Bulletin 351 October, 1962

# FLUOROSIS IN BEEF CATTLE

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THE UNIVERSITY OF TENNESSEE
AGRICULTURAL EXPERIMENT STATION
JOHN A. EWING, DIRECTOR
KNOXVILLE

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# Acknowledgments

Grateful acknowledgment is hereby made to the many individuals, agencies, and institutions who contributed to this research, and to the presentation of the data therefrom.

Special acknowledgment is made to W. H. MacIntire (deceased), L. J. Hardin, Mary D. Buehler, and other workers of the Tennessee Agricultural Experiment Station who made the fluorine analyses reported.

The authors express their appreciation to Fletcher Sweet for editing this bulletin and to R. J. Cooper for assistance with the statistical analyses.

This study was made possible by State and Federal funds, supplemented substantially by grants-in-aid from the Aluminum Company of America for Experiments I, II and V; and, in addition, the Company gave cooperative support along with that of Monsanto Chemical Company and Victor Chemical Works for Experiment IV. The collaboration and the financial support given by these corporations have been of inestimable value in the furtherance of this research.

# Foreword

Tennessee workers by 1947 were aware of a fluorosis problem affecting livestock in the area of the main Agricultural Experiment Station (Blount Farm) and in the area of the branch station at Columbia (Middle Tennessee Agricultural Experiment Station). Factors considered in connection with the problem included the proximity of an aluminum smelting-production plant near Blount Farm, and phosphate processing plants, and high-phosphate soils, in the Columbia area.

A survey of the teeth of animals, and chemical determinations of fluorine (F) content of forage, feed, and animal bones in the areas were used in determining the scope of the problem and planning further investigations.

Research was initiated in the fall of 1947 to determine the effects of different levels and sources of F, and possible alleviators of F effects, on cattle, sheep and laboratory animals. Results of various feeding, metabolism and grazing experiments with cattle and sheep and experiments with laboratory animals were reported by Hobbs *et al.* (1954) and Merriman *et al.* (1956).

The reader is referred to Hobbs *et al.* (1954) for details of sampling, methods of analyses and other procedures used during the first four and one-half years of the 10 years' work on Experiment I; and the first two of the eight years' work on Experiment II.

Experiment I and a large portion of Experiment II were designed to determine: (1) the physiologic effects upon cattle of F from sodium fluoride (NaF) and of forage contaminated with fumes from an aluminum smelting plant; (2) the relative toxicity of the two sources; and (3) the level at which cattle could ingest F from either source without an economic loss of productivity in the animal.

Hobbs *et al.* (1954) reported on digestion and metabolism and blood studies in Experiments I and II. They also reported an experiment in which F as NaF was fed to heifers at levels ranging to a maximum of 1,200 parts per million. Studies were reported in which laboratory animals and sheep were used to determine effects of ingested F, with and without possible alleviators.

Experiment II not only served as a partial replicate of Experiment I, but was designed to determine the value of aluminum sulfate as an alleviator of F effects in animals ingesting F from NaF at levels of 20 to 50 ppm in the ration. Information on the efficacy of the alleviator would be of value in

industrial areas in which escaping F could not be entirely controlled by the processing plants.

The degree of toxicity of F from raw rock phosphate (RRP), and from soil sources and similar F-bearing compounds, is of concern to the feed and fertilizer industries and to farmers grazing livestock on soils high in F. Experiment IV was designed to determine the relative toxicity to livestock of various levels of F from RRP, and from sodium fluoride (NaF).

There are instances where industry reduced the F output to the extent that F contamination was no longer serious on adjacent agricultural lands. Experiment V was designed to evaluate the rate of recovery from fluorine effects of cattle after removal from F contaminated pastures.

The results of Experiments I, II, IV and V are reported in this bulletin.

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# General Summary

Cows were used in the study of physiologic effects of various levels of ingested fluorine (F). In Experiments I and IV fluorine as sodium fluoride (NaF) or raw rock phosphate (RRP) was added to concentrate feeds for some groups of cows while other groups consumed hay, or hay and pasture, contaminated with F from an industrial source. In Experiment II aluminum sulfate hydrate was added as an alleviator to rations containing NaF. In Experiment V groups of cows were removed after approximately 100, 200, 400, 600, and 800 days on pastures contaminated with F from an industrial source. Cattle were started on experiment at 14 to 22 months of age. The studies covered various periods up to 10 years, providing data indicating the following:

**Feed Consumption**

1. Cows in Experiment I, ingesting F added as NaF at a level of 30 parts per million (ppm) or less (a total of 38 ppm F); cows grazing pastures with average F analyses up to 44 ppm; and cows consuming hays (1948 through 1952) averaging up to 66 ppm F for a winter period, showed no significantly lowered feed consumption during 10 years on test.

2. Cows in Experiment II which were a few months older at the start of the experiment and were continued on test for approximately eight years showed no significantly lowered feed consumption while ingesting F added as NaF at a level of 40 ppm or less (total of 48 ppm F) with and without an alleviator, and 50 ppm F (total of 58 ppm F) plus an alleviator.

3. Cows ingesting F added as NaF at levels of 40 and 50 ppm (total of 48 and 58 ppm F) in Experiment I consumed significantly less feed after two and one-half years on test. In Experiment II cows ingesting 50 ppm F as NaF without an alleviator consumed significantly less feed after three years on test.

4. Cows in Experiment I consuming rations with F added as NaF at levels of 70 and 100 ppm F, and 100 ppm F plus defluorinated phosphate, consumed significantly less feed within one and one-half years on test. The cows in Experiment IV, consuming F as NaF at levels of 50 and 100 ppm in the ration, did not show lowered feed consumption during the 32 months on test.

5. Cows consuming F added as RRP (Experiment IV) at a level of 200 ppm or less for 32 months did not show lowered feed consumption.

Cows consuming F added as NaF (Experiment IV) at 200 and 300 ppm levels consumed less feed within one year, while those consuming 300 ppm F from RRP did not show a lowering of feed consumption until after approximately two years on test.

At levels of 600 ppm (Experiment IV), F added as NaF caused an immediate decrease in feed consumption while the same level added as RRP did not cause a decrease until the second year.

6. Cattle grazed F contaminated pastures containing a maximum average of 473 ppm initially and a minimum of 29 ppm for periods up to 837 days, and were then removed to a non-contaminated pasture. Cows remaining at the end of the test did not show significant differences in feed consumption compared to the controls. From data in Experiments I, II, and V it was concluded that F from NaF is more toxic than a comparable level of F in the contaminated hays or pastures.

**Weights and Gains.** Cows fed rations containing up to 50 ppm F added as NaF with and without an alleviator and up to 100 ppm F showed no appreciable differences in weights and gains. Cows consuming F added to the ration as NaF at levels of 200, 300 and 600 ppm F had lower weights and gains than the controls but no decrease in weights and gains was caused by the ingestion of the same levels of F from RRP. Consumption of hay or pasture contaminated with F from the aluminum smelting plant did not result in appreciable differences in weight gains of cows.

**Reproduction and Calf Records.** Cattle receiving F added as NaF (Experiment I) at levels of 70 and 100 ppm showed decreased reproductive efficiency that probably was an indirect effect of F ingestion. In other experiments, ingestion of F added as NaF or RRP at levels up to 300 ppm or added as RRP at levels up to 600 ppm did not interfere with reproduction. Ingestion of F contaminated hays and pastures did not interfere with reproduction. Average daily gains of calves were not significantly different due to level of F ingested, except where feed consumption of cows was decreased to where it lowered milk production.

**Fluorine Content of Bones.** Fluorine content of rib sections taken by biopsy at intervals, or of ribs, metatarsal bones, metacarpal bones and jaws collected at slaughter was related to the level of F ingestion, source of F ingested, and length of period of ingestion. Ingestion of F as RRP resulted in a much lower bone F content than ingestion of a similar level of F as NaF. Ingestion of aluminum sulfate hydrate simultaneously with F as NaF reduced bone F storage. When cattle were removed from an F contaminated pasture, F levels in bone gradually decreased.

**Blood Studies.** There were no significant changes in blood composition due to F ingestion.

**Urinary Fluorine.** Level of urinary fluorine varied in general with the level of F ingested and the source of F. Addition of aluminum sulfate

hydrate to rations containing F caused decreased urinary F concentrations. Cows ingesting F as RRP generally had lower urinary F levels than cows ingesting comparable levels of F from NaF.

**Teeth.** Changes in appearance and structure of teeth due to increased F ingestion occurred in animals which ingested F during the period of teeth development. Severity of teeth effects caused by F was generally related to the level of F ingested; availability of F for intestinal absorption; and the stage of tooth development and length of time during which F was ingested. Generally, if cattle were removed from an F contaminated pasture to a control area, incisor teeth erupting six months and later after removal showed little or no evidence of changes due to F ingestion.

**Gross Changes in Bone and Other Tissue.** Ingestion of F at various levels and from different sources did not cause specific changes in the internal organs examined. Palpation for bone changes due to F ingestion were not reliable in cows ingesting F added as NaF at levels below 70 ppm. Cows ingesting F added as NaF at levels of 40 ppm (a total of 48 ppm F in ration) in Experiment I and at 50 ppm F as NaF without alleviator in Experiment II showed hypertrophic changes in the metatarsal bones at autopsy. However, gross hypertrophic changes were either absent or slight in cows on F contaminated pasture. Ingestion of F as NaF at 70 ppm and above caused generalized hypertrophy of bone.

At 300 ppm F, hypertrophic changes caused by F from RRP were similar to those caused by F as NaF.

The occurrence and degree of fluorosis in cattle depends upon many factors including: (1) the level of fluorine ingested; (2) the age of the animal and the stage of tooth development; (3) the length of time exposed to the increased fluorine ingestion; (4) the initial fluorine stored in the animal's body; and (5) the solubility and availability of the fluorine material ingested.

# Introduction and Review of Literature

Interest in fluorosis has been stimulated by the recognition that certain functional disabilities suffered by livestock and by man are due to ingestion of excessive amounts of fluorine. Occurrences of chronic fluorine intoxication have been described in flocks and herds grazing in many parts of the world. Symptoms of fluorosis have been reported among animals grazing in the vicinity of superphosphate plants, aluminum plants, brick kilns, steel production centers and other processing operations.

In Iceland, as early as 1100 A.D., attention was called to a disease of domestic animals, which appeared particularly in grazing sheep after volcanic eruptions (Roholm, 1937). The symptoms described were similar to those in cases later diagnosed as fluorosis. As early as 1670 it was known that glass was attacked by the fumes produced when fluorspar was treated with sulfuric acid; and in 1802 Morichini used the glass test to determine the presence of such "fumes" in substances of animal origin. As a result of these studies, fluorine was detected in fossil teeth. In 1805, Guy-Lussac and Berthollet found fluorine in enamel of normal teeth and thus raised the question concerning the extent and significance of the occurrence of fluorine in teeth and other body substances. The presence of fluorine has been reported in the ash of blood and of milk; in brain; yolk and shell of the egg; and in various organs and tissues of the animal body. A summary of literature on the fluorine content of foods and beverages was given by McClure (1939).

Fluorosis has been reported as occurring in grazing animals; in animals fed mineral supplements containing excessive amounts of fluorine; in animals drinking fluorine-contaminated water (Rand and Schmidt, 1952; and Peirce, 1954); and in animals grazing on phosphatic limestone soils, especially where the phosphatic rocks appeared near the surface (Phillips, 1952).

A voluminous literature has resulted from the numerous investigations which for the most part, have been devoted to the study and description of symptoms, relative toxicities of different fluorine compounds, and quantities of fluorine required to bring about gross changes in different animal species. Information describing toxic effects of fluorine on the different

tissues and organs of the animal body has been reviewed by Dean (1936), McClure (1933), Peirce (1939), DeEds and Thomas (1933), and Gettler and Ellerbrook (1939). Mitchell and Edman (1952) presented an extensive summary of literature concerned with the fluorine hazard in livestock feeding, with special emphasis on the relative toxicities of the various fluorine compounds. One of the early reviews of the literature on fluorine intoxication is the monograph by Roholm (1937). Later reviews include those by Allcroft (1956), Phillips *et al.* (1955), and McGin (1956).

Several workers have reported the effects of fluorine on metabolism and digestion. Chamberlain *et al.* (1956) reported the effects of fluoride on carbohydrate metabolism in animals. The use of $F^{18}$ in the study of the mode of action of fluorine in the body has been reported by Perkinson *et al.* (1955), Chamberlain *et al.* (1957, 1960), Chamberlain (1959), and Bell *et al.* (1961). Other studies on the mode of action of fluorine have been reported by Neeley and Harbough (1954), Allcroft (1954), Griffith *et al.* (1954, 1955, 1956), Miller (1955), Merriman and Hobbs (1957), and Chamberlain and Burroughs (1960).

Chronic fluorosis in cattle has been produced experimentally and reported by several investigators, including Reed and Huffman (1930), Phillips *et al.* (1934), Elmslie (1936), Majumda *et al.* (1943), Hobbs *et al.* (1953, 1954, 1958), Schmidt *et al.* (1954, 1956), Newell and Schmidt (1958), Stoddard *et al.* (1954), Wagner *et al.* (1958), Suttie *et al.* (1957a, 1959, 1960, 1961).

The problem of fluorosis in livestock production was reviewed by Phillips *et al.* (1960).

Hobbs *et al.* (1953) reported that acute fluorine intoxication symptoms of anorexia, loss of weight, emaciation and general weakness developed in animals ingesting 6.5 mg. of fluorine/kg. of body weight (600 parts per million).

Safe levels of fluorine in the total ration for cattle are generally considered to be 30 to 50 parts per million (ppm) from sodium fluoride or other soluble forms, and 60 to 100 ppm from phosphatic limestone or rock phosphates (National Research Council, 1960).

The pathology of chronic bovine fluorosis is extensively covered in work reported by Shupe *et al.* (1955). These workers concluded that the most sensitive biological reaction in the body resulting from fluorine intoxication occurs in the teeth. They observed some definite structural changes in bone containing more than 4,000 ppm of fluorine (F). They stated that the soft tissue evaluation and interpretation are made more difficult by the frequent association of conditions unrelated to fluorine intoxication. They say that clinical, histopathological, radiological and chemical findings must be carefully evaluated to interpret properly fluorine intoxication.

Schmidt and Newell (1956) reported that F levels (0.15 to 2.5 mg./kg.

of body weight/day) which they used caused no appreciable effect on milk production, blood analysis, weight gains, number of breedings per conception, days in gestation, percent of live births, or birth weight of calves. They used two-year-old Holstein heifers, and found that the urinary fluorine tended to show a relationship with the amount of fluorine ingested. They found that F deposition in the bone and cartilage was the most reliable indicator of the level of F ingested. They found the greatest amount of F was deposited in the rib cartilage; followed by the rib, mandible, and leg in decreasing concentrations.

Schmidt and Newell substantiated the conclusions of Hobbs *et al.* (1954) and others that the degree of dental fluorosis is dependent on the length of time of ingestion, the amount of F ingested, age of cow when fluorine was first administered, and whether the permanent teeth had erupted when the experiment was begun. They noted that a year and a half after the start of the experiment slight exostoses developed in the metatarsal bones of two cows fed the 2.5 mg. level. They also noted that there was no appearance of unthriftiness or roughened hair coat in the cows fed the 2.0 and 2.5 mg. levels of fluorine. They reported no histopathological changes in the soft tissues, and no appreciable amount of F stored in the soft tissues. The bone pathology was described as a roughening of the periosteum in the metacarpal, metatarsal and rib bones. These changes were most noticeable in the 2.0 and 2.5 mg. level groups.

Other investigators have reported similar histopathological and pathological findings. Details may be found in the following articles: Peirce (1954), Allcroft (1954), Hobbs *et al.* (1954), Garlick (1955), Griffith *et al.* (1954, 1955, 1956), Dale and Crampton (1955), McClendon and Cohen (1955), Merriman and Hobbs (1957), Suttie *et al.* (1957b, 1958) and Hayashi and Okauchi (1960).

The literature prior to 1954 dealing with the effects of F on teeth, was reviewed by Hobbs *et al.* (1954). This work also described the teeth classification system used by the Tennessee workers. Classification systems for humans were set up by Dean (1938). The system used by Shupe *et al.* (1955) is similar to that proposed by Dean with some slight modifications.

Hobbs *et al.* (1954), Griffith *et al.* (1954, 1955, 1956), and Hobbs and Merriman (1959) reported that adding 0.5 percent aluminum sulfate to rations containing up to 50 ppm F for cattle, and aluminum sulfate or aluminum chloride to rations containing up to 100 ppm F for wether lambs, resulted in a 20 to 40 percent decrease in F deposition. They also reported that the addition of aluminum sulfate to rations containing increased levels of F caused a decrease in the fluorine content of the bones and decreased the effects of F on developing teeth of cows, ewes, lambs and rats.

The literature on the subject of antidotes or alleviators was reviewed by

Boddie (1955). He points out that several writers have reported value in the use of calcium carbonate and aluminum compounds, such as aluminum sulfate and aluminum chloride. In a later article Boddie (1957) reported the use of F alleviators, calcium carbonate and aluminum oxide, used separately and in mixtures with rats. The mixture of the two was found to be more effective than when calcium carbonate was used alone. Boddie later (1960) described a trial measuring the effectiveness of a mixture of calcium carbonate and aluminum oxide with cattle, and his report further substantiates the findings of the Tennessee workers. Other writers have reported similar results, but in no reported case does the alleviator completely eliminate the storage of ingested F.

# Methods of Sampling and Analyzing

**Sampling Procedures.** The feed supplements used in the experiments with cattle were mixed by hand in the early period of the tests, and later in a twin spiral electric mixer of 1,000-pound capacity. These mixtures consisted of ground corn and a protein supplement. Fluorine and/or alleviators were added to these mixtures as indicated in Tables 1, 18, and 29. The additives were pre-mixed for uniformity with a small portion of the supplement, then added routinely to the supply for each individual lot as feeds were mixed. Representative samples were taken to make a composite sample for fluorine analysis.

Samples of hay were taken at the time of feeding and composited for periodic analyses. During the digestion trials, feed samples, feed refusals, and daily collections of urine and feces were taken and the representative aliquots refrigerated (7 or 10 days) and composited for analysis at the end of the studies. The pasture samples were taken every two weeks or monthly from various places throughout the pasture to obtain a representative sample of the forage consumed. Samples were taken every 50 paces in the pasture field, which was covered by a definite procedure, depending upon the forage and the shape of the field, to obtain a representative sample for analysis.

The forage samples were placed in a jar containing a fixative (calcium oxide plus ammonium carbonate) to prevent loss of fluorine during the storage period previous to being dried, ground and analyzed.

Fluorine concentration was determined in the various materials by a slight modification of the perchloric acid distillation and thorium nitrate titration method as described by Willard and Winter (1933). Details of these modifications varied with the samples, since the materials included feeds, urine, feces and bones. Fluorine quantities in urine, feeds and soft tissues are reported in parts per million fluorine on the basis of the sample taken. Fluorine content of bones is reported in ppm in the bone ash (to convert to a fat-free basis multiply the fluorine content on an ash basis by approximately two-thirds).

Proximate analyses of feeds and feces were made according to procedures of the Association of Official Agricultural Chemists (1950). These analyses included ash, calcium, phosphorus, moisture, crude protein, ether extract, crude fiber and nitrogen-free extract, and provided the basis for the digestibility determinations.

Routine bone samples were taken for fluorine analysis from the right

mandible, right metacarpal and right ninth and tenth ribs when an animal was autopsied. The mandible sample was taken from the angle of the right mandible. The metacarpal sample was taken from the medial proximal quarter of right metacarpal. The rib samples were obtained from the distal three to four inches of the ninth and tenth ribs. The rib biopsy samples were obtained from either the left ninth, tenth, eleventh or twelfth ribs.

Blood samples were taken periodically from which serum was used for determinations of calcium, inorganic phosphorus, sodium, potassium, and magnesium. Calcium was determined according to the Clark-Collip modification of the Kramer-Tisdall method as described by Hawk *et al.* (1949).

The method of Fiske and Subbarow as described by Hawk *et al.* (1949) was used with slight modification, for the determination of serum inorganic phosphorus. Sodium and potassium were determined by use of a flame photometer as described in the Perkin-Elmer Instructions Manual (1949); and serum magnesium was determined by a combination of the method described by Simorsen *et al.* (1947) and the modified Denis method as described by Hawk *et al.* (1949).

Citrated whole blood samples were employed for the measurement of hemoglobin, packed cell volume, and specific gravity and for red and white blood cell counts. Additional fresh blood samples were taken for differential white cell counts. The procedures employed were as follows: hemoglobin, as described in the Evelyn Photoelectric Colorimeter Manual (1948); specific gravity, as described by Hawk *et al.* (1949); packed cell volume by centrifugation at 3,000 revolutions per minute for 15 minutes; white blood cell, red blood cell, and differential counts were made according to the procedure described by Parker (1948).

The dye sulfabromophthalein sodium was used in modifications of methods of Mixner and Robertson (1957) and Frame (personal communication, 1958) to determine liver function of cattle. A pre-injection blood sample was followed by injection of 5 mg. of the dye per kilogram of body weight. Blood samples were collected at intervals of 5, 10, 15, 30 and 45 minutes. The amount of dye retained was determined colorimetrically.

## EXPERIMENT I—LOTS 1–11 AND 14–16

### Objectives

This experiment was designed to determine the physiological changes in beef cows, associated with: (1) feeding of various levels (0–100 ppm F) of fluorine as sodium fluoride, (2) feeding of hays with different degrees of fluorine contamination, (3) pasturing on grass having different degrees of fluorine contamination, and (4) feeding of high levels of calcium and phosphorus with fluorine.

Observations included effects of fluorine on:

1. Feed consumption and efficiency.
2. Growth, gains, and general physical condition.
3. Reproduction of cows and calf production.
4. Digestion and mineral balance.
5. Bone fluorine content and changes.
6. Blood components.
7. Urinary fluorine content.
8. Teeth changes, description, and classification.
9. Gross tissue changes.

## Experimental Procedure

The cattle used in this experiment were grade Hereford heifers purchased as yearlings in the Midwest in the winter and spring of 1948. The heifers were free from tuberculosis and Bangs disease when shipped. When they arrived at the Tennessee Station they were immunized against brucellosis.

The first group of heifers was divided into 11 uniform lots of two animals each, based on source, weight, type grade, and condition. In addition to Lots 1 through 11, referred to as the barn-fed groups, 12 heifers were allotted to each of Lots 14 and 15, and 10 animals to Lot 16, all designated as pasture groups. The heifers in Lots 1 through 11 were started on test in April, 1948. A second group of heifers in Lots 14, 15 and 16, and one additional animal each in Lots 1 through 11, were started in May and June, 1948.

**Barn-Fed Lots.** The heifers in Lots 1 through 11 were individually fed rations consisting of three parts ground No. 2 yellow corn and one part of 41 percent cottonseed meal. The heifers were fed two pounds of concentrates per head daily from the beginning of experiment to November, 1948; three pounds of concentrates per head daily from November, 1948, to February, 1949; four pounds per head daily until March, 1954; and two pounds per head daily from March, 1954, until the end of the experiment in June–July, 1958. In addition to the concentrates, all heifers were fed hays free choice.

The fluorine was added to the concentrate mixture as sodium fluoride (NaF) in Lots 2 through 8, and 11. The amount of NaF added to the ration for each group was calculated on the basis of parts of F per million parts (ppm) of air-dry ration consumed. At the end of each 28-day period the consumption was checked and the amount of NaF was adjusted according to the average daily consumption for each lot. Feed consumption and weight gains were summarized to the fall of 1957, but individual feeding and records were maintained until each animal was slaughtered for autopsy. The experimental plan is outlined in Table 1.

Defluorinated rock phosphate was added to the concentrate ration of

| Lot no. | Number cows Initial | Oct. 1957 | F added to ration ppm | Total ppm F in ration Initial (1948) to Oct. 1950 | Initial (1948) to Oct. 1957 | Av. initial wt., lbs. 1948 | Av. daily mg. F/kg. body weight Initial (1948) to Oct. 1950 | Initial (1948) to Oct. 1957 |
|---|---|---|---|---|---|---|---|---|
| 1 | 3 | 3 | 0 | 8 | 8 | 489 | 0.15 | 0.17 |
| 2 | 3 | 3 | 10 | 18 | 18 | 496 | 0.38 | 0.39 |
| 3 | 3 | 1 [a] | 20 | 28 | 28 | 498 | 0.62 | 0.59 |
| 4 | 3 | 3 | 30 | 38 | 38 | 500 | 0.83 | 0.91 |
| 5 | 3 | 3 | 40 | 48 | 48 | 507 | 1.04 | 1.03 |
| 6 | 3 | 3 | 50 | 58 | 58 | 510 | 1.28 | 1.24 |
| 7 | 3 | 3 | 70 | 78 | 78 | 462 | 1.69 | 1.56 |
| 8 | 3 | 2 [b] | 100 | 108 | 108 | 473 | 2.06 | 1.96 |
| 9 | 3 | 3 | $B_1$ hay | 27 [c] | $B_1$ hay | 480 | 0.63 | 0.46 |
| 10 | 3 | 3 | $B_2$ hay | 44 [c] | $B_2$ hay | 495 | 0.97 | 0.67 |
| 11 | 3 | 3 | 100 + Def.[d] | 108 + Def. | 108 + Def. | 490 | 2.39 | 2.18 |
| 14 | 12 | 4 [e] | $B_2$ pasture and hay | 44 [c] | 34 | 498 | | |
| 15 | 12 | 4 [f] | $B_1$ pasture and hay | 31[c] | 24 | 488 | | |
| 16 | 10 | 4 [g] | Control pasture and hay | 10 | 8 | 486 | | |

[a] One animal died 7–5–49 (lost in calving); one animal died 6–3–55.

[b] One animal sacrificed 6–9–53.

[c] The hays fed in barn the first winter (1948–9) contained the following ppm F respectively: Lot 9, 46.7 ppm F; Lot 15, 59.8 ppm F; Lot 10, 55.8 ppm F; and Lot 14, 66.1 ppm F.

[d] Defluorophos guaranteed analyses are: Ca not less than 31.00%, P not less than 13.10%, F not more than 00.05%. Ingredients: Defluorinated phosphate containing not more than 500 ppm F and not less than 65.60% B.P.L. These results reported by International Minerals and Chemical Corporation.

[e] Three animals sacrificed May, 1949; two animals sacrificed October, 1949; one animal sacrificed August 1950; one animal died March, 1951; one animal sacrificed November, 1956.

[f] Three animals sacrificed May, 1949; two animals sacrificed October, 1949; one animal died July, 1949; one animal sacrificed December, 1955; one animal died March, 1956.

[g] One animal sacrificed May, 1949; one animal sacrificed June, 1949; two animals sacrificed October, 1949; one animal sacrificed November, 1954; one animal died June, 1956.

Lot 11 at a level of 0.5 percent of the total air-dry ration. This material contained F and increased slightly the total F in the ration. The concentrate mixture including NaF for each lot was prepared for 14 to 28-day periods.

Hay used in these tests was good quality lespedeza-grass or alfalfa-grass mixtures containing at least 50 percent legume. Lot 10 was fed control concentrate and $B_2$ hay which contained as high an amount of fluorine as any hay that could be purchased in the area. Hay fed Lot 9 ($B_1$ hay) was selected to be of similar quality but with an F content about midway between the control and $B_2$ hay. Beginning with the fifth year and continuing throughout the remainder of the experiment, control hay was fed to Lots 9 and 10. The change was necessary because hay of similar F content to that purchased earlier could not be obtained. This was due to F recovery measures adopted by an aluminum smelting plant in the area. Thereafter, hay with an F content above 25 ppm could not be purchased in the area being studied. All hays were analyzed for fluorine before purchase and again as fed. In the early part of the study all hay was fed as it came from the bale, but later it was chopped for feeding. Cows were individually fed equal amounts of their respective concentrate mixture, also the hay was individually fed *ad lib*. Individuals within a lot were offered the same amount of hay, but the amount offered daily was two or three pounds over the highest consumption of any one animal within that lot.

Starting with summer of 1953 the cows were permitted to graze pasture for the following periods:

| | | | |
|---|---|---|---|
| 4– 9–53 | to | 9– 3–53 | inclusive |
| 4–10–54 | to | 9–11–54 | inclusive |
| 4–22–55 | to | 9– 5–55 | inclusive |
| 4–28–56 | to | 10– 3–56 | inclusive |
| 4–12–57 | to | 7–28–57 | inclusive |

The cows were brought into the barn each morning and individually fed two pounds of the concentrate mixture containing fluorine at a level based on previous daily consumption in dry-lot, and milligrams of F per kg. of body weight. The cows were held in the barn from early morning until afternoon to allow sufficient time for the consumption of the concentrate containing each cow's daily F allowance.

During the first two years, the cows were handled as described heretofore at calving time. During the second year, considerable trouble was encountered from navel infection, resulting in losses of calves. During the third and fourth calving periods, the cows and calves were put into a pasture paddock a few days at calving time. The cows then went back to the regular schedule, but the calves remained in the clean lot while the cows were in the barn. After this practice was started the calves were nursed twice a day until weaning time. From the fifth year until the end of the

test either this procedure was used or the cows were turned on pasture with their calves.

In 1950, Experiment II was initiated, which was a replicate of the following treatments of Experiment I: control and control plus 20, 30, 40, and 50 ppm F as NaF (20A–24A). Similar lots were included with an alleviator added (Lots 20B–24B). Additional groups (Lots 25 and 26) were added to pasture lots 16 and 14, respectively.

**Pasture Lots.** Lot 14 cows were grazed on Blount 2 ($B_2$) pasture during the summer. During the first two winters and also during the winters of 1956–57 and 1957–58, they were kept in a barn with an outside paved lot. $B_2$ pastures were selected on the basis of the fluorine content of the forage, which was found to average approximately 40 to 60 ppm F on an air-dry basis during the grazing season. The fluorine content was higher in the winter period due to accumulation when the forage grows slowly or is dormant. Hay was usually from the same source as that fed Lot 10 in the barn.

A concentrate mixture similar to that fed to Lot 1, barn control group, was fed to all three pasture groups, Lots 14, 15 and 16, during the first two and last two winters. The pasture groups received no concentrate mixture during the third through the eighth winters.

Lot 15 cows were grazed on Blount 1 ($B_1$) pastures which averaged approximately 20 to 40 ppm F air-dry basis. This was about half-way between the F level of pastures for Lots 14 and 16 during the grazing seasons. The $B_1$ hay fed to this group was, generally, from the same source as hay fed to Lot 9 in the barn-fed groups. Beginning in the winter of 1952–53, control hay was fed to all pasture groups and to Lots 9 and 10.

Lot 16 cows were grazed on a pasture out of the area of possible contamination with fluorine from an aluminum smelting plant. Animals in Lot 16 were managed and fed similarly to Lots 14 and 15.

Pasture cows were put on the pastures about April 10 and were taken off about the first of October in the first two and last two years. During the third through the eighth winters, the cattle remained on pasture with access to hay.

Cattle in Lots 1 through 11 and 14 through 16 had similar management except for feeding. They were weighed at 28-day intervals. In the early part of the test, teeth were examined and records made at three- to six-month intervals. This time lapse was decreased until approximately monthly readings were made during the period of teeth development. Later, the teeth were examined approximately three times yearly. Beginning in 1953, cattle in all lots were palpated over the ribs, head and legs for bone changes. Natural-color pictures of the teeth were taken early in the experiment. It was in the spring of 1951, however, that the picture-taking technique was perfected so that satisfactory pictures were obtained

for reproduction. Colored pictures of the teeth were taken approximately three times per year. Equipment for making pictures and the methods used are decribed in Tennessee Agricultural Experiment Station Bulletin 347 (1962).

All cows were bred to calve at two years of age. A leg bone was taken for chemical analysis from calves dying at or after birth. The calves were weaned at approximately six months of age. The first calf crop was wintered after weaning and sold in the early Spring. The 1950–51 calves were sold for slaughter at weaning time, and bones were taken for chemical analyses. This also was true of the calves from cows in Lots 1 through 11 in 1952, but from Lots 14 through 16 only the steer calves were sold. Heifer calves were carried on for data on their ability to grow out.

In 1955 male calves were sold and heifers retained. In 1956 the calves were sold but in 1957 the calves were retained. In 1958 bone samples were taken for chemical analyses from all calves that were slaughtered, and from any fetus obtained from cows slaughtered.

Pasture samples for chemical analyses were taken every two weeks. Composite monthly samples of hay and composite three-month samples of the concentrate mixture were taken. Defluorinated phosphate was sampled as each batch was purchased. Metabolism trials were conducted on animals in Lots 1 through 11 in 1951, 1952, and 1955. Urine samples were collected at various intervals for analyses of fluorine content.

Sections of ribs one inch to two inches in length were removed from cows for chemical analyses. These biopsies, performed under local anesthesia, were done in 1950 (one cow per lot), 1953, 1954, and 1955 for Lots 1–11; and in 1954, 1955, and 1956 for Lots 14–16. From approximately 300 rib resections made in the F experiments at this station, only two animals were lost. In one there was delayed healing and the animal was subsequently destroyed. In the other, fatal hemorrage occurred in the night a few hours after surgery.

**Necropsy.** The cows in Lots 1–11 were slaughtered for examination in May–July, 1958, after 10 years on experimental rations. All tissues were carefully examined for gross lesions. Heart, liver, spleen, thyroid, kidneys, adrenals and pituitary bodies were weighed. Each bone was carefully examined and all thickenings and irregularities measured. The right horizontal ramus of the mandible and the shaft of the right femur, tibia, metatarsus, humerus, radius and metacarpus were divided at given locations to allow for measurements of the medullary cavities. All ribs of the right side were measured. X-rays were made of the metatarsal and metacarpal areas after slaughter of the animals. These radiographs were made before and after removal of hides and flesh. Teeth were examined at necropsy.

Cattle of Lots 14, 15 and 16 were slaughtered for necropsy after more than nine and one-half years on test, in January–March, 1958. The nec-

ropsy procedure used for these cattle was nearly identical with that for cattle in Lots 1–11.

## Results and Discussion

**Feed Consumption.** The record of feed consumed by periods is given in Table 2 for Lots 1 through 11. In studying and analyzing the feed consumption records, weight gains and calving records of the cows should be considered.

For the period from April to October, 1948, there was no appreciable difference in feed consumption among lots. For the period from October, 1948, to October, 1949 (18 months on test) daily hay consumption per animal for Lots 7 (70 ppm added), 8 (100 ppm added), and 11 (100 ppm added plus defluorophos) compared to Lot 1 (control lot), showed a decrease of 1.97 lbs., 3.17 lbs., and 3.10 lbs., respectively. These differences were statistically significant. The concentrate consumption was appreciably lower only in Lot 8, which had a decrease of 0.96 lbs. per head daily.

During the period of October, 1949, to October, 1950 (one and one-half to two and one-half years on test), the cows in Lots 8 and 11 continued to consume less hay per animal daily than the other lots, with Lot 8 consuming less concentrates per animal daily. Lot 7 consumed 0.85 lbs. per animal per day less hay than the control lot.

The cows in Lots 5 (40 ppm added) and 6 (50 ppm added) consumed less hay than Lots 1, 2, 3, 4, 9 and 10 during the period of October, 1950, to October, 1951 (two and one-half to three and one-half years on test). Thus, the control cows, Lot 1, consumed an average of 19.28 lbs. total feed per animal daily, which was more by the following amounts than: Lot 5, 1.93 lbs.; Lot 6, 2.11 lbs.; Lot 7, 2.84 lbs.; Lot 8, 5.07 lbs.; and Lot 11, 4.98 lbs. These differences are statistically significant. There was no appreciable difference in concentrate consumption.

For the period of October, 1951, to October, 1952 (three and one-half to four and one-half years on test), Lot 1 had an average daily hay consumption of 18.60 lbs. per animal, which was 2.10 lbs. more than Lot 5, 2.48 lbs. more than Lot 6, 2.94 lbs. more than Lot 7, 7.20 lbs. more than Lot 8, and 5.24 lbs. more than Lot 11.

In a comparison of the average daily feed consumption for the period from spring of 1948 to October 1957 (nine and one-half years on test), there was no appreciable difference in the feed consumption of Lots 1, 2, 3, 4, 9 and 10. The decrease in average daily hay consumption for the total period (nine and one-half years) of Lots 5, 6, 7, 8 and 11 compared to Lot 1 (control) was 1.74 lbs., 2.48 lbs., 2.30 lbs., 5.64 lbs., and 4.93 lbs., respectively. These differences were significant ($P < 0.05$ and also at the one percent level, $P < 0.01$) for Lots 8 and 11.

## Table 2.—Feed Consumption of Cows, Lots 1–11

| Lot no. | Total F in ration ppm | April 1948 to Oct. 1948 Av. daily Hay lbs. | Conc. lbs. | Oct. 1948 to Oct. 1949 Av. daily Hay lbs. | Conc. lbs. | Oct. 1949 to Oct. 1950 Av. daily Hay lbs. | Conc. lbs. | Oct. 1950 to Oct. 1951 Av. daily Hay lbs. | Conc. lbs. | Oct. 1951 to Oct. 1952 Av. daily Hay lbs. | Conc. lbs. |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 7 | 11.81 | 2.00 | 13.02 | 3.50 | 14.91 | 3.99 | 19.28 | 3.98 | 18.60 | 3.98 |
| 2 | 17 | 12.01 | 2.00 | 13.27 | 3.55 | 14.78 | 4.00 | 19.34 | 3.97 | 19.00 | 3.99 |
| 3 | 27 | 11.49 | 2.00 | 13.18 | 3.51 | 14.67 | 4.00 | 18.16 | 3.90 | 18.77 | 3.99 |
| 4 | 37 | 12.13 | 1.98 | 13.02 | 3.49 | 14.81 | 4.00 | 18.75 | 3.98 | 18.33 | 3.96 |
| 5 | 47 | 12.15 | 2.00 | 12.86 | 3.46 | 14.76 | 4.00 | 17.35 [b] | 3.98 | 16.50 [a] | 3.96 |
| 6 | 57 | 11.87 | 2.00 | 12.70 | 3.45 | 14.32 | 3.99 | 17.17 [b] | 3.96 | 16.12 [a] | 3.89 |
| 7 | 77 | 12.03 | 2.00 | 11.05 [b] | 3.31 | 14.06 [a] | 3.99 | 16.44 [b] | 3.96 | 15.66 [b] | 3.96 |
| 8 | 107 | 11.65 | 2.00 | 9.85 [b] | 2.54 | 12.81 [b] | 3.49 | 14.21 [b] | 3.84 | 11.40 [b] | 3.76 |
| 9 | $B_1$ Hay | 11.78 | 2.00 | 12.40 | 3.49 | 14.22 | 4.00 | 18.67 | 3.98 | 18.89 | 3.99 |
| 10 | $B_2$ Hay | 12.17 | 2.00 | 12.73 | 3.48 | 13.89 [a] | 4.00 | 18.36 | 3.95 | 17.20 | 3.97 |
| 11 | 107 + Def. | 11.64 | 2.00 | 9.92 [b] | 3.25 | 13.46 [b] | 3.99 | 14.30 [b] | 3.96 | 13.36 [b] | 3.98 |

(Table 2.—Continued next page)

TABLE 2.—(CONTINUED FROM PAGE 16)

| Lot no. | Total F in ration ppm | Oct. 1952 to Oct. 1953 Av. daily Hay lbs. | Conc. lbs. | Oct. 1953 to Oct. 1954 Av. daily Hay lbs. | Conc. lbs. | Oct. 1954 to Oct. 1955 Av. daily Hay lbs. | Conc. lbs. | Oct. 1955 to Oct. 1956 Av. daily Hay lbs. | Conc. lbs. | Oct. 1956 to Oct. 1957 Av. daily Hay lbs. | Conc. lbs. | April 1948 to Oct. 1957 Av. daily Hay lbs. | Conc. lbs. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 8 | 20.63 | 2.68 | 20.30 | 2.82 | 20.92 | 1.97 | 21.66 | 2.00 | 23.27 | 2.33 | 18.15 | 2.98 |
| 2 | 18 | 19.92 | 2.68 | 20.13 | 2.82 | 20.55 | 1.99 | 18.82 | 1.99 | 19.79 | 2.33 | 17.60 | 2.99 |
| 3 | 28 | 18.45 [c] | 2.67 | 19.74 | 2.81 | 21.21 [c] | 2.00 | 22.18 | 1.99 | 24.38 | 2.34 | 17.31 | 3.14 |
| 4 | 38 | 20.04 | 2.65 | 20.36 | 2.82 | 20.99 | 1.98 | 19.99 | 1.99 | 21.56 | 2.33 | 17.73 | 2.98 |
| 5 | 48 | 16.65 [a] | 2.59 | 17.10 [a] | 2.82 | 18.14 [a] | 1.98 | 19.05 [a] | 1.99 | 20.88 [a] | 2.32 | 16.41 [a] | 2.97 |
| 6 | 58 | 16.52 [a] | 2.44 | 17.29 [a] | 2.81 | 18.07 [a] | 1.96 | 16.52 [a] | 1.99 | 16.92 [a] | 2.31 | 15.67 [a] | 2.93 |
| 7 | 78 | 16.40 [a] | 2.56 | 17.60 [a] | 2.82 | 18.19 [a] | 1.94 | 19.02 [a] | 1.96 | 20.87 [a] | 2.30 | 15.85 [a] | 2.94 |
| 8 | 108 | 11.89 [b] | 2.41 | 12.48 [d, b] | 2.70 | 13.85 [b] | 1.84 | 15.13 [b] | 1.95 | 14.62 [b] | 2.22 | 12.51 [b] | 2.81 |
| 9 | $B_1$ Hay | 21.26 | 2.70 | 21.06 | 2.81 | 21.40 | 1.99 | 20.10 | 1.99 | 21.34 | 2.32 | 17.77 | 2.98 |
| 10 | $B_2$ Hay | 19.96 | 2.64 | 19.18 | 2.81 | 20.72 | 1.98 | 20.86 | 1.99 | 22.87 | 2.32 | 17.44 | 2.97 |
| 11 | 108 + Def. | 13.63 [b] | 2.58 | 14.60 [b] | 2.72 | 14.39 [b] | 1.90 | 13.42 [b] | 1.97 | 14.34 [b] | 2.27 | 13.22 [b] | 2.92 |

[a] Significant at .05 level.
[b] Significant at .01 level.
[c] One animal died 7–5–49; one animal sacrificed 6–3–55.
[d] One animal sacrificed 6–9–53.

TABLE 3.—FEED CONSUMPTION FOR 1948–1958 AND FLUORINE CONTENT OF PASTURE GRASSES AND HAYS CONSUMED BY PASTURE GROUPS, LOTS 14 AND 26, 15, 16 AND 25

| | May 1948 to Oct. 1948 | Oct. 1948 to April 1949 | April 1949 to Oct. 1949 | Oct. 1949 to April 1950 | April 1950 to Oct. 1950 | Oct. 1950 to April 1951 | April 1951 to Oct. 1951 | Oct. 1951 to April 1952 | April 1952 to Oct. 1952 | Oct. 1952 to April 1953 | April 1953 to Oct. 1953 | Oct. 1953 to April 1954 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Lot 14 | | | | | | Lots 14 and 26 | | | | | |
| Av. F content grass ppm | 45.0 | | 42.7 | | 33.1 | 70.3 | 47.6 | 43.5 | 33.8 | 49.0 | 37.5 | 62.5 |
| Av. F content hay ppm | | 66.1 | | 60.2 | | 33.0 | | 30.0 | | 5.8 | | 7.0 |
| Av. daily hay, lb. | | 13.8 | | 16.1 | | | | | | | | |
| Av. daily conc., lb. | | 3.1 | | 4.0 | | | | | | | | |
| Mg. F/Kg. body wt. | | 1.26 | | 1.11 | | | | | | | | |
| | Lot 15 | | | | | | | | | | | |
| Av. F content grass ppm | 28.4 | | 32.4 | | 16.6 | 27.1 | 25.3 | 16.5 | 19.3 | 21.5 | 20.5 | 14.0 |
| Av. F content hay ppm | | 59.8 | | 38.3 | | 31.0 | | 15.0 | | 8.0 | | 7.5 |
| Av. daily hay, lb. | | 13.8 | | 16.3 | | | | | | | | |
| Av. daily conc., lb. | | 3.1 | | 4.0 | | | | | | | | |
| Mg. F/Kg. body wt. | | 1.40 | | .80 | | | | | | | | |
| | Lot 16 | | | | | | Lot 16 and 25 | | | | | |
| Av. F content grass ppm | 11.7 | | 11.1 | | 6.5 | 15.5 | 8.8 | 16.0 | 8.0 | 9.0 | 9.0 | 9.5 |
| Av. F content hay ppm | | 13.2 | | 7.3 | | 5.0 | | 4.5 | | 4.0 | | 4.0 |
| Av. daily hay, lb. | | 13.8 | | 18.0 | | | | | | | | |
| Av. daily conc., lb. | | 3.1 | | 4.0 | | | | | | | | |
| Mg. F/Kg. body wt. | | .29 | | .20 | | | | | | | | |

(Table 3.—Continued next page)

TABLE 3.—(CONTINUED FROM PAGE 18)

| | April 1954 to Nov. 1954 | Nov. 1954 to Mar. 1955 | Mar. 1955 to Sep. 1955 | Sep. 1955 to April 1956 | April 1956 to Nov. 1956 | Nov. 1956 to April 1957 | | April 1957 to Oct. 1957 | Total Initial to Oct. 1957 | | Feed Consumption Winter 1957–1958 137 days | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Lots 14 and 26 | | | | | Lot 14 [a] | Lot 26 | | Lot 14 | Lot 26 | Lot 14 [a] | Lot 26 [a] |
| Av. F content grass ppm | 27.5 [b] | 36.0 | 47.5 | 97.3 | 43.4 | 51.0 [c] | 44.0 | 31.0 [d] | 43.4 | 44.5 | | |
| Av. F content hay ppm | | 4.5 | | 10.0 | | 4.0 | 11.0 | | 25.0 | 14.8 | | |
| Av. daily hay, lb. | | | | | | 21.45 | | | | | 19.24 | 19.61 |
| Av. daily concentrate, lb. | | | | | | 2.00 | | | | | 2.00 | 2.00 |
| | Lot 15 | | | | | Lot 15 [a] | | | | Lot 15 [a] | Lot 15 [a] | |
| Av. F content grass ppm | 27.5 [b] | 36.0 | 47.5 | 97.3 | 43.4 | 51.0 [c] | | 31.0 [d] | | 28.3 | | |
| Av. F content hay ppm | | 4.5 | | 10.0 | | 4.0 | | | | 20.0 | | |
| Av. daily hay, lb. | | | | | | 21.45 | | | | | 19.37 | |
| Av. daily concentrate, lb. | | | | | | 2.00 | | | | | 2.00 | |
| | Lots 16 and 25 | | | | | Lot 16 [a] | Lot 25 | | Lot 16 | Lot 25 | Lot 16 [a] | Lot 25 [a] |
| Av. F content grass ppm | 10.0 | | 11.0 | 12.0 | 8.0 | | 10.0 | 7.0 [d] | 10.2 | 10.1 | | |
| Av. F content hay ppm | | 9.0 | | 5.0 | | 4.0 | 7.0 | | 6.2 | 5.4 | | |
| Av. daily hay, lb. | | | | | | 21.54 | | | | | 19.58 | 19.76 |
| Av. daily concentrate, lb. | | | | | | 2.00 | | | | | 2.00 | 2.00 |

[a] No significant difference in feed consumption between treatments.
[b] Lots 15, 14, and 26 were grouped together from this date to end of test except where shown separately.
[c] Lots 14, 15, and 16 were barn-fed 123 days, and on pasture 25 days within this period.
[d] Remained in barn until 4–10–57.

Results from experiments at this station indicate that, excepting effects upon teeth, a reduction in feed consumption is one of the first measurable effects of F ingestion upon cattle performance.

One should keep in mind that these cows were started on F feeding when they were about 12 to 15 months old, bred as yearlings at a light weight to calve as two-year-olds, and were subjected to rigorous conditions which should contribute to maximum effects of increased levels of F ingestion. Further, these cows were fed continuously in barn and dry-lot without any pasture or succulent feed until the spring of 1953.

Table 3 shows feed consumption of Lots 14, 15, 16, 25 and 26. There were no significant differences between cattle from the control Lots 16 and 25 compared to those from the F contaminated pastures, Lots 14, 15 and 26.

In comparing the fluorine intake for cows of Lot 15 with those of any other groups of pasture cows, either on the basis of milligrams of F per kilogram of body weight or ppm of F in the feed, one should keep in mind that Lot 15, during the first winter at approximately 22 to 27 months of age, received hay that contained 59.8 ppm F as compared to 66.1 ppm F in hay fed cattle in Lot 14.

On the basis of fluorine content (ppm) in pasture and hay, the fluorine intake of the cattle on the different experimental pastures can be related to that for cattle in the various barn-fed lots where the source of fluorine was sodium fluoride. The major period of teeth formation for cattle in Lots 14–16 was approximately spring, 1948, through summer, 1950. During this period the fluorine content of hays and pastures for Lot 14 was comparable to that in feed of cattle in Lot 5 while, in the same period, the fluorine content of pastures and hays for Lot 15 was comparable, with slight variations, to that of feed for cattle in Lot 4. For the nine and one-half year period the fluorine content of pastures and hays for Lots 14 and 26 was, on the average, comparable to the fluorine level of feed for Lot 4, while hay and pasture fluorine levels for Lot 15 were comparable with fluorine levels fed Lot 3.

**Weights and Gains.** A study of the average daily gains in Table 4 for the period of April to October, 1948, shows that of the barn-fed cattle, those in Lots 4, 5 and 9, gained slightly more than the others while those in Lot 11 gained the least. Within the pasture groups for this period, Lot 14 on $B_2$ pasture (with an average of 45 ppm fluorine in the forage) gained appreciably more than any other pasture or barn-fed group. Lot 15 gained least of the pasture groups. A probable explanation for this difference is that dogs, kept at houses near $B_1$ pasture, molested the cattle and kept them in a nervous condition during the first two grazing seasons. This is further verified by weights in October, 1952, which show that the cows in Lot 15

were slightly heavier and had made slightly more gain (38 lbs.) than control, Lot 16, cows.

Data to October, 1957, (nine and one-half years) indicate that there was no appreciable difference in weights or gains among cattle in Lots 1–11.

In a comparison of gains of cattle of the pasture groups during the nine and one-half years on experiment, it was observed that cattle in Lot 14 made slightly more average daily gain (0.20 pounds) than cattle in Lot 15 (0.17 pounds) or Lot 16 (0.16 pounds). Average fluorine content of feeds in the various pastures was, during this same period, 43.4 ppm F in pasture and 25 ppm F in hay for Lot 14; 28.3 ppm F in pasture and 20 ppm in hay for Lot 15; and 10.2 ppm F in pasture and 6.2 ppm in hay in Lot 16.

Lots 25 and 26 (Table 20) were pastured and fed with Lots 16 and 14, respectively, from August, 1950. Thus, considering all pasture lots, Lots 14 and 26, 15, 16 and 25, there were no appreciable differences in weights or gains for the periods on test between May, 1948, and October, 1957.

**Reproduction and Calf Records.** In studying the calving records one should keep in mind the following factors: (1) All lots of heifers were bred while weighing an average under 550 pounds, which is at a lighter weight than that recommended as a general practice. It was realized that breeding under such conditions probably would contribute to the cows' having difficulties at first calving. Conditions for barn-fed cattle were more severe than those under which most farm herds would be managed. (2) Lots 1 through 11 were handled under continuous barn and dry-lot conditions for the first four and one-half years. They had pasture in the summer during the latter years on test and were fed F daily in the barn, at the specified level. In general, pastures provide better nutrition, health, sanitation and production conditions than do continuous, year-round barn and dry-lot conditions. Lots 14, 15 and 16 were in the barn for the first and last two winters and were on pasture for all other periods. (3) There were only three animals per group; no animals were culled for any reason, such as not calving, calving late, poor production, or other reasons. This is contrary to what would be done under good farm conditions.

Sixty grade Hereford heifers were purchased in a feeder calf sale in 1945 to start an experimental herd at the University of Tennessee Tobacco Experiment Station (TES). The record of this herd can be used for comparison with the barn-fed and pasture groups. The cows at TES were managed under very good environmental conditions. They were not bred until they were two years old, to calve as three-year-olds. To start the experiment, 48 of the 60 two-year-olds were selected for breeding. In 1947, all of the 48 cows (100 percent of the total) raised calves. In 1948, 43 cows (89.6 percent of the originally selected 48) raised calves. In 1949, for the third calf crop, 42 cows (87.5 percent of the originally selected group) raised calves.

## TABLE 4.—WEIGHTS AND GAINS OF COWS, LOTS 1–11 AND 14–16
(All weights are in pounds)

| Lot no. | Total F in ration ppm | Initial weight | Weight Oct. 1948 | Av. daily gain initial to Oct. 1948 | Weight Oct. 1949 | Av. daily gain Oct. 1948 to Oct. 1949 | Weight Oct. 1950 | Av. daily gain Oct. 1949 to Oct. 1950 | Weight Oct. 1951 | Av. daily gain Oct. 1950 to Oct. 1951 | Weight Oct. 1952 | Av. daily gain Oct. 1951 to Oct. 1952 | Weight Oct. 1953 | Av. daily gain Oct. 1952 to Oct. 1953 | Weight Oct. 1954 | Av. daily gain Oct. 1953 to Oct. 1954 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 8 | 489 | 626 | .76 | 765 | .38 | 926 | .44 | 1092 | .46 | 1113 | .06 | 1252 | .41 | 1274 | .06 |
| 2 | 18 | 496 | 635 | .77 | 754 | .32 | 872 | .33 | 1033 | .44 | 1110 | .20 | 1147 | .11 | 1074 | −.20 |
| 3 | 28 | 479 | 608 | .75 | 724 | .32 | 924 | .55 | 1025 | .28 | 1178 | .41 | 1240 | .18 | 1166 | −.20 |
| 4 | 38 | 500 | 653 | .85 | 730 | .21 | 878 | .40 | 1049 | .47 | 1217 | .45 | 1218 | .00 | 1062 | −.42 |
| 5 | 48 | 507 | 660 | .85 | 721 | .17 | 914 | .53 | 1032 | .32 | 1151 | .32 | 1144 | −.02 | 1070 | −.20 |
| 6 | 58 | 510 | 636 | .70 | 762 | .34 | 830 | .18 | 978 | .41 | 1091 | .30 | 1147 | .16 | 1038 | −.29 |
| 7 | 78 | 462 | 596 | .74 | 717 | .33 | 914 | .54 | 1078 | .45 | 1206 | .34 | 1213 | .02 | 1189 | −.06 |
| 8 | 108 | 473 | 601 | .71 | 675 | .20 | 827 | .42 | 970 | .39 | 1010 | .11 | 1024 | .05 | 988 [a] | −.15 |
| 9 | $B_1$ Hay | 480 | 630 | .83 | 764 | .36 | 930 | .46 | 989 | .16 | 1100 | .30 | 1158 | .17 | 1071 | −.24 |
| 10 | $B_2$ Hay | 495 | 637 | .79 | 798 | .44 | 920 | .34 | 1051 | .36 | 1095 | .12 | 1137 | .12 | 1095 | −.11 |
| 11 | 108 + Def. | 490 | 602 | .62 | 679 | .21 | 838 | .44 | 931 | .26 | 1015 | .22 | 1063 | .14 | 972 | −.24 |
| 14 | $B_2$ Past. | 453 [b] | 682 | 1.24 | 932 | .72 | 1049 | .32 | 1067 | .05 | 1119 | .14 | 1152 | .09 | 1132 | −.05 |
| 15 | $B_1$ Past. | 491 [b] | 618 | .69 | 773 | .44 | 894 | .33 | 980 | .24 | 1073 | .25 | 1042 | −.08 | 1070 | .07 |
| 16 | Control Past. | 523 [b] | 679 | .85 | 899 | .63 | 969 | .19 | 1017 | .13 | 1067 | .14 | 1059 | −.02 | 1107 | .13 |

(Table 4.—Continued next page)

TABLE 4.—(CONTINUED FROM PAGE 22)

| Lot no. | Total F in ration ppm | Weight Oct. 1955 | Av. daily gain Oct. 1954 to Oct. 1955 | Weight Oct. 1956 | Av. daily gain Oct. 1955 to Oct. 1956 | Weight Oct. 1957 | Av. daily gain Oct. 1956 to Oct. 1957 | Av. daily gain initial to Oct. 1957 | Average gain of cows at end of test by number of calves raised | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 |
| 1 | 8 | 1219 | −.15 | 1175 | −.12 | 1238 | .17 | .22 | | | | | .23 (1) | | .21 (1) | .22 (1) | | | |
| 2 | 18 | 1072 | −.00 | 1070 | .01 | 1090 | .05 | .18 | | .22 (1) | | | | | | | .18 (1) | .13 (1) | |
| 3 | 28 | 1170 [c] | .04 | 1215 | .12 | 1190 | −.07 | .20 | | | | | | | | .20 (1) | | | |
| 4 | 38 | 1008 | −.15 | 1097 | .24 | 1064 [d] | −.09 | .16 | | | | | | | | .17 (1) | .14 (1) | .17 (1), [e] | |
| 5 | 48 | 1080 | .03 | 1072 | −.02 | 1022 | −.14 | .15 | | | | | | .16 (1) | .14 (2) | | | | |
| 6 | 58 | 1027 | −.03 | 982 | −.12 | 978 | −.01 | .14 | | | | | | | .13 (2) | | .14 (1) | | |
| 7 | 78 | 1117 | −.20 | 1112 | −.01 | 1105 | −.02 | .19 | | .21 (1) | | | | .22 (1) | .13 (1) | | | | |
| 8 | 108 | 1032 | .12 | 1008 | −.07 | 1042 | .10 | .17 | .15 (1) | | | | | .18 (1) | | | | | |
| 9 | $B_1$ Hay | 1098 | .08 | 1072 | −.07 | 1080 | .02 | .17 | | | | | | | .18 (1)[e] | .16 (1) | | .18 (1) | |
| 10 | $B_2$ Hay | 1023 | −.20 | 1068 | .12 | 1068 | .00 | .17 | | | | | | | .13 (1) | | .18 (2) | | |
| 11 | 108 + Def. | 953 | −.05 | 932 | −.06 | 960 | .08 | .14 | | .13 (1) | | | | | .15 (1) | | | .13 (1) | |
| 14 | $B_2$ Pasture | 1099 | −.10 | 1185 | .21 | 1158 [f] | −.03 | .20 | | | | | | .26 (1) | | | .23 (1) | .16 (2) | |
| 15 | $B_1$ Pasture | 1017 | −.16 | 1034 [g] | −.06 | 1044 | .03 | .17 | | | | | | | | | .16 (3) | .18 (1) | |
| 16 | Control Past. | 1070 [h] | −.14 | 1141 [h] | .11 | 1056 | −.26 | .16 | | | | | | | | .16 (1) | | .17 (2) | .12 (1), [e] |

[a] One animal sacrificed 6–9–53.
[b] Heifers were killed from each lot within the first two years, which accounts for differences in initial weight of the remaining heifers compared to other lots.
[c] One animal sacrificed 6–3–55.
[d] One animal not weighed October 7, weight calculated from July and November weights.
[e] One cow had twins.
[f] One animal sacrificed 11–12–56.
[g] One animal sacrificed 12–16–55; one animal died 3–23–56.
[h] One animal sacrificed 11–27–54; one animal died 6–22–56.
() Number in parentheses refers to number of cows that had raised the number of calves shown.

