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The effects of irradiation from atomic bomb fall-out upon a group of Hereford cattle

James Merrill Bird

To the Graduate Council:

I am submitting herewith a thesis written by James Merrill Bird entitled "The effects of irradiation from atomic bomb fall-out upon a group of Hereford cattle." I have examined the final electronic copy of this thesis for form and content and recommend that it be accepted in partial fulfillment of the requirements for the degree of Master of Science, with a major in Animal Husbandry.

Charles S. Hobbs, Major Professor

We have read this thesis and recommend its acceptance:

Accepted for the Council:
Carolyn R. Hodges

Vice Provost and Dean of the Graduate School

(Original signatures are on file with official student records.)

March 4, 1952

To the Graduate Council:

I am submitting herewith a thesis written by James Merrill Bird entitled "The Effects of Irradiation from Atomic Bomb Fall-out Upon A Group of Hereford Cattle." I recommend that it be accepted for nine quarter hours of credit in partial fulfillment of the requirements for the degree of Master of Science, with a major in Animal Husbandry.

Charles S. Hobbs
Major Professor

We have read this thesis
and recommend its acceptance:

L V Skold

H. R. Duncan

R. J. Warwick

Accepted for the Council:

E. G. Watts
Dean of the Graduate School

THE EFFECTS OF IRRADIATION FROM ATOMIC BOMB FALL-OUT UPON A GROUP OF HEREFORD CATTLE

A THESIS

Submitted to
The Graduate Council
of
The University of Tennessee
in
Partial Fulfillment of the Requirements
for the degree of
Master of Science

by
James Merrill Bird

March 1952

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Special acknowledgement is due Mr. John R. Paysinger who assisted in gathering the data in this study, to Prof. Henry R. Duncan who graded the cattle, to Prof. Sam L. Hansard and Mr. M. P. Plumlee for the blood analysis, to Dr. John L. West and Major T. C. Jones for the Pathology studies, and to the Atomic Energy Commission which financed the study.

I wish also to thank Mr. Toliver Thomas and the other farm personnel who fed and cared for the cattle.

TABLE OF CONTENTS

(continued) PAGE

LIST OF TABLES

LIST OF TABLES (Continued)

LIST OF FIGURES

INTRODUCTION

A herd of grade Hereford cattle was accidentally exposed to radioactive particles from the first atomic bomb explosion near Alamagardo, New Mexico in July 1945. These cattle were purchased by the government and shipped to Oak Ridge, Tennessee, in December of that year to be maintained and observed. In the spring of 1948, Dr. A. H. Holland, Chief of the Office of Research and Medicine, for the Oak Ridge Operations of the Atomic Energy Commission, requested assistance from the University of Tennessee in developing a program for determining what effect, if any, this irradiation had upon these cattle. Because little was known about the effects of any type of irradiation on farm animals, and because of great possibilities that human beings as well as other farm animals might be exposed to similar irradiation, either from our own tests or from enemy action, Dr. Holland further expressed the need for a detailed study:

(a) To determine if there had been any irradiation damage to the germ plasm of the exposed animals.

(b) To determine the relative fertility of the exposed animals and their offspring.

(c) To determine the long-range effects which irradiation exposure may have on domestic animals.

(d) To identify, if possible, pathological changes occurring in the exposed animals.

(e) To determine whether or not malignant degeneration would occur in the keratosic lesions on the exposed cattle.

(f) To determine, by means of a control herd, whether or not the biological findings were significant.

As these cattle and the facilities at Oak Ridge offered a unique opportunity for the investigation and the accumulation of valuable biological information of great interest and importance to the Commission, the University and the public; a cooperative program was developed known as the UT-AEC Agricultural Research Program, with its primary objective being that of determining the effects of the bomb irradiation upon these cattle.

The background information concerning the irradiation of these cattle, and any other available information about the cattle, was requested by The University and Oak Ridge research workers, but was not available because it was part of the TOP SECRET report on the first atomic bomb explosion.

REVIEW OF LITERATURE

The medical profession has employed X-rays or roentgen rays and radium in the diagnosis and treatment of certain diseases for many years. Warren (1946) observed at Hiroshima and Nagasaki that the late effect of atomic bomb explosions were similar to those of X-rays.

Henson (1942) found that litter survival from male rats exposed to 100, 500, 1000 and 3000 r of X-radiation and mated to normal females was as follows: The embryonic litter survival values of progeny of males receiving 100 and 500 r was about one-half that of the controls. Litters sired by males receiving 1000 r had only about one-third the number of individuals as in the litters sired by control males. Males exposed to 3000 r were sterile. Murphree et al., (1952) found that male rabbits receiving relatively low levels of whole body X-radiation (100 to 300 r) when mated to normal females produced smaller litters than the control matings.

Furth and Boon (1947) reported that four to six weeks old mice exposed to X-radiation ranging from 87 to 350 r, developed ovarian tumors beginning at about eleven months of age. Almost every mouse living to seventeen months of age developed ovarian tumors regardless of the irradiation dose.

Henshaw et al., (1949) found that rats exposed to Beta rays from P^{32} developed practically every type tumor that could arise from the skin and connective tissue within ten to twelve months. The optimum single dose for tumor induction appeared to be in the range of 4000 to 6000 rep. For repeated treatments 50 rep-per-day

seemed to be the most effective. They also found that irradiation as applied in these studies caused non-malignant abnormalities, such as extra claws on the toes and soft tissue growths on the feet and nose of rats.

Rust (1951) in a review report, stated that the skin was very sensitive to the use of roentgen rays for diagnostic or therapeutic aid. Skin ulcers sometimes developed which healed slowly. Pigmentation was altered and the hair texture and color affected. Moderate doses of ionizing irradiation reduced the number of lymphocytes. Greater doses caused lymph nodes to disappear and epithelial cells of the gastrointestinal canal to break down.

Glasser et al., (1947) reported:

> "For any given radiation effect - say death - some types of cells or of biologic organisms require much greater doses of radiation than others. Any information obtained with one kind of organism or tissue cannot be assumed to apply directly to any other. Thus the results of animal experiments cannot be applied directly to man . . . . . Furthermore great variations in radiosensitivity exist among apparently identical individuals."

Dunlap (1948) in reporting upon the effects of radiation states that the changes in the blood are due to injuries to the blood-forming organs rather than destruction of cells already in circulation.

OBJECTIVES OF STUDY

The objectives of this study were to investigate any general and/or specific effects of the 1945 bomb irradiation upon the general health, growth, breeding efficiency and relative fertility of the exposed Hereford cattle and their offspring.

PROCEDURE

Cattle Used

The cattle available for this study were all Herefords. The irradiated herd included 31 cows, 15 steers, 4 two-year old bulls (That were in dam at time of bomb explosion) and 1 irradiated bull. In August 1948, approximately 32 months after the first shipment of irradiated cattle to Oak Ridge, 10 cows and 3 steers from the original irradiated groups were shipped from Alamagardo, New Mexico, to Oak Ridge, Tennessee, for adding to the cattle in this study.

A herd of 74 cows, very similar in type, condition, size, breed, and raised in a similar environment to that in which the irradiated cows were raised, was purchased in June 1948 as a control herd. These animals were selected by Dr. Charles S. Hobbs, Head of the Animal Husbandry-Veterinary Science Department of the University of Tennessee and Dr. James C. Kyle, Veterinarian who had received the original irradiated cattle in 1945 and who had been Veterinarian-in-charge until the University took over their management.

A portion of the heifers produced from these groups of cows were added to the breeding herds as they matured. Some young bulls were added to the stud. A total of 211 breeding cows, 290 calves, 11 bulls and 18 mature irradiated steers were used in this study.

Description of Irradiated Cattle

From a distance the exposed cattle presented a frosty or roan appearance. On closer examination one found that the top portion of the animals showed the greatest damage, or effects. Figure 1 shows a side view of a typical irradiated animal, cow number 88, as she appeared in the spring of 1949. Figures 2 and 3 are close-ups of the backs of other typical exposed cattle as they appeared in August of 1948. Figures 4 and 5 show the back of cow, brand number 89, as she appeared in August of 1948 and June 1951 respectively. It can be noted in Figures 2, 3, and 4, that the animals appeared to be in an extremely unthrifty condition, were thin and had not shed the previous winter's coat. A detailed description of each irradiated animal was made at the beginning of this study. An example of this description is for cow number 89, which follows:

> Left side: Extensive epilation extending from anterior withers to tail head, hyperkeratotic for 6 to 8 inches laterally. Hyperkeratotic tissue is grayish white in areas of depigmented hair--long white haired area of withers, and reddish brown in pigmented hair areas. The skin is fixed, immobile and thickened. Localized epilated area posterior to 13th rib in lumbar fossa. These are horny proliferations along the back. The skin in general is scaly--broad, firmly adherent reddish brown scales.

There was mild hyperkeratosis on old brand left hip. The hair is long over the affected portion of the back.

Right side: Same as left.

Essentially, the appearance of the hair and hide made little change during the period of this study.

Herd Management

The entire herd was maintained, in as far as possible, under similar conditions and feed. Mature animals were fed in the open, except for short periods in the early spring of 1949 and 1950 when the brood cows were fed in open barns. Cows freshening in the fall of 1948 and 1949 were given a slight advantage by wintering them where they had access to a limited amount of fall sown pasture. The nutritional level was high at all times as indicated by the gains in weight of all groups of cattle. See Table I.

Feeds

The cattle were grazed on wild native grasses and clovers during the growing seasons of 1948 and 1949. In 1950 and 1951 the pastures, for the most part, were improved orchard grass and ladino clover sods. During the winter periods the cows were fed all the corn silage they would clean up before the next feeding and a limited amount of poor quality mixed hay (lespedeza and Johnson grass). One pound of protein supplement, either cotton seed meal or soybean oil meal, per head per day, was fed on the silage. The feeding was done once each day.

