January 2002

Reproductive Responses in the NE Index Line

Rodger K. Johnson
University of Nebraska-Lincoln, rjohnson5@unl.edu

D. B. Petry
University of Nebraska-Lincoln

Reproductive Responses in the NE Index Line Estimated in Pure-line and Crossbred Litters

D. B. Petry
R.K. Johnson[1]

Summary and Implications

The NE Index Line (Line I) has been selected since 1981 only for litter size and as a pure-line has 3.5 to 4 more pigs per litter than its randomly selected control (Line C). Line I has been released to the industry where it is being used in crossbreeding applications, but whether the response realized in the pure-line is expressed in crossbreeding applications is not known. The objective of this experiment was to estimate responses in reproduction in Line I in pure-line sows, in pure-line sows mated to produce F_1 litters and in F_1 sows mated to produce three-way cross litters. A total of 850 litters were produced over six-year seasons. There were 224 pure-line I and C litters, 393 F_1 litters produced from I and C females mated with Danbred® USA Landrace (L) or DH (T) boars, and 233 litters by IxL and CxL females mated with T boars. Contrasts of means were used to estimate the genetic difference between I and C and interactions of line differences with mating type. Farrowing rate of Lines I and C (93.3 vs 91.8%) did not differ. Averaged across all groups, mean number born alive per litter and number and weight of pigs weaned per litter, both adjusted for number nursed and weaning age of 12 days, were 10.1 pigs, 9.7 pigs, and 75.9 lb, respectively. Direct genetic effects of I were greater ($P < 0.05$) than C for total born (3.53 pigs), number born alive (2.53 pigs), number of mummified pigs (0.22 pigs), and litter birth weight (4.72 lb). Line I was less than C ($P < 0.05$) for litter weaning weight (–4.15 lb). However, interactions of line effects with crossing system were significant. In pure-line litters, I exceeded C by 4.18 total pigs and 1.76 stillborn pigs per litter; whereas in F_1 litters the difference between I and C was 2.74 total pigs and 0.78 stillborn pigs per litter. The contrast between I and C for number weaned and litter weaning weight in pure-line litters was 0.32 pigs and -0.62 lb, respectively, compared with 0.25 pigs and -4.72 lb in F_1 litters. Reproductive performance of Line I substantially exceeds that of the control line. Although the response realized in crossbreeding applications was somewhat less than in the pure-line, crossbreeding is an effective way to utilize the enhanced reproductive efficiency of the Index line.

Background

Population

The populations studied were the NE Index line that has been selected for increased litter size and its control line. The base population of Large White and Landrace was formed by reciprocally crossing boars and sows of the two breeds in 1979. Random mating of the F_1 and F_2 was used to produce F_3 litters that were born in 1981. These litters, designated Generation 0, were randomly assigned to the Control line (C), that was randomly selected, or the Index line (I), that was selected for an index of ovulation rate and embryonic survival. Selection during Generations 12 through 14 in I was on number of fully formed pigs per litter at birth. During Generations 15 and 16, I was selected for number born alive and birth weight.

Mating Design

The experiment reported herein used pigs from eight different genetic backgrounds that included pure Line I and C pigs and pigs produced by crossing lines I and C with Danbred® USA Landrace (L) and the 3/4 Duroc x 1/4 Hampshire terminal sire (T). Pure Line-I and Line-C Generation 16 gilts were randomly assigned to be mated naturally to boars of their own line or to be inseminated with semen of L to produce Generation 17 I x I, L x I, C x C, and L x C litters. Artificial insemination was used to produce crossbred litters because the biosecurity policy at the experimental farm prohibited introduction of live boars. Lines I and C were maintained throughout the selection experiment with 15 boars per generation and a 3:1 sow-to-boar ratio. Labor was not available to train and collect semen from pure-line I and C boars so natural service was used to produce pure-line litters. A random sample of I and C sows was retained after weaning their litters and inseminated with semen of T to produce T x I and T x C litters at their second parity. Sows were culled after weaning their second litter.

