Expected genetic gain using lactation efficiency and its components in a breeding program in dam lines

R. Bergsma[1] and E.F. Knol

[1] Correspondence: Institute for Pig Genetics, P.O. Box 43, 6640 AA Beuningen, The Netherlands; phone: 0031 246779999; fax: 0031 246779800; E-mail: Rob.Bergsma@IPG.nl

1. Introduction

Genetic and management changes during the last decades have increased litter size and milk production of sows. Because the nutritional and energy requirements of lactating sows are closely related to milk production these requirements of sows have increased as well. At the same time, the amount of body reserves of young sows to support extra requirements has decreased because of selection against fatness. Voluntary feed intake of lactating sows has not increased in proportion with the higher energy requirements (Noblet et al., 1998), or may even have decreased (Kerr and Cameron, 1996). A loss of body reserves is the result. Numerous experiments were performed in this area to influence reproductive traits, especially weaning to oestrus interval (Clowes, 2003). Inadequate feed intake during lactation is particularly evident in primiparous sows because relative to multiparous sows they need extra energy for body weight gain.

An obvious solution would be to increase the feed intake capacity of sows. Another alternative solution is to improve efficiency of feed during lactation. Bergsma et al. (2006) described an energetic model of lactating sows, where the different energy sources of the input (feed and body reserves) and the output (lipid- and protein deposition of piglets and maintenance) are taken into account. The trait lactation efficiency was introduced.

To include new traits, like lactation efficiency and its underlying components, in a breeding goal, genetic parameters are necessary. Only a few experiments were carried out to obtain them (Grandinson et al., 2005; Damgaard et al., 2003). Their research covered only a part of the genetic parameters needed. To fill the gap Bergsma et al. (2006a) estimated heritability's and genetic correlations for lactation efficiency, its components and the most common reproduction traits.

The aim of the current study was to investigate whether or not the trait lactation efficiency and the different sources of variation of lactation efficiency can improve breeding programs for dam lines.

2. Material and methods

Lactation efficiency is defined as an energetic efficiency of sows. The higher the lactation efficiency the more of the available energy (input) is used for piglet growth (output). Schematically the energy metabolism of lactating sows is given in Figure 1 (Bergsma et al., 2006).

Genetic parameters were used from the experiment of Bergsma et al. (2006a). They performed univariate analyses to estimate the heritability and repeatability of lactation efficiency, its underlying components and some reproduction traits, and bivariate analyses to obtain the genetic and phenotypic covariances between traits (Table 1).

To predict the consequences of a modern breeding program on the present traits, the simulation program: SelAction was used (Rutten et al., 2002).