Figure 1. Irradiated cow Number 88 as she appeared in the spring of 1949.

Figure 2. A close-up view of the rump of cow number 141, August, 1948.

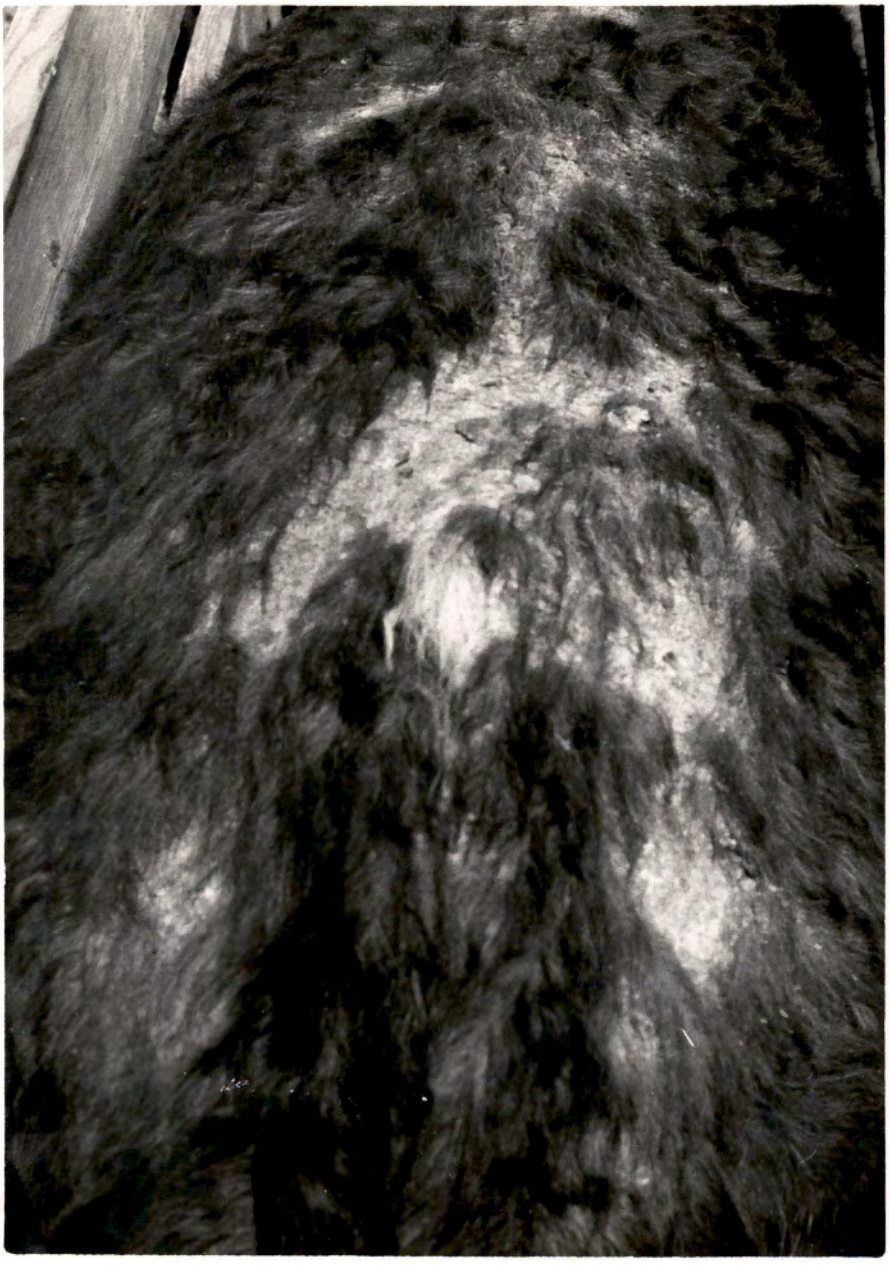

Figure 3. A close-up view of the rump and loin of steer Number 208, August, 1948.

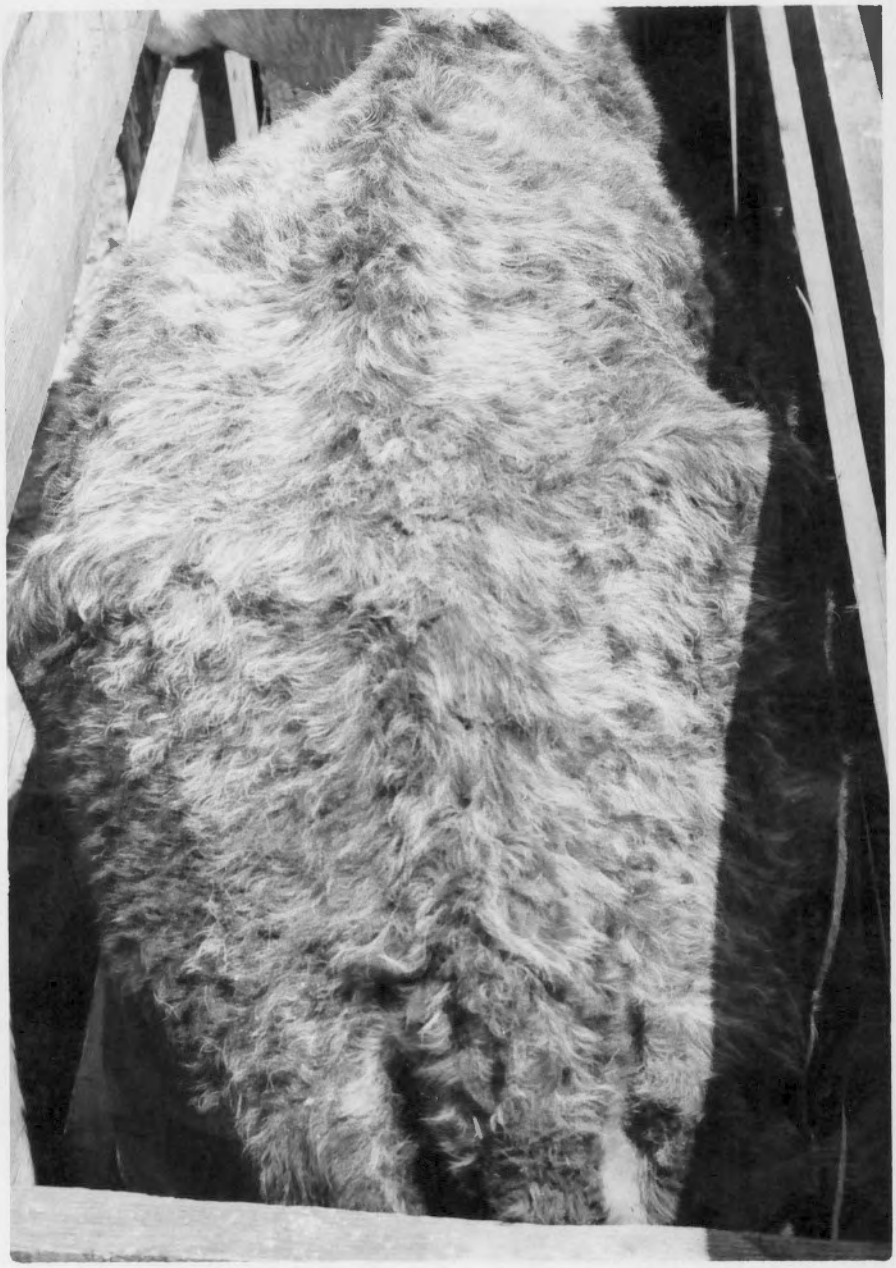

Figure 4. A close-up view of the top line of cow Number 89, August, 1948.