Pure-line and F_1 gilts from the first litters were retained for breeding to produce Generation 18 progeny. Pure-line females were again randomly

(Continued on next page)

assigned to be mated naturally to boars of their own line or to be inseminated with semen of L boars. F_1 females were inseminated with semen from T boars. Genetic types produced in Generation 18 were I x I, L x I, C x C, L x C, T(L x I), and T(L x C). A random sample of both pure-line and F_1 sows was retained after weaning their litters and inseminated with semen of T boars to produce T x I, T x C, T(L x I), and T(L x C) litters at their second parity. No pigs in these litters were retained for breeding and all sows were culled after weaning their second litter.

Pure-line and F_1 gilts from Generation 18 were retained and mated according to the same design as used to produce Generation 18 litters. After weaning these litters, a random sample of sows was retained for a second litter. Pure-line I and C sows were inseminated with semen of L boars, and F_1 gilts were inseminated with semen of T boars. The mating design by generation and parity, and the number of litters produced are illustrated in Table 1.

Table 1. Number of litters of each group produced per year/season

Genetic group[a]			Year/season					
Sire	Dam	Litter	1998/1	1998/2	1999/1	1999/2	2000/1	2000/2
C	C	C	36		39		35	
I	I	I	44		35		35	
L	C	L x C	45		35		26	24
L	I	L x I	49		27		25	20
T	C	T x C		47		32		
T	I	T x I		43		20		
T	L x C	T (L x C)			43	18	37	22
T	L x I	T (L x I)			43	17	33	20

[a]C = Control, I = Index, L = Danbred® USA Landrace Sire, T = Danbred® Duroc-Hampshire Terminal Sire.

Selection

Selection of pure Line-I gilts and boars was done by ranking litters on number born alive. Line-I boars were selected from the 15 largest litters. The two boars with the greatest birth weight were selected from each litter. One was designated a breeder and the other an alternate. Gilts were selected similarly; however because more gilts were needed, they were selected from the upper 50% of the litters for number born alive. Within these litters, gilts with low birth weight were culled and a maximum of four gilts per litter was selected. Replacements in C were selected randomly within paternal half sib family (boars) and litters (gilts) to give 15 breeding boars and the necessary number of gilts each generation.

Data

A total of 850 litters over six seasons, consisting of 224 pure-line, 393 F_1, and 233 3-way crosses, was studied. Farrowing rate (FR) was calculated as the percentage of females designated for breeding that farrowed a litter. Number of fully formed pigs (FF), number born alive (BA), numbers of stillborn (SB) and mummified piglets (MUM), and litter birth weight (LBW) were recorded at birth of litters. Number weaned (NW) and weight of the litter (LWW) were recorded at weaning.

Statistical Analysis

Farrowing rate was analyzed with a chi-square test. Birth and litter traits were analyzed with general linear models that included year/season/genetic group. Litter weight was recorded as a trait of the dam. Because crossfostering of pigs among different genetic groups occurred, procedures were used to account for genetic makeup of pigs nursed by dams, age when pigs were weaned,

Table 2. Estimates of contrasts among means for traits measured at birth and for traits measured at weaning.

	Traits measured at birth[b]					Weaning traits[c]	
Contrast[a]	FF	NBA	SB	MUM	LBW (lb)	LWW (lb)	NW (pigs)
I – C	3.53** ± .30	2.53** ± .30	0.99** ±0.18	0.22** ± 0.06	4.72** ± 0.77	-4.15* ± 1.61	-0.26 ± 0.16
R:P – F_1	-1.21* ± 0.57	NS	-.75** ± 0.33	NS	NS	12.52** ± 3.90	1.80** ± 0.39
$(I – C)_P$	4.18** ± 0.39		1.76** ± 0.22			-0.62 ± 1.10	0.32** ± 0.11
$(I – C)_{F1}$	2.75** ± 0.30		0.78** ± 0.18			-4.72** ± 1.81	-0.56** ± 0.18
F_1 – P	-0.83** ± 0.28	-0.52 ± 0.28	-0.30 ± 0.16	-0.05 ± 0.06	1.08 ± 0.73	12.24** ± 1.19	0.25* ± 0.12
T – F_1	1.71** ± .29	1.51** ± 0.29	0.21 ± 0.17	-0.03 ± 0.06	7.65** ± 0.73		