## TABLE 5.—REPRODUCTION AND CALVING RECORDS OF COWS, LOTS 1–11 AND 14–16 [a]

| Lot no. | Total F in ration ppm | No. cows | 1949 | | | 1950 | | | 1951 | | | 1952 | | | 1953 | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | No. cows calving | Calves raised | | No. cows calving | Calves raised | | No. cows calving | Calves raised | | No. cows calving | Calves raised | | No. cows calving [b] | Calves raised | |
| | | | | No. | Av. daily gain | | No. | Av. daily gain | | No. | Av. daily gain | | No. | Av. daily gain | | No. | Av. daily gain |
| 1 | 8 | 3 | 2 | 2 | 1.30 | 3 | 3 | 1.36 | 2 | 2 | 1.21 | 3 | 3 | 1.67 | 0 | 0 | — |
| 2 | 18 | 3 | 2 | 2 | 1.65 | 3 | 3 | 1.09 | 2 | 2 | 1.55 | 2 | 2 | 1.62 | 1 | 1 | 1.68 |
| 3 | 28 | 3 [c] | 3 | 2 | 1.47 | 1 | 1 | 1.43 | 2 | 1 | 1.44 | 1 | 0 | — | 0 | 0 | — |
| 4 | 38 | 3 | 3 | 3 | 1.50 | 3 | 3 | 1.39 | 2 | 2 | 1.44 | 2 | 1 | 2.25 | 1 | 1 | 2.04 |
| 5 | 48 | 3 | 3 | 2 | 1.53 | 2 | 1 | 1.40 | 2 | 2 | 1.57 | 1 | 1 | 1.71 | 0 | 0 | — |
| 6 | 58 | 3 | 2 | 2 | 1.54 | 3 | 3 | 1.65 | 3 | 3 | 1.39 | 1 | 1 | 1.82 | 0 | 0 | — |
| 7 | 78 | 3 | 2 | 1 | 1.24 | 2 | 1 | 1.25 | 1 | 0 | — | 0 | 0 | — | 0 | 0 | — |
| 8 | 108 | 3 [d] | 1 | 1 | 1.24 | 1 | 0 | — | 0 | 0 | — | 0 | 0 | — | 0 | 0 | — |
| 9 | $B_1$ hay | 3 | 2 | 2 | 1.47 | 2 | 1 | 1.31 | 3 | 4 [h] | 1.47 | 3 | 3 | 1.27 | 1 | 1 | 1.63 |
| 10 | $B_2$ hay | 3 | 3 | 2 | 1.48 | 2 | 2 | 1.29 | 3 | 2 | 1.23 | 2 | 2 | 1.53 | 0 | 0 | — |
| 11 | 108 + Def. | 3 | 2 | 1 | 1.34 | 2 | 2 | 1.34 | 2 | 2 | 1.20 | 1 | 1 | 1.58 | 1 | 1 | 1.42 |
| 14 | $B_2$ pasture | 5 [e] | 3 | 3 | 2.10 | 5 | 5 | 1.80 | 4 | 4 | 1.89 | 4 | 4 | 1.64 | 5 | 4 | 1.82 |
| 15 | $B_1$ pasture | 6 [f] | 3 | 2 | 1.58 | 4 | 4 | 2.15 | 6 | 6 | 1.83 | 6 | 6 | 1.83 | 6 | 6 | 1.73 |
| 16 | Control past. | 6 [g] | 6 | 6 | 2.10 | 6 | 6 | 2.00 | 4 | 4 | 1.88 | 6 | 6 | 1.77 | 5 | 5 | 1.69 |

(Table 5.–Continued next page)

TABLE 5.—(CONTINUED FROM PAGE 24)

| Lot no. | Total F in ration ppm | 1954 | | | 1955 | | | 1956 | | | 1957 | | | 1949–1957 | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | No. cows calving | Calves raised | | No. cows calving | Calves raised | | No. cows calving | Calves raised | | No. cows calving | Calves raised | | No. cows calving | Calves raised | |
| | | | No. | Av. daily gain | | No. | Av. daily gain | | No. | Av. daily gain | | No. | Av. daily gain | | No. | Av. daily gain |
| 1 | 8 | 1 | 1 | 1.39 | 2 | 1 | 1.55 | 2 | 2 | 1.20 | 2 | 2 | 1.74 | 17 | 16 | 1.43 |
| 2 | 18 | 2 | 2 | 1.27 | 2 | 2 | 1.47 | 2 | 2 | 1.69 | 2 | 2 | 1.76 | 18 | 18 | 1.50 |
| 3 | 28 | 1 | 1 | 1.56 | 1 | 1 | 1.54 | 1 | 1 | 1.57 | 1 | 1 | 1.80 | 11 | 8 | 1.54 |
| 4 | 38 | 3 | 3 | 1.49 | 3 | 4 [h] | 1.41 | 3 | 3 | 1.54 | 3 | 3 | 1.68 | 23 | 23 [h] | 1.55 |
| 5 | 48 | 2 | 2 | 1.17 | 2 | 2 | 0.86 | 2 | 2 | 1.31 | 3 | 3 | 1.73 [i] | 17 | 15 | 1.39 [i] |
| 6 | 58 | 3 | 3 | 1.22 | 2 | 2 | 1.36 | 3 | 3 | 1.51 | 3 | 3 | 1.62 | 20 | 20 | 1.49 |
| 7 | 78 | 1 | 1 | 1.03 | 2 | 2 | 1.30 | 2 | 2 | 1.24 | 2 | 2 | 1.60 | 12 | 9 | 1.31 |
| 8 | 108 | 1 | 1 | 0.70 | 1 | 1 | 1.15 | 1 | 1 | 1.52 | 1 | 0 | — | 6 | 4 | 1.15 |
| 9 | $B_1$ hay | 2 | 2 | 1.50 | 2 | 2 | 1.42 | 3 | 2 | 1.69 | 3 | 2 | 1.95 | 21 | 19 [h] | 1.51 |
| 10 | $B_2$ hay | 3 | 3 | 1.13 | 3 | 3 | 1.09 | 3 | 3 | 1.39 | 3 | 3 | 1.48 | 22 | 20 | 1.32 |
| 11 | 108 + Def. | 2 | 2 | 1.30 | 2 | 2 | 1.03 | 2 | 2 | 1.24 | 2 | 2 | 1.53 | 16 | 15 | 1.31 |
| 14 | $B_2$ pasture | 5 | 5 | 1.47 | 5 | 5 | 1.66 | 3 | 3 | 1.60 | 3 | 3 | 2.08 | 37 | 36 | 1.76 |
| 15 | $B_1$ pasture | 4 | 4 | 1.64 | 5 | 5 | 1.69 | 4 | 4 | 1.66 | 4 | 4 | 1.85 | 42 | 41 | 1.78 |
| 16 | Control pasture | 5 | 5 | 1.47 | 5 | 5 | 1.61 | 5 | 4 | 1.49 | 4 | 5 [h] | 1.60 | 46 | 46 [h] | 1.75 |

[a] All calf weights are adjusted on a comparable basis for age, sex, and age of dam.
[b] Cows not bred immediately in order to adjust to calving schedule.
[c] One animal died 7–5–49; one animal sacrificed 6–3–55 and her calf, raised by another cow in same lot, is included.
[d] One animal sacrificed 6–9–53.
[e] Three animals sacrificed May, 1949; two animals sacrificed October, 1949; one animal sacrificed 8–15–50; one animal died March, 1951; one animal sacrificed 11–12–56.
[f] Three animals sacrificed May, 1949; one animal died July, 1949; two animals sacrificed October, 1949; one animal sacrificed December 1955; one animal died 3–23–56.
[g] One animal sacrificed May, 1949; one animal sacrificed June, 1949; two animals sacrificed October, 1949; one animal sacrificed November, 1954; one animal died June, 1956.
[h] One cow had twins.
[i] One cow calved late, not included in average daily gain.

In 1950, for the fourth calf crop, 40 cows (83.3 percent of the original group) raised calves. In 1951, the fifth calf crop, 27 cows (56.2 percent of the original cows) raised calves. Many producers cull cows as was done in this herd, or fail to cull cows and are not aware of their true calf production. Thus, in evaluating the records of the barn-fed groups, which were under more rigorous conditions than the above-described herd, and which underwent no culling, one should consider all these factors when estimating the effect of increased fluorine ingestion on calving records. Table 5 shows that there was no appreciable difference between the number of calves born and number of calves raised in Lots 1, 2, 3, 4, 5, 6, 9 and 10. This is further substantiated by results from Lots 20 through 24 (Experiment II) as shown in Table 19, which represents a replication of part of this test. In both Experiments I and II the groups on pasture had an appreciably better calving record than the barn-fed groups.

Compared to the other lots a smaller percentage of the cows in Lots 7 and 8 gave birth to calves. The feeding of defluorinated phosphate definitely improved the breeding conditions as shown by calving records of cows in Lot 11 compared with those of cows in Lot 8.

The calves from all pasture groups made generally higher average daily gains than calves from barn-fed lots. In comparing the calving records and average daily gains, Lot 14 should be paired with Lot 26 (Table 21), and Lot 16 with Lot 25 (Table 21). When these groups are studied together the data from the nine and one-half years show no differences in reproduction of cows or average daily gains of calves between animals in Lots 14 and 26, 15 and 16 and 25 even though there were marked differences in fluorine content of pastures and hays ingested by the three groups, as previously stated.

**Digestion and Balance Studies.** Balance studies were conducted in 1951 and 1952 with the barn-fed cows in Experiment I and in 1952 with cows in Experiment II.

Details of the early tests are given in Bulletin No. 235, Hobbs, *et al.* (1954). The differences in the balance of calcium, phosphorus and nitrogen did not appear to be associated with the level of F ingested. With increased F intake there was an increase in the total excretion of F in the urine and feces and also an increase in the retention and total storage of F.

**Fluorine Content of Bones.** Data in Bulletin 235 dealt with accumulation of F in the metacarpal (leg) bones and mandibles (jaw bones) of cows in pasture Lots 14, 15 and 16 of Experiment I during the first 33 months of the test. It was shown that after 13 months, during which time pastures of Lot 14 averaged 54 ppm F and the hay 66 ppm F, the F content of bones from cows of Lot 14 was about 5.8 times greater than that of bones from Lot 16 cows. During that time the average F level of Lot 16 pastures had been 14 ppm and of the hay 13 ppm F. In the same 13-month period the

pasture F content of Lot 15 averaged 34 and the hay F content 60 ppm. There was approximately 3.6 times the content of F in bones of Lot 15 cattle as compared to Lot 16 cattle. The ratio of F content in bones of the various pasture lots continued to follow a similar pattern for the next 20 months of the test. After that period, periodic slaughter of cattle was discontinued as a means of obtaining bones for analyses. But it had been shown that continued ingestion of relatively constant levels of F by cattle in Lots 14 and 15 caused continued increases in F storage in bones, and this storage was greater in the jaw bone than in the leg bone.

The data in Table 6 show rib F storage by years for cattle in pasture Lots 14, 15 and 16 of Experiment I and Lots 25 (control) and 26 (in the same pasture as Lot 14) of Experiment II. Cattle in Experiment II went on test about 30 months after the cattle in Experiment I and were a few months older at the start of their test. These age and time factors, plus the installation of an F recovery system at the aluminum smelting plant, probably were factors in reducing content of F in ribs of cows in Lot 26 below that in Lot 14 after 1954.

After Experiment I cows had been on test approximately 10 years (1958), average rib F content of cows in Lot 14 was significantly greater (approximately 5.3 times) than that of cows in Lot 16 and significantly greater (1.3 times) than for cows in Lot 15. Rib F concentrations at the same time were significantly greater (some 4 times) for Lot 15 cattle than for the controls in Lot 16.

In 1958, after eight and one-third years on test, the average rib F concentrations for cattle in Lot 26 were comparable to those for cattle in Experiment I, Lot 15, and were significantly greater (some 5.7 times) than those for Lot 25, the Experiment II pasture controls. In 1958, the average F concentrations in ribs of cattle in Experiment I Lot 14 were approximately 1.2 times those for the cattle of Experiment II Lot 26.

The data in Table 7 show the fluorine content of metacarpals, metatarsals and mandibles for cows of Lots 14, 15, 16, 25 and 26. These bones had been collected for analyses at the time of slaughter. Experiment I cattle had been on test approximately 10 years and Experiment II cattle approximately eight and one-third years. The F content of these bones is comparable to that of the ribs.

The data in Table 8 also show that there is a direct relationship between the amount of F ingested from a given source and the F content in ribs of the cattle in Lots 1–11.

There was little change in rib F content, as shown in Table 8, for a given animal from 1950 (26 months on test) or 1953 (62 months on test) until 1958 (122 months on test). During this period each animal in Lots 2–8 and 11 was ingesting a constant level of F from NaF in each ration. Although cows in Lots 9 and 10 began receiving control hay rather than contami-

TABLE 6.—RIB FLUORINE CONTENT OF COWS, LOTS 14–16 AND 25–26

(All analyses are reported on ash basis)

| Lot no. | An. no. | Average F content in ribs of animals in each lot 1954 | 1955 | 1956 | 1958 [a] |
|---|---|---|---|---|---|
| | 40 | 6600 | 6940 | — | 6020 |
| | 43 | 9700 | 9680 | 7360 | 7410 |
| 14 | 56 | 9100 | 9750 | 7760 | 7935 |
| | 57 | 5600 | 7960 | 7520 | 6315 |
| | Av. | 7750 | 8582 | 7547 | 6920 |
| | 59 | 4800 | 6810 | 8800 | 5790 |
| | 3 | 4400 | — | — | — |
| 15 | 52 | 4400 | 5080 | 5320 | 4860 |
| | 33 | 4200 | 5350 | 5160 | 4780 |
| | 41 | 4000 | 5280 | 5190 [c] | |
| | 55 | 4500 | 5680 | — | 5670 |
| | Av. | 4383 | 5640 | 6118 | 5275 |
| | 37 | 1400 | 1360 | 1480 | 1435 |
| | 65 | 1300 | 1330 | — | 1305 |
| 16 | 44 | 1400 | 1300 | — | 1230 |
| | 14 | 1500 | 1410 | 1470 | 1435 |
| | 38 | 1200 | 1180 | — | 1110 |
| | Av. | 1360 | 1316 | 1475 | 1303 |

| Lot no. | An. no. | Average F content in ribs of animals in each lot 1954 | 1955 | 1956 | 1958 |
|---|---|---|---|---|---|
| | 90 | 7600 | 6000 | 5300 | 5670 |
| | 91 | 5500 | 5540 | 4900 | 5110 |
| 26 | 92 | 6600 | 7000 | 5720 | 5820 |
| | 94 | 6500 | 6460 | 5860 | 5250 |
| | 95 | 6700 | 6380 | — | 5340 |
| | 96 | 6800 | 7120 | 5900 | 5910 |
| | 97 | 8700 | 8950 | — | 8150 [b] |
| | Av. | 6914 | 6778 | 5536 | 5893 |
| | 80 | 1100 | 1180 | 1050 | 1135 |
| | 81 | 1000 | 1040 | 930 | 945 |
| 25 | 82 | 900 | 980 | 900 | 960 |
| | 83 | 1000 | 1080 | 1100 | 1045 |
| | 84 | 1000 | 1180 | 870 | 975 |
| | 85 | 900 | 1100 | — | 1085 |
| | Av. | 983 | 1093 | 970 | 1024 |

Duncan's Multiple Range Test

| | | | | | | |
|---|---|---|---|---|---|---|
| 1954 | Lot No. | 25 | 16 | 15 | 26 | 14 |
| | Av. | 983 | 1360 | 4383 | 6914 | 7750 |
| | P<0.05 | | | | | |
| 1955 | Lot No. | 25 | 16 | 15 | 26 | 14 |
| | Av. | 1093 | 1316 | 5640 | 6778 | 8582 |
| | P<0.05 | | | | | |
| 1956 | Lot No. | 25 | 16 | 26 | 15 | 14 |
| | Av. | 970 | 1475 | 5536 | 6118 | 7547 |
| | P<0.05 | | | | | |
| 1958 | Lot No. | 25 | 16 | 15 | 26 | 14 |
| | Av. | 1024 | 1303 | 5275 | 5893 | 6920 |
| | P<0.05 | | | | | |

[a] Average of 9th and 10th ribs.
[b] Killed 3–17–57.
[c] Killed 3–22–56, av. 9th and 10th ribs.

nated hay in 1952 there was little change in the concentration of F in ribs of these animals between 1953 and 1958. This indicates that the F content of a bone may reflect the level of ingested F months or even years before the bone sample was obtained.

Data in Table 8 also give information on the relative toxicity of F from NaF and from fumes of an aluminum smelter. The level of milligrams of F ingested per kilogram of body weight (mg./kg.) for Lot 9 was between Lots 2 and 3 for the entire test, but about the same as Lot 3 for the period of 1948 to October, 1950. Yet the F content in ribs of cows in Lot 9 was less than that in ribs of cows in Lot 2. Similarly, the F intake, based on mg./kg. for cattle in Lot 10, was between Lots 3 and 4 for the entire test, but between Lots 4 and 5 for the period of 1948 to October, 1950. The rib F storage for Lot 10 cattle, however, was less than for cattle in Lot 3. These facts further confirm data on teeth effects showing that, at comparable levels, F from an aluminum smelter was less toxic than F from NaF.

Cattle in the barn-fed lots (1–11) of Experiment I were killed 10 years after the test began. Fluorine contents of the ribs, metatarsals, metacar-

TABLE 7.—FLUORINE CONTENT OF RIBS, METATARSALS, METACARPALS, AND MANDIBLES, LOTS 14, 15 AND 16; AND EXPERIMENT II, LOTS 25 AND 26

| Lot no. | An. no. | Av. F Content in Bones | | | | Lot no. | An. no. | Av. F Content in Bones | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Ribs | Metatarsals | Metacarpals | Mandibles | | | Ribs | Metatarsals | Metacarpals | Mandibles |
| | 40 | 6020 | 7420 | 7200 | 5800 | | 92 | 5820 | 4820 | 5580 | 6080 |
| | 43 | 7410 | 6500 | 7060 | 7300 | | 96 | 5910 | 5700 | 5400 | 5820 |
| 14 | 56 | 7935 | 9200 | 7520 | 7110 | 26[a,b] | 94 | 5250 | 5460 | 5580 | 4540 |
| | 57 | 6315 | 7420 | 7200 | 5600 | | 95 | 5340 | 5160 | 5460 | 2355 [c] |
| | | | | | | | 90 | 5670 | 3180 | 4520 | 6860 |
| | Av. | 6920 | 7635 | 7245 | 6452 | | 91 | 5110 | 3070 | 4920 | 5100 |
| | | | | | | | Av. | 5517 | 4565 | 5243 | 5126 |
| | 59 | 5790 | 5340 | 5520 | 5340 | | | | | | |
| 15 | 33 | 4780 | 2470 | 3890 | 4460 | | | | | | |
| | 52 | 4860 | 5920 | 5100 | 5160 | | | | | | |
| | 55 | 5670 | 5580 | 5160 | 5160 | | | | | | |
| | Av. | 5275 | 4828 | 4918 | 5030 | | | | | | |
| | 37 | 1435 | 1020 | 1160 | 1330 | | 83 | 1045 | 980 | 1060 | 1050 |
| 16 | 44 | 1230 | 1420 | 1370 | 1260 | | 80 | 1135 | 1050 | 1060 | 1060 |
| | 14 | 1435 | 1380 | 1350 | 1230 | | 81 | 945 | 950 | 920 | 1000 |
| | 38 | 1110 | 1430 | 1290 | 1160 | 25 | 82 | 960 | 910 | 870 | 1000 |
| | | | | | | | 84 | 975 | 920 | 950 | 1020 |
| | Av. | 1302 | 1312 | 1292 | 1245 | | 85 | 1085 | 990 | 1190 | 1080 |
| | | | | | | | Av. | 1024 | 967 | 1008 | 1035 |

Duncan's Multiple Range Test, Lot Av. of Four Bones

| Lot no. | 25 | 16 | 15 | 26 | 14 |
|---|---|---|---|---|---|
| Av. | 1008 | 1289 | 5012 | 5113 | 7064 |
| $P < 0.05$ | | | | | |

[a] Does not include "extra" cow 132.
[b] Does not include one cow killed 3–17–57.
[c] Two analyses averaged.

## TABLE 8.—RIB FLUORINE CONTENT OF COWS, LOTS 1–11

(All analyses are reported on ash basis)

| Lot no. | Total F in ration ppm | Animal number | Comparison of F in ribs from same animal, months on trial: 25 | 62 | 74 | 86 | 122 |
|---|---|---|---|---|---|---|---|
| | | | 1950 | 1953 | 1954 | 1955 | 1958[a] |
| 1 | 8 | 13 | — | 1000 | 1000 | 1200 | 1410 |
| | | 24 | 1500 | 1700 | 1300 | 1500 | 1740 |
| | | 42 | — | 1200 | 1200 | 1200 | 1330 |
| | | Av. | **1500** | **1300** | **1167** | **1300** | **1493** |
| 2 | 18 | 11 | 3200 | 3500 | 3200 | 3200 | 3555 |
| | | 16 | — | 3500 | 2800 | 3200 | — |
| | | 46 | — | 3100 | 2900 | 3200 | 3350 |
| | | Av. | **3200** | **3367** | **2967** | **3200** | **3452** |
| 3 | 28 | 32 | 6200 | 5500 | 5200 | — | — |
| | | 47 | — | 5100 | 4700 | 5100 | 5230 |
| | | Av. | **6200** | **5300** | **4950** | **5100** | **5230** |
| 4 | 38 | 30 | — | 6000 | 5800 | 6200 | 7050 |
| | | 31 | 7100 | 8200 | 7300 | 7600 | 7250 |
| | | 48 | — | 5900 | 5900 | 6900 | 6260 |
| | | Av. | **7100** | **6700** | **6333** | **6900** | **6853** |
| 5 | 48 | 9 | 8900 | 8600 | 7800 | 8500 | 9350 |
| | | 23 | — | 7900 | 7500 | 8300 | 7730 |
| | | 49 | — | 8100 | 6900 | 8300 | 9050 |
| | | Av. | **8900** | **8200** | **7400** | **8367** | **8710** |
| 6 | 58 | 1 | 10400 | 9000 | 8900 | 9400 | 10250 |
| | | 6 | — | 9400 | 8900 | 9400 | 9650 |
| | | 50 | — | 9400 | 9000 | 8800 | 10200 |
| | | Av. | **10400** | **9267** | **8933** | **9200** | **10033** |
| 7 | 78 | 2 | — | 11700 | 10900 | 11200 | 12950 |
| | | 21 | — | 12100 | 10500 | 11400 | 12950 |
| | | 58 | — | 10900 | 10700 | 10600 | 12150 |
| | | Av. | | **11567** | **10700** | **11067** | **12683** |
| 8 | 108 | 29 | 12100 | 12700 | 12300 | 12200 | 15350 |
| | | 61 | — | 10800 | 9800 | 9800 | 10200 |
| | | 28 | — | 13300 | — | — | — |
| | | Av. | **12100** | **12267** | **11050** | **11000** | **12775** |
| 9 | $B_1$ Hay | 26 | — | 3100 | 2800 | 3000 | 2760 |
| | | 27 | — | 1200 | 2500 | 2200 | 2280 |
| | | 63 | — | 2800 | 2600 | 2800 | 2785 |
| | | Av. | | **2367** | **2633** | **2667** | **2608** |
| 10 | $B_2$ Hay | 19 | — | 3300 | 3400 | 3400 | 3415 |
| | | 20 | — | 4200 | 4200 | 4200 | 3220 |
| | | 67 | — | 4900 | 4300 | 4400 | 4090 |
| | | Av. | | **4133** | **3967** | **4000** | **3575** |
| 11 | 108 + Def. | 12 | 12500 | 14200 | 13500 | 14900 | 16750 |
| | | 25 | — | 14200 | 13700 | 14300 | 16050 |
| | | 70 | — | 12700 | 11800 | 12800 | 13750 |
| | | Av. | **12500** | **13700** | **13000** | **14000** | **15517** |

Duncan's Multiple Range Test

| | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1953 | Lot no. | 1 | 9 | 2 | 10 | 3 | 4 | 5 | 6 | 7 | 8 | 11 |
| | Av. | 1300 | 2367 | 3367 | 4133 | 5300 | 6700 | 8200 | 9267 | 11567 | 12267 | 13700 |
| | $P < 0.05$ | | | | | | | | | | | |
| 1954 | Lot no. | 1 | 9 | 2 | 10 | 3 | 4 | 5 | 6 | 7 | 8 | 11 |
| | Av. | 1167 | 2633 | 2967 | 3967 | 4950 | 6333 | 7400 | 8933 | 10700 | 11050 | 13000 |
| | $P < 0.05$ | | | | | | | | | | | |
| 1955 | Lot no. | 1 | 9 | 2 | 10 | 3 | 4 | 5 | 6 | 7 | 8 | 11 |
| | Av. | 1300 | 2667 | 3200 | 4000 | 5100 | 6900 | 8367 | 9200 | 11000 | 11067 | 14000 |
| | $P < 0.05$ | | | | | | | | | | | |
| 1958 | Lot no. | 1 | 9 | 2 | 10 | 3 | 4 | 5 | 6 | 7 | 8 | 11 |
| | Av. | 1493 | 2608 | 3452 | 3575 | 5230 | 6853 | 8710 | 10033 | 12683 | 12775 | 15517 |
| | $P < 0.05$ | | | | | | | | | | | |

[a] Average of 9th and 10th ribs.

TABLE 9.—BONE FLUORINE CONTENT OF COWS AT AUTOPSY, LOTS 1–11
(All analyses are reported on ash basis)

| Lot no. | Total F in ration ppm | An. no. | Av. F Content: Ribs | Metatarsals | Metacarpals | Mandibles |
|---|---|---|---|---|---|---|
| | | 13 | 1410 | 1390 | 1620 | 1640 |
| 1 | 8 | 24 | 1740 | 1600 | 1810 | 1560 |
| | | 42 | 1330 | 1250 | 1360 | 1490 |
| | | Av. | **1160** | **1413** | **1597** | **1563** |
| | | 11 | 3555 | 3710 | 3210 | 3560 |
| 2 | 18 | | — | — | — | — |
| | | 46 | 3350 | 3240 | 3670 | 3420 |
| | | Av. | **3452** | **3475** | **3440** | **3490** |
| 3 | 28 | 47 | 5230 | 5620 | 5620 | 5020 |
| | | Av. | **5230** | **5620** | **5620** | **5020** |
| | | 30 | 7050 | 5920 | 6640 | 6300 |
| 4 | 38 | 31 | 7250 | 8550 | 6720 | 6890 |
| | | 48 | 6260 | 6460 | 6420 | 6640 |
| | | Av. | **6853** | **6977** | **6593** | **6610** |
| | | 9 | 9350 | 10400 | 9800 | 8000 |
| 5 | 48 | 23 | 7730 | 8400 | 7820 | 8880 |
| | | 49 | 9050 | 10700 | 7900 | 8550 |
| | | Av. | **8710** | **9833** | **8507** | **8477** |
| | | 1 | 10250 | 10000 | 8500 | 10000 |
| 6 | 58 | 6 | 9650 | 10300 | 8700 | 7940 |
| | | 50 | 10200 | 11000 | 9970 | 8800 |
| | | Av. | **10033** | **10433** | **9057** | **8913** |
| | | 2 | 12950 | 13300 | 12900 | 11400 |
| 7 | 78 | 21 | 12950 | 7220 | 13700 | 12200 |
| | | 58 | 12150 | 13300 | 12300 | 11400 |
| | | Av. | **12683** | **11273** | **12967** | **11667** |
| | | 29 | 15350 | 8620 | 16100 | 13400 |
| 8 | 108 | 61 | 10200 | 10600 | 10100 | 9500 |
| | | Av. | **12775** | **9610** | **13100** | **11450** |
| | | 26 | 2760 | 2940 | 3210 | 2540 |
| 9 | $B_1$ Hay | 27 | 2280 | 2420 | 2480 | 2300 |
| | | 63 | 2785 | 3130 | 2720 | 2660 |
| | | Av. | **2606** | **2830** | **2803** | **2500** |
| | | 19 | 3415 | 3950 | 4020 | 3210 |
| 10 | $B_2$ Hay | 20 | 3220 | 3700 | 3610 | 3490 |
| | | 67 | 4090 | 4420 | 4160 | 4280 |
| | | Av. | **3576** | **4023** | **3930** | **3660** |
| | | 12 | 16750 | 9780 | 16600 | 13900 |
| 11 | 108 + Def. | 25 | 16050 | 17800 | 17700 | 13600 |
| | | 70 | 13750 | 14400 | 13200 | 12700 |
| | | Av. | **15516** | **13993** | **15833** | **13400** |

Duncan's Multiple Range Test, Lot Av. of Four Bones

| Lot No. | 1 | 9 | 2 | 10 | 3 | 4 | 5 | 6 | 8 | 7 | 11 |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Lot Av. (ppm) | 1516 | 2685 | 3465 | 3798 | 5373 | 6758 | 8882 | 9609 | 11734 | 12148 | 14686 |
| $P < 0.05$ | | | | | | | | | | | |

TABLE 10A.—GROSS EXOSTOSES AND HYPERTROPHY OF BONES OF COWS, LOTS 1–11 AND 14–16 [a]

| Lot no. | Total F in ration ppm | An. no. | Hyoid [b] | Head and skull | Mandible | Scapula | Humerus | Radius and ulna | Metacarpus | Bony pelvis | Femur | Tibia | Metatarsus |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | 42 | NVL | NVL | NVL | NVL | NVL | NVL | NVL | NVL | NVL | NVL | NVL |
| 1 | 8 | 13 | NVL | NVL | NVL | NVL | NVL | NVL | T [c,d] | NVL | NVL | NVL | T Ex |
| | | 24 | NVL | NVL | NVL | NVL | NVL | NVL | T [c,d] | NVL | NVL | NVL | NVL |
| | | 46 | NVL | NVL | NVL | NVL | NVL | NVL | NVL | NVL | NVL | NVL | NVL |
| 2 | 18 | 11 | NVL | T | NVL | NVL | NVL | NVL | T | T Ex [d] | NVL | NVL | T Ex |
| 3 | 28 | 47 | — | NVL | NVL | NVL | NVL | NVL | NVL | T Ex [d] | T | NVL | NVL |
| | | 48 | NVL | NVL | NVL | NVL | NVL | NVL | T [c,d] | NVL | NVL | NVL | NVL |
| 4 | 38 | 30 | NVL | NVL | NVL | NVL | NVL | NVL | NVL | NVL | NVL | NVL | T Ex |
| | | 31 | NVL | Sus. | NVL | NVL | NVL | NVL | T [c,d] | NVL | NVL | NVL | T Ex |
| | | 49 | NVL | NVL | S-M | NVL | NVL | T | Sus.[d] | NVL | NVL | NVL | Sus.[d] |
| 5 | 48 | 9 | NVL | T | S-M | NVL | NVL | T | T [d] | Sus.[d] | NVL | NVL | Gen. |
| | | 23 | NVL | Sus. | Sus. | NVL | NVL | NVL | T [d] | NVL | Sus. | NVL | Gen. |
| | | 1 | NVL | Sus. | NVL | NVL | NVL | S | T [d] | S | Sus. | Sus.[d] | Gen. |
| 6 | 58 | 50 | NVL | NVL | S-M | NVL | NVL | NVL | T | NVL | S | S [d] | Gen. |
| | | 6 | NVL | NVL | Sus. | NVL | NVL | T [d] | S Ex | S | S | S [d] | Gen. |
| | | 58 | NVL | Gen. | S | Gen. | Gen. | Gen. | Gen. | S | Gen. | Gen. | Gen.[e] |
| 7 | 78 | 2 | Sus. | Gen. | M-H | Sus. | S Ex | Gen. | M | Gen. | Gen. | Gen. | Gen.[e] |
| | | 21 | Gen. | Gen. | H | NVL | S | S | Gen. | S | S | S | Gen.[e] |
| | | 29 | Gen. | Gen. | Gen. | S | Gen. | Gen. | Gen. | Gen. | Gen. | Gen. | Gen. |
| 8 | 108 | 61 | Gen. | Gen. | Gen. | Sus.[d] | T | Sus.-S | S | Sus.-S | S | Gen. | Gen.[g] |
| | | 63 | NVL | NVL | NVL | NVL | NVL | NVL | T [e] | NVL | NVL | NVL | Sus.[d] |
| 9 | $B_1$ Hay | 26 | NVL | NVL | NVL | NVL | NVL | NVL | NVL | NVL | NVL | NVL | NVL |
| | | 27 | NVL | NVL | Sus. | NVL | NVL | NVL | NVL | NVL | NVL | NVL | S [d] |

(Table 10a—Continued next page)

TABLE 10A.—(CONTINUED FROM PAGE 32)

| | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 10 | $B_2$ Hay | 67 | NVL | NVL | S | NVL | NVL | NVL | Sus.[d] | NVL | NVL | NVL | Sus. |
| | | 19 | NVL | Sus. | Sus. | NVL | NVL | NVL | T [e] | S [d] | S [d] | NVL | Sus. |
| | | 20 | NVL | Sus. | S | NVL | NVL | NVL | T [e,d] | NVL | Sus.[d] | NVL | Sus. |
| 11 | 108 + Def. | 70 | Gen. | Gen. | Gen. | S | Gen. | Gen. | Gen. [f] | Gen. | Gen. | Gen. | Gen.[e] |
| | | 12 | Gen. | Gen. | Gen. | S | M-H | Gen. | Gen.[f] | S-Gen. | Gen. | Gen. | Gen.[e] |
| | | 25 | Gen. | Gen. | Gen. | S | Sus.[d] | Gen. | Gen.[f] | S-Gen. | Gen. | E | Gen.[e] |
| 14 | $B_2$ Pasture and hay | 40 | NVL | NVL | NVL | NVL | NVL | NVL | T [e] | NVL | NVL | NVL | NVL |
| | | 56 | NVL | NVL | NVL | NVL | NVL | NVL | T [e] | NVL | Sus. | Sus. | NVL |
| | | 57 | NVL | NVL | NVL | NVL | NVL | Sus. | S | NVL | NVL | Sus. | NVL |
| | | 43 | NVL | NVL | Sus. | Sus. | Sus. | Sus. | Sus. | NVL | NVL | NVL | NVL |
| 15 | $B_1$ Pasture and hay | 52 | NVL | NVL | NVL | NVL | NVL [h] | NVL [h] | NVL | Sus.[h] | NVL [h] | NVL [h] | T [e,d] |
| | | 55 | NVL | NVL | NVL | NVL | NVL | NVL | NVL | NVL | Sus.[d] | NVL | NVL |
| | | 59 | NVL | NVL | NVL | NVL | NVL | NVL | T [e] | NVL | NVL | NVL | NVL |
| | | 33 | Sus. | Sus. | Sus. | NVL | NVL | Sus. | T [e] | Sus.[d] | NVL | NVL | Sus. |
| 16 | Control pasture | 44 | NVL | NVL | NVL | NVL | NVL | NVL | T [e] | NVL | NVL | NVL | NVL |
| | | 38 | — | NVL | NVL | NVL | NVL | NVL | T [e] | NVL | NVL | NVL | NVL |
| | | 37 | NVL | NVL | NVL | NVL | NVL | NVL | T [e,d] | S [d] | NVL | NVL | NVL |
| | | 14 | NVL | NVL | NVL [i] | NVL | NVL | NVL | T [e,d] | NVL | NVL | NVL | NVL |

[a] Bilateral on paired bones unless otherwise indicated.
[b] Greater cornua.
[c] Calcification of adjacent tissue on medial margins.
[d] Unilateral.
[e] Diameter enlarged 2½ to 4 times.
[f] Diameter enlarged 1½ times.
[g] Diameter enlarged 4 times.
[h] Left lost.
[i] Large.

Sus.—Suspected hypertrophy.
NLV—No visible lesion.
T—Traces, less than ⅛ of bone involved.
S—Slight, ⅛ to ¼ of bone involved.
M—Medium, ¼ to ½ of bone involved.
H—Heavy, ½ to ¾ of bone involved.
E—Excessive, ¾ or more of bone involved.
Gen.—General hypertrophy.
Ex—Exostoses.

pals and mandibles collected at slaughter are shown in Table 9. The jaws had the lowest average F content of these four bones in six of 11 lots. The average F content of the bone having the highest content in a given lot was never more than 26 percent greater (Lot 8) than that of the bone with the lowest F content in that same lot.

The frequency and type of gross lesions on several different bones of cattle in Experiment I are shown in Table 10a. Some lesions were localized, some generalized hypertrophy and some of both types. They were observed when the animals were slaughtered after nine and one-half to 10 years on experiment, when the cattle were 10½ to 11 years old. Discolorations, interruptions in articular surfaces, and similar nonpathologic phenomena were included only when they were not also present on bones of control cattle.

Bony plates, extending posteriorly from the medial margins, were found loosely attached to the bone of the fore shanks (metacarpal bones) of cows in the barn-fed and pasture control lots. These plates, apparently resulting from calcification of adjacent soft tissues, were usually two to five centimeters (cm.) long, less than one cm. in thickness, and one or more cm. in width.

Levels of 48 ppm F and above from NaF in the total ration caused hypertrophy (localized or generalized enlargements) of the metacarpal and metatarsal (rear shank) bones. Hypertrophy of the bones of the lower jaw (mandible) was generally pronounced in cattle which had been on dietary levels of F from NaF of 58 ppm and above. Generalized hypertrophy was seen in the majority of bones, including the pelvis, from cows consuming rations of 78 to 108 ppm F (Lots 7, 8 and 11). In these cattle, hypertrophy had resulted in enlargement of the metatarsal and metacarpal shafts to about 3½ times normal diameter. None of these cows had shown acute lameness and only an occasional cow showed some awkwardness of gait before slaughter.

There were only minor hypertrophic bone lesions in cattle of Lots 9 and 10. During the years 1948 through 1952 these cows had been fed hay contaminated with F from an aluminum smelter plant. From 1952 to 1958 they were fed control hay. Probably none of the lesions in cattle of these two lots or in Lots 14 and 15 would have been of diagnostic value under usual clinical conditions.

Only "suspected" hypertrophic lesions and non-specific calcifications of soft tissues were found in cattle in Lots 14 and 15 maintained on fluorine-contaminated pastures for approximately 10 years. Calcifications of soft tissue adjacent to the metacarpal bones were found in all four of the control-pasture cattle killed at the end of the experiment. Thus, it is evident that these calcifications might have been due to age, physical impact or other factors not related to F intake.

The medullary cavities of long bones were larger in cattle on intakes of 70 and 100 ppm F from NaF than in cattle on control rations.

Hypertrophy of ribs was found in cattle on rations containing 70 ppm or more of F from NaF. The hypertrophy generally caused smooth, uniform enlargement of bone and in the living animals was of no use in diagnosing fluorosis. Table 10b shows that there was a variable increase in width of ribs due to hypertrophy resulting from ingestion of higher levels of F.

Detection of bone changes by palpation of the live animals proved inadequate for diagnosis of fluorosis. While the nature of the bone changes observed was quite characteristic, changes could not be detected with accuracy in cows consuming rations with F concentrations from NaF of less

TABLE 10B.—AVERAGE MAXIMUM WIDTH OF RIBS OF COWS AT AUTOPSY, LOTS 1–11

| Lot no. | 8th | 9th | 10th | 11th | 12th |
|---|---|---|---|---|---|
| | cm | cm | cm | cm | cm |
| 1 | 5.4 | 4.9 | 5.0 | 4.3 | 3.8 |
| 2 | 5.0 | 5.0 | 5.8 | 4.0 | 3.2 |
| 3 | — | — | 4.3 | 4.0 | 4.8 |
| 4 | 5.4 | 5.2 | 4.6 | 4.4 | — |
| 5 | 5.4 | 5.2 | 5.2 | 4.4 | 4.4 |
| 6 | 5.8 | 4.4 | 4.9 | 4.4 | 3.8 |
| 7 | 6.2 | 5.7 | 5.2 | 5.2 | 4.4 |
| 8 | 5.2 | 4.9 | — | 5.0 | 4.9 |

than 70 ppm. Changes on the ribs were not reliable diagnostic criteria in live animals at any level of F intake. Palpation of the metatarsal bones is more reliable than palpation of other bones. Table 11 is a record of findings of animal palpations of metatarsals and mandibles in cows of Lots 1 through 11.

The data presented in Table 12 reveal that the increased ingestion of F by the cows in Lots 2 through 11 resulted in relatively little transfer of F to the fetus or through the milk, above amounts for the calves of Lot 1.

However, data on bone F storage of calves in Lots 14 and 15, compared with that for calves in Lot 16, show that calves raised with cows in pastures with a high F content has increased bone F storage. That this is apparently due to the fact that these calves grazed the fluorine-contaminated vegetation is indicated by a comparison of bone fluorine levels in calves of Lots 14–16 with 1–11.

**Blood.** Ingestion of F caused no effect upon quantity or appearance of blood cells, specific gravity of blood and plasma, or levels of calcium, phosphorus, and magnesium during the first five years of the experiment. De-

TABLE 11.—FINDINGS OF ANNUAL PALPATIONS OF MANDIBULAR AND METATARSAL AREAS OF COWS, LOTS 1–11

| Lot no. | Total F in ration ppm | An. no. | Degree of palpable or visual change in: Metatarsus 1954 | 1955 | 1956 | 1957 | Mandible 1954 | 1955 | 1956 | 1957 |
|---|---|---|---|---|---|---|---|---|---|---|
| | | 13 | N | N | N | — | — | N | N | — |
| 1 | 8 | 24 | N | N | N | N | N | N | N | N |
| | | 42 | N | N | N | N | N | S | N | N |
| | | 16 | N | — | Su | N | N | S | N | S |
| 2 | 18 | 11 | N | N | N | N | N | N | N | N |
| | | 46 | N | N | N | N | N | N | N | N |
| 3 | 28 | 47 | N | N | N | N | N | Su | N | N |
| | | 30 | N | N | — | N | Su | N | S | S |
| 4 | 38 | 31 | N | N | N | S | N | S | S | N |
| | | 48 | N | S | N | S | N | N-S | N | S |
| | | 49 | N | S | S | N | N | N | S | S |
| 5 | 48 | 9 | N | S | S | N | N | S | M | S |
| | | 23 | N-S | S | S | S-M | N | S | N | N-Su |
| | | 6 | N | S | Su | N | N | S | S | S |
| 6 | 58 | 1 | N | N | S | S | N | S | S | S |
| | | 50 | N | S | S | N | S | S | S | S |
| | | 58 | S | S | S | H | S | S | M-H | S-M |
| 7 | 78 | 2 | S | S-M | M | M | S | S | S | N |
| | | 21 | S | S | S | S | S | S | M | M |
| | | 29 | E | E | S | H-E | E | M | H | M-H |
| 8 | 108 | 61 | S-M | S | — | S-M | S | S | S-M | S |
| | | 27 | Su | N | N | N | N | Su | Su | Su |
| 9 | $B_1$ hay | 63 | S | N | N | N | N | N | N | N |
| | | 26 | S | S | S | S | N | N | S | N |
| | | 19 | N | S | N | N | Su | N | S | N |
| 10 | $B_2$ hay | 67 | N | S | N | N | N-Su | Su | S | S |
| | | 20 | S | S | S | S | S | Su | S | N |
| | | 70 | S | S | H | H | M | M | S-H | M-H |
| 11 | 108 + Def. | 12 | M | H | H | E | S | S | S | S |
| | | 25 | S-M | H | H | H | S | S | — | M-H |

N = No lesions; Su = Suspected; S = Slight; M = Medium; H = Heavy; and E = Excessive.

tails of hematology and blood chemistry for that period were reported in Bulletin 235.

Complete blood studies were conducted on cattle in Lots 1, 6 and 8 in 1957 and on all cattle at the time of slaughter. Results are shown in Tables 13a and 13b. Hemoglobin and hematocrit levels for cattle of Lots 1, 2 and 3 were as high as, or slightly higher than, "normal" averages (Coffin, 1953) and slightly higher than for cattle of Lots 6, 7, 8 and 11. Hematocrit and hemoglobin levels for all lots were within normal limits. Total red cell and

TABLE 12.—BONE FLUORINE CONTENT OF CALVES FROM COWS, LOTS 1–11 AND 14–16

| Lot no. | Total F in ration ppm | Average F content of metacarpals, ppm | | | | | | | | Age in days, range |
|---|---|---|---|---|---|---|---|---|---|---|
| | | 1950 | 1951 | 1952 | 1953 | 1955 | 1956 | 1957 | 1950–57 | |
| 1 | 8 | 240(2) [a] | 170(2) | 90(3) | — | 130(1) | 210(2) | 190(1) | 166(11) | 15–248 |
| 2 | 18 | 243(3) | 135(2) | 65(2) | — | 150(2) | 220(2) | 160(1) | 169(12) | 109–260 |
| 3 | 28 | 220(1) | 70(1) | 220(1) | — | — | 220(1) | — | 182(4) | 3–243 |
| 4 | 38 | 240(3) | 150(2) | 370(1) | — | 237(3) | 287(3) | 270(1) | 248(13) | 119–279 |
| 5 | 48 | 300(1) | 255(2) | 140(1) | — | 390(2) | 310(2) | 200(1) | 283(9) | 73–251 |
| 6 | 58 | 320(2) | 247(3) | 140(1) | — | 210(1) | 313(3) | 220(1) | 263(11) | 159–248 |
| 7 | 78 | 400(1) | — | — | — | 300(2) | 355(2) | 250(1) | 327(6) | 156–209 |
| 8 | 108 | — | — | — | — | 320(1) | 400(1) | 390(1) | 370(3) | 52–213 |
| 9 | $B_1$ hay | 230(1) | 118(4) | 103(3) | — | 130(1) | 190(2) [b] | 380(1) | 158(12) | 0–247 |
| 10 | $B_2$ hay | 335(2) | 240(3) | 140(2) | — | 180(1) | 213(3) | 200(2) | 215(13) | 131–231 |
| 11 | 108 + Def. | 320(1) | 215(2) | 230(1) | — | 300(2) | 405(2) | 380(1) | 308(9) | 145–205 |
| 14 & 26 | $B_2$ Pasture | 1580(5) | 1312(12) | 813(3) [c] | 1667(3) | 400(1) | 805(10) | 140(1) | 1134(35) | 0–283 |
| 15 | $B_1$ Pasture | 655(4) | 542(6) | 470(3) | 500(2) | — | 1024(5) | — | 670(20) | 64–271 |
| 16 & 25 | Control Past. | 607(6) | 425(6) | 147(3) | 250(4) | — | 137(6) [d] | 160(1) | 331(26) | 1–304 |

[a] The number in parentheses is the number of calves represented for the average F content reported.
[b] One sample analyzed 3,070 ppm, not included.
[c] One sample analyzed 160 ppm, not included.
[d] Two samples analyzed 1,400 and 1,570 ppm, not included.

TABLE 13A.—DATA ON BLOOD AND BLOOD CELLS OF COWS, LOTS 1–11 AND 14–16

| Lot no. | Total F in ration ppm | Number of animals | Whole blood: Hemoglobin (gm./100 ml.) | Whole blood: Hematocrit percent | Whole blood: Specific gravity | Whole blood: RBC (Cmm.) | Whole blood: WBC (Cmm.) | Differentials: Eosinophils percent | Differentials: Basophils percent | Differentials: Neutrophils percent | Differentials: Lymphocytes percent | Differentials: Monocytes percent | Plasma: Specific gravity |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 8 | 3 | 15.4 | 42.7 | 1.057 | 6,855,000 | 8,275 | 20 | 1 | 19 | 59 | 1 | 1.038 |
| 2 | 18 | 3 | 14.7 | 43.0 | 1.060 | 6,605,000 | 6,192 | 14 | 2 | 15 | 68 | 1 | 1.031 |
| 3 | 28 | 1 | 15.2 | 41.0 | 1.057 | 6,270,000 | 5,000 | 19 | 3 | 9 | 68 | 1 | 1.031 |
| 4 | 38 | 3 | 13.2 | 37.7 | 1.052 | 6,740,000 | 6,083 | 16 | 4 | 10 | 69 | 0 | 1.030 |
| 5 | 48 | 3 | 14.2 | 39.7 | 1.054 | 6,527,000 | 6,150 | 23 | 4 | 14 | 59 | 0 | 1.031 |
| 6 | 58 | 3 | 12.7 | 33.2 | 1.053 | 6,653,000 | 6,700 | 17 | 1 | 21 | 58 | 3 | 1.032 |
| 7 | 78 | 3 | 12.5 | 39.0 | 1.051 | 6,230,000 | 5,200 | 12 | 1 | 6 | 81 | 0 | 1.030 |
| 8 | 108 | 2 | 13.0 | 37.5 | 1.057 | 6,818,000 | 7,762 | 14 | 1 | 22 | 60 | 3 | 1.031 |
| 9 | $B_1$ hay | 3 | 14.3 | 40.3 | 1.057 | 7,077,000 | 6,183 | 17 | 3 | 10 | 70 | 0 | 1.033 |
| 10 | $B_2$ hay | 3 | 14.2 | 38.7 | 1.057 | 6,935,000 | 6,350 | 30 | 2 | 9 | 59 | 0 | 1.031 |
| 11 | 108 + Def. | 3 | 13.6 | 38.8 | 1.054 | 7,267,000 | 6,367 | 15 | 2 | 15 | 68 | 0 | 1.030 |
| 14 | $B_2$ pasture | 4 | 15.0 | 39.6 | 1.057 | 7,051,000 | 5,669 | 10 | 1 | 9 | 78 | 2 | 1.037 |
| 15 | $B_1$ pasture | 4 | 13.4 | 36.2 | 1.058 | 5,739,000 | 5,688 | 8 | 0 | 16 | 70 | 6 | 1.041 |
| 16 | Control past. | 4 | 14.4 | 37.2 | 1.054 | 6,599,000 | 5,138 | 15 | 1 | 15 | 68 | 1 | 1.039 |

## TABLE 13B.—CHEMICAL COMPOSITION OF BLOOD, AND LIVER FUNCTION TESTS, ON COWS, LOTS 1–11 AND 14–16

| Lot No. | Total F in ration ppm | No. An. | Whole blood | | | Serum | | | | Bromsulphalein levels (mg./100 ml.) | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | Blood sugar (mg./100 ml.) | Blood urea nitrogen (mg./100 ml.) | Non-protein nitrogen (mg./100 ml.) | Calcium (mg./100 ml.) | Organic phos-phorus (mg./100 ml.) | Inorganic phos-phorus (mg./100 ml.) | Mag-nesium (mg./100 ml.) | Pre-injec-tion | Post-injections | | | | |
| | | | | | | | | | | | 5 min. | 10 min. | 15 min. | 30 min. | 45 min. |
| 1 | 8 | 3 | 82.1 | 7.11 | 15.5 | 10.9 | 8.5 | 6.17 | 2.36 | 0.15 | 17.80 | 9.74 | 6.64 | 2.37 | 0.89 |
| 2 | 18 | 3 | 67.8 | 6.84 | 14.1 | 10.8 | 10.9 | 6.48 | 2.20 | 0.18 | 10.23 | 6.15 | 3.32 | 1.21 | 0.58 |
| 3 | 28 | 1 | 69.2 | 6.75 | 19.2 | 11.7 | 9.7 | 6.91 | 2.66 | 0.39 | 9.16 | 5.36 | 3.34 | 0.93 | 0.34 |
| 4 | 38 | 3 | 64.4 | 7.92 | 17.3 | 10.0 | 11.2 | 6.38 | 2.07 | 0.10 | 8.48 | 5.60 | 3.32 | 0.72 | 0.44 |
| 5 | 48 | 3 | 77.5 | 7.87 | 15.3 | 13.2 | 10.6 | 5.96 | 2.37 | 0.13 | 6.71 | 5.48 | 3.82 | 1.13 | 0.44 |
| 6 | 58 | 3 | 86.8 | 5.15 | 16.6 | 14.0 | 11.1 | 5.70 | 2.17 | 0.08 | 9.82 | 6.68 | 4.88 | 1.56 | 0.49 |
| 7 | 78 | 3 | 72.1 | 6.91 | 16.7 | 10.4 | 10.5 | 6.06 | 2.07 | 0.17 | 9.25 | 5.16 | 3.05 | 0.74 | 0.29 |
| 8 | 108 | 2 | 80.7 | 9.26 | 19.1 | 10.9 | 10.1 | 6.30 | 2.44 | 0.11 | 7.71 | 4.48 | 2.74 | 0.95 | 0.34 |
| 9 | $B_1$ Hay | 3 | 68.1 | 6.28 | 14.0 | 11.1 | 10.8 | 7.20 | 2.37 | — | — | — | — | — | — |
| 10 | $B_2$ Hay | 3 | 48.5 | 7.85 | 20.6 | 11.0 | 8.8 | 5.16 | 1.94 | — | — | — | — | — | — |
| 11 | 108 + Def. | 3 | 62.6 | 7.87 | 12.4 | 10.6 | 9.2 | 6.49 | 2.75 | 0.07 | 8.98 | 5.66 | 3.24 | 1.00 | 0.52 |
| 14 | $B_2$ Past. | 4 | 79.4 | 12.09 | 21.9 | — | 10.9 | 5.28 | 2.22 | 0.16 | 10.51 | 6.26 | 4.50 | 1.08 | 0.39 |
| 15 | $B_1$ Past. | 4 | 77.6 | 14.15 | 22.0 | — | 11.8 | 5.21 | 2.36 | 0.12 | 8.61 | 5.49 | 3.50 | 0.96 | 0.36 |
| 16 | Control Past. | 4 | 68.8 | 12.76 | 21.6 | — | 12.3 | 5.22 | 2.16 | 0.15 | 8.84 | 4.52 | 2.79 | 0.86 | 0.29 |

white cell counts were within normal limits. Generally there was no difference in differential white cell counts among lots, but in all cases the percentage of eosinophils was higher than usually reported. Since this difference appeared in all lots, it may have been caused by age, management, or other factors. In the pasture cattle, there were no marked differences in cellular components among lots.

Chemical composition of blood did not appear affected by F ingestion. Levels of blood sugar were generally higher than reported normals and the values for total non-protein nitrogen were lower than published normals. Blood calcium levels were not obtained for cattle in Lots 14–16.

TABLE 14.—FLUORINE CONTENT OF URINE AND FECES OF COWS, LOTS 1–11

| Lot no. | Total F in ration ppm | No. animals | Urinary values of seven-day composite sample [a] | | Fecal fluorine |
|---|---|---|---|---|---|
| | | | F content ppm | Av. daily F mg. | Av. mg. per day |
| 1 | 8 | 3 | 6 | 33 | 31 [b] |
| 2 | 18 | 2 | 11 | 60 | 46 [c] |
| 3 | 28 | 1 | 16 | 85 | 31 |
| 4 | 38 | 2 | 27 | 144 | 54 [c] |
| 5 | 48 | 3 | 33 | 164 | 61 |
| 6 | 58 | 2 | 49 | 234 | 82 [c] |
| 7 | 78 | 3 | 45 | 247 | 85 |
| 8 | 108 | 2 | 48 | 248 | 96 |
| 9 | $B_1$ Hay | 3 | 5 | 31 | 24 |
| 10 | $B_2$ Hay | 3 | 6 | 35 | 20 [b] |
| 11 | 108 + Def. | 2 | 53 | 259 | 122 |

[a] Trials conducted in Fall of 1955 and Spring of 1956.
[b] Two animals.
[c] Three animals.

The dye, sulfabromophthalein, was used in 1958 as one measure of liver function (Mixner and Robertson, 1957). Results were based on the milligram percent of the dye retained by the blood at intervals of 5, 10, 15, 30 and 45 minutes following intravenous administration of a dose carefully standardized to body weight. This test, the results of which are shown in Table 13b, indicated no interference with liver function due to F ingestion.

**Urinary Fluorine.** The history of and reasons for urinary F determinations were presented in Bulletin 235 along with data on urinary F concentrations of cattle in Lots 1–11 in 1952. It was shown that there is a relationship between current F intake and the level of F in urine. It was also observed that there were marked variations in the urinary F content of cows on given levels of F ingestion.

Average levels of urinary F for cows in Lots 1–11 are given in Table 14.

The determinations were made on seven-day composite samples obtained while the animals were in metabolism crates in 1955. It should be noted that even though the 1955 rib samples of cows in Lots 9 and 10 had two to three times the concentration of F in comparable rib samples from cows of Lot 1, the urinary F levels of cows in Lots 9 and 10 were comparable to those in Lot 1. At the time the urine samples were obtained, the cattle in Lots 9 and 10 had been eating control hay rather than contaminated hay for approximately three years. This substantiates previous work at this Station which showed that F content of urine may reflect the level of F being ingested at the time the urine sample is obtained.

The variations of urinary F concentrations among cattle of a given lot and the lack of sharp differences in urinary F values between some of the lots emphasize the need for caution in using urinary F content as an aid in diagnosing fluorosis. The use of urinary F content data should be supported by examination of teeth, chemical analyses of feed and bones, and general observations of cattle.

**Teeth.** The importance of changes in teeth in the diagnosis of fluorosis in animals is recognized. Because of the emphasis that has been placed upon teeth changes as a measurement of the extent of structural and physiological effects associated with fluorosis, a comparative pictorial record of teeth from cattle consuming various levels of fluorine is presented.

Detailed information on nomenclature, as well as earlier results of detailed studies of normal cattle teeth and dental fluorosis in cattle, is presented in Bulletin 235 of the Agricultural Experiment Station, University of Tennessee.

The following is a brief list of criteria in ascending order of severity used in diagnosis of dental fluorosis.

I. *Minor Enamel Imperfections*
   A. Chalkiness or Mottling: focal, cross, porcelain, diffuse, excessive.
   B. Milky Plaques: these are not associated with dental fluorosis but Garlick (1954) reports possible inheritance or breed-associated effect.

II. *Staining*
   A. Intra-enamel: color—yellow, brown, or black.
      Area covered—focal, diffuse, cross, or longitudinal.
   B. Vegetative Stain: an extraneous stain derived from feeds or other materials; not associated with dental fluorosis.

III. *Dental Caries* (*Focal Hypoplasia*)
   A. Caries: pre-carious, caries, pinpoint.
   B. Erosion: loss of enamel substance from the surface of the tooth.

IV. *Hypoplasia*
   A. Enamel Hypoplasia: pit, patch, or shell.

B. Tooth Hypoplasia: may be manifested by (a) a simple reduction in size or (b) a decrease in overall length with an apparent increase in the anterior-posterior thickness.

C. Enamel and Tooth Hypoplasia may occur in the premolar and molar teeth as well as the incisor teeth.

Teeth not affected by fluorine may have defects or apparent abnormalities such as chipped caps, longitudinal cracks, grooves, "milky plaques," rough enamel, exposed pulp cavities, chalkiness, facets, vegetative staining, etc.

With variations of six months or more, permanent teeth of cattle erupt in the following periods (Sisson and Grossmon, 1938).

| *Permanent Incisor Teeth Designation* | *Age of Cattle at Eruption* |
|---|---|
| First incisors, 1st pair (centrals) | 1½ to 2 years |
| Second incisors, 2nd pair (intermediates) | 2 to 2½ years |
| Third incisors, 3rd pair (laterals) | 3 years |
| Fourth incisors, 4th pair (corners) | 3½ to 4 years |

| *Permanent Molar Teeth Designation* | *Age of Cattle at Eruption* |
|---|---|
| 1st pair (1st premolars) | 2 to 2½ years |
| 2nd pair (2nd premolars) | 1½ to 2½ years |
| 3rd pair (3rd premolars) | 2½ to 3 years |
| 4th pair (1st molars) | 5 to 6 months |
| 5th pair (2nd molars) | 1 to 1½ years |
| 6th pair (3rd molars) | 2 to 2½ years |

Teeth are affected by fluorine only during their formation and not after eruption.

V. *Dental Wear*

A. Kind: normal, uneven, rolling, bevel or appositional.

B. Amount: in order to provide uniformity in nomenclature, a definition is given for the amount of tooth area affected for chalkiness, erosion, enamel hypoplasia and/or wear as follows:

a. Slight—approximately ⅛ or less of the area of a tooth involved.

b. Medium—approximately ¼ or less of the area of a tooth involved.

c. Heavy—approximately ½ or less of the area of a tooth involved.

d. Excessive—approximately ¾ or more of the area of a tooth involved.