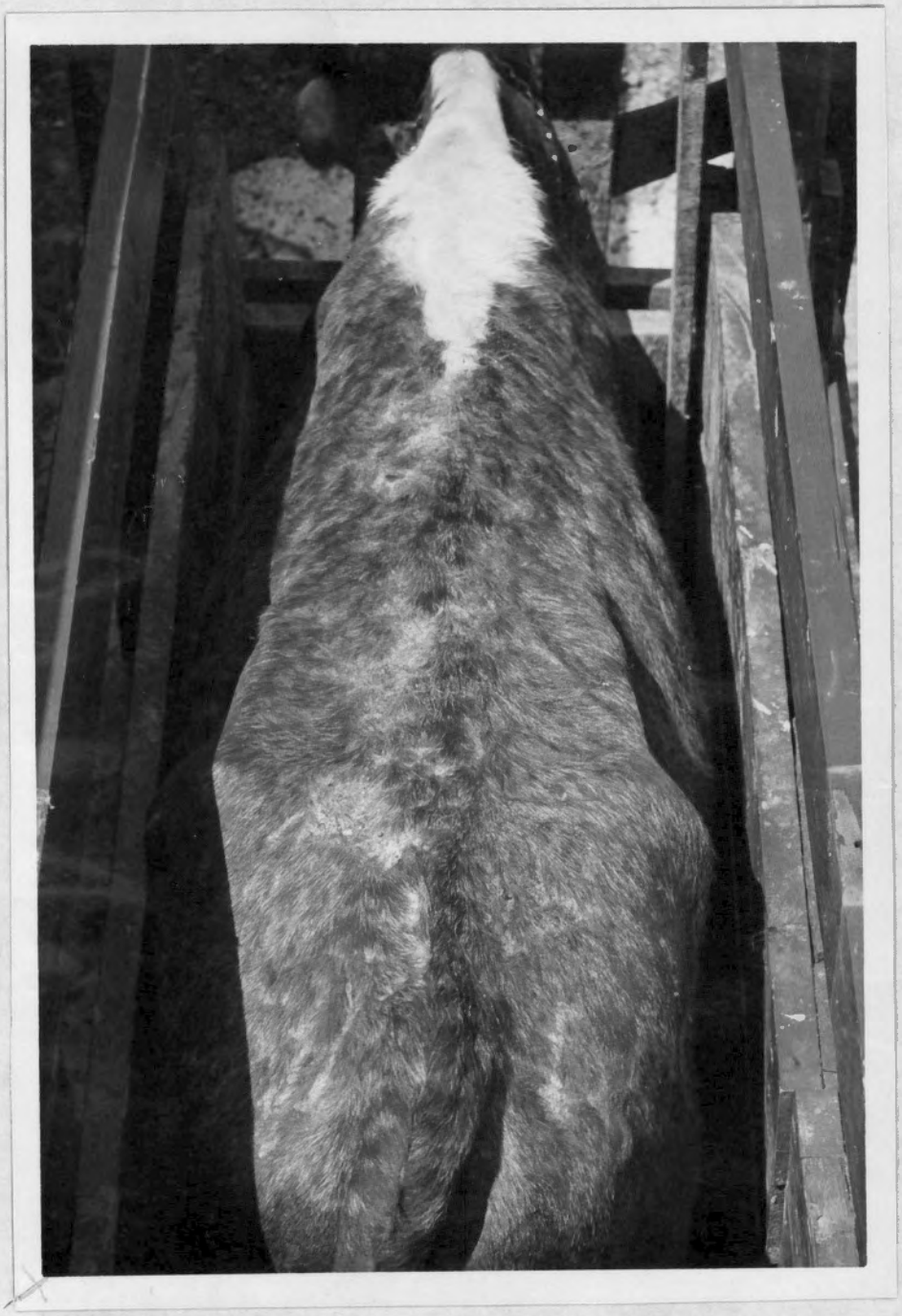

Figure 5. Cow Number 89 as she appeared, top view, June, 1951.

Weight Record

The cattle were weighed at approximately 28 day intervals in 1948, 1949 and 1950. In 1951 weights were taken at approximately three-month intervals. Calves were weighed at birth, at weaning, and with the other cattle at regular weigh periods. At the beginning and end of each winter feeding period the calves were weighed on three consecutive days, the average of each of these three day weights was used as the initial and final weights respectively.

Identification of Animals

Each animal was identified with an ear tag, a tattoo in both ears, and a hot iron brand on the right hip corresponding with the tattoo number. Calves were ear tagged and tattooed at birth and were branded the following fall after the danger from screw worms had passed.

Calf Management

Calves ran with their mothers receiving no feed other than their mothers' milk and pasture. In the fall of 1949 and 1950 they were weaned and separated into groups according to their sires. Each group was fed individually in a shed type barn entirely open on the south side, adjoining a concrete lot, twenty feet by thirty-six feet (20'X 36') with a concrete water trough in a corner of each lot. The barn had concrete feed mangers adjacent to the alley. Mixed hay, lespedeza and Johnson grass, and corn silage were fed according to their appetites. In 1949 the hay was chopped (having been harvested

with a field harvester) and contained 50% or more lespedeza. The 1950 hay was harvested with a pickup bailer, contained very little lespedeza and was a coarse, poor quality, Johnson grass. In addition to these roughages, the 1949 calves received 3 pounds whole oats and .65 pound cottonseed meal per head per day. In 1950 the calves received 4.9 pounds per head daily of the following mixture: 653 pounds corn and cob meal, 327 pounds soybean oil meal, 10 pounds salt, 10 pounds steam bone meal. Any feed not consumed before the next feeding period was removed, weighed and credited to the respective lot. Because of the poor quality hay in 1950, two to three times as much hay was put in the mangers each day as the calves were expected to eat, giving them a chance to select the better part. The grain mixture was fed on top of the silage in the morning and the hay was fed in the afternoon. Calves had access to salt at all times.

Breeding

The eleven bulls used in this study included one irradiated bull, "Atom", two sons of "Atom", out of irradiated cows, two bulls that were in dam at time of irradiation, five purebred bulls, and one grade control bull.

At the beginning of each breeding season the cows, except the purebreds, were allotted into as nearly comparable groups as possible, considering origin, type, condition, age, date of calving, etc. However, the purebred control cows were allotted equally between the irradiated bull "Atom" and the purebred bull "Pal" in 1948 and 1949.

Herd Health

Some of the irradiated cows were known to have been positive to the test for Bangs disease before this study was started. The control cows were all clean, and since the two groups were to be maintained together, it was deemed advisable to vaccinate all animals with strain 19 Brucella Abortus. All heifers were vaccinated against Bangs disease at approximately six months of age. All calves were vaccinated for blackleg at the time they were weaned.

Three cows from the control herd and one from the irradiated herd died suddenly in the fall of 1949. The trouble was diagnosed as anaplasmosis. To eliminate the carriers of this disease arrangements were made with Dr. L. T. Giltner, in the Bureau of Animal Industry in Washington, D. C., to test the herd. Several blood samples of the entire herd were drawn, prepared and sent to Dr. Giltner. From the results of these tests 73.2% of the irradiated and 37.6% of the control herd was identified as being carriers of anaplasmosis. These animals were sold for slaughter.

Every effort was made to avoid spreading any infection while bleeding, vaccinating, castrating, dehorning, etc.

RESULTS OF STUDY

Weight and Condition, Original Cattle

When this study began in July 1948 the irradiated cattle were very thin as their average weight shown in Table I indicates. It was not known if this thin condition was due to poor feed conditions or an effect of the irradiation exposure; however, representatives of AEC thought the thin condition was likely due to the effects of irradiation. The people responsible for caring for the cattle before they were turned over to the University, reported that they had been fed an ample ration of legume hay and grain all the winter before.

Cows were purchased in New Mexico for the control herd. These control animals were selected to be as similar in type, condition, size, and breed as possible, to the irradiated group. The gains in weight (see Table I, July 1948 weights compared to July 1949 and 1950) indicated that the thin condition in the beginning was due primarily to management and feed rather than an effect of the irradiation.

Deaths

Losses of cattle due to death and cause of death, when known, is shown in Table II. An annual death loss of 2% is not considered heavy for an operation such as this.[1] A greater percent of the controls died than did the irradiated.

---

[1] Roscoe R. Snapp, Beef Cattle (New York: John Wiley and Sons Inc., 1948), p. 94.

TABLE I

AVERAGE WEIGHT OF ORIGINAL MATURE CATTLE BY GROUPS AND PERIODS[a]

Date	Irradiated Cows		Irradiated Steers		New Mexico Control Cows		Purebred Control Cows	
	No.	Weight	No.	Weight	No.	Weight	No.	Weight
July 1948	32	713 lbs.	15	905 lbs.	76	686 lbs.	16	957 lbs.
Jan. 1949	42	835 lbs.	18	1,097 lbs.	73	768 lbs.	15	1,104 lbs.
July 1949	41	928 lbs.	18	1,240 lbs.	72	919 lbs.	15	1,181 lbs.
Jan. 1950	38	957 lbs.	15	1,314 lbs.	70	917 lbs.	15	1,251 lbs.
July 1950	39	996 lbs.	16	1,465 lbs.	66	985 lbs.	15	1,355 lbs.
Feb. 1951	39	1,031 lbs.	11	1,521 lbs.	45	1,022 lbs.	14	1,377 lbs.
July 1951	11	1,005 lbs.			38	977 lbs.	11	1,396 lbs.

(a) Initial weight for purebred control cows was August 2, 1948. Average age 1948 as estimated by checking the teeth of grade animals August 1949, and from pedigree of purebreds was as follows:

Irradiated cows - 5.8 years
Irradiated steers - 4.0 years
N. M. controls - 6.8 years
Purebred controls - 2.0 years

TABLE I

AVERAGE WEIGHT OF ORIGINAL MATURE CATTLE BY GROUPS AND PERIODS[a] (Continued)

The difference in numbers of cattle included in these average weights is explained as follows:

(1) The increase in the number of irradiated cows and steers in the January 1949 weights over the July 1948 weights is because additional irradiated cattle were received from Alamagordo, New Mexico, after the study was begun.

(2) The total number of these cattle gradually decreased as a result of deaths and/or sales.

(3) Occasionally an animal was not with the group at weighing time.

(4) All irradiated steers were slaughtered or sold prior to July 1951.

