ALLEVIATION OF INDUSTRIAL FLUOROSIS IN A HERD

by

Ruth Allcroft and K. N. Burns
Weybridge, Surrey, England

The degree of alleviation of fluorosis that can be achieved in farm livestock will depend on the nature of the source of the fluoride and on the management of the stock as well as on the amount of fluoride ingested.

Where the sources are industrial, the most obvious form of alleviation is reduction or termination of emission. This may involve reduction of industrial efficiency, which could be undesirable for the overall economy. In certain industries such as brick-manufacturing, it would be difficult, or perhaps impossible, to reduce emission by any significant amount.

On the agricultural side, intensification of livestock production, as well as expansion of industry, has made it necessary to investigate practical methods of minimizing the toxic effects of fluoride.

Such methods have concerned investigators for the last 30 years or so. Hobbs and his colleagues at the University of Tennessee demonstrated that addition of aluminum sulphate at 0.5% of the total diet, reduced by 30-40% the accumulation of fluorine in the bones of stalled Hereford cattle. Sodium fluoride had been added to their rations to provide levels of 28-58 ppm fluorine (1, 2).

In 1953 we began an investigation to determine the possibility of counteracting the effect of fluorosis in a self-contained dairy herd. It lasted for 8 years. The farm was maintained under commercial farming conditions. It was surrounded on all sides by various industrial works from which sufficient fluorine-containing particulate and gaseous emissions were likely to be given off to produce damaging fluorosis.

The Herd and its Management

The original herd consisted of 24 Ayrshire cows obtained from an uncontaminated area. They were negative to diagnostic tests for brucellosis, vibriosis and Johne's disease. Their copper status was normal. They were divided into three groups of 8,

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From the Central Veterinary Laboratory, Ministry of Agriculture Fisheries and Food, New Haw, Weybridge, Surrey, England.

each group containing four in-calf heifers and four 2nd-3rd calvers. All three groups were managed as one herd and received a similar fluorine intake from pasture, kale, silage and hay grown on the farms. Two of the groups were given mineral supplements consisting of aluminum sulphate only in one group, aluminum sulphate plus calcium and phosphorus compounds in the other. The third group was treated as a control. It received no mineral supplements. Table I shows the type and amount of mineral supplements given to each group for 6 years.

TABLE I

Experimental Groups and Treatment

Group	Mineral Supplements	Amount per Day
I	Nil	-
II	Aluminum sulphate $(Al_2(SO_4)314H_20$	112 g a.m. and p.m.
III	Aluminum sulphate $Al_2(SO_4)_314H_20$	112 g a.m. and p.m.
	Calcium carbonate	56 g a.m.
	Anhydrous sodium acid Phosphate: NaH_2 PO_4	28 g

Heifer calves were allocated to the same group and given the same treatment as their dams. Most male calves were killed within three days of birth for determination of the F content of the skeleton. Weight and iodine content of thyroid glands of new-born calves of fluorosed cows was also checked.

Regarding housing and feeding, the herd was managed as far as possible as a commercial herd. A concentrate mixture was fed to young stock and cows but as much home-produced forage as possible was used so as to provide maximum intake of deposited fluorides. As most of the pastures were in a poor and unproductive condition when the farm was taken over for this experiment, a program of ploughing and reseeding was carried out over a 5 year period.

For the last 2 1/2 year period of the experiment, no form of mineral supplement was fed. This enabled us to assess the value of reasonably good farming practices in maintaining a satisfactory level of production in a fluorine-contaminated area.

Samples for Estimation of Fluorine

Representative pasture samples were taken at monthly intervals from fields in which the cows were grazing and from other fields in grass at the time. Standard deposit gauges were set up in two of the main cow pastures to measure the amount of F deposited from the atmosphere at monthly intervals for correlation with F values of herbage.

Bone samples were obtained by tail-bone biopsy each year from some animals in each group including both cows and young stock, and also from incidental post-mortem examinations. At the beginning of each month throughout the whole 8-year period, a urine sample was taken from each of the lactating cows after both the morning and afternoon milkings. Milk samples were obtained at intervals for analysis of their F content. Blood and liver samples were also taken at frequent intervals for the determination of other constituents.