Example: Excessive wear would be interpreted to mean that ¾ or more of the height of a tooth was worn off.

CLASSIFICATION AND CONDITION OF INCISOR TEETH: Incisor teeth were classified according to the system presented in Table 15.

## TABLE 15.—CLASSIFICATION OF THE EFFECTS OF DIETARY FLUORINE ON TEETH OF CATTLE [1]

| Classification | Wear greater than normal for age and conditions | Chalkiness or mottling (Incisors) | | | | | Staining | Caries and/or erosions | Hypoplasia | | Relative effects greater than normal on each tooth |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Focal | Cross Chalky | Chalky striations cross or longitudinal | Porcelain | Excessive | | | Enamel | Tooth | |
| 1A | Depends on age and individual variations | **May be very slight Luster—good** | | | | | | | | | None |
| 1B | Depends on age and individual variations | **Slight to medium Luster—good** | | | May be very slight | | **May be suspiciously discolored** | | | | None |
| 2 | Depends on age and individual variations | Slight to diffuse Luster—good to fair | | | Slight to medium | | **Usually very slight to heavy** brown | | | | Questionable to slight |
| 3 | Table surface may be good on cattle to 6 years of age | Slight to heavy Luster—good to fair | | | Slight to heavy | | Usually slight to heavy | **Usually Pathognomonic** | | | Slight |
| 4 | Table surface may show negligible to medium wear | May show some of the above effects Lusterless | | | Slight to heavy | May be only partially | Slight to excessive brown and black stain | May be pre-carious or carious after 1 to 2 years in wear | **Suspected to slight** | None | Slight to medium |
| 5A | Wear variable slight to medium | May show some of the above effects | | | | May be partially | Slight to excessive brown and black stain | Progressive type of erosions may be present | **Slight to medium** | May be suspicious | Medium |
| 5B | Wear variable slight to excessive | | | | | May be partially | Slight to excessive brown and black stain | Progressive type of erosions may be present | **Medium to heavy** | May be slight to medium | Medium to heavy |
| 5C | Medium to excessive wear | | | | | May be partially | Slight to excessive brown and black stain | Progressive type of erosions may be present | **Heavy to excessive** | May be medium to excessive | Heavy to excessive |

"X" when added to classification number denotes an abnormality other than those traceable to fluorine.
Boldface terms indicate symptoms which would definitely determine the classification of a tooth.
[1] This table is a reprint from The University of Tennessee Agricultural Experiment Station Bulletin No. 235. Detailed definitions and explanations of nomenclature are given in Bulletin No. 235.

The classifications were then converted to numerical values as follows: 1A—0; 1B—1, 2—2; 3—3; 4—4; 5A—5; 5B—6; 5C—7.

To represent numerically the degree of F effect upon teeth, an index of incisor teeth condition is made by averaging the classifications of all teeth in each pair for all animals in each lot, then taking the average of the average classifications. The higher the number for a given pair or for the index of all four pairs, the greater the effect of F ingestion upon teeth.

TABLE 16.—INDEX OF INCISOR TEETH CONDITION AND RANGE OF TEETH CLASSIFICATIONS, LOTS 1–11 AND 14–16

| Lot no. | Total F in ration ppm | Index [a] of incisor teeth condition | | | | | Teeth classification range |
|---|---|---|---|---|---|---|---|
| | | C | I | L | Co. | Av. | |
| 1 | 8 | 0.3 | 0.1 | 0.2 | 0.3 | 0.2 | 1A–2 |
| 2 | 18 | 0.9 | 1.6 | 2.4 | 3.1 | 2.0 | 1A–5A |
| 3 | 28 | 0.5 | 2.0 | 3.0 | 3.2 | 2.2 | 1A–5B |
| 4 | 38 | 2.7 | 4.3 | 5.4 | 5.4 | 4.4 | 1B–5C |
| 5 | 48 | 2.5 | 4.4 | 5.7 | 6.0 | 4.6 | 1A–5C |
| 6 | 58 | 3.5 | 4.8 | 5.5 | 6.0 | 5.0 | 2–5C |
| 7 | 78 | 4.7 | 6.1 | 6.6 | 6.4 | 6.0 | 3–5C |
| 8 | 108 | 4.5 | 5.8 | 6.6 | 6.8 | 5.9 | 3–5C |
| 9 | $B_1$ hay | 1.8 | 3.7 | 4.0 | 3.6 | 3.3 | 1A–5B |
| 10 | $B_2$ hay | 1.7 | 4.1 | 3.4 | 4.0 | 3.3 | 1A–5B |
| 11 | 108 + Def. | 3.9 | 6.4 | 6.8 | 6.5 | 5.9 | 3–5C |
| 14 | $B_2$ pasture | 3.6 | 5.1 | 4.9 | 4.9 | 4.6 | 1B–5C |
| 15 | $B_1$ pasture | 1.8 | 4.1 | 3.3 | 3.8 | 3.2 | 1A–5B |
| 16 | Control pasture | 0.0 | 0.1 | 0.1 | 0.1 | 0.1 | 1A–1B |

[a] Index is calculated by taking an average of average classifications, 1953–57. C = Centers; I = Intermediates; L = Laterals; and Co. = Corners.

Duncan's Multiple Range Test

| Lot No. | 1 | 2 | 3 | 9 | 10 | 4 | 5 | 6 | 8 | 11 | 7 |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Lot Av. | 0.2 | 2.0 | 2.2 | 3.3 | 3.3 | 4.4 | 4.6 | 5.0 | 5.9 | 5.9 | 6.0 |
| $P<0.05$ | | | | | | | | | | | |

The index of incisor teeth condition and average range of incisor teeth classifications (Table 16) show that the addition of 10 ppm F (Lot 2) from NaF caused a significant increase (Duncan's multiple range test) in index of incisor teeth condition compared to that of Lot 1. Increased amounts of F from NaF in Lots 2 through 6 caused definite increases in F effects upon teeth. However, there was no significant difference between the indexes of incisor teeth in 78 and 108 ppm lots, but these were significantly different from Lots 1 through 5, and 9 and 10. In general, the increase in index of incisor teeth condition as the intake of F was increased corresponded closely with the increases of F in bone and urine, decreases in

feed consumption (48 ppm and above) and decrease in reproductive efficiency (78 ppm and above).

The incisor teeth condition index for Lot 9 was identical with that for Lot 10. During the first two years of the test the F intake, based on mg. F per kg. of body weight, of cows in Lots 9 and 10 was approximately equal and in some periods was comparable to that for cows in Lot 5. There were no significant differences between incisor indexes for cows in Lots 3, 9 and 10. Likewise, there were apparent but not significant differences in indexes of incisor teeth conditions between Lots 9 and 10 compared to 4.

In the pasture groups, fluorine effects on teeth, as shown by the pictures of teeth and the index of incisor teeth condition, were much greater for Lots 14 and 15 than for 16, the pasture controls. The differences between indexes of cows in Lots 14, 15 and 16 were all highly significant. Yet there were no differences between these groups in weight gains and reproduction of cows, weight gains of calves, or, in the winters of 1956–57 and 1957–58, in feed consumption by cows. The teeth effects, however, in cows of Lot 14 were similar to the teeth effects in barn-fed cattle of Experiments I and II consuming rations containing 40 and 50 ppm F added from NaF. In these barn-fed groups, Lot 6 in Experiment I and Lot 24A in Experiment II, the ingestion of F has caused a decrease in feed consumption after two and one-half years for Lot 6 and after three and one-half years for Lot 24A. This indicates either a lower toxicity of the F from the smelter compared to that from NaF or an "alleviation factor" in pasture, or both.

The effects upon cattle teeth resulting from ingested F above normal amounts, therefore, depend upon many factors, including:

1. The age of the animal and the stage of tooth development.
2. The level of fluorine ingested.
3. The length of time of increased fluorine ingestion.
4. The initial fluorine stored in the animal body.
5. The solubility of the fluorine material ingested.

Other factors, such as the level of nutrition, pregnancy, and lactation may modify the effects of above-normal amounts of F ingested by cattle.

While the clinical symptoms of classical dental fluorosis are distinctive, it is emphasized that the general clinical condition of the animal does not necessarily correspond to or agree with the apparent effect of F upon the teeth. The presence of dental fluorosis in cattle, literally interpreted, means only that fluorine was ingested in amounts sufficient to damage or to mark the teeth during the period that the affected teeth were developing. Despite this fact, tooth changes are of great value in diagnosis, especially when they are correlated with other symptomatic criteria of fluorosis.

The teeth pictures are presented by lots with pictures and readings for 1952 (four and one-half years on test) followed on the opposite page by

pictures taken in 1957–1958 of the same animals within the lot. Along with these pictures are given the incisor and molar descriptions for late 1957 (9½ years on test and end of the experiment) or early 1958 before each animal was sacrified.

## DESCRIPTIONS AND PICTURES

### LOT NO. 1 (7 ppm F), 1948–1953 [a]

### ANIMAL NO. 42

CENTRALS: *Luster*—good; *Chalkiness*—focal, slight; * Longitudinal cracks; *Staining*—vegetative, slight; *Classification*—1A.

INTERMEDIATES: *Luster*—good; *Chalkiness*—focal, slight; * Longitudinal cracks; *Classification*—1A.

LATERALS: *Luster*—good; *Chalkiness*—focal, slight,* milky plaque in lower ¼; *staining*—vegetative, slight; *Classification*—1A.

CORNERS: *Luster*—good; *Chalkiness*—focal,* (right) lower ½ milky plaque, brown stained, (left) center ⅓ milky plaque, brown stained; *Classification*—1A.

GINGIVAE: Slight to moderate gingivitis.

PREMOLARS AND MOLARS: Normal stain and wear.

### ANIMAL NO. 13

CENTRALS: *Chipped Cap*—(Left) slight; *Luster*—good; *Chalkiness*—longitudinal, slight; * *staining*—vegetative stain in grooves, slight; *Classification*—1A.

INTERMEDIATES: *Chalkiness*—focal, slight; *staining*—vegetative; *Classification*—1A.

LATERALS: *Chipped Cap*—Slight; *Chalkiness*—focal, slight; *staining*—vegetative, slight; *Classification*—1A.

CORNERS: *Luster*—good; *Chalkiness*—focal; *Staining*—vegetative, slight; *Classification*—1A.

GINGIVAE: Slight to moderate gingivitis.

PREMOLARS AND MOLARS: Normal stain and wear.

### ANIMAL NO. 24

CENTRALS: *Chipped Cap; Luster*—good; *Chalkiness*—vertical, cross, slight; *Staining*—vegetative, slight; root exposed 2 mm.; *Classification*—1A.

INTERMEDIATES: *Luster*—very good; *Chalkiness*—cross, slight; *Staining*—vegetative, slight; spacing—2.5 mm. between intermediates and centrals; *Classification*—1A.

LATERALS: *Luster*—good; *Chalkiness*—upper ¼ focal; *Staining*—vegetative; *Enamel hypoplasia*—transverse band which is located at junction of upper and middle thirds with loss of medial ⅕ of cap, pit. Hypoplastic

[a] These descriptions represent effects on teeth for the period 1948 to 1953.

* Not visible in pictures.

abnormality is of unknown cause which makes this a 1-AX classification on hypoplasia alone, if due to fluorine it would be a 5-A classification (see discussion on enamel hypoplasia).

CORNERS: *Luster*—good; *Chalkiness*—focal, cross; *Staining*—vegetative, slight; *Classification*—1A.

GINGIVAE: Moderate to heavy gingivitis.

PREMOLARS AND MOLARS: Normal stain and wear.

Note the roughness of some enamel in incisor teeth of each mouth which is a common occurrence in normal teeth, especially in new teeth and on the corners.

## LOT NO. 1 (8 ppm F), 1948–1958 [a]

### ANIMAL NO. 42

CENTRALS: *Cap*—(right) chipped and uneven; *Luster*—good; *Wear*—(left) normal, (right) slight and uneven; *Classification*—1A.

INTERMEDIATES: *Caps*—uneven; *Luster*—good; *Wear*—slight, or slight to medium and uneven; *Other*—roots exposed (left) about 1 mm., (right) about 3 mm.; *Classification*—1A.

LATERALS: *Cap*—(left) uneven; *Luster*—good; *Chalkiness*—slight focal, with large milky plaques, the one on the right being stained; *Wear*—(left) slight, (right) normal; *Classification*—1A.

CORNERS: *Cap*—(right) chipped heavily on right; *Luster*—good; *Chalkiness*—slight to medium and cross; *Wear*—(left) slight and uneven, (right) normal; *Classification*—1A.

PREMOLARS AND MOLARS: Normal staining on all pairs. Normal shortness of teeth in animals 10 to 11 years old made evaluation of wear difficult. Wear was normal or slight on all pairs except upper sixth in which wear was medium.

### ANIMAL NO. 13

CENTRALS: *Luster*—good; *Chalkiness*—heavy focal; *Staining*—slight discoloration; *Other*—roots exposed; *Wear*—normal (called slight on 5–6–58); *Classification*—1B.

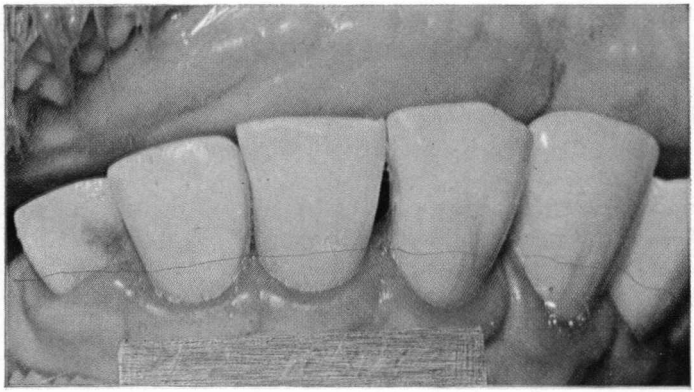
INTERMEDIATES: *Luster*—good; *Wear*—normal; *Other*—roots exposed 6 or 7 mm. and a purulent discharge from gum around left; *Classification*—1A.

LATERALS: *Luster*—good; *Chalkiness*—(left) medium focal; *Wear*—normal; *Other*—roots exposed about 5 mm. with a purulent discharge around each, labial surface rough; *Classification*—(left) 1B, (right) 1A.

CORNERS: *Luster*—good; *Chalkiness*—(left) medium to heavy focal; *Wear*—normal; *Classification*—(left) 1B, (right) 1A.

PREMOLARS AND MOLARS: Normal staining. Normal or slight wear except for lower fourth pairs which had slight to medium wear.

[a] These descriptions represent effects on teeth for the period 1948 to 1958.



**LOT NO. 1, 1948–1953**

**Control Ration**
**(7 ppm Fluorine)**

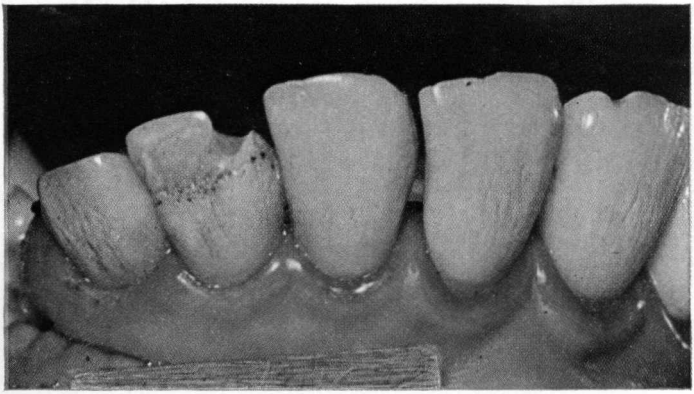
**Cow No. 42**

**Photographed Oct., 1952**
**Milky plaque in corner**



**Cow No. 13**

**Photographed Oct., 1952**



**Cow No. 24**

**Photographed Oct., 1952**

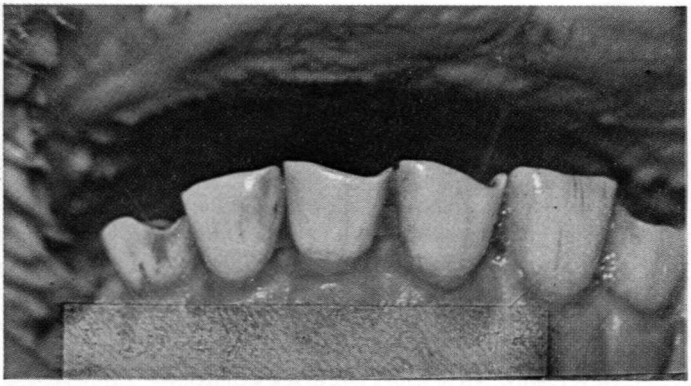
**Note: Chipped cap and uneven wear; roughness variation in all teeth; vegetative staining, especially No. 13; chalkiness, especially from centers to corners; enamel hypoplasia in laterals of No. 24; gingivitis in all animals**

**LOT NO. 1, 1948–1958**

**Control Ration**
**(8 ppm Fluorine)**

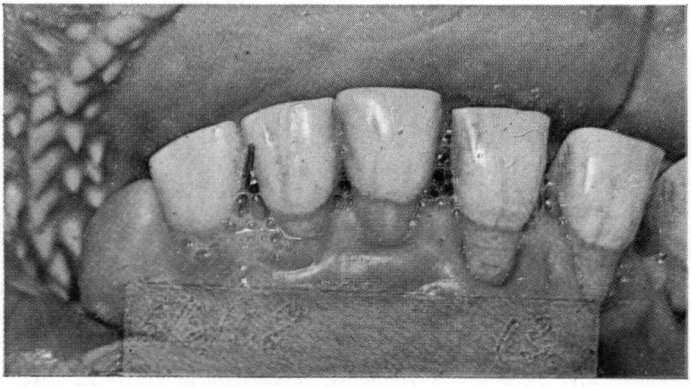
**Cow No. 42**

**Photographed Nov., 1957**



**Cow No. 13**

**Photographed May, 1958**



**Cow No. 24**

**Photographed Nov., 1957**



**ANIMAL NO. 24**

CENTRALS: (right) missing, (left) *Luster*—good; *Wear*—normal; *Other*—root exposed 12 mm. and tooth becoming loose; *Classification*—1A.

INTERMEDIATES: *Luster*—good; *Wear*—normal; *Other*—roots exposed; *Classification*—1A.

LATERALS: *Luster*—good; *Chalkiness*—slight focal; *Enamel hypoplasia*—at the caps are worn hypoplastic-like pits; *Wear*—medium and uneven; *Other*—roots exposed about (left) 8 mm., (right) about 3 mm.; *Classification*—1AX.

CORNERS: *Luster*—good; *Chalkiness*—slight to medium focal; *Wear*—normal; *Classification*—1A.

PREMOLARS AND MOLARS: Normal staining except for suspected staining on lower sixth pairs. Wear is slight on left member of second pairs (upper) and fourth pairs (lower).

**LOT NO. 2 (17 ppm F), 1948–1953**

**ANIMAL NO. 46**

CENTRALS AND INTERMEDIATES: *Luster*—good; *Chalkiness*—focal, vertical striations, slight; *Staining*—vegetative, slight; *Classification*—1A.

LATERALS: *Chipped Cap*—very slight; *Luster*—good; *Chalkiness*—cross porcelain, medium; *Staining*—light brown, slight, vegetative; *Wear*—slight; *Classification*—2.

CORNERS: *Luster*—fair; *Chalkiness*—focal, cross and porcelain, medium, (left) milky plaque creamy; *Wear*—slight; *Classification*—1B.

GINGIVAE: Slight to medium gingivitis.

PREMOLARS AND MOLARS: FIRST, SECOND, FOURTH and FIFTH PAIRS: Normal. THIRD PAIRS: *Wear*—(uppers) slight. SIXTH PAIRS: *Wear*—(uppers) medium.

**ANIMAL NO. 16**

CENTRALS: *Luster*—fair; *Chalkiness*—focal, slight; *Staining*—vegetative, medium; *Wear*—uneven; *Classification*—1A.

INTERMEDIATES: *Luster*—fair; *Staining*—light brown, medium, lower ¾ vegetative; *Wear*—beveled, uneven; *Classification*—2.

LATERALS: *Chipped Cap*—slight; *Chalkiness*—focal, slight; *Staining*—brown, focal, medium, vegetative; *Classification*—2.

CORNERS: *Luster*—fair; *Chalkiness*—focal, heavy; *Staining*—light brown, vegetative, slight; *Enamel hypoplasia*—pit, slight; *Classification*—4.

GINGIVAE: Slight to medium gingivitis.

PREMOLARS AND MOLARS: FIRST, SECOND, FOURTH, and FIFTH PAIRS: Normal. THIRD PAIRS: *Staining*—light brown. SIXTH PAIRS: *Staining*—light brown; *Wear*—(uppers) medium to heavy.

**ANIMAL NO. 11**

CENTRALS: *Chipped Cap*—slight; *Luster*—fair to good; *Chalkiness*—focal, slight; *Staining*—light brown centrally, medium; *Classification*—2.

INTERMEDIATES: *Luster*—fair to poor; *Chalkiness*—focal; *Staining*—focal, brown, slight; *Caries*—superficial pre-carious foci; *Classification*—2, which may become 3 with time.

LATERALS: *Chalkiness*—(right) excessive, (left) focal; *Staining*—(right) brown, heavy, (left) yellow-brown, slight; *Caries*—(right) lower ½ (left) possible erosion, slight, black stains; *Enamel hypoplasia*—(right) suspicious; *Classification*—(right) 4, (left) 2 that may become 3.

CORNERS: *Chalkiness*—focal, diffuse; *Staining*—light brown, slight; *Enamel hypoplasia*—(right) pit, transverse, slight, (left) suspicious; *Classification*—5A.

GINGIVAE: Slight gingivitis.

PREMOLARS AND MOLARS: FIRST, SECOND, and FOURTH PAIRS: Normal. THIRD PAIRS: *Wear*—(uppers) slight. FIFTH PAIRS: *Wear*—(uppers) medium. SIXTH PAIRS: *Wear*—(uppers) excessive.

## LOT NO. 2 (18 ppm F), 1948–1958

### ANIMAL NO. 46

CENTRALS: *Luster*—fair to good; *Chalkiness*—medium focal; *Wear*—normal; *Other*—roots exposed approximately 7 mm.; *Classification*—1A or 1B.

INTERMEDIATES: *Luster*—fair to good; *Chalkiness*—medium to heavy cross and focal; *Wear*—normal to slight; *Other*—roots exposed approximately 5 mm.; Classification—1B.

LATERALS: *Luster*—fair to good; *Chalkiness*—medium to heavy focal and cross with a milky plaque on left; *Staining*—slight discoloration and slight vegetative; *Wear*—normal to slight; *Other*—roots exposed; *Classification*—1B.

CORNERS: *Luster*—fair to good; *Chalkiness*—medium focal and cross; *Staining*—slight vegetative; *Wear*—normal; *Other*—enamel slightly rough; *Classification*—1B.

PREMOLARS AND MOLARS: FIRST, SECOND, FOURTH and FIFTH PAIRS: Normal. THIRD PAIRS: *Staining*—brown and light brown; *Wear*—(lowers) slight to medium. SIXTH PAIRS: *Staining*—brown and light brown.

### ANIMAL NO. 11

CENTRALS: *Luster*—good; *Chalkiness*—medium focal; *Wear*—normal; *Other*—roots exposed about 4 mm.; *Classification*—1B.

INTERMEDIATES: *Luster*—fair to good; *Chalkiness*—medium to heavy cross and focal; *Wear*—normal to slight; *Other*—flecks in enamel, (left) roots are exposed about 4 mm.; *Classification*—1B.

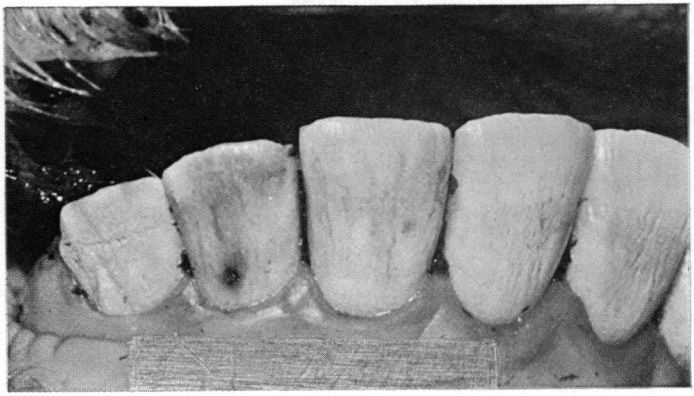
LATERALS: *Luster*—good; *Chalkiness*—medium focal and cross; *Staining*—(left) slight discoloration, (right) slight, light brown; *Enamel hypoplasia*—hypoplastic-like pits have caused some difficulty in classification; *Caries and erosion*—(right) pinhead caries in lower ½; *Wear*—normal; *Classification*—(left) 1BX (because of hypoplastic-like pits), (right) 3.



**LOT NO. 2, 1948–1953**

**Control Ration + 10 ppm Fluorine added as NaF (Total F = 17 ppm)**

**Cow No. 46**
**Photographed Oct., 1952**



**Cow No. 11**

**Photographed Oct., 1952**



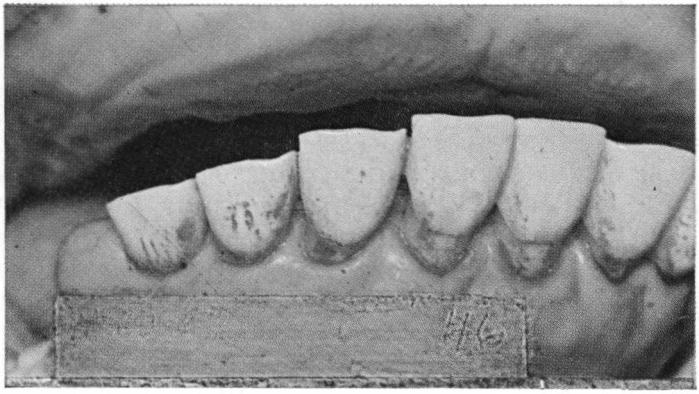
**LOT NO. 3, 1948–1953**
**Control Ration + 20 ppm Fluorine added as NaF (Total F = 27 ppm)**

**Cow No. 47**

**Photographed Oct., 1952**

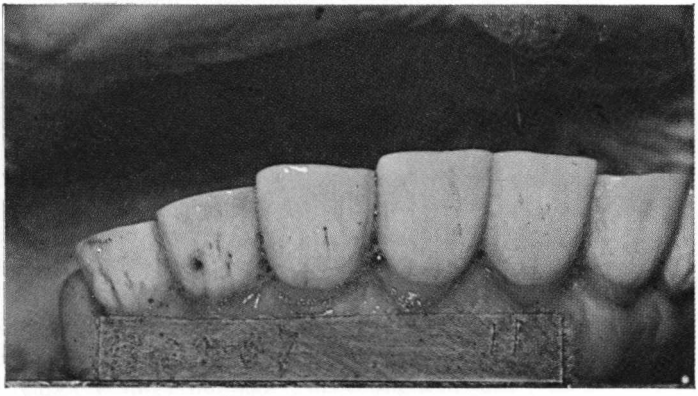
**LOT NO. 2, 1948–1958**
**Control Ration + 10 ppm Fluorine added as NaF (Total F = 18 ppm)**

**Cow No. 46**
**Photographed Nov., 1957**



**Cow No. 11**

**Photographed Nov., 1957**



**LOT NO. 3, 1948–1958**

**Control Ration + 20 ppm Fluorine added as NaF (Total F = 28 ppm)**

**Cow No. 47**

**Photographed Nov., 1957**



CORNERS: *Luster*—good; *Chalkiness*—medium focal and cross; *Staining*—(left) slight, light brown; *Enamel hypoplasia*—suspected to slight with a transverse row of pits showing slightly in picture near cap; *Wear*—(left) slight, (right) normal; *Classification*—4.

PREMOLARS AND MOLARS: FIRST and FIFTH PAIRS: Normal. SECOND PAIRS *Staining*—brown; *Wear*—normal to slight. THIRD PAIRS: *Staining*—light brown; *Wear*—normal to slight. FOURTH PAIRS: *Staining*—(lowers) brown; *Wear*—(lowers) medium. SIXTH PAIRS: *Staining*—brown and light brown; *Wear*—(uppers) slight to medium and (lowers) normal to slight.

## LOT NO. 3 (27 ppm F), 1948–1953

### ANIMAL NO. 32

CENTRALS: *Luster*—fair to good; *Chalkiness*—focal, slight to medium; *Staining*—(right) brown, focal, slight, (left) light yellow, slight; *Caries*—(right) upper ⅓; *Classification*—(left) 2, (right) 3.

INTERMEDIATES: *Luster*—good, upper ¼; *Chalkiness*—diffuse, lower ⅔; *Staining*—brown, slight to medium; *Caries*—(left) pre-carious pinhead, medially upper ½, (right) pre-carious upper ⅓, pinhead central lower ½; *Erosions*—(left) upper ½, (right) upper ⅓; *Wear*—slight; *Classification*—3.

LATERALS: *Chalkiness*—excessive; *Staining*—brown, heavy, black at cap; *Caries*—(left) pre-carious, pinhead lower ⅓ laterally; *Enamel hypoplasia*—slight; *Wear*—medium; *Classification*—4.

CORNERS: *Chalkiness*—excessive; *Staining*—focal, brown, slight to medium, transverse at cap; *Caries*—(left) pre-carious foci at cap; *Enamel hypoplasia*—slight; *Wear*—slight; *Classification*—4.

PREMOLARS AND MOLARS: FIRST PAIRS: *Staining*—brown, slight. SECOND PAIRS: *Staining*—brown, slight; *Wear*—slight. THIRD PAIRS: *Staining*—brown, slight; *Wear*—medium. FOURTH PAIRS: Normal. FIFTH PAIRS: (lowers) normal, (uppers) long posteriorly. SIXTH PAIRS: *Staining*—brown, excessive *Wear*—(uppers) excessive, (lowers) long posteriorly.

### ANIMAL NO. 47

CENTRALS: *Luster*—good; teeth spaced 1 to 3 mm.; *Classification*—1A.

INTERMEDIATES: *Luster*—upper ⅓ good; *Chalkiness*—upper ⅓ focal, cross, lower ⅔ diffuse chalky; *Staining*—transverse brown at junction of upper and central ⅓, light brown lower ⅔, heavy; *Wear*—slightly uneven; *Classification*—2.

LATERALS: *Luster*—fair; *Chalkiness*—focal upper ⅕, lower ⅘ diffuse; *Staining*—transverse upper ⅓, light brown, medium to heavy; *Caries*—(left) pre-carious lower ⅓, (right) pre-carious central ⅓; *Wear*—slight; *Classification*—3.

CORNERS: *Chalkiness*—excessive; *Staining*—light brown, excessive; *Erosions*—(right) medial ½ at cap; *Enamel hypoplasia*—slight; *Wear*—slight; *Classification*—4.

GINGIVAE: Slight gingivitis.

PREMOLARS AND MOLARS: FIRST PAIRS: *Staining*—slight. SECOND PAIRS: *Staining*—slight to medium, *Wear*—slight to normal. THIRD PAIRS: medium to heavy, *Wear*—medium. FOURTH and FIFTH PAIRS: Normal. SIXTH PAIRS: *Staining*—(lowers) brown, heavy, *Wear*—(uppers) excessive, (lowers) slightly long posteriorly.

**LOT NO. 3 (28 ppm F), 1948–1958**

**ANIMAL NO. 47**

CENTRALS: *Luster*—good; *Chalkiness*—slight to medium focal; *Staining*—slight focal vegetative; *Wear*—normal; *Other*—dark marks on left are part of tooth; *Classification*—1A or 1B.

INTERMEDIATES: *Caps*—chipped and uneven; *Luster*—good; *Staining*—slight and light brown in upper ½; *Wear*—slight and uneven; *Classification*—2.

LATERALS: *Luster*—fair; *Chalkiness*—heavy and diffuse; *Staining*—medium light brown; *Enamel hypoplasia*—difficult to evaluate; *Wear*—slight; *Classification*—2 or 4.

CORNERS: *Luster*—poor; *Chalkiness*—heavy focal and diffuse; *Staining*—heavy, light brown; *Enamel hypoplasia*—difficult to evaluate; *Wear*—slight; *Classification*—2 or 4.

PREMOLARS AND MOLARS: FIRST PAIRS: *Staining*—brown; *Wear*—(uppers) normal to slight. SECOND PAIRS: *Staining*—brown and light brown; *Wear*—(uppers) normal to slight and (lowers) slight to medium. THIRD PAIRS: *Staining*—brown and light brown; *Wear*—(lowers) slight to medium. FOURTH and FIFTH PAIRS: Normal. SIXTH PAIRS: *Staining*—dark brown and black; *Wear*—(uppers) heavy to excessive and (lowers) slight to medium long.

**LOT NO. 4 (37 ppm F), 1948–1953**

**ANIMAL NO. 48**

CENTRALS: *Luster*—upper ¼ good; *Chalkiness*—lower ½ diffuse, upper ½ cross and porcelain, heavy; *Staining*—light brown, medium to heavy; *Classification*—2.

INTERMEDIATES: *Luster*—medium at cap; *Chalkiness*—excessive; *Staining*—light brown, excessive; *Erosions*—(right) superficial, center near cap; *Enamel hypoplasia*—suspected; *Wear*—slight to medium; *Classification*—4.

LATERALS: *Chalkiness*—excessive; *Staining*—light to dark brown, excessive; *Enamel hypoplasia*—slight to medium; *Wear*—medium; *Classification*—5A.

CORNERS: *Chalkiness*—excessive; *Staining*—brown, excessive; *Enamel hypoplasia*—slight to medium; *Wear*—slight; (left) bucco-medioclination; *Classification*—5A.

GINGIVAE: Slight gingivitis.

PREMOLARS AND MOLARS: FIRST PAIRS: *Staining*—brown. SECOND PAIRS: *Staining*—brown, *Wear*—(uppers) medium and (lowers) slight. THIRD PAIRS: *Staining*—brown, *Wear*—medium. FOURTH and FIFTH PAIRS: Normal. SIXTH PAIRS: *Wear*—(uppers) excessive, (lowers) sheer anteriorly and long centrally.

**ANIMAL NO. 30**

CENTRALS: *Chipped Cap; Luster*—upper ⅓ good; *Chalkiness*—porcelain and cross, heavy, lower ⅓ excessive; *Staining*—light brown, heavy; *Erosions*—deep central ⅓, slight to medium; *Classification*—3.

INTERMEDIATES: *Chipped Cap; Luster*—good at cap; *Chalkiness*—excessive; *Staining*—light brown, excessive; *Enamel hypoplasia*—pit, transverse lower ⅓, slight; *Wear*—uneven, slight; *Classification*—4.

LATERALS: *Chalkiness*—excessive; *Staining*—light brown, excessive; *Enamel hypoplasia*—slight to medium; *Wear*—slight to medium; *Classification*—5A.

CORNERS: *Chalkiness*—excessive; *Staining*—light brown, excessive; *Enamel hypoplasia*—shell and patch, slight to medium; *Wear*—slight; *Classification*—5A.

GINGIVAE: Medium gingivitis.

PREMOLARS AND MOLARS: FIRST PAIRS: *Staining*—brown. SECOND PAIRS: *Staining*—(uppers) brown, *Wear*—(uppers) medium to heavy, (lowers) slight. THIRD PAIRS: *Staining*—brown; *Wear*—(uppers) heavy, (lowers) medium. FOURTH and FIFTH PAIRS: Normal. SIXTH PAIRS: *Wear*—(upper) heavy to excessive, (lowers) sheer anteriorly and long posteriorly.

**ANIMAL NO. 31**

CENTRALS: *Luster*—upper ⅓ good; *Chalkiness*—cross and porcelain upper ⅓, lower ⅔ excessive; *Staining*—brown, focal, medium; *Erosions*—superficial and undermining, dark brown centrally, medium; *Classification*—3.

INTERMEDIATES: *Luster*—upper ¼ fair; *Chalkiness*—excessive; *Staining*—light and dark brown, medium to heavy; *Caries* and *Erosions*—superficial and deep, medium; *Enamel hypoplasia*—slight; *Wear*—medium, (left) sheer; *Classification*—4.

LATERALS: *Chalkiness*—excessive; *Staining*—light brown, excessive; *Enamel hypoplasia*—patch, medium; *Tooth hypoplasia*—suspicious; *Wear*—medium; *Classification*—5B.

CORNERS: *Chalkiness*—excessive; *Staining*—light brown, excessive; *Enamel hypoplasia*—patch, medium; *Wear*—slight; *Classification*—5B.

GINGIVAE: Medium to heavy gingivitis.

PREMOLARS AND MOLARS: FIRST PAIRS: *Staining*—brown. SECOND PAIRS: *Staining*—(uppers) brown, *Wear*—(uppers) medium. THIRD PAIRS: *Staining*—brown, *Wear*—(uppers) heavy, (lowers) medium to heavy. FOURTH and FIFTH PAIRS: Normal. SIXTH PAIRS: *Wear*—(uppers) excessive, (lowers) slightly long.

## LOT NO. 4 (38 ppm F), 1948–1958

### ANIMAL NO. 48

CENTRALS: *Luster*—good; *Chalkiness*—medium or heavy focal, cross, diffuse, with slight porcelain; *Staining*—medium to heavy, light brown; *Wear*—normal; *Other*—roots exposed 2 to 4 mm.; *Classification*—2.

INTERMEDIATES: *Caps*—uneven; *Luster*—poor; *Chalkiness*—excessive and diffuse; *Staining*—excessive, light brown; *Enamel hypoplasia*—suspected to slight; *Caries* and *erosions*—(right) a worn caries; *Wear*—medium and uneven; *Other*—roots exposed 2 and 4 mm.; *Classification*—4.

LATERALS: *Luster*—poor; *Chalkiness*—excessive and diffuse; *Staining*—excessive, light brown; *Enamel hypoplasia*—suspected; *Wear*—medium to heavy and uneven; *Other*—roots exposed 2 or 3 mm. laterally; *Classification*—4.

CORNERS: *Luster*—poor to fair; *Chalkiness*—diffuse and focal; *Staining*—slight and light brown; *Enamel hypoplasia*—suspected; *Wear*—medium; *Classification*—4.

PREMOLARS AND MOLARS: FIRST PAIRS: *Staining*—brown; *Wear*—(uppers) normal to slight and (lowers) slight and uneven. SECOND PAIRS: *Staining*—brown, *Wear*—medium to heavy and uneven. THIRD PAIRS: *Staining*—brown; *Wear*—(uppers) excessive and (lowers) medium. FOURTH PAIRS: *Wear*—(lowers) slight to medium. FIFTH PAIRS: *Staining*—light brown; *Wear*—(uppers) slightly long. SIXTH PAIRS: *Staining*—brown; *Wear*—(uppers) excessive and into gum line and (lowers) slight to medium and long posteriorly.

### ANIMAL NO. 30

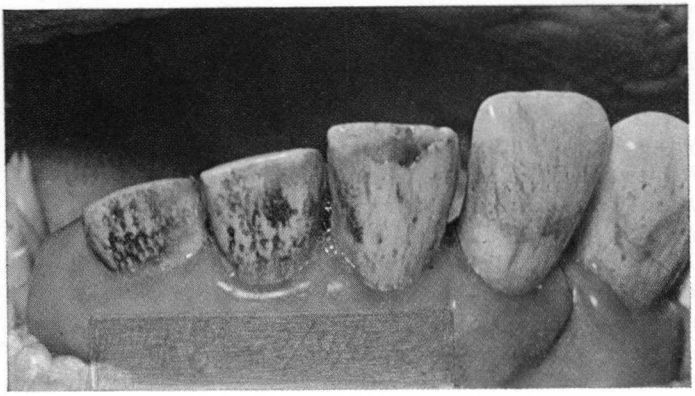
CENTRALS: *Caps*—chipped and uneven; *Luster*—good; *Chalkiness*—medium to heavy cross, focal and diffuse with slight porcelain; *Caries and erosions*—centrally there are remnants of eroded areas; *Wear*—normal to slight and uneven; *Other*—roots exposed approximately 4 mm.; *Classification*—3.

INTERMEDIATES: *Luster*—fair; *Chalkiness*—excessive and diffuse; *Staining*—excessive and light brown; *Enamel hypoplasia*—medium patch type; *Tooth hypoplasia*—slight; *Wear*—heavy; *Other*—roots exposed about 5 mm.; *Classification*—5A or 5B.

LATERALS: *Luster*—fair to good; *Chalkiness*—excessive and diffuse; *Staining*—excessive and light brown; *Enamel hypoplasia*—medium to heavy, patch type; *Tooth hypoplasia*—slight to medium; *Wear*—medium to heavy; *Other*—roots exposed; *Classification*—5B.

CORNERS: *Luster*—poor; *Chalkiness*—excessive and diffuse; *Staining*—excessive and light brown with, on the right, darker area at the cap; *Enamel hypoplasia*—medium to heavy, patch type; *Tooth hypoplasia*—suspected; *Caries and erosions*—(right) remnant of a caries at the cap; *Wear*—heavy; *Classification*—5B.

PREMOLARS AND MOLARS: *Staining*—(uppers) dark brown and (lowers) light brown; *Wear*—(uppers) slight to medium. SECOND and THIRD

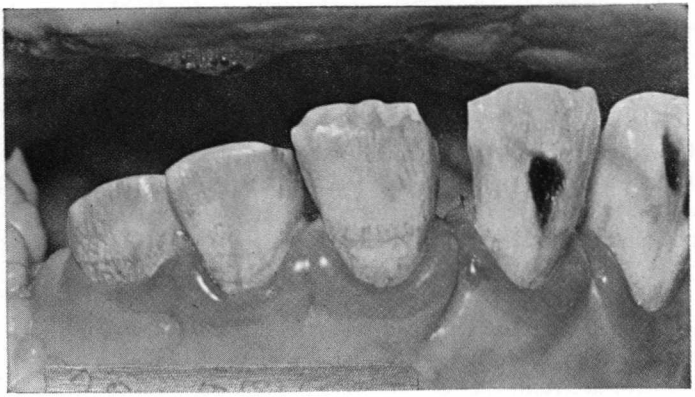


**LOT NO. 4, 1948–1953**

**Control Ration + 30 ppm Fluorine added as NaF (Total F = 37 ppm)**

**Cow No. 48**

**Photographed Oct., 1952**



**Cow No. 30**

**Photographed Oct., 1952**



**Cow No. 31**

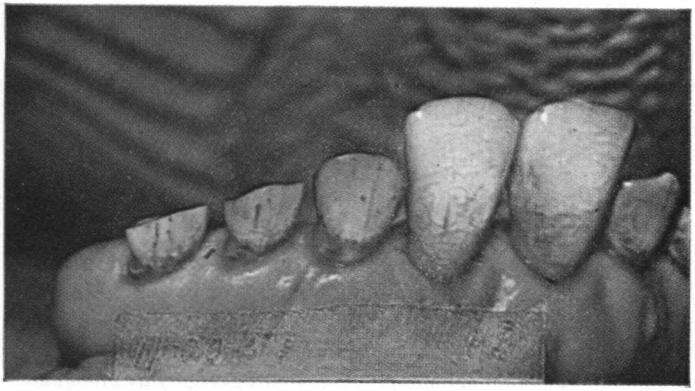
**Photographed Oct., 1952**

**LOT NO. 4, 1948–1958**

**Control Ration + 30 ppm Fluorine added as NaF (Total F = 38 ppm)**

**Cow No. 48**

**Photographed Nov., 1957**



**Cow No. 30**

**Photographed May, 1958**



**Cow No. 31**

**Photographed May, 1958**



PAIRS: *Staining*—brown; *Wear*—(uppers) excessive and (lowers) medium and uneven. FOURTH PAIRS: Normal. FIFTH PAIRS: *Staining*—(uppers) light brown. SIXTH PAIRS: *Staining*—dark brown and black; *Wear*—(uppers) excessive, but slightly long posteriorly and (lowers) slight and uneven.

**ANIMAL NO. 31**

CENTRALS: *Caps*—uneven; *Luster*—poor to fair; *Chalkiness*—heavy and diffuse; *Staining*—medium to heavy, light brown; *Enamel hypoplasia*—suspected and difficult to evaluate; *Wear*—medium and uneven; *Other*—roots exposed approximately 10 mm.; *Classification*—2 or 4.

INTERMEDIATES: *Caps*—uneven; *Luster*—poor; *Chalkiness*—excessive and diffuse; *Staining*—excessive, light brown; *Enamel hypoplasia*—slight to medium; *Caries and erosions*—worn pinpoint caries; *Wear*—heavy and uneven; *Other*—roots exposed 8 to 10 mm.; *Classification*—4.

LATERALS: *Luster*—poor to fair; *Chalkiness*—excessive and diffuse; *Enamel hypoplasia*—heavy to excessive shell type; *Staining*—excessive light brown; *Tooth hypoplasia*—medium to heavy; *Wear*—(left) heavy, (right) excessive; *Classification*—5C.

CORNERS: *Luster*—poor; *Chalkiness*—excessive and diffuse; *Staining*—excessive and light brown; *Enamel hypoplasia*—heavy to excessive, shell type; *Tooth hypoplasia*—medium to heavy; *Wear*—excessive; *Classification*—5C.

PREMOLARS AND MOLARS: FIRST and FIFTH PAIRS: *Staining*—light brown and brown. SECOND PAIRS: *Staining*—brown; *Wear*—(uppers) excessive and (lowers) slight on left and heavy on right. THIRD PAIRS: *Staining*—brown; *Wear*—(uppers) excessive and (lowers) slight to medium. FOURTH PAIRS: Normal. SIXTH PAIRS: *Staining*—dark brown and black; *Wear*—(uppers) excessive and (lowers) medium to excessive and uneven.

**LOT NO. 5 (47 ppm F), 1948–1953**

**ANIMAL NO. 49**

CENTRALS: *Luster*—good to very good; *Chalkiness*—focal, cross; *Staining*—(left) pale yellow, focal in lateral ½, medium, slight labio-medio-clination of left; *Classification*—(right) 1A, (left) 2.

INTERMEDIATES: This pair showed a non-bilateral effect which is observed occasionally. *Luster*—upper ¼ good, (right) good on lateral ¾ at cap; *Chalkiness*—(left) lower ¾ diffuse, (right) lower ⅘ excessive; *Staining*—(left) transverse yellow at junction of upper and central thirds and in lower ⅓, heavy, (right) excessive light brown to black in eroded areas; *Caries* and *Erosions*—(right) deep erosions upper ⅔, medium; *Enamel hypoplasia*—lower ⅓ slight; *Classification*—4.

LATERALS: *Chalkiness*—excessive; *Staining*—light brown to black, excessive; *Caries* and *Erosions*—(right) deep, undermining, heavy (left) under-

mining, slight; *Enamel hypoplasia*—(right) slight to medium and (left) slight; *Wear*—medium; *Classification*—5A.

CORNERS: *Chalkiness*—excessive; *Staining*—light brown to black, focal, excessive; *Caries* and *Erosions*—focal caries at cap, slight; *Enamel hypoplasia*—patch, medium; *Wear*—slight; *Classification*—5B.

GINGIVAE: Slight gingivitis.

PREMOLARS AND MOLARS: FIRST PAIRS: *Staining*—brown. SECOND PAIRS: *Staining*—brown, *Wear*—(uppers) slight. THIRD PAIRS: *Staining*—brown, *Wear*—(uppers) medium. FOURTH PAIRS: Normal. FIFTH PAIRS: *Staining*—brown, *Wear*—(uppers) slight. SIXTH PAIRS: *Staining*—excessive, *Wear*—(uppers) excessive and long posteriorly.

**ANIMAL NO. 23**

CENTRALS: *Chipped Cap; Luster*—upper ⅓ good; *Chalkiness*—upper ½ cross and porcelain, lower ½ diffuse; *Staining*—light brown to black, medium; *Caries* and *Erosions*—centrally slight; *Classification*—3.

INTERMEDIATES: *Chalkiness*—longitudinal striations, excessive; *Staining*—black, heavy; *Erosions*—medium to heavy; *Enamel hypoplasia*—pit, slight; *Wear*—slight; *Classification*—4.

LATERALS: *Chalkiness*—excessive; *Staining*—light brown, excessive; *Caries* (right) focal; *Enamel hypoplasia*—patch, diffuse, medium; *Tooth hypoplasia*—slight; *Wear*—medium; *Classification*—5B.

CORNERS: *Chalkiness*—excessive; *Staining*—light brown to black, excessive; *Caries*—slight pre-carious foci and pinhead upper ⅓; *Enamel hypoplasia*—diffuse, patch, medium; *Tooth hypoplasia*—slight; *Wear*—medium; *Classification*—5B.

GINGIVAE: Medium gingivitis.

PREMOLARS AND MOLARS: FIRST and SECOND PAIRS: *Staining*—brown. THIRD PAIRS: *Staining*—brown, *Wear*—(uppers) heavy and (lowers) slight. FOURTH and FIFTH PAIRS: Normal. SIXTH PAIRS: *Staining*—dark brown, excessive, *Wear*—(uppers) excessive and (lowers) long posteriorly.

**ANIMAL NO. 9**

CENTRALS: *Chipped Cap; Luster*—upper ⅕ good; *Chalkiness*—upper ¼ cross and porcelain and lower ¾ excessive; *Staining*—brown to black centrally, heavy; *Erosions*—superficial centrally, medium; *Classification*—3.

INTERMEDIATES: *Chalkiness*—excessive; *Staining*—(left) brown to black, excessive, (right) brown to black, heavy; *Caries* and *Erosions*—superficial and undermining, medium; *Enamel hypoplasia*—slight; *Wear*—slight to medium, (right) longitudinal cracks; Spacing—2 to 3 mm. from centrals; *Classification*—5A.

LATERALS: *Chalkiness*—excessive; *Staining*—(right) light brown, excessive, (left) brown to black, excessive; *Caries* and *Erosions*—(left) upper ¼; *Enamel hypoplasia*—diffuse, patch, medium; *Tooth hypoplasia*—slight to medium; *Wear*—rolling, medium; *Classification*—5B.

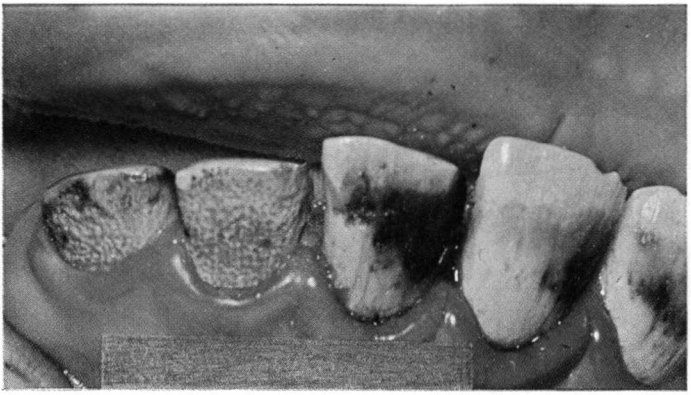


**LOT NO. 5, 1948–1953**

**Control Ration + 40 ppm F added as NaF (Total F = 47 ppm)**

**Cow No. 49**

**Photographed March, 1953**



**Cow No. 23**

**Photographed Oct., 1952**



**Cow No. 9**

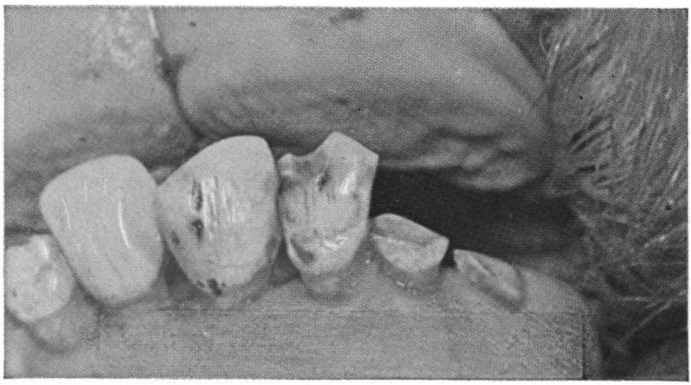
**Photographed March, 1953**

**LOT NO. 5, 1948–1958**

**Control Ration + 40 ppm Fluorine added as NaF (Total F = 48 ppm)**

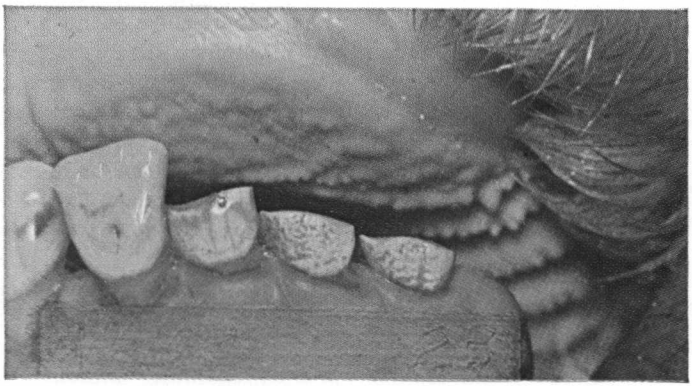
**Cow No. 49**

**Photographed Nov., 1957**



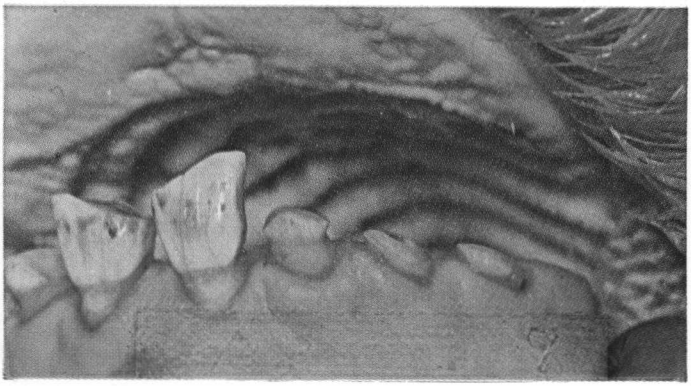
**Cow No. 23**

**Photographed May, 1958**



**Cow No. 9**

**Photographed May, 1958**



CORNERS: *Chalkiness*—excessive; *Staining*—brown, excessive; *Enamel hypoplasia*—patch, medium; *Wear*—slight to medium; *Classification*—5B.

GINGIVAE: Slight gingivitis.

PREMOLARS AND MOLARS: FIRST PAIRS: Normal. SECOND PAIRS: *Staining*—brown, *Wear*—(uppers) medium. THIRD PAIRS: *Staining*—brown, *Wear*—(uppers) heavy and (lowers) slight. FOURTH PAIRS: Normal. FIFTH PAIRS: *Staining*—(uppers) brown, *Wear*—medium, long posteriorly. SIXTH PAIRS: *Staining*—brown, *Wear*—(uppers) excessive and (lowers) sheer anteriorly and long posteriorly.

MANDIBLE: This animal previously had lump jaw.

## LOT NO. 5 (48 ppm F), 1948–1958

### ANIMAL NO. 49

CENTRALS: *Luster*—(left) fair, (right) good; *Chalkiness*—(left) medium to heavy diffuse and cross, (right) slight to medium focal; *Staining*—(left) heavy, light brown with dark foci; *Caries* and *Erosions*—(left) several pinhead-size caries; *Wear*—(left) slight to medium and uneven, (right) normal; *Other*—roots exposed 4 to 7 mm.; *Classification*—(left) 3, (right) 1B.

INTERMEDIATES: *Luster*—poor; *Chalkiness*—excessive and diffuse; *Staining*—excessive light brown with dark foci; *Enamel hypoplasia*—suspected to slight patch type; *Caries and erosions*—(left) small eroded area along medial margin and caries centrally, (right) remnant of eroded area at cap; *Wear*—(left) slight and uneven, (right) medium to heavy and uneven; *Other*—roots exposed about (left) 3mm., (right) 5 mm.; *Classification*—(left) 4, (right) 5A.

LATERALS: *Luster*—poor; *Chalkiness*—excessive and diffuse; *Staining*—excessive and light brown; *Enamel hypoplasia*—(left) medium, (right) heavy to excessive; *Tooth hypoplasia*—medium; *Wear*—(left) heavy, (right) excessive; *Other*—roots exposed about 3 mm.; *Classification*—(left) 5A or 5B, (right) 5C.

CORNERS: *Luster*—poor; *Chalkiness*—excessive and diffuse; *Staining*—excessive and light brown; *Enamel hypoplasia*—heavy, shell type; *Tooth hypoplasia*—heavy; *Wear*—excessive; *Classification*—5B or 5C.

PREMOLARS AND MOLARS: FIRST PAIRS: *Staining*—brown; *Wear*—normal. SECOND PAIRS: *Staining*—brown and light brown; *Wear*—slight. THIRD PAIRS: *Staining*—brown; *Wear*—heavy to excessive. FOURTH and FIFTH PAIRS: Normal. SIXTH PAIRS: *Staining*—brown and dark brown; *Wear*—(uppers) excessive and (lowers) normal and long.

### ANIMAL NO. 23

CENTRALS: *Luster*—good; *Chalkiness*—medium to heavy focal and diffuse; *Staining*—slight and light brown centrally; *Caries* and *Erosions*—(left) worn eroded area centrally, (right) worn erosion on medial margin

and a worn pinpoint caries; *Wear*—normal and uneven; *Other*—roots exposed about (left) 4 mm., (right) about 8 mm.; *Classification*—3.

INTERMEDIATES: *Luster*—fair; *Chalkiness*—excessive and diffuse; *Staining*—excessive and light brown with slightly darker areas; *Enamel hypoplasia*—(left) slight, pit type, (right) suspected; *Caries* and *Erosions*—remnant of caries at cap on both; *Wear*—medium to heavy and uneven; *Other*—roots exposed about (left) 2 mm., (right) 5 mm.; *Classification*—(left) 5A, (right) 4.

LATERALS: *Luster*—poor to fair; *Chalkiness*—excessive and diffuse; *Staining*—excessive and light brown; *Enamel hypoplasia*—medium patch and pit type; *Wear*—medium to heavy; *Other*—roots exposed and worn along lateral margins; *Tooth hypoplasia*—suspected to slight; *Classification*—5B.

CORNERS: *Luster*—poor; *Chalkiness*—excessive and diffuse; *Staining*—excessive and light brown; *Enamel hypoplasia*—heavy patch type; *Tooth hypoplasia*—(left) slight, (right) medium; *Wear*—(left) heavy, (right) excessive; *Classification*—(left) 5B, (right) 5C.

PREMOLARS AND MOLARS: FIRST PAIRS: *Staining*—brown; *Wear*—(lowers) slight. SECOND PAIRS: *Staining*—brown; *Wear*—heavy. THIRD PAIRS: *Staining*—brown, *Wear*—(uppers) excessive and (lowers) medium. FOURTH PAIRS: Normal. FIFTH PAIRS: *Staining*—brown; *Wear*—(lowers) slightly long posteriorly. SIXTH PAIRS: *Staining*—brown and black; *Wear*—(uppers) excessive and slightly long posteriorly and (lowers) uneven.

**ANIMAL NO. 9**

CENTRALS: *Caps*—chipped and uneven; *Luster*—fair; *Chalkiness*—heavy, focal and diffuse; *Staining*—medium and light brown with dark foci; *Caries* and *Erosions*—multiple and worn pinpoint and pinhead caries; *Wear*—(left) medium and uneven, (right) heavy and uneven; *Other*—roots exposed about 6 mm.; *Classification*—3.

INTERMEDIATES: *Luster*—poor; *Chalkiness*—excessive and diffuse; *Staining*—excessive, light brown; *Enamel hypoplasia*—medium; *Tooth hypoplasia*—slight; *Wear*—excessive; *Other*—roots exposed 3 to 5 mm.; *Classification*—5A or 5B.