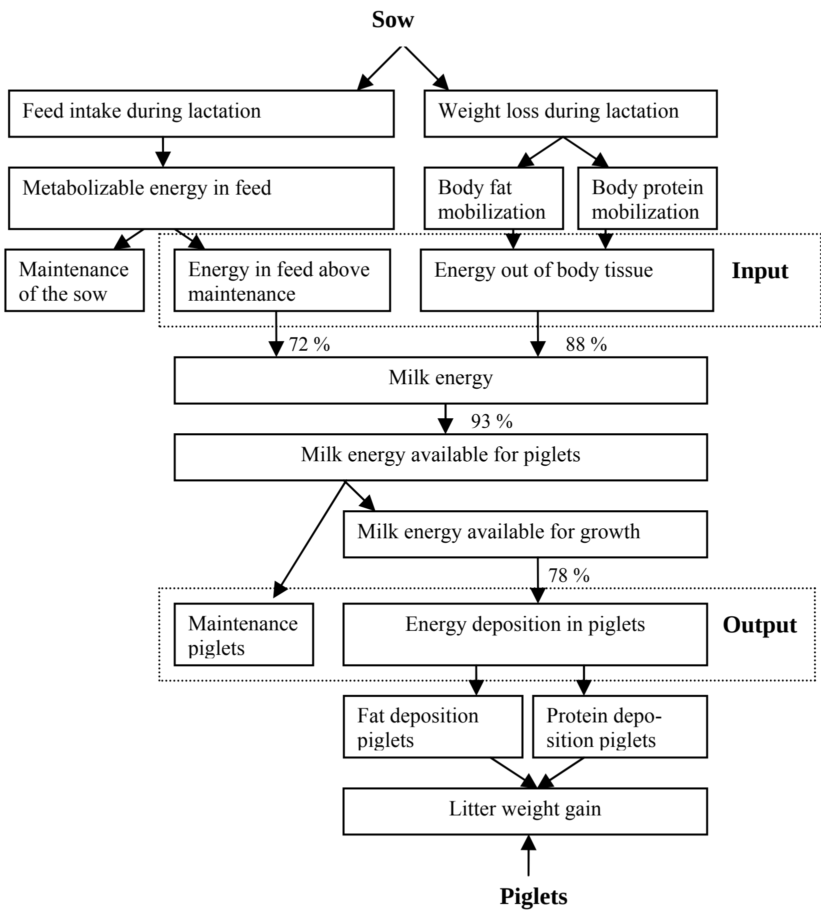

Figure 1. Schematic flowchart of the energy metabolism in lactating sows.

Genetic parameters

Table 1. Genetic parameters for the different traits. Heritability's on the diagonal (italic), correlations above the diagonal. Bold printed correlations differ significantly from zero ($p<0.05$).

	Total number born (#)	Litter mortality (%)	% Prolonged interval	Survival 1st litter (%)	Start weight (kg)	Fat mass at start (kg)	Feed intake ad lib (kg)	Weight losses (kg)	Fat losses (kg)	Litter weight gain (kg)	Lactation efficiency (%)
Total number born (#)	*0.13*	**+0.39**	-0.06	+0.12	-0.15	**-0.27**	+0.01	0.00	+0.11	**+0.45**	+0.09
Litter mortality (%)		*0.04*	+0.09	-0.20	-0.07	-0.13	-0.05	-0.10	-0.34	**-0.43**	-0.24
% Prolonged interval			*0.08*	-0.14	+0.24	+0.20	+0.18	+0.02	+0.22	+0.15	+0.10
Survival 1st litter (%)				*0.05*	**+0.50**	**+0.39**	**-0.60**	+0.29	+0.43	-0.23	+0.30
Start weight (kg)					*0.45*	**+0.71**	+0.18	-0.27	-0.25	-0.08	**+0.25**
Fat mass at start (kg)						*0.52*	+0.03	-0.21	+0.10	-0.13	-0.09
Feed intake ad lib (kg)							*0.30*	**-0.62**	**-0.85**	**+0.48**	-0.38
Weight losses (kg)								*0.20*	**+0.86**	+0.28	+0.08
Fat losses (kg)									*0.06*	+0.04	-0.18
Litter weight gain (kg)										*0.18*	+0.23
Lactation efficiency (%)											*0.12*

% prolonged interval is a binary trait. 100 when the interval weaning to oestrus exceeds the six days. Zero when sows were inseminated within one week after weaning. As a prediction of stayability the trait *1st litter survival* was introduced. *1st litter survival* is a binary trait. Definition starts from the moment of first insemination. When sows were inseminated after weaning their first litter, 1st litter survival = 100%. Otherwise 1st litter survival = 0%.

SelAction

A fictitious breeding program for a dam line was simulated:
- An active population of 5000 sows, with an annual replacement of 40%;
- 40 sires were used every year.
- 10% of the produced litters were purebred litters for which only second parity sows were used;
- Each sow produced 2.35 litters per year;
- Per purebred litter 3.5 female piglets and 2.1 male piglets were reared;

Two selection stages were assumed:
1. After rearing until puberty, BLUP selection of males and females was performed. After rearing, 40% of the males and 85% of the females were available for selection; Piglets that were not reared or were not available for selection at the end of the rearing period were selected for other reasons than the breeding goal.
2. After the 1st (crossbred) litter, females were selected to produce a purebred litter based upon own performance and those of her full- and half sibs. For males there was no second stage assumed.

These assumptions result in a 'proportion of selected male parents' of 0.041 and a 'proportion of selected female parents' of 0.400.

Three breeding goals were analysed:
- -1- Common: representing a common breeding goal for dam lines. This breeding goal was constructed to put 50% of the emphasis on total number born, 25 % on preventing litter mortality and 25% against a prolonged interval weaning – oestrus; To achieve this, economic values were chosen as given in Table 2. Only observations on traits included in the breeding goal were assumed to be available.
- -2- Litter weight gain only. This alternative was chosen to maximize output. Selection strategy -2- implies observations of litter weight at weaning and litter weight at birth. Observations on total number born, litter mortality and prolonged interval were assumed to be available too.
- -3- Common + Lactation efficiency. This breeding goal can give an answer to the question whether or not the trait lactation efficiency can improve breeding goals for dam lines. Observations on all evaluated traits were assumed to be available. Lactation efficiency was given the same economic weight as total number born by lack of proper derivation of the real economic weight.

