Estimation of Direct and Service Sire Genetic Parameters for Reproductive Traits in Yorkshire

B. W. Kim, S. D. Kim[1], I. J. Lee[2], K. H. Chung[3], O. S. Kwon[1], J. K. Ha and J. G. Lee*
Division of Applied Life Science, Gyeongsang National University, Chinju 660-701, Korea

ABSTRACT : Direct and service sire genetic parameters for total number of pigs born (TNB), number of pigs born alive (NBA), total pig weight at birth (TWB), and average pig birth weight (ABW) were estimated by DF-REML under a multiple trait animal model. Data on 3,078 litters of the Yorkshire from Jan, 1975 to Dec, 1998 at National Livestock Research Institute were obtained. The animal model included fixed contemporary group effects and random additive direct, service sire, and residual effects. Additive genetic relationships among animals were included. A separate relationship matrix for service sires and their sire was also included. Additive direct heritability estimates for TNB, NBA, TWB, and ABW were 0.19, 0.18, 0.25 and 0.39, respectively. Service sire heritability estimates for TNB, NBA, TWB, and ABW were 0.02, 0.01, 0.02 and 0.01, respectively. The genetic and phenotypic correlations of TNB with NBA estimated in this study were 0.81 and 0.81, respectively, and the genetic and phenotypic correlations of TNB with TWB estimated were 0.82 and 0.76, respectively. Results indicate that service sires account for 1 to 2% of the total variation for TNB, NBA, TWB, and ABW. Further investigation is needed to determine whether the service sire effect is primarily genetic or environmental. ***(Asian-Aust. J. Anim. Sci. 2002. Vol 15, No. 9 : 1232-1236)***

Key Words : Service Sire Effect, Genetic Correlation, Litter Size, Litter Weight, Genetic Parameters

INTRODUCTION

Genetic evaluation has been conducted on reproductive traits, number born alive (NBA), as an aid to accelerate genetic improvement. This improvement requires knowledge on the heritability for the trait of interest. Variance component estimates are also needed for additional random effects that may be included in the genetic prediction model. These estimates are specific for a given population over a defined period of time (See et al., 1993). Both Mabry et al. (1988) and Feng (1991) reported that the service sire accounted for 3% of the total variation in NBA, and Buytels and Long (1991) found the service sire to be a significant effect, accounting for 1% of the total variation. Strang (1970) reported a significant effect due to the service sire on NBA that accounted for 0.3% of the total variation. With a reported range of 0.3 to 3% of the total variation in NBA, it seems that the service sire has a very small but significant effect on NBA in swine. Woodward et al. (1993) reported that the correlations between the 918 true and predicted sire breeding values was considerably lower for the animal model without a service sire effect than when it was included (0.53 vs 0.74, respectively). However, the difference was cut in half (0.66 vs 0.77) when only sire with greater than five daughter records were included. The high accuracy of the animal model with a random service sire effect indicates that the proposed model adequately accounts for the variation found in records for number of pigs born alive.

See et al. (1993) also reported that service sires were found account for 1 to 2% of the total variation for NBA. Genetic effects influencing NBA seemed to be small in these data sets, but selection for increased NBA was effective. Therefore, genetic effects of service sire genetic parameters on NBA are needed in selection program. The purpose of this study was to estimate direct and service sire genetic parameters for four litter sizes and litter weight traits in Yorkshires by a multiple trait animal model.

MATERIALS AND METHODS

Data

Reproductive traits were observed of the 3,078 litters of 2,101 sows farrowing between Jan, 1975 to Dec, 1998 at National Livestock Research Institute, RDA in Korea. The total number of animals in the pedigree file was 32,286. The traits included in simultaneous analysis were total number of pigs born (TNB), number of pigs born alive (NBA), total pig weight at birth (TWB), and average pig birth weight (ABW).

Data that were greater than three standard deviations from the mean were eliminated. The sow records with service sire record within three standard deviations from the mean were used. Number of records, year of birth, year of farrowing, season of farrowing, month of farrowing, and parity are presented in Table 1. The number of service sire and sow by year of farrowing are presented in Table 2.