LATERALS: (left) not enough enamel to describe, (right) *Luster*—poor; *Chalkiness*—excessive and diffuse; *Staining*—excessive and light brown; *Enamel hypoplasia*—heavy; *Tooth hypoplasia*—medium; *Wear*—excessive; *Other*—(right) root is exposed; *Classification*—(left) estimated 5C, (right) 5B.

CORNERS: *Luster*—poor; *Chalkiness*—excessive and diffuse; *Staining*—excessive light brown; *Enamel hypoplasia*—heavy; *Tooth hypoplasia*—medium; *Wear* (left) excessive, (right) heavy; *Classification*—5C.

PREMOLARS AND MOLARS: FIRST PAIRS: *Staining*—brown and dark brown; *Wear*—(uppers) medium to heavy. SECOND PAIRS: *Staining*—dark brown; *Wear*—(uppers) excessive and (lowers) medium on left and excessive on right. THIRD PAIRS: *Staining*—brown; *Wear*—(uppers) excessive and (lowers) medium on left and heavy on right. FOURTH PAIRS: Normal. FIFTH PAIRS: *Staining*—brown and light brown. SIXTH PAIRS:

*Staining*—brown and black; *Wear*—(uppers) excessive into gums and (lowers) uneven.

## LOT NO. 6 (57 ppm F), 1948–1953

### ANIMAL NO. 50

CENTRALS: *Chipped Cap; Luster*—good at cap; *Chalkiness*—focal, porcelain, cross with lower ⅓ diffuse; *Staining*—transverse at junction of lower and central ⅓ and brown-black in medial portion of central ⅓; *Erosion*—superficial in medial portion of central ⅓; exposed root; *Classification*—3.

INTERMEDIATES: *Chipped Cap; Luster*—fair; *Chalkiness*—focal at cap; lower ¾ diffuse, excessive; *Staining*—light yellow, slight; *Enamel hypoplasia*—pit, slight; *Wear*—uneven, slight; *Classification*—4.

LATERALS: *Chalkiness*—excessive; *Staining*—light brown, excessive; *Enamel hypoplasia*—patch, pit, slight to medium; *Wear*—medium; *Classification*—5A.

CORNERS: *Chalkiness*—excessive; *Staining*—light brown, excessive; *Enamel hypoplasia*—patch, medium; *Wear*—slight to medium; *Classification*—5B.

GINGIVAE: Slight to medium gingivitis.

PREMOLARS AND MOLARS: FIRST PAIRS: *Staining*—brown. SECOND PAIRS: *Staining*—brown, *Wear*—medium. THIRD PAIRS: *Staining*—brown, *Wear*—(uppers) heavy, (lowers) medium. FOURTH PAIRS: Normal. FIFTH PAIRS: *Wear*—(uppers) medium and long posteriorly. SIXTH PAIRS: *Staining*—brown, *Wear*—(uppers) excessive, (lowers) excessive and uneven.

### ANIMAL NO. 6

CENTRALS: *Chipped Cap; Luster*—good at cap; *Chalkiness*—focal, cross and porcelain at cap, lower ⅘ focal to excessive; *Staining*—light brown to brown, heavy; *Caries*—pre-carious foci lower ½, apparently non-hypoplastic pits in upper ⅔; *Classification*—3.

INTERMEDIATES: *Chalkiness*—excessive; *Staining*—light brown, excessive; *Caries* and *Erosions*—pinhead upper ⅓; *Enamel hypoplasia*—slight; *Wear*—slight to medium; *Classification*—4.

LATERALS: *Chalkiness*—excessive; *Staining*—focal dark brown, excessive; *Enamel hypoplasia*—pit, patch, slight to medium; *Wear*—slight to medium; *Classification*—5A.

CORNERS: *Chalkiness*—excessive; *Staining*—light to dark brown, excessive; *Enamel hypoplasia*—patch, medium; *Wear*—slight; *Classification*—5B.

GINGIVAE: Slight to medium gingivitis.

PREMOLARS AND MOLARS: FIRST PAIRS: *Staining*—brown. SECOND PAIRS: *Staining*—brown, *Wear*—(uppers) medium. THIRD PAIRS: *Staining*—brown, *Wear*—medium to heavy. FOURTH and FIFTH PAIRS: Normal. SIXTH PAIRS: *Staining*—brown-black, *Wear*—(uppers) excessive, (lowers) sheer anteriorly and long posteriorly.

**ANIMAL NO. 1**

CENTRALS: *Chipped Cap; Luster*—upper ¼ fair; *Chalkiness*—excessive; *Staining*—transverse, brown-black at junction of upper and center ⅓ and light brown lower ½; excessive; *Caries* and *Erosions*—transverse upper ⅓, slight to medium; *Enamel hypoplasia*—suspected; *Wear*—uneven, slight; *Classification*—4.

INTERMEDIATES: *Chalkiness*—excessive; *Staining*—light brown, excessive; *Caries*—slight; *Erosions*—upper ⅕, deep; *Enamel hypoplasia*—pit, patch, medium; *Tooth hypoplasia*—slight; *Wear*—medium; *Classification*—5B.

LATERALS: *Chalkiness*—excessive; *Staining*—very light brown, excessive; *Enamel hypoplasia*—shell, patch, medium; *Wear*—slight; *Classification*—5B.

CORNERS: *Chalkiness*—excessive; *Staining*—very light brown, excessive; *Enamel hypoplasia*—shell, patch, medium; *Wear*—slight; *Classification*—5B.

GINGIVAE: Slight to medium gingivitis.

PREMOLARS AND MOLARS: FIRST PAIRS: *Staining*—brown. SECOND PAIRS: *Staining*—brown, *Wear*—(uppers) slight. THIRD PAIRS: *Staining*—brown-black, *Wear*—(uppers) slight. FOURTH and FIFTH PAIRS: Normal. SIXTH PAIRS: *Staining*—brown-black, *Wear*—(uppers) excessive (lowers) sheer anteriorly and long posteriorly.

**LOT NO. 6 (58 ppm F), 1948–1958**

**ANIMAL NO. 50**

CENTRALS: *Luster*—good; *Chalkiness*—slight to medium diffuse; *Staining*—slight, light brown and focal; *Caries and erosions*—remnants of caries centrally; *Wear*—(left) normal, (right) slight; *Other*—roots exposed 8 to 10 mm.; *Classification*—3.

INTERMEDIATES: *Luster*—good; *Chalkiness*—medium, focal and diffuse; *Enamel hypoplasia*—suspected to slight, pit type; *Cracks*—longitudinal on left; *Caries and erosions*—(right) pinhead caries centrally; *Wear*—medium; *Other*—roots exposed about 5 mm.; *Classification*—4.

LATERALS: *Luster*—fair; *Chalkiness*—excessive and diffuse; *Staining*—slight discoloration with brown foci at cap; *Enamel hypoplasia*—medium; *Tooth hypoplasia*—slight; *Wear*—heavy to excessive; *Other*—roots exposed 2 or 3 mm.; *Classification*—5A or 5B.

CORNERS: *Luster*—fair; *Chalkiness*—heavy and diffuse; *Staining*—slight discoloration; *Enamel hypoplasia*—medium to heavy; *Tooth hypoplasia*—silght; *Wear*—heavy; *Classification*—5B or 5C.

PREMOLARS AND MOLARS: FIRST PAIRS: *Staining*—brown; *Wear*—(uppers) medium to heavy. SECOND PAIRS: *Staining*—brown; *Wear*—heavy to excessive. THIRD PAIRS: *Staining*—brown; *Wear*—(uppers) excessive into the gum and (lowers) slight to medium. FOURTH PAIRS: Normal. FIFTH

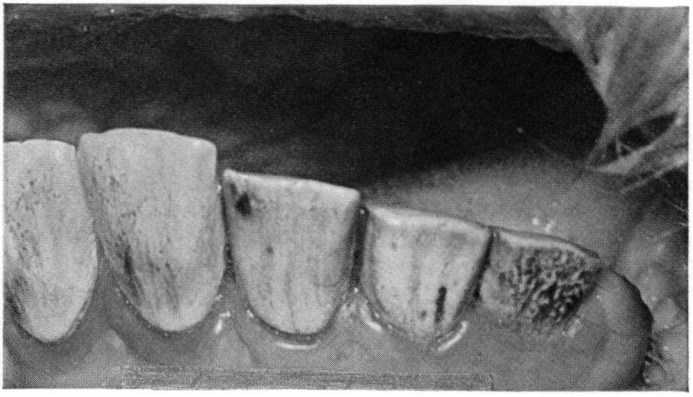


**LOT NO. 6, 1948–1953**

**Control Ration + 50 ppm Fluorine added as NaF (Total F = 57 ppm)**

**Cow No. 50**

**Photographed Oct., 1952**



**Cow No. 6**

**Photographed Oct., 1952**



**Cow No. 1**

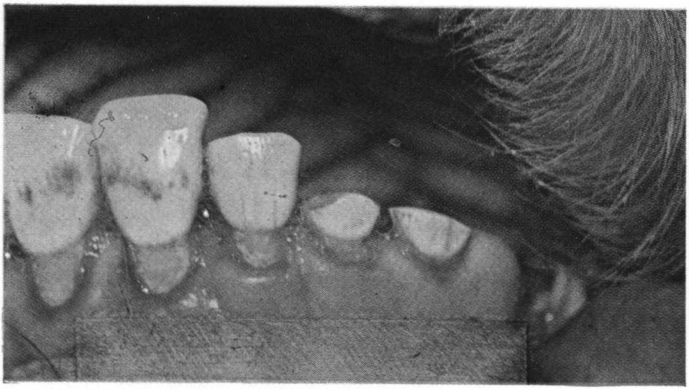
**Photographed Oct., 1952**

**LOT NO. 6, 1948–1958**

**Control Ration + 50 ppm Fluorine added as NaF (Total F = 58 ppm)**

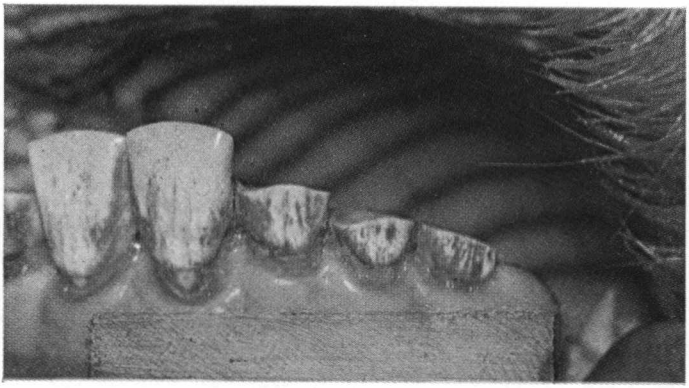
**Cow No. 50**

**Photographed Nov., 1957**



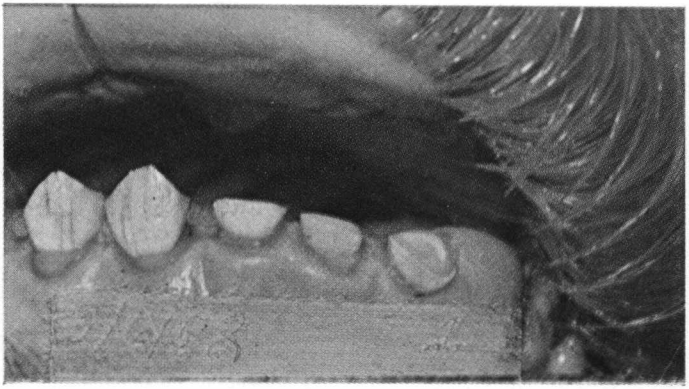
**Cow No. 6**

**Photographed May, 1958**



**Cow No. 1**

**Photographed May, 1958**



PAIRS: *Staining*—light brown; *Wear*—(uppers) medium long posteriorly. SIXTH PAIRS: *Staining*—brown; *Wear*—heavy and uneven.

**ANIMAL NO. 6**

CENTRALS: *Luster*—poor to fair; *Chalkiness*—medium focal, and slight porcelain cross and diffuse; *Staining*—medium and light brown; *Cracks*—lightly stained longitudinal; *Caries* and *erosions*—flecks and foci, especially along the longitudinal cracks; *Wear*—normal; *Other*—roots exposed (left) about 4 mm., (right) 2 mm.; *Classification*—2X or 3.

INTERMEDIATES: *Luster*—poor; *Chalkiness*—excessive and diffuse; *Staining*—slight discoloration and vegetative; *Enamel hypoplasia*—suspected to slight; *Wear*—heavy; *Other*—roots exposed about 2 or 3 mm.; *Classification*—4.

LATERALS: *Luster*—poor; *Chalkiness*—excessive and diffuse; *Staining*—excessive and light brown; *Enamel hypoplasia*—slight to medium; *Tooth hypoplasia*—suspected to slight; *Wear*—heavy to excessive; *Classification*—5A or 5B.

CORNERS: *Luster*—poor; *Chalkiness*—excessive and diffuse; *Staining*—excessive and light brown and vegetative; *Enamel hypoplasia*—heavy; *Tooth hypoplasia*—slight to medium; *Wear*—heavy; *Classification*—5B.

PREMOLARS AND MOLARS: FIRST PAIRS: *Staining*—dark brown; *Wear*—(uppers) slight and uneven. SECOND PAIRS: *Staining*—brown; *Wear*—(uppers) heavy to excessive and (lowers) heavy. THIRD PAIRS: *Staining*—brown; *Wear*—(uppers) excessive and (lowers) slight to medium. FOURTH PAIRS: Normal. FIFTH PAIRS: *Staining*—brown and variable; *Wear*—(uppers) slightly long posteriorly. SIXTH PAIRS: *Staining*—dark brown and black; *Wear*—(uppers) excessive into the gum and (lowers) heavy and uneven and long posteriorly.

**ANIMAL NO. 1**

CENTRALS: *Caps*—chipped, pointed and uneven; *Luster*—fair; *Chalkiness*—excessive and diffuse; *Staining*—slight discoloration with browner areas; *Cracks*—longitudinal; *Enamel hypoplasia*—medium pit or patch; *Wear*—medium to heavy and uneven; *Classification*—5A.

INTERMEDIATES: *Luster*—fair to good; *Chalkiness*—excessive and diffuse; *Enamel hypoplasia*—medium to heavy pit and patch (has been called heavy to excessive); *Tooth hypoplasia*—slight (has been called medium); *Wear*—excessive; *Other*—roots exposed about 2 mm.; *Classification*—5B.

LATERALS: *Luster*—poor; *Chalkiness*—excessive and diffuse; *Staining*—excessive and light brown; *Enamel hypoplasia*—(left) excessive shell, (right) heavy, pit type; *Tooth hypoplasia*—medium; *Wear*—excessive; *Classification*—5C.

CORNERS: *Caps*—uneven; *Luster*—poor to fair; *Chalkiness*—excessive and diffuse; *Staining*—slight discoloration; *Enamel hypoplasia*—excessive, shell; *Tooth hypoplasia*—medium; *Wear*—heavy to excessive; *Classification*—5C.

PREMOLARS AND MOLARS: FIRST PAIRS: *Staining*—brown and black; *Wear*—(uppers) medium and (lowers) normal to slight. SECOND PAIRS: *Staining*—brown, *Wear*—(uppers) heavy to excessive and (lowers) slight to medium. THIRD PAIRS: *Staining*—brown; *Wear*—(uppers) excessive into gums and (lowers) normal to slight on left and medium on right. FOURTH PAIRS: *Staining*—(lowers) brown. FIFTH PAIRS: *Staining*—(uppers) dark brown and black and (lowers) light brown; *Wear*—(uppers) medium long posteriorly. SIXTH PAIRS: *Staining*—brown; *Wear*—(uppers) excessive into gum and (lowers) uneven.

## LOT NO. 7 (77 ppm F), 1948–1953

### ANIMAL NO. 2

CENTRALS: *Chipped Cap*—left; *Luster*—good upper ¼; *Chalkiness*—porcelain at cap, longitudinal, slight, lower ¾ excessive; *Staining*—brown and black, (right) excessive, (left) medium; *Caries*—(left) multiple pinpoint and pinhead; *Erosions*—(right) superficial, heavy, (left) slight; *Classification*—3.

INTERMEDIATES: *Chalkiness*—excessive; *Staining*—light brown, excessive, focal black; *Caries* and *Erosions*—slight on medial margins; *Enamel hypoplasia*—patch, heavy; *Tooth hypoplasia*—slight; *Wear*—slight to medium; *Classification*—5C.

LATERALS: *Chalkiness*—excessive; *Staining*—light brown, excessive; *Enamel hypoplasia*—patch, heavy; *Wear*—medium; *Classification*—5C.

CORNERS: *Chalkiness*—excessive; *Staining*—light brown, excessive; *Enamel hypoplasia*—patch, heavy; *Wear*—slight; *Classification*—5C.

GINGIVAE: Medium gingivitis.

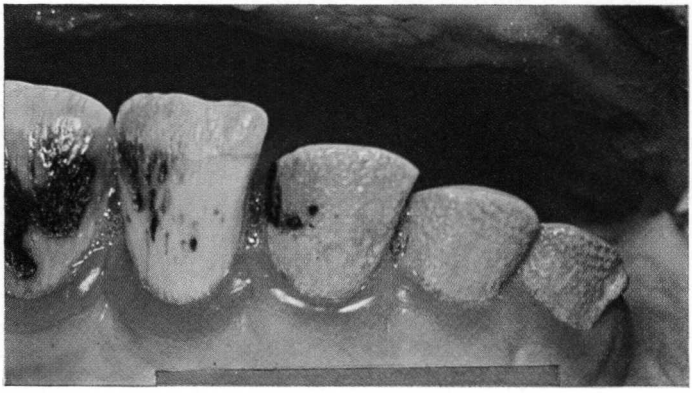
PREMOLARS AND MOLARS: FIRST PAIRS: *Staining*—brown-black. SECOND PAIRS: *Staining*—dark brown, excessive, *Wear*—(uppers) heavy and (lowers) slight. THIRD PAIRS: *Staining*—brown-black, excessive, *Wear*—(uppers) medium to heavy, (lowers) medium. FOURTH PAIRS: Normal. FIFTH PAIRS: (uppers) long posteriorly. SIXTH PAIRS: *Staining*—brown-black, excessive, *Wear*—(uppers) excessive to gum line and (lowers) long posteriorly and sheer anteriorly.

### ANIMAL NO. 58

CENTRALS: *Luster*—fair, upper ⅛; *Chalkiness*—excessive; *Staining*—light and dark brown, excessive; *Erosions*—superficial and undermining, heavy to excessive; *Enamel hypoplasia*—patch, lower ⅓, slight; *Classification*—5A.

INTERMEDIATES AND LATERALS: *Chalkiness*—excessive; *Staining*—light brown, excessive; *Enamel hypoplasia*—shell and focal, patch, heavy; *Tooth hypoplasia*—medium; *Wear*—medium; *Classification*—5C.

CORNERS: *Chalkiness*—excessive; *Staining*—light brown, excessive; *Enamel hypoplasia*—shell and focal, patch, heavy; *Tooth hypoplasia*—medium; *Wear*—medium; slight bucco-labioclination; *Classification*—5C.

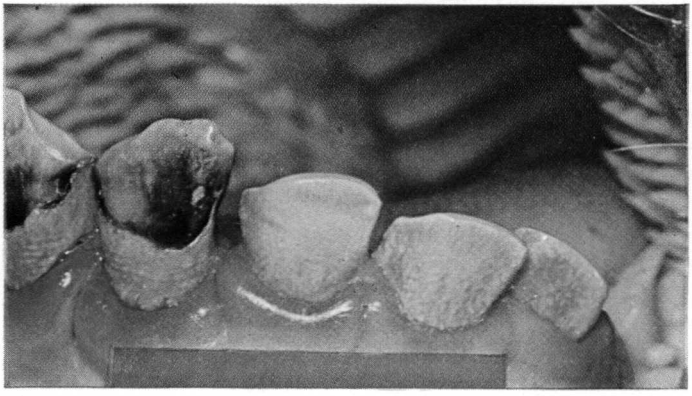


**LOT NO. 7, 1948–1953**

**Control Ration + 70 ppm Fluorine added as NaF (Total F = 77 ppm)**

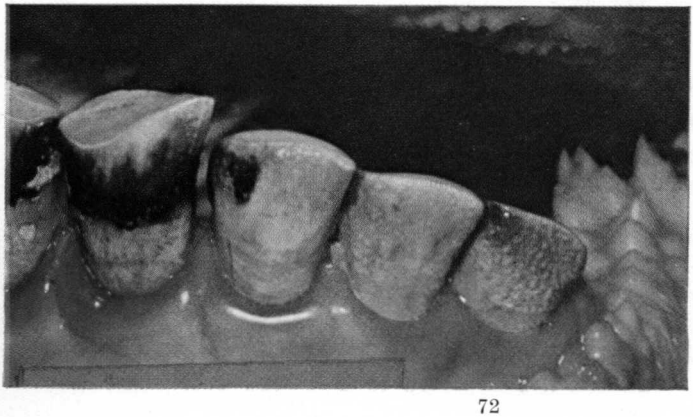
**Cow No. 2**

**Photographed Oct., 1952**



**Cow No. 58**

**Photographed Oct., 1952**



**Cow No. 21**

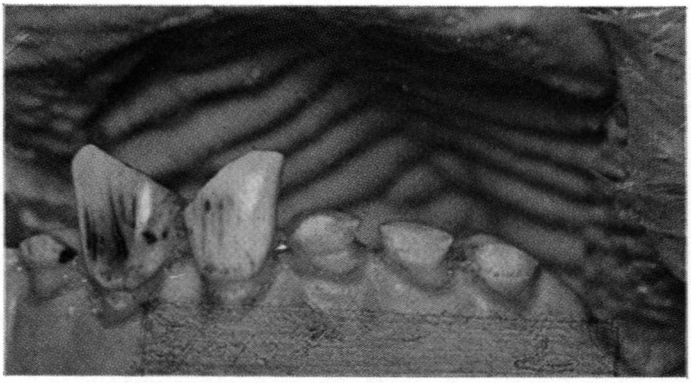
**Photographed Oct., 1952**

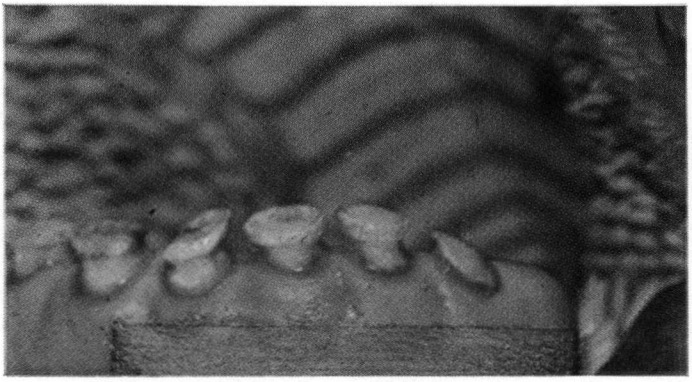
**LOT NO. 7, 1948–1958**

**Control Ration + 70 ppm Fluorine added as NaF (Total F = 78 ppm)**

**Cow No. 2**

**Photographed May, 1958**





**Cow No. 58**

**Photographed Nov., 1957**

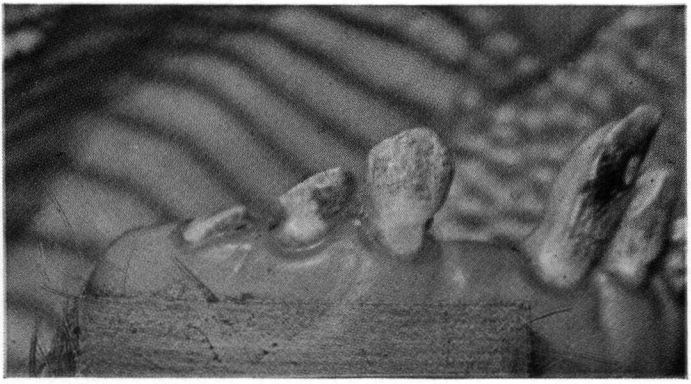
**LOT NO. 8, 1948–1958**

**Control Ration + 100 ppm Fluorine added as NaF (Total F = 108 ppm)**

**Cow No. 29**

**Photographed April, 1957**

**(For comparison see pictures on Page 77)**



GINGIVAE: Medium gingivitis.

PREMOLARS AND MOLARS: FIRST PAIRS: *Staining*—brown, *Wear*—(uppers) slight. SECOND and THIRD PAIRS: *Staining*—brown, *Wear*—(uppers) medium and (lowers) slight. FOURTH PAIRS: Normal. FIFTH PAIRS: *Staining*—light brown, slight. SIXTH PAIRS: *Staining*—(uppers) brown, excessive; *Wear*—medium and (lowers) long posteriorly.

**ANIMAL NO. 21**

CENTRALS: *Luster*—fair lateral cap; *Chalkiness*—excessive; *Staining*—brown and black-brown, excessive; *Erosions*—superficial and undermining, heavy to excessive; *Enamel hypoplasia*—patch, lower ⅓ slight; *Classification*—5A.

INTERMEDIATES: *Chalkiness*—excessive; *Staining*—light brown, excessive, focal black; *Erosions*—medially near cap, black stained, slight; *Enamel hypoplasia*—shell, patch, heavy; *Tooth hypoplasia*—slight; *Wear*—slight to medium; *Classification*—5C.

LATERALS: *Chalkiness*—excessive; *Staining*—light brown, excessive; *Enamel hypoplasia*—shell, patch, heavy; *Tooth hypoplasia*—slight; *Wear*—slight to medium; *Classification*—5C.

CORNERS: *Chalkiness*—excessive; *Staining*—light brown, excessive with dark foci at cap; *Enamel hypoplasia*—patch, heavy; *Wear*—slight; *Classification*—5C.

GINGIVAE: Medium gingivitis.

PREMOLARS AND MOLARS: FIRST PAIRS: *Staining*—dark brown, *Wear*—(uppers) slight. SECOND and THIRD PAIRS: *Staining*—brown, *Wear*—(uppers) medium and (lowers) slight. FOURTH PAIRS: Normal. FIFTH PAIRS: (uppers) long posteriorly. SIXTH PAIRS: *Staining*—brown, black, *Wear*—(uppers) excessive and (lowers) heavy, uneven, long posteriorly.

**LOT NO. 7 (78 ppm F), 1948–1958**

**ANIMAL NO. 2**

CENTRALS: *Caps*—uneven and long laterally; *Luster*—(left) good, (right) poor to fair; *Staining*—(left) medium light brown, diffuse and focal, (right) heavy, dark brown diffuse and focal; *Cracks*—stained, longitudinal; *Caries and erosions*—multiple, worn caries, pinpoint to pinhead size; *Wear*—medium and uneven; *Other*—roots exposed about 4 mm.; *Classification*—3.

INTERMEDIATES: *Luster*—poor; *Chalkiness*—excessive and diffuse; *Staining*—excessive and light brown on both with (right) a dark area; *Enamel hypoplasia*—heavy patch type; *Tooth hypoplasia*—medium; *Wear*—excessive and uneven; *Other*—roots exposed about 4 mm.; *Classification*—5B.

LATERALS: *Luster*—fair; *Chalkiness*—excessive and diffuse; *Staining*—excessive and light brown or slight discoloration; *Enamel hypoplasia*—excessive patch and shell; *Tooth hypoplasia*—medium; *Wear*—excessive; *Other*—roots exposed about 3 mm. and worn on lateral margin; *Classification*—5C.

CORNERS: *Luster*—(left) poor, (right) fair; *Chalkiness*—excessive and diffuse; *Staining*—excessive and light brown or slight discoloration, and (on left) a dark area at the cap; *Enamel hypoplasia*—heavy to excessive; *Tooth hypoplasia*—medium; *Wear*—(left) heavy; (right) excessive; *Classification*—(left) 5B or 5C, (right) 5C.

PREMOLARS AND MOLARS: FIRST PAIRS: (lower left missing after 7–26–56). *Staining*—brown; *Wear*—(uppers) medium. SECOND PAIRS: *Staining*—brown; *Wear*—(uppers) excessive and (lowers) heavy on left and excessive on right. THIRD PAIRS: *Staining*—brown; *Wear*—(uppers) excessive and (lowers) medium to heavy. FOURTH PAIRS: Normal. FIFTH PAIRS: *Staining*—(uppers) brown; *Wear*—(uppers) medium to heavy long posteriorly. SIXTH PAIRS: *Staining*—brown and black; *Wear*—excessive and (lowers) medium long posteriorly.

**ANIMAL NO. 58**

CENTRALS: *Luster*—poor; *Chalkiness*—excessive and diffuse; *Staining*—slight discoloration; *Enamel hypoplasia*—medium to heavy; *Tooth hypoplasia*—medium; *Wear*—excessive; *Other*—roots exposed about 6 mm. and worn; *Classification*—5B.

INTERMEDIATES: *Luster*—fair; *Chalkiness*—excessive and diffuse; *Staining*—slight discoloration; *Enamel hypoplasia*—excessive; *Tooth hypoplasia*—medium; *Wear*—excessive; *Other*—roots exposed about 5 mm.; *Classification*—5C.

LATERALS: *Luster*—fair; *Chalkiness*—excessive and diffuse; *Staining*—slight discoloration; *Enamel hypoplasia*—excessive; *Tooth hypoplasia*—medium to heavy; *Wear*—excessive; *Other*—roots exposed and worn; *Classification*—5C.

CORNERS: Enamel completely worn away; *Wear*—excessive; *Classification*—5C (estimated).

PREMOLARS AND MOLARS: FIRST PAIRS: *Staining*—brown; *Wear*—(uppers) medium to heavy. SECOND PAIRS: *Staining*—brown and dark brown; *Wear*—(uppers) excessive into the gum and (lowers) heavy. THIRD PAIRS: *Staining*—dark brown; *Wear*—(uppers) excessive into gum and (lowers) medium and uneven. FOURTH PAIRS: Normal. FIFTH and SIXTH PAIRS: *Staining*—brown; *Wear*—excessive and uneven.

**LOT NO. 8 (108 ppm F), 1948–1958**

**ANIMAL NO. 29**

CENTRALS: (right) missing, (left) *Luster*—poor; *Chalkiness*—excessive and diffuse; *Staining*—excessive black and brown with a gray plaque; *Enamel hypoplasia*—slight to medium, patch type; *Wear*—wear on the medial margin of the tooth and root; *Other*—root is exposed about 6 mm.; *Classification*—5A.

INTERMEDIATES: *Caps*—uneven; *Luster*—poor; *Chalkiness*—excessive and diffuse; *Staining*—excessive, light brown with darker foci; *Enamel*

*hypoplasia*—heavy patch type; *Tooth hypoplasia*—suspected to slight; *Wear*—medium and uneven; *Other*—roots exposed about 5 mm. and worn on margins; *Classification*—5B.

LATERALS: *Luster*—poor; *Chalkiness*—excessive and diffuse; *Staining*—excessive and light brown with darker area; *Enamel hypoplasia*—excessive patch type; *Tooth hypoplasia*—medium; *Wear*—heavy to excessive and uneven; *Other*—roots exposed about 4 mm.; *Classification*—5C.

CORNERS: Enamel completely worn away; *Wear*—excessive; *Classification* 5C (estimated).

PREMOLARS AND MOLARS: FIRST PAIRS: *Staining*—dark brown; *Wear*—(uppers) heavy. SECOND PAIRS: *Staining*—dark brown; *Wear*—(uppers) excessive and (lowers) heavy. THIRD PAIRS: *Staining*—brown; *Wear*—(uppers) excessive and (lowers) heavy on left and medium on right. FOURTH PAIRS: Normal. FIFTH PAIRS: *Staining*—(uppers) dark brown and black and (lowers) light brown; *Wear*—(uppers) normal but uneven with long points anteriorly and posteriorly. SIXTH PAIRS: *Staining*—dark brown; *Wear*—(uppers) excessive and uneven with long posterior and anterior points and (lowers) excessive anteriorly.

## LOT NO. 8 (107 ppm F), 1948–1953

### ANIMAL NO. 28

CENTRALS: *Chipped Cap; Luster*—fair at cap; *Chalkiness*—excessive, porcelain in cap area; *Staining*—light brown to black, excessive; *Erosion*—superficial, deep and undermining centrally, heavy; *Enamel hypoplasia*—patch, lower ¼ slight; *Wear*—slightly uneven; *Classification*—5A.

INTERMEDIATES: *Chalkiness*—excessive; *Staining*—very light brown, excessive; *Enamel hypoplasia*—patch, shell, heavy; *Tooth hypoplasia*—slight; *Wear*—slight; *Classification*—5C.

LATERALS: *Chalkiness*—excessive; *Staining*—yellow to light brown, excessive; *Enamel hypoplasia*—shell, heavy; *Tooth hypoplasia*—slight; *Wear*—slight to medium; *Classification*—5C.

CORNERS: Similar to laterals except slight wear and slight bucco-medio-clination; *Classification*—5C.

GINGIVAE: Medium gingivitis.

PREMOLARS AND MOLARS: FIRST PAIRS: *Staining*—brown, *Wear*—(uppers) slight. SECOND and THIRD PAIRS: *Staining*—brown, *Wear*—(uppers) medium to heavy and (lowers) slight to medium. FOURTH PAIRS: Normal. FIFTH PAIRS: (uppers) gouged posterior third with long spicule at extreme posterior. SIXTH PAIRS: *Staining*—brown, *Wear*—(uppers) excessive and (lowers) medium, long centrally.

### ANIMAL NO. 29

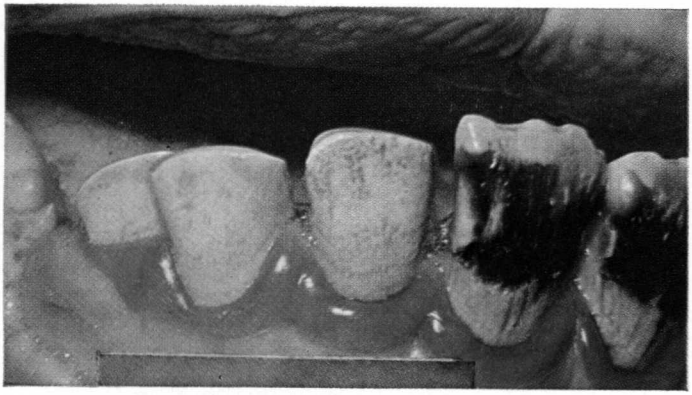
CENTRALS: *Chipped Cap; Luster*—fair at cap; *Chalkiness*—excessive; *Staining*—light brown to black, excessive; *Erosion*—superficial, deep, undermining, heavy, centrally; *Enamel hypoplasia*—patch, lower ⅓ slight; *Classification*—5A.

**LOT NO. 8, 1948–1953**

**Control Ration + 100 ppm Fluorine added as NaF (Total F = 107 ppm)**

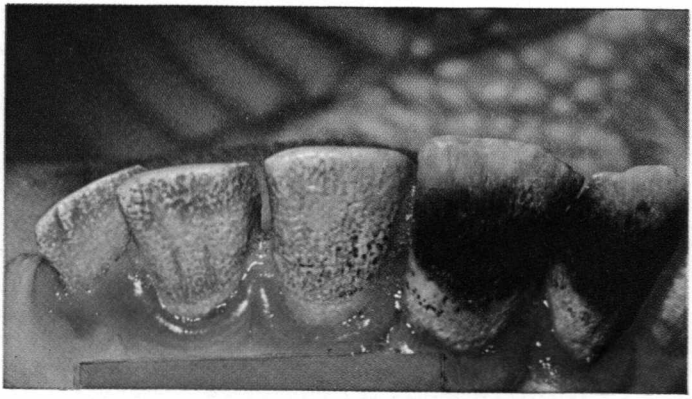
**Cow No. 28**

**Photographed Oct., 1952**



**Cow No. 29**

**Photographed Oct., 1952**



**Cow No. 61**

**Photographed Oct., 1952**



INTERMEDIATES AND LATERALS: *Chalkiness*—excessive; *Staining*—light brown, excessive; *Enamel hypoplasia*—shell, patch, heavy; *Wear*—slight; *Classification*—5C.

CORNERS: *Chalkiness*—excessive; *Staining*—light brown, excessive; *Enamel hypoplasia*—shell, patch, heavy; *Wear*—slight; medio-buccoclination; *Classification*—5C.

GINGIVAE: Heavy gingivitis.

PREMOLARS AND MOLARS: FIRST PAIRS: *Staining*—dark brown. SECOND and THIRD PAIRS: *Staining*—dark brown, *Wear*—(lowers) slight, (uppers) medium. FOURTH PAIRS: Normal. FIFTH PAIRS: *Wear*—(uppers) medium, long posteriorly. SIXTH PAIRS: *Staining*—(lowers) brown, *Wear*—(uppers) heavy, long posteriorly, (lowers) medium, long centrally with sharp medial points.

**ANIMAL NO. 61**

CENTRALS: *Chipped Cap; Luster*—fair at cap; *Chalkiness*—excessive; *Staining*—light brown to black, excessive; *Erosions*—superficial, deep and undermining centrally, heavy; *Enamel hypoplasia*—patch, lower ⅕ slight; *Classification*—5A.

INTERMEDIATES: *Chalkiness*—excessive; *Staining*—light brown to black, excessive; *Erosions*—deep, undermining centrally and medially, slight; *Enamel hypoplasia*—patch, shell, heavy; *Tooth hypoplasia*—slight; *Wear*—medium; *Classification*—5C.

LATERALS: *Chalkiness*—excessive; *Staining*—light brown to black, excessive; *Enamel hypoplasia*—patch, heavy; *Tooth hypoplasia*—slight; *Wear*—medium; *Classification*—5C.

CORNERS: *Chalkiness*—excessive; *Staining*—light brown to black, excessive; *Enamel hypoplasia*—patch, shell, heavy; *Tooth hypoplasia*—slight; *Wear*—medium; *Classification*—5C.

GINGIVAE: Slight gingivitis.

PREMOLARS AND MOLARS: FIRST PAIRS: *Staining*—brown, *Wear*—(uppers) slight. SECOND and THIRD PAIRS: *Staining*—brown, *Wear*—medium. FOURTH and FIFTH PAIRS: Normal, except (upper) 5th is long posteriorly. SIXTH PAIRS: *Staining*—brown, *Wear*—(uppers) excessive, (lowers) medium, uneven, slightly long posteriorly.

**LOT NO. 10 ($B_2$ Hay), 1948–1953**

**ANIMAL NO. 19**

CENTRALS: *Chipped Cap; Luster*—upper ⅓ good; *Chalkiness*—porcelain, cross upper ⅓, lower ⅔ excessive; *Staining*—very light brown centrally, slight; *Wear*—normal, uneven; *Classification*—2.

INTERMEDIATES: *Luster*—fair; *Chalkiness*—heavy to excessive; *Staining*—very light brown, excessive; *Caries*—(left) upper ⅓ pinpoint, super-

ficial; *Enamel hypoplasia*—suspected; *Wear*—(left) medium, (right) slight; *Classification*—4.

LATERALS: *Chalkiness*—diffuse; *Staining*—light brown, slight to medium; *Classification*—2.

CORNERS: *Chalkiness*—cross and porcelain at cap, lower ⅘ diffuse; *Staining*—light brown, heavy; *Classification*—2.

GINGIVAE: Slight gingivitis.

PREMOLARS AND MOLARS: FIRST PAIRS: *Staining*—light brown. SECOND PAIRS: *Staining*—light brown, *Wear*—(uppers) medium, (lowers) slight. THIRD PAIRS: *Staining*—light brown, *Wear*—slight. FOURTH PAIRS: Normal. FIFTH PAIRS: *Wear*—slight. SIXTH PAIRS: *Staining*—brown, *Wear*—(uppers) heavy, (lowers) medium, long posteriorly.

**ANIMAL NO. 67**

CENTRALS: *Luster*—good; *Chalkiness*—focal, cross upper ½; *Staining*—vegetative; *Classification*—1A.

INTERMEDIATES: *Luster*—fair at cap; *Chalkiness*—upper ⅕ porcelain, and cross and lower ⅘ diffuse chalky; *Staining*—focal, diffuse; *Enamel hypoplasia*—pit, suspected to slight; *Classification*—4.

LATERALS: *Chalkiness*—excessive; *Staining*—light brown, excessive; *Enamel hypoplasia*—diffuse, pit, slight; *Wear*—slight; *Classification*—5A.

CORNERS: *Chalkiness*—excessive; *Staining*—medium brown, excessive; *Enamel hypoplasia*—diffuse, pit, slight to medium; *Wear*—slight; *Classification*—5A.

GINGIVAE: Slight gingivitis.

PREMOLARS AND MOLARS: FIRST PAIRS: *Staining*—light brown, *Wear*—(uppers) slight. SECOND and THIRD PAIRS: *Staining*—light brown, *Wear*—medium. FOURTH and FIFTH PAIRS: Normal. SIXTH PAIRS: *Staining*—brown, *Wear*—(uppers) heavy.

**ANIMAL NO. 20**

CENTRALS: *Chipped Cap; Luster*—fair at cap; *Chalkiness*—cross, upper ⅛ porcelain, rest excessive; *Staining*—light brown, heavy; *Caries* and *Erosions*—(left) focal, medially, slight; *Classification*—3.

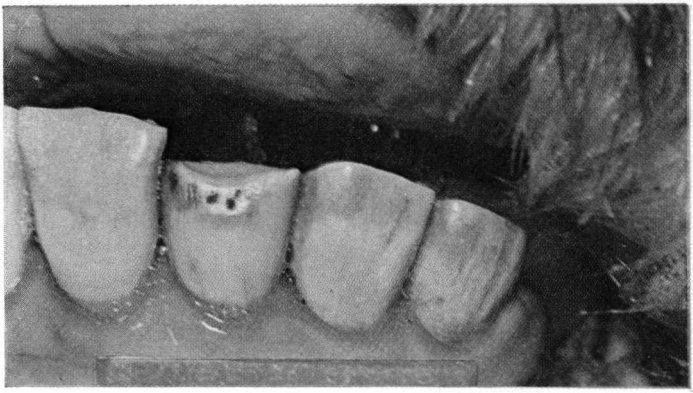
INTERMEDIATES: *Chalkiness*—excessive; *Staining*—light brown, excessive; *Enamel hypoplasia*—(left) suspected to slight, (right) suspected; *Wear*—medium; *Classification*—(left) 4 to 5A, (right) 4.

LATERALS: *Chalkiness*—excessive; *Staining*—light brown, excessive; *Enamel hypoplasia*—slight; *Wear*—slight; *Classification*—4 to 5A.

CORNERS: *Chalkiness*—excessive; *Staining*—light brown, excessive; *Enamel hypoplasia*—patch, slight; *Wear*—slight; *Classification*—5A.

GINGIVAE: Slight gingivitis.

PREMOLARS AND MOLARS: FIRST PAIRS: *Staining*—light brown, *Wear*—(uppers) slight. SECOND and THIRD PAIRS: *Staining*—brown, *Wear*—medium. FOURTH PAIRS: Normal. FIFTH PAIRS: *Wear*—(uppers) medium and long centrally. SIXTH PAIRS: *Staining*—brown, *Wear*—(uppers) excessive and (lowers) medium.



**LOT NO. 10, 1948–1953**

**$B_2$ Hay + Control Concentrate**

**Cow No. 19**

**Photographed Oct., 1952**



**Cow No. 67**

**Photographed Oct., 1952**



**Cow No. 20**

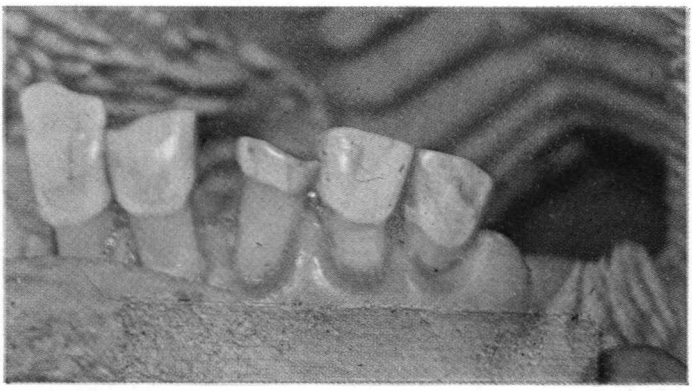
**Photographed Oct., 1952**

**LOT NO. 10, 1948–1958**

**$B_2$ Hay + Control Concentrate**

**Cow No. 19**

**Photographed May, 1958**



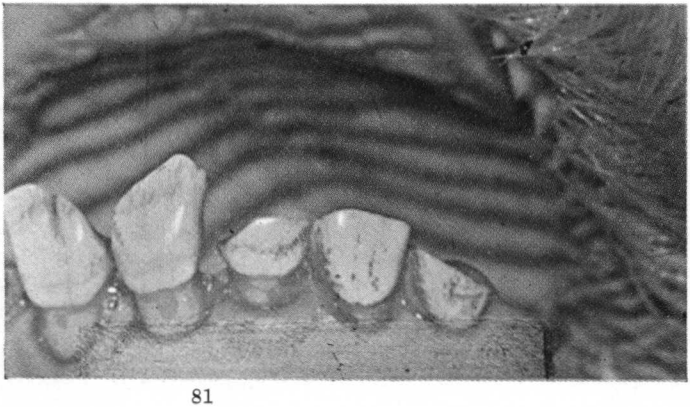
**Cow No. 67**

**Photographed Nov., 1957**



**Cow No. 20**

**Photographed Nov., 1957**



## LOT NO. 10 ($B_2$ Hay), 1948–1958

### ANIMAL NO. 19

CENTRALS: *Caps*—uneven and chipped; *Luster*—good; *Chalkiness*—heavy, focal, cross and diffuse; *Staining*—medium and light brown; *Wear*—(left) medium and uneven, (right) slight and uneven; *Other*—roots exposed about 12 mm.; *Classification*—2.

INTERMEDIATES: *Caps*—chipped and uneven; *Luster*—good; *Chalkiness*—excessive and diffuse; *Staining*—excessive and light brown with darker foci; *Enamel hypoplasia*—suspected to slight; *Tooth hypoplasia*—none to medium; *Wear*—(left) excessive, (right) heavy; *Classification*—4 or 5A.

LATERALS: *Luster*—good; *Chalkiness*—heavy cross and focal and slight porcelain; *Staining*—slight discoloration; *Wear*—slight; *Other*—roots exposed 5 to 7 mm.; *Classification*—1B or 2.

CORNERS: *Luster*—fair to good; *Chalkiness*—heavy cross and focal; *Staining*—medium and light brown; *Wear*—normal; *Classification*—2.

PREMOLARS AND MOLARS: FIRST PAIRS: *Staining*—brown, *Wear*—(lowers) medium on the right. SECOND PAIRS: *Staining*—brown; *Wear*—(uppers) excessive on left and heavy on right. THIRD PAIRS: *Staining*—brown; *Wear*—(lowers) slight. FOURTH PAIRS: Normal. FIFTH PAIRS: *Staining*—(uppers) dark brown; *Wear*—(uppers) medium long posteriorly. SIXTH PAIRS: *Staining*—dark brown; *Wear*—(uppers) slight and (lowers) medium to heavy.

### ANIMAL NO. 67

CENTRALS: *Luster*—good; *Chalkiness*—slight to medium focal and cross; *Wear*—normal; *Other*—roots exposed about 4 mm.; *Classification*—1A.

INTERMEDIATES: *Cap chipped*—(left) medium, (right) very small; *Luster*—fair to good; *Chalkiness*—excessive focal and diffuse; *Staining*—slight discoloration with brown foci; *Enamel hypoplasia*—suspected to slight; *Caries and erosions*—(left) small erosion upper ½ and caries in lower ½; *Wear*—normal; *Other*—roots exposed about 3 mm.; *Classification*—4.

LATERALS: *Luster*—fair; *Chalkiness*—heavy to excessive focal and diffuse; *Staining*—slight discoloration with light brown foci; *Enamel hypoplasia*—slight, pit type; *Wear*—medium; *Other*—roots exposed about 3 mm.; *Classification*—5A.

CORNERS: *Luster*—fair; *Chalkiness*—medium to heavy cross, focal and diffuse; *Staining*—slight discoloration with light brown foci; *Enamel hypoplasia*—suspected to slight, pit type; *Wear*—normal; *Classification*—4 or 5A.

PREMOLARS AND MOLARS: FIRST PAIRS: *Staining*—brown, *Wear*—(uppers) slight on the right. SECOND PAIRS: *Staining*—light brown and brown, *Wear*—(uppers) heavy and (lowers) heavy on left and slight to medium uneven on right. THIRD PAIRS: *Staining*—brown and light brown, *Wear*—(uppers) heavy and (lowers) slight. FOURTH and FIFTH PAIRS: Normal. SIXTH PAIRS: *Staining*—brown; *Wear*—(uppers) excessive into gum line and (lowers) normal, but long posteriorly.

**ANIMAL NO. 20**

CENTRALS: *Caps*—chipped and uneven; *Luster*—fair; *Chalkiness*—heavy diffuse and cross; *Cracks*—(right) dark stained near cap; *Staining*—medium and light brown; *Wear*—slight to medium and uneven; *Other*—roots exposed about 8 mm.; *Classification*—2.

INTERMEDIATES: *Luster*—fair; *Chalkiness*—excessive and diffuse; *Staining*—slight discoloration with light brown areas; *Enamel hypoplasia*—suspected to slight; *Wear*—heavy and uneven; *Other*—roots exposed about 5 mm.; *Classification*—4 or 5A.

LATERALS: *Luster*—fair to good; *Chalkiness*—medium focal and cross; *Enamel hypoplasia*—difficult to evaluate; *Wear*—normal to slight; *Other*—roots exposed (left) 3 mm., (right) 5 mm.; *Classification*—4 or 1BX.

CORNERS: *Luster*—poor; *Chalkiness*—excessive and diffuse; *Staining*—vegetative plus slight discoloration with light brown areas or foci; *Enamel hypoplasia*—slight to medium; *Wear*—heavy; *Classification*—5A.

PREMOLARS AND MOLARS: FIRST PAIRS: *Staining*—brown; *Wear*—(uppers) medium to heavy. SECOND PAIRS: *Staining*—brown; *Wear*—heavy. THIRD PAIRS: *Staining*—(uppers) light brown and (lowers) dark brown; *Wear*—(lowers) slight. FOURTH PAIRS: Normal. FIFTH PAIRS: *Staining*—light brown; *Wear*—normal to slight. SIXTH PAIRS: *Staining*—brown and black; *Wear*—slight.

**LOT NO. 11 (107 ppm F + Def. P), 1948–1953**

**ANIMAL NO. 25**

CENTRALS: *Luster*—fair at cap; *Chalkiness*—cross, focal, excessive; *Staining*—light brown to black, heavy; *Caries*—multiple pinpoint and pinhead; *Erosions*—superficial in center and lower ⅓; *Classification*—3.

INTERMEDIATES: *Chalkiness*—excessive; *Staining*—light brown, excessive, vegetative; *Enamel hypoplasia*—diffuse, patch, heavy; *Tooth hypoplasia*—medium; *Wear*—slight to medium; *Classification*—5C.

LATERALS: *Chalkiness*—excessive; *Staining*—light brown, excessive, vegetative; *Enamel hypoplasia*—shell, heavy to excessive; *Tooth hypoplasia*—medium; *Wear*—medium; *Classification*—5C.

CORNERS: *Chalkiness*—excessive; *Staining*—light brown, excessive; *Enamel hypoplasia*—shell, heavy to excessive; *Tooth hypoplasia*—medium; *Wear*—medium; *Classification*—5C.

GINGIVAE: Slight gingivitis.

PREMOLARS AND MOLARS: FIRST PAIRS: *Staining*—brown, *Wear*—(uppers) slight. SECOND PAIRS: *Staining*—brown, *Wear*—(uppers) medium, (lowers) slight. THIRD PAIRS: *Staining*—brown, *Wear*—(uppers) heavy, (lowers) medium. FOURTH PAIRS: Normal. FIFTH PAIRS: *Wear*—(uppers) medium, long posteriorly. SIXTH PAIRS: *Staining*—(lowers) brown-black, *Wear*—(uppers) excessive and (lowers) excessive and long posteriorly.

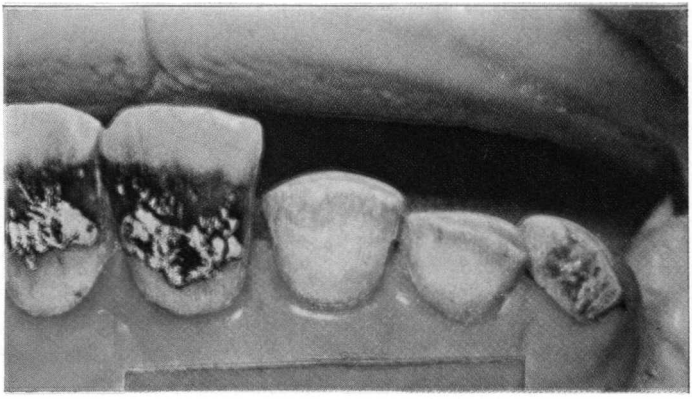


**LOT NO. 11, 1948–1953**

**Control Ration + 100 ppm Fluorine added as NaF and 0.5 percent Defluorinated Phosphate (Total F = 107 ppm + Def. P)**

**Cow No. 25**

**Photographed Oct., 1952**



**Cow No. 12**

**Photographed Oct., 1952**



**Cow No. 70**

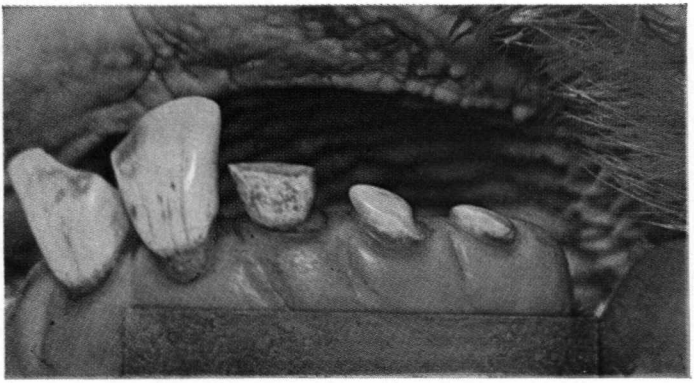
**Photographed Oct., 1952**

**LOT NO. 11, 1948–1958**

**Control Ration + 100 ppm Fluorine added as NaF and 0.5 percent Defluorinated Phosphate (Total F = 108 ppm + Def. P)**

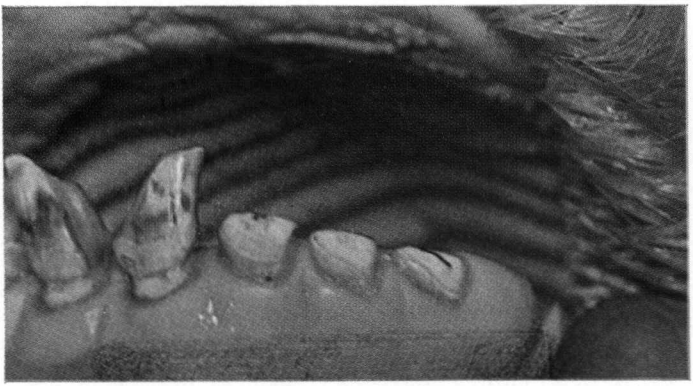
**Cow No. 25**

**Photographed May, 1958**



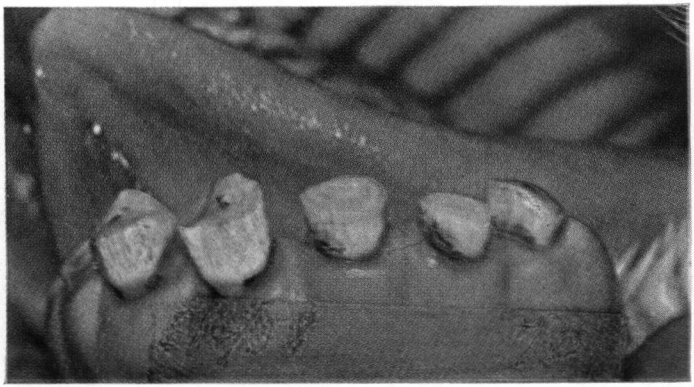
**Cow No. 12**

**Photographed Nov., 1957**



**Cow No. 70**

**Photographed Nov., 1957**



**ANIMAL NO. 12**

CENTRALS: *Luster*—upper ⅓ good; *Chalkiness*—cross, porcelain at cap, heavy; *Staining*—light brown to black centrally, heavy; *Erosions*—superficial, deep and undermining centrally; *Classification*—3.

INTERMEDIATES AND LATERALS: *Chalkiness*—excessive; *Staining*—yellow to light brown, excessive with dark brown in corners at cap; *Enamel hypoplasia*—heavy to excessive; *Wear*—medium; *Classification*—5C.

CORNERS: *Chalkiness*—excessive; *Staining*—light to dark brown, excessive; *Enamel hypoplasia*—shell, patch, heavy to excessive; *Tooth hypoplasia*—slight to medium; *Wear*—medium; *Classification*—5C.

GINGIVAE: Slight gingivitis.

PREMOLARS AND MOLARS: FIRST PAIRS: *Staining*—brown, *Wear*—(uppers) slight and (lowers) medium. SECOND and THIRD PAIRS: *Staining*—brown, *Wear*—(uppers) heavy and (lowers) medium. FOURTH PAIRS: Normal. FIFTH PAIRS: *Wear*—(uppers) medium. SIXTH PAIRS: *Staining*—brown and black, *Wear*—(uppers) excessive and (lowers) medium and long posteriorly.

**ANIMAL NO. 70**

CENTRALS: *Luster*—fair at cap; *Chalkiness*—excessive; *Staining*—light to dark brown, excessive; *Erosions*—superficial, undermining, medium lower part of upper ½; *Enamel hypoplasia*—patch, lower ⅓ slight; *Classification*—5A.

INTERMEDIATES: *Chalkiness*—excessive; *Staining*—yellow to brown, excessive; *Enamel hypoplasia*—shell, heavy; *Tooth hypoplasia*—heavy; *Wear*—medium; *Classification*—5C.

LATERALS: *Chalkiness*—excessive; *Staining*—yellow to light brown, excessive; *Enamel hypoplasia*—shell, heavy; *Tooth hypoplasia*—heavy; *Wear*—medium; *Classification*—5C.

CORNERS: *Chalkiness*—excessive; *Staining*—light and dark brown; *Enamel hypoplasia*—shell and patch, heavy; *Tooth hypoplasia*—slight to medium; *Wear*—slight; *Classification*—5C.

GINGIVAE: Slight gingivitis.

PREMOLARS AND MOLARS: FIRST PAIRS: *Staining*—brown, *Wear*—(uppers) medium. SECOND and THIRD PAIRS: *Staining*—brown, *Wear*—(uppers) heavy and (lowers) medium. FOURTH PAIRS: Normal. FIFTH PAIRS: *Staining*—brown, *Wear*—(uppers) medium and long posteriorly. SIXTH PAIRS: *Staining*—brown-black, *Wear*—(uppers) excessive, long posteriorly and (lowers) heavy and long posteriorly.

**LOT NO. 11 (108 ppm F + Def. P), 1948–1958**

**ANIMAL NO. 25**

CENTRALS: *Caps*—uneven; *Luster*—fair to good; *Chalkiness*—heavy focal and diffuse; *Cracks*—stained longitudinal; *Staining*—medium, light brown; *Caries and erosions*—worn multiple pinpoint and pinhead caries; *Wear*—

slight and uneven; *Other*—roots exposed (left) 3 mm., (right) 1 mm.; *Classification*—3.

INTERMEDIATES: (right) enamel worn away, description cannot be made. (left) *Luster*—poor; *Chalkiness*—excessive and diffuse; *Staining*—excessive and light brown; *Enamel hypoplasia*—heavy patch type; *Tooth hypoplasia*—suspected to slight; *Wear*—heavy; *Classification*—(left) 5B or 5C, (right) 5C (estimated).