Table 2. Input parameters for traits included in different selection strategies.

Trait	$\sigma^2_{phenotypic}$	h^2	Relative economic value		
			Strategy -1-	Strategy -2-	Strategy -3-
Total number born (#)	9.82	0.128	1.0000		1.0000
Litter mortality (%)	153.9	0.044	-0.4665		-0.4665
Prolonged interval weaning –oestrus (%)	981.2	0.077	-0.0683		-0.0683
Litter weight gain (kg)	105.4	0.176		1.0000	
Lactation efficiency (%)	112.7	0.122			1.0000

3. Results and discussion

Table 3. Simulated selection responses of different selection strategies using SelAction. Genetic progress per generation.

	Selection strategy[1)]			
	-1-	-2-	-1a -	-3-
	Index	Litter weight gain	Index full observations	Index incl. lactation efficiency
	50/25/25		55/34/11	31/22/11/36
Total number born (#)	**+0.19**	**+0.20**	**+0.30**	**+0.21**
Litter mortality (%)	**-0.21**	**-0.27**	**-0.39**	**-0.33**
Prolonged interval (%)	**-1.4**	**+0.5**	**-0.9**	**-1.2**
Stayability (%)	+0.6	-0.5	**+3.1**	**+3.9**
Weight start lactation (kg)	-0.6	-0.3	**-1.4**	**+0.1**
Fat mass start lactation (kg)	-0.3	-0.2	**-0.5**	**-0.4**
Weight loss during lactation (kg)	+0.1	+0.5	**+1.8**	**+0.4**
Fat loss during lactation (kg)	+0.03	+0.02	**+0.47**	**+0.11**
Feed intake ad lib (kg)	-0.14	+1.59	**-0.84**	**-0.42**
Litter weight gain (kg)	+0.6	**+1.4**	**+0.8**	**+0.8**
Lactation efficiency (%)	+0.2	+0.3	**+0.4**	**+1.0**

1) Bold printed selection responses, indicate that observations on that trait were part of the selection strategy.

The presented genetic progress is the progress per generation. The simulated breeding program will yield a generation interval of around 15 months.

Selection strategy -1-
Represents a basic breeding goal for dam lines. No major changes in traits other than the breeding goal traits occur according to the simulation, which is a reassuring observation in the light of discussion on negative consequences of current breeding programs (Table 3).

Selection strategy -2-
Implies a certain risk for the sow. Selection for weaning gain only will increase interval weaning – oestrus and modestly decrease stayability of the sow. Feed intake will increase.

Selection strategy -1a-
Uses the same index as strategy -1-. Extra observations on non breeding goal traits increase the reliability of the breeding values for breeding goal traits and therewith increase the genetic progress. In this simulation the effect of extra observations is given. Observations on all traits given in Table 3 were assumed to be available. Using these extra observations changes the emphasis on the different traits in the breeding goal. The effective emphasis on total number born becomes 55%, on litter mortality 34% and on % prolonged interval 11%.

Selection strategy -3-
Implies an extension of the observation protocol, exactly the same as in 1a. Results of both strategies show little changes in genetic progress of total number born and % prolonged interval weaning – oestrus. Litter mortality improves, stayability of the sow improves and (obviously) lactation efficiency improves. The effective emphasis on total number born became 31%, on litter mortality 22% on % prolonged interval 11% and on lactation efficiency 36%. Because of the intensive observation protocol the costs of such a breeding program are higher.

4. Conclusions

- A breeding goal for dam lines with emphasis on total number born, litter mortality and % prolonged interval weaning – oestrus will not change feeding behaviour and efficiency of the sow during lactation dramatically, a reassuring thought;
- Alternatively, genetic variation in stayability and lactation efficiency seems to be quite promising for genetic selection, maintaining genetic progress in current production traits. A heavier observation protocol is necessary with higher costs for the breeding program as a consequence.

5. Literature cited

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