TABLE II

CATTLE LOST BY DEATH, AND CAUSE OF DEATH JULY 1948-JAN. 1952

	Irradiated		Control		Total	
	Calves and Yearlings	Adults	Calves and Yearlings	Adults	Calves and Yearlings	Adults
Abscess on lungs & kidneys		1				1
Accidental			1	1	1	1
Anaplasmosis		1	1	4	1	5
Birth abnormalities	1		1		2	
Bloat	2	1	2		4	1
Complications at parturition		1		3		4
Disowned by mother			1		1	
Extravasation of fluid in throat region		1				1
Ketosis				1		1
Navel infection at birth			3		3	
Nephrosis of Kidneys and Bladder				1		1

TABLE II

CATTLE LOST BY DEATH, AND CAUSE OF DEATH JULY 1948-JAN. 1952 (Continued)

	Irradiated		Control		Total	
	Calves and Yearlings	Adults	Calves and Yearlings	Adults	Calves and Yearlings	Adults
Scours			1		1	
Unknown	3	1	1	6	4	7
Total	6	6	11	16	17	22

Grand Total Number of Deaths 39

Total Number Cattle in Study
Irradiated 211
Control 338

Average Death Loss Percentage per year
Irradiated 1.62
Control 2.28
Entire Herd 2.0

Pathology

Report on Autopsies. In December 1949 the two steers, brand numbers 211 and 221, that appeared most affected by the irradiation were sacrificed for a detail pathological study. This study was made in colloboration with Major T. G. Jones of the Armed Forces Institute of Pathology and was reported in detail in March 1950 in report UT-AEC I, entitled "Fission Product Retention and Pathology of Alamagordo Cattle". The following is taken from that report:

> Tissues from the cattle exposed to the "outfall" of radioactive materials at Alamogordo showed no alpha-beta-gamma-activity or uranium content above the naturally occurring level some 4-1/2 years after exposure.
>
> In general, gross changes in exposed animals consist of marked thickening of the skin principally involving the region from the withers to the tail head and extending laterally for variable distances; the skin is non-pliable, firm and fixed showing marked to extensive hyperkeratosis; the surface is horny in nature, fissured and scaly, with localized or larger areas of partial to complete alopecia, graying of hair; there are a few sessile or pedunculated papillomas.
>
> Microscopic findings indicate that the severest changes are confined to the superficial parts of the skin and are compatible with radiation injury. The small cutaneous nodule studied is believed to be an adenoma of sebacceous gland type and not a malignant neoplasm. Changes observed in the intestinal tract and kidney do not appear to be related to the skin lesions or the radiation injury.

In December 1950, 24 irradiated and 10 control cattle suspected as being anaplasmosis carriers were sold for slaughter. To further check for gross pathological changes, Dr. West, Station Veterinary Pathologist, examined these cattle on the killing floor. The following is taken from his report:

> Detailed examination of these cattle was not possible due to the fairly rapid rate of slaughter. Of the cattle exposed

to the atom bomb burst, no gross abnormalities were observed other than has been previously reported involving the skin. Gross involvement of severely affected skin terminated abruptly at the dermis. Musculature and subcutis underlying the severely affected areas were macrospically normal. The extreme paleness of the psoas muscle group as observed in steers (211, 221) slaughtered at Oak Ridge in early December 1949 was not observed. The carcasses in general graded high.

Comparison of the blood of exposed and control cattle. It is an established fact that the blood picture of animals is indicative of many pathological changes in the body. Relative low doses of penetrating radiation, such as X-rays and gamma rays, result in rapid and conspicuous changes in the number of circulatory white blood cells of various types.[2] Therefore, on three occasions blood studies were made comparing that of the irradiated cattle with the controls. The selection of animals for bleeding was made at random, the number of cattle sampled in each study being limited to the number of samples which could be processed at that time.

There appeared to be no real difference in the blood picture of the two groups of cattle, in any of the studies. See Tables III, IV and V which summarize results. The decrease in the percentage of eosinophils probably indicates that the parasitic population of both groups greatly decreased from February 1949 to January 1950. The percentage of lymphocytes was considerably higher in all tests than was expected, but is not believed to be significant.[3]

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[2]Raymond E. Zirkle, Biological Effects of External Beta Radiation (McGraw-Hill Book Co. Inc., 1951), p. 179.

[3]William Bloom, Histopathology of Irradiation from External and Internal Sources (McGraw-Hill Book Co. Inc., 1948), p. 751.

TABLE III

SUMMARY OF DATA ON BLOOD ANALYSIS STUDIES FROM FIFTY-NINE (59) CATTLE
(FEBRUARY 1949)

Blood Studies Made	Controls (42)		Irradiated (17)		Expected Normal Range (a)
	Mean	Range	Mean	Range	
Hemoglobin (gms/100cc)	11.8	8.8 -14.6	10.6	8.5-12.2	8-14.5
Red Blood Cells (millions/ml)	5.97	3.55- 9.3	5.6	3.6- 7.7	5-10.3
White Blood Cells (thousands/ml)	5.53	3.5 - 8.9	6.13	4.6- 8.7	5-12
Red Blood Cell Volume (%)	40.45	28-53	37.7	31-44	30-50
Differential Count (%)					
Eosinophils	8.62	1-25	5.4	0-19	3- 7
Myelocytes	0.07	0-1	--	--	
Basophils	0.2	0-2	--	--	
Neutrophils					Total 24-40%
(1) Juveniles	0.17	0-3	--	--	
(2) Segmented	30.45	--	27.8	5-45	
(3) Stabs	0.01	0-3	--	--	

TABLE III

SUMMARY OF DATA ON BLOOD ANALYSIS STUDIES FROM FIFTY-NINE (59) CATTLE
(FEBRUARY 1949) (Continued)

Blood Studies Made	Controls (42)		Irradiated (17)		Expected Normal Range (a)
	Mean	Range	Mean	Range	
Lymphocytes	55.5	28-88	62.5	29-87	20-54.1
Monocytes	5.1	0-15	4.2	0-16	3-15

(a) John A. Kolmer and Fred Boerner, Approved Laboratory Technic, 4th Ed. D. Appleton Century Co., N. Y. 1945. P. 52.

TABLE IV

SUMMARY OF DATA ON BLOOD ANALYSIS STUDIES FROM THIRTY (30) CATTLE
(AUGUST 1949)

Blood Studies Made	Controls (21)		Irradiated (9)		Expected Normal Range (a)
	Mean	Range	Mean	Range	
Hemoglobin (gms/100cc)	12.2	6.9-14.3	11.4	9.7-12.6	8-14.5
Red Blood Cells (millions/ml.)	5.6	3.4- 7.1	5.7	4.1- 6.9	5-10.3
White Blood Cells (thousands/ml)	8.4	5.4-11.3	8.36	5.2-11.3	5-12
Red Blood Cell Volume (%)	37.2	22.5-43.5	35.1	27.0-40.5	30-50
Differential Count (%)					
Eosinophils	3.5	0.0-13.0	3.3	2-6	3-7
Myelocytes	0.0		0.0		
Basophils	.1	0.0- 1.0	0.25	0.0-1.5	
Neutrophils					Total 24-40%
(1) Juveniles	.32	0.0- 1.0	.4	0.0-1.0	
(2) Segmented	19.5	3.0-65.0	35.1	8.0-63.0	
(3) Stabs	.65	0.0- 4.5	1.6	0.0-4.5	

TABLE IV

SUMMARY OF DATA ON BLOOD ANALYSIS STUDIES FROM THIRTY (30) CATTLE
(AUGUST 1949) (Continued)

Blood Studies Made	Controls (21)		Irradiated (9)		Expected Normal Range (a)
	Mean	Range	Mean	Range	
Lymphocytes	74.1	31.0-96.0	54.7	28.0-84.0	20-54.1
Monocytes	1.7	0.0- 8.0	4.5	1.0-13.0	3-15

(a) John A. Kolmer and Fred Boerner, Approved Laboratory Technic, 4th Ed. D. Appleton Century Co., N. Y. 1945, P. 52.

TABLE V

SUMMARY OF DATA ON BLOOD ANALYSIS STUDIES FROM THIRTY-FIVE (35) CATTLE
(JANUARY 1950)

Blood Studies Made	Controls (23)		Irradiated (12)		Expected Normal Range (a)
	Mean	Range	Mean	Range	
Hemoglobin (gms/100cc)	10.6	9.6-12.6	10.9	8.6-13.6	8-14.5
Red Blood Cells Vol. (%)	36.5	31.0-47.0	34.6	29.0-39.0	30-50
Differential Count (%)					
Eosinophils	.52	0.0- 3.0	1.17	0.0- 5.0	3- 7
Myelocytes	0.00	--	0.00	--	
Basophils	.21	0.0- 2.0	0.5	0.0- 3.0	
Neutrophils					Total 24-40%
(1) Juveniles	.61	0.0- 3.0	.83	0.0- 2.0	
(2) Segmented	19.69	2.0-66.0	25.9	10.0-57.0	
(3) Stabs	.91	0.0- 3.0	.92	0.0- 4.0	

TABLE V

SUMMARY OF DATA ON BLOOD ANALYSIS STUDIES FROM THIRTY-FIVE (35) CATTLE
(JANUARY 1950) (Continued)

Blood Studies Made	Controls (23)		Irradiated (12)		Expected Normal Range (a)
	Mean	Range	Mean	Range	
Lymphocytes	76.51	33.0-98.0	68.8	32-96	20-54.1
Monocytes	1.56	0.0- 8.0	1.5	0.0-7.0	

(a) John A. Kolmer and Fred Boerner, Approved Laboratory Technic, 4th Ed. D. Appleton Century Co., N. Y. 1945, P. 52

Rate of healing of artifically produced wounds in irradiated and control cattle.[4] Employing procaine hydrochloride infiltration anesthesia, skin biopsies were taken from six of the exposed cattle, and five control cattle. A section of skin approximately 60 to 65 mm in length by 8 to 10 mm in width and extending to the subcutes was removed.

It was consistently observed that the skin of control cattle required greater pressure or force in making incisions than did the irradiated cattle. The suturing needle likewise penetrated the skin of the irradiated cattle with less resistance than in the control cattle. Somewhat less bleeding occurred in the irradiated than in the control animals. The lips of the wounds were approximated and retained by 4 interrupted chronic catgut sutures. Insofar as possible equivalent tension was applied in all cases.

Progress of and type of healing observations were made at weekly intervals. In general in the wounds of control animals, the lips of the incision were firmly adherent at 7 days. The lips of the wounds in the skin of the irradiated cattle were relaxed and gaping. A large blood clot filled the interior of the wounds in the irradiated cattle by 14 days. The incision in the control cattle was a reddish soft pliable slightly depressed streak. The wounds in the irradiated cattle were essentially the same as at 7 days, although opposition and adherence had occurred at the ventral and dorsal aspects of the incision for a distance of 7 to 8 mm.