LATERALS: (right) enamel worn away, description cannot be made, (left) *Luster*—poor; *Chalkiness*—excessive and diffuse; *Staining*—slight discoloration; *Enamel hypoplasia*—excessive, shell type; *Tooth hypoplasia*—heavy; *Wear*—excessive; *Classification*—(left) 5C, (right) 5C (estimated).

CORNERS: (right) enamel worn away so that a description cannot be made; (left) *Luster*—poor; *Chalkiness*—excessive and diffuse; *Staining*—excessive, light brown; *Enamel hypoplasia*—excessive shell type; *Wear*—excessive; *Classification*—(left) 5C, (right) 5C (estimated).

PREMOLARS AND MOLARS: FIRST PAIRS: (lower right missing after 4–12–54) *Staining*—brown; *Wear*—(uppers) heavy to excessive and (lowers) normal to slight. SECOND PAIRS: *Staining*—brown; *Wear*—(uppers) excessive into gum line and (lowers) heavy to excessive. THIRD PAIRS: *Staining*—dark brown and black; *Wear*—(uppers) excessive into gum line and (lowers) medium to heavy and uneven. FOURTH PAIRS: Normal. FIFTH PAIRS: *Staining*—light brown; *Wear*—normal, uneven and (uppers) excessively long posteriorly. SIXTH PAIRS: *Staining*—brown, *Wear*—excessive and (uppers) slightly long posteriorly.

**ANIMAL NO. 12**

CENTRALS: *Caps*—uneven, with medial wear on right extending to root; *Luster*—good in upper ¼ but poor in lower ¾; *Chalkiness*—excessive and diffuse; *Staining*—excessive light brown with darker foci; *Enamel hypoplasia*—suspected, difficult to evaluate; *Caries and erosions*—worn caries and small eroded areas; *Wear*—uneven; *Other*—roots exposed; *Classification*—3 or 4.

INTERMEDIATES: *Luster*—poor; *Chalkiness*—excessive and diffuse; *Staining*—slight discoloration; *Enamel hypoplasia*—excessive, shell type; *Tooth hypoplasia*—heavy; *Wear*—excessive; *Other*—roots exposed 1 or 2 mm.; *Classification*—5C.

LATERALS: *Luster*—poor; *Chalkiness*—excessive and diffuse; *Staining*—excessive and light brown; *Enamel hypoplasia*—excessive shell type; *Tooth hypoplasia*—heavy; *Wear*—excessive; *Other*—pulp cavity has become filled with "secondary dentin"; *Classification*—5C.

CORNERS: *Luster*—poor; *Chalkiness*—excessive and diffuse; *Staining*—excessive and light brown; *Enamel hypoplasia*—excessive, shell type; *Tooth hypoplasia*—medium to heavy; *Wear*—excessive; *Other*—pulp cavities partly open; *Classification*—5C.

PREMOLARS AND MOLARS: FIRST PAIRS: *Staining*—dark brown and black; *Wear*—(uppers) slight and uneven and (lowers) excessive on left and heavy on right. SECOND PAIRS: *Staining*—light brown, *Wear*—exces-

sive. THIRD PAIRS: *Staining*—brown; *Wear*—excessive and (lowers) uneven. FOURTH PAIRS: Normal. FIFTH PAIRS: *Staining*—(uppers) dark brown (lowers) light brown; *Wear*—(uppers) medium and uneven, long posteriorly and (lowers) normal and slightly long. SIXTH PAIRS: *Staining*—brown, *Wear*—excessive and uneven.

**ANIMAL NO. 70**

CENTRALS: *Caps*—uneven; *Luster*—poor; *Chalkiness*—excessive and diffuse; *Staining*—excessive and light brown; *Enamel hypoplasia*—medium; *Tooth hypoplasia*—suspected or suspected to slight; *Wear*—heavy and uneven; *Classification*—5A or 5B.

INTERMEDIATES: *Luster*—poor; *Chalkiness*—excessive and diffuse; *Staining*—excessive and light brown; *Enamel hypoplasia*—(left) heavy pit and patch type, (right) excessive pit and patch type; *Tooth hypoplasia*—(left) slight to medium, (right) heavy; *Wear*—(left) medium to heavy, (right) excessive; *Classification*—(left) 5B, (right) 5C.

LATERALS: (right) enamel worn away, description cannot be made, (left) *Luster*—poor; *Chalkiness*—excessive and diffuse; *Staining*—slight vegetative and slight discoloration; *Enamel hypoplasia*—excessive, shell type; *Tooth hypoplasia*—medium to heavy; *Wear*—heavy to excessive; *Classification*—(left) 5C.

CORNERS: (right) enamel worn away, description cannot be made, (left) *Luster*—poor; *Chalkiness*—excessive and diffuse; *Staining*—excessive and light brown with foci of vegetative staining; *Enamel hypoplasia*—medium pit; *Tooth hypoplasia*—slight; *Wear*—heavy; *Classification*—5B.

PREMOLARS AND MOLARS: FIRST PAIRS: *Staining*—(uppers) brown and (lowers) dark brown and black; *Wear*—(uppers) excessive and (lowers) slight. SECOND PAIRS: *Staining*—brown and dark brown; *Wear*—(uppers) excessive into gum and (lowers) heavy to excessive. THIRD PAIRS: *Staining*—brown and dark brown; *Wear*—(uppers) excessive into the gum and (lowers) medium. FOURTH PAIRS: *Wear*—(lowers) slight. FIFTH PAIRS: *Staining*—(uppers) dark brown and black; *Wear*—(uppers) excessive and excessively long posteriorly and (lowers) normal to slight. SIXTH PAIRS: *Staining*—dark brown; *Wear*—excessive and uneven wear with long posterior points on uppers.

**LOT NO. 16 (Control Pasture, 10.6 ppm F; and Hay, 8.0 ppm F), 1948–1953**

**ANIMAL NO. 37**

CENTRALS: *Luster*—very good; *Staining*—vegetative, slight; Longitudinal grooves; *Classification*—1A.

INTERMEDIATES: *Luster*—very good; *Staining*—vegetative, slight; *Classification*—1A.

LATERALS AND CORNERS: *Luster*—good; *Staining*—vegetative, slight; Enamel slightly rough lower ⅓; *Classification*—1A.

PREMOLARS AND MOLARS: All normal except (upper) third slightly short.

**ANIMAL NO. 53**

CENTRALS: *Luster*—very good; *Staining*—vegetative, slight; teeth separated 2 to 3 mm.; *Classification*—1A.

INTERMEDIATES: *Luster*—good; *Chalkiness*—milky plaque right upper ½ centrally; *Staining*—vegetative, slight; *Wear*—slight; *Classification*—1A.

LATERALS AND CORNERS: *Luster*—good; *Chalkiness*—focal, slight; *Staining*—vegetative, slight; Enamel lower ⅓ rough; *Classification*—1A.

PREMOLARS AND MOLARS: Normal wear and stain.

**ANIMAL NO. 65**

CENTRALS: *Luster*—very good; *Classification*—1A.

INTERMEDIATES: *Chipped Cap*—(right) medially; *Luster*—very good; *Chalkiness*—focal, slight; *Staining*—vegetative, slight; *Classification*—1A.

LATERALS: *Chipped Cap*—(left) medially; *Luster*—good; *Chalkiness*—focal, slight; *Staining*—vegetative, slight; enamel lower ⅓ slightly rough; *Classification*—1A.

CORNERS: *Luster*—good; *Chalkiness*—(right) focal, slight, milky plaque lower ⅓; *Staining*—vegetative, slight; *Classification*—1A.

PREMOLARS AND MOLARS: Normal wear and stain.

**LOT NO. 16 (Control Pasture, 10.2 ppm F; and Hay, 6.2 ppm F), 1948–1958**

**ANIMAL NO. 37**

CENTRALS: *Luster*—good; *Cracks*—longitudinal grooves; *Wear*—normal; *Other*—roots exposed (left) 10 mm., (right) 8 mm.; *Classification*—1A.

INTERMEDIATES: *Luster*—good; *Chalkiness*—(left) slight focal; *Wear*—(left) slight, (right) normal; *Other*—roots exposed about 6 to 8 mm.; *Classification*—1A.

LATERALS: *Luster*—good; *Staining*—(right) slight vegetative; *Wear*—(left) slight, (right) normal; *Other*—a longitudinal fleck centrally on left, roots exposed about 4 mm.; *Classification*—1A.

CORNERS: *Luster*—good; *Chalkiness*—slight focal; *Staining*—slight focal vegetative; *Wear*—normal to slight and uneven; *Classification*—1A.

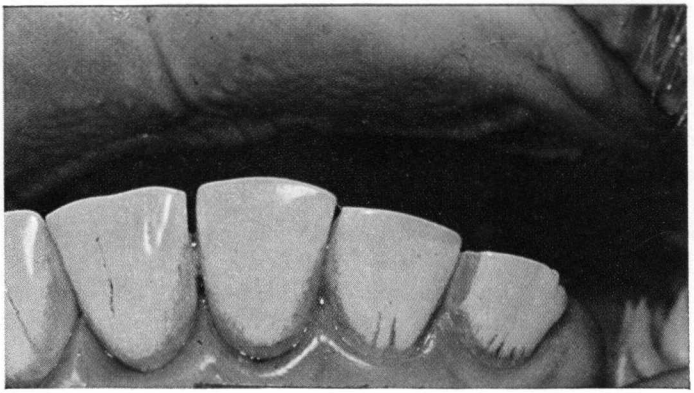
PREMOLARS AND MOLARS: Normal stain and wear.

**ANIMAL NO. 14**

CENTRALS: *Luster*—good; *Wear*—normal; *Other*—roots exposed about 10 mm.; *Classification*—1A.

INTERMEDIATES: *Luster*—good; *Wear*—normal; *Other*—roots exposed about 8 mm.; *Classification*—1A.

LATERALS: *Luster*—good; *Wear*—slight and uneven; *Other*—roots exposed about 6 to 8 mm. with some wear on the lateral edge of the left root; *Classification*—1A.



**LOT NO. 16, 1948–1953**

**Control Pasture**
**Pasture 10.6 ppm F**
**Hay 8.0 ppm F**

**Cow No. 37**

**Photographed**
**April, 1953**



**Cow No. 53**

**Photographed**
**April, 1953**



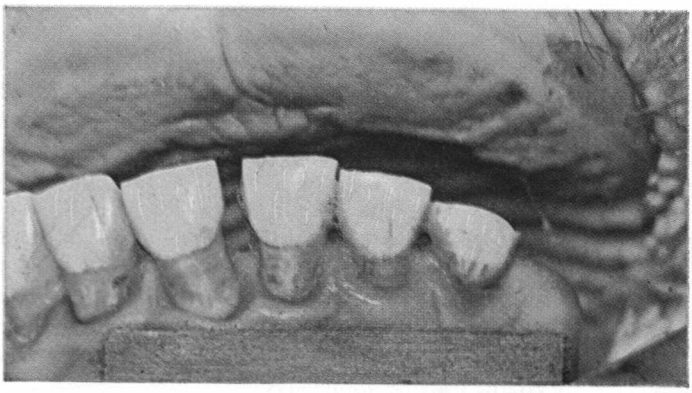
**Cow No. 65**

**Photographed**
**April, 1953**

**LOT NO. 16, 1948–1958**
**Control Pasture**
**Pasture 10.2 ppm F**
**Hay 6.2 ppm F**

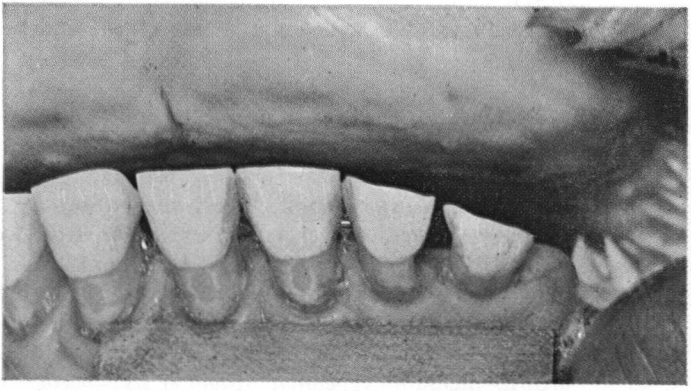
**Cow No. 37**

**Photographed Feb., 1958**



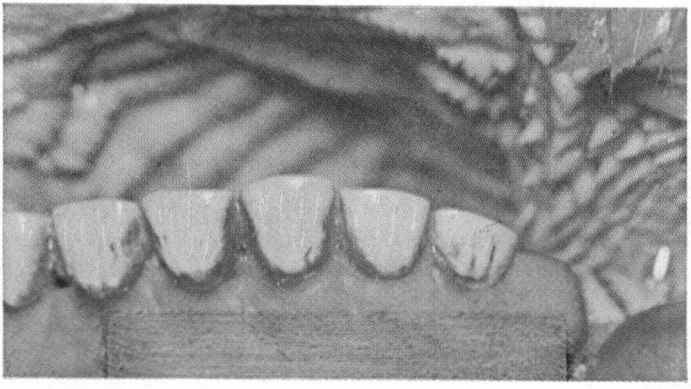
**Cow No. 14**

**Photographed Feb., 1958**



**Cow No. 38**

**Photographed Nov., 1957**



CORNERS: *Caps*—slightly uneven; *Luster*—good; *Wear*—normal to slight; *Classification*—1A.

PREMOLARS AND MOLARS: Normal stain and wear except lower right first is missing.

**ANIMAL NO. 38**

CENTRALS: *Luster*—good; *Staining*—slight or medium vegetative, focal; *Wear*—slight; *Classification*—1A.

INTERMEDIATES: *Luster*—normal; *Staining*—slight vegetative or slight discoloration; *Wear*—normal; *Classification*—1A or 1B.

LATERALS: *Luster*—good; *Staining*—slight focal vegetative; *Wear*—normal to slight; *Classification*—1A.

CORNERS: *Luster*—good; *Chalkiness*—slight focal; *Staining*—slight focal vegetative; *Cracks*—longitudinal vegetative stained grooves; *Wear*—slight; *Classification*—1A.

PREMOLARS AND MOLARS: FIRST PAIRS: *Wear*—(uppers) slight to medium and (lowers) normal to slight. SECOND, FOURTH, FIFTH and SIXTH PAIRS: Normal. THIRD PAIRS: *Wear*—(lowers) slight to medium.

**LOT NO. 15 ($B_1$ Pasture, 24.9 ppm F; and Hay, 40.0 ppm F) 1948–1953**

**ANIMAL NO. 3**

CENTRALS: *Luster*—good; *Chalkiness*—focal; *Staining*—suspicious discoloration lower ½, vegetative; longitudinal grooves; *Classification*—1B.

INTERMEDIATES: *Luster*—good at cap and lower ⅓; *Chalkiness*—focal; longitudinal cracks; *Staining*—yellow to light brown centrally, heavy, vegetative; *Wear*—uneven, slight; *Classification*—2.

LATERALS: *Luster*—fair; *Chalkiness*—diffuse; *Staining*—yellow to light brown, medium, vegetative; *Enamel hypoplasia*—pit, slight; *Wear*—medium; *Classification*—4.

CORNERS: *Chalkiness*—focal, diffuse, porcelain, slight; *Staining*—yellow to light brown, heavy, vegetative; *Enamel hypoplasia*—suspicious; enamel rough; *Classification*—4.

PREMOLARS AND MOLARS: FIRST PAIRS: *Staining*—light brown. SECOND and THIRD PAIRS: *Staining*—brown, *Wear*—(uppers) medium and (lowers) slight. FOURTH and FIFTH PAIRS: Normal. SIXTH PAIRS: *Wear*—(uppers) excessive to gum line and (lowers) slightly long anteriorly and centrally and short posteriorly.

**ANIMAL NO. 59**

CENTRALS: *Luster*—upper ½ good, lower ½ fair; *Chalkiness*—focal, cross, porcelain, heavy; *Staining*—medium, vegetative, light brown; *Caries*—(right) pinhead medial central; *Classification*—(right) 3, (left) 2.

INTERMEDIATES: *Chalkiness*—excessive; *Staining*—light brown, excessive; *Enamel hypoplasia*—slight; *Wear*—uneven, medium to heavy; *Classification*—4.

LATERALS: *Chipped Cap; Chalkiness*—cross, porcelain, heavy; *staining*—yellow to light brown, medium, vegetative; *Erosion*—(left) upper ½ medial, slight, black staining; *Wear*—slight; longitudinal crack (left) dark staining; *Classification*—(right) 2, (left) 3.

CORNERS: *Chalkiness*—diffuse; *Staining*—slight, vegetative, light brown; *Enamel hypoplasia*—pit, slight; *Wear*—slight; *Classification*—4.

PREMOLARS AND MOLARS: FIRST PAIRS: *Staining*—brown. SECOND and THIRD PAIRS: *Staining*—brown, *Wear*—slight to medium. FOURTH and FIFTH PAIRS: Normal. SIXTH PAIRS: *Wear*—(uppers) excessive, nearly to gum line and (lowers) long posteriorly, sheer anteriorly.

**ANIMAL NO. 41**

CENTRALS: *Luster*—good upper ½; *Chalkiness*—cross; *Staining*—light brown lower ½, slight, vegetative; longitudinal cracks stained; *Classification*—2.

INTERMEDIATES: *Chalkiness*—excessive; *Staining*—light brown to black, heavy; *Erosions*—(right) superficial centrally; *Enamel hypoplasia*—patch, slight; *Wear*—heavy, uneven; longitudinal cracks; *Classification*—5A.

LATERALS: *Chalkiness*—diffuse, excessive; *Staining*—light brown, medium; *Enamel hypoplasia*—pit, slight; *Wear*—slight to medium; longitudinal cracks; *Classification*—4.

CORNERS: *Chalkiness*—excessive; *Staining*—light brown to black, excessive; *Enamel hypoplasia*—slight to medium; *Classification*—5A.

PREMOLARS AND MOLARS: FIRST PAIRS: *Staining*—brown. SECOND and THIRD PAIRS: *Staining*—(uppers) brown and (lowers) dark brown, excessive, *Wear*—(uppers) medium and (lowers) slight. FOURTH and FIFTH PAIRS: Normal. SIXTH PAIRS: *Staining*—brown, excessive; *Wear*—(uppers) excessive centrally and (lowers) excessive anteriorly and long posteriorly.

**LOT NO. 15 ($B_1$ Pasture, 28.3 ppm F; and Hay, 20.0 ppm F), 1948–1958**

**ANIMAL NO. 33**

CENTRALS: *Luster*—fair to good; *Chalkiness*—medium diffuse and cross and slight porcelain; *Cracks*—stained longitudinal; *Wear*—normal; *Other*—roots exposed about 2 or 3 mm.; *Classification*—2.

INTERMEDIATES: *Luster*—fair; *Chalkiness*—medium to heavy focal and diffuse and slight porcelain in lower ¼; *Staining*—slight and light brown at cap; *Enamel hypoplasia*—difficult to evaluate; *Wear*—(left) medium, (right) heavy; *Other*—roots exposed 3 or 4 mm.; *Classification*—2 or 4.

LATERALS: *Luster*—fair to good; *Chalkiness*—medium to heavy cross and diffuse and (right) slight porcelain; *Enamel hypoplasia*—suspected; *Wear*—medium; *Classification*—4.

CORNERS: *Cap*—uneven; *Luster*—fair; *Chalkiness*—heavy cross; *Staining*—slight discoloration; *Enamel hypoplasia*—suspected; *Wear*—medium and uneven; *Classification*—4.



**LOT NO. 15, 1948–1953**

**Pasture 24.9 ppm F**
**Hay 40.0 ppm F**

**Cow No. 3**

**Photographed April, 1953**



**Cow No. 59**

**Photographed Oct., 1952**



**Cow No. 41**

**Photographed Oct., 1952**

**LOT NO. 15, 1948–1958**

**Pasture 28.3 ppm F**
**Hay 20.0 ppm F**

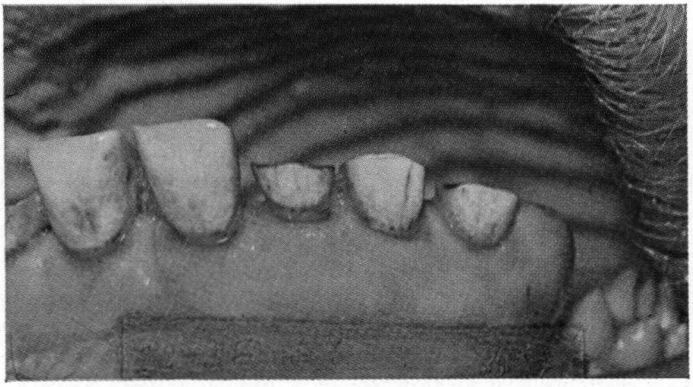
**Cow No. 33**

**Photographed Feb., 1958**



**Cow No. 59**

**Photographed Nov., 1957**



**Cow No. 52**

**Photographed July, 1958**



PREMOLARS AND MOLARS: FIRST PAIRS: *Staining*—brown; *Wear*—(uppers) medium to heavy and (lowers) slight to medium. SECOND PAIRS: *Staining*—brown, *Wear*—medium. THIRD PAIRS: *Staining*—brown; *Wear*—(lowers) slight. FOURTH PAIRS: Normal. FIFTH PAIRS: *Staining*—light brown. SIXTH PAIRS: *Staining*—(uppers) dark brown and black and (lowers) light brown; *Wear*—(uppers) medium to heavy and uneven and (lowers) normal to slight and uneven.

**ANIMAL NO. 59**

CENTRALS: *Luster*—fair to good; *Chalkiness*—heavy cross, focal and diffuse with slight porcelain; *Staining*—medium, light brown and diffuse and focal; *Wear*—normal; *Other*—roots exposed 1 or 2 mm.; *Classification*—2.

INTERMEDIATES: *Luster*—poor; *Chalkiness*—excessive and diffuse; *Staining*—excessive and light brown with dark foci at cap; *Enamel hypoplasia*—suspected to slight; *Caries and erosions*—(left) in the medial ½ a worn caries; *Wear*—(left) heavy to excessive, (right) medium to heavy; *Classification*—4.

LATERALS: *Luster*—fair; *Chalkiness*—medium diffuse and focal; *Staining*—medium, light brown; *Wear*—slight to medium and uneven; *Classification*—2.

CORNERS: *Cap*—chipped on the left; *Luster*—fair to good; *Chalkiness*—heavy, focal and diffuse; *Enamel hypoplasia*—suspected to slight; *Caries and erosions*—(left) worn erosion at left; *Wear*—medium to heavy; *Classification*—4 or 5A.

PREMOLARS AND MOLARS: FIRST PAIRS: *Staining*—dark brown and black; *Wear*—(uppers) uneven, ranging from slight to heavy. SECOND PAIRS: *Staining*—brown; *Wear*—(uppers) heavy and (lowers) uneven, ranging from normal to heavy. THIRD PAIRS: *Staining*—(uppers) light brown and (lowers) dark brown; *Wear*—(uppers) left is heavy and uneven and right slight to medium. FOURTH PAIRS: *Wear*—(uppers) right is slight to medium. FIFTH PAIRS: *Staining*—suspected. SIXTH PAIRS: *Staining*—dark brown and black; *Wear*—uneven, slight to heavy and (uppers) slightly long posteriorly.

**ANIMAL NO. 52**

CENTRALS: *Luster*—good; *Chalkiness*—medium to heavy, focal, diffuse and cross with slight porcelain; *Staining*—slight and light brown; *Wear*—normal; *Other*—roots exposed 6 to 8 mm.; *Classification*—2.

INTERMEDIATES: *Luster*—fair; *Chalkiness*—heavy diffuse and focal; *Staining*—slight discoloration with darker foci; *Enamel hypoplasia*—slight to medium; *Tooth hypoplasia*—suspected; *Wear*—heavy; *Other*—roots exposed about (left) 10 mm., (right) 6 mm.; *Classification*—5A.

LATERALS: *Luster*—fair; *Chalkiness*—medium diffuse and, in lower ¼, slight porcelain; *Staining*—slight discoloration; *Enamel hypoplasia*—suspected to slight; *Caries* and *Erosions*—2 or 3 flecks (left) may be carious; *Wear*—medium; *Other*—roots exposed about 3 to 5 mm.; *Classification*—4.

CORNERS: *Luster*—poor; *Chalkiness*—(left) medium and diffuse, (right) excessive and diffuse; *Staining*—slight discoloration with darker areas at cap; *Enamel hypoplasia*—suspected to slight; *Wear*—(left) slight, (right) medium; *Classification*—2 or 4.

PREMOLARS AND MOLARS: FIRST PAIRS: *Staining*—brown, *Wear*—(lowers) uneven. SECOND PAIRS: *Staining*—brown; *Wear*—(uppers) heavy and (lowers) uneven, slight to excessive. THIRD PAIRS: *Staining*—(uppers) brown and (lowers) light brown; *Wear*—(uppers) slight to medium and (lowers) heavy and uneven on left and slight on right. FOURTH PAIRS: Upper left missing after 3–25–55. Otherwise normal. FIFTH PAIRS: *Staining*—(uppers) light brown and (lowers) normal to suspected. SIXTH PAIRS: *Staining*—dark brown and black; *Wear*—(uppers) excessive and uneven and (lowers) medium to heavy and uneven.

**LOT NO. 14 ($B_2$ Pasture, 44.9 ppm F; and Hay, 51.0 ppm F), 1948–1953**

**ANIMAL NO. 43**

CENTRALS: *Luster*—fair to good; *Chalkiness*—focal, porcelain, cross in upper ½ and diffuse in lower ⅓; *Staining*—vegetative, very light yellow in lower ⅔; *Caries*—pinhead foci lower ⅓; *Classification*—3.

INTERMEDIATES: *Chalkiness*—excessive; *Staining*—focal, light to dark brown, heavy; *Caries* and *Erosions*—central ⅓ medially; *Enamel hypoplasia*—pit and patch, slight; *Wear*—uneven and short medially, heavy; *Classification*—4.

LATERALS: *Chalkiness*—excessive; *Staining*—light brown, focal, heavy; *Enamel hypoplasia*—pit, patch, slight; *Wear*—medium to heavy; *Classification*—4.

CORNERS: *Chalkiness*—excessive; *Staining*—lower ½ light brown and upper ½ dark brown, excessive; *Enamel hypoplasia*—pit, slight; *Wear*—medium; *Classification*—5A or 4.

GINGIVAE: Normal.

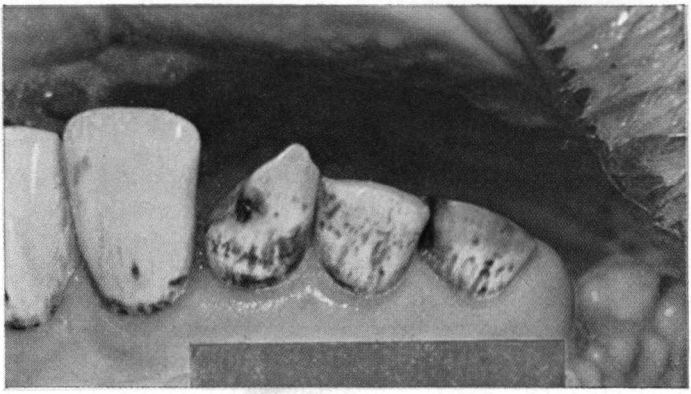
PREMOLARS AND MOLARS: FIRST PAIRS: *Staining*—dark brown. SECOND and THIRD PAIRS: *Staining*—dark brown, *Wear*—(uppers) heavy, (lowers) medium. FOURTH and FIFTH PAIRS: Normal. SIXTH PAIRS: *Staining*—dark brown, *Wear*—(uppers) heavy and (lowers) sheer anteriorly and long posteriorly.

**ANIMAL NO. 56**

CENTRALS: *Luster*—good at cap; *Chalkiness*—cross, porcelain, focal upper ¼, lower ⅔ excessive; *Staining*—light to dark brown, focal, medium, vegetative; *Enamel hypoplasia*—suspicious; *Wear*—(left) medium, sheer medially; *Classification*—4.

INTERMEDIATES: *Chalkiness*—excessive; *Staining*—excessive, vegetative, focal, light brown; *Enamel hypoplasia*—pit, slight; *Wear*—heavy; *Classification*—5A.

LATERALS: *Chalkiness*—excessive; *Staining*—vegetative, light brown, focal,

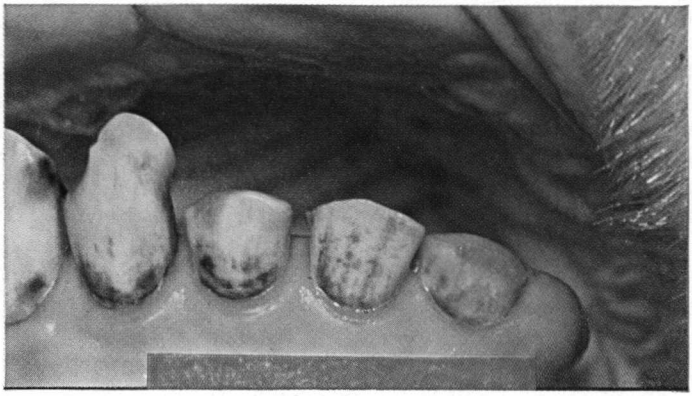


**LOT NO. 14, 1948–1953**

| | |
|---|---|
| **Pasture** | **44.9 ppm F** |
| **Hay** | **51.0 ppm F** |

**Cow No. 43**

**Photographed Jan., 1953**



**Cow No. 56**

**Photographed Jan., 1953**

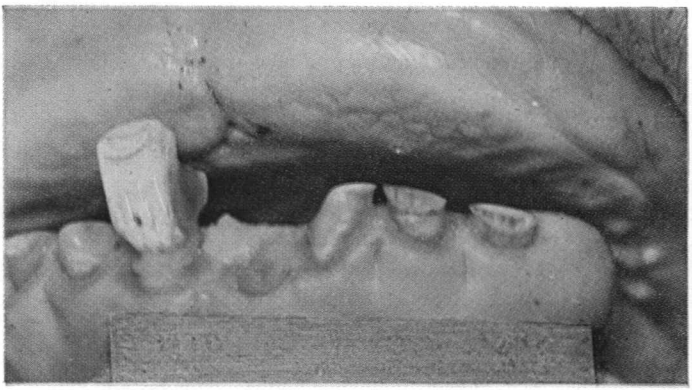


**Cow No. 71**

**Photographed Oct., 1952**

LOT NO. 14, 1948–1958

Pasture 43.4 ppm F
Hay 25.0 ppm F



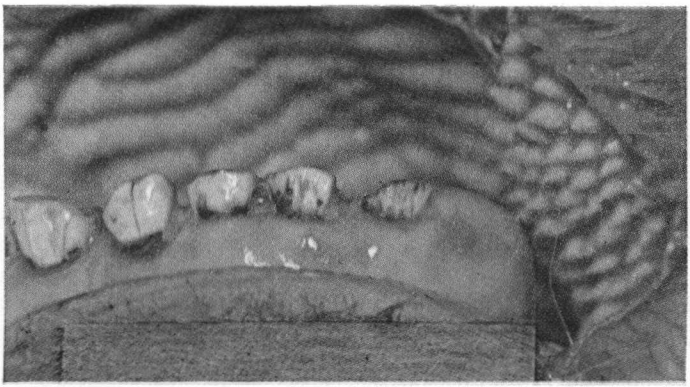
Cow No. 43

Photographed Feb., 1958



Cow No. 56

Photographed Nov., 1957



Cow No. 71

Photographed Aug., 1956

medium; *Enamel hypoplasia*—focal, pit, slight; *Wear*—medium; *Classification*—4.

CORNERS: *Chalkiness*—excessive; *Staining*—light brown to brown, excessive; *Enamel hypoplasia*—patch, suspicious to slight; *Wear*—slight; *Classification*—4.

PREMOLARS AND MOLARS: FIRST PAIRS: *Staining*—brown, *Wear*—(uppers) medium and (lowers) slight. SECOND and THIRD PAIRS: *Staining*—brown, *Wear*—medium. FOURTH PAIRS: Normal. FIFTH PAIRS: *Wear*—(uppers) heavy centrally and long posteriorly, (lowers) normal. SIXTH PAIRS: *Staining*—brown, *Wear*—(uppers) medium and (lowers) medium anteriorly and long centrally.

**ANIMAL NO. 71**

CENTRALS: *Chalkiness*—excessive; *Staining*—excessive, vegetative, upper ½ brown-black and lower ½ light brown; *Erosions*—superficial and undermining upper ⅔; *Enamel hypoplasia*—suspicious; *Wear*—uneven, short medially, heavy; *Classification*—4.

INTERMEDIATES: *Chalkiness*—excessive; *Staining*—excessive, vegetative, light brown to black; *Enamel hypoplasia*—lower ½ pit, slight to medium; *Wear*—uneven, heavy; *Tooth hypoplasia*—suspicious; *Classification*—5A.

LATERALS: *Chalkiness*—excessive; *Staining*—light brown to black, excessive; lower part vegetative; *Enamel hypoplasia*—focal, pit, slight; *Wear*—uneven, medium to heavy; Longitudinal Cracks—dark brown stained; *Classification*—5A or 4.

CORNERS: *Chalkiness*—excessive; *Staining*—yellow to brown with (right) cap black, excessive; *Caries* and *Erosions*—medially gingival ⅓, slight; *Enamel hypoplasia*—focal, pit, slight; *Wear*—slight to medium; *Classification*—5A or 4.

PREMOLARS AND MOLARS: FIRST PAIRS: *Staining*—light brown, *Wear*—(uppers) medium. SECOND PAIRS: *Staining*—brown, *Wear*—medium to heavy. THIRD PAIRS: *Staining*—brown, *Wear*—medium to heavy. FOURTH and FIFTH PAIRS: Normal. SIXTH PAIRS: *Staining*—(lowers) brown, *Wear*—(uppers) excessive and (lowers) medium to heavy anteriorly.

**LOT NO. 14 ($B_2$ Pasture, 43.4 ppm F; and Hay, 25.0 ppm F), 1948–1958**

**ANIMAL NO. 43**

CENTRALS: (left) missing, (right) *Luster*—fair to good; *Chalkiness*—heavy and cross, focal and diffuse; *Staining*—medium and light brown; *Caries* and *Erosions*—caries centrally; *Wear*—normal; *Other*—uneven and unusual wear along medial margin, root exposed about 7 mm.; *Classification*—3.

INTERMEDIATES: (left) Almost all and (right) all of enamel is worn away so that accurate descriptions cannot be made; *Classification*—5C (estimated).

LATERALS: *Luster*—poor; *Chalkiness*—excessive and diffuse; *Staining*—

excessive and light brown with darker areas; *Enamel hypoplasia*—medium; *Tooth hypoplasia*—slight to medium; *Wear*—excessive; *Classification*—5A or 5B.

CORNERS: *Luster*—poor; *Chalkiness*—excessive and diffuse; *Enamel hypoplasia*—medium to heavy; *Tooth hypoplasia*—medium; *Wear*—excessive; *Classification*—5A or 5B.

PREMOLARS AND MOLARS: FIRST PAIRS: *Staining*—dark brown and black; SECOND PAIRS: *Staining*—brown, *Wear*—excessive. THIRD PAIRS: *Staining*—brown, *Wear*—(uppers) excessive and (lowers) slight on right and medium uneven on left. FOURTH PAIRS: Normal. FIFTH PAIRS: *Staining*—brown; *Wear*—(uppers) slightly long posteriorly. SIXTH PAIRS: *Staining*—light brown; *Wear*—(upper) excessive and (lowers) medium and uneven.

**ANIMAL NO. 56**

CENTRALS: *Caps*—uneven; *Luster*—fair; *Chalkiness*—heavy, diffuse; *Staining*—(left) slight discoloration and, near root, slight focal; (right) medium and light brown; *Cracks*—slight longitudinal; *Enamel hypoplasia*—suspected; *Wear*—medium and uneven; *Other*—roots exposed about 5 to 7 mm.; *Classification*—2 or 4.

INTERMEDIATES: *Luster*—poor; *Chalkiness*—heavy to excessive and diffuse; *Staining*—excessive and light brown; *Enamel hypoplasia*—(left) suspected, (right) slight to medium; *Tooth hypoplasia*—(right) suspected to slight; *Wear*—heavy; *Other*—roots exposed about 4 mm.; *Classification*—(left) 4, (right) 5A.

LATERALS: *Luster*—poor; *Chalkiness*—heavy and focal and diffuse; *Staining*—(left) slight discoloration, (right) slight, brown, focal; *Enamel hypoplasia*—suspected; *Caries* and *Erosions*—(right) multiple pinpoint to pinhead in size; *Wear*—medium to heavy; *Classification*—4.

CORNERS: *Luster*—poor; *Chalkiness*—excessive and diffuse; *Staining*—excessive and light brown; *Enamel hypoplasia*—suspected to medium; *Tooth hypoplasia*—suspected to slight; *Wear*—heavy; *Classification*—4 or 5B.

PREMOLARS AND MOLARS: FIRST PAIRS: *Staining*—brown; *Wear*—(uppers) left is medium and right heavy and (lowers) slight. SECOND PAIRS: *Staining*—brown; *Wear*—(uppers) excessive and (lowers) heavy and uneven. THIRD PAIRS: *Staining*—brown; *Wear*—(uppers) excessive into gum and (lower) slight and uneven. FOURTH PAIRS: Normal. FIFTH PAIRS: *Staining*—brown; *Wear*—(uppers) slightly long posteriorly. SIXTH PAIRS: *Staining*—brown; *Wear*—slight to medium, uneven.

**ANIMAL NO. 71**

CENTRALS: *Luster*—poor to fair; *Chalkiness*—heavy, diffuse and focal; *Staining*—medium, light brown, focal and diffuse; *Cracks*—stained longitudinal; *Enamel hypoplasia*—suspected to slight; *Caries* and *Erosions*—caries, or remnants of caries, centrally; *Wear*—heavy and uneven; *Other*—(left) root exposed 2 or 3 mm.; *Classification*—4.

INTERMEDIATES: *Luster*—poor; *Chalkiness*—excessive and diffuse; *Staining*—excessive and light brown with darker areas at the cap and vegetative

near the gum; *Enamel hypoplasia*—slight to medium; *Tooth hypoplasia*—suspected; *Wear*—heavy; *Classification*—5A.

LATERALS: *Luster*—poor; *Chalkiness*—excessive and diffuse; *Staining*—excessive and light brown with darker foci and also vegetative at gum line; *Enamel hypoplasia*—slight to medium patch type (pits and patches are nearly all worn away); *Tooth hypoplasia*—suspected to slight; *Wear*—heavy and uneven; *Classification*—5A.

CORNERS: *Luster*—poor; *Chalkiness*—excessive and diffuse; *Staining*—excessive light brown with dark foci; *Enamel hypoplasia*—suspected; *Caries* and *Erosions*—(left) pinpoint in size and (right) pinhead in size; *Wear*—excessive; *Classification*—4.

PREMOLARS AND MOLARS: FIRST PAIRS: *Staining*—dark brown and black; *Wear*—(uppers) heavy. SECOND PAIRS: *Staining*—brown; *Wear*—(uppers) heavy and (lowers) excessive into gum. THIRD PAIRS: *Staining*—brown; *Wear*—(uppers) excessive and (lowers) medium to heavy, uneven. FOURTH PAIRS: Normal. FIFTH PAIRS: *Staining*—brown; *Wear*—(uppers) slightly long posteriorly. SIXTH PAIRS: *Staining*—brown; *Wear*—heavy and uneven.

**Gross Changes in Internal Organs.** Ingestion of F caused no gross changes in organs of the endocrine, respiratory, digestive, circulatory, urinary or reproductive systems. Average weights for various organs are shown in Table 17. There were no appreciable differences due to ingestion of F.

TABLE 17.—AVERAGE WEIGHTS OF INTERNAL ORGANS AT SLAUGHTER, LOTS 1–11 AND 14–16

| Lot no. | Total F in ration ppm | Slaughter weight | Weight of organs | | | | | |
|---|---|---|---|---|---|---|---|---|
| | | | Heart lb. | Spleen lb. | Liver lb. | Thyroid gm. | Pituitary gm. | Kidneys[1] lb. |
| 1 | 8 | 1106(3) | 4.5(3) | 1.5(3) | 9.7(2) | 40.5(3) | 3.3(3) | 2.2(3) |
| 2 | 18 | 958(2) | 4.1(1) | 1.4(2) | 8.05(2) | 31.8(2) | 3.2(2) | 2.0(2) |
| 3 | 28 | 1055(1) | 4.2(1) | 1.4(1) | 9.7(1) | 33.8(1) | 2.2(1) | 2.4(1) |
| 4 | 38 | 948(3) | 4.5(3) | 1.4(2) | 8.8(3) | 42.3(3) | 3.4(3) | 2.3(3) |
| 5 | 48 | 899(3) | 4.2(3) | 1.4(3) | 8.9(3) | 33.2(2) | 2.9(3) | 2.2(3) |
| 6 | 58 | 977(3) | 4.1(3) | 1.4(3) | 8.8(2) | 31.0(3) | 3.6(2) | 2.3(2) |
| 7 | 78 | 1012(3) | 4.0(2) | 1.4(2) | 9.2(3) | 31.3(3) | 3.4(3) | 2.1(3) |
| 8 | 108 | 910(2) | 3.6(2) | 1.4(2) | 8.8(2) | 34.2(1) | 3.4(2) | 1.8(2) |
| 9 | $B_1$ Hay | 1010(3) | 4.8(3) | 1.5(3) | 9.5(3) | 40.4(3) | 3.9(3) | 1.5(3) |
| 10 | $B_2$ Hay | 950(3) | 4.4(3) | 1.5(3) | 10.0(2) | 35.0(3) | 3.6(3) | 2.2(3) |
| 11 | 108 + Def. | 802(3) | 3.4(3) | 1.2(3) | 7.3(2) | 27.5(3) | 2.7(3) | 1.8(3) |
| 14 | $B_2$ Past. | 1141(4) | 4.9(3) | 1.4(4) | 9.6(3) | 32.2(3) | 3.6(4) | 2.3(4) |
| 15 | $B_1$ Past. | 1061(4) | 5.0(4) | 1.4(3) | 9.7(4) | 37.0(2) | 3.6(4) | 2.5(4) |
| 16 | Control Past. | 1110(4) | 4.7(4) | 1.4(4) | 10.3(4) | 34.0(3) | 3.2(4) | 2.8(4) |

[1] Left and right combined.

( ) Number in parentheses is the number of animals or organs in average.

While the hearts of cattle in Lot 1 were heavier than those of cattle in Lots 8 and 11, the heart made up virtually the same percentage of body weights in each case.

**Symptoms and Signs of Fluorosis.** Teeth changes, increased F storage in bone, excretion in urine, and decreased feed consumption were, under conditions of this experiment, criteria for measurement of the degree of F intoxication. Under field conditions, the determination of F content in feeds is needed. While cows in Lots 8 and 11 showed, in later years, some awkwardness of gait, there was no severe lameness at any time due to F ingestion. There was no evidence of diarrhea in cows or of elongated hooves due to F intake.

## Summary

Yearling Hereford heifers were started on test in April and June, 1948. The following treatments were used:

| *Lot* | *Treatment* |
|---|---|
| 1 | Control (8 ppm) (hay and concentrates) |
| 2 | Control plus 10 parts per million (ppm) fluorine (F) |
| 3 | Control plus 20 ppm F |
| 4 | Control plus 30 ppm F |
| 5 | Control plus 40 ppm F |
| 6 | Control plus 50 ppm F |
| 7 | Control plus 70 ppm F |
| 8 | Control plus 100 ppm F |
| 11 | Control plus 100 ppm F plus defluorophos |
| 9 | Hay from F contaminated area |
| 10 | Hay from F contaminated area |
| 14 | F contaminated pasture |
| 15 | F contaminated pasture |
| 16 | Control pasture and hay |

The added fluorine was sodium fluoride (NaF). The F contaminated hay was harvested in an area near an aluminum smelting plant. The F contaminated pastures were in an area near the same aluminum smelting plant.

**Feed Consumption.** The 70 ppm, 100 ppm, and 100 ppm + defluorinated phosphate lots after about 18 months on test showed a significant

decrease in feed consumption compared to Lot 1, controls, that continued for the entire test period (10 years). There was a statistically significant decrease in feed consumption for 48 ppm and 58 ppm F lots compared to Lot 1 after two and one-half years on test which continued for the remainder of the experiment. There was no appreciable difference in feed consumption among Lots 1, 2, 3, 4, 9 and 10 during the 10 years on test.

**Weights and Gains.** In cattle receiving F from NaF up to 100 ppm added (Lots 2–11) weights and gains varied among lots and individuals, but there appeared to be no significant differences due to F intake. Pasture lots 14, 15, and 16 showed no appreciable difference.

**Reproduction of Cows and Calf Records.** Cows in 78 and 108 ppm F lots had lower reproduction records than cows of other lots. The addition of 0.5 percent defluorinated phosphate to ration containing 100 ppm F as NaF improved feed consumption of cows, and calf production.

**Digestion and Balance Studies.** The higher F levels apparently did not significantly affect digestibility under conditions in this experiment.

**Bones.** Fluorine content of the bones was related to level of F ingestion and the age of the animals and length of time the given levels were ingested. Analyses of fetal bones and bones from calves at weaning time, which secured most of their nutrients from cow's milk, showed that increased F ingestion resulted in no appreciable increased transfer of F to the fetus or to the calf through the cow's milk. Calves with their dams on F contaminated pastures had a higher content of F in their bones at weaning time, due to the calves' grazing the pastures.

**Blood.** The ingestion of F did not cause significant changes in blood composition. Neither did tests with sulfabromophthalein indicate changes in liver function due to F ingestion.

**Urinary Fluorine.** The F content of the urine varied with the current level of intake. When the level in the ration was about 25 ppm F or below, the differences in urinary F content were similar between lots and the overlapping of urinary F levels between lots was greater.

**Gross Tissue Changes.** Gross changes in bone, as revealed by autopsy, were related to the level of F ingestion. Some over-growth or hypertrophy was found on the metatarsal bones of cows ingesting rations containing 48 ppm F or more. In animals consuming rations containing 70–100 ppm F from NaF, bone changes were extensive. There were no changes in internal organs due to F ingestion. During the trial there was no evidence of elongated hooves, severe lameness, or diarrhea which could be attributed to ingestion of fluorine.

**Teeth.** The occurrence and degree of dental fluorosis was dependent upon the level and availability of F ingested, period of time, age of animal, and amount of F stored in the body.

## EXPERIMENT II—LOTS 20A–26

### Objectives

This experiment was designed to determine the physiological changes in beef cows associated with the feeding of various levels of fluorine (0–50 ppm F) as sodium fluoride (NaF) and to determine the effectiveness of aluminum sulfate in the alleviation of F toxicosis. This experiment, designed as a partial replication of Experiment I, was conducted from October, 1950, through October of 1958.

The several phases of this experiment include studies of effects on:

1. Feed consumption.
2. Weights and gains.
3. Reproduction of cows, and calf records.
4. Bones, including amounts of fluorine stored in bones of cows and calves, and gross anatomical changes.
5. Various components of blood.
6. Urinary fluorine.
7. Teeth.

### Experimental Procedure

Grade Hereford heifers purchased as yearlings in Texas and Tennessee in the summer of 1950 were used in this experiment. These heifers were born in the period of January through April, 1949.

The heifers were free from tuberculosis and Brucellosis when shipped and were injected with Strain 19 Brucella vaccine after arrival at the experiment station.

The heifers were allotted on the bases of type grade, condition, source and weight, into 12 lots with three animals per lot for the barn group and 6 to 9 animals for the pasture groups, as shown in Table 18.

Lots 20A through 24B were fed individually in the barn, starting in October, 1950. All animals in these lots were placed on control rations for two weeks in order to adjust them to barn conditions. At the end of this period, the heifers were started on their respective rations.

The concentrate for Lots 20A through 24B was the same basic mixture fed to cows in Experiment I, with NaF and aluminum sulfate hydrate ($Al_2(SO_4)_3 \cdot 18\ H_2O$)[a] added in the manner described for NaF in Experiment I. During all or part of each summer from 1953 through 1958 these cattle were given access to pasture. During the pasture periods, the animals were brought to the barn once daily and were given the allotted concentrates with the appropriate amounts of NaF and/or aluminum sulfate. The

[a] Aluminum sulfate hydrate will be referred to as aluminum sulfate in text.

TABLE 18.—PLAN OF EXPERIMENT II, LOTS 20A–26

| Lot no. | No. Cows | | F added to ration as NaF ppm | Aluminum sulfate added to ration, percent | Total F in ration | Av. initial weight of cows | Av. daily Mg. F/Kg. body weight | |
|---|---|---|---|---|---|---|---|---|
| | Initial Oct. 1950 | Oct. 1958 | | | | | Initial (1950) to Oct. 1952 | Oct. 1958 |
| 20A | 3 | 1[a] | 0 | 0.0 | 8 | 647 | 0.18 | 0.14 |
| 20B | 3 | 3 | 0 | 0.5 | 8 | 653 | 0.18 | 0.17 |
| 21A | 3 | 2[b] | 20 | 0.0 | 28 | 665 | 0.60 | 0.56 |
| 21B | 3 | 3 | 20 | 0.5 | 28 | 628 | 0.67 | 0.61 |
| 22A | 3 | 3 | 30 | 0.0 | 38 | 653 | 0.83 | 0.84 |
| 22B | 3 | 2[c] | 30 | 0.5 | 38 | 654 | 0.82 | 0.74 |
| 23A | 3 | 2[d] | 40 | 0.0 | 48 | 660 | 1.05 | 1.00 |
| 23B | 3 | 1[e] | 40 | 0.5 | 48 | 651 | 1.04 | 1.00 |
| 24A | 3 | 2[f] | 50 | 0.0 | 58 | 656 | 1.20 | 1.17 |
| 24B | 3 | 3 | 50 | 0.5 | 58 | 655 | 1.25 | 1.15 |
| 25 | 6 | 6 | Control pasture | | 10 | 646 | | |
| 26 | 9 | 4[g] | $B_2$ pasture | | 45 | 679 | | |

[a] One animal died 3–30–54; one animal sacrificed 7–2–57.
[b] One animal sacrificed 6–2–55.
[c] One animal sacrificed 9–3–52.
[d] One animal died 6–13–55.
[e] Two animals sacrificed March, 1958.
[f] One animal died 6–29–54.
[g] One animal sacrificed December, 1957; one, January, 1958; one, 2–25–52; one died 2–25–54, and another, 3–17–57.

management of the animals was similar to that described for Experiment I.

In addition to the barn-fed groups, Lots 25 through 26 were started on pasture. These groups were added to Lots 16 and 14, respectively, in Experiment I. These heifers were placed on pasture in October, 1950, and were started on concentrate mixture two weeks later. They were fed individually 1 pound of concentrate mixture daily until June, 1951. It was found that the heifers getting the concentrate containing aluminum sulfate would not consume their concentrate feed. Concentrate feeding was discontinued and the lots were designated only as 25 and 26 without the letters added.

After June, 1951, animals in Lots 25 through 26 were managed in the same way as those in Lots 16 and 14, respectively. The animals in these lots were confined to the barn for 200 days in the winter of 1957 in order that their consumption of concentrate feed and hay could be measured. In the fall of 1958 they were placed in a barn where they remained until all were slaughtered.

Lots 20 through 26 were bred to calve at two years of age or older and were handled, during and after calving, the same as animals in Experiment I.

The same general procedures regarding teeth pictures, weights, calving, feed sampling, etc., followed in Experiment I were applied in Experiment II.

## Results and Discussion

**Feed Consumption.** Results shown in Table 19 reveal no appreciable difference in feed consumption among cattle in the various lots from October, 1950, through October of 1953. During the period of October, 1953, to October, 1954, after three years on test, the cattle in Lot 24A, consuming F at the level of 58 ppm, showed a highly significant decrease in hay consumption compared to all other groups, which was also true for 1955–56, 1956–57, and 1957–58. In 1954–55, the hay consumption of Lot 24A was significantly lower than all other lots except Lots 21A and 24B.

The level of hay consumption of cows in Experiment II in general was comparable with the levels of hay consumption of cows in Experiment I on similar intakes of F. There were two notable exceptions. First, the Experiment II cattle receiving F daily at the level of 48 ppm did not show a decrease in feed consumption during the eight years on test. The cattle on the same level of F in Experiment I did show a decrease in feed consumption after 2½ years in the experiment. The average daily intake of F on the basis of milligrams F per kilogram of body weight for 48 ppm F treatment for the first two years was 1.05 in Experiment II, and 1.04 in Experiment I.

Second, while the cows on the 58 ppm F level in Experiment I showed a decrease in hay consumption after 2½ years on test, a comparable decrease in hay consumption at the same level of F intake did not occur in Experiment II until the cattle had been on test over 3 years. At the beginning of the trial, heifers in Experiment II were about six months older and weighed from 621 to 694 pounds, compared to 453 to 523 pounds for those in Experiment I. Furthermore, heifers in Experiment II had been on good pasture all summer in Texas and Tennessee: whereas, heifers in Experiment I had been on dry winter feed and were wintered in average-to-thin condition prior to being started on test. In winter periods when feed consumption was measured, there was no difference in feed consumption between the pasture groups 25 and 26 (data included in Table 3 of Experiment I).

**Weights and Gains.** During the entire course of this experiment, although there were variations within and between years, there was no appreciable difference between the average daily gains or total gains and weights of any of the groups, as shown in Table 20.

**Reproduction and Calf Records.** The first calving season for cows in this experiment was in 1951. Table 21 gives the yearly and over-all average of the number of calves born, average daily calf gain, and over-all number of calves born and raised for the entire period. All calf weights were

TABLE 19.—FEED CONSUMPTION OF COWS, LOTS 20A–24B [a]

| Lot no. | Total F in ration ppm | Aluminum sulfate added to ration percent | Initial to Oct. 1951 Av. daily | | Oct. 1951 to Oct. 1952 Av. daily | | Oct. 1952 to Oct. 1953 Av. daily | | Oct. 1953 to Oct. 1954 Av. daily | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | Hay lbs. | Concentrate lbs. | Hay lbs. | Concentrate lbs. | Hay lbs. | Concentrate lbs. | Hay lbs. | Concentrate lbs. |
| 20A | 8 | 0 | 15.17 | 3.11 | 15.48 | 3.98 | 18.92 | 2.68 | 19.09 | 2.81 |
| 20B | 8 | 0.5 | 15.40 | 3.11 | 15.81 | 3.96 | 18.80 | 2.48 | 18.99 | 2.76 |
| 21A | 28 | 0 | 14.30 | 3.11 | 14.87 | 3.97 | 18.33 | 2.70 | 18.73 | 2.72 |
| 21B | 28 | 0.5 | 14.54 | 3.10 | 15.35 | 3.97 | 18.43 | 2.39 | 18.60 | 2.70 |
| 22A | 38 | 0 | 13.92 | 3.11 | 15.16 | 3.95 | 18.68 | 2.65 | 18.92 | 2.74 |
| 22B | 38 | 0.5 | 15.86 | 3.10 | 16.11 | 3.99 | 18.96 | 2.40 | 18.72 | 2.64 |
| 23A | 48 | 0 | 15.81 | 3.10 | 16.12 | 3.99 | 18.96 | 2.60 | 18.65 | 2.75 |
| 23B | 48 | 0.5 | 14.19 | 3.05 | 15.22 | 3.97 | 18.68 | 2.45 | 18.91 | 2.71 |
| 24A | 58 | 0 | 13.86 | 3.11 | 14.12 | 3.99 | 17.43 | 2.60 | 16.41 [b] | 2.71 |
| 24B | 58 | 0.5 | 15.53 | 3.10 | 16.23 | 3.99 | 19.14 | 2.40 | 18.51 | 2.55 |

(Table 19—Continued next page)

TABLE 19.—(CONTINUED FROM PAGE 108)

| Lot no. | Total F in ration ppm | Aluminum sulfate added to ration percent | Oct. 1954 to Oct. 1955 Av. daily | | Oct. 1955 to Oct. 1956 Av. daily | | Oct. 1956 to Oct. 1957 Av. daily | | Oct. 1957 to Oct. 1958 Av. daily | | Initial to Oct. 1958 Av. daily | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | Hay lbs. | Concentrate lbs. | Hay lbs. | Concentrate lbs. | Hay lbs. | Concentrate lbs. | Hay lbs. | Concentrate lbs. | Hay lbs. | Concentrate lbs. |
| 20A | 8 | 0 | 20.00 | 1.99 | 21.55 | 2.00 | 23.95 | 2.31 | 24.37 | 1.99 | 18.17 | 2.78 |
| 20B | 8 | 0.5 | 19.64 | 1.94 | 21.83 | 1.99 | 23.52 | 2.27 | 23.75 | 1.99 | 19.34 | 2.57 |
| 21A | 28 | 0 | 19.18 | 1.98 | 21.52 | 1.99 | 23.34 | 2.32 | 23.80 | 1.99 | 18.22 | 2.71 |
| 21B | 28 | 0.5 | 19.54 | 1.89 | 21.48 | 1.96 | 23.17 | 2.24 | 23.46 | 1.98 | 18.88 | 2.54 |
| 22A | 38 | 0 | 19.46 | 1.97 | 21.39 | 1.98 | 23.48 | 2.33 | 23.73 | 2.00 | 18.88 | 2.60 |
| 22B | 38 | 0.5 | 19.73 | 1.88 | 21.87 | 1.96 | 23.40 | 2.22 | 23.80 | 1.90 | 19.47 | 2.52 |
| 23A | 48 | 0 | 19.57 | 1.98 | 21.35 | 1.99 | 23.62 | 2.32 | 24.10 | 1.99 | 18.93 | 2.70 |
| 23B | 48 | 0.5 | 19.50 | 1.84 | 21.40 | 1.92 | 22.88 | 2.19 | 23.48 | 1.98 | 18.36 | 2.57 |
| 24A | 58 | 0 | 18.49 [b] | 1.94 | 19.57 [b] | 1.97 | 21.04 [b] | 2.28 | 21.14 [b] | 1.99 | 16.91 [b] | 2.68 |
| 24B | 58 | 0.5 | 19.21 | 1.84 | 21.62 | 1.94 | 23.75 | 2.20 | 24.04 | 1.97 | 19.43 | 2.50 |

Duncan's Multiple Range Test, Daily Hay Consumption

| | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 1953–54 | Lot no. | 24A | 24B | 21B | 23A | 22B | 21A | 23B | 22A | 20B | 20A |
| | Av. | 16.41 | 18.56 | 18.60 | 18.65 | 18.72 | 18.73 | 18.91 | 18.92 | 18.99 | 19.09 |
| | $P < 0.05$ | | | | | | | | | | |
| 1954–55 | Lot no. | 24A | 21A | 24B | 22A | 23B | 21B | 23A | 20B | 22B | 20A |
| | Av. | 18.49 | 19.18 | 19.22 | 19.46 | 19.50 | 19.54 | 19.57 | 19.64 | 19.73 | 20.00 |
| | $P < 0.05$ | | | | | | | | | | |
| 1955–56 | Lot no. | 24A | 23A | 22A | 23B | 21B | 21A | 20A | 24B | 20B | 22B |
| | Av. | 19.58 | 21.35 | 21.39 | 21.40 | 21.48 | 21.52 | 21.54 | 21.63 | 21.83 | 21.87 |
| | $P < 0.05$ | | | | | | | | | | |
| 1956–57 | Lot no. | 24A | 23B | 21B | 21A | 22B | 22A | 20B | 23A | 24B | 20A |
| | Av. | 21.04 | 22.88 | 23.17 | 23.34 | 23.40 | 23.48 | 23.53 | 23.62 | 23.75 | 23.95 |
| | $P < 0.05$ | | | | | | | | | | |
| 1957–58 | Lot no. | 24A | 21B | 23B | 22A | 20B | 22B | 21A | 24B | 23A | 20A |
| | Av. | 21.14 | 23.44 | 23.48 | 23.73 | 23.75 | 23.80 | 23.80 | 24.04 | 24.10 | 24.37 |
| | $P < 0.05$ | | | | | | | | | | |

[a] See Table 18 for disposition of animals.