Results

This long-term experiment yielded a large amount of information. Only a brief summary of the results and conclusions can be presented here.

1. F Content of Herbage: F values for all monthly pasture samples taken over the whole period showed wide variations with an overall range of 8 to 292 ppm. A seasonal trend was apparent. The highest values occurred in winter and the lowest ones in summer. Mean F concentrations of monthly pasture samples for yearly periods showed a significant decline throughout the 8 years. The overall mean for the first 4 year period was 82 ppm and that for the second 4 years 45 ppm.

TABLE 2

Relationship Between Pasture and Deposit Gauge F Concentrations

	Pasture F ppm	Deposit Gauge F mg/m^3 of air
1956	98.0	3.90
1957	74.1	2.92
1958	61.9	2.48
1959	71.8	3.52
1960	47.3	3.25
1961	36.0	3.12

Table 2 shows the relationship between mean monthly F values from the main cow pasture and from the deposit gauge placed in it for yearly periods. The amount of F deposited from the atmosphere remained fairly constant whereas there was a significant decline in pasture F concentration over the last 6 year period. This could be related to improved pasture management. A more rapid turnover of herbage reduced the duration of its exposure to F deposition.

2. Urinary F Concentrations: Although mean urine F values for the two supplemented groups were significantly lower than those for the control group during the 5-year period, the values for most of the urine samples from all groups ranged between 10 and 40 ppm. throughout the whole period. These values are above the normal range for cattle and within that usually associated with fluorosis. There was no significant difference between the two groups which received mineral supplements.

Despite marked fluctuations in F levels of both urine and herbage, there was a high degree of correlation between them. Both showed a similar but somewhat irregular seasonal pattern. It tended to be low in summer, to rise in late autum and winter and fall again during the early spring period.

3. Skeletal F Accumulation: After about 2 1/2 years on the farm bone F values were above 4, 000 ppm in bone ash. At the end of the experiment they were between 6, 000 to 7, 000 ppm in the original animals. The two supplemented groups had significantly lower levels than the controls but did not differ significantly from each other. The additional supplement of calcium and phosphorus to the aluminum sulphate therefore did not result in a greater reduction of F storage in bones than that produced by aluminum sulphate alone. The overall reduction in the supplemented groups for the 8-year period was of the order of 22 per cent. Nevertheless the F accumulation to damaging levels was merely delayed and not prevented.

4. Lameness and Dental Lesions: There was generalized lameness or stiffness in some animals but acute severe lameness did not occur.

No significant difference in the severity of the dental lesions between control and supplemented groups was observed. Moderate to severe stain, wear and hypoplasia of teeth developed in all 3 groups.

5. General Health and Reproductive Performance: Throughout the experiment general health and reproduction were satisfactory. Milk production was not directly affected by the F levels of contaminated herbage, but was handicapped by the conditions of the experiment during the period 1953-58 when the mineral supplements were

fed. When the feeding of these supplements ceased, milk yield increased by 37 per cent. It was only slightly below the National Average during 1959-61. No adverse effect of feeding aluminum sulphate at a level of about 1 per cent of the total dry ration was apparent.

A severe copper deficiency developed in all cattle on the farm during the first 2 years of their stay. This deficiency was not correlated with the contamination of the herbage by F compounds. It resulted in poor growth and loss of condition in young stock before it was controlled by injections of suitable copper preparations.

SUMMARY

In order to determine the alleviating effect of aluminum and calcium in fluorosis, a herd of 24 Ayshire cows was exposed to airborne fluoride and divided in 3 groups. Under proper experimental conditions one group was given supplements of aluminum sulfate, another aluminum sulfate plus calcium carbonate and anhydrous sodium phosphate. A third group was used as control. Urinary fluorine excretion, skeletal fluoride accumulation and the general health of the animals were evaluated. Aluminum sulfate reduced bone fluoride storage by 22% in comparison with controls. The calcium phosphorus supplement did not enhance the effect of aluminum sulfate alone. However, it appeared that fluoride accumulation was merely delayed and storage to undesirable levels could not be prevented by the aluminum sulfate treatment.

REFERENCES

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