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Genetic and economic evaluation of cross breeding schemes using an indirect selection criterion for feed efficiency in pigs

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Summary

The aim of this study was to evaluate the use of insulin-like growth factor-I (IGF-I) as an indirect selection criterion. IGF-I is highly correlated with feed conversion ratio (FCR). The computer program ZPLAN was used to evaluate a range of scenarios with different recording strategies for IGF-I in males and females in dam and sire lines in a four-way cross breeding scheme. Furthermore, the effect of not recording FCR any more on profit per sow is shown for a number of genetic correlations assumed between FCR and IGF-I. The cost benefit-ratios and the amount of money necessary for investment are shown for the different schemes.

Returns per sow are maximised when both traits, FCR and IGF-I, are recorded in all performance recorded animals in all purebred lines. However, this scenario requires a high input. By omitting measurements of FCR costs are reduced which leads to the highest profit per sow. The profit increased further, if the cost per IGF-I measurement decreased. The genetic correlation between FCR and IGF-I was gradually decreased from 0.66 to 0.44. In all cases, profit per sow was higher than profit per sow in the base situation where only FCR was recorded. Under the assumed parameters IGF-I is a useful indirect selection criterion for high genetic improvement of FCR leading to a higher profit in pig production.

1. Introduction

Feed efficiency is an economically important trait in pig production. Selection strategies to improve feed efficiency were discussed by Cameron (1998) who concluded that direct selection on feed efficiency is unlikely to be an appropriate method for genetic improvement. In addition, indirect selection on traditional performance traits used in breeding programs will not yield a higher response in feed efficiency than direct selection for feed efficiency (Cameron, 1998). However, benefits of indirect selection for feed efficiency are not only dependent on the achievable response but also on the costs of recording the indirect selection criterion. For these reasons insulin-like growth factor-I (IGF-I) is a possible indirect trait. It can be accurately measured in the blood of young animals (Owens et al., 1990), has a heritability of 0.2 and a high genetic correlation with feed efficiency (Bunter, 1996).

The program ZPLAN (Karras et al., 1997) enables a genetic and economic evaluation of breeding schemes. The program was used to investigate the effects of recording IGF-I within a cross-breeding scheme and to undertake a cost-benefit analysis of recording IGF-I. This study presents overall returns, costs and profit per sow in the total population of breeding schemes with different strategies for recording IGF-I in pigs.

2. Material and Method

2.1. Program

The approach of predicting the annual genetic gain is deterministic. One round of selection is considered with its impact on a given time horizon with specific discount rates. All selection groups in the whole population are to be defined, each with a specific selection intensity and with particular information sources used in the selection index. The program ZPLAN (Karras et al., 1997) applies the gene-flow method first described by

McClintock and Cunningham (1974) to calculate the number of standardised discounted expressions (SDE-values) for each trait in each selection group. This is required to get both, discounted economic weights for the objective traits and the discounted return over the given investment period. Fixed and variable costs are calculated for certain breeding strategies and used to derive the profit per sow in the total population. The basis for comparison of different selection strategies is the profit per sow after one round of selection. Further details of the method are given in Nitter et al. (1994). An example of using the program for cross-breeding in pigs is demonstrated by Wünsch (1998).

2.2. Population structure

A four-way cross breeding system with four parental lines (L1, L2, L3 and L4), F_1-sows and F_1-boars as well as the terminal products is considered. Both dam lines (L1 and L2) consist of 2500 sows each, with 500 sows in the nucleus and 2000 sows in the multiplier level. The F_1-generation (L1 x L2) includes 24000 sows. The terminal sire lines (L3 and L4) contain 300 purebred sows each. The nucleus in each line includes 150 sows. Further, 150 purebred sows in both lines are required to produce 500 F_1-boars (L3 x L4). In total the population consists of 29600 sows.

