THE EFFECT OF PATERNAL IRRADIATION ON BODY WEIGHT AND DEPTH OF FAT IN PIGS¹

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Received September 28, 1967

THE average effect of irradiating spermatogonia on the quantitative traits of pigs in the first generation has been studied since 1960. In the first few replications of the work, significant but inconsistent effects of paternal exposure on body weight at 154 days were reported by WILLHAM and Cox (1962). Recent studies of the weight at birth did not detect any significant difference between progeny of irradiated males and contemporary controls (Cox 1967). The purpose here is to summarize the results on body weight and depth of fat in pigs 154 days old using data collected through 1966 when the main experiment was terminated.

MATERIALS AND METHODS

The animals were from a herd of pigs formed in 1959 by purchases from the Duroc and Hampshire breeds in Iowa and neighboring states. Matings were made so that animals were born in two 6-week periods each year, one during March and April, and the other during September and October. Only the animals that lived for at least 5 months after birth were used in this study. Observations on 21,038 pigs born over the 7-year period between 1960 and 1966 were included.

The basic experimental design was equivalent to a randomized block with two treatments. The blocks were double-first-cousin families formed by mating a pair of brothers with several pairs of sisters. The treatments were randomized over each pair of brothers; one received 300r X-irradiation and the other received no irradiation. The X-rays were given in a single exposure at approximately 100r per minute and at least 5 months before the males were used for breeding so that the progeny were descendants of irradiated spermatogonia (WILLHAM and Cox 1961).

The variance used to test for treatment differences in a randomized block experiment is the residual variance among the experimental units after removing the average effect of treatments and blocks. In this experiment the experimental units, the units to which treatments were randomly assigned, were the males. The treatment effects were measured in the offspring of the treated males. The appropriate error was based on differences among the means of paternal half-sib groups within the cousin families and not on the differences among individual pigs within the groups.

Males were purchased from herds in Iowa and used in only one mating period except in the first three periods when some males were used in two successive periods. The females purchased to begin the work were given an opportunity to produce two litters in successive seasons and then were replaced by animals born in the herd. Females saved for breeding came from litters by control and irradiated sires, but no females were saved from litters with irradiated maternal grandsires.

Each litter was raised in an individual 8-by-16 foot pen. All male pigs were castrated when they were about 10 days old. The dam was removed from the pen 6 weeks after the pigs were born. The pigs had access to feed and water at all times. The measurements studied were the

¹ Journal Paper No. J-5786 of the Iowa Agricultural and Home Economics Experiment Station, Ames, Iowa. Project No. 1424. This work has received assistance from Contract AT(11-1)-707 with the U.S. Atomic Energy Commission.

weight at 154 days and the depth of fat on the back as measured on the live animal at 154 days. The weights were recorded in tenths of pounds and transformed to kilograms. The fat was measured in tenths of inches at three sites, as described by HAZEL and KLINE (1952), and transformed to centimeters. The average depth of fat was adjusted for body weight as described by Cox (1963). The weight was adjusted for several factors before the analysis of treatment effects was made. The procedures used in the adjustment of the data are described with the results.

RESULTS AND DISCUSSION

The factors used to adjust the observations on individual pigs were taken from a least-squares analysis of the data and are given in Table 1. Constants were fitted for the effects of period of birth and sex in each breed. The model also included the regressions of weight at 154 days on weight at 42 days and on the number of pigs in the litter. The fat measurements were adjusted in each breed and sex by the linear regression of fat on weight within litters.

The differences in weight at 154 days between the periods of birth reflect seasonal differences and differences in herd management and health over the 7 years studied. Males were 4 to 5 kilograms heavier than females. The adjustments for weight at 42 days and the number of pigs per litter were made to reduce the contribution from maternal influences and the pen environment. Irradiation effects have been reported in the Duroc breed for the number born per litter (Cox 1964), but no significant differences were found at 42 days and later ages.

The adjusted data were analyzed with procedures appropriate for a randomized block experiment with two treatments and unequal numbers of observations

TABLE 1

Least squares constants and regressions used to adjust the weight and fat at 154 days

		Duroc	Hampshire
Weight (kg) mean		84.9	76.2
Constants for period of birth:	1960 Spring	+2.83	-4.36
	Fall	+1.99	-0.68
	1961 Spring	-7.41	-7.99
	Fall	-5.42	-2.12
	1962 Spring	+1.94	+4.63
	Fall	+2.58	+2.28
	1963 Spring	-0.49	+1.76
	Fall	+2.52	+4.05
	1964 Spring	-1.09	-1.05
	Fall	+4.60	+4.61
	1965 Spring	-3.51	-5.32
	Fall	+1.92	+4.44
	1966 Spring	-3.72	-7.01
	Fall	+3.26	+6.77
Constants for sex: male		2.47	2.08
female		-2.47	-2.08
Regression on weight at 42 days		3.31	3.31
Regression on litter size at 42 days		-0.10	0.00
Fat (cm) mean		3.32	2.61
Regression on weight at 154 days: males		0.0398	0.0318
females		0.0378	0.0308