[a]I – C estimates the overall effect of the index line vs the control.
R: $_{P – F1}$ tests the interaction of selection response between I and C in pure-line dams with pure-line litters vs pure line dams with F_1 litters.
$(I – C)_P$ estimates the difference between index and control when measured in pure-line litters produced from pure-line dams.
$(I – C)_{F1}$ estimates the difference between index and control and when measured in F_1 pigs produced from pure-line dams.
F_1 – P is the difference between averages of F_1 litters by pure-line dams and pure-line line litters by pure-line dams.
T – F_1 is the difference between averages of 3-way cross litters produced from F_1 dams and F_1 litters produced by pure-line dams.
[b]FF = Number of fully formed pigs, NBA = Number of pigs born alive, SB = Number of stillborn pigs, MUM = Number of mummified pigs, LBW = Litter birth weight.
[c]LWW = Litter weaning weight, NW = Number weaned.
se = Standard error.
** P < 0.01, *P < 0.05, NS = Not significant (P > 0.05).

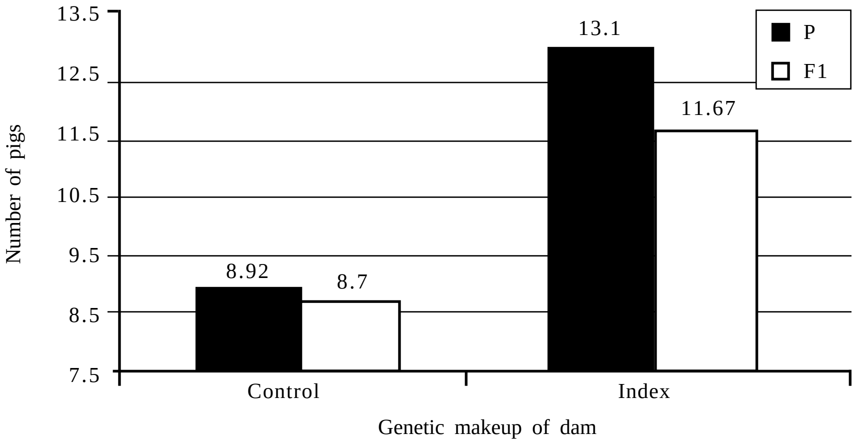

Figure 1. Number of fully formed pigs per litter for pure-line Control and Index dams with pure-line litters (P) and pure-line dams with F_1 litters (F_1).

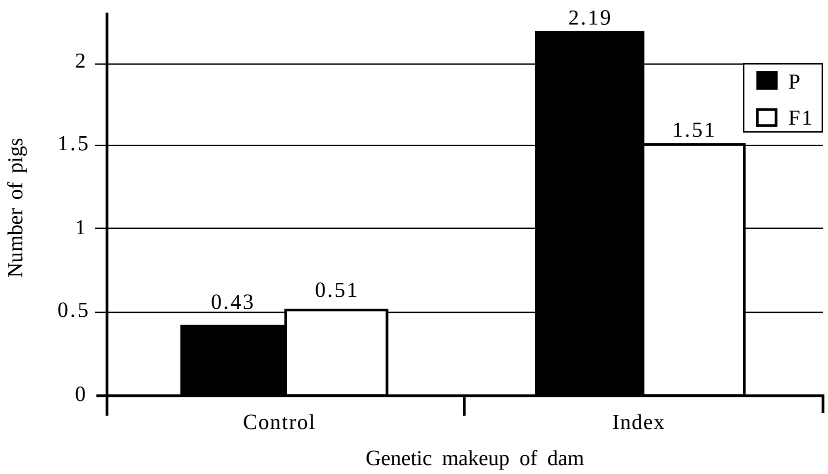

Figure 2. Number of stillborn pigs per litter for pure-line Control and Index dams with pure-line litters (P) and pure line dams with F_1 litters (F_1).

and number of pigs in the litter after crossfostering was completed. Therefore, number weaned and litter weaning weight are traits of the sow as if they were nursing the same number of pigs of the same genetic makeup. Contrasts were used to estimate differences in the overall effect of I vs C and to test whether the response was different in pure line, F_1 and three-way cross litters. Also, the effect of crossing was estimated as the average difference between pure-line, F_1 and three-way cross litters.