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[4]John L. West, "Comparison of the Healing of Artifically Produced Wounds in Irradiated and Control Cattle". Unpublished data.

At 21 days incisions in the control cattle were visible as at 14 days. Some transverse contraction of the incisions in the irradiated cattle had occurred. The blood clots were displaced by reddish or reddish white granulation tissue. A blood clot was present in one animal.

At 28 days the wound lips in the irradiated cattle were still relaxed or gapping in 2 cases. In the others the surface was epithitralized. The tissue was glistening, pale reddish white in color, and scaling.

At 35 days the incision area in the irradiated cattle was 5 to 8 mm in width. The surface was covered with a glistening, scaly, dry, wrinkled tissue. These areas were moderately pliable. A small tongue-like proliferation originating from a suture area was observed.

At 42 days the incision area in the irradiated cattle was essentially the same as at 35 days. Dry brownish heavy proliferations were observed in the center of the healed area of one animal.

Calf performance. From the detail records of the performance of the calves from these controlled matings the following tables have been compiled comparing the performance of calves by cow groups and by sire groups.

Tables VI through IX compare birth weights, weaning weights, feed lot performance and pasture performance of calves by cow groups. Table XII through XV make the same comparisons for the sire progeny groups. Tables X and XVI compare the live animal grades

of the calves by cow groups and by sire progeny groups. Tables XI and XVII compare the breeding efficiency and relative fertility of the different cow groups and of the sires respectively.

Generally the male calves weighed more at birth than the females, averaging one and one-half pounds for all groups of cows. An exception occurred with the calves out of control cows in 1949 and with calves out of first generation irradiated cows in 1951, see Table VI. Also the male calves weaned heavier than the heifers, averaging 54.2 pounds for all groups. An exception occurred with the calves from first generation irradiated cows in 1951. In this group the heifers averaged 28.7 pounds heavier than the males at weaning.

Comparing the calves of the irradiated cows with those of the controls, the calves from the irradiated cows averaged 1.6 pounds more at birth and 34.8 pounds more at weaning than the calves out of the control cows. However, in 1950 the male calves out of control cows averaged 0.6 pounds heavier at birth and 6.3 pounds heavier at weaning than the male calves from the irradiated cows.

Comparing the feed lot performance of the two groups of calves Table VIII shows that in 1949-50 the heifers from the control cows gained 11.9 pounds more than the heifers from irradiated cows. However, their final average weight was still 39.3 pounds less than the heifers from the irradiated cows. The 1950 male calves from the irradiated cows averaged gaining .16 pounds per day more than the male calves from control cows. But here again their final average weight was 33.2 pounds less than the male calves from the control

cows. The feed lot performance of the two groups of calves is probably not significant.

Gains on pasture following the first winter feeding periods (see Table IX) were in general satisfactory for all groups of calves.[5] In 1950 the male and female calves from irradiated cows averaged gaining .06 and .02 pounds per day respectively more than the calves from control cows. In 1951 the male calves from both groups of cows averaged gaining .89 pounds per day. The heifers from irradiated cows gained .84 pounds per day compared to .80 for heifers from control cows. These differences are probably not significant.

At weaning the calves from the control cows averaged 1/9 of a grade higher on type than the calves from irradiated cows and the same grade on condition (see Table X). For all practicable purposes there was no difference in type and condition of these two groups of calves.

The difference in feed lot performance by sire groups could not be correlated with irradiation. The calves by the irradiated bull "Atom" averaged gaining 1.48 pounds per day. The calves by the bulls in dam at time of exposure, 40 and 137, averaged gaining 1.25 and 1.31 pounds per day respectively. Calves by the pure bred control bulls, Pal, and -50, and the grade control bull 91, averaged gaining 1.49, 1.32 and 1.53 pounds per day respectively.

Breeding efficiency of cow groups. Table XI indicates that the conception rate for the control cows during the breeding season of

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[5] F. B. Morrison, Feeds and Feeding, 20th Edition (New York: The Morrison Publishing Co., 1947), p. 713.

TABLE VI

COMPARISON OF CALF BIRTH WEIGHTS BY SEX AND CON GROUPS FOR YEARS 1949, 1950 AND 1951[a]

	Irradiated Cows				Control Cows			
	Original		First Generation		Original		First Generation	
	Males	Females	Males	Females	Males	Females	Males	Females
No. and Av. Wt. 1949	(20) 74.0	(12) 71.6	0	0	(24) 64.5	(27) 70.1	0	0
No. and Av. Wt. 1950	(16) 77.3	(18) 68.8	(2) 77.5	(2) 67.0	(33) 77.9	(37) 72.3	0	0
No. and Av. Wt. 1951	(6) 73.3	(6) 71.5	(12) 67.8	(6) 70.8	(24) 69.7	(24) 68.8	(12) 70.2	(9) 69.2
Av. for 3 Year Period	(42) (75.2)	(36) 70.2	(14) 69.2	(8) 69.9	(81) 71.5	(88) 70.7	(12) 70.2	(9) 69.2
Percent by Sex	53.8	46.2	63.6	36.4	47.9	52.1	57.1	42.9

(a) Calves fully developed but still-born are included in this summary.

Figures in () indicate numbers in each group.

TABLE VII

COMPARISON OF SPRING CALF WEANING WEIGHTS BY SEX AND COW GROUPS FOR YEARS 1949, 1950 AND 1951[a]

	Irradiated Cows				Control Cows			
	Original		First Generation		Original		First Generation	
	Males	Females	Males	Females	Males	Females	Males	Females
1949 No. and av. wt.	(13) 408.7	(7) 371.4	(1) 417.0	---	(10) 328.8	(7) 312.9	---	---
1950 No. and av. wt.	(13) 456.8	(14) 414.7	(1) 505.0	(1) 373.0	(25) 463.1	(21) 407.9	---	(1) 324.0
1951 No. and av. wt.	(5) 473.8	(6) 434.1	(1) 352.0	(3) 380.7	(20) 433.9	(22) 403.6	(4) 440.0	(3) 389.3
Av. for 3 yrs.	446.4	406.7	423.3	---	408.6	374.8	---	---
Av. for last 2 yrs.	465.3	424.4	428.5	378.5	448.5	405.8	440.0[b]	356.6
2 yr. av. of all calves	444.5		403.5		427.1		---	

(a) Weaning weight corrected to 187 days. Figures in ( ) indicate the number of calves weaned in each group. Calves by unknown sires not included in study. Inbred calves not included.

(b) One year average.

TABLE VIII

COMPARISON OF FEED LOT PERFORMANCE OF SPRING CALVES BY SEX AND COW GROUP FOR 1949-50 AND 1950-51[a]

	Irradiated Cows				Control Cows			
	Original		First Generation		Original		First Generation	
	Males	Females	Males	Females	Males	Females	Males	Females
1949-50								
Av. wt. beginning of feed period	(12) 429.2	(7) 383.4	(1) 440.0	---	(9) 343.3	(6) 332.2	---	---
Av. wt. at end	517.8	469.3	540.0	---	429.4	430.0	---	---
Av. total gain	88.6	85.9	100.0	---	86.1	97.8	---	---
Total days fed	88	88	88	---	88	88	---	---
Av. daily gain	1.00	.97	1.13	---	.97	1.11	---	---
1950-51								
Av. wt. beginning of feed period	(8) 478.8	(13) 455.3	(1) 582.0	(1) 402.0	(18) 533.1	(18) 466.6	---	(1) 445.0
Av. wt. at end	699.1	649.6	818.0	602.0	732.3	662.9	---	605.0
Av. total gain	220.3	194.3	236.0	200.0	199.2	196.3	---	160.0
Total days fed	126	126	126	126	126	126	---	126

TABLE VIII

COMPARISON OF FEED LOT PERFORMANCE OF SPRING CALVES BY SEX AND COW GROUP FOR 1949-50 AND 1950-51(a) (Continued)

	Irradiated Cows				Control Cows			
	Original		First Generation		Original		First Generation	
	Males	Females	Males	Females	Males	Females	Males	Females
Av. daily gain	1.74	1.54	1.87	1.59	1.58	1.55	---	1.27
Av. total gain for 2 yrs.	154.4	140.1	168.0	---	142.6	147.0	---	---
Av. no. of days fed	107	107	107	---	107	107	---	---
Av. daily gain	1.44	1.30	1.57	---	1.33	1.37	---	---

(a) Figures in ( ) indicate number of animals in test. Study was concluded with the weaning of the 1951 calves.

TABLE IX

COMPARISON OF PASTURE PERFORMANCE OF YEARLINGS BY SEX AND COW GROUPS FOR 1950 AND 1951 GRAZING SEASONS [a]

	Irradiated Cows				Control Cows			
	Original		First Generation		Original		First Generation	
	Males	Females	Males	Females	Males	Females	Males	Females
1950								
Av. wt. beginning pasture period	(11) 513.2	(7) 469.3	---	---	(8) 418.1	(4) 406.3	---	---
Av. wt. Nov. 1	716.5	643.1	---	---	608.4	574.8	---	---
Av. total gain	203.3	173.8	---	---	190.3	168.5	---	---
No. of days on pasture	211	211	---	---	211	211	---	---
Av. daily gain	.96	.82	---	---	.90	.80	---	---
1951								
Av. wt. beginning of pasture period	(4) 775.8	(11) 655.1	---	(1) 602.0	(8) 751.3	(18) 662.9	---	(1) 605.0
Av. wt. Nov. 1	946.8	832.8	---	729.0	935.6	831.5	---	772.0

TABLE IX

COMPARISON OF PASTURE PERFORMANCE OF YEARLINGS BY SEX AND COW GROUPS FOR 1950 AND 1951 GRAZING SEASONS[a] (Continued)

	Irradiated Cows				Controls Cows			
	Original		First Generation		Original		First Generation	
	Males	Females	Males	Females	Males	Females	Males	Females
Av. total gain	171.0	177.7	---	127.0	184.3	168.6	---	167.0
No. days on pasture	210	210	---	210	210	210	---	210
Av. daily gain	.81	.85	---	.60	.88	.80	---	.80
Av. total gain for 2 yrs.	187.1	175.7	---	---	187.3	168.6	---	---
Av. no. days on pasture	210.5	210.5	---	---	210.5	210.5	---	---
Av. daily gain	.89	.84	---	---	.89	.80	---	---

(a) Not all the animals fed were continued on pasture, hence the smaller numbers. Figures in ( ) indicate the number of animals in test.