Figure 1 shows the structure of the transmission matrix of genes of the different lines and/or selection groups. The transmission matrix takes into account the flow of genes from the top of the breeding program (nucleus level) to the bottom of the breeding program (slaughter animals). Breeding animals are on the top x-axis and descendants are on the y-axis.

	NB_L1	NS_L1	NB_L2	NS_L2	NB_L3	NS_L3	NB_L4	NS_L4	PB_F1	PS_F1
NB_L1	1	2								
NS_L1	3	4								
NB_L2			5	6						
NS_L2			7	8						
NB_L3					9	10				
NS_L3					11	12				
NB_L4							13	14		
NS_L4							15	16		
PB_F1					17	18	19	20		
PS_F1	21	22	23	24						
TP									25	26

NB = breeding boars; NS = breeding sows; L1 = Landrace; L2 = Large White; L3 = Sire line 3; L4 = Sire line 4; PB = production boars; PS = production sows; F1 = F_1-generation boars (L3 x L4); F1 = F_1-generation sows (L1 x L2); TP = Terminal Products ((L3 x L4) x (L1 x L2)); > = produce; 1, 5, 9, 13 = breeding boars > breeding boars; 2, 6, 10, 14 = breeding sows > breeding boars; 3, 7, 11, 15 = breeding boars > breeding sows; 4, 8, 12, 16 = breeding sows > breeding sows; 17, 19, 21, 23 = breeding boars > F_1-sows; 18, 20, 22, 24 = breeding sows > F_1-sows; 25 = F_1-boars > terminal products; 26 = F_1-sows > terminal products

Figure 1. Transmission matrix of four-way cross with 26 selection groups. Origin of parents (gene donors) in columns, offspring (gene recipients) in rows

2.3. Input parameters

Calculations are based on an investment period of 10 years. The fixed costs of the breeding program are assumed to be $A 100,000. In addition, opportunity costs per sow in the nucleus of $A 100 and per sow in the multiplier level of $A 50 are taken into account. Variable costs include costs for measuring performance traits. The costs per record are $A 1 for average daily gain (ADG) and backfat (BF), $A 18 for feed conversion ratio (FCR), $A 3 for the carcass and meat quality traits weight of the slash boned ham (LMW) and colour (MC) and $A 12 for insulin-like growth factor I (IGF-I). Recording of litter size is a standard management practice and therefore no costs occur related to the breeding program. Usual biological parameters are assumed.

The breeding objective includes ADG, FCR, LMW, drip loss percentage (DLP) and litter size (NBA) with economic weights of 0.09, -28.0, 3.75, -3.75 and 4.00, respectively. Traits used as selection criteria are ADG, BF, FCR, LMW, MC, IGF-I and NBA. Genetic parameters between these traits were taken from Hermesch (1996) and Bunter (1996). The selection criterion IGF-I has a heritability of 0.20 and a phenotypic standard deviation of 25.1. Genetic correlations between IGF-I and other traits used in this study are -0.38 for ADG, 0.24 for BF, 0.66 for FCR, -0.43 for LMW, -0.22 for DLP, -0.11 for MC and -0.26 for NBA. FCR and IGF-I are recorded on one male per litter in the dam lines and two males per litter in the sire lines. Three females per litter are tested for IGF-I.

2.4. Evaluated recording schemes

A basic breeding program is defined and evaluated first. Alternative strategies are then compared in regard to returns, costs and profit per sow in the total population. In scheme one FCR is recorded in boars but no animals are tested for IGF-I. In scheme two IGF-I is recorded in boars in all lines. Within scheme three IGF-I is measured on all performance recorded animals and in scheme four the cost of measuring IGF-I are reduced to 50 % ($A 6). Furthermore, in schemes five to seven FCR is not recorded and the effect of a lower genetic correlation between FCR and IGF-I is investigated.