[b] Significant difference ($P < 0.01$).

## TABLE 20.—WEIGHTS AND GAINS OF COWS, LOTS 20A–26 [a]

| Lot no. | Total F in ration ppm | Aluminum sulfate added to ration percent | Initial Wt. Oct. 1950 | Wt. Oct. 1951 | Av. daily gain Oct. 1950 to Oct. 1951 | Wt. Oct. 1952 | Av. daily gain Oct. 1951 to Oct. 1952 | Wt. Oct. 1953 | Av. daily gain Oct. 1952 to Oct. 1953 | Wt. Oct. 1954 | Av. daily gain Oct. 1953 to Oct. 1954 | Wt. Oct. 1955 | Av. daily gain Oct. 1954 to Oct. 1955 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 20A | 8 | 0 | 647 | 879 | .61 | 1020 | .38 | 1166 | .42 | 1091 | −.18 | 1067 | −.07 |
| 20B | 8 | 0.5 | 653 | 864 | .56 | 1008 | .39 | 1113 | .31 | 1054 | −.16 | 1047 | −.02 |
| 21A | 28 | 0 | 665 | 852 | .50 | 984 | .36 | 1135 | .44 | 1146 | .03 | 1035 | −.12 |
| 21B | 28 | 0.5 | 628 | 781 | .41 | 923 | .38 | 1059 | .40 | 1010 | −.13 | 1005 | −.01 |
| 22A | 38 | 0 | 653 | 838 | .49 | 959 | .33 | 1031 | .21 | 963 | −.18 | 985 | .06 |
| 22B | 38 | 0.5 | 693 | 849 | .41 | 988 | .38 | 1116 | .37 | 1056 | −.16 | 1034 | −.06 |
| 23A | 48 | 0 | 660 | 867 | .55 | 1080 | .58 | 1148 | .20 | 1132 | −.04 | 1092 | .04 |
| 23B | 48 | 0.5 | 651 | 841 | .50 | 940 | .27 | 1035 | .28 | 1004 | −.08 | 1043 | .11 |
| 24A | 58 | 0 | 656 | 836 | .48 | 1011 | .48 | 1106 | .27 | 988 | −.11 | 988 | .00 |
| 24B | 58 | 0.5 | 655 | 942 | .76 | 1037 | .26 | 1211 | .48 | 1106 | −.29 | 1089 | −.05 |
| 25 | Control Pasture | | 650 | 937 | .76 | 988 | .14 | 1054 | .18 | Nov. 1080 | .06 | Sept. 1064 | −.05 |
| 26 | $B_2$ Pasture | | 673 | 866 | .51 | 1014 | .40 | 1117 | .29 | 1102 | .06 | 1136 | .11 |

(Table 20.—Continued on next page)

## TABLE 20.—(CONTINUED FROM PAGE 110)

| Lot no. | Total F in ration ppm | Aluminum sulfate added to ration percent | Wt. Oct. 1956 | Av. daily gain Oct. 1955 to Oct. 1956 | Wt. Oct. 1957 | Av. daily gain Oct. 1956 to Oct. 1957 | Wt. Oct. 1958 | Av. daily gain Oct. 1957 to Oct. 1958 | Av. daily gain Initial to Oct. 1958 | Average gain of cows at end of test by number of calves raised 5 | 6 | 7 | 8 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 20A | 8 | 0 | 1075 | .02 | 1200 | −.69 | 1098 | −.28 | .15 | | | .15(1) | |
| 20B | 8 | 0.5 | 1100 | .14 | 1148 | .13 | 1022 | −.35 | .13 | | | .14(2) | .11(1) |
| 21A | 28 | 0 | 1070 | .09 | 1060 | −.03 | 1026 | −.09 | .13 | | .13(1) | .12(1) | |
| 21B | 28 | 0.5 | 1095 | .24 | 1068 | −.07 | 978 | −.26 | .12 | | .16(1) | .10(2) | |
| 22A | 38 | 0 | 987 | .00 | 1010 | .06 | 910 | .27 | .09 | .10(1) | | .06(1) | .10(1) |
| 22B | 38 | 0.5 | 1092 | .16 | 1062 | −.08 | 1134 | .20 | .15 | .20(1) | | .11(1) | |
| 23A | 48 | 0 | 1085 | −.02 | 1080 | −.01 | 992 | −.24 | .11 | | .13(1) | .10(1) | |
| 23B | 48 | 0.5 | 1100 | .15 | 1083 | −.04 | 930 | −.04 | .10 | | | | .10(1) |
| 24A | 58 | 0 | 965 | −.06 | 1065 | .27 | 940 | −.34 | .11 | .12(1) | .10(1) | | |
| 24B | 58 | 0.5 | 1135 | .12 | 1200 | .18 | 1093 | −.29 | .15 | | .18(2) | | .09(1) |
| 25 | Control Pasture | | Sept. 1198 | .37 | 1114 | −.22 | 1119 | .01 | .16 | .23(1) | .11(2) | .17(3) | |
| 26 | $B_2$ Pasture | | 1174 | .10 | 1197 | −.07 | 1028 | −.21 | .12 | | .14(1) | .11(1) | .12(2) |

[a] See Table 18 for disposition of animals.
( ) Number in parentheses indicates number of cows that raised the number of calves shown.

TABLE 21.—REPRODUCTION AND CALVING RECORDS OF COWS, LOTS 20A–26 [a]

| Lot no. | Total F in ration ppm | Aluminum sulfate added to ration, percent | No. cows 1951 | 1951–1958 | | | |
|---|---|---|---|---|---|---|---|
| | | | | Total no. cows available to calve | No. calving | Calves raised | |
| | | | | | | No. | Av. daily gain [b,c] |
| 20A | 8 | 0 | 3 | 17 | 11 | 11[d] | 1.45 |
| 20B | 8 | 0.5 | 3 | 24 | 22 | 21 | 1.41 |
| 21A | 28 | 0 | 3 | 20 | 15 | 11 | 1.35 |
| 21B | 28 | 0.5 | 3 | 24 | 20 | 18 | 1.56 |
| 22A | 38 | 0 | 3 | 24 | 20 | 18 | 1.55 |
| 22B | 38 | 0.5 | 3 | 16 | 14 | 12 | 1.52 |
| 23A | 48 | 0 | 3 | 20 | 14 | 13 | 1.39 |
| 23B | 48 | 0.5 | 3 | 22 | 21 | 18 | 1.33 |
| 24A | 58 | 0 | 3 | 19 | 12 | 8 | 1.34 |
| 24B | 58 | 0.5 | 3 | 24 | 20 | 18 | 1.54 |
| 25 | Control Pasture | | 6 | 48 | 38 | 35 | 1.80 |
| 26 | $B_2$ Pasture | | 9 | 55 | 41 | 37 | 1.87 |

[a] See Table 18 for disposition of animals.
[b] All calf weights have been adjusted to a comparable basis for sex, age, and age of dam.
[c] Calves sacrificed in August, 1958; calf gain not included.
[d] One cow had twins.

adjusted to a comparable basis for age, sex, and age of dam. There were no appreciable differences in reproduction or in calf gains attributable to levels of F ingested, except that if all factors are considered there may be an indication that calf production was lower in Lot 24A. The calves in the pasture groups (Lots 25 and 26) gained significantly more rapidly than calves of the barn-fed groups (Lots 20A–24B).

## Fluorine Content of Bones

The F content of rib sections taken from various cows after approximately 34, 45, 58, 71 and 97 months on test are given in Table 22. Samples taken from 1953 to 1956 were biopsies from a single rib of each cow. Samples collected in 1958 were composites of the 9th and 10th ribs secured when each animal was slaughtered.

Rib F storage of cows was directly related to the level of F in the ration and length of time of ingestion.

The F storage in ribs of cows was significantly lower in Lots 22B, 23B and 24B which had aluminum sulfate as 0.5 percent of the ration, compared to companion Lots 22A, 23A and 24A without alleviator, respec-

tively. The F storage in ribs of cows in Lot 21B was significantly lower than F storage in ribs of cows in Lot 21A for 1954, 1955, and 1956.

Of the 30 cattle started on the barn-feeding phase of this experiment (Lots 20A–24B), 24 lived until slaughtered eight years later. The mandibles, right metacarpals, right metatarsals and right 9th and 10th ribs were taken at autopsy for F analyses. Data from these analyses and Duncan's multiple range test of significant differences are shown in Table 23. Cow 101 died one year, and Cow 111 died three months, before the scheduled slaughter dates. Bone analyses for both these animals are included in Table 23.

The data in Table 23 show that the metacarpal and metatarsal bones had similar F contents. The F contents in mandibles and ribs were also similar. Data from Experiments I and IV indicate that when F ingestion is at a given level the mandible and rib usually will have a slightly higher F content than the metacarpals and metatarsals.

The gross changes in bones at slaughter are shown in Table 24. There were no gross changes in bones of cows which had been consuming rations containing up to 48 ppm F without alleviator or in cows of any of the alleviator groups. The metatarsals of one of two cows consuming F at 48 ppm without alleviator showed hypertrophy suggestive of fluorosis. At 58 ppm F without alleviator there were marked gross changes in bone structure.

The F contents of metacarpal bones of calves from cows in Lots 20A–24B for 1951 through 1958 and Duncan's multiple range test for significant differences are shown in Table 25. Adequate numbers were available for statistical analyses in 1953, 1955, and 1956. The F levels in these bones were significantly higher in Lots 21A, 22A, 23A, and 24A in 1952 than for the corresponding B lots. In 1956 the calves in Lot 24A had significantly greater F storage in bones than calves in Lot 24B. In general, calves from cows consuming F as NaF at levels of 40 and 50 ppm without alleviators in the rations had a significant increase in bone F storage compared to calves of the control ration cows.

**Blood.** Data reported in 1954 on composition of blood of cows in Lots 20A–24B showed no differences due to F ingestion (Hobbs *et al.* 1954). Data on blood samples taken in May, 1958, are reported in Table 26. There were no differences in hematocrit (packed cell volume), hemoglobin level, total red cell count, or total and differential white cell counts which were attributable to ingestion of F or aluminum sulfate. While all average red cell counts for each lot were within reported normal ranges (Coffin, 1953), both the hematocrit and hemoglobin values were uniformly high in most lots. The total white cell counts were well within normal limits except for that of one cow included in the average for Lot 24B. Cow 127 of that lot had a total white cell count of only 3,525. Percentages of neutro-

## TABLE 22.—RIB FLUORINE CONTENT OF COWS, LOTS 20A–24B[a]

(All analysis are reported on ash basis)

| Lot no. | Total in ration ppm | Aluminum sulfate added to ration, percent | An. no. | Comparison of F in ribs from same animals | | | | | F reduction, percent [b] | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | 1953 ppm | 1954 ppm | 1955 ppm | 1956 ppm | 1958 [c] ppm | 1953 | 1954 | 1955 | 1956 | 1958 | Av. |
| | | | 100 | 800 | | | | | | | | | | |
| 20A | 8 | 0 | 101 | 600 | 800 | 980 | 980 | 1030 | | | | | | |
| | | | 102 | 600 | 800 | 1010 | 960 | 1225 | | | | | | |
| | | | **Av.** | **667** | **800** | **995** | **970** | **1128** | | | | | | |
| | | | 103 | 600 | 700 | 860 | 1200 | 1190 | | | | | | |
| 20B | 8 | 0.5 | 104 | 700 | 800 | 900 | 1000 | 1080 | | | | | | |
| | | | 105 | 700 | 900 | 1200 | 1000 | 1395 | | | | | | |
| | | | **Av.** | **667** | **800** | **987** | **1067** | **1222** | | | | | | |
| | | | 106 | 2900 | 3500 | 3660 | 3900 | 4420 | | | | | | |
| 21A | 28 | 0 | 107 | 1800 | 2500 | 3300 | 5300 | 3660 | | | | | | |
| | | | 108 | 2100 | 2700 | | | | | | | | | |
| | | | **Av.** | **2267** | **2900** | **3480** | **4600** | **4040** | | | | | | |
| | | | 109 | 1800 | 1900 | 2360 | 2400 | 3000 | | | | | | |
| 21B | 28 | 0.5 | 110 | 1500 | 1600 | 1960 | 2300 | 2625 | | | | | | |
| | | | 111 | 2100 | 2200 | 2760 | 2600 | | | | | | | |
| | | | **Av.** | **1800** | **1900** | **2360** | **2433** | **2812** | **21** | **34** | **32** | **47** | **30** | **33** |
| | | | 113 | 3000 | 3800 | 4860 | 4400 | 4470 | | | | | | |
| 22A | 38 | 0 | 114 | 3600 | 4300 | 5070 | 5400 | 5550 | | | | | | |
| | | | 119 | 3200 | 4000 | 4470 | 4800 | 5550 | | | | | | |
| | | | **Av.** | **3267** | **4033** | **4800** | **4867** | **5190** | | | | | | |
| 22B | 38 | 0.5 | 112 | 2100 | 2700 | 3250 | 3200 | 3555 | | | | | | |
| | | | 117 | 2100 | 2700 | 3190 | 3200 | 3245 | | | | | | |
| | | | **Av.** | **2100** | **2700** | **3220** | **3200** | **3400** | **36** | **33** | **32** | **34** | **34** | **34** |
| | | | 115 | 3900 | 5000 | 5470 | 5500 | 7700 | | | | | | |
| 23A | 48 | 0 | 118 | 3900 | 4700 | 5790 | 5000 | 7040 | | | | | | |
| | | | 120 | 4200 | 4600 | | | | | | | | | |
| | | | **Av.** | **4000** | **4767** | **5630** | **5250** | **7370** | | | | | | |

(Table 22.—Continued on next page)

TABLE 22.—(CONTINUED FROM PAGE 114)

| | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 23B | 48 | 0.5 | 121 | 2100 | 2500 | 2880 | 3000 | 3100 | | | | | | |
| | | | 123 | 2500 | 3300 | 3490 | | 4680 | | | | | | |
| | | | 125 | 2400 | 3000 | 3490 | 3200 | 3855 | | | | | | |
| | | | Av. | **2333** | **2933** | **3287** | **3100** | **3878** | **42** | **38** | **42** | **41** | **47** | **42** |
| 24A | 58 | 0 | 122 | 5200 | 5600 | 6240 | 6000 | 6810 | | | | | | |
| | | | 124 | 4400 | 5300 | | | | | | | | | |
| | | | 126 | 5300 | 6800 | 7830 | 7800 | 8200 | | | | | | |
| | | | Av. | **4967** | **5900** | **7035** | **6900** | **7505** | | | | | | |
| 24B | 58 | 0.5 | 127 | 2400 | 3100 | 5400 | 3800 | 4700 | | | | | | |
| | | | 128 | 3200 | 3100 | 3900 | 3900 | 4310 | | | | | | |
| | | | 129 | 3700 | 4600 | 4880 | 4400 | 5760 | | | | | | |
| | | | Av. | **3100** | **3600** | **4060** | **4033** | **4923** | **38** | **39** | **42** | **42** | **34** | **39** |

Duncan's Multiple Range Test

| | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 1953 | Lot No. | 20B | 20A | 21B | 22B | 21A | 23B | 24B | 22A | 23A | 24A |
| | Av. | 667 | 667 | 1800 | 2100 | 2267 | 2333 | 3100 | 3267 | 4000 | 4967 |
| | $P < 0.05$ | | | | | | | | | | |
| 1954 | Lot No. | 20B | 20A | 21B | 22B | 21A | 23B | 24B | 22A | 23A | 24A |
| | Av. | 800 | 800 | 1900 | 2700 | 2900 | 2933 | 3600 | 4033 | 4767 | 5900 |
| | $P < 0.05$ | | | | | | | | | | |
| 1955 | Lot No. | 20B | 20A | 21B | 22B | 23B | 21A | 24B | 22A | 23A | 24A |
| | Av. | 987 | 995 | 2360 | 3220 | 3287 | 3480 | 4060 | 4800 | 5630 | 7035 |
| | $P < 0.05$ | | | | | | | | | | |
| 1956 | Lot No. | 20A | 20B | 21B | 23B | 22B | 24B | 21A | 22A | 23A | 24A |
| | Av. | 970 | 1067 | 2433 | 3100 | 3200 | 4033 | 4600 | 4867 | 5250 | 6900 |
| | $P < 0.05$ | | | | | | | | | | |
| 1958 | Lot No. | 20A | 20B | 21B | 22B | 23B | 21A | 24B | 22A | 23A | 24A |
| | Av. | 1128 | 1222 | 2812 | 3400 | 3878 | 4040 | 4923 | 5190 | 7370 | 7505 |
| | $P < 0.05$ | | | | | | | | | | |

[a] See Table 18 for disposition of animals.
[b] Reduction in F storage attributed to dietary aluminum sulfate.
[c] Av. of 9th and 10th ribs.

## TABLE 23.—BONE FLUORINE CONTENT OF COWS, LOTS 20A–24B [a]

(All analyses are reported on ash basis)

| Lot no. | Total F in ration ppm | Aluminum sulfate added to ration percent | An. no. | F content of bones, ppm | | | | F reduction, percent [c] | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | Metacarpals | Metatarsals | Mandibles | Ribs [b] | Metacarpals | Metatarsals | Mandibles | Ribs |
| 20A | 8 | 0 | 101 | 840 | — | 1040 | 1030 | | | | |
| | | | 102 | 1350 | 1060 | 1410 | 1225 | | | | |
| | | | **Av.** | **1095** | **1060** | **1225** | **1128** | | | | |
| | | | 103 | 1200 | 1190 | 1210 | 1190 | | | | |
| 20B | 8 | 0.5 | 104 | 1180 | 2155 | 1030 | 1080 | | | | |
| | | | 105 | 1470 | 1410 | 1500 | 1395 | | | | |
| | | | **Av.** | **1283** | **1585** | **1247** | **1222** | | | | |
| 21A | 28 | 0 | 106 | 3590 | 3320 | 3960 | 4420 | | | | |
| | | | 107 | 3230 | 3520 | 3260 | 3660 | | | | |
| | | | **Av.** | **3410** | **3420** | **3610** | **4040** | | | | |
| | | | 109 | 2430 | 2350 | 2520 | 3000 | | | | |
| 21B | 28 | 0.5 | 110 | 2240 | 2150 | 2490 | 2625 | | | | |
| | | | 111 | 2100 | 2380 | 2560 | — | | | | |
| | | | **Av.** | **2257** | **2293** | **2523** | **2812** | **34** | **33** | **30** | **30** |
| | | | 113 | 4300 | 4300 | 5040 | 4470 | | | | |
| 22A | 38 | 0 | 114 | 4920 | 4920 | 5400 | 5550 | | | | |
| | | | 119 | 4860 | 5280 | 5220 | 5550 | | | | |
| | | | **Av.** | **4693** | **4833** | **5220** | **5190** | | | | |
| 22B | 38 | 0.5 | 112 | 2940 | 2430 | 3690 | 3555 | | | | |
| | | | 117 | 2970 | 2400 | 2790 | 3245 | | | | |
| | | | **Av.** | **2955** | **2415** | **3240** | **3400** | **37** | **50** | **38** | **34** |
| 23A | 48 | 0 | 115 | 6340 | 5840 | 7120 | 7700 | | | | |
| | | | 118 | 6280 | 6280 | 6380 | 7040 | | | | |
| | | | **Av.** | **6310** | **6060** | **6750** | **7370** | | | | |
| | | | 121 | 2360 | 2590 | — | 3100 | | | | |
| 23B | 48 | 0.5 | 123 | 3480 | 2970 | 3800 | 4580 | | | | |
| | | | 125 | 2760 | 3110 | 4360 | 3855 | | | | |
| | | | **Av.** | **2867** | **2890** | **4080** | **3878** | **55** | **52** | **40** | **47** |
| 24A | 58 | 0 | 122 | 6640 | 6320 | 6920 | 6810 | | | | |
| | | | 126 | 8080 | 9050 | 7840 | 8200 | | | | |
| | | | **Av.** | **7360** | **7685** | **7380** | **7505** | | | | |
| | | | 127 | 4700 | 4660 | 4120 | 4700 | | | | |
| 24B | 58 | 0.5 | 128 | 3680 | 4000 | 4300 | 4310 | | | | |
| | | | 129 | 3860 | 4360 | 5040 | 5760 | | | | |
| | | | **Av.** | **4080** | **4340** | **4487** | **4923** | **45** | **43** | **39** | **34** |

Duncan's Multiple Range Test

| | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| RMT Lot No. | 20A | 20B | 21B | 22B | 23B | 21A | 24B | 22A | 23A | 24A |
| Av. | 1060 | 1585 | 2293 | 2415 | 2890 | 3420 | 4340 | 4833 | 6060 | 7685 |
| $P < 0.05$ | | | | | | | | | | |
| RMC Lot No. | 20A | 20B | 21B | 23B | 22B | 21A | 24B | 22A | 23A | 24A |
| Av. | 1095 | 1283 | 2257 | 2867 | 2955 | 3410 | 4080 | 4693 | 6310 | 7360 |
| $P < 0.05$ | | | | | | | | | | |
| Mandibles Lot No. | 20A | 20B | 21B | 22B | 21A | 23B | 24B | 22A | 23A | 24A |
| Av. | 1225 | 1247 | 2523 | 3240 | 3610 | 4080 | 4487 | 5220 | 6750 | 7380 |
| $P < 0.05$ | | | | | | | | | | |

[a] See Table 18 for disposition of animals.
[b] Average of 9th and 10th ribs.
[c] Reduction in F storage attributed to dietary aluminum sulfate.

TABLE 24.—GROSS CHANGES IN FIVE DIFFERENT BONES OF COWS AFTER EIGHT YEARS' INGESTION OF FLUORINE AND FLUORINE PLUS ALUMINUM SULFATE

| Lot no. | Total F in ration ppm | Aluminum sulfate added to ration, percent | An. no. | Gross appearance of bones | | | | |
|---|---|---|---|---|---|---|---|---|
| | | | | Meta-carpals | Meta-tarsals | Mandi-bles | 9th rib | 10th rib |
| 20A | 8 | 0 | 102 | NVL | NVL | NVL | NVL | NVL |
| | | | 103 | NVL | NVL | NVL | NVL | NVL |
| 20B | 8 | 0.5 | 104 | NVL | NVL | NVL | NVL | NVL |
| | | | 105 | NVL | NVL | NVL | NVL | NVL |
| 21A | 28 | 0 | 106 | NVL | NVL | NVL | NVL | NVL |
| | | | 107 | SH | NVL | NVL | NVL | NVL |
| | | | 109 | NVL | NVL | NVL | NVL | NVL |
| 21B | 28 | 0.5 | 110 | NVL | NVL | NVL | NVL | NVL |
| | | | 111 | NVL | NVL | NVL | NVL [b] | NVL |
| | | | 113 | NVL | NVL | NVL | NVL | NVL |
| 22A | 38 | 0 | 114 | NVL | NVL | NVL | NVL | NVL |
| | | | 119 | NVL | NVL | NVL | NVL | NVL |
| 22B | 38 | 0.5 | 112 | NVL | NVL | NVL | NVL | TE |
| | | | 117 | NVL | NVL | NVL | NVL | NVL |
| 23A | 48 | 0 | 115 | NVL | NVL | NVL | NVL | NVL |
| | | | 118 | NVL | MH | NVL | NVL | NVL |
| | | | 121 | NVL | NVL | — | NVL | NVL |
| 23B | 48 | 0.5 | 123 | NVL | NVL | NVL | NVL [b] | NVL |
| | | | 125 | NVL | NVL | NVL | NVL | NVL |
| 24A | 58 | 0 | 122 | NVL | — | GH | NVL | NVL |
| | | | 126 | GH | GH | GH | NVL | NVL |
| | | | 129 | NVL | NVL | NVL | NVL | NVL |
| 24B | 58 | 0.5 | 127 | NVL | NVL | NVL | NVL | NVL |
| | | | 128 | NVL | NVL | NVL | NVL | TH |

[a] See Table 18 for disposition of animals.
[b] Used left side rather than right.

TH = Trace of hypertrophy.
SH = Slight hypertrophy.
GH = Generalized hypertrophy.
NVL = No visible lesions.
MH = Medium hypertrophy.
TE = Trace of exostosis.

phils and monocytes were uniformly lower than most published norms, and percentages of eosinophils were uniformly high.

**Urinary Fluorine.** Average F contents of urinary samples collected in 1955 and 1957 and Duncan's multiple range test of significant differences are reported in Table 27. Single voidation samples (1957) showed no sig-

## TABLE 25.—BONE FLUORINE CONTENT OF CALVES FROM COWS, LOTS 20A–24B

| Lot no. | Total F in ration ppm | Aluminum sulfate added to ration percent | An. no. | Av. F in metacarpal bones, ppm | | | | | | | Range in days of age |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | 1951 | 1952 | 1954 | 1955 | 1956 | 1957 | 1958 | |
| 20A | 8 | 0 | 100 | 120 | 65 | | | | | | |
| | | | 101 | | 134 | | 240 | 170 | 140 | | |
| | | | 102 | | 65 | | 140 | 230 | | | |
| | | | Av. | 120 | 88 | | 190 | 200 | 140 | | 2–236 |
| 20B | 8 | 0.5 | 103 | | 64 | | 180 | | | 140 | |
| | | | 104 | 230 | 108 | 200 | 260 | 220 | | 160 | |
| | | | 105 | 180 | 110 | | | 190 | | 170 | |
| | | | Av. | 205 | 94 | 200 | 220 | 205 | | 157 | 0–236 |
| 21A | 28 | 0 | 106 | 200 | | | 260 | | | | |
| | | | 107 | 220 | 167 | | 180 | 190 | | | |
| | | | 108 | | 250 | | | | | | |
| | | | Av. | 210 | 208 | | 220 | 190 | | | 47–245 |
| 21B | 28 | 0.5 | 109 | | | | 210 | | | 140 | |
| | | | 110 | 160 | 100 | | | 220 | | 160 | |
| | | | 111 | 210 | 80 | | 210 | 240 | | 180 | |
| | | | Av. | 185 | 90 | | 210 | 230 | | 160 | 100–255 |
| 22A | 38 | 0 | 113 | | 185 | | 420 | 240 | | 160 | |
| | | | 114 | 220 | 136 | | 350 | 280 | 240 | 200 | |
| | | | 119 | | 144 | | | 240 | 200 | 170 | |
| | | | Av. | 220 | 155 | | 385 | 253 | 220 | 177 | 1–241 |
| 22B | 38 | 0.5 | 112 | 190 | 124 | | 160 | | | 150 | |
| | | | 117 | 180 | 104 | | | 240 | 230 | | |
| | | | Av. | 185 | 114 | | 160 | 240 | 230 | 150 | 0–232 |
| 23A | 48 | 0 | 115 | 210 | 230 | | 320 | 280 | | 300 | |
| | | | 118 | 260 | 152 | | | 310 | 240 | | |
| | | | 120 | 180 | 250 | | | | | | |
| | | | Av. | 217 | 211 | | 320 | 295 | 240 | 300 | 2–240 |
| 23B | 48 | 0.5 | 121 | 200 | 118 | | 180 | 280 | | 110 | |
| | | | 123 | 150 | 168 | | 250 | 260 | | 170 | |
| | | | 125 | | 116 | | 160 | 240 | 450 | | |
| | | | Av. | 175 | 134 | | 197 | 260 | 450 | 140 | 3–256 |
| 24A | 58 | 0 | 122 | 230 | 249 | 300 | | 310 | | 680 | |
| | | | 124 | 500 | | 300 | | | | | |
| | | | 126 | 140 | | | 400 | 280 | 440 | 260 | |
| | | | Av. | 290 | 249 | 300 | 400 | 295 | 440 | 470 | 0–243 |
| 24B | 58 | 0.5 | 127 | | 156 | | | 200 | | | |
| | | | 128 | | 124 | | | 240 | 180 | 190 | |
| | | | 129 | 240 | 134 | | 200 | 240 | | 200 | |
| | | | Av. | 240 | 138 | | 200 | 227 | 180 | 195 | 121–240 |

Duncan's Multiple Range Test

| | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 1952 | Lot no. | 20A | 21B | 20B | 22B | 23B | 24B | 22A | 21A | 23A | 24A |
| | Av. | 88 | 90 | 94 | 114 | 134 | 138 | 155 | 208 | 211 | 249 |
| | $P < 0.05$ | | | | | | | | | | |
| 1955 | Lot no. | 22B | 20A | 23B | 24B | 21B | 20B | 21A | 23A | 22A | 24A |
| | Av. | 160 | 190 | 197 | 200 | 210 | 220 | 220 | 320 | 385 | 400 |
| | $P < 0.05$ | | | | | | | | | | |
| 1956 | Lot no. | 21A | 20A | 20B | 24B | 21B | 22B | 22A | 23B | 23A | 24A |
| | Av. | 190 | 200 | 205 | 227 | 230 | 240 | 253 | 260 | 295 | 295 |
| | $P < 0.05$ | | | | | | | | | | |

TABLE 26.—AVERAGE LEVELS OF HEMOGLOBIN, PACKED CELL VOLUME, AND CELL CONCENTRATIONS, LOTS 20A–24B

| Lot no. | Total F in ration ppm | Aluminum sulfate added to ration, percent | No. animals | Hemoglobin (gms./100 ml.) | Hematocrit percent | Red blood cells (cmm) | White blood cells (cmm) | Differential cell count | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | Neutrophils percent | Lymphocytes percent | Eosinophils percent | Basophils percent | Monocytes percent | Others percent |
| 20A | 8 | 0 | 1 | 10.4 | 32 | 6,685,000 | 5,750 | 11 | 66 | 21 | 2 | 0 | 0 |
| 20B | 8 | 0.5 | 3 [a] | 12.6 | 38 | 6,752,000 | 5,966 | 14 | 68 | 16 | 2 | 0 | 0 |
| 21A | 28 | 0 | 2 | 13.9 | 44 | 6,817,000 | 6,425 | 14 | 70 | 12 | 2 | 2 | 0 |
| 21B | 28 | 0.5 | 3 | 13.0 | 37 | 7,052,000 | 6,616 | 12 | 68 | 17 | 3 | 0 | 0 |
| 22A | 38 | 0 | 3 | 13.3 | 38 | 6,881,000 | 6,316 | 10 | 67 | 19 | 3 | 1 | 0 |
| 22B | 38 | 0.5 | 2 | 15.5 | 42 | 7,007,000 | 6,662 | 14 | 64 | 17 | 4 | 1 | 0 |
| 23A | 48 | 0 | 2 | 13.9 | 40 | 6,875,000 | 7,075 | 15 | 65 | 18 | 2 | 0 | 0 |
| 23B | 48 | 0.5 | 1 | 12.2 | 37 | 7,140,000 | 5,275 | 7 | 70 | 18 | 4 | 1 | 0 |
| 24A | 58 | 0 | 2 | 15.2 | 42 | 5,972,000 | 6,438 | 15 | 65 | 18 | 1 | 0 | 1 |
| 24B | 58 | 0.5 | 3 | 13.4 | 36 | 6,873,000 | 6,058 | 9 | 69 | 18 | 3 | 0 | 1 |

[a] No differential white cell count on one animal.

## Table 27.—Fluorine Content of Urine from Cows, Lots 20A–24B

| Lot no. | Total F in ration ppm | Aluminum sulfate added to ration, percent | Single voidation [a] | | One-day [b] | | Seven-day [b] | |
|---|---|---|---|---|---|---|---|---|
| | | | No. analyses | Av. F content ppm | No. analyses | Av. F content ppm | No. analyses | Av. F content ppm |
| 20A | 8 | 0 | 2 | 2.4 | 2 | 2.5 | 2 | 5.5 |
| 20B | 8 | 0.5 | 2 | 2.4 | 3 | 3.5 | 3 | 4.5 |
| 21A | 28 | 0 | 2 | 2.1 | 2 | 9.0 | 2 | 16.0 |
| 21B | 28 | 0.5 | 5 | 5.7 | 3 | 10.7 | 3 | 11.3 |
| 22A | 38 | 0 | 6 | 5.6 | 3 | 23.0 | 3 | 25.7 |
| 22B | 38 | 0.5 | 3 | 7.3 | 2 | 12.5 | 2 | 14.0 |
| 23A | 48 | 0 | 4 | 8.6 | 2 | 29.0 | 2 | 27.0 |
| 23B | 48 | 0.5 | 2 | 14.1 | 2 | 15.0 | 2 | 15.5 |
| 24A | 58 | 0 | 4 | 8.2 | 2 | 42.0 | 2 | 41.5 |
| 24B | 58 | 0.5 | 5 | 7.6 | 3 | 20.0 | 3 | 21.7 |

Duncan's Multiple Range Test

| | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 Day | Lot No. | 20A | 20B | 21A | 21B | 22B | 23B | 24B | 22A | 23A | 24A |
| | Av. | 2.50 | 3.53 | 9.00 | 10.66 | 12.50 | 15.00 | 20.00 | 23.00 | 29.00 | 42.00 |
| | $P < 0.05$ | | | | | | | | | | |
| 7 Day | Lot No. | 20B | 20A | 21B | 22B | 23B | 21A | 24B | 22A | 23A | 24A |
| | Av. | 4.47 | 5.50 | 11.33 | 14.00 | 15.50 | 16.00 | 21.66 | 25.67 | 27.00 | 41.50 |
| | $P < 0.05$ | | | | | | | | | | |

[a] Samples taken in 1957.
[b] Data collected in 1955.

nificant differences, at the 5 percent level, in F content among the various lots. The F contents of one- and seven-day composite urine samples from the cows of the 50 ppm F without aluminum sulfate lot were significantly higher than those for cows of all other lots.

Data in Table 27 show that F content of one- and seven-day composite urine samples provide a better measure of current F ingestion than single voidation composite samples. Urinary F values are directly related to the amount of F being ingested and inversely to the number of hours after ingestion. The aluminum sulfate alleviator reduced the F content of the urine of cows compared to that of cows ingesting the same amount of F without an alleviator.

**Teeth.** Pictures of incisor teeth of representative cattle and descriptions of incisors, premolars and molars of cattle in Lots 20A–24B are presented on the following pages. A comparison of pictures of Lots 21B, 22B, 23B, and 24B (alleviator lots) with their respective companion Lots 21A, 22A, 23A, and 24A and a comparison of the teeth indexes definitely show that aluminum sulfate as an alleviator decreased the effects of F ingestion on teeth. Average indexes of incisor teeth condition with the range of classifications for teeth of cattle in Lots 20A–26 are presented in Table 28. Formation of central incisors was nearly complete when these cattle went on experiment. Therefore, the central (or first pair of) incisors were not included in the indexes of incisor condition.

The low average indexes of incisor teeth condition for cattle in Lots 20A and 20B indicate no F effects. Addition of the alleviator to the ration of cows in Lots 21B (28 ppm F) and 22B (38 ppm F) caused decreases in F effects upon teeth. The addition of aluminum sulfate to the rations of cows containing 48 and 58 ppm F caused significant decreases in teeth effects compared to cows receiving 48 and 58 ppm F, respectively, without alleviator.

Alleviator added to the ration containing 58 ppm F caused the incisor teeth index of those cows to be similar to that of cows receiving 38 ppm F without the alleviator.

In most cases, the F effects appeared to be greater on lateral teeth than on intermediates or corners.

The index of incisor teeth condition (4.2) for cattle in pasture Lot 26 agrees closely with the index of 4.6 for Lot 14 of Experiment I. These two groups were together most of the time after 1950.

Lateral incisor teeth index gave a slightly better estimation of the levels of F ingested than did either the corner or intermediate incisors.

These data for teeth indexes, along with the bone F content, feed consumption data, and information on bone effects, provide good diagnostic guides and agree closely with results of Experiment I.

TABLE 28.—INDEX OF INCISOR TEETH CONDITION AND RANGE OF TEETH CLASSIFICATIONS LOTS 20A–26

| Lot no. | Total F in ration ppm | Aluminum sulfate added to ration ppm | Index [a] of Incisor Teeth Condition I | L | Co. | Av. [b] | Teeth classification range |
|---|---|---|---|---|---|---|---|
| 20A | 8 | 0 | 0.7 | 0.6 | 0.1 | 0.5 | 1A-3 |
| 20B | 8 | 0.5 | 0.4 | 0.3 | 0.3 | 0.3 | 1A-2 |
| 21A | 28 | 0 | 1.4 | 2.2 | 2.0 | 1.9 | 1A-5A |
| 21B | 28 | 0.5 | 1.2 | 1.2 | 1.6 | 1.3 | 1A-5B |
| 22A | 38 | 0 | 1.9 | 2.1 | 2.1 | 2.0 | 1A-4 |
| 22B | 38 | 0.5 | 0.3 | 1.2 | 1.2 | 0.9 | 1A-4 |
| 23A | 48 | 0 | 1.8 | 4.3 | 3.8 | 3.3 | 1B-5C |
| 23B | 48 | 0.5 | 1.1 | 1.8 | 2.1 | 1.7 | 1A-4 |
| 24A | 58 | 0 | 3.2 | 5.0 | 5.0 | 4.4 | 2-5C |
| 24B | 58 | 0.5 | 1.9 | 2.9 | 2.9 | 2.6 | 1A-5AX |
| 25 | Control Pasture | | 0.0 | 0.2 | 0.2 | 0.2 | 1A-2[c] |
| 26 | $B_2$ Pasture | | 2.7 | 5.4 | 4.4 | 4.2 | 1A-5C |

Duncan's Multiple Range Test

| Index-Laterals | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Lot No. | 25 | 20B | 20A | 22B | 21B | 23B | 22A | 21A | 24B | 23A | 24A | 26 |
| Av. | 0.2 | 0.3 | 0.6 | 1.2 | 1.2 | 1.8 | 2.1 | 2.2 | 2.9 | 4.3 | 5.0 | 5.4 |
| $P < 0.05$ | | | | | | | | | | | | |

| Averages of all index | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Lot No. | 25 | 20B | 20A | 22B | 21B | 23B | 21A | 22A | 24B | 23A | 26 | 24A |
| Av. | 0.2 | 0.3 | 0.4 | 0.9 | 1.3 | 1.7 | 1.9 | 2.0 | 2.6 | 3.3 | 4.2 | 4.4 |
| $P < 0.05$ | | | | | | | | | | | | |

[a] Index is calculated by taking an average of average classifications, 1953–58.

[b] "Center" teeth are not included since they were erupting when cattle were placed on experiment.

[c] One tooth, Cow 80, was twice read 1AX or 4.

I = Intermediates; L = Laterals; Co. = Corners.

## LOT NO. 20A (8 ppm F)

### ANIMAL NO. 102

CENTRALS: *Luster*—good; *Chalkiness*—(left) slight to medium focal; *Wear*—normal; *Other*—roots exposed about 8 mm. and purulent discharge from gums; *Classification*—1A.

INTERMEDIATES: *Luster*—good; *Chalkiness*—medium to heavy cross and focal; *Staining*—slight discoloration; *Cracks*—stained longitudinal; *Wear*—normal; *Other*—roots exposed 8 to 10 mm. with wear along medial margin of left root; *Classification*—1B.

LATERALS: *Luster*—good; *Chalkiness*—(left) medium cross and focal,

(right) heavy focal; *Staining*—(left) slight discoloration; *Wear*—normal; *Classification*—1B.

CORNERS: *Luster*—good; *Chalkiness*—(right) slight focal; *Wear*—normal; *Other*—grass between left corner and lateral; *Classification*—1A.

PREMOLARS AND MOLARS: Normal stain and wear.

## LOT NO. 21A (28 ppm F)

### ANIMAL NO. 107

CENTRALS: *Luster*—good; *Wear*—normal; *Other*—roots exposed about 5 mm.; *Classification*—1A.

INTERMEDIATES: *Cap*—chipped, slight; *Luster*—good; *Chalkiness*—medium focal; *Cracks*—stained longitudinal; *Staining*—(right) slight discoloration; *Wear*—normal; *Other*—roots exposed about 3 mm.; *Classification*—1B.

LATERALS: *Caps*—(left) slight and (right) medium chipped; *Luster*—fair to good; *Chalkiness*—heavy cross, slight porcelain; *Staining*—medium, light brown; *Wear*—(left) normal, (right) slight; *Classification*—2.

CORNERS: *Luster*—fair to good; *Chalkiness*—(left) heavy cross and focal and slight porcelain, (right) medium cross and focal; *Staining*—(left) slight discoloration, (right) slight and light brown; *Caries and erosions*—(right) black focal area may or may not be a fluorine "caries"; *Wear*—(left) normal, (right) normal to slight and uneven; *Classification*—(left) 1B to 2, (right) 2X to 3.

PREMOLARS AND MOLARS: Normal stain and wear.

## LOT NO. 22A (38 ppm F)

### ANIMAL NO. 113

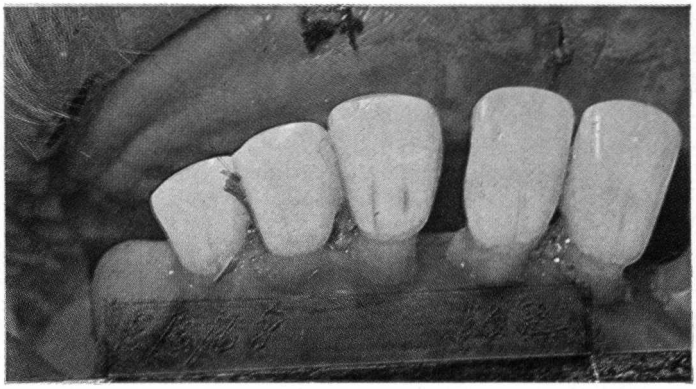
CENTRALS: *Luster*—good; *Wear*—normal; *Other*—roots exposed 1 or 2 mm.; *Classification*—1A.

INTERMEDIATES: *Luster*—good; *Chalkiness*—medium to heavy cross and focal; *Staining*—slight discoloration to slight light brown; *Wear*—normal; *Classification*—1B to 2.

LATERALS: *Luster*—good; *Chalkiness*—(left) heavy and (right) slight focal with large milky plaques; *Staining*—(left) medium and light brown; *Wear*—normal; *Classification*—(left) 2, (right) 1B.

CORNERS: *Luster*—fair to good; *Chalkiness*—heavy cross and focal; *Staining*—(left) heavy to excessive and light brown, (right) slight discoloration to heavy, light brown; *Wear*—normal; *Classification*—2.

PREMOLARS AND MOLARS: Third Pairs: *Staining*—brown, *Wear*—(lowers) left, slight and right, medium. All Other Pairs: Normal stain and wear.



**LOT NO. 20A**

**Control Ration (8 ppm Fluorine)**

**Cow No. 102**

**Photographed May, 1958**

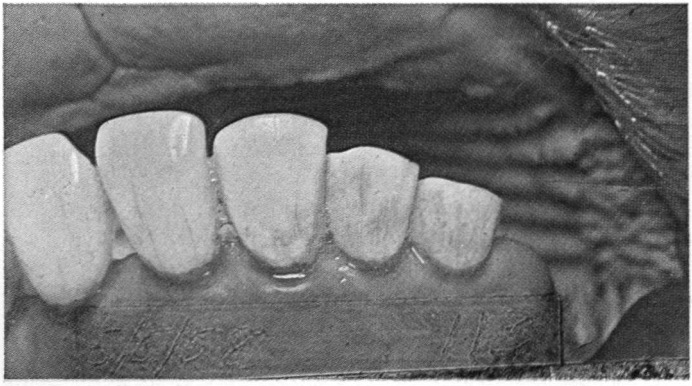


**LOT NO. 21A**

**Control Ration + 20 ppm Fluorine added as NaF (Total F = 28 ppm)**

**Cow No. 107**

**Photographed May, 1958**



**LOT NO. 22A**

**Control Ration + 30 ppm Fluorine added as NaF (Total F = 38 ppm)**

**Cow No. 113**

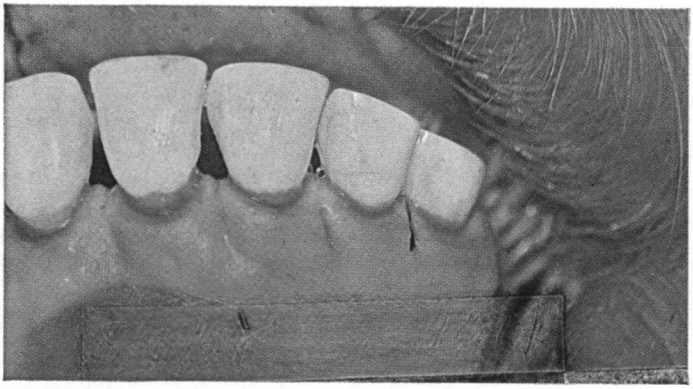
**Photographed May, 1958**

**LOT NO. 20B**

**Control Ration + Alleviator (Total F = 8 ppm + Alleviator)**

**Cow No. 104**

**Photographed May, 1958**

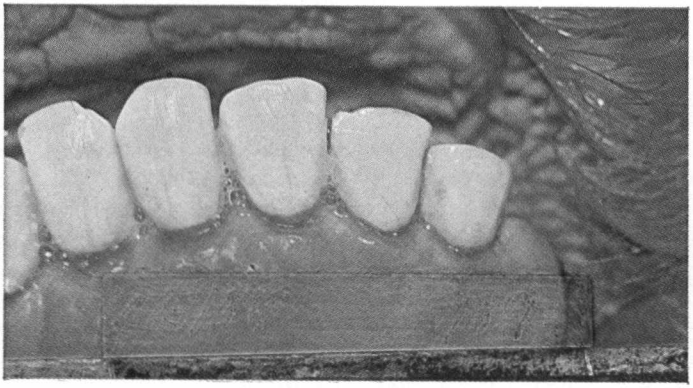


**LOT NO. 21B**

**Control Ration + 20 ppm Fluorine added as NaF + Alleviator (Total F = 28 ppm + Alleviator)**

**Cow No. 109**

**Photographed May, 1958**

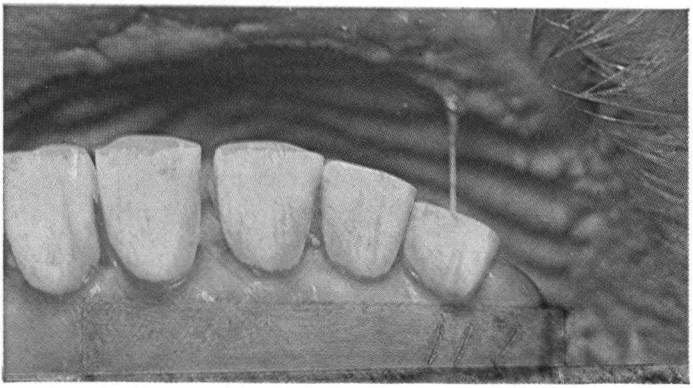


**LOT NO. 22B**

**Control Ration + 30 ppm Fluorine added as NaF + Alleviator (Total F = 38 ppm + Alleviator)**

**Cow No. 117**

**Photographed May, 1958**



**LOT NO. 20B (8 ppm F + Alleviator)**

**ANIMAL NO. 104**

CENTRALS: *Luster*—good; *Wear*—normal; *Other*—roots exposed about 3 mm.; *Classification*—1A.

INTERMEDIATES: *Luster*—good; *Wear*—(left) normal to slight, (right) normal; *Other*—roots exposed about 1 mm.; *Classification*—1A.

LATERALS: *Luster*—good; *Chalkiness*—slight focal and (left) a milky plaque; *Staining*—slight vegetative along medial margin; *Wear*—(left) slight, (right) normal; *Classification*—1A.

CORNERS: *Luster*—good; *Chalkiness*—slight focal; *Staining*—slight vegetative at gum lines; *Wear*—normal; *Classification*—(left) 1A, (right) 1B.

PREMOLARS AND MOLARS: Normal stain and wear.

**LOT NO. 21B (28 ppm F + Alleviator)**

**ANIMAL NO. 109**

CENTRALS: *Caps*—chipped and uneven; *Luster*—good; *Wear*—normal and uneven; *Other*—roots exposed about 1 mm.; *Classification*—1A.

INTERMEDIATES: *Luster*—good; *Chalkiness*—(left) slight to medium cross and focal, (right) medium to heavy cross; *Wear*—normal; *Classification*—1A to 1B.

LATERALS: *Caps*—slightly chipped; *Luster*—good; *Chalkiness*—slight to medium focal; *Wear*—normal; *Classification*—1A to 1B.

CORNERS: *Luster*—good; *Chalkiness*—slight to medium focal; *Wear*—normal; *Classification*—1A to 1B.

PREMOLARS AND MOLARS: Normal stain and wear.

**LOT NO. 22B (38 ppm F + Alleviator)**

**ANIMAL NO. 117**

CENTRALS: *Caps*—slightly chipped and uneven; *Luster*—good; *Staining*—slight focal vegetative; *Wear*—normal; *Classification*—1A.

INTERMEDIATES: *Luster*—good; *Chalkiness*—slight to medium focal; *Staining*—(left) slight vegetative; *Wear*—normal; *Classification*—1A.

LATERALS: *Luster*—good; *Chalkiness*—(left) slight focal, (right) medium to heavy cross and focal; *Staining*—slight vegetative; *Wear*—normal; *Classification*—1B.

CORNERS: *Luster*—fair to good; *Chalkiness*—slight to heavy cross; *Staining*—slight vegetative; *Wear*—normal; *Classification*—1A to 1B.

PREMOLARS AND MOLARS: Normal stain and wear.

## LOT NO. 23A (48 ppm F)

**ANIMAL NO. 118**

CENTRALS: *Caps*—(right) slightly uneven; *Luster*—good; *Wear*—normal; *Other*—roots exposed 8 to 10 mm.; *Classification*—1A.

INTERMEDIATES: *Luster*—(left) good, (right) poor to fair; *Chalkiness*—(left) medium and focal, (right) heavy, diffuse and focal; *Staining*—(left) slight discoloration, (right) medium to heavy light brown; *Wear*—(left) normal, (right) medium and uneven; *Other*—roots exposed about 6 to 8 mm.; *Classification*—(left) 1B, (right) 2.

LATERALS: *Caps*—chipped and uneven; *Luster*—poor; *Staining*—excessive brown with black foci; *Enamel hypoplasia*—(left) suspected to slight, (right) heavy, thin enamel type; *Tooth hypoplasia*—(left) suspected, (right) medium; *Caries and erosion*—right has worn caries at cap; *Wear*—excessive; *Other*—roots exposed about 6 to 8 mm. and a purulent discharge from right; *Classification*—(left) 4 to 5B, (right) 5C.

CORNERS: *Caps*—enamel, but not dentin, heavily chipped; *Luster*—poor; *Chalkiness*—excessive and diffuse; *Staining*—excessive and brown with darker foci; *Enamel hypoplasia*—suspected to slight; *Caries and erosions*—worn erosions at cap; *Wear*—heavy; *Classification*—4.

PREMOLARS AND MOLARS: First, Fourth and Fifth Pairs: normal. Second Pairs: *Staining*—(uppers) light brown. Third Pairs: *Staining*—light brown, *Wear*—(uppers) normal to slight, (lowers) uneven and, on right slight to medium and on left, medium to heavy. Sixth Pairs: *Staining*—brown, *Wear*—(uppers) excessive.

## LOT NO. 24A (58 ppm F)

**ANIMAL NO. 122**

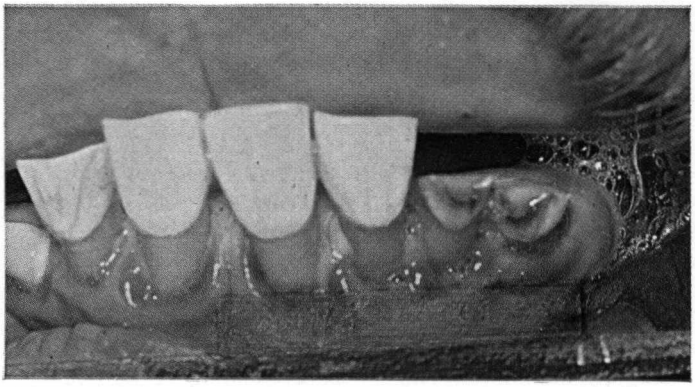
CENTRALS: *Luster*—fair to good; *Chalkiness*—medium focal; *Staining*—slight discoloration; *Wear*—normal; *Other*—roots exposed about 2 mm.; *Classification*—1B.

INTERMEDIATES: *Luster*—fair to good; *Chalkiness*—heavy focal, cross and diffuse; *Staining*—medium and light brown; *Wear*—(left) medium and uneven, (right) normal to slight and uneven; *Classification*—2.

LATERALS: *Luster*—poor to fair; *Chalkiness*—excessive cross, focal, and diffuse; *Staining*—medium and light brown with slightly darker areas; *Enamel hypoplasia*—suspected, (right) traces of hypoplastic pits at cap; *Wear*—medium to heavy; *Classification*—4.

CORNERS: *Luster*—poor, *Chalkiness*—excessive and diffuse; *Staining*—excessive and light brown with dark, pin-head-size area on left; *Enamel hypoplasia*—suspected to slight with traces of pits at the cap; *Wear*—heavy; *Classification*—4.

PREMOLARS AND MOLARS—First, Second, Fourth and Fifth Pairs: normal. Third Pairs: *Staining*—brown and light brown, *Wear*—(uppers)

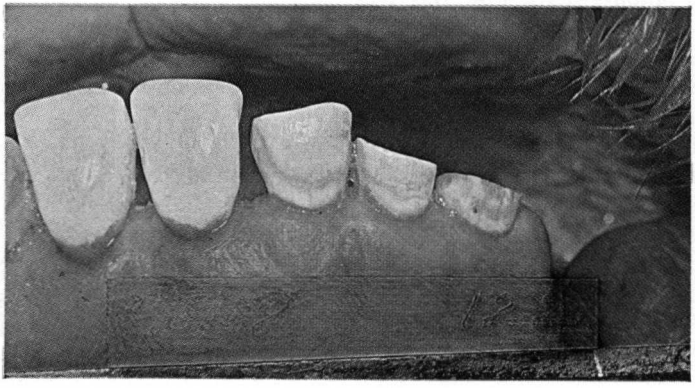


**LOT NO. 23A**

**Control Ration + 40 ppm Fluorine added as NaF (Total F = 48 ppm)**

**Cow No. 118**

**Photographed Oct., 1958**



**LOT NO. 24A**

**Control Ration + 50 ppm Fluorine added as NaF (Total F = 58 ppm)**

**Cow No. 122**

**Photographed May, 1958**



**Cow No. 126**

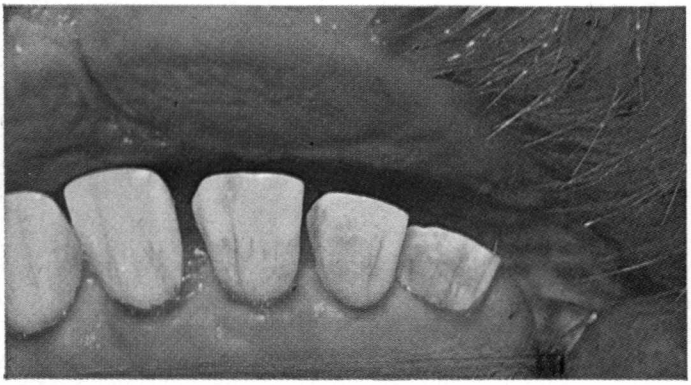
**Photographed Nov., 1958**

**LOT NO. 23B**

**Control Ration + 40 ppm Fluorine added as NaF + Alleviator (Total F = 48 ppm + Alleviator)**

**Cow No. 125**

**Photographed Nov., 1957**



**LOT NO. 24B**

**Control Ration + 50 ppm Fluorine added as NaF + Alleviator (Total F = 58 ppm + Alleviator)**

**Cow No. 128**

**Photographed Oct., 1958**



**Cow No. 129**

**Photographed Nov., 1957**



normal to slight, (lowers) medium and uneven. Sixth Pairs: *Staining*—light brown, *Wear*—(uppers) excessive.

**ANIMAL NO. 126**

CENTRALS: *Luster*—good; *Chalkiness*—slight to medium cross; *Wear*—normal; *Classification*—1A.

INTERMEDIATES: *Caps*—uneven; *Luster*—poor; *Chalkiness*—excessive and diffuse; *Staining*—(left) slight discoloration, (right) medium and light brown; *Enamel hypoplasia*—slight; *Wear*—heavy and uneven; *Other*—pulp cavities open; *Classification*—4 to 5A.

LATERALS: *Luster*—poor; *Chalkiness*—excessive and diffuse; *Staining*—excessive and light brown; *Enamel hypoplasia*—medium; *Tooth hypoplasia*—slight; *Wear*—excessive; *Classification*—5A to 5B.

CORNERS: Excessive wear, difficult to describe and classify; *Wear*—excessive; *Classification*—5B (estimated).

PREMOLARS AND MOLARS: First Pairs: *Staining*—dark brown, *Wear*—(uppers) normal but uneven, (lowers) slight. Second and Third Pairs: *Staining*—light brown, *Wear*—excessive. Fourth Pairs: Normal. Fifth Pairs: *Wear*—(lowers) slight to medium and uneven. Sixth Pairs: *Staining*—light brown, *Wear*—(uppers) excessive.

**LOT NO. 23B (48 ppm F + Alleviator)**

**ANIMAL NO. 125**

CENTRALS: *Luster*—good; *Staining*—slight discoloration; *Wear*—normal; *Classification*—1A to 1B.

INTERMEDIATES: *Luster*—good; *Chalkiness*—medium focal and cross and (left) a milky plaque developing near cap; *Cracks*—stained longitudinal on left; *Staining*—medium and light brown; *Wear*—normal; *Classification*—2.

LATERALS: *Luster*—fair; *Chalkiness*—heavy focal and cross; *Staining*—heavy, and light brown; *Wear*—normal; *Classification*—2.

CORNERS: *Luster*—poor to fair; *Chalkiness*—heavy cross and slight porcelain; *Staining*—heavy and light brown; *Wear*—slight; *Classification*—2.

PREMOLARS AND MOLARS: First, Second, Fourth and Fifth Pairs: Normal. Third Pairs: *Staining*—(uppers) light brown, (lowers) suspected. Sixth Pairs: *Staining*—(uppers) suspected, *Wear*—(uppers) normal to slight and uneven.

**LOT NO. 24B (58 ppm F + Alleviator)**

**ANIMAL NO. 128**

CENTRALS: *Luster*—good; *Wear*—normal; *Other*—roots exposed about 4 mm.; *Classification*—1A.

INTERMEDIATES: *Luster*—good; *Chalkiness*—medium to heavy cross and

focal, slight porcelain, and, on left, a milky plaque near the cap; *Staining*—slight discoloration; *Wear*—normal; *Other*—roots exposed about 3 mm.; *Classification*—1B.

LATERALS: *Cap*—(left) chipped and uneven; *Luster*—fair to good; *Chalkiness*—heavy cross with porcelain; *Staining*—(left) slight discoloration, (right) medium to heavy and light brown; *Wear*—(left) slight and uneven, (right) normal; *Other*—roots exposed about 2 mm. on left and 4 mm. on right; *Classification*—(left) 1B, (right) 2.

CORNERS: *Luster*—poor to fair; *Chalkiness*—heavy cross and diffuse with porcelain; *Staining*—heavy and light brown; *Wear*—normal; *Classification*—2.

PREMOLARS AND MOLARS: FIRST PAIRS: *Staining*—suspected. SECOND PAIRS: *Staining*—(uppers) light brown and (lowers) suspected. THIRD PAIRS: *Staining*—light brown, *Wear*—(lowers) slight. FOURTH and FIFTH Pairs: Normal. Sixth Pairs: *Staining*—light brown, *Wear*—(uppers) heavy on right and slight on left.

**ANIMAL NO. 129**

CENTRALS: *Luster*—good; *Chalkiness*—slight to medium focal; *Wear*—normal; *Other*—roots exposed about 3 mm.; *Classification*—1A.