* Address reprint request to J. G. Lee. Tel: +82-55-751-5509, Fax: +82-55-751-6113, E-mail: jglee@nongae.gsnu.ac.kr
[1] National Livestock Research Institute, Rural Development Administration, Cheonan 330-801, Korea.
[2] Darby Pig Breeding Co., Ltd. Anseong-city, Kyounggi-do 456-915, Korea.
[3] Institute of Agriculture and Life Science, Gyeongsang National University, Chinju 660-701, Korea.
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Table 1. Number of animals by year of birth, year of farrowing, season of farrowing, month of farrowing and parity

No. of records[1]	YS[2]	Year of Birth	No.[1]	Year of Farrowing	No.[1]	Season of Farrowing	No.[1]	Month of Farrowing	No.[1]	Parity	No.[1]
3,078	50	1974	243	1975	32	winter	1,376	1	10	1	881
		1975	124	1976	80	summer	1,702	2	94	2	626
		1976	55	1977	110			3	468	3	484
		1977	101	1978	132			4	440	4	365
		1978	93	1979	133			5	451	5	275
		1979	146	1980	87			6	179	6&7	306
		1980	81	1981	104			7	55	8&over	141
		1981	51	1982	99			8	159		
		1982	54	1983	88			9	408		
		1983	78	1984	68			10	450		
		1984	42	1985	59			11	285		
		1985	74	1986	62			12	79		
		1986	86	1987	73						
		1987	89	1988	68						
		1988	105	1989	76						
		1989	142	1990	110						
		1990	90	1991	109						
		1991	151	1992	108						
		1992	184	1993	138						
		1993	215	1994	241						
		1994	228	1995	269						
		1995	249	1996	263						
		1996	235	1997	264						
		1997	122	1998	237						
		1998	40	1999	68						
Total	50		3,078		3078		3,078		3,078		3,078

[1] Number of records including those with reproductive trait records.
[2] Number of records with year-season.

Statistical model

Although NBA is measured on the litter of a sow, it is considered a measurement of the sow's reproductive ability. The sow's influence on the performance of her offspring is not limited to direct genetic effects, but also includes maternal and permanent environmental effects. Ignoring maternal effects in a selection program for sow productivity could actually prevent genetic progress because of a negative relationship between direct and maternal effects (Southwood and Kennedy, 1990). However, there was very little change in rank when sire and gilt breeding values were estimated with direct-only and direct and maternal effects models (Southwood and Kennedy, 1991). Because of the difficulty in separating maternal effects on NBA from direct genetic effects on uterine environment, ovulation rate, embryo survival, and other reproductive functions, separate direct and maternal effects were not fit for NBA. The model used for estimation of direct and service sire effects' genetic parameters, in matrix notation, is

$$Y=Xb+Zu+Ws+e \quad \ldots\ldots [1]$$

where y is the vector of observations, b is a vector of fixed contemporary group effects, u is a vector of random additive direct a genetic effects, s is a vector of random service sire effects, and e is a vector of random residual effects particular to each litter. The matrices X, Z, and W are all incidence matrices relating litter records to the expectations of the random effects and are assumed to be zero. The variance-covariance matrix is as follows:

It is assumed that

$$\text{var}\begin{bmatrix}\mathbf{u}\\ \mathbf{s}\\ \mathbf{e}\end{bmatrix} = \begin{bmatrix} g_{11}\mathbf{A} & g_{12}\mathbf{A} & \mathbf{0} \\ g_{21}\mathbf{A} & g_{22}\mathbf{A} & \mathbf{0} \\ \mathbf{0} & \mathbf{0} & \mathbf{I}\sigma_e^2 \end{bmatrix}$$

Where

g_{11} =additive genetic variance for direct effects,

g_{22} =additive genetic variance for service sire effects.

g_{12}=additive genetic covariance between direct and service sire effects.

σ_e^2=residual error variance.

