unit (€/weaned piglet)	33.46
Total profit (€/farrowed sow and year)	356.64
Total profitability of the production system (%)	10.54

Table 2. Economic weights (EW), genetic standard deviations (GSD), genetic correlations (above diagonal) and accuracy of estimated breeding values (on diagonal)

Trait	EW[1]	GSD	TNB[2]	PBA[3]	NW[4]	FI[5]
TNB	-	-	0.390	0.932	0.857	0.050
PBA	23.57	0.719		0.420	0.643	0.027
NW	-	-			0.350	0.028
FI	-3.52	1.300				0.220

[1]In € per sow and farrowing interval, [2]Total number of born piglets, [3]Number born piglets alive, [4]Number of weaned piglets, [5]Farrowing interval

Table 3. Accuracy of selection indices, genetic and economic response on selection

Index[1]	Accuracy of SI (%)	Trait	Genetic response[2] (year)	Economic response[3] (year)
A	39.67	PBA	0.151	8.42
		FI	-0.006	0.02
B	45.94	PBA	0.163	9.07
		FI	-0.003	0.01
C	77.28	PBA	0.180	10.05
		FI	0.000	0.00
D	69.23	PBA	0.170	9.48
		FI	-0.001	0.01

[1]Description of indices see Material and Method. [2] Expressed in number of piglets for PBA and days for FI, [3]Expressed in €.

was defined when multiplying the selection response with the economic value of the appropriate trait.

When constructing the variants of the reproduction selection index (RSI) followed information source were used:

A: PBA and FI were considered in reproduction index.

B: PBA, NW and FI were used in reproduction index.

C: TNB, PBA, NW and FI, were taken into account in reproduction index. Proportion of traits was aimed to reach maximal reliability and selection response of the index.

D: TNB, PBA, NW and FI, were taken into account in reproduction index. Proportion of traits in reproduction index was based on breeders' preferences (Krupová et al., 2017)

As the last step, the estimated breeding values of active animals were applied to each of four variants of reproduction index. The Spearman's rank correlation coefficients (SAS, 2016) were calculated between top 1%, 2%, 5% and 10% of animals ordered by obtained RSI values.

Results and discussion

The basic production and economic performance of the local dam pig breed populations calculated by the bio-economic model of the program EWPIG are listed in Table 1. The average productive lifetime of sows was 4.98 farrowing.

The profit in the whole integrated production system presented in Table 1 is the sum of revenues and costs from the four units (facilities): breeding, nursery, and finishing units, and unit for rearing of breeding animals. A positive profit (356.64 € per farrowed sow and year) was obtained, regardless of whether or not government subsidies were taken into account. This is very important for the correct economic evaluation of the functional traits (reproductive traits and survival traits). At a negative profit (e.g. when the slaughter pigs are produced with loss) the economic values of functional traits could be underestimated (Krupová et al., 2009). The economic weights for reproduction traits, calculated for analyzed breeds by program EWPIG (Wolf et al., 2016) are presented in Table 2. The economic weights for almost 30 traits (production, reproduction, carcass, feed efficiency and survival) can be calculated by the program EWPIG (Wolf et al. 2016). The economic result of the modelled production system will increase by 23.57 € per sow and farrowing interval when number of piglets born alive will increase by one piglet. Consequently, the economic result will increase by 3.52 € when farrowing interval of sows decrease by one day. In the Czech Republic, marginal economic values were previously calculated by Houška et al. (2004) for several traits by applying the model of de Vries (1989) to commercial farms with crossbred sows. These are expressed per different units (e.g. per purchased gilt, fattened animal) and therefore cannot be directly compared to our results. Next to the mentioned models, economic values (importance) of traits can be directly defined by the breeders. Preferences of the Czech pig breeders vary among groups of traits (Krupová et al., 2017). This means that opinions of the farmers and breeders should be taken into account, along with the direct economic impact of traits on the economic efficiency of pig production when breeding objectives are defined.

The genetic correlations between analyzed traits, accuracies of estimated breeding values and genetic standard deviations for traits are presented in Table 2. The genetic correlations between litter size traits were high. Genetic correlations between litter size traits and farrowing interval were low and positive. Observed average accuracies of estimated breeding values are relatively low. The breeding values of all analyzed animals (18 397) were used to compute accuracies.

The genetic and economic responses to selection in analyzed RSIs together with accuracy of the RSI are presented in Table 3. Selection response on PBA was in all indices positive varying from 0.151 to 0.180 pigs born alive per sow and per year. The highest response (genetic and economic) and the highest accuracy (77.28%) were calculated in the index C. On the other hand, the genetic and economic response on FI is there the lowest (equal to zero) and therefore it can be supposed that FI would not be shortened when using this index. The relative contribution of traits in selection indices are shown in Figure 1. Kasprzyk (2007) found genetic trends 0.17 pigs per year and 0.10 pigs per year for PBA and NW, respectively. Chen et al. (2006) found slight positive but non-significant correlated response for TNB when selection on lean growth rate was used. Latter authors conclude that selection for growth trait has no an effect on litter size. Cleveland et al. (1988) reported that index selection for average daily gain and back fat thickness for lean growth resulted in negative but non-significant correlated responses for TNB, PBA. Vangen (1980) reported positive correlated responses for TNB and PBA to index selection for lean growth in the Norwegian Landrace

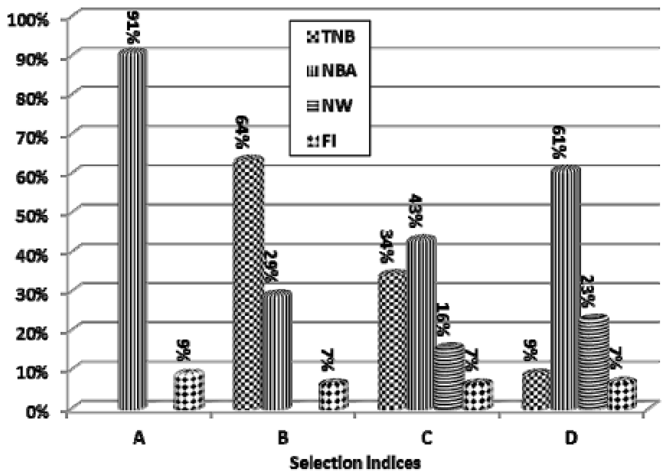

Figure 1. Contribution of traits (%) in appropriate selection indices

line. Fredeen and Mikami (1986) noted significant negative phenotypic trends for PBA over years in a Lacombe line selected for rate of lean growth.

The Spearman's rank correlation coefficients between top 1%, 2%, 5%, 10% of animals ranked by indices A to D were close to one. The lowest correlation confidents were observed for index D with all other RSI. The correlation between index C and D for top 5% and top 10% of animals were 0.922 and 0.932, respectively. Correlation of animals ranked by index A, B and C increased from 0.978 (for top 5% of animals, between index A and C) to 0.994 (for top 10% of animals, between RSI A and B). All the computed rank correlation coefficients were statistically highly significant (p<0.0001).

Conclusion

Selection on litter size as the only index trait caused correlated response in the farrowing interval. This response is unfavorable and thus increases the length of farrowing interval. Construction of the comprehensive reproduction index based on the traits related to litter size and farrowing interval would gain positive selection response in litter size along with slightly reduced number of days between subsequent farrowing. The highest genetic and economic response on selection was calculated in reproduction index C where four reproduction traits are considered. Therefore, the highest gain is expected in the local dam pig population when animals will be selected by this reproduction index.

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