INTERMEDIATES: *Caps*—uneven; *Luster*—fair; *Chalkiness*—heavy diffuse and focal and slight porcelain; *Staining*—medium to heavy and light brown; *Cracks*—stained longitudinal; *Wear*—normal to slight and uneven; *Other*—roots exposed about 2 mm.; *Classification*—2.

LATERALS: *Caps*—chipped and uneven; *Chalkiness*—heavy cross or focal and diffuse; *Staining*—slight and light brown with darker areas; *Enamel hypoplasia*—suspected; *Caries and erosions*—remnants of caries or erosions centrally; *Wear*—heavy and uneven; *Classification*—4.

CORNERS: *Luster*—poor; *Chalkiness*—excessive and diffuse; *Staining*—(left) excessive and light brown, (right) medium and brown; *Enamel hypoplasia*—(right) suspected; *Caries* and *Erosions*—(left) black-stained caries centrally with smaller caries apparently developing; *Wear*—(left) normal to slight and uneven, (right) excessive; *Classification*—(left) 3, (right) 4.

PREMOLARS AND MOLARS: FIRST and SECOND PAIRS: *Staining*—(uppers) light brown, *Wear*—(uppers) slight. THIRD PAIRS: *Staining*—brown, *Wear*—slight to medium and uneven. FOURTH and FIFTH PAIRS: Normal. SIXTH PAIRS: *Staining*—brown, *Wear*—(uppers) excessive and (lowers) normal to slight.

## Summary

The effects upon cattle of rations containing fluorine (F) added as sodium fluoride (NaF) compared to rations containing added F plus an alleviator (aluminum sulfate) were determined. The effects of F upon (1) feed consumption; (2) weights and gains; (3) reproduction of cows

and calf records; (4) bone; (5) blood; (6) urinary F; and (7) teeth of cows were evaluated in this eight-year experiment (1950–1958).

There were ten barn-fed and two pasture-fed groups of cows. The cows were allotted into 10 uniform groups and individually fed as follows:

| Ration (plus) | Added ppm F | Percent aluminum sulfate added |
|---|---|---|
| Control (8 ppm F) | none | none |
| " | " | 0.5 |
| " | 20 | none |
| " | 20 | 0.5 |
| " | 30 | none |
| " | 30 | 0.5 |
| " | 40 | none |
| " | 40 | 0.5 |
| " | 50 | none |
| " | 50 | 0.5 |

Two groups of cattle were also maintained on pasture, without alleviator, with cattle of Experiment I, in a control pasture and a contaminated pasture ($B_2$) near an aluminum smelting plant.

**Feed Consumption.** After three years cows consuming a ration containing 50 ppm F as NaF without alleviator showed a significant decrease in feed consumption which continued to the end of the test. This level of F plus alleviator in the rations, or lower levels with or without alleviator did not cause a decrease in feed consumption at any time.

**Weights and Gains.** Cows on 58 ppm or less F with and without an alleviator did not show a decrease in weights and daily gains.

**Reproduction and Calf Records.** Calves in pasture groups made significantly better daily gains than calves from barn-fed cows. There was no appreciable difference in daily gains of calves from cows in any of the barn-fed groups. No appreciable differences in reproductive efficiency of the cows resulted from the ingestion of F as NaF, F from pasture, or the "alleviator."

**Bones.** Addition of aluminum sulfate to the ration caused a significant decrease in F content of ribs after 34, 45, 58, 71 and 97 months compared with cows on the same levels of F intake without alleviator. Reductions of F content attributable to the feeding of aluminum sulfate were observed in the metacarpal and metatarsal bones and the mandibles after 97 months on experiment. Hypertrophic bone changes were observed at autopsy only in cows consuming F as NaF without the alleviator at the levels of 40 and 50 ppm.

Calves from cows consuming 40 and 50 ppm F as NaF without alleviator

had slightly higher concentrations of F in metacrapal bones than did the control calves.

**Blood.** No changes in blood components were observed which could be attributed to ingestion of F or aluminum sulfate.

**Urinary Fluorine.** Fluorine content in one-day and seven-day composite samples of urine showed a direct relationship to the level of F as NaF in the ration. Urine of cows receiving F plus alleviator had a lower F content than the urine of cows receiving a comparable level of F without aluminum sulfate.

**Teeth.** Pictures and descriptions of incisor teeth of representative cattle and descriptions of premolar and molar teeth are presented. Cattle consuming rations containing aluminum sulfate plus F as NaF at levels of 40 and 50 ppm had significantly less teeth effects due to F ingestion than cattle on comparable F levels without the alleviator.

## EXPERIMENT IV—LOTS 40–45B

Among important factors determining the degree of fluorosis in animals is the source of fluorine (F). Sodium fluoride (NaF) has been used in numerous investigations with cattle. However, raw rock phosphate (RRP), because it is used, when defluorinated, as a mineral supplement in animal feeds and because it is similar to the form of F found in highly phosphatic soils, is a likely source of F ingested by livestock. Investigation of its toxicity to cattle, therefore, would be pertinent. Huffman and Reed (1930), Chang *et al.* (1934), and Phillips (1934, 1952), were among the early workers who indicated that RRP could produce toxicosis in cattle. Hobbs (cited by Merriman *et al.* 1956) compared the toxicity of RRP with that of NaF when the two were consumed by cattle at comparable levels of total F.

### Objectives

This experiment was planned to provide a comparison of the effects upon beef heifers of identical levels of ingested F from both RRP and NaF.

Observations included effects of F from the two sources on:

1. Feed consumption.
2. Weights and gains.
3. Reproduction of cows and calf records.
4. Bone fluorine content.
5. Various components of the blood.
6. Urinary fluorine.
7. Teeth.

### Experimental Procedure

Seventeen grade Hereford heifers approximately 14 to 20 months of age were used in this study, which was initiated on August 12, 1952. The cattle

TABLE 29.—PLAN OF EXPERIMENT IV, LOTS 40–45B

| Lot no. | No. of cows | F added in ration ppm | Total F in ration ppm | Av. initial weight Aug. 1952 | Av. daily mg. F/kg. body wt.[a] |
|---|---|---|---|---|---|
| 40 | 3 | 0 | 8 | 430 | 0.18 |
| 41A | 2 | 50 NaF | 58 | 438 | 1.07 |
| 41B | 2 | 50 RRP | 58 | 430 | 1.06 |
| 42A | 1 | 100 NaF | 108 | 430 | 2.15 |
| 42B | 1 | 100 RRP | 108 | 425 | 1.99 |
| 43A [b] | 1 | 200 NaF | 208 | 432 | 4.53 |
| 43B | 1 | 200 RRP | 208 | 432 | 3.86 |
| 44A | 2 | 300 NaF | 308 | 415 | 5.73 |
| 44B | 2 | 300 RRP | 308 | 431 | 6.10 |
| 45A [c] | 1 | 600 NaF | 608 | 429 | 10.90 |
| 45B [d] | 1 | 600 RRP | 608 | 428 | 9.88 |

[a] Computed for the entire period each animal was in experiment.
[b] One animal sacrificed after 573 days of experiment.
[c] One animal died after 191 days of experiment.
[d] One animal sacrificed after 896 days of experiment.

were negative for brucellosis and tuberculosis. The animals were allotted in 11 lots on the bases of weight, condition, and type grade. The experimental design is shown in Table 29. The control ration was a concentrate mixture containing three parts of ground No. 2 yellow corn, one part of 41 percent cottonseed meal, and chopped mixed hay. This ration averaged approximately 8 ppm F during the experiment.

Fluorine was added as either RRP or NaF to the concentrate feed of the 10 lots receiving additional F as shown in Table 29. The levels reported were for F in the total air-dry ration. The concentrate was offered to each animal individually at the rate of 4 pounds per animal daily. Cow 45A, receiving F from NaF at a level of 600 ppm, refused to consume her concentrate feed and NaF was administered by capsule. Although cow 45B, receiving the same level of F from RRP, continued to eat concentrate quite well, she also was given the RRP by capsule. The use of capsules began 44 days after the start of the experiment and continued for the life of each cow.

After 482 days on test, Cows in Lot 44A, ingesting 300 ppm F from NaF, began refusing their concentrate and, consequently, were given NaF by capsule. This procedure was continued to the end of the experiment. The two cows on 300 ppm F from RRP continued to consume their concentrate, and therefore were not given the material by capsule.

Concentrate and hay were fed once daily. The amount of hay offered to each lot was adjusted to 2 or 3 pounds more than the highest daily consumption of any animal in the lot. All the refused feed was weighed daily to determine the total daily consumption of concentrate and hay. The cattle

had free access to salt and water, but were restricted to the barn or dry-lot during the experimental period.

The heifers were bred to calve in the spring of 1954 and again in the spring of 1955. However, only the 1954 calves were raised, since the cows were sacrificed at the end of the 1955 calving season.

Determinations of F content of bone, feed, and urine samples were made by a slight modification of the method which Willard and Winter described in 1933. The methods used for blood analyses were those reported by Hobbs *et al.* (1954). Blood samples were collected periodically throughout the experiment.

Samples of rib for F determinations were obtained by biopsy 12 and 24 months after the start of the experiment. The values for urinary F as reported in this bulletin were obtained from samples collected from cattle in Lots 41 and 44 at intervals of 2, 6, 10, and 24 hours after they had ingested the fluorine-containing rations.

Incisor, premolar and molar teeth were examined, described, and classified at intervals throughout the experiment. Both black-and-white and color photographs were made of the incisor teeth.

## Results and Discussion

**Feed Consumption.** Average daily feed consumption is shown in Table 30. There was a marked difference in the effects of F from the two sources upon feed consumption. The levels of 200 ppm F and below from raw rock phosphate (RRP) did not cause a decrease in feed consumption during the two-and-one-half-year test. The one animal fed a ration containing 200 ppm F from NaF consumed significantly less feed during the test. The animal was lost at calving in the third period of the trial. Levels of 100 ppm and 50 ppm F from NaF or RRP in the ration did not cause decreases in feed consumption.

Although the addition of 300 ppm F from NaF caused a decrease in feed consumption within one year and for the entire test, 300 ppm F from RRP did not result in a significant decrease in feed consumption until the third period, November, 1954, to April, 1955. In fact, during the second year of the trial, the feed consumption was higher for cattle consuming 300 ppm F from RRP than for control cattle.

Cow 45A, fed 600 ppm F as NaF, had a significant decrease in feed consumption which was so drastic that it was necessary to give the NaF by capsule after 44 days so that the intake of F at this level could be maintained. After 191 days on test, Cow 45A died because this level of F ingestion affected her appetite so drastically that she starved.

It was shown in Experiment I and Experiment II that, to determine differences in hay consumption of cows ingesting between 50 ppm F and 40 ppm F from NaF a feeding period over two and one-half years was needed.

TABLE 30.—FEED CONSUMPTION (IN POUNDS) OF COWS, LOTS 40–45B

| Lot no. | F added in ration ppm | Aug. 1952–Oct. 1953 Average Daily Hay | Aug. 1952–Oct. 1953 Average Daily Conc. | Oct. 1953–Nov. 1954 Average Daily Hay | Oct. 1953–Nov. 1954 Average Daily Conc. | Nov. 1954–Apr. 1955 Average Daily Hay | Nov. 1954–Apr. 1955 Average Daily Conc. | Initial–Apr. 1955 Average Daily Hay | Initial–Apr. 1955 Average Daily Conc. |
|---|---|---|---|---|---|---|---|---|---|
| 40 | 0 | 9.06 | 4.00 | 12.75 | 4.00 | 17.04 | 4.00 | 11.90 | 4.00 |
| 41A | 50 NaF | 9.29 | 4.00 | 12.76 | 4.00 | 16.86 | 4.00 | 11.98 | 4.00 |
| 41B | 50 RRP | 8.28 | 4.00 | 12.50 | 4.00 | 16.30 | 4.00 | 11.35 | 4.00 |
| 42A | 100 NaF | 8.82 | 4.00 | 12.40 | 4.00 | 15.86 | 4.00 | 11.46 | 4.00 |
| 42B | 100 RRP | 7.89 | 4.00 | 12.40 | 3.98 | 16.13 | 4.00 | 11.12 | 3.99 |
| 43A [a] | 200 NaF | 6.24 [b] | 4.00 | 5.95 [c] | 3.87 | | | | |
| 43B | 200 RRP | 9.11 | 4.00 | 12.37 | 4.00 | 15.85 | 4.00 | 11.57 | 4.00 |
| 44A | 300 NaF | 5.81 [b] | 3.55 | 7.39 [c] | 3.34 | 7.94 [c] | 3.53 | 6.81 [b] | 3.46 |
| 44B | 300 RRP | 7.89 | 3.98 | 13.23 | 4.00 | 14.79 [b] | 4.00 | 11.23 | 3.99 |
| 45A [d] | 600 NaF | 3.22 [c] | 1.64 | | | | | | |
| 45B [e] | 600 RRP | 7.78 | 3.87 | 10.58 [c] | 3.65 | 10.90 [c] | 3.58 | | |

Duncan's Multiple Range Test for Hay

| | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| Aug. 1952 to Oct. 1953: | | | | | | | | | | |
| Lot no. | 44A | 43A | 45B | 44B | 42B | 41B | 42A | 40 | 43B | 41A |
| Av. | 5.81 | 6.24 | 7.78 | 7.89 | 7.89 | 8.28 | 8.82 | 9.06 | 9.11 | 9.29 |
| $P < 0.05$ | | | | | | | | | | |
| Oct. 1953 to Nov. 1954 | | | | | | | | | | |
| Lot no. | 44A | 45B | 43B | 42B | 42A | 41B | 40 | 41A | 44B | |
| Av. | 7.39 | 10.58 | 12.37 | 12.40 | 12.40 | 12.50 | 12.75 | 12.76 | 13.23 | |
| $P < 0.05$ | | | | | | | | | | |
| Nov. 1954 to Apr. 1955 | | | | | | | | | | |
| Lot no. | 44A | 44B | 43B | 42A | 42B | 41B | 41A | 40 | | |
| Av. | 7.94 | 14.79 | 15.85 | 15.86 | 16.13 | 16.30 | 16.86 | 17.04 | | |
| $P < 0.05$ | | | | | | | | | | |
| Av. from Aug. 1952 to Apr. 1955 | | | | | | | | | | |
| Lot no. | 44A | 44B | 42B | 41B | 43B | 42A | 40 | 41A | | |
| Av. | 6.54 | 10.42 | 10.69 | 10.99 | 11.02 | 11.15 | 11.59 | 11.62 | | |
| $P < 0.05$ | | | | | | | | | | |

[a] Sacrificed after 573 days of experiment.
[b] Significantly different, $P < 0.05$.
[c] Significantly different, $P < 0.01$.
[d] Died after 191 days of experiment.
[e] Sacrificed after 896 days of experiment.

**Weights and Gains.** Weight gains of the cows on each treatment are shown in Table 31. During the first period the average daily gains were less for the cattle receiving NaF than for those receiving RRP on F levels of 200 ppm and above. At levels of 50 ppm and 100 ppm, neither F material exerted a marked effect on average daily gain. A comparison of the effects of varying levels of F from RRP from 0 to 300 shows no appreciable difference in weights or gains that may be directly related to treatment.

During the first two months of the test, Cow 45B, ingesting 600 ppm F

# TABLE 31.—WEIGHTS AND GAINS OF COWS, LOTS 40–45B

| Lot no. | F added in ration ppm | Initial weight 8–12–52 | Wt. Oct. 1952 | Av. da. gain initial to Oct. 1952 | Wt. Oct. 1953 | Av. da. gain Oct. 1952 to Oct. 1953 | Wt. Nov. 1954 | Av. da. gain Oct. 1953 to Nov. 1954 | Wt. Apr. 1955 | Av. da. gain Nov. 1954 to Apr. 1955 [a] | Av. da. gain initial to Apr. 1955 | Average gain of cows by number of calves born: 0 | 1 | 2 | 3 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 40 | 0 | 430 | 501 | 1.00 | 788 | 0.82 | 891 | 0.25 | 868 | −0.13 | 0.44 | | | .44(3) | |
| 41A | 50 NaF | 438 | 504 | 0.92 | 836 | 0.95 | 929 | 0.23 | 924 | −0.03 | 0.49 | | | .49(2) | |
| 41B | 50 RRP | 430 | 496 | 0.92 | 780 | 0.82 | 857 | 0.19 | 934 | 0.47 | 0.51 | | | .51(2) | |
| 42A | 100 NaF | 430 | 502 | 1.01 | 775 | 0.78 | 885 | 0.27 | 851 | −0.20 | 0.42 | | | .42(1) | |
| 42B | 100 RRP | 425 | 487 | 0.87 | 730 | 0.70 | 849 | 0.29 | 846 | −0.02 | 0.42 | | | .42(1) | |
| 43A [b] | 200 NaF | 432 | 464 | 0.45 | 718 | 0.73 | | | | | | | | | |
| 43B | 200 RRP | 423 | 466 | 0.60 | 830 | 1.04 | 838 | 0.02 | 954 | 0.70 | 0.54 | | | .54(1) | |
| 44A | 300 NaF | 415 | 426 | 0.15 | 602 | 0.51 | 722 | 0.30 | 682 | −0.24 | 0.27 | | .27(2) | | |
| 44B | 300 RRP | 431 | 460 | 0.41 | 805 | 0.99 | 858 | 0.13 | 905 | 0.29 | 0.48 | | | .45(1) | .51(1) Twins |
| 45A [c] | 600 NaF | 429 | 357 | −1.01 | | | | | | | | | | | |
| 45B [d] | 600 RRP | 428 | 475 | 0.66 | 825 | 1.00 | 818 | −0.02 | | | | | .47(1) | | |

[a] Cows calved during these months.
[b] Sacrificed after 573 days of experiment.
[c] Died after 191 days of experiment.
[d] Sacrificed after 896 days of experiment.
( ) Number in parentheses refers to number of cows that raised the number of calves shown.

from RRP, gained 0.66 lb. per day; but during the period of October, 1952, to October, 1953, she lost an average of 0.02 lb. per day. Cow 45B remained on experiment more than two years when, because of a calving injury, she was destroyed. Her mate, receiving 600 ppm F from NaF, lived only 191 days and lost an average of 1.01 lb. per day.

**Reproduction and Calf Records.** Data on reproduction for both calving periods are shown in Table 32. Of the 17 cows started on test, 15 remained on experiment at the first calving season, 1954; and 14 at the second calving season, 1955. Fourteen cows calved in 1954. One cow in Lot 44A failed to calve. There is no evidence that reproduction in this instance was affected by F intake. Again, in 1955, only one cow of those still on test failed to calve. This failure, in Lot 44A, was not by the same cow which failed to calve in 1955.

The cow in Lot 43A did not calve, but it was found that her fetus was full-term at the time of autopsy in 1954. The cow in Lot 45B calved in 1954 and was pregnant at the time of autopsy immediately prior to the 1955 calving season. Because of recurring vaginal prolapse she was slaughtered at this time.

The adjusted average daily gains of the calves raised in 1954 are also shown in Table 32. The one calf born and raised in Lot 44A had a lower

TABLE 32.—REPRODUCTION OF COWS, AND CALF RECORDS, LOTS 40–45B

| Lot no. | F added in ration ppm | 1954 | | | | 1955 |
|---|---|---|---|---|---|---|
| | | | | Calves raised | | |
| | | No. cows | No. cows calving | No. | Adj. av. daily gain [a] | No. cows calving [b] |
| 40 | 0 | 3 | 3 | 3 | 1.27 | 3 |
| 41A | 50 NaF | 2 | 2 | 2 | 1.31 | 2 |
| 41B | 50 RRP | 2 | 2 | 2 | 1.30 | 2 |
| 42A | 100 NaF | 1 | 1 | 1 | 1.22 | 1 |
| 42B | 100 RRP | 1 | 1 | 1 | 1.19 | 1 |
| 43A [c] | 200 NaF | | [c] | | | |
| 43B | 200 RRP | 1 | 1 | 1 | 1.32 | 1 |
| 44A | 300 NaF | 2 | 1 | 1 | 0.85 | 1 |
| 44B | 300 RRP | 2 | 2 | 3 [d] | 1.10 | 2 |
| 45A [e] | 600 NaF | | | | | |
| 45B | 600 RRP | 1 | 1 | 0 | | [f] |

[a] All calf weights have been adjusted to a comparable basis for sex and age of dam.
[b] Cows were sacrificed and calves sold at that time.
[c] Sacrificed after 573 days of experiment; pregnant at time of death.
[d] One cow had twins.
[e] Died after 191 days of experiment.
[f] Pregnant—died just prior to calving.

TABLE 33.—FLUORINE CONTENT OF RIBS OF COWS, LOTS 40–45B [a]

| Lot no. | F added in ration ppm | No. an. | Av. daily mg. F/kg. body wt. | PPM F in rib after 12 months | Reduction percent [b] | PPM F in rib after 24 months | Reduction percent [b] | PPM F in rib after 32 months | Reduction percent [b] |
|---|---|---|---|---|---|---|---|---|---|
| 40 | 0 | 3 | 0.178 | 500 | | 533 | | 737 | |
| 41A | 50 NaF | 2 | 1.069 | 3000 | | 4100 | | 5375 | |
| 41B | 50 RRP | 2 | 1.058 | 1950 | 35.0 | 2850 | 30.5 | 4060 | 24.5 |
| 42A | 100 NaF | 1 | 2.147 | 5800 | | 8900 | | 11400 | |
| 42B | 100 RRP | 1 | 1.993 | 3100 | 46.6 | 4800 | 46.1 | 6820 | 40.2 |
| 43A [c] | 200 NaF | 1 | 4.533 | 12200 | | | | | |
| 43B | 200 RRP | 1 | 3.857 | 5800 | 52.4 | 7700 | | 9400 | |
| 44A | 300 NaF | 2 | 5.730 | 11150 | | 13150 | | 15150 | |
| 44B | 300 RRP | 2 | 6.100 | 7000 | 37.2 | 9900 | 24.7 | 11975 | 21.0 |
| 45A [d] | 600 NaF | 1 | 10.904 | | | | | | |
| 45B | 600 RRP | 1 | 9.878 | 8000 | | 9500 | | 10550 | |

Duncan's Multiple Range Test

| | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 1953 | Lot no. | 40 | 41B | 41A | 42B | 42A | 43B | 44B | 45B | 44A | 43A |
| | Av. | 500 | 1950 | 3000 | 3100 | 5800 | 5800 | 7000 | 8000 | 11150 | 12200 |
| | $P < 0.05$ | | | | | | | | | | |
| 1954 | Lot no. | 40 | 41B | 41A | 42B | 43B | 42A | 45B | 44B | 44A | 43A |
| | Av. | 530 | 2850 | 4100 | 4800 | 7700 | 8900 | 9500 | 9900 | 13150 | 13700 |
| | $P < 0.05$ | | | | | | | | | | |
| 1955 | Lot no. | 40 | 41B | 41A | 42B | 43B | 45B | 42A | 44B | 44A | |
| | Av. | 740 | 4060 | 5380 | 6820 | 9400 | 10550 | 11400 | 11980 | 15150 | |
| | $P < 0.05$ | | | | | | | | | | |
| 1953, 1954, 1955 | Lot no. | 40 | 41B | 41A | 42B | 43B | 42A | 45B | 44B | 43A | 44A |
| | Av. | 590 | 2950 | 4160 | 4910 | 7630 | 8700 | 9350 | 9630 | 12950 | 13150 |
| | $P < 0.05$ | | | | | | | | | | |

[a] Raw Rock Phosphate contained an average of 3.16 percent F.
[b] Based on F content of bone from sodium fluoride groups.
[c] Sacrificed after 573 days of experiment.
[d] Sacrificed after 191 days of experiment.

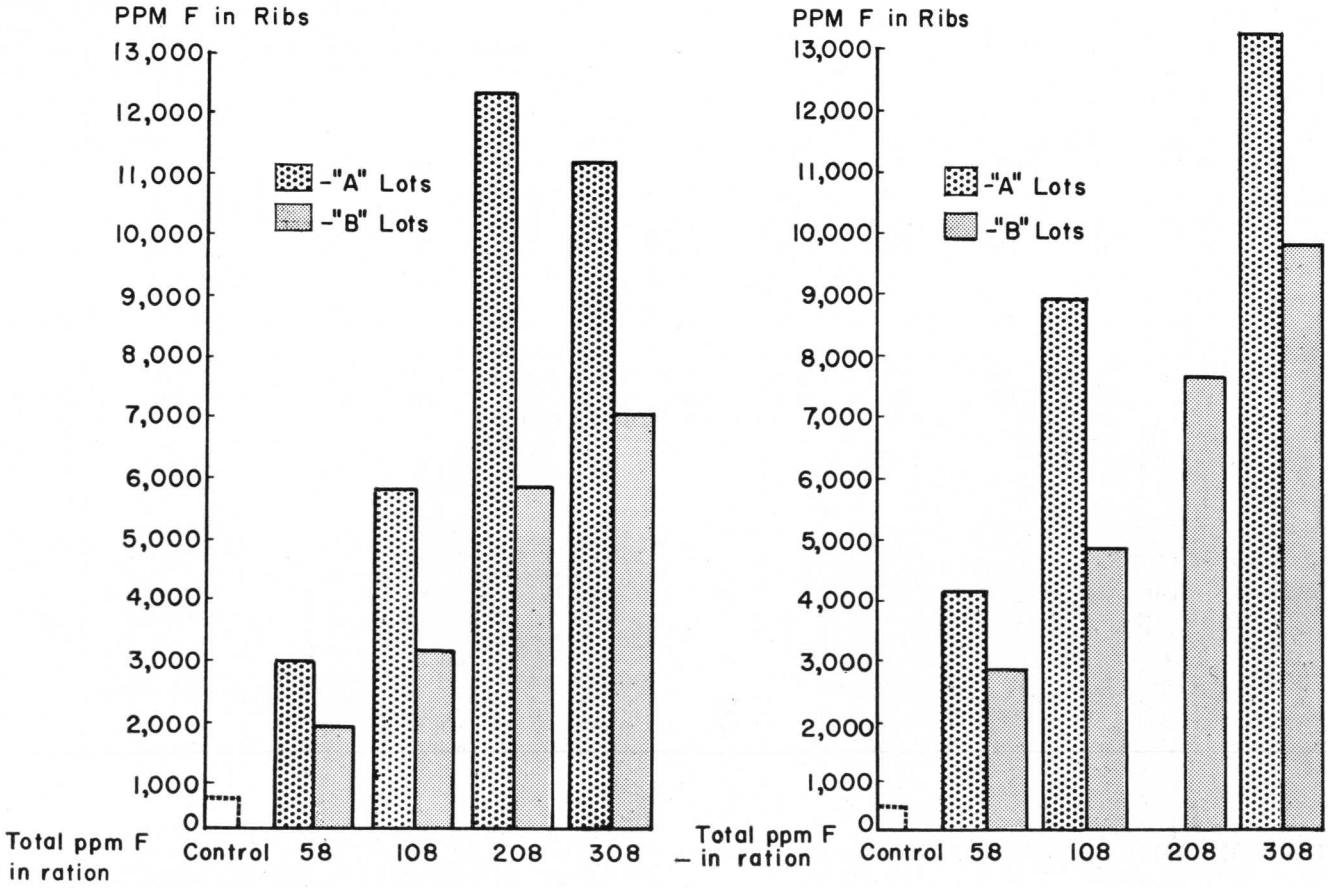



**Figure 1.—Fluorine content of ribs of cows fed identical levels of F from NaF and RRP. (Left figure represents bone F levels after 12 months and right figure those after 24 months of test).**

average daily gain than the two calves in Lot 44B or the calves in any of the other lots. Except for this possible manifestation of the effect of F from NaF, there seemed to be no definite differences in daily calf gains attributable to level and source of F for lots 41A through 44B.

**Fluorine Content of Bones.** The F content of ribs collected at biopsy or autopsy 12, 24, and 32 months after the initiation of the experiment is shown in Table 33. It will be noted that, for each source of F fed, the F content of the rib tended to increase with increased F ingested and the time on test.

The F content of the ribs of cows ingesting F from RRP was 21 to 52 percent less than F content of ribs of cows ingesting similar levels as NaF. These differences in F content in the ribs were significant at F levels in the ration above 50 ppm F added. Figure 1 gives a comparison of F content of ribs of cows fed identical levels of F from NaF and RRP.

**Gross Changes in Bones and Other Tissue.** Table 34 shows the number of times changes in mandibles, metatarsals (rear shanks) and ribs could be seen or palpated in the living animals after 12 and 24 months on test. One jaw (mandible) which showed enlargement was that of Cow 40–3 (con-

TABLE 34.—DETECTABLE ANTE MORTEM CHANGES IN COWS, LOTS 40–45B ON 4–14–54 AND 2–3–55

| Lot no. | Total F in ration ppm | No. cows palpated | Date palpated | Rami of mandibles | Meta-tarsals | Ribs |
|---|---|---|---|---|---|---|
| 40 | 8 | 3 | 4–14–54 | 1 | 0 | 0 |
| | | | 2–3–55 | 1 | 0 | 0 |
| 41A | 58 | 2 | '54 | 0 | 0 | 1 |
| | | | '55 | 2 | 0 | 1 |
| 41B | 58 | 2 | '54 | 0 | 0 | 0 |
| | | | '55 | 1 | 0 | 0 |
| 42A | 108 | 1 | '54 | 1 | 1 | 0 |
| | | | '55 | 1[a] | 1 | 1 |
| 42B | 108 | 1 | '54 | 0 | 0 | 0 |
| | | | '55 | 0 | 1 | 1 |
| 43B | 208 | 1 | '54 | 1[a] | 0 | 0 |
| | | | '55 | 1[a] | 0 | 0 |
| 44A | 308 | 2 | '54 | 2 | 2 | 0 |
| | | | '55 | 2 | 2 | 1 |
| 44B | 308 | 2 | '54 | 2 | 2 | 0 |
| | | | '55 | 1[a] | 2 | 1 |
| 45B | 608 | 1 | '54 | 1 | 1 | 0 |
| | | | '55 | 1 | 1 | 0 |

[a] Called "Suspected."

TABLE 35.—BLOOD CONSTITUENTS OF COWS, LOTS 40–45B

| Lot no. | F added in ration ppm | No. animals | Whole Blood | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | RBC (Millions per Cmm.) [a] | WBC (Cmm.) [a] | Hemoglobin gms./(100 ml.) [a] | Cell volume percent [a] | Sedimentation rate | Specific gravity [b] | NPN (mgs./100 ml.)[c] | Glucose [b] |
| 40 | 0 | 3 | 7.9 | 8,318 | 13.69 | 37.6 | 2.04 | 1.060 | 30.59 | 65.10 |
| 41A | 50 NaF | 2 | 7.9 | 9,461 | 13.36 | 37.7 | 1.83 | 1.059 | 27.28 | 75.27 |
| 41B | 50 RRP | 2 | 8.7 | 8,972 | 14.58 | 41.3 | 1.83 | 1.062 | 29.68 | 68.17 |
| 42A | 100 NaF | 1 | 7.4 | 8,530 | 12.07 | 33.8 | 2.25 | 1.055 | 26.33 | 63.90 |
| 42B | 100 RRP | 1 | 7.9 | 7,862 | 15.48 | 41.9 | 1.75 | 1.062 | 29.98 | 83.86 |
| 43A | 200 NaF | 1 | 8.2 | 10,100 | 11.44 | 32.2 | — | 1.054 | 27.54 | 63.25 |
| 43B | 200 RRP | 1 | 8.5 | 10,180 | 12.91 | 36.3 | 1.75 | 1.056 | 27.85 | 61.38 |
| 44A | 300 NaF | 2 | 8.4 | 7,450 | 13.54 | 36.8 | 2.06 | 1.058 | 29.88 | 74.08 |
| 44B | 300 RRP | 2 | 7.6 | 11,720 | 12.53 | 34.0 | 2.19 | 1.056 | 29.04 | 65.04 |
| 45A | 600 NaF | 1 [d] | | | | | | | | |
| 45B | 600 RRP | 1 | 8.7 | 9,988 | 12.05 | 34.4 | 2.12 | 1.055 | 27.64 | 61.31 |

(Table 35—Continued next page)

TABLE 35.—(CONTINUED FROM PAGE 142)

| Lot no. | F added in ration ppm | No. animals | Differentials [e] Eosinophils percent | Basophils percent | Lymphocytes percent | Monocytes percent | Neutrophils percent | Plasma [c] Specific gravity | Serum [a] Calcium (mgs./100 ml.) | Phosphorus (mgs./100 ml.) | Magnesium (mgs./100 ml.) |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 40 | 0 | 3 | 6.0 | 0.0 | 56.7 | 11.7 | 25.7 | 1.031 | 9.6 | 6.9 | 2.4 |
| 41A | 50 NaF | 2 | 7.0 | 0.5 | 57.5 | 9.5 | 25.5 | 1.030 | 10.0 | 7.5 | 2.2 |
| 41B | 50 RRP | 2 | 6.0 | 0.5 | 44.0 | 17.0 | 32.5 | 1.031 | 9.8 | 7.4 | 2.4 |
| 42A | 100 NaF | 1 | 0.0 | 0.0 | 70.0 | 20.0 | 10.0 | 1.029 | 9.5 | 7.3 | 2.6 |
| 42B | 100 RRP | 1 | 7.0 | 0.0 | 47.0 | 9.0 | 37.0 | 1.029 | 10.3 | 6.7 | 2.4 |
| 43A | 200 NaF | 1 | 3.0 | 0.0 | 60.0 | 7.0 | 30.0 | 1.029 | 9.1 | 9.0 | 2.7 |
| 43B | 200 RRP | 1 | 6.0 | 0.0 | 61.0 | 16.0 | 17.0 | 1.028 | 10.1 | 7.9 | 2.3 |
| 44A | 300 NaF | 2 | 14.5 | 0.0 | 56.5 | 11.0 | 18.0 | 1.030 | 9.2 | 8.4 | 2.5 |
| 44B | 300 RRP | 2 | 0.5 | 0.0 | 67.5 | 7.0 | 25.0 | 1.030 | 9.3 | 7.8 | 2.3 |
| 45A | 600 NaF | 1 | | | | | | | | | |
| 45B | 600 RRP | 1 | 6.0 | 0.0 | 64.0 | 13.0 | 17.0 | 1.029 | 9.7 | 8.1 | 2.5 |

[a] Represents average of five determinations.
[b] Represents average of four determinations.
[c] Represents average of eight determinations.
[d] This animal died after 191 days of experiment.
[e] Made on 2–5–54.

trol) and was found at autopsy to be as large as that of the mandible of any animal in Lots 41A or 41B. This emphasizes the inaccuracies which individual variations in size and conformation may cause in palpation for bone changes. Palpable lesions became quite definite at F levels of 100 ppm and above from NaF, and at 300 ppm and above from RRP.

Autopsies were conducted on all cows to detect changes in bone and other tissue. Cows in Lot 45A, 45B, and 43A died or were killed before the scheduled end of the experiment. Cows in all other lots were killed in May or June, 1955.

Gross examinations of the various organs showed no changes due directly to ingestion of F. The extreme emaciation of Cow 45A was comparable to that of a starving animal.

Bone changes were those of hypertrophy or "overgrowth," in which excess bone was built up, usually in smooth layers, upon the bone shafts. This overgrowth could best be observed on metatarsals (rear shanks), metacarpals (fore shanks), and mandibles (lower jaw). There were no signs of hypertrophy in the control cattle, or in those consuming F from either source at levels of 50 ppm in the ration. Metatarsals and mandibles of the cows consuming rations of 100 ppm F had similar degrees of hypertrophy regardless of source of F. However, the metacarpals of only the cow on NaF showed definite bone overgrowth. F from either source caused marked bone hypertrophy in cows ingesting 300 ppm; the metatarsals were approximately twice normal diameter. Hypertrophy of bone was marked in the two cows on the 600 ppm F level. Data are shown for only one cow in Table 34; the other cow died in 1953. There was a difference in pattern of bone overgrowth between the two cows probably due to the great difference in periods during which each was ingesting fluorine.

**Blood.** There was no marked variations between animals for some blood components or properties as shown in Table 35. All values for eryth-

TABLE 36.—FLUORINE CONTENT OF URINE OF COWS, LOTS 40, 41A–B, AND 44A–B

| Hours after ingestion | Control | 50 ppm F | | Difference,[a] percent | 300 ppm F | | Difference,[a] percent |
|---|---|---|---|---|---|---|---|
| | ppm F | NaF | RRP | | NaF | RRP | |
| 2 | 4 | 27 | 18 | 33 | 70 | 25 | 64 |
| 6 | 4 | 22 | 14 | 36 | 65 | 38 | 41 |
| 10 | 5 | 20 | 15 | 25 | 52 | 31 | 40 |
| 16 | 4 | 19 | 15 | 21 | 43 | 24 | 44 |
| 24 | 4 | 13 | 4 | 69 | 32 | 22 | 31 |

[a] Based on F content of urine from sodium fluoride group.

rocyte, total leucocyte, sedimentation rate, non-protein nitrogen, serum calcium and serum phosphorus (inorganic) and magnesium values were within normal ranges reported by Coffin (1953) and Dukes (1955). Values for hemoglobin were slightly elevated for Lot 42B (1 cow, 100 ppm F), but normal for all others, while hematocrit values were slightly elevated for Lots 42B and 41B (100 and 50 ppm F, respectively).

Specific gravity of whole blood was slightly elevated in the case of Lots 40, 41B, and 42B. In Lots 41A, 42B and 44A, blood glucose levels appeared to be slightly elevated.

The monocyte count was high and neutrophil and eosinophil counts were exceptionally low for Lot 42A. The monocyte count in Lots 41B and 43B were slightly elevated.

**Urinary Fluorine.** The data presented in Table 36 show the F content of urine samples collected at intervals of 2, 6, 10, 16 and 24 hours following ingestion of RRP or NaF. These samples were obtained from cows in Lots 40, 41A and B, and 44A and B. Urinary levels of F for control animals ranged from 4 to 5 ppm. The urinary F content for the animals on each F source was directly related to the level being ingested. Highest observed values were 70 ppm in urine of cows ingesting F from NaF at a level of 300 ppm.

The peak urinary F content was reached two to four hours following ingestion, after which the content gradually decreased until the next feeding. Urinary F from cows on RRP was 21 to 69 percent less than the urinary F values for cattle on comparable levels of F from NaF. This reduction in urinary F of the RRP groups is attributed to the insolubility of RRP.

## Teeth

Following herewith are pictures of incisor teeth of representative cattle and descriptions of incisor, premolar and molar teeth.

The indexes of incisor teeth condition are shown in Table 37. The average index for each lot is an average of average classifications for all pairs of permanent incisors within that lot. As in Experiments I and II, an increase in numerical index indicates an increase in F effects upon teeth.

Fluorine levels of 108 ppm or less in the ration were not sufficient to cause marked effects upon the central incisors. These teeth were already being formed at the beginning of the experiment. However, F levels in the ration of 208 ppm and above caused marked enamel defects in the central incisors even though, at the start of the experiment, those teeth were in stages of development comparable to those for central incisors of cattle in Lots 40 to 42.

In Lots 41 and 42, consuming F at levels of 58 and 108 ppm, respectively, the indexes of incisor teeth condition were lower for the cattle consuming F from RRP than for those consuming NaF. Since Cow 43A (200

TABLE 37.—INDEX OF INCISOR TEETH CONDITION AND RANGE OF TEETH CLASSIFICATION, LOTS 40–45B

| Lot no. | Total F in ration ppm | Index of incisor teeth condition | | | | | Classification range |
|---|---|---|---|---|---|---|---|
| | | Centrals | Intermediates | Laterals | Corners | Av. | |
| 40 | 8 | 0.4 | 1.1 | 0.1 | 0.0 | 0.4 | 1A–2 |
| 41A | 58 NaF | 1.0 | 3.8 | 4.0 | 4.5 | 3.3 | 1A–5B |
| 41B | 58 RRP | 0.3 | 2.2 | 2.4 | 5.0 | 2.5 | 1A–5A |
| 42A | 108 NaF | 0.4 | 5.7 | 5.9 | 6.0 | 4.5 | 1A–5C |
| 42B | 108 RRP | 1.1 | 4.2 | 3.0 | 4.4 | 3.1 | 1A–5A |
| 43A [a] | 208 NaF | 2.8 | 4.3 | T [b] | T | | 2 –5B |
| 43B | 208 RRP | 3.3 | 5.4 | 5.7 | 5.0 | 4.8 | 2 –5B |
| 44A | 308 NaF | 3.1 | 6.4 | 7.0 | T | 5.5 | 2 –5C |
| 44B | 308 RRP | 3.4 | 5.8 | 6.2 | 5.5 | 5.2 | 2 –5C |
| 45A | 608 NaF | Died before teeth erupted | | | | | |
| 45B | 608 RRP | 2.4 | 6.2 | 7.0 | 7.0 | 5.6 | 2 –5C |

[a] Cow sacrificed after 573 days of experiment.
[b] T = Temporary teeth.

ppm F) died before the last two pairs of incisors erupted, no comparison can be made for that treatment.

Thus, when F levels in the ration were 100 ppm or less, NaF caused more marked effects upon teeth than did RRP. However, differences in effects of the two sources upon teeth tended to disappear when F levels in the ration were 300 ppm or above.

### LOT NO. 41A (58 ppm F – NaF)

**ANIMAL NO. 41–2**

CENTRALS: *Caps*—chipped medium on left and slight on right; *Luster*—fair to good; *Chalkiness*—heavy diffuse and focal with slight porcelain; *Staining*—heavy to excessive light brown; *Wear*—normal; *Classification*—2.

INTERMEDIATES: *Luster*—poor; *Chalkiness*—excessive diffuse; *Staining*—excessive brown with black foci; *Enamel hypoplasia*—suspected; *Caries and erosions*—multiple, black stained foci, apparently carious or pre-carious; *Wear*—(left) normal, (right) slight; *Classification*—4.

LATERALS: *Luster*—poor; *Chalkiness*—excessive diffuse; *Staining*—excessive brown with black foci; *Enamel hypoplasia*—slight to medium; *Caries and erosions*—multiple black-stained carious or pre-carious foci; *Wear*—not yet in full wear; *Classification*—5A.

CORNERS: Temporary.

PREMOLARS AND MOLARS: First Pairs: *Staining*—brown. Second Pairs: *Staining*—brown; *Wear*—slight. Third Pairs: *Staining*—light brown. Fourth and Fifth Pairs: Normal. Sixth Pairs: *Staining*—light brown; *Wear*—(uppers) medium and (lowers) normal to slight.

**LOT NO. 41B (58 ppm F – RRP)**

**ANIMAL NO. 41–5**

CENTRALS: *Cap*—(right) slight chip; *Luster*—good; *Wear*—normal; *Classification*—1A.

INTERMEDIATES: *Cap*—(right) slight chip; *Luster*—good; *Chalkiness*—medium cross and slight diffuse; *Staining*—slight light brown; *Wear*—normal; *Classification*—2.

LATERALS: *Luster*—poor to fair; *Chalkiness*—excessive diffuse; *Staining*—medium brown; *Wear*—slight; *Classification*—2.

CORNERS: *Luster*—poor; *Chalkiness*—excessive, *Staining*—excessive brown and black; *Enamel hypoplasia*—slight pit type; *Caries and erosions*—black-stained superficial erosions and (right) carious foci; *Wear*—not yet in full wear; *Classification*—4 to 5A.

PREMOLARS AND MOLARS: Normal stain and wear.

**LOT NO. 42A (108 ppm F – NaF)**

**ANIMAL NO. 42A**

CENTRALS: *Luster*—good; *Chalkiness*—medium to heavy cross; *Staining*—(right) slight discoloration at cap, (both) medium vegetative; *Wear*—normal; *Classification*—1B.

INTERMEDIATES: *Caps*—uneven; *Luster*—poor; *Chalkiness*—excessive diffuse; *Staining*—excessive brown; *Enamel hypoplasia*—medium to heavy pit and patch; *Wear*—slight and uneven; *Classification*—5B.

LATERALS: *Luster*—poor; *Chalkiness*—excessive and diffuse; *Staining*—excessive brown; *Enamel hypoplasia*—heavy patch type; *Wear*—medium to heavy; *Classification*—5B.

CORNERS: *Luster*—poor; *Chalkiness*—excessive diffuse; *Staining*—excessive brown; *Enamel hypoplasia*—heavy patch type; *Wear*—apparently slight, but tooth not yet in full wear; *Classification*—5B.

PREMOLARS AND MOLARS: First Pairs: *Staining*—brown; *Wear*—slight. Second Pairs: *Staining*—brown; *Wear*—heavy to excessive. Third and Sixth Pairs: *Staining*—brown; *Wear*—heavy. Fourth and Fifth Pairs: Normal.

**LOT NO. 42B (108 ppm F – RRP)**

**ANIMAL NO. 42B**

CENTRALS: *Luster*—good; *Chalkiness*—slight focal; *Staining*—slight, light brown; *Wear*—normal; *Classification*—1B to 2.



**LOT NO. 41A**

**Control Ration + 50 ppm Fluorine added as NaF (Total F = 58 ppm)**

**Cow No. 41–2**
**Photographed Feb., 1955**



**LOT NO. 41B**

**Control Ration + 50 ppm Fluorine added as RRP (Total F = 58 ppm)**

**Cow No. 41–5**
**Photographed Feb., 1955**



**LOT NO. 42A**

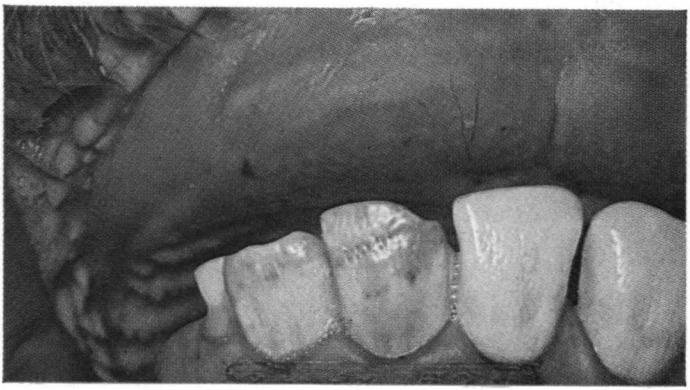
**Control Ration + 100 ppm Fluorine added as NaF (Total F = 108 ppm)**

**Cow No. 42A**
**Photographed Feb., 1955**

**LOT NO. 42B**

**Control Ration + 100 ppm Fluorine added as RRP (Total F = 108 ppm)**

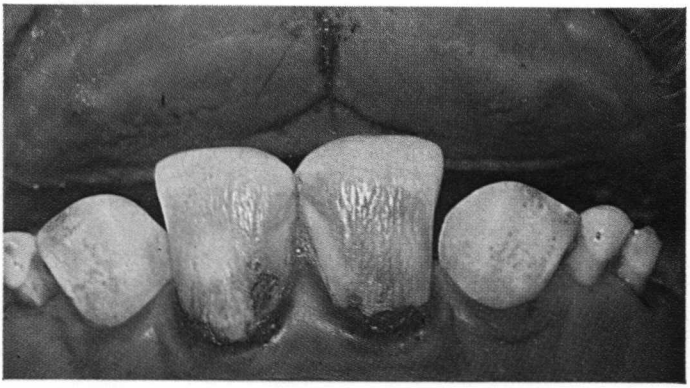
**Cow No. 42B Photographed Sept., 1954**



**LOT NO. 43A**

**Control Ration + 200 ppm Fluorine added as NaF (Total F = 208 ppm)**

**Cow No. 43A Photographed Jan., 1954**



**LOT NO. 43B**

**Control Ration + 200 ppm Fluorine added as RRP (Total F = 208 ppm)**

**Cow No. 43B Photographed Feb., 1955**



INTERMEDIATES: *Caps*—uneven; *Luster*—fair to good; *Chalkiness*—diffuse; *Staining*—excessive light brown with darker foci; *Enamel hypoplasia*—suspected with shallow pits; *Caries and erosions*—carious foci centrally; *Wear*—normal to slight and uneven; *Classification*—4.

LATERALS: *Cap*—(right) slight chip; *Luster*—poor; *Chalkiness*—heavy cross and diffuse; *Staining*—excessive light brown, darker near cap; *Enamel hypoplasia*—suspected; *Wear*—not in full wear; *Classification*—4.

CORNERS: Temporary.

PREMOLARS AND MOLARS: First and Third Pairs: *Staining*—light brown. Second Pairs: *Staining*—brown; *Wear*—(uppers) heavy. Fourth and Fifth Pairs: normal. Sixth Pairs: *Staining*—brown, *Wear*—medium.

## LOT NO. 43A (208 ppm F – NaF)

### ANIMAL NO. 43A

CENTRALS: *Luster*—poor to fair in lower ⅔, good at cap; *Chalkiness*—medium to heavy cross and diffuse; *Staining*—excessive brown with black areas near root; *Caries and erosions*—erosions near gum line; *Wear*—normal; *Classification*—3.

INTERMEDIATES: *Luster*—poor to fair; *Chalkiness*—excessive diffuse; *Staining*—excessive light brown with darker areas; *Enamel hypoplasia*—heavy shell type; *Wear*—not in full wear; *Classification*—5B.

LATERALS AND CORNERS: Temporary. (Cow died in 1954 at calving)

PREMOLARS AND MOLARS: First Pairs: *Staining*—light brown; *Wear*—slight. Second and Third Pairs: (uppers) temporary, (lowers) *Staining*—brown; *Wear*—slight to medium. Fourth and Fifth Pairs: normal. Sixth Pairs: not erupted sufficiently for examination.

## LOT NO. 43B (208 ppm F – RRP)

### ANIMAL NO. 43B

CENTRALS: *Cap*—(left) slight chips; *Luster*—fair to good; *Chalkiness*—heavy cross, focal and diffuse; *Staining*—slight, light brown; *Enamel hypoplasia*—suspected to slight with shallow pits in lower ¼; *Caries* and *Erosions*—brown-stained precarious foci; *Wear*—normal; *Classification*—4.

INTERMEDIATES: *Caps*—uneven; *Luster*—poor; *Chalkiness*—excessive diffuse; *Staining*—excessive light brown with darker foci and areas; *Enamel hypoplasia*—medium patch; *Caries and erosions*—brown-stained carious foci on both; *Wear*—medium and uneven; *Classification*—5A to 5B.

LATERALS: *Luster*—poor; *Chalkiness*—excessive diffuse; *Staining*—excessive light brown; *Enamel hypoplasia*—medium patch; *Wear*—slight; *Classification*—5A to 5B.

CORNERS: *Luster*—poor; *Chalkiness*—excessive diffuse; *Staining*—exces-

**LOT NO. 44A**

**Control Ration + 300 ppm Fluorine added as NaF (Total F = 308 ppm)**

**Cow No. 44–2 Photographed Feb., 1955**



**LOT NO. 44B**

**Control Ration + 300 ppm Fluorine added as RRP (Total F = 308 ppm)**

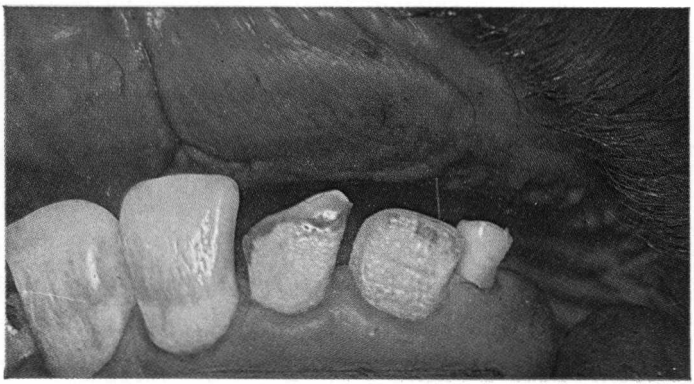
**Cow No. 44–4 Photographed Feb., 1955**



**LOT NO. 45B**

**Control Ration +600 ppm Fluorine added as RRP (Total F = 608 ppm)**

**Cow No. 45-B Photographed Sept., 1954**



sive light brown with darker foci; *Enamel hypoplasia*—medium; *Wear*—slight; *Classification*—5A to 5B.

PREMOLARS AND MOLARS: First Pairs: *Staining*—light brown. Second Pairs: *Staining*—light brown; *Wear*—slight. Third Pairs: *Staining*—brown; *Wear*—(uppers) normal to slight and (lowers) medium to heavy. Fourth and Fifth Pairs: Normal. Sixth Pairs: *Staining*—brown; *Wear*—(uppers) medium to excessive and uneven and (lowers) heavy.

### LOT NO. 44A (308 ppm F – NaF)

**ANIMAL NO. 44–2**

CENTRALS: *Luster*—good in upper ⅓ and poor in lower ⅔; *Chalkiness*—cross and porcelain in upper ⅓ and diffuse in lower ⅔; *Staining*—excessive brown and black in lower ⅔; *Caries and erosions*—black-stained erosions in lower ½; *Wear*—normal; *Classification*—3.

INTERMEDIATES: *Cap*—uneven; *Luster*—poor; *Chalkiness*—excessive diffuse; *Staining*—excessive light brown; *Enamel hypoplasia*—heavy to excessive; *Tooth hypoplasia*—medium; *Wear*—heavy; *Other*—(left) pulp cavity partly open; *Classification*—5C.

LATERALS: *Luster*—poor; *Chalkiness*—excessive diffuse; *Enamel hypoplasia*—heavy to excessive; *Tooth hypoplasia*—slight; *Wear*—slight to medium; *Classification*—5C.

CORNERS: Temporary.

PREMOLARS AND MOLARS: First Pairs: *Staining*—light brown; *Wear*—normal to slight. Second Pairs: *Staining*—brown; *Wear*—(uppers) medium and (lowers) slight. Third Pairs: *Staining*—light brown; *Wear*—slight to medium. Fourth and Fifth Pairs: Normal. Sixth Pairs: *Staining*—brown; *Wear*—excessive.

### LOT NO. 44B (308 ppm F – RRP)

**ANIMAL NO. 44–4**

CENTRALS: *Luster*—fair to good; *Chalkiness*—cross near cap, excessive diffuse in lower ⅔; *Staining*—heavy light brown with brown and black foci; *Enamel hypoplasia*—suspected to slight with shallow pits in lower ½; *Caries and erosions*—brown-stained caries and black areas of erosion centrally; *Wear*—normal; *Classification*—4.

INTERMEDIATES: *Luster*—poor; *Chalkiness*—excessive diffuse; *Staining*—excessive light brown; *Enamel hypoplasia*—heavy patch; *Tooth hypoplasia*—slight to medium; *Wear*—medium; *Classification*—5B to 5C.

LATERALS: *Luster*—poor; *Chalkiness*—excessive diffuse; *Enamel hypoplasia*—heavy patch; *Tooth hypoplasia*—suspected; *Wear*—slight; *Classification*—5B to 5C.

CORNERS: *Luster*—poor; *Chalkiness*—excessive diffuse; *Staining*—excessive light brown; *Enamel hypoplasia*—heavy; *Tooth hypoplasia*—suspected to slight; *Wear*—apparently slight, but not yet in full wear.

PREMOLARS AND MOLARS: First Pairs: *Staining*—brown, *Wear*—(uppers) slight. Second Pairs: *Staining*—brown; *Wear*—(uppers) medium to heavy and uneven and (lowers) slight. Third Pairs: *Staining*—brown; *Wear*—(uppers) normal to slight and (lowers) medium. Fourth and Fifth Pairs: Normal. Sixth Pairs: *Staining*—brown, *Wear*—uneven.

### LOT NO. 45A (608 ppm F – NaF)

**ANIMAL NO. 45A**

Died before eruption of permanent teeth.

### LOT NO. 45B (608 ppm F – RRP)

**ANIMAL NO. 45B**

CENTRALS: *Luster*—good; *Chalkiness*—heavy cross and diffuse; *Staining*—medium light brown; *Wear*—normal; *Classification*—2 (called 2 on 6 readings and 4 on one).

INTERMEDIATES: *Caps*—uneven and chipped; *Luster*—poor to fair; *Chalkiness*—excessive diffuse; *Staining*—excessive light brown with dark brown at caps; *Enamel hypoplasia*—heavy; *Tooth hypoplasia*—slight to medium; *Caries and erosions*—worn erosions near caps; *Wear*—medium to heavy and uneven; *Classification*—5B to 5C.

LATERALS: *Luster*—poor to fair; *Chalkiness*—excessive diffuse; *Staining*—excessive light brown; *Enamel hypoplasia*—heavy to excessive shell and patch; *Tooth hypoplasia*—slight; *Caries and erosions*—(left) eroded area at cap; *Wear*—slight to medium; *Classification*—5C.

CORNERS: Temporary

PREMOLARS AND MOLARS: FIRST PAIRS: *Staining*—brown. SECOND and Third Pairs: *Staining*—brown; *Wear*—medium to heavy. Fourth and Fifth Pairs: Normal. Sixth Pairs: *Staining*—brown; *Wear*—(uppers) excessive and (lowers) heavy.

## Summary

The effects upon cattle of various levels of fluorine (F) from sodium fluoride (NaF) were compared with the effects of similar levels of F from raw rock phosphate (RRP). The RRP and NaF were added to the concentrate mixture at specified levels. Seventeen grade Hereford heifers were allotted and fed individually as follows:

Control ration 8 ppm F (3 heifers)

Control ration plus 50 parts per million (ppm) F as NaF (2 heifers)
Control ration plus 50 ppm F as RRP (2 heifers)

" " " 100 ppm F as NaF (1 heifer)
" " " 100 ppm F as RRP (1 heifer)

Control ration plus 200 ppm F as NaF (1 heifer)
" " " 200 ppm F as RRP (1 heifer)

" " " 300 ppm F as NaF (2 heifers)
" " " 300 ppm F as RRP (2 heifers)

" " " 600 ppm F as NaF (1 heifer)
" " " 600 ppm F as RRP (1 heifer)

The test continued for 32 months.

**Feed Consumption.** The feed consumption of Cow 45A fed 600 ppm F as NaF decreased markedly within 40 days. The animal refused nearly all feed and died in 191 days. Cow 45B on a comparable level of F as RRP, remained on experiment more than two years. At levels of 200 and 300 ppm F in the ration from NaF, feed consumption was significantly less ($P < 0.05$) than for controls or for cows fed up to 100 ppm F as NaF, or for cows fed up to 200 ppm F as RRP. There were no significant differences among cows consuming up to 100 ppm F as NaF or up to 200 ppm F as RRP.

**Weights and Gains.** Cows ingesting F from NaF at levels up to 100 ppm and from RRP at levels up to 600 ppm did not have appreciably lower weight gains than the control cattle. At levels of 200, 300 and 600 ppm F from NaF weight gains were less than for controls.

**Reproduction and Calf Records.** There were no differences in reproduction due to F from either source. Daily gains were appreciably lower for the calf whose dam consumed F from NaF at levels of 300 ppm in the ration.

**Fluorine Concentration and Gross Changes in Bones.** After 12, 24 and 33 months on test, rib fluorine concentrations for the cows consuming rations with comparable concentrations of F from RRP were 21 percent to 52 percent less than for cows consuming rations with comparable levels of F from NaF. These reductions were highly significant and occurred at each level of F intake, except for Lots 41A and 41B (50 ppm F) in 1953 and 1955.

Examination of the cattle at slaughter showed no gross changes in bones from cows fed F from either source at 50 ppm F in the ration. At 100 ppm F in the ration, the cow fed NaF had somewhat more gross bone change than the cow on RRP. Levels of 300 to 600 ppm in the ration caused marked bone changes with no apparent differences due to source of F.

**Blood.** Neither the level of F intake nor the source of F caused appreciable or consistent differences in concentration of minerals or cells in the blood.

**Urinary Fluorine.** Detailed studies with the four animals consuming F at 50 ppm and the four consuming F at 300 ppm revealed that cows receiv-

ing RRP had from 21 percent to 69 percent lower F concentrations in urine than did cows ingesting comparable levels of F as NaF.

**Teeth.** F in the ration as NaF appeared to cause more teeth effects than F as RRP at levels of 50 to 100 ppm. At levels greater than this, the effects were similar for the two sources.