3. Results and Discussion

3.1. Different recording strategies for IGF-I

For scheme one returns and costs per sow in the total population are $A 32.10 and $A 8.63, respectively, leading to a profit per sow of $A 23.47 (Table 1). Measuring IGF-I in boars (scheme two) increases the returns by $A 3.67, whereas the costs increase by $A 0.71. Therefore, profit increases by $A 2.96 to $A 26.43 per sow equivalent to 113 % in comparison to scheme one. This scheme requires additional costs due to measuring IGF-I of $A 21,120. This scheme is favourable when funds available for investment are limited. The cost-benefit-ratio, the gained profit per invested dollar in measuring IGF-I, is 1:4.1. When IGF-I is measured on all performance-tested purebreds, boars and sows (scheme three) an investment of $A 72,000 is required due to the higher number of tested females. Although the cost-benefit ratio decreases to 1:1.7, profit per sow increases by $A 4.07 or 17 % in comparison to scheme one.

When the cost of IGF-I recording was assumed to be $A 12, this accounted for 25 % of the overall costs. A cost reduction to $A 6 per IGF-I recording leads to a decrease in these costs and a $A 1.54 increase in the profit in scheme six to $A 29.08 (124 %).

3.2. Effect of measuring IGF-I without recording FCR

In scheme five the same number of animals as in scheme three are measured for IGF-I but feed conversion ratio is not recorded. As a result, $A 39,600 less costs occur. This change leads to a decrease in returns and costs of $A 0.66 and $A 0.11, respectively. As a consequence overall profit increases by $A 0.45 to $A 27.99 equivalent to 119 % in comparison to scheme one. To calculate the cost-benefit-ratio the cost savings without FCR recording have to be subtracted from the costs of measuring IGF-I resulting in a cost-benefit-ratio of 1:4.1 when compared with one. Therefore, profit for a cross-breeding program can be increased through cost reduction by measuring IGF-I instead of FCR.

Table 1. Comparison of different applications of IGF-I measurements on males and females in dam and sire lines and F_1-boars as well as exclusion of FCR measurements under the assumption of different genetic correlations for a four way cross breeding scheme

Scheme	IGF-I m. / f.	$r_{g\ FCR/IGF-I}$	FCR tested	Returns [1] $A	Costs [1] $A	Profit [1] $A	Profit %	Costs [2] $A	CBR [3] 1:
1	-- / --	.66	x	32.10	8.63	23.47	100	0	---
2	x / --	.66	x	35.77	9.34	26.43	113	21,120	4.1
3	x / x	.66	x	38.59	11.05	27.54	117	72,000	1.7
4	x / x	.66	x	38.59	9.51	29.08	124	36,000 [4]	4.6
5	x / x	.66	--	37.93	9.94	27.99	119	32,400 [5]	4.1
6	x / x	.55	--	35.98	9.94	26.04	111	32,400 [5]	2.3
7	x / x	.44	--	34.25	9.94	24.31	104	32,400 [5]	0.8

m. = male tested, f. = female tested, [1] Per sow in the total population, [2] Costs of recording IGF-I, [3] Cost-benefit-ratio, [4] $A 6 per IGF-I recording, [5] Costs of recording IGF-I minus costs for FCR recording in preceding schemes

3.3. Effect of different genetic correlation between IGF-I and FCR

Because genetic parameters are population specific the results for the same breeding scheme can be different. This fact is especially valid for genetic correlations. Reducing the genetic correlation between FCR and IGF-I from 0.66 to 0.55 (scheme six) has no effect on costs, but the return decreases to $A 35.98. Consequently, the profit decreases to $26.04 (111 %). Reducing the correlation to 0.44 (scheme seven), the profit decreases further to 104 % in comparison to scheme 1. The cut-off point in comparison to scheme one, where IGF-I is not measured at all, will be at a genetic correlation of 0.40 between FCR and IGF-I. With this low genetic correlation it can not be economically justified to measure IGF-I but not FCR. In a scheme where FCR is recorded the threshold of the genetic correlation for using IGF-I would be higher.

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