EFFECTS OF RADIATION ON LITTER SIZE IN SWINE

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RADIATION of the male parent may influence the average litter size in the first generation by changes in the capacity of the sperm to fertilize and in the ability of the zygote to survive. The purpose here is to present the results from studies of the effects of paternal irradiation on the number born in two breeds of domestic swine.

MATERIALS AND METHODS

Pigs from the Duroc and Hampshire breeds were used for the experimental work. These breeds represent the two largest swine registries in the United States. A herd was assembled by purchasing breeding animals from farms in Iowa and neighboring states. Males were purchased for each breeding season as the work continued. Females were replaced by animals born in the experimental herd.

Studies of direct effects of radiation on sperm production were undertaken for information on the pattern of sperm production following irradiation of the testes and the timing necessary to insure that the sperm used in the matings had descended from irradiated spermatogonia. The objective of the work was to find the highest single dose of X rays that would meet the practical limitations of the available facilities and provide information on the genetic effects of spermatogonial irradiation.

Four levels of exposure, 0, 300, 600, and 900r, were chosen for the study. The X rays were produced by a 250 kvp machine and given in a single dose to the testes of 6-month-old males. The dose rate was approximately 100r per minute measured at the center of the testes. Details of the work have been reported (WILLHAM and COX 1961).

The main conclusion from this work was that 300r was the maximum dose that would allow sperm production and fertility to return 5 or 6 months after exposure and not exceed other practical limitations of the experiment. Sperm number was minimum about 60 days after exposure. Recovery occurred in each group, but, at higher levels of irradiation, some sperm counts were only 10 to 20 percent of the control level 7 to 8 months after treatment. Males remained healthy and sexually active after irradiation.

The experimental design provided for comparisons between progeny of irradiated and non-irradiated males within families related as double first cousins. A diagram of the mating plan is shown in Figure 1. Males were purchased in sets of two full brothers. One male in each pair, chosen at random, was exposed to X rays. Pairs of males were bred to several pairs of full sisters from the same breed. Female descendants of exposed and unexposed males were used in the breeding herd. No females were exposed to X rays, and no females were used whose maternal grandsire had been exposed to X rays. The experiment was not designed to detect completely recessive mutations but rather to assess the heterozygous effects of mutations induced by irradiation. The effect of a new mutation in heterozygous form may be small but the sum of such effects are of major importance in determining the mean fitness in random mating populations.

Analyses of radiation effects on the first generation used the groups of double first cousins as blocks. Blocks contained pigs born in the same farrowing season from matings of a single pair of brothers with several pairs of sisters. Female pairs in each farrowing season were grouped according to whether they had previously produced none, one, or more than one litter, and all female parents in a block were in one of these three groups. The experimental error used to

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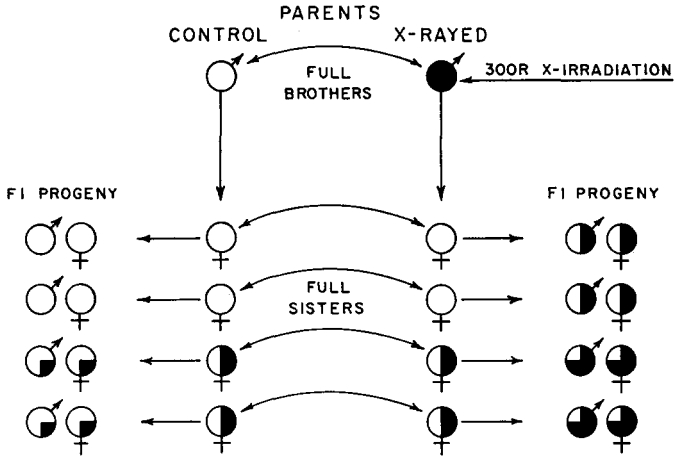

FIGURE 1.—Mating plan for double first cousin families. Two full brothers mated to several pairs of full sisters. Shading indicates relative proportion of genetic material exposed to X irradiation.

evaluate treatment effects was based on differences among paternal half-sib groups within the blocks. Statistical methods used were those appropriate to the analysis of two treatments randomized in blocks of two plots, with adjustments for a variable number of observations in each block.