Table 2. Number of service sire and sow by year of farrowing and farrowing frequency

No. of records[a]	Year of farrowing	No. of records	No. of service sire	No. of sow
3,078	1975	32	6	32
	1976	80	6	51
	1977	110	7	60
	1978	132	8	75
	1979	133	12	77
	1980	87	11	61
	1981	104	7	62
	1982	99	10	55
	1983	88	9	52
	1984	68	7	54
	1985	59	6	41
	1986	62	7	45
	1987	73	9	51
	1988	68	11	54
	1989	76	10	56
	1990	110	12	76
	1991	109	12	72
	1992	108	10	75
	1993	138	11	105
	1994	241	18	164
	1995	269	26	210
	1996	263	32	210
	1997	264	38	197
	1998	237	30	166
	1999	68	12	65
Total		3,078	327	2,101

[a]Number of records including those with reproductive trait records.

The variance of vector is as follows

$$\text{Var}(y) = [\,Z\ W\,]\begin{pmatrix} g_{11}A & g_{12}A \\ g_{21}A & g_{22}A \end{pmatrix}\begin{bmatrix} Z' \\ W' \end{bmatrix} + I\sigma_e^2$$

The best linear unbiased estimator (BLUE) of estimable functions of b and the BLUP of u and s in equation [1] is obtained by solving the following mixed-model equations

$$\begin{bmatrix} X'X & X'Z & X'W \\ Z'X & Z'Z + A^{-1}\alpha_1 & Z'W + A^{-1}\alpha_2 \\ W'X & W'Z + A^{-1}\alpha_2 & W'W + A^{-1}\alpha_3 \end{bmatrix}\begin{bmatrix} \hat{b} \\ \hat{u} \\ \hat{s} \end{bmatrix} = \begin{bmatrix} X'y \\ Z'y \\ W'y \end{bmatrix}$$

(MME).

With

$$G = \begin{pmatrix} g_{11} & g_{12} \\ g_{21} & g_{22} \end{pmatrix}\quad G^{-1} = \begin{pmatrix} g^{11} & g^{12} \\ g^{21} & g^{22} \end{pmatrix}\quad \text{and}\quad \begin{pmatrix} \alpha_1 & \alpha_2 \\ \alpha_2 & \alpha_3 \end{pmatrix} = \sigma_e^2\begin{pmatrix} g^{11} & g^{12} \\ g^{21} & g^{22} \end{pmatrix}$$

Genetic evaluation of reproductive traits in swine have been performed by using an animal model which included additive direct and service sire genetic effects as random effects (e.g., Woodward et al., 1993; See et al., 1993).

Parameter estimation

Derivative-free REML estimation of variance and covariance components was performed using MTDFREML (Boldman et al., 1995) with 10^{-9} of simplex variance stopping criterion. Restricted maximum likelihood is generally recognized as the method most able to avoid biases due to selection (Henderson, 1986; Searle, 1989). Variance components were estimated using the solution obtained from the model, with relationships including service sire.

RESULTS AND DISCUSSION

The means and their standard errors for four traits are presented in Table 3. Variance components and the proportions of the total variation that accounted for service sire genetics are presented for four traits in Table 4. Estimates of variance on service sire components were very similar to those reported by Buytels and Long (1991) from data set collected from 26 Australian farms. Heritability, genetic correlations and ratio of contribution for four traits are presented in Table 5.

Woodward et al. (1993) reported that the high accuracy of the animal model with a random service sire effect indicates that the proposed model adequately accounts for the variation found in records for number of pigs born alive.

See et al. (1993) also reported that service sires were founded account for 1 to 2% of the total variation for NBA. Genetic effects influencing NBA seemed to be small in these data sets, but selection for increased NBA should be effective.

Often simultaneous selection for two or more traits is recommended to improve overall economic response. For example, in swine breeding, improvement of litter size results in reduction of piglet birth weight which in turn increases pre- and postnatal mortality and decreases early postnatal growth (Roehe, 1998).