Results and Discussion

Line I and C did not differ in farrowing rate. Thus, no correlated response in fertility from selection for litter size in Line I was detected. The overall mean farrowing rate was 90.8%. A slight reduction in farrowing rate occurred when pure-line females were mated to L boars. The average difference in farrowing rate between pure-line females mated pure and those mated AI to L boars was 10.6%. This reduction is not likely a genetic effect of line of service sire, but could have been caused by AI techniques. Pure-line dams artificially inseminated to produce F_1 litters had 8.6% lower farrowing rate than F_1 dams producing three-way cross progeny.

Contrasts were designed to estimate effects due to genetic makeup of the dam. Season and line of pig the dam produced were confounded (see Table 1), so differences could not be averaged across all subclasses. Differences between I and C within interaction subclasses (pure-line, F1 and 3-way) were estimated only if an interaction was detected ($P < 0.05$). Table 2 contains contrasts among means for traits measured at birth.

Responses to selection for increased litter size were 3.53 $\pm$ .30 ($P < 0.0001$) fully formed pigs, 2.53$\pm$ 0.30 ($P < 0.0001$) live pigs, 0.99$\pm$ 0.18 ($P < 0.0001$) stillborn pigs, and 0.22 $\pm$ 0.06 ($P < 0.01$) mummified piglets per litter. The difference in litter birth weight between I and C was estimated to be 4.72 $\pm$ 0.77 lb ($P < 0.0001$).

An interaction of selection response (I minus C) with mating group occurred ($P < 0.05$). The response in I for fully formed pigs when measured in pure-line dams producing pure-line pigs was 4.18 $\pm$ 0.39 ($P < 0.0001$) pigs and when measured in pure-line dams producing F_1 pigs response was 2.75$\pm$ 0.30 ($P < 0.0001$) pigs. The difference between I and C in number of stillborn pigs per litter measured in pure-line dams producing pure-line pigs was 1.76 $\pm$ 0.22 ($P < 0.0001$) pigs, whereas the difference in pure-line dams producing F_1 pigs was 0.78$\pm$ 0.18 ($P < 0.0001$) pigs. Figures 1 and 2 illustrate these interactions.

Interactions were not significant for litter birth weight, which may explain the interactions for numbers of pigs. If uterine capacity allows only a certain weight of pigs to be carried to term, then pure-line pigs with F_1 litters, for which each individual pig was heavier, could produce that same weight with fewer pigs than pure-line dams with pure line

(Continued on next page)

pigs. It is also possible that better timing of insemination with ovulation occurred with natural matings used in pure-line production and that fewer eggs were fertilized when artificial insemination in F_1 production was used.

The average I and C F_1 litters produced from pure-line dams had fewer fully formed pigs (-0.83 $\pm$ 0.28; P < 0.01) than the average of pure-line I and C litters. A possible explanation is that pure-line dams producing F_1 progeny were inseminated artificially whereas pure-line progeny were produced with natural matings. Alternatively, uterine capacity may limit total weight of the litter so that litter birth weight is similar for pure-line dams with F_1 litters and pure-line dams with pure-line litters. F_1 dams with three-way cross pigs produced 1.71 $\pm$ 0.29 more fully formed pigs, 1.51 $\pm$ 0.29 live pigs and 7.65 $\pm$ 0.73 lb more litter birth weight than pure-line sows with F_1 litters (P < 0.001). These increases are due to heterosis as three-way cross pigs produced from an F_1 dam express 100% individual and maternal heterosis whereas F_1 pigs produced from pure line dams express only 100% individual heterosis.

Correlated response in litter weaning weight to selection for increased litter size was –4.15 $\pm$ 1.61 lb (P < 0.05); however, no response in number weaned was detected. Both of these traits were adjusted for number of pigs after fostering. Litter weaning weight measures both weight and number of pigs; whereas number weaned measures survival rate. These results indicate better milking ability for C than for I sows, but survival rate of pigs was not affected.