TABLE X

COMPARISON OF TYPE AND CONDITION OF SPRING CALVES AT WEANING BY SEX AND CON GROUPS FOR YEARS 1949, 1950 AND 1951(a)

	Irradiated Cows				Control Cows			
	Original		First Generation		Original		First Generation	
	Males	Females	Males	Females	Males	Females	Males	Females
1949								
Av. Type(b)	(14) LG	(7) LG	(1) HG	-	(9) LG	(6) LG	-	-
Av. Condition	(14) LComm	(7) Comm	(1) HComm	-	(9) Comm	(6) LComm	-	-
1950								
Av. Type	(13) HM	(14) LG	(1) HG	(1) M	(25) LG	(21) G	-	(1) G
Av. Condition	(13) Comm	(14) LG	(1) G	(1) Comm	HComm	(21) HComm		(1) LG
1951								
Av. Type	(7) G	(4) HG	(1) LG	(3) LC	(18) HG	(22) HG	(3) LC	(4) G
Av. Condition	(7) G	(4) G	(1) LG	(3) G	(18) LG	(22) HG	(3) G	(4) G

TABLE X

COMPARISON OF TYPE AND CONDITION OF SPRING CALVES AT WEANING BY SEX AND COW GROUPS FOR YEARS 1949, 1950 AND 1951(a) (Continued)

	Irradiated Cows				Control Cows			
	Original		First Generation		Original		First Generation	
	Males	Females	Males	Females	Males	Females	Males	Females
Average for Three Year Period								
Type	LG	G -	G ≠	-	LG ≠	G	-	-
Condition	HComm -	LG -	LG	-	HComm	LG	-	-
Average for 1950-1951								
Type	LG	G	G	LG ≠	G	G ≠	-	G
Condition	LG -	LG ≠	LG ≠	LG -	LG -	LG ≠	-	G -

(a) Figures in () indicate numbers of calves in averages. Professor H. R. Duncan of the Animal Husbandry Department of the University of Tennessee graded the calves each year.

TABLE X

COMPARISON OF TYPE AND CONDITION OF SPRING CALVES AT WEANING BY SEX AND COW GROUPS FOR YEARS 1949, 1950 AND 1951[a] (Continued)

(b) Type is feeder grade. Condition is slaughter grade.

Symbols:

Type		Condition	
C	Choice	G	Good
LC	Low Choice	LG	Low Good
HG	High Good	HComm	High Commercial
G	Good	Comm	Commercial
LG	Low Good		
HM	High Medium		

TABLE XI

COMPARISON OF THE BREEDING EFFICIENCY AND RELATIVE FERTILITY OF COW GROUPS FOR BREEDING SEASONS 1948, 1949 AND 1950

	Irradiated Cows		Control Cows	
	Original	First Generation	Original	First Generation
		1948		
No. Lotted with Bull	30	1	68	0
No. Live Calves Produced	22	1	21	0
% of Live Calves Produced	73.3	100	30.8	0
No. Still Births	0	0	6	0
No. Known Abortions	2	0	4	0
Total No. Known Conceptions	24	1	31	0
% of Known Conceptions	80.0	100	45.5	0
		1949		
No. Lotted with Bull	38	5	81	1
No. Live Calves Produced	32	4	67	1
% of Live Calves Produced	84.2	80.0	82.7	100

TABLE XI

COMPARISON OF THE BREEDING EFFICIENCY AND RELATIVE FERTILITY OF COW GROUPS FOR BREEDING SEASONS 1948, AND 1950 (Continued)

	Irradiated Cows		Control Cows	
	Original	First Generation	Original	First Generation
	1949 (Continued)			
No. Still Births	1	0	2	0
No. Known Abortions	0	0	0	0
Total No. Known Conceptions	33	4	69	1
% of Known Conceptions	86.8	80.0	85.1	100
	1950			
No. Lotted with Bull	12	21	52	17
No. Live Calves Produced	12	16	48	15
% of Live Calves Produced	100	76.1	92.3	88.2
No. Still Births	0	4	0	2
No. Known Abortions	0	0	0	0
Total No. Known Conceptions	12	20	48	17

TABLE XI

COMPARISON OF THE BREEDING EFFICIENCY AND RELATIVE FERTILITY OF COW GROUPS FOR BREEDING SEASONS 1948, 1949 AND 1950 (Continued)

	Irradiated Cows		Control Cows	
	Original	First Generation	Original	First Generation
	1950 (Continued)			
% of Known Conceptions	100	95.2	92.3	100
	Summary for Three Years			
No. Lotted with Bulls	80	27	201	18
No. Live Calves Produced	66	21	136	16
% of Live Calves Produced	82.5	77.7	67.6	88.8
No. Still Births	1	4	8	2
No. Known Abortions	2	0	4	0
Total No. Known Conceptions	69	25	148	18
% Known Conceptions	86.2	92.6	73.6	100

TABLE XI

COMPARISON OF THE BREEDING EFFICIENCY AND RELATIVE FERTILITY OF COW GROUPS FOR BREEDING SEASONS 1948, 1949 AND 1950 (Continued)

	Irradiated Cows		Control Cows	
	Original	First Generation	Original	First Generation
	Summary for 1949 and 1950			
No. Lotted with Bulls	50	26	133	18
No. Live Calves Produced	44	20	115	16
% of Live Calves Produced	88.0	76.9	86.4	88.8
No. Still Births	1	4	2	2
No. Known Abortions	0	0	0	0
Total No. Known Conceptions	45	24	117	18
% Known Conceptions	90.0	92.3	87.9	100

TABLE XII

COMPARISON OF AVERAGE CALF BIRTH WEIGHTS BY SEX AND BY SIRES FOR YEARS 1949, 1950 AND 1951[a]

	1949		1950		1951		Total		
Bulls	M	F	M	F	M	F	M	F	M&F
Atom[a]	(5) 73.2	(2) 82.5	(19) 77.6	(18) 68.1	(13) 68.2	(5) 68.6	(37) 73.7	(25) 69.4	71.5
Pal[c]	(5)76.2	(3) 67.6	(8) 82.0	(17) 73.1	(9) 74.7	(8) 69.7	(22) 77.7	(28) 71.5	74.6
-50[c]	(3) 74.6	(6) 69.3	(6) 75.8	(7) 64.8	(8) 64.8	(7) 64.7	(17) 70.4	(20) 66.1	68.2
40[d]	(6) 73.5	(4) 72.5	(6) 85.1	(7) 79.4	-	-	(12) 79.3	(11) 76.9	78.1
137[d]	(7) 66.1	(3) 73.3	(7) 74.4	(2) 72.5	-	-	(14) 70.2	(5) 73.0	71.6
91[e]	-	-	(5) 63.6	(5) 68.6	-	-	(5) 63.6	(5) 68.6	66.1
-3[c]	-	-	-	-	(17) 76.5	(15) 72.8	(17) 76.5	(15) 72.8	74.6
245[f]	-	-	-	-	(13) 69.8	(7) 64.7	(13) 69.8	(7) 64.7	67.2
246[c]	-	-	-	-	(2) 66.5	(3) 68.0	(2) 66.5	(3) 68.0	67.2

TABLE XII

COMPARISON OF AVERAGE CALF BIRTH WEIGHTS BY SEX AND BY SIRES FOR YEARS 1949, 1950 AND 1951[a] (Continued)

	1949		1950		1951		Total		
Bulls	M	F	M	F	M	F	M	F	M&F
238[e]	-	-	-	-	(2) 72.5	(2) 62.0	(2) 72.5	(2) 62.0	67.2
225[f]	-	-	-	-	(2) 73.0	(1) 70.0	(2) 73.0	(1) 70.0	71.5

(a) Fully developed calves but still born are included in average. Also the fall calves of 1951 are included, nowhere else are they considered.

(b) Irradiated bull.

(c) Purebred bull.

(d) In dam at time of irradiation

(e) Grade control bull.

(f) Atom's son out of an irradiated cow.