Late fetal deaths found in various states of degeneration were included in the total number born. Comparisons were confined to the results from complete double first cousin families. Restricting the data to the complete cousin families eliminates the possible bias in using groups where one male of the pair did not reproduce or other types of imbalances, other than differences in litter size, occurred. The trends using all data followed the results given here for complete cousin sets.

RESULTS AND DISCUSSION

The analysis of differences between the number born in litters produced by control and irradiated brothers mated to pairs of sisters is given in Table 1. Duroc males exposed to X rays produced larger litters than their unexposed brothers.

TABLE 1

Effect of paternal irradiation on litter size at birth

Source	Duroc		Hampshire	
	Degrees of freedom	Mean square	Degrees of freedom	Mean square
Treatments (0 *vs.* 300r)	1	30.53	1	24.40
Blocks × Treatments	104	5.64	101	7.10
	Duroc		Hampshire	
Total litters	382		418	
Litter size (0r)	10.71		9.89	
Litter size (300r)	11.28		9.41	
Difference	−0.57 ± 0.24		+0.48 ± 0.26	
Probability based on F test	.025 > P > .01		.10 > P > .05	

Hampshire males exposed to X rays produced smaller litters than their unexposed brothers. The probability that the differences found in either breed have occurred by chance is small. The differences between the control and irradiated groups were studied separately for each breed and season. At least 21 litters were represented in each breed and season mean within each treatment. Duroc males exposed to X rays produced larger litters than their untreated brothers in each of the seven farrowing seasons. Hampshire males exposed to X rays produced smaller litters than their untreated brothers in five of the seven farrowing seasons. No significant differences were found between the effects of paternal irradiation in litters from females sired by irradiated males compared with females sired by unexposed males.

A previous report on this experiment inferred that paternal irradiation had no influence on litter size at birth (Cox and WILLHAM 1962). The numbers involved in previous studies were such that the small but contrasting differences within each breed were not considered important, and results from the two breeds were combined. However, paternal irradiation apparently did influence the litter size in the first generation, with the direction of the effect depending on the breed studied.

Data on conception rates showed that the percentage of first services resulting in conception was 6 percent higher for Duroc males exposed to X rays than for their unexposed brothers. The opposite trend was found in Hampshires; the rate for unexposed males was 3 percent higher than for their brothers exposed to X rays. These differences were not statistically significant but are in the same direction as the differential response of the breeds in the number born.

The nature of the effects makes hypotheses based on changes in fertilization rates more plausible than changes in embryonic or fetal survival due to induced mutations. However, explanations for the results given here require further experiments on the possible mechanisms involved.

Postnatal mortality is influenced by litter size. Therefore, differences in the number born between two groups of animals complicates the comparison of survival in the two groups. The percentage of the pigs born, excluding late fetal deaths, that survived to 42 days was 70.0 and 66.4 in the Duroc litters from unexposed and exposed males, respectively. The corresponding percentages in Hampshires was 68.7 and 70.2. The group with the higher initial litter size in each breed had the lower percentage surviving. A previous report of this work combined the results from the two breeds and concluded that paternal irradiation slightly increases postnatal mortality (Cox and WILLHAM 1962). That conclusion must now be reevaluated considering the initial breed and treatment differences in the number born.

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SUMMARY

A total of 382 Duroc and 418 Hampshire litters arranged in sets of double first cousins were used for an analysis of the effects of paternal irradiation on litter size at birth. One male from each pair of brothers used in the mating plan was exposed to 300r X irradiation 5 to 6 months before the matings were made. Litters from X-rayed Duroc males were 0.6 pigs larger than litters from their control brothers. Litters from X-rayed Hampshire males were 0.5 pigs smaller than litters from their control brothers. In each breed, the treatment group that had the highest initial litter size showed the higher percentage of mortality between birth and 42 days.

LITERATURE CITED

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