## EXPERIMENT V—LOTS 51–56

When cattle have consumed large amounts of fluorine (F) from either pasture or feed over any given period and then are moved to a normal F area or are given feed which has a normal F content these questions are raised: Did the increased F ingestion injure the animal, and if so, to what extent? What are the effects of short-term ingestion of excessive amounts of fluorine?

This information is needed, for example, in areas where excessive amounts of F have escaped from a manufacturing or processing plant and settled upon vegetation of the surrounding area; and where subsequently the plant applied measures to prevent the escape of excessive amounts of F.

### Objectives

This experiment was designed to: (1) Determine the effects upon cows of grazing for a limited period on pastures contaminated by F from an aluminum smelting plant; and (2) Observe the recovery of these animals from F effects when they were removed from the contaminated pasture at various intervals from approximately 100 to 800 days and placed on a control pasture.

The several phases of this experiment include observations from July, 1951, to Fall, 1958, of effects on:

1. Feed consumption.
2. Weights and gains.
3. Reproduction of cows, and calf records.
4. Bones, including F storage in bones of cows and calves, and gross changes of bones from cows.
5. Urinary fluorine.
6. Teeth, descriptions and classifications.

### Experimental Procedure

Grade Hereford heifers approximately 16 to 20 months of age, purchased in Texas in the spring of 1951, were allotted into six lots on the bases of weight, type grade, and condition, July 22, 1951.

The lots, number of animals per lot, days on control pastures and on F contaminated pastures ($B_3$) are shown in Table 38.

TABLE 38.—PLAN OF EXPERIMENT V, LOTS 51–56

| Lot no. | No. of cows | | Date moved from $B_3$ pasture to control pasture | Days on | |
|---|---|---|---|---|---|
| | Initial 7–22–51 | Fall 1958 | | $B_3$ pasture | Control pasture |
| 51 | 12 | 4 [a] | — | 0 | 2617 |
| 52 | 6 | 3 [b] | 11–2–51 | 102 | 2519 |
| 53 | 6 | 2 [c] | 2–16–52 | 209 | 2413 |
| 54 | 12 | 3 [d] | 9–4–52 | 409 | 2219 |
| 55 | 12 | 2 [e] | 4–22–53 | 639 | 1998 |
| 56 | 12 | 2 [f] | 11–6–53 | 837 | 1797 |

[a] Three animals sacrificed July, 1951; two, December, 1953; one, July, 1954; two, December, 1956.

[b] Three animals sacrificed November, 1951.

[c] Two animals sacrificed February, 1952; one died July, 1954; one died May, 1958.

[d] Two animals sacrificed September, 1952; three, April, 1953; two, December, 1953; one, July, 1954; one transferred to Lot 56, September, 1952.

[e] Three animals transferred to Lot 56, April, 1953; two sacrificed December, 1953; two, July, 1954; one, February, 1955; one, December, 1956; one died February, 1957.

[f] One animal sacrificed June, 1952; three, April, 1953; two, December, 1953; two, 1954; three, December, 1956; one died September, 1952, one, February, 1955, one, March, 1958.

The 12 heifers in the control lot (Lot 51) were taken directly to the control pastures which were out of the area of F contamination from industrial sources. Periodically, animals from the control pastures were slaughtered to supply bones for F analyses and study. These pastures were 16 miles south of an aluminum smelting plant.

The remaining lots, 52 through 56, were placed near the aluminum smelting plant on $B_3$ pastures which had the highest F concentration of any pasture available.

After 102 days on the contaminated pasture three cows in Lot 52 were slaughtered and bone analyses were made to determine the F content. The other three cows were moved to the control pasture.

After 209 days on $B_3$ pasture, two cows from Lot 53 were slaughtered. The remaining four animals were taken to the control pasture. Of these four, one died some two years, and one some six years, after being taken to the control pasture.

Four hundred and nine days after being placed on the contaminated pasture, two animals of Lot 54 were slaughtered and one transferred to Lot 56. The remaining nine cows were moved to the control pasture. Six of these were sacrificed between September, 1952, and July, 1954.

After 639 days on test, three cows in Lot 55 were transferred to Lot 56 and the remaining ones moved to the control pasture. While these were on the control fields, one died and six were sacrificed between April, 1953, and February, 1957.

Four cows of Lot 56 were slaughtered while that group was still on contaminated pasture. After 837 days on the contaminated pasture, two ad-

## TABLE 39.—FLUORINE CONTENT OF PASTURE GRASSES AND HAYS CONSUMED BY CATTLE, LOTS 51–56

| | Initial July 1951 to Oct. 1951 | Oct. 1951 to Apr. 1952 | Apr. 1952 to Oct. 1952 | Oct. 1952 to Apr. 1953 | Apr. 1953 to Oct. 1953 | Oct. 1953 to Apr. 1954 | Apr. 1954 to Oct. 1954 | Oct. 1954 to Apr. 1955 | Apr. 1955 to Oct. 1955 | Oct. 1955 to Apr. 1956 | Apr. 1956 to Oct. 1956 | Oct. 1956 to Apr. 1957 | Apr. 1957 to Oct. 1957 | Oct. 1957 to Apr. 1958 | Apr. 1958 to Fall 1958 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | ppm | ppm | ppm | ppm | ppm | ppm | ppm | ppm | ppm | ppm | ppm | ppm | ppm | ppm | ppm |
| Lot 51 | | | | | | | | | | | | | | | |
| Grass | 8.2 | 8.2 | 7.3 | 6.1 | 9.4 | 15.3 | 14.6 | | 12.6 | 7.0 | 5.7 | 22.4 | 14.1 | 14.0 | 15.0 |
| Hay | | 4.0 | | 2.0 | | 8.0 | | 10.0 | | 8.0 | | 10.0 | | 3.0 | |
| Lot 52 | | | | | | | | | | | | | | | |
| Grass | 473.6 | 410.0 [a] | Analyses same as Lot 51 from 11–2–51 to Fall 1958 | | | | | | | | | | | | |
| Hay | | 17.0 [a] | | | | | | | | | | | | | |
| Lot 53 | | | | | | | | | | | | | | | |
| Grass | 473.6 | 265.0 [b] | Analyses same as Lot 51 from 2–16–52 to Fall 1958 | | | | | | | | | | | | |
| Hay | | 17.0 [b] | | | | | | | | | | | | | |
| Lot 54 | | | | | | | | | | | | | | | |
| Grass | 473.6 | 161.8 | 37.9 [c] | Analyses same as Lot 51 from 9–4–52 to Fall 1958 | | | | | | | | | | | |
| Hay | | 17.0 | | | | | | | | | | | | | |
| Lot 55 | | | | | | | | | | | | | | | |
| Grass | 473.6 | 161.8 | 46.2 | 29.4 [d] | Analyses same as Lot 51 from 4–22–53 to Fall 1958 | | | | | | | | | | |
| Hay | | 17.0 | | 8.0 [d] | | | | | | | | | | | |
| Lot 56 | | | | | | | | | | | | | | | |
| Grass | 473.6 | 161.8 | 46.2 | 29.4 | 47.8 | 117.0 [e] | Analyses same as Lot 51 from 11–6–53 to Fall 1958 | | | | | | | | |
| Hay | | 17.0 | | 8.0 | | 8.0 [e] | | | | | | | | | |

[a] Moved to control pasture 11–2–51.
[b] " " " " 2–16–52.
[c] " " " " 9–4–52.
[d] " " " " 4–22–53.
[e] " " " " 11–6–53.

ditional cows were removed for slaughter and the remaining cows were moved to the control pasture. While these were on the control pasture, three died of various causes and five were slaughtered.

Hay but no concentrate was fed all cattle on pastures in the winter.

General management and methods concerning weighing, sampling, teeth examinations and pictures, rib biopsies, and autopsies were comparable to those of Experiments I, II, and IV. Urine samples for determination of F content were collected in July, 1954, from the cows on the control pasture. All cattle were removed to another control area on November 20, 1956. In order to measure the effects of earlier ingestion of F upon feed consumption, all cattle remaining in the test in October, 1957, were fed individually in a barn for 82 days. The animals were then kept on a control pasture until all were slaughtered in September and October, 1958.

## Results and Discussion

**Feed Consumption and F Content of Forage.** The fluorine (F) analyses of hays and pastures used in this experiment, shown in Table 39, ranged from 5.7 parts per million (ppm) to 22.4 ppm, for the control pasture; two to 10 ppm for control hay; 473.6 to 29 ppm for the contaminated pastures; 17 ppm for hay fed on the contaminated pastures for the first winter; 8 ppm for hay fed on contaminated pastures the second and third winters.

No differences in feed consumption among the remaining cattle were observed during the 82-day feeding period (Table 40).

TABLE 40.—INDIVIDUAL FEED CONSUMPTION OF LOTS 51–56, 82 DAYS, OCTOBER 24, 1957, TO JANUARY 13, 1958

| Lot no. | 51 | 52 | 53 | 54 | 55 | 56 |
|---|---|---|---|---|---|---|
| Av. daily hay | 18.74 | 18.66 | 18.71 | 18.62 | 18.72 | 18.51 |
| Av. daily concentrate | 2.00 | 2.00 | 2.00 | 2.00 | 2.00 | 2.00 |

**Weights and Gains.** The average weights and average daily gains by number of calves raised are shown in Table 41. There were no significant differences among the results of various treatments.

**Reproduction and Calf Records.** The number of calves born and raised and the average daily gains of calves are shown in Table 42. While the number of calves raised per lot varied, there were no appreciable differences between the lots. There was no appreciable difference between treatments in average daily gains of the calves.

**Fluorine Content of Bones.** The fluorine contents of metacarpal and metatarsal bones, mandibles, and ribs are shown in Table 43 with the total number of days on test represented by each sample. Response of rib F levels to treatment is shown in Figure 2. The high levels of F in the

## Table 41.—Weights and Gains of Cows, Lots 51–56 [a]

| Lot no. | Days on $B_3$ pasture | Av. initial weight 7–22–51 | Av. weight 11–2–51 | Av. weight 2–11–52 | Av. weight 9–4–52 | Av. weight 4–22–53 | Av. weight 10–28–53 | Av. weight 11–17–54 | Av. weight 10–12–55 | Av. weight 11–20–56 | Av. weight 10–8–57 | Av. weight Sept.–Oct. 1958 | Av. daily gain of cows at end of test by number of calves raised 4 | 5 | 6 | 7 | 8 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 51 | 0 | 575 | — | 724 | 832 | 939 | 1014 | 1104 | 1052 | 1177 | 1151 | 1274 | | | .32(2) | | .27(2) [b] |
| 52 | 102 | 558 | 609 | 692 | 785 | 944 | 1013 | 1016 | 968 | 1038 | 1063 | 1182 | | | .28(1) | .21(2) | |
| 53 | 209 | 550 | 594 | 708 | 754 | 849 | 892 | 919 | 913 | 1042 | 1038 | 1135 | | | | .22(2) | |
| 54 | 409 | 554 | 602 | 708 | 784 | 852 | 934 | 956 | 970 | 1095 | 1077 | 1248 | .24(1) | | .33(1) | .21(1) | |
| 55 | 639 | 558 | 604 | 721 | 763 | — | 1009 | 1008 | 932 | 1115 | 1002 | 1180 | | | | .20(2) | |
| 56 | 837 | 548 | 594 | 712 | 784 | — | 923 | 967 | 945 | 1049 | 1065 | 1108 | | .25(1) | | .21(1) | |

[a] See Table 38 for disposition of animals.
[b] One cow had twins.
[c] Number in parentheses refers to number of cows that raised the number of calves shown.

TABLE 42.—REPRODUCTION AND CALVING RECORDS OF COWS, LOTS 51–56 [a]

| Lot no. | Days on $B_3$ pasture | No. cows [b] | 1952 No. cows calving | 1952 Calves raised No. | 1952 Calves raised Av. daily [c] gain | 1953 No. cows calving | 1953 Calves raised No. | 1953 Calves raised Av. daily gain | 1954 No. cows calving | 1954 Calves raised No. | 1954 Calves raised Av. daily gain | 1955 No. cows calving | 1955 Calves raised No. | 1955 Calves raised Av. daily gain |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 51 | 0 | 4 | 2 | 2 | 1.73 | 4 | 4 | 2.08 | 4 | 4 | 1.85 | 4 | 4 | 1.69 |
| 52 | 102 | 3 | 3 | 2 | 1.72 | 3 | 2 | 1.94 | 3 | 3 | 1.88 | 3 | 2 | 1.65 |
| 53 | 209 | 3 | 3 | 3 | 1.82 | 3 | 3 | 1.93 | 3 | 3 | 1.85 | 3 | 3 | 1.48 |
| 54 | 409 | 3 | 1 | 1 | 1.74 | 3 | 2 | 2.13 | 3 | 2 | 1.79 | 2 | 2 | 1.59 |
| 55 | 639 | 3 | 3 | 3 | 1.89 | 2 | 2 | 1.98 | 3 | 3 | 1.87 | 3 | 3 | 1.39 |
| 56 | 837 | 3 | 2 | 2 | 1.81 | 3 | 3 | 2.15 | 3 | 3 | 1.77 | 2 | 1 | 1.42 |

| Lot no. | 1956 No. cows calving | 1956 Calves raised No. | 1956 Calves raised Av. daily gain | 1957 No. cows calving | 1957 Calves raised No. | 1957 Calves raised Av. daily gain | 1958 No. cows calving | 1958 Calves raised No. | 1958 Calves raised Av. daily gain | 1952–1958 No. cows calving | 1952–1958 Calves raised No. | 1952–1958 Calves raised Av. daily gain |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 51 | 4 | 4 | 1.84 | 4 | 4 | 1.94 | 4 | 4 | 2.33 | 26 | 26 | 1.94 |
| 52 | 3 | 3 | 1.85 | 3 | 3 | 1.72 | 2 | 2 | 2.52 | 20 | 17 | 1.88 |
| 53 | 3 | 3 | 1.73 | 3 | 3 | 1.91 | 2 | 2 | 2.24 | 20 | 20 | 1.83 |
| 54 | 2 | 2 | 1.93 | 3 | 3 | 2.01 | 3 | 3 | 2.41 | 17 | 15 | 1.99 |
| 55 | 2 | 2 | 1.78 | 3 | 2 | 1.81 | 2 | 2 | 2.06 | 18 | 17 | 1.81 |
| 56 | 3 | 3 | 2.05 | 3 | 2 | 2.02 | 3 | 3 | 2.18 | 19 | 17 | 1.97 |

[a] See Table 38 for disposition of animals.
[b] Includes only cows that remained in experiment from initial to 1958.
[c] All calf weights have been adjusted to a comparable basis for age, sex, and age of dam.

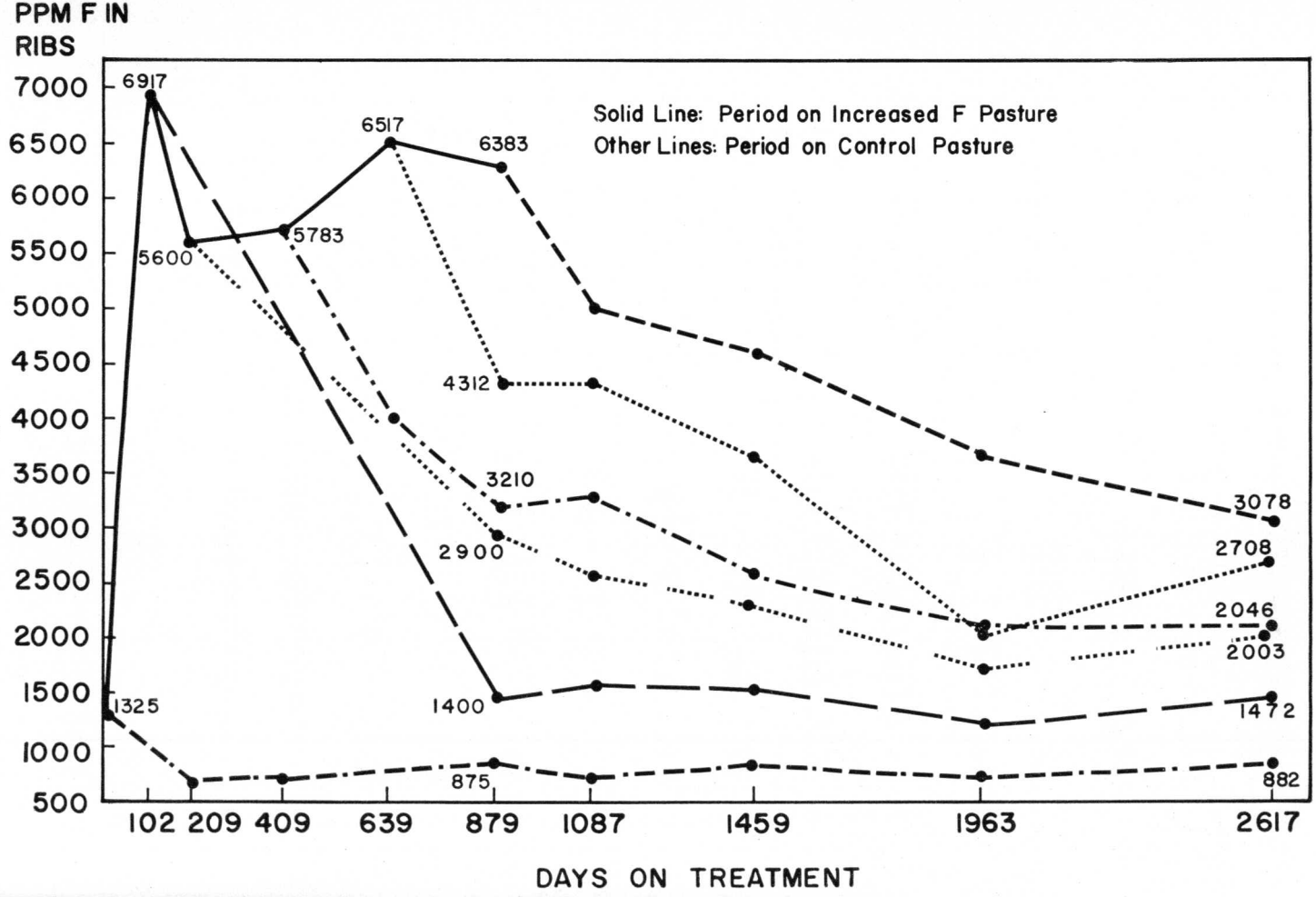
## Table 43.—Fluorine Content of Bones from Cows, Lots 51–56

| | Lot no. | Days on $B_3$ pasture | Fluorine content of bones (ppm) | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Year | | | 1951 | 1951 | 1952 | 1952 | 1952 | 1953 | 1953 | 1954 | 1955 | 1955 | 1956 | 1957 | 1958 |
| Days on test | | | 0 | 102 | 209 | 319 | 409 | 639 | 879 | 1087 | 1235 | 1459 | 1963 | 2039 | Autopsy [a] |
| Mandibles | 51 | 0 | 1600 | | | | | | 800 | 800 | | | 590 | | 870 |
| | 52 | 102 | | 5033 | | | | | | | | | | | 1357 |
| | 53 | 209 | | | 6700 | 5400 | | | | 2700 | | | | | 1733 |
| | 54 | 409 | | | | | 5567 | 4500 | 3200 | 3600 | | | | | 2240 |
| | 55 | 639 | | | | | | 5833 | 4050 | 4850 | | | | 2270 | 2670 |
| | 56 | 837 | | | | | | | 6250 | 5250 | 5500 | | | | 3110 |
| Ribs | 51 | 0 | 1325 | | 683 | | 770 | | 875 | 767 | | 867 | 730 | | 881 |
| | 52 | 102 | | 6917 | | | | | 1400 | 1667 | | 1633 | 1283 | | 1472 |
| | 53 | 209 | | | 5600 | 4600 | | | 2900 | 2633 | | 2333 | 1797 | | 2003 |
| | 54 | 409 | | | | | 5783 | 3917 | 3210 | 3300 | | 2633 | 2163 | | 2047 |
| | 55 | 639 | | | | | | 6517 | 4312 | 4367 | | 3700 | 2130 | 3008 | 2708 |
| | 56 | 837 | | | | | | | 6383 | 5000 | 5000 | 4633 | 3700 | | 3248 |
| Metacarpals | 51 | 0 | 1267 | | | | | | 900 | 1100 | | | 610 | | 970 |
| | 52 | 102 | | 3667 | | | | | | | | | | | 1800 |
| | 53 | 209 | | | 4450 | 3900 | | | | 3400 | | | | | 2995 |
| | 54 | 409 | | | | | 4867 | 4600 | 3850 | 3900 | | | | | 3743 |
| | 55 | 639 | | | | | | 5500 | 4700 | 5600 | | | | 3430 | 3675 |
| | 56 | 837 | | | | | | | 6250 | 5400 | 5800 | | | | 4533 |
| Metatarsals | 51 | 0 | | | | | | | | | | | | | 945 |
| | 52 | 102 | | | | | | | | | | | | | 1777 |
| | 53 | 209 | | | | | | | | | | | | | 2763 |
| | 54 | 409 | | | | | | | | | | | | | 3413 |
| | 55 | 639 | | | | | | | | | | | | | 3360 |
| | 56 | 837 | | | | | | | | | | | | | 4747 |

Duncan's Multiple Range Test of Bones, Autopsy 1958

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| Mandibles | Lot no. | 51 | 52 | 53 | 54 | 55 | 56 |
| | Av. | 870 | 1357 | 1733 | 2240 | 2670 | 3110 |
| | $P < 0.05$ | | | | | | |
| Ribs | Lot no. | 51 | 52 | 53 | 54 | 55 | 56 |
| | Av. | 881 | 1472 | 2003 | 2047 | 2708 | 3248 |
| | $P < 0.05$ | | | | | | |
| Metacarpals | Lot no. | 51 | 52 | 53 | 55 | 54 | 56 |
| | Av. | 970 | 1800 | 2995 | 3675 | 3743 | 4633 |
| | $P < 0.05$ | | | | | | |
| Metatarsals | Lot no. | 51 | 52 | 53 | 55 | 54 | 56 |
| | Av. | 945 | 1777 | 2763 | 3360 | 3413 | 4747 |
| | $P < 0.05$ | | | | | | |

[a] September, October, 1958.
Ribs analyzed for F content in 1953 (879 days), 1954, 1955 and 1956 were collected by biopsy; all other bones were collected at slaughter.


PPM F IN RIBS
7000
6500
6000
5500
5000
4500
4000
3500
3000
2500
2000
1500
1000
500
Solid Line: Period on Increased F Pasture
Other Lines: Period on Control Pasture
6917
6517
6383
5783
5600
4312
3210
3078
2900
2708
2046
2003
1325
1400
1472
875
882
102 209 409 639 879 1087 1459 1963 2617
DAYS ON TREATMENT

bones of cattle (Lot 52) slaughtered after 102 days on the contaminated ($B_3$) pasture were comparable to the bone F levels of cattle removed for slaughter from the contaminated pasture after 209, 319, 409, 639 and 837 days. The similarity of bone F storage after 102 days, compared to the longer periods on $B_3$ pastures, may be due to (1) the ability of bone to absorb large quantities of F in a short time; and (2) the drastic decrease in F content of the $B_3$ pasture from an average 473 ppm in the fall of 1951 to 47.8 ppm in the summer of 1953 (Table 39). Data in Table 43 show that the F contents of ribs and mandibles are similar, and those of the metatarsal and metacarpal bones are similar. When animals consume above-normal levels of F continuously the mandibles and ribs show a higher F content than metatarsal or metacarpal bones. A comparison of F content of bones for the years 1951 to 1954, taken when F content of forage was highest, with F content of bones taken at autopsy in 1958 (Table 43) shows that the F content of the mandibles and ribs decreased more during this time than the F content of metacarpal bones.

Fluorine levels of ribs at biopsy in 1953, 1954, 1955 and 1956 and at autopsy in 1958 are directly related to the level of F ingested and the length of time cattle had grazed the $B_3$ pastures (Table 43 and Figure 2).

Table 43 includes a multiple range test for significance of differences in F contents of bones collected at autopsy in 1958.

TABLE 44.—GROSS CHANGES IN BONES AT SLAUGHTER, 1958, LOTS 51–56.

| Lot no. | Days on $B_3$ pasture | Cow no. | Gross Changes in | | | | |
|---|---|---|---|---|---|---|---|
| | | | Right metatarsals | Left metatarsals | Right metacarpals | Left metacarpals | Mandibles |
| 51 | 0 | G166 | N | N | N | N | N |
| | | G164 | N | N | N | N | N |
| | | G167 | N | N | N | N | N |
| | | G168 | N | N | N | N | N |
| 52 | 102 | G174 | N | N | N | N | N |
| | | G175 | N | N | N | N | N |
| | | G176 | S | N | N | S | N |
| 53 | 209 | G183 | N | S | N | N | N |
| | | G184 | M | M | S | M | N |
| 54 | 409 | G187 | N | S | N | N | N |
| | | G193 | N | N | N | N | S |
| | | G194 | N | N | N | N | N |
| 55 | 639 | G205 | S | S | N | N | N |
| | | G206 | S | N | N | S | S |
| 56 | 837 | G204 | S | S | N | N | — |
| | | G214 | N | N | N | N | N |

N—No change in gross appearance.
S—Slight hypertrophy.
M—Medium hypertrophy.

TABLE 45.—FLUORINE CONTENT OF CALF BONES FROM COWS, LOTS 51–56

| Lots | Days on $B_3$ pasture | Av. F Content 1952 | | Av. F Content 1954 | | Av. F Content 1955 | | Av. F Content 1956 | | Av. F Content 1957 | | Av. F Content 1958 | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Calf no. | Metacarpals ppm | Calf no. | Metacarpals ppm | Calf no. | Metacarpals ppm | Calf no. | Metacarpals ppm | Calf no. | Metacarpals ppm | Calf no. | Metacarpals ppm |
| 51 | 0 | 304 | 290 | 520 | 190 | | | 664 | 80 | 804 | 260 | 895 | 210 |
| | | | | | | | | 736 | 80 | 788 | 230 | 854 | 180 |
| | | | | | | | | 665 | 120 | 794 | 290 | 879 | 250 |
| | | | | | | | | | | 778 | 220 | 860 | 180 |
| | Av. | | **290** | | **190** | | | | **93** | | **250** | | **205** |
| 52 | 102 | 308 | 200 | | | 565 | 740 | 707 | 80 | 811 | 240 | 914 | 170 |
| | | | | | | | | 679 | 130 | 766 | 250 | 888 | 170 |
| | | | | | | | | | | 819 | 240 | | |
| | Av. | | **200** | | | | **740** | | **105** | | **243** | | **170** |
| 53 | 209 | 301 | 240 | 491 | 70 | 620 | 280 | 723 | 130 | 793 | 290 | 916 | 200 |
| | | | | | | | | 730 | 120 | 768 | 90 | 889 | 150 |
| | | | | | | | | | | 799 | 280 | | |
| | Av. | | **240** | | **70** | | **280** | | **125** | | **220** | | **175** |
| 54 | 409 | 338 | 310 | 517 | 70 | 609 | 640 | 731 | 80 | 815 | 210 | 887 | 170 |
| | | 339 | 310 | | | | | 709 | 100 | 783 | 240 | 880 | 160 |
| | | | | | | | | | | 784 | 240 | 949 | 110 |
| | Av. | | **310** | | **70** | | **640** | | **90** | | **230** | | **147** |
| 55 | 639 | 335 | 2200 | 471 | 120 | 566 | 200 | 717 | 120 | 772 | 330 | 873 | 180 |
| | | | | 457 | 160 | 624 | 160 | 733 | 90 | 791 | 280 | 930 | 180 |
| | Av. | | **2200** | | **140** | | **180** | | **105** | | **305** | | **180** |
| 56 | 837 | 337 | 1400 | 460 | 90 | 605 | 860 | 693 | 120 | 779 | 240 | 923 | 200 |
| | | 333 | 2200 | | | 587 | 270 | 706 | 120 | 801 | 200 | 929 | 170 |
| | | | | | | | | 722 | 100 | | | | |
| | Av. | | **1800** | | **90** | | **565** | | **113** | | **220** | | **185** |

TABLE 46.—URINE AND RIB FLUORINE CONTENT OF CATTLE, LOTS 51–56

| Lot no. | Days on $B_3$ pasture | No. of urine samples | Av. F content (ppm) | |
|---|---|---|---|---|
| | | | Urine [a] | Rib [b] |
| 51 | 0 | 7 | 1 | 800 |
| 52 | 102 | 3 | 1 | 1775 |
| 53 | 209 | 3 | 2 | 2900 |
| 54 | 409 | 4 | 2 | 3400 |
| 55 | 639 | 6 | 2 | 4450 |
| 56 | 837 | 8 | 2 | 4900 |

[a] Urine samples taken on July 6, 1954.
[b] Rib data based on average analyses of the ninth and tenth ribs of one animal from each lot taken July 9, 1954, or July 12, 1954. F content for Lot 52 is an average of three animals and for Lot 55 an average of two animals.

Gross changes in bones determined at autopsy in 1958 are shown in Table 44. Gross changes in bones of the 16 cows autopsied at the end of the test were small. The metatarsal bones were more sensitive than others to gross changes caused by increased F ingestion.

Table 45 shows the F content of metacarpal bones from calves of cows for 1952 through 1958. Analyses of the data for 1956, 1957 and 1958, when sufficient numbers were available for statistical analyses, show that there was no significant difference in the F content of bones from the calves of the various lots. Bone F concentrations in calves of Lots 55 and 56 for 1952 show the effect of grazing on $B_3$ pasture while calves nursed their dams.

**Urinary Fluorine.** Fluorine levels in urine samples collected in 1954, after Lot 56 cattle had been on control pasture approximately eight months, were all similar. The results of these urine studies and the average rib F contents of the cattle in 1954 are shown in Table 46.

**Teeth.** Data in Table 47 show that the effects of F from $B_3$ pastures on developing teeth of cows grazing the pastures were directly related to the F levels of the $B_3$ pastures when grazed, and to length of grazing period. When cows were removed from the $B_3$ pastures the F effects appeared on teeth erupting for about six months afterward. Comparison of the classifications of the intermediates, laterals and corners, respectively, of Lots 52, 53 and 54 in Table 47 definitely shows this picture of decreased F effects. Data on F content of bone and urine, and gross changes in teeth, indicate that cattle under conditions comparable to those of this experiment can recover from symptoms of fluorosis when the source of F is removed. However, teeth marked by changes due to F ingestion will remain marked.

The decreasing F content of $B_3$ pasture, as shown in Table 39, and

the decreasing F effects on teeth of Lots 55 and 56 (Table 47) further substantiate the relationship between level of F and length of time of increased F ingestion. The F effects on teeth of cows grazing $B_3$ pastures are directly related to the decreased F content of pasture forage as shown for grazing periods of 1952 and 1953 in Table 39.

The multiple range test in Table 47 shows that there is no significant difference between Lots 53, 54 and 55. There is a significant difference between these and other lots.

Incisor teeth descriptions, classifications, colored pictures, and indexes and descriptions of premolars and molars are presented on the following pages.

TABLE 47.—TEETH INDEXES OF CATTLE INGESTING VARIOUS LEVELS OF FLUORINE, LOTS 51–56

| Lot no. | Days on $B_3$ pasture | An. no. | Index [a] of incisor teeth condition | | | | | Teeth classification range |
|---|---|---|---|---|---|---|---|---|
| | | | C | I | L | Co. | Av. | |
| | | 164 | 0.0 | 0.0 | 0.1 | 0.1 | 0.0 | 1A–1B |
| 51 | 0 | 166 | 3.4 | 0.0 | 0.0 | 0.1 | 0.9 | 1A–5A |
| | | 167 | 0.0 | 0.1 | 0.3 | 0.2 | 0.2 | 1A–2 |
| | | 168 | 0.0 | 0.0 | 0.0 | 0.1 | 0.0 | 1A–1B |
| | | **Av.** | **0.8** | **0.0** | **0.1** | **0.1** | **0.2** | |
| | | 176 | 0.1 | 1.9 | 4.1 | 0.2 | 1.6 | 1A–5C |
| 52 | 102 | 174 | 1.9 | 4.9 | 0.1 | 0.1 | 1.8 | 1A–5B |
| | | 175 | 2.0 | 4.5 | 0.0 | 0.0 | 1.6 | 1A–5B |
| | | **Av.** | **1.3** | **3.8** | **1.4** | **0.1** | **1.6** | |
| | | 180 | 2.0 | 6.2 | 0.5 | 0.1 | 2.2 | 1A–5C |
| 53 | 209 | 183 | 3.0 | 6.6 | 0.9 | 0.7 | 2.8 | 1A–5C |
| | | 184 | 0.0 | 2.8 | 7.0 | 3.7 | 3.4 | 1A–5C |
| | | **Av.** | **1.7** | **5.2** | **2.8** | **1.5** | **2.8** | |
| | | 187 | 3.0 | 6.2 | 3.3 | 0.1 | 3.2 | 1A–5C |
| 54 | 409 | 193 | 2.0 | 5.4 | 3.2 | 0.6 | 2.8 | 1A–5B |
| | | 194 | 2.0 | 6.4 | 2.1 | 0.4 | 2.7 | 1A–5C |
| | | **Av.** | **2.3** | **6.0** | **2.9** | **0.4** | **2.9** | |
| | | 205 | 0.0 | 1.2 | 3.9 | 6.4 | 2.9 | 1A–5C |
| 55 | 639 | 206 | 1.8 | 4.3 | 3.4 | 1.3 | 2.7 | 1A–5B |
| | | **Av.** | **0.9** | **2.8** | **3.6** | **3.8** | **2.8** | |
| | | 204 | 1.6 | 5.8 | 4.9 | 4.0 | 4.1 | 1B–5C |
| 56 | 837 | 214 | 2.9 | 5.2 | 4.5 | 3.1 | 3.9 | 2–5C |
| | | 216 | 3.2 | 6.6 | 5.6 | 4.6 | 5.0 | 2–5C |
| | | **Av.** | **2.6** | **5.9** | **5.0** | **3.9** | **4.4** | |

Duncan's Multiple Range Test

| Lot no. | 51 | 52 | 53 | 55 | 54 | 56 |
|---|---|---|---|---|---|---|
| Av. indexes of all teeth | 0.2 | 1.6 | 2.8 | 2.8 | 2.9 | 4.4 |
| $P < 0.05$ | | | | | | |

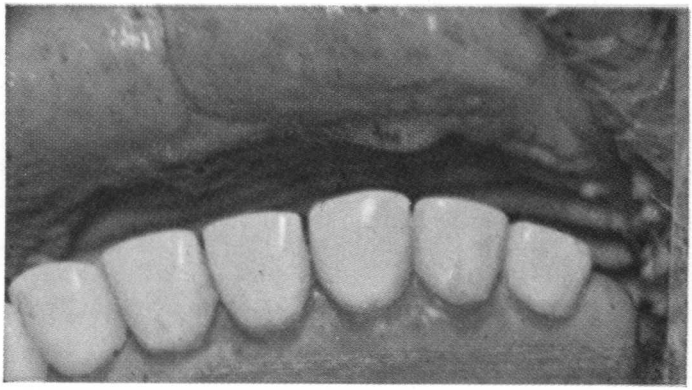
[a] Indexes are only for cows carried through the entire experiment.

**LOT NO. 51**

**Control Pasture**

**Cow No. G168**

**Photographed Sept., 1957**



**LOT NO. 52**

**Contaminated Pasture**
**102 days**
**Moved to Control**
**Pasture 11–2–51**

**Cow No. G174**

**Photographed Oct., 1953**



**Cow No. G174**

**Photographed Jan., 1958**



**LOT NO. 51 (Control Pasture 7–22–51 until removal)**

**ANIMAL NO. G168**

CENTRALS: *Luster*—good; *Wear*—normal; *Classification*—1A.
INTERMEDIATES: *Luster*—good; *Wear*—normal; *Other*—roots exposed approximately 1mm.; *Classification*—1A.
LATERALS: *Cap*—(right) slight chip; *Chalkiness*—slight focal and (left) large milky plaque; *Wear*—normal; *Classification*—1A.
CORNERS: *Luster*—good; *Chalkiness*—slight focal; *Wear*—normal; *Classification*—1A.
PREMOLARS AND MOLARS: Normal stain and wear.

**LOT NO. 52 (Contaminated Pasture 102 days. On Control Pasture 11–2–51.)**

**ANIMAL NO. G174**

CENTRALS: *Cap*—chipped and uneven; *Luster*—fair to good; *Staining*—slight and light brown; *Wear*—normal but uneven; *Classification*—2.
INTERMEDIATES: *Luster*—poor to fair; *Chalkiness*—heavy focal and diffuse; *Staining*—dark brown at cap and lighter brown centrally; *Enamel hypoplasia*—slight; *Caries and erosions*—eroded areas in upper ¼; *Wear*—medium; *Classification*—5A.
LATERALS: *Luster*—good; *Chalkiness*—slight cross and focal; *Staining*—slight vegetative; *Wear*—normal; *Classification*—1A.
CORNERS: Right is temporary and description is of left only; *Luster*—good; *Chalkiness*—slight to medium cross; *Staining*—slight vegetative; *Wear*—normal; *Classification*—1A.
PREMOLARS AND MOLARS: FIRST PAIRS: Not in wear. SECOND and THIRD PAIRS: (uppers) left temporary and right not yet in wear. FOURTH PAIRS: *Wear*—slight. FIFTH PAIRS: *Wear*—(uppers) medium and (lowers) slight. SIXTH PAIRS: *Wear*—(uppers) heavy and (lowers) medium.

**ANIMAL NO. G174**

CENTRALS: *Caps*—uneven; *Luster*—good; *Chalkiness*—medium to heavy cross and diffuse; *Caries and erosions*—(left) a probable caries in lower ⅓; *Wear*—normal; *Classification*—(left) 1B to 3, (right) 1B.
INTERMEDIATES: *Luster*—fair to good; *Enamel hypoplasia*—slight to medium; *Tooth hypoplasia*—suspected; *Wear*—medium to heavy; *Classification*—5B to 5C.
LATERALS: *Luster*—good; *Wear*—normal; *Classification*—1A.
CORNERS: *Luster*—good; *Chalkiness*—(left) medium focal; *Wear*—normal; *Classification*—(left) 1B, (right) 1A.
PREMOLARS AND MOLARS: FIRST, THIRD and FOURTH PAIRS: Normal. SECOND PAIRS: *Staining*—light brown, *Wear*—(uppers) medium and (lowers) excessive. FIFTH PAIRS: *Staining*—light brown. SIXTH PAIRS: *Staining*—(uppers) light brown and (lowers) dark brown, *Wear*—(lowers) heavy.

**LOT NO. 53 (Contaminated Pasture 209 days. On Control Pasture 2–16–52).**

**ANIMAL NO. G180 (1953)**

CENTRALS: *Luster*—poor; *Chalkiness*—focal and diffuse; *Cracks*—stained longitudinal; *Staining*—heavy and light brown; *Wear*—slight; *Other*—flecks on picture are not caries; *Classification*—2.

INTERMEDIATES: *Luster*—poor; *Staining*—light brown with darker foci; *Enamel hypoplasia*—heavy to excessive shell; *Tooth hypoplasia*—suspected to slight; *Wear*—medium and uneven; *Classification*—5C.

LATERALS: *Luster*—good; *Chalkiness*—medium to heavy focal and cross; *Wear*—normal; *Classification*—1B.

CORNERS: Temporary.

PREMOLARS AND MOLARS: FIRST PAIRS: *Staining*—brown, *Wear*—(uppers) slight. SECOND PAIRS: *Staining*—brown, *Wear*—(uppers) heavy and (lowers) slight. THIRD PAIRS: (lower left) temporary with permanent showing, *Staining*—brown, *Wear*—(uppers) excessive on left and medium on right and (lowers) slight on right. FOURTH PAIRS: Normal. FIFTH PAIRS: *Staining*—brown and light brown, *Wear*—(uppers) heavy and uneven and (lowers) slight. SIXTH PAIRS: *Staining*—brown, *Wear*—(uppers) excessive and (lowers) medium.

**ANIMAL NO. G180 (1958)**

CENTRALS: *Luster*—fair; *Staining*—medium to heavy and light brown; *Wear*—slight; *Other* (right) root exposed 2 mm.; *Classification*—2.

INTERMEDIATES: *Luster*—fair; *Enamel hypoplasia*—medium to heavy pit type; *Tooth hypoplasia*—slight to medium; *Wear*—heavy; *Classification*—5B.

LATERALS: *Cap*—(left) chipped slightly; *Luster*—good; *Chalkiness*—(left) medium cross, (right) slight focal; *Wear*—normal; *Other*—gums inflamed; *Classification*—(left) 1A to 1B, (right) 1A.

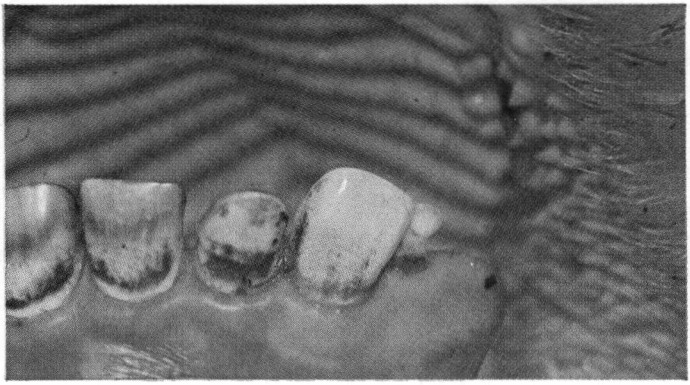
CORNERS: *Luster*—good; *Chalkiness*—(left) slight to medium focal with stained milky plaque in lower ¼; *Wear*—normal; *Classification*—1A.

PREMOLARS AND MOLARS: First Pairs: *Staining*—brown, *Wear*—normal to slight. SECOND and THIRD PAIRS: *Staining*—(lowers) brown and (uppers) light brown, *Wear*—medium to heavy. FOURTH PAIRS: Normal. FIFTH PAIRS: *Staining*—(uppers) light brown and (lowers) brown, *Wear*—(uppers) medium and (lowers) normal and slightly long. Sixth Pairs: *Staining*—(uppers) light brown and (lowers) black, *Wear*—(uppers) heavy and (lowers) slight to medium.

**ANIMAL NO. G185 (1954)**

CENTRALS: *Caps*—uneven; *Luster*—poor; *Chalkiness*—heavy to excessive, diffuse and focal with porcelain at cap; *Cracks*—stained longitudinal; *Staining*—heavy light brown; *Wear*—normal but uneven; *Classification*—2.

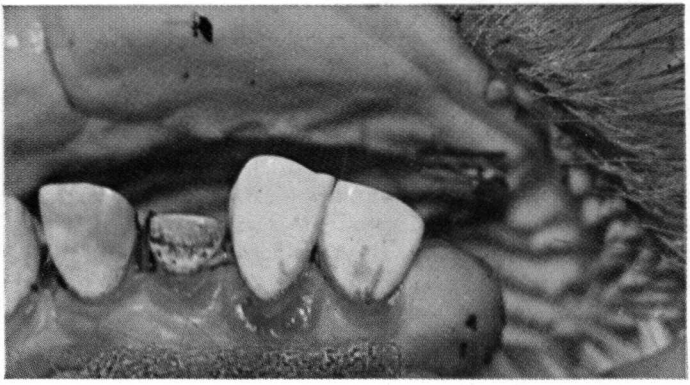
INTERMEDIATES: *Luster*—poor to fair; *Staining*—slight discoloration with darker foci and areas; *Enamel hypoplasia*—heavy, pit type; *Tooth*



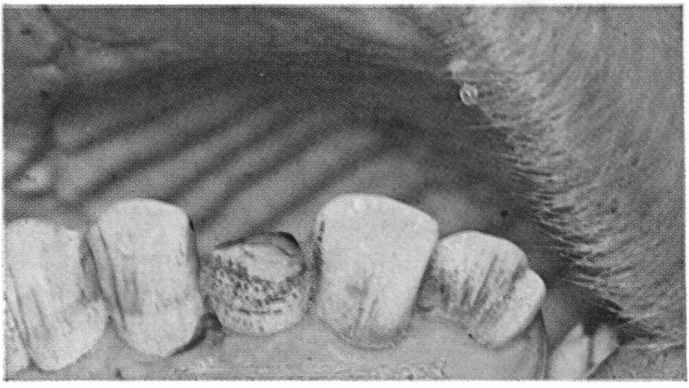
**LOT NO. 53**

**Contaminated Pasture**
**209 Days**
**Moved to Control**
**Pasture 2–16–52**

**Cow No. G180**
**Photographed Oct., 1953**



**Cow No. G180**
**Photographed Jan., 1958**



**Cow No. G185**
**(Photographed June, 1954)**

**(Killed July, 1954)**

*hypoplasia*—suspected to slight; *Wear*—medium to heavy; *Classification*—5B.

LATERALS: *Luster*—(left) good, (right) fair; *Chalkiness*—slight focal and (left) a stained milky plaque; *Enamel hypoplasia*—(right) suspected to slight *Classification*—(left) 1A, (right) 4.

CORNERS: *Luster*—good; *Staining*—heavy vegetative; *Wear*—normal; *Other*—labial surface is irregular; *Classification*—1A.

PREMOLARS AND MOLARS—FIRST PAIRS: *Staining*—light brown and brown. SECOND PAIRS: *Staining*—light brown and brown, *Wear*—medium to heavy. THIRD PAIRS: *Staining*—light brown and brown, *Wear*—(lowers) slight to medium. FOURTH PAIRS: Normal. FIFTH PAIRS: *Staining*—(uppers) dark brown and (lowers) light brown. SIXTH PAIRS: *Staining*—brown, *Wear*—(uppers) excessive and (lowers) slight and uneven.

**LOT NO. 54 (Contaminated Pasture 409 days. On Control Pasture 9–4–52)**

**ANIMAL NO. G187 (1958)**

CENTRALS: *Luster*—poor; *Chalkiness*—excessive and diffuse; *Cracks*—slight longitudinal; *Staining*—excessive light brown with dark foci; *Caries and erosions*—multiple pin head sized caries centrally; *Wear*—normal to slight and uneven; *Other*—(left) root exposed 2 mm.; *Classification*—3.

INTERMEDIATES: *Luster*—fair; *Chalkiness*—excessive diffuse; *Staining*—excessive light brown; *Enamel hypoplasia*—medium to heavy pit and patch; *Tooth hypoplasia*—suspected to slight; *Wear*—(left) heavy, (right) medium; *Classification*—5B.

LATERALS: *Luster*—fair to good; *Chalkiness*—medium diffuse and focal; *Enamel hypoplasia*—suspected with pits in central portion; *Wear*—(left) slight, (right) normal; *Classification*—4.

CORNERS: *Luster*—good; *Staining*—slight vegetative; *Wear*—normal; *Classification*—1A.

PREMOLARS AND MOLARS: FIRST PAIRS: *Staining*—brown, *Wear*—(lowers) medium to heavy. SECOND PAIRS: *Staining*—light brown and brown, *Wear*—heavy to excessive. THIRD PAIRS: *Staining*—(uppers) light brown and (lowers) dark brown. FOURTH PAIRS: *Staining*—light brown. FIFTH PAIRS: *Staining*—brown and light brown, *Wear*—(lowers) slight to medium. SIXTH PAIRS: *Staining*—(uppers) light brown and (lowers) dark brown, *Wear*—medium to excessive and uneven.

**LOT NO. 55 (Contaminated Pasture 639 days. On Control Pasture 4–22–53)**

**ANIMAL NO. G206 (1953)**

CENTRALS—*Caps*—(left) multiple chips; *Luster*—poor to fair; *Chalkiness*—diffuse and focal; *Staining*—slight discoloration, brown foci and slight vegetative; *Caries* and *Erosions*—(right) caries on medial margin near point of appositional wear; *Wear*—normal; *Classification*—(left) 2, (right) 3.



**LOT NO. 54**

**Contaminated Pasture**
**409 days**
**Moved to Control**
**Pasture 9–4–52**

**Cow No. G187**
**Photographed Jan., 1958**



**LOT NO. 55**

**Contaminated Pasture**
**639 days**
**Moved to Control**
**Pasture 4–22–53**

**Cow No. G206**
**Photographed April, 1953**



**Cow No. G206**
**Photographed Jan., 1957**

INTERMEDIATES: *Luster*—poor to fair; *Staining*—light brown with darker foci; *Caries* and *Erosions*—(left erosions at cap and small carious lesions centrally and in lower ¼, (right) small caries centrally; *Enamel hypoplasia*—suspected; *Wear*—normal; *Classification*—4.

LATERALS—*Luster*—poor in lower ⅔, fair in upper ⅓; *Chalkiness*—focal and diffuse; *Staining*—excessive light brown; *Enamel hypoplasia*—suspected pit type; *Wear*—normal; *Other*—erupting; *Classification*—4.

CORNERS: Temporary.

PREMOLARS AND MOLARS: FIRST and SECOND PAIRS: *Staining*—brown, *Wear*—not yet in wear. THIRD PAIRS: upper right is temporary and others are erupting. FOURTH PAIRS: *Staining*—light brown, *Wear*—slight. FIFTH PAIRS: *Staining*—brown, *Wear*—(uppers) heavy and uneven, (lowers) normal to slight. SIXTH PAIRS: *Staining*—brown, *Wear*—(uppers) excessive and (lowers) slight and uneven.

**ANIMAL NO. G206 (1957)**

CENTRALS: *Caps*—uneven; *Luster*—good; *Chalkiness*—medium to heavy focal and diffuse; *Cracks*—stained longitudinal; *Staining*—slight and light brown; *Wear*—slight and uneven; *Classification*—2.

INTERMEDIATES: *Caps*—uneven; *Luster*—poor; *Chalkiness*—excessive and diffuse; *Staining*—excessive and light brown with darker foci and areas; *Enamel hypoplasia*—medium to heavy patch type; *Tooth hypoplasia*—suspected; *Wear*—medium to heavy and uneven; *Classification*—5B.

LATERALS: *Luster*—poor; *Chalkiness*—diffuse; *Staining*—excessive and light brown; *Enamel hypoplasia*—suspected, but difficult to evaluate; *Wear*—slight; *Classification*—2 to 4.

CORNERS: *Luster*—(left) good, (right) fair; *Chalkiness*—(left) slight cross and focal, (right) medium diffuse and focal; *Staining*—(right) slight discoloration, (both) slight vegetative; *Enamel hypoplasia*—(right suspected pit type that is difficult to evaluate; *Wear*—(left) normal, (right) slight; *Classification*—(left) 1A to 1B, (right) 1BX or 4.

PREMOLARS AND MOLARS: FIRST PAIRS: *Staining*—dark brown. SECOND PAIRS: *Staining*—dark brown, *Wear*—(uppers) excessive and (lowers) heavy. THIRD PAIRS: *Staining*—(uppers) light brown and (lowers) dark brown, *Wear*—(uppers) heavy to excessive and (lowers) slight. FOURTH PAIRS: Normal. FIFTH PAIRS: *Staining*—brown, *Wear*—(uppers) slight on left. SIXTH PAIRS: *Staining*—(uppers) light brown and (lowers) dark brown, *Wear*—(uppers) heavy to excessive and (lowers) normal to slight.

**LOT NO. 56 (Contaminated Pasture 837 days. On Control Pasture 11–6–53)**

**ANIMAL NO. G161 (1954)**

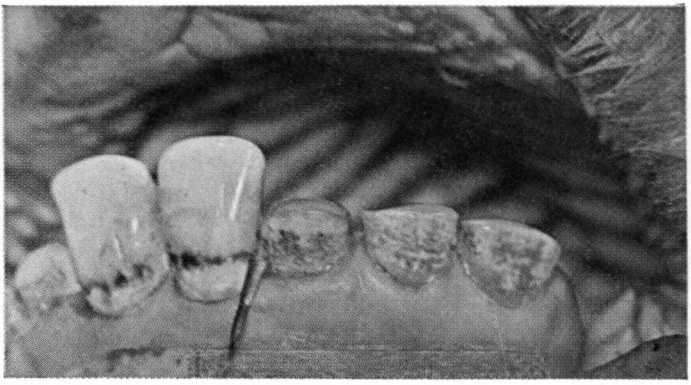
CENTRALS: *Luster*—good; *Chalkiness*—focal and diffuse; *Staining*—brown and black foci; *Caries* and *Erosions*—eroded foci in lower ½; *Wear*—normal; *Classification*—3.



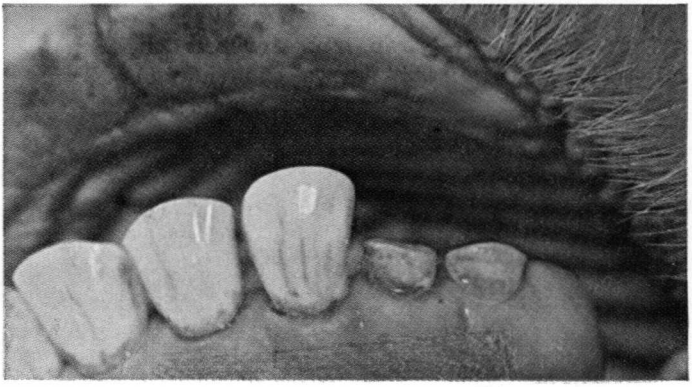
**LOT NO. 56**

**Contaminated Pasture**
**837 days**
**Moved to Control**
**Pasture 11–6–53**

**Cow No. G161**
**Photographed June, 1954**



**Cow No. G215**
**Photographed June, 1956**



**Cow No. G210**
**Photographed June, 1956**

INTERMEDIATES: *Luster*—poor; *Chalkiness*—diffuse; *Staining*—excessive light brown with darker areas; *Enamel hypoplasia*—heavy to excessive; *Tooth hypoplasia*—slight; *Wear*—medium and uneven; *Classification*—5C.

LATERALS: *Luster*—poor; *Chalkiness*—excessive; *Staining*—excessive light brown with darker areas and foci; *Enamel hypoplasia*—heavy; *Tooth hypoplasia*—suspected to slight; *Caries* and *Erosions*—superficial caries in upper ½; *Wear*—slight to medium; *Classification*—5B to 5C.

CORNERS: *Luster*—poor; *Chalkiness*—heavy diffuse; *Staining*—light brown with darker foci at caps and medium vegetative; *Enamel hypoplasia*—suspected to slight; *Wear*—not in wear until shortly before the picture was made; *Classification*—4 to 5A.

PREMOLARS AND MOLARS: FIRST PAIRS: *Staining*—brown, *Wear* (uppers) slight. SECOND PAIRS: *Staining*—dark brown, *Wear*—(uppers) heavy and (lowers) medium. THIRD PAIRS: *Staining*—dark brown, *Wear*—not yet in full wear. FOURTH PAIRS: *Staining*—light brown. FIFTH PAIRS: *Staining*—light brown, *Wear*—(uppers) slight and uneven. SIXTH PAIRS: *Staining*—dark brown and black, *Wear*—(uppers) excessive and (lowers) heavy and uneven.

**ANIMAL NO. G215 (1956)**

CENTRALS: *Luster*—good; *Chalkiness*—medium to heavy cross and diffuse; *Staining*—medium light brown with dark foci in lower ⅓; *Caries* and *Erosions*—pin-head size caries in lower ⅓; *Wear*—normal; *Other*—grass between centrals and intermediates; *Classification*—3.

INTERMEDIATES: *Luster*—poor; *Chalkiness*—excessive diffuse; *Staining*—excessive light brown; *Enamel hypoplasia*—heavy to excessive patch and thin enamel; *Tooth hypoplasia*—medium; *Wear*—heavy; *Classification*—5C.

LATERALS: *Luster*—fair to good; *Chalkiness*—excessive diffuse; *Staining*—light brown with darker foci; *Enamel hypoplasia*—medium pit and patch; *Wear*—heavy; *Classification*—5A to 5B.

CORNERS: *Luster*—poor to fair; *Chalkiness*—heavy diffuse; *Staining*—excessive light brown; *Enamel hypoplasia*—medium patch; *Wear*—slight to medium; *Classification*—5A.

PREMOLARS AND MOLARS: FIRST PAIRS: *Staining*—brown, *Wear*—(uppers) slight. SECOND PAIRS: *Staining*—brown, *Wear*—(uppers) excessive and lowers) medium. THIRD PAIRS: *Staining*—brown, *Wear*—(uppers) excessive and (lowers) slight. FOURTH PAIRS: Normal. FIFTH PAIRS: (uppers) Normal, (lowers) no reading. SIXTH PAIRS: (uppers) *Staining*—brown, *Wear*—heavy, (lowers) no reading.

**ANIMAL NO. G210 (1956)**

CENTRALS: *Luster*—good; *Chalkiness*—(left) slight focal with large milky plaque centrally; *Cracks*—longitudinal; *Wear*—slight; *Classification*—1A.

INTERMEDIATES: *Luster*—good; *Chalkiness*—medium focal and diffuse; *Staining*—(left) slight discoloration to slight light brown, (right) light discoloration; *Wear*—normal; *Classification* (left) 1B to 2, (right) 1B.

LATERALS: *Luster*—poor; *Chalkiness*—excessive diffuse; *Staining*—excessive, light brown; *Enamel hypoplasia*—excessive; *Tooth hypoplasia*—medium to heavy; *Wear*—excessive; *Classification*—5C.

CORNERS: *Luster*—poor; *Chalkiness*—excessive diffuse; *Staining*—excessive light brown; *Enamel hypoplasia*—heavy; *Tooth hypoplasia*—medium; *Wear*—heavy to excessive; *Classification*—5B to 5C.

PREMOLARS AND MOLARS: FIRST, FOURTH and FIFTH PAIRS: Normal. SECOND PAIRS: *Staining*—(uppers) light brown. THIRD PAIRS: *Staining*—brown, *Wear*—(uppers) excessive and (lowers) excessive on left and medium on right. SIXTH PAIRS: *Staining*—(uppers) brown, and (lowers) suspected, *Wear*—normal to slight.

## Summary

The effects upon cattle of grazing on fluorine (F) contaminated pastures for intervals of 102 to 837 days before removal to a control pasture were determined. The effects of F upon (1) feed consumption; (2) weights and gains; (3) reproduction of cows and calf records; (4) bones; (5) urinary F; and (6) teeth were evaluated in this 7-year experiment, 1951–1958. The treatments were as follows:

| Days on contaminated pasture | Range in F content of contaminated pasture for each period |
|---|---|
| 0 | — |
| 102 | 473 to 410 |
| 209 | 473 to 265 |
| 409 | 473 to 38 |
| 639 | 473 to 29 |
| 837 | 473 to 29 |

**Feed Consumption.** Surviving cows showed no differences in feed consumption, compared to controls, during an 82-day period of individual feeding near the end of the test (winter of 1957–58).

**Weights and Gains.** No significant differences were found in weights and gains of cows among the six lots.

**Reproduction of Cows and Calf Records.** There were no significant differences in reproduction or in daily gains of calves.

**Bones.** Fluorine content in metacarpals, metatarsals, mandibles and ribs increased rapidly when cattle were placed on F contaminated pasture. The F content of ribs decreased when cows were removed from F contaminated pasture and placed on control pasture.

In the 16 cows carried for the entire experiment, signs of bone hypertrophy at slaughter in 1958 were few.

For the years 1956 through 1958, there were no significant differences in F content in metatarsal bones of calves from the various treatments. Calves raised with cows on F contaminated pastures had increased bone F content. The F content of bones of cows on contaminated pasture was directly related to level of F ingested and the length of the ingestion period.

**Teeth.** Effects on incisor teeth being formed in cows grazing $B_3$ pasture were directly related to the level of F consumed and length of time the higher F content was ingested. Teeth erupting approximately six months after cows were removed from $B_3$ pasture showed much less effect from previously increased F ingestion. This agrees with other work at this Station which shows that during formation incisor teeth directly reflect the current level of F being ingested and provide valuable evidence in the diagnosis of fluorosis in cattle.

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