TABLE XIII

COMPARISON OF SPRING CALF WEANING WEIGHTS BY SEX AND BY BULLS FOR YEARS 1949, 1950 AND 1951[a]

	Atom[b]	Pal[c]	-50[c]	40[d]	137[d]	91[e]	-3[c]	245[f]	246[c]	238[c]	225[f]
1949											
Males	(5) 393.4	(5) 362.5	(4) 419.7	(5) 388.4	(5) 307.4	-	-	-	-	-	-
Females	(2) 377.5	(2) 322.0	(3) 351.0	(4) 358.2	(3) 301.6	-	-	-	-	-	-
1950											
Males	(10) 477.9	(6) 476.3	(5) 473.2	(6) 477.8	(7) 486.5	(5) 349.2	-	-	-	-	-
Females	(11) 393.1	(6) 433.5	(7) 402.4	(6) 429.5	(2) 420.0	(5) 381.8	-	-	-	-	-
1951											
Males	(2) 519.5	-	(5) 410.6	-	-	-	(7) 420.5	(12) 446.8	(2) 504.0	(2) 376.0	(2) 458.0
Females	(3) 432.0	(1) 342.0	(7) 418.5	-	-	-	(10) 408.9	(7) 393.2	(3) 382.0	(1) 327.0	-

TABLE XIII

COMPARISON OF SPRING CALF WEANING WEIGHTS BY SEX AND BY BULLS FOR YEARS 1949, 1950 AND 1951[a] (Continued)

	(b) Atom	(c) Pal	(c) -50	(d) 40	(d) 137	(e) 91	(c) -3	(f) 245	(c) 246	(c) 238	(f) 225
Average for Three Years											
Males	463.6	419.4[g]	434.5	437.1[g]	411.9[g]	-	-	-	-	-	-
Females	400.8	365.8	390.6	401.0[g]	349.0[g]	-	-	-	-	-	-
1950 AND 1951 Average											
Males	498.7	476.3[g]	441.9	-	-	349.2[h]	420.5[i]	446.8[i]	504.0[i]	376.0[i]	458.0[i]
Females	412.5	387.7	410.4	-	-	381.8[h]	408.9[i]	393.2[i]	382.0[i]	327.0[i]	-

(a) Corrected to 187 days.

(b) Irradiated Bull.

(c) Purebred Bull.

(d) Bull in dam at time of irradiation.

(e) Grade Control Bull.

TABLE XIII

COMPARISON OF SPRING CALF WEANING WEIGHTS BY SEX AND BY BULLS FOR YEARS 1949, 1950 AND 1951[a] (Continued)

(f) Atom's son out of a irradiated cow.

(g) First two years only.

(h) 1950 only.

(i) 1951 only.

Figures in () indicate numbers in averages.

TABLE XIV

COMPARISON OF FEED LOT PERFORMANCE OF SPRING CALVES BY SEX AND BY BULLS FOR 1949-1950 AND 1950-1951[a]

	Atom[b]		Pal[c]		-50[c]		40[d]		137[d]		91[e]	
	M	F	M	F	M	F	M	F	M	F	M	F
1949-1950												
Av. Wt. Beginning Feed Period	(5) 408.0	(2) 401.5	(4) 413.5	(2) 349.0	(4) 405.2	(3) 363.3	(5) 407.0	(4) 376.7	(4) 332.7	(2) 289.5	-	-
Av. Wt. at End	502.0	510.0	515.0	455.0	491.2	455.0	479.0	448.7	422.5	387.5	-	-
Av. Total Gain	94.0	108.5	101.5	106.0	86.0	91.7	72.0	72.0	89.8	98.0	-	-
Av. Total Day Fed	88	88	88	88	88	88	88	88	88	88	-	-
Av. Daily Gain	1.06	1.23	1.15	1.20	.97	1.04	.81	.81	1.02	1.11	-	-
Feed Per 100 lbs. Gain												
Concentrate	314		366		366		447		350		-	
Hay	548		381		478		749		389		-	
Silage	649		504		650		836		461		-	

TABLE XIV

COMPARISON OF FEED LOT PERFORMANCE OF SPRING CALVES BY SEX AND BY BULLS FOR 1949-1950 AND 1950-1951[a] (Continued)

	Atom[b]		Pal[c]		-50[c]		40[d]		137[d]		91[e]	
	M	F	M	F	M	F	M	F	M	F	M	F
1950-1951												
Av. Wt. Beginning Feed Period	(6) 509.1	(9) 433.1	(3) 581.3	(5) 475.4	(4) 507.5	(6) 484.1	(3) 523.7	(6) 466.3	(7) 345.8	(2) 496.0	(4) 446.7	(5) 438.8
Av. Wt. at End	731.3	627.4	788.3	702.8	722.2	659.1	717.0	665.8	744.7	672.0	646.5	625.8
Av. Total Gain	222.2	194.3	207.0	227.4	214.7	175.0	193.3	199.5	198.9	176.0	199.8	187.0
Av. Total Day Fed	126	126	126	126	126	126	126	126	126	126	126	126
Av. Daily Gain	1.76	1.54	1.64	1.80	1.70	1.38	1.53	1.58	1.57	1.39	1.58	1.48
Feed Per 100 lbs. Gain												
Concentrate	320		287		332		321		322		323	
Hay	167		164		177		181		202		195	
Silage	975		1072		1144		1040		1161		1117	

TABLE XIV

COMPARISON OF FEED LOT PERFORMANCE OF SPRING CALVES BY SEX AND BY BULLS FOR 1949-1950 AND 1950-1951[a] (Continued)

	Atom[b]		Pal[c]		-50[c]		40[d]		137[d]		91[e]	
	M	F	M	F	M	F	M	F	M	F	M	F
Summary For Two Periods												
Av. Wt. Beginning Feed Period	458.5	417.3	497.4	412.2	456.3	423.7	465.3	421.5	439.2	392.7	446.7[f]	438.8[f]
Av. Wt. End	625.6	568.7	651.6	578.9	606.7	557.0	598.0	557.2	583.6	529.7	646.5	625.8
Av. Total Gain	167.1	151.4	154.2	166.7	150.4	133.3	132.7	135.7	144.4	137.0	199.8	187.0
Av. No. Days Fed	107	107	107	107	107	107	107	107	107	107	126	126
Av. Daily Gain	1.56	1.41	1.44	1.55	1.40	1.24	1.24	1.26	1.34	1.28	1.58	1.48
Av. Gain M and F	159.2		160.4		141.8		134.2		140.7		193.4[f]	
Av. Daily Gain	1.48		1.49		1.32		1.25		1.31		1.53	
Feed Per 100 lbs. Gain												
Concentrate	317.0		326.5		349.0		384.0		336.0		323.0	
Hay	357.5		272.5		327.5		465.0		295.5		195.0	

TABLE XIV

COMPARISON OF FEED LOT PERFORMANCE OF SPRING CALVES BY SEX AND BY BULLS FOR 1949-1950 AND 1950-1951[a] (Continued)

	Atom[b]		Pal[c]		-50[c]		40[d]		137[d]		91[e]	
	M	F	M	F	M	F	M	F	M	F	M	F
Silage	812.0		788.0		897.0		938.0		811.0		1117.0	

(a) Figure in () indicate numbers in averages.

(b) Irradiated Bull.

(c) Purebred Bull.

(d) In dam at time cow was irradiated.

(e) Grade Control Bull.

(f) 1950-1951 only.

TABLE XV

COMPARISON OF PASTURE PERFORMANCE OF YEARLINGS BY SEX AND BY SIRE FOR 1950 AND 1951 GRAZING SEASONS [a]

	Atom [b]		Pal [c]		-50 [c]		40 [d]		137 [d]		91 [e]	
1950	M	F	M	F	M	F	M	F	M	F	M	F
	(4)	(2)	(2)	(1)	(4)	(2)	(5)	(4)	(4)	(2)		
Av. wt. beginning	490.5	510.0	485.0	425.0	491.2	447.5	479.0	448.7	422.5	387.5	-	-
Av. wt. Nov. 1	729.0	696.5	746.0	610.0	626.5	631.5	661.2	607.2	632.2	553.0	-	-
Av. total gain	238.5	186.5	261.0	185.0	135.3	184.0	182.2	158.5	209.7	165.5	-	-
Days on pasture	211	211	211	211	211	211	211	211	211	211	-	-
Av. daily gain	1.13	.88	1.23	.87	.64	.87	.86	.75	.99	.78	-	-
1951												
		(8)	(2)	(5)	(3)	(6)	(1)	(6)	(6)	(2)		(4)
Av. wt. beginning	-	635.2	773.5	702.8	748.0	659.1	750.0	665.8	761.4	672.0	-	604.8
Av. wt. Nov. 1	-	816.2	984.0	878.2	909.6	839.6	869.0	809.1	951.0	869.0	-	760.5
Av. total gain	-	181.0	210.5	175.4	161.6	180.5	119.0	143.3	189.6	197.0	-	155.7
Days on pasture	-	210	210	210	210	210	210	210	210	210	-	210
Av. daily gain	-	.86	1.00	.83	.77	.85	.56	.68	.90	.93	-	.74

TABLE XV

COMPARISON OF PASTURE PERFORMANCE OF YEARLINGS BY SEX AND BY SIRE FOR 1950 AND 1951 GRAZING SEASONS[a] (Continued)

	Atom[b]		Pal[c]		-50[c]		40[d]		137[d]		91[e]	
	M	F	M	F	M	F	M	F	M	F	M	F
Av. total gain for both seasons:	238.5[f]	183.7	235.7	180.2	148.4	182.2	150.6	150.9	199.6	181.2	-	155.7[g]
Av. for M and F	211.1		207.9		165.3		150.7		190.4			
Days on pasture	211.0	210.5	210.5	210.5	210.5	210.5	210.5	210.5	210.5	210.5	-	210.0
Av. daily gain	1.13	.87	1.11	.85	.70	.86	.71	.71	.94	.86	-	.74
M and F	1.00		.98		.78		.71		.90			

(a) Not all animals fed were continued on pasture. Figure in () indicate number in average.

(b) Irradiated bull.

(c) Purebred bull.

(d) Bull in dam at time cow was irradiated.

(e) Grade control bull.

(f) 1950 only.

(g) 1951 only.

