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Biology Laboratory
Hanford Laboratories
General Electric Company, Richland, Washington

For Submission to Nature.

* Work performed under Contract No. AT(45-1)-1350 between the General Electric Company and the Atomic Energy Commission.

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A long term study designed to determine the biological effects of daily Sr^{90} ingestion in miniature swine has been underway in this laboratory since 1958. The ultimate objective of this study is to provide data that will assist in defining for man the levels of dietary Sr^{90} at which there is no damage or negligible damage to him or his progeny. The animals being used in these studies are Pitman-Moore miniature swine which have a mature weight of 60 to 80 kg[(1)]. The dietary requirements, gastrointestinal tract, and bone mass of miniature swine are quite similar to man. These factors, along with a relatively long life span, dictated their use in this study.

In considering the long term effects of any toxic agent, one area of concern is the influence upon the reproductive performance of the individual. As evidenced by the large amount of pertinent data presented at a recent conference on this subject[(2)], an extensive amount of work has been done on the effects of radiation on reproduction. For the most part, these studies were performed on the smaller, commonly used laboratory species. Almost without exception, these experiments have utilized external whole-body gamma, neutron, or x-irradiation. This report summarizes some data on the reproductive performance of a large animal where the source of radiation is internal.

The basic experimental procedure as applied to each level of radionuclide feeding is shown in Table 1. A more detailed description of the experimental

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TABLE 1

BASIC EXPERIMENTAL PROCEDURE

Original females	Sr^{90} feeding initiated at nine months of age. Breeding to control male initiated at approximately nine and one-half months of age.
F_1 Generation	Sr^{90} available in utero via placental transfer; suckling period via the dam's milk; six weeks to three months of age, Sr^{90} fed at 1/4 the dam's level; three months to six months of age, Sr^{90} fed at 1/2 dam's level; six months of age, Sr^{90} fed at dam's level. Breeding to control male begun at nine months of age.
F_2 Generation	Same procedure as F_1 generation, except animals are not bred.

design and the procedures utilized was presented elsewhere[3]. Feeding levels used are 0, 1, 5, 25, 125, 625, and 3100 μc of Sr^{90} per day. At the two highest levels, the basic experimental procedure is not completed because of the early death of the original females and/or their offspring.

All animals are maintained in group housing, which is equipped with individual feeding facilities to control dietary intake. Sr^{90} is administered each day in a single large feed pellet with the morning aliquot of the ration.

All females scheduled for breeding are checked daily with a vasectomized male to determine if they are in estrus. Bred females are removed from group housing to individual farrowing pens approximately one week before they are due to farrow. All offspring are weighed shortly after birth.

No apparent differences have been noted in the frequency and duration of the estrus cycle or in the number of repeat breedings. Difficultues associated with parturition have been minimal in all groups.

Table 2 summarizes birth data on all litters born on the main Sr^{90} experiment. No differences in litter size are apparent at levels up to 25 μc Sr^{90}/day. The differences which are seen at the 125 μc and 625 μc Sr^{90}/day levels may be real; however, insufficient numbers preclude definitive conclusions. No great differences in average birth weight are noted between levels. At the 625 μc Sr^{90}/day level, there was a suggestion of change with one of the two litters born being of subnormal size, while the other was of normal size. Out of the litters (110) observed to date, only five offspring were stillborn, one control and two each at the 1 μc and 5 μc Sr^{90}/day levels; this is well within the normal range.

At the 3.1 mc Sr^{90}/day level, the animals succumb at about 100 days after initiation of the feeding, which does not allow time for a term pregnancy. At the time of the death of the animals, developing fetuses were observed. These fetuses appeared to be of normal morphology and size. A blood sample obtained from one of these fetuses was examined and exhibited normal values. Presumably, had the dam survived to term, viable offspring would have been born.