The proportion of the total variation for four traits due to service sire in Yorkshire was TNB 0.02 (TNB), 0.01 (NBA), 0.02 (TWB), and 0.01 (ABW) and those were in close agreement with previous studies.

Both Mabry et al. (1988) and Feng (1991) reported that the service sire accounted for 3% of the total variation in NBA, and Buytels and Long (1991) found the service sire to be a significant effect, accounting for 1% of the total

Table 3. Least square means on the traits observed and their standard errors

Source	TNB[a]	NBA	TWB	ABW
	heads	heads	kg	kg
LSmeans	10.066	9.170	12.005	1.201
Standard errors	0.050	0.046	0.061	0.004

[a]TNB=Total number of born, NBA=Number of born alive. TWB=Total weight at birth, ABW=Average pig birth weight.

Table 4. Genetic and environmental variance for each traits by model with direct genetic and service sire effects

Traits	σ_a^2 [a]	σ_{ass}	σ_{ss}^2	σ_e^2	σ_p^2
TNB	1.350	0.044	0.1086	5.532	7.034
NBA	1.175	0.003	0.077	5.108	6.363
TWB	2.712	-0.126	0.257	7.961	10.805
ABW	0.0141	0.001	0.0001	0.021	0.036

[a] σ_a^2=Direct genetic variance, σ_{ass}=Covariance between direct genetic and service sire effects, σ_{ss}^2=Service sire variance, σ_e^2=Error variance, σ_p^2=Total variance.

Table 5. Heritability, genetic correlations and ratio of contribution for each traits by model with direct genetic and service sire effects

Traits	h_a^2 [a]	h_{ss}^2	r_{ass}	ρ_e
TNB	0.19	0.02	0.11	79
NBA	0.18	0.01	0.01	80
TWB	0.25	0.02	-0.15	74
ABW	0.39	0.01	0.54	58

[a] h_a^2= Direct genetic heritability, h_{ss}^2=Service sire heritability. r_{ass}=Correlation between direct genetic and service sire effects. ρ_e=Ratio of contribution by error.

variation. Strang (1970) also reported a significant effect due to the service sire on NBA that accounted for 0.3% of the total variation. With a reported range of 0.3 to 3% of the total variation in NBA, it seems that the service sire has a very small but significant effect on NBA in swine. Van Vleck and Johnson (1980), in a study on the effect of service sire on dairy cattle milk production, found that the service sire accounted for 1% of the variation in milk yield and that the correlation between the service sire and sire of the cow was nearly zero.

However, Van Vleck and Johnson (1980) concluded that the genetic and economic implications of the service sire effect were not important probably. The service sire could influence NBA either by semen quality and quantity or by genetic effects that influence embryo development and survival. Further research is needed to investigate whether the service sire effect is largely genetic or environmental, whether a covariance exists between the service sire and the sire of sow, whether direct selection on service sire can improve NBA, and whether improvements in accuracy of breeding value prediction can be made by including this effect in the prediction model (See et al., 1993).

The NBA showed the positive genetic relationship with TNB (0.84) and TWB (0.82), but negative with ABW (-0.25) (Table 6). The NBA showed the positive phenotypic relationship with TNB (0.86) and TWB (0.81), but negative with ABW (-0.01). Especially, negative genetic correlation estimates were obtained between ABW and the other TNB and NBA.

Table 6. Genetic (below diagonal) and phenotypic (above diagonal) correlations among the four traits observed

Traits	TNB[a]	NBA	TWB	ABW
TNB		0.86	0.76	-0.22
NBA	0.84		0.81	-0.01
TWB	0.82	0.81		0.42
ABW	-0.25	-0.06	0.29	

[a] TNB=Total number of born, NBA=Number of born alive. TWB=Total weight at birth, ABW=Average pig birth weight.

CONCLUSION

As a conclusion, the service sire effect showed 1 to 2% heritabilities, and it could be considerable in terms of low heritabilities in reproductive traits. However, there could be various effects influencing reproductive traits, further research is needed to find out whether the service sire effect is genetic or environmental.

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