TABLE XVI

COMPARISON OF TYPE AND CONDITION OF SPRING CALVES AT WEANING BY SEX AND BY BULLS FOR YEARS 1949, 1950 AND 1951[a]

	Atom[b]		Pal[c]		-50[c]		40[d]		137[d]		91[e]	
1949	M	F	M	F	M	F	M	F	M	F	M	F
Av. Type	(4) LG	(2) LG	(5) HM	(2) HG	(4) G	(3) LG	(5) HM	(4) HM	(5) LG	(3) LG	-	-
Av. Condition	Comm	Comm	Comm	Comm	Comm	Comm	Comm	Comm	LComm	Comm	-	-
1950												
Av. Type	(10) LG	(11) LG	(6) G	(6) G	(5) G	(7) HM	(6) LG	(6) HM	(7) LG	(2) M	(5) HM	(5) LG
Av. Condition	HComm	HComm	HComm	LG	HComm	HComm	Comm	HComm	HComm	HComm	Comm	HComm
1951												
Av. Type	(2) HG	(3) HG	-	(1) HC	(4) HG	(7) HG	-	-	-	-	-	-
Av. Condition	G	G	-	C	LG	HG	-	-	-	-	-	-
Av. of all calves:												
Type	(16) G-	(16) LG/	(11) LG/	(9) HG-	(13) HG-	(17) G-	(11) HM/	(10) HM	(12) LG-	(5) HM	(5) HM	(5) LG-
Condition	HComm/	HComm/	HComm-	LG/	HComm/	LG/	Comm	HComm-	Comm-	Comm/	Comm/	HComm/

TABLE XVI

COMPARISON OF TYPE AND CONDITION OF SPRING CALVES AT WEANING
BY SEX AND BY BULLS FOR YEARS 1949, 1950 AND 1951[a] (Continued)

	-3[c]		245[f]		246[c]		238[c]		225[f]	
1949	M	F	M	F	M	F	M	F	M	F
Av. Type	-	-	-	-	-	-	-	-	-	-
Av. Condition	-	-	-	-	-	-	-	-	-	-
1950										
Av. Type	-	-	-	-	-	-	-	-	-	-
Av. Condition	-	-	-	-	-	-	-	-	-	-
1951										
Av. Type	(6) LC-	(10) HG-	(12) G-	(7) G-	(2) C	(3) LC	(2) LG ≠	(1) LG	(2) G ≠	-
Av. Condition	LG	G ≠	LG ≠	G-	G ≠	G ≠	HComm ≠	G	G	-
Av. of all calves:										
Type	(6) LC-	(10) HG-	(12) G-	(7) G-	(2) C	(3) LC	(2) LG ≠	(1) LG	(2) G ≠	-
Condition	LG	G ≠	LG ≠	G-	G ≠	G ≠	HComm ≠	G	G	-

TABLE XVI

COMPARISON OF TYPE AND CONDITION OF SPRING CALVES AT WEANING BY SEX AND BY BULLS FOR YEARS 1949, 1950 AND 1951[a] (Continued)

(a) Number in () indicates number in averages.

(b) Irradiated bull.

(c) Purebred bull.

(d) Bull in dam at time cow irradiated.

(e) Grade control bull.

(f) Atom's sons out of irradiated cows.

Symbols:

Type		Condition	
HC	High Choice	G	Good
C	Choice	LG	Low Good
LC	Low Choice	HComm	High Commercial
HG	High Good	Comm	Commercial
G	Good	LComm	Low Commercial
LG	Low Good		
HM	High Medium		
M	Medium		

TABLE XVII

COMPARISON OF THE BREEDING EFFICIENCY AND RELATIVE FERTILITY OF BULLS FOR BREEDING SEASONS 1948, 1949 AND 1950

1948	(a) Atom	(b) Pal	(b) -50	(c) 40	(c) 137	(d) 91	(b) -3	(e) 245	(b) 246	(b) 238	(e) 225
No. cows exposed	20	24	18	19	18	-	-	-	-	-	-
Age of bull	4	6	3	2	2	-	-	-	-	-	-
No. live calves produced	8	8	9	9	10	-	-	-	-	-	-
% live calves produced	40.0	33.3	50.0	47.4	55.5	-	-	-	-	-	-
No. stillbirths	1	1	1	1	2	-	-	-	-	-	-
No. known abortions	-	2	2	1	1	-	-	-	-	-	-
Total no. known conceptions	9	11	12	11	13	-	-	-	-	-	-
% Conceptions	45.0	45.8	67.8	57.9	72.2	-	-	-	-	-	-
1949											
No. cows exposed	41	28	16	15	14	11	-	-	-	-	-
Age of bull	5	7	4	3	3	-	-	-	-	-	-
No. live calves produced	34	24	14	13	9	10	-	-	-	-	-

TABLE XVII

COMPARISON OF THE BREEDING EFFICIENCY AND RELATIVE FERTILITY OF BULLS FOR BREEDING SEASONS 1948, 1949 AND 1950 (Continued)

1949	(a) Atom	(b) Pal	(b) -50	(c) 40	(c) 137	(d) 91	(b) -3	(e) 245	(b) 246	(b) 238	(e) 225
% live calves produced	82.9	85.7	93.7	86.6	64.3	90.9	-	-	-	-	-
No. stillbirths	1	2	-	-	-	-	-	-	-	-	-
No. known abortions	-	-	-	-	-	-	-	-	-	-	-
Total no. known conceptions	35	26	14	13	9	10	-	-	-	-	-
% Conceptions	85.4	92.8	93.7	86.6	64.3	90.9	-	-	-	-	-
1950											
No. cows exposed	18	11	16	-	-	-	26	19	6	3	3
Age of bull	6	8	5	-	-	-	2	3	1	1	2
No. live calves produced	17	8	15	-	-	-	21	19	5	3	3
% live calves produced	94.4	72.7	93.7	-	-	-	80.8	100.0	83.3	100.0	100.0
No. stillbirths	1	3	-	-	-	-	3	-	9	-	-

TABLE XVII

COMPARISON OF THE BREEDING EFFICIENCY AND RELATIVE FERTILITY OF BULLS FOR BREEDING SEASONS 1948, 1949 AND 1950 (Continued)

1950	Atom (a)	Pal (b)	-50 (b)	40 (c)	137 (c)	91 (d)	-3 (b)	245 (e)	246 (b)	238 (b)	225 (e)
No. known abortions	-	-	-	-	-	-	-	-	-	-	-
Total no. known conceptions	18	11	15	-	-	-	24	19	5	3	3
% Conceptions	100.0	100.0	93.7	-	-	-	92.3	100.0	83.3	100.0	100.0
Summary for test:											
No. cows exposed	79	63	50	34	32	11	26	19	6	3	3
No. live calves	59	40	38	22	19	10	21	19	5	3	3
% live calves	74.6	63.5	76.0	64.7	59.3	90.9	80.8	100.0	83.3	100.0	100.0
No. stillbirths	3	6	1	1	2	-	3	-	-	-	-
No. known abortions	-	2	2	1	1	-	-	-	-	-	-
No. known conceptions	62	48	41	24	22	10	24	19	5	3	3
% Conceptions	78.4	76.2	82.0	70.5	68.7	90.9	92.3	100.0	83.3	100.0	100.0

TABLE XVII

COMPARISON OF THE BREEDING EFFICIENCY AND RELATIVE FERTILITY OF BULLS FOR BREEDING SEASONS 1948, 1949 AND 1950 (Continued)

(a) Irradiated bull.

(b) Purebred bull.

(c) Bull in dam at time cow was irradiated.

(d) Grade control bull.

(e) Atom's sons out of irradiated cows.

1948 was only 45.5 percent compared with 80.0 percent for the irradiated cows. This low percentage for the control cows is probably due to the fact that they had not become acclimated to our conditions and to their thin condition. After the first year both groups of cows had satisfactory calf crops.

Breeding efficiency of sires. The breeding efficiency of the individual sires could not be correlated with irradiation. The exposed bull "Atom" settled 78.4 percent of his cows compared to 76.2 percent for the control bull Pal. The breeding efficiency of all bulls was considered satisfactory under the conditions of this study.

SUMMARY

The appearance of the hair of the exposed cattle (graying, thin areas, dead appearing) was an effect of the irradiation.

The skin condition of the exposed cattle was an effect of irradiation.

The thin condition of the exposed cattle at the beginning of this study was a nutritional effect rather than irradiation, based on a comparison of beginning weights, rate of gain and general appearance of the exposed and control cattle.

These exposed cattle made satisfactory growth and weight gains when fed an adequate ration.

Percent of cattle lost by death was slightly higher in control herd than in the irradiated herd.

Pathological changes in the exposed cattle were the most severe in the superficial parts of the skin. There was a marked thickening of the skin, it was non-pliable, firm and fixed, with extensive hyperkeratosis. Artifically produced wounds required 2 to 3 times as long to heal as similar wounds on control cattle. Less pressure was required to incise the skin of exposed animals than the controls.

No significant difference was found in the blood picture of the two groups of cattle. Both appeared to be within normal range.

The calves from exposed cows performed equally as well as the calves from the control cows.

There was very little difference in the performance of calves by the irradiated sires and control sires.

The breeding efficiency and relative fertility were as good in the irradiated herd as in the control herd.

Breeding efficiency of all the sires used in this study was satisfactory.

CONCLUSION

In so far as these studies could determine, the irradiation received by the herd of Hereford cattle from the "fall-out" of the first atomic bomb in New Mexico July 1945 did not affect the general health, growth or breeding efficiency of the original cattle, or of their offspring.

The irradiation damage was confined to the skin of these cattle, causing the thinning and graying of the hair, and a marked thickening of the skin. This condition was not transmitted to their offspring.

These statements apply only to the cattle and conditions in this study and under no circumstances should this information lead to the assumption that irradiation received from exposure to an atomic explosion, or exposure to other types of irradiation would produce similar results on animals or humans.

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