TABLE 2

LITTER SIZE AND BIRTH WEIGHTS OF ANIMALS IN Sr^{90} EXPERIMENT

	Adult Level of Sr^{90} Feeding (μc/day)					
	0	1	5	25	125	625
Number of litters	16	45	19	22	6	2
Average litter size ± Standard Deviation	5.6 ± 2.0	5.4 ± 1.5	5.2 ± 1.1	5.3 ± 1.7	4.0 ± 1.4	6.5
Number of offspring	89	242	98	117	24	13
Average birth weight in kg ± Standard Deviation	0.73 ± .16	0.69 ± .15	0.75 ± .13	0.69 ± .13	0.71 ± .12	0.61 ± .14

It can be generalized from the experimental data presented that for a large animal comparable in size to man, viable offspring of normal morphology will be born to females fed high levels of Sr^{90} daily if the animals survive long enough to allow pregnancy to go to term. It should be recognized that the limited data presented here for higher levels might not permit detection of subtle changes in reproductive performance which would be readily apparent with a larger number of animals. In this regard, it is intended that a more comprehensive statistical analysis of the data will be undertaken when additional data is available for the higher feeding levels.

These results are not surprising in view of the radionuclide under consideration and its metabolic and physical characteristics. Strontium, with a metabolic pattern analogous to calcium, concentrates almost exclusively in the osseous tissues of the animal. Further, Sr^{90}, with a half life of approximately 28 years, decays with emission of an 0.54 Mev beta particle. Its daughter, Y^{90}, with a half life of 64 hours, decays with emission of a 2.27 Mev beta particle. The range of these beta particles in bone is not great, about 1 mm for the higher energy beta and about 0.2 mm for the lower energy; in soft tissue, the range is somewhat greater.

On the basis of these physical factors, it is readily apparent that in a large animal essentially all of the radiation energy from absorbed Sr^{90} would be released in bone or adjacent tissue. Furthermore, since the reproductive tissues are not contiguous to bone, the radiation dose from this source would be negligible. Perhaps the greatest source of radiation to the reproductive tissues of the female will be from unabsorbed Sr^{90} in the gastrointestinal tract. Considering the thin wall of the gastrointestinal tract, the large percentage of ingested Sr^{90} that is not absorbed (about 90 per cent in the adult), and the proximity of the ovaries to the gastrointestinal tract, this may be a significant source of radiation.

Prelimiminary radiation dose measurements at the location of the ovary in an animal fed 3.1 mc Sr^{90} daily for about 100 days verified these assumptions.

Since the developing fetus has the thickness of the uterine wall and the placental membranes and fluids between it and the gastrointestinal tract, it is doubtful if radiation originating from the gastrointestinal tract would be significant to the fetuses. Undoubtedly the greatest source of radiation to the fetuses of a dam ingesting Sr^{90} is the Sr^{90} it incorporates into its own skeleton. The fetuses have the advantage of the various discriminatory processes between the dam and her bone or plasma against strontium relative to calcium, and in addition have the further discriminatory process of the placenta. The overall effect is such that only about one-eighth as much Sr^{90} relative to calcium is found in the fetal bone as is found in the adult[(4)]. The radiation dose rate to the fetal bone reflects this discrimination, so that the average radiation dose rate to the bone of a full term fetus at the 25 μc per day level is about 0.5 rad per day. Of significance, too, is that for earlier periods of fetal life when ossification is less complete, the dose rate would be much less. The same limitations of range of the beta particles that were pointed out for the adult animal apply to considerable degree for the fetuses, since at least in late stages in fetal life when ossification is progressing rapidly, the fetuses have obtained considerable size.

It is well to point out, however, that the above assumptions and the experiment to date only consider the effect of the radiation emitted by the Sr^{90} on the reproductive tissues or fetuses of the young adult swine. It is, of course, conceivable that if these females were bred later in life after a considerable radiation dose had been accumulated by the skeleton and associated tissues, the generalized debilitated condition of the animal might preclude normal reproduction or, possibly, if pregnancy were to occur, the associated stresses might jeopardize the life of the dam or offspring.

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REFERENCES

1. Horstman, V. G., Clarke, W. J., Hackett, P. L., Kerr, M. E., Persing, R. L., and Bustad, L. K. Hanford Biology Research Annual Report for 1959. HW-65500, 59 (1960).

2. International Symposium on the Effects of Ionizing Radiation on the Reproductive System, September 17-19, Colorado State University, Fort Collins, Colorado, 1962.

3. McClellan, R. O., Clarke, W. J., McKenney, J. R., and Bustad, L. K., 1962. Am. J. Vet. Res. 23, 910 (1962).

4. McKenney, J. R., Case, A. C., Clarke, W. J., Horstman, V. G., McClellan, R. O., and Bustad, L. K. Hanford Biology Research Annual Report for 1960. HW-69500, 25 (1961).

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