(KEMPTHORNE 1952). The treatments were whether or not the pigs measured descended from irradiated spermatogonia. The unequal numbers arose from deaths, reproductive failure and the variability in litter size. A summary of the mean differences between the progeny of control and irradiated sires is given in Table 2. In each case, the progeny of the irradiated sires have less fat and weigh less than the progeny of the control sires. Three of the four differences are approximately equal to one standard error and do not approach conventional levels of statistical significance. The error variance is based on slightly more than 200 degrees of freedom in each comparison. The difference between the weights at 154 days of pigs from control and irradiated males in the Duroc breed is over twice as large as its standard error, and the probability that such a difference occurred by chance is between 0.05 and 0.01.

The data were further divided into two groups according to the treatment of the maternal grandsire. No evidence for the influence of maternal grandsire irradiation was found, and no consistent trend over the four treatment classes formed by sire and maternal grandsire treatment was evident. The difference between the weights of progeny from control and irradiated males in the Duroc breed was $+1.27 \pm 0.50$, when measured in litters with nonirradiated maternal grandsires, and $\pm 0.33 \pm 0.61$, when measured in litters with irradiated maternal grandsires.

In nine of the 14 periods of birth, pigs from nonirradiated males were heavier than pigs from irradiated males in the Duroc breed. The treatment difference in Durocs was consistently larger among pigs born in the spring and raised in the summer than for pigs born in the fall and raised in the winter. The average weight of all pigs raised in the summer was over 4 kilograms less than pigs raised in the winter. The stress of high temperature and humidity as well as intestinal disorders that are more prevalent in the summer was the most probable reason.

The total evidence for any detectable effect of paternal irradiation in these data is not strong. The one comparison that reaches the conventional level of statistical significance is found in the Duroc breed. A similar pattern of effects was reported for the number born by Cox (1964). The results do not allow generalizations concerning the consequences of spermatogonial irradiation on the body weight of the first generation. The differences in Duroc pigs were larger in periods where the average weight of all pigs was lower, indicating a possible relationship between the expression of germinal damage and environmental stress. However, the effect was not repeated in the Hampshire breed. Although the explanation of environmental stress enhancing the genetic effects of irradiation sounds plausible, it may be only a fortuitous trend in these data.

TABLE 2

Differences between pigs from control (C) and irradiated (X) males in traits measured at 154 days

Breed	Fat (cm)	Difference (C-X) Weight (kg)
Duroc	$+0.013 \pm 0.019$	$+0.85 \pm 0.40$
Hampshire	$+0.020 \pm 0.016$	$+0.35 \pm 0.37$

TABLE 3

*The variance within litters for traits measured at 154 days
Each variance based on approximately 2300 pigs from 340 litters*

Treatment of sire Treatment of maternal grandsire		0r 0r	0r 300r	300r 0r	300r 300r
Variance of weight (kg)	Duroc	79.4	75.1	81.9	80.4
	Hampshire	82.9	70.6	72.2	76.1
Variance of fat (cm)	Duroc	0.1900	0.1946	0.1898	0.1844
	Hampshire	0.1163	0.1001	0.1031	0.0933

The effect of paternal irradiation on the variability of the traits was studied by comparing the variance among pigs within litters in each treatment group. The data from the first two periods were omitted since they contained only two of the four treatment groups. The results are summarized in Table 3. The standard error of each estimate is about 2.3 kg, for the variance of weight, and 0.0043 cm for the variance of fat. No trends or consistent differences were found in the variances among the different treatment groups.

The results previously published by WILLHAM and Cox (1961), where significant but inconsistent differences due to sire irradiation were reported, have not been reproduced in subsequent replications of the work. Pooling the results from both breeds, the progeny from irradiated males weighed 0.60 ± 0.27 kilograms less than contemporary individuals from related but nonirradiated males. The comparison of depth of fat in the same two groups showed the descendants of irradiated spermatogonia to be 0.016 ± 0.013 centimeters less than the controls.

SUMMARY

The effect of spermatogonial irradiation on the weight and depth of fat at 154 days in the first generation was studied in over 21,000 pigs from two breeds. The pigs from irradiated spermatogonia weighed less and had less fat than contemporary controls, but the treatment effects were small and not significant except in Durocs where a shift of 0.85 kilograms, representing one per cent of the average weight, was detected. No significant trends in the variance among pigs within a litter were noted in the various treatment groups.

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