An interaction on both number and weight of litters weaned in the expression of the selection response (I – C) when measured in pure-line dams vs F_1 dams occurred (P < 0.05). The response in F_1 dams was –4.72 $\pm$ 1.81 lb (P < 0.01) and response in pure-line dams was -0.62 $\pm$ 1.10 lb (P > 0.05). The response in number weaned in F_1 dams was -0.56 $\pm$ 0.18 pigs (P < 0.01) and in pure-line dams it was 0.32 $\pm$ 0.11 (P < 0.01) pigs. Figure 3 and 4 illustrate these interactions. Overall, F_1 dams had litters that weighed 12.23 $\pm$ 1.19 lb (P < 0.0001) more with 0.25 $\pm$ 0.12 (P < 0.05) more pigs than pure-line dams.

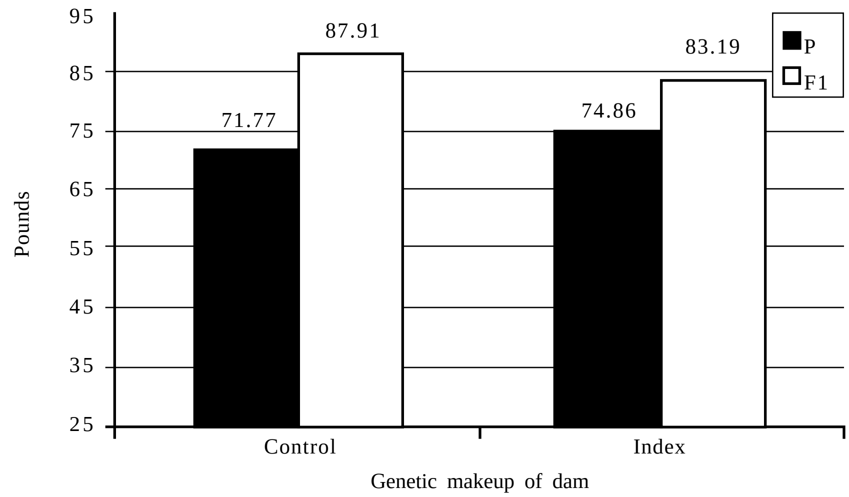

Figure 3. Weight of pigs weaned in standardized litters of pure-line Control and Index dams (P) and F_1 dams (F_1).

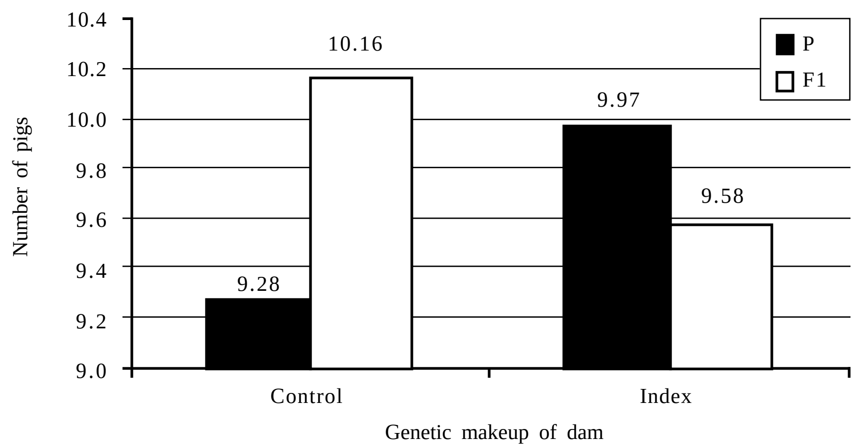

Figure 4. Number of pigs weaned per litter for pure-line Control and Index dams (P) and F_1 dams (F_1).

Conclusion

Responses for litter size in pure lines were consistent with estimates obtained after 14 generations of selection. Responses in included increased total number of pigs and number of live pigs at birth, but also increased incidence of stillborn and mummified pigs and decreased litter weaning weight. Crossbreeding reduced the incidences of stillborn and mummified piglets and litter weaning weight increased greatly in F_1 sows. Sow productivity of Line I at birth and weaning was improved with crossbreeding.

---

[1]D. Petry is a graduate student and technician and R. Johnson is professor in the Department of Animal Science.