LXXXIV. THE EFFECT OF ULTRA-VIOLET LIGHT ON THE MINERAL METABOLISM OF THE LACTATING ANIMAL.

(PRELIMINARY COMMUNICATION.)

BY JOHN BOYD ORR, HUGH EDWARD MAGEE
AND JOHN McASKILL HENDERSON.

From the Rowett Research Institute, Aberdeen.

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DURING the past few years a considerable amount of work has been done on the mineral metabolism of lactating animals. A review of the recent literature is given by Meigs [1922].

It has been found that, during a large part of the period of lactation, the heavy milking cow usually suffers a loss of certain mineral elements from her body. The negative balance of calcium may continue even though there is an abundance of this element in the ration [Forbes and others, 1922]. There is evidence to show that privation of calcium adversely affects reproduction in cows [Hart, Steenbock and Humphrey, 1920], and it has been suggested that the disturbance of equilibrium in mineral metabolism is a predisposing cause, not only of sterility and abortion, but also of several other diseases to which dairy cows seem specially liable.

During the last few years work on metabolism in lactation has been carried out at this Institute. Some of the data which have been accumulated seem to indicate that the rate of assimilation of calcium and phosphorus is greater in summer than in winter, and the difference cannot be wholly accounted for by variations in the composition of the diet. Recent work on the influence of ultra-violet rays on nutrition suggested that these rays might be the unknown factor, and that they might have an influence on the assimilation of calcium and phosphorus in the lactating animal. The results of some preliminary work showed that the exposure of cows to ultra-violet rays from a carbon arc lamp had no marked immediate effect on milk yield. In work with growing pigs, however, it was found that, on certain diets at least, exposure to the rays of the carbon arc lamp very markedly increased calcium and phosphorus retention [Orr, Henderson and Magee, 1924; Henderson, 1925]. It was thought that ultra-violet rays might have a similar influence in mature animals with a very active mineral metabolism. An investigation on the effects of ultra-violet rays on the calcium, phosphorus and nitrogen balances during lactation was therefore carried out.

It was originally intended to defer publication of the results referred to in this paper until certain other investigations of a kindred nature were completed.

Meanwhile, however, Hart, Steenbock and Elvehjem [1924] have published results which show that ultra-violet rays may convert negative balances of calcium and phosphorus in the lactating goat to positive balances. As this influence of ultra-violet rays on the mineral metabolism during lactation is of very great potential practical importance, it was thought that the present note confirming the findings of these workers should be published.

EXPERIMENTAL.

This note deals only with the calcium balance, which is the one of greatest practical importance, and gives the details of only one experiment. Figures summarising the results of the other two experiments which differ only in detail are included in Table III.

Methods. The experimental work was done on goats as they are more convenient subjects for balance experiments than cows.

The diet consisted of 900 g. hay, 300 g. oatmeal and 50 g. linseed meal. Preliminary tests showed that this diet, both in composition and amount, suited the goat's appetite at the beginning of the experimental period. During the period of irradiation the appetite improved and 100 g. oatmeal per day were added to the diet from the sixth day of irradiation onwards. The necessary precautions were taken to ensure that the exact intake of calcium and phosphorus for each day should be known.

The goat was kept in a pen for 3 weeks before the experiment was begun, to accustom it to confinement and to the experimental ration. It was then confined to a metabolism cage. Collection and analysis of excreta were carried out for a total period of 54 days. From the 13th to the 34th day the animal was irradiated for a total period of 4 hours per day at a distance of 4 feet, about a sixth of the animal's body being exposed to the rays at a time.

RESULTS.

Table I. *Calcium balance in g. for three-day periods.*

Periods	Intake Ca	Output Ca	Balance Ca
Pre-period	15.09	16.33	- 1.24
	15.09	16.60	- 1.51
	14.75	14.60	+ 0.15
	14.92	15.09	- 0.17
Irradiation period	15.60	15.35	+ 0.25
	15.58	12.59	+ 2.99
	15.89	15.75	+ 0.14
	15.85	16.24	- 0.39
	15.89	17.05	- 1.16
	15.89	14.72	+ 1.17
	15.89	14.84	+ 1.05
Post-period	15.78	16.02	- 0.24
	15.72	15.85	- 0.13
	15.89	18.24	- 2.35
	15.89	17.46	- 1.57
	15.89	16.28	- 0.39
	15.89	16.29	- 0.40
	15.89	15.43	+ 0.46

Table II. *Average daily balances (Ca in g.) in the pre-, irradiation- and post-periods.*

Pre-period	Irradiation period	Post-period
-0.24	+0.16	-0.22

Table III. *Alteration in the balances produced by irradiation.*

	Exp. 1		Exp. 2		Exp. 3		
Daily averages in g. Ca	Pre- period	Irradiation period	Pre- period	Irradiation period	Pre- period	Irradiation period	
Intake	4.98	5.27	8.38	8.38	6.55	6.53	
Output {	Faeces	3.97	3.85	8.41	8.24	6.20	5.80
	Urine	0.21	0.20	0.09	0.09	0.29	0.30
	Milk	1.04	1.07	0.29	0.25	0.30	0.44
	Total	5.22	5.11	8.79	8.58	6.80	6.54
Balance	- 0.24	+ 0.16	- 0.41	- 0.20	- 0.25	- 0.01	

Table IV. *G. of calcium per 100 cc. milk (first and third experiments*).*

Pre-period	Irradiation period	Post-period
0.168	0.171	0.167
0.177	0.184	0.181

* The figures for Exp. 2 are not available, as washings with distilled water were added to the milk before analysis.

DISCUSSION.

In the first experiment, under the influence of the irradiation an average negative balance of 0.24 g. per day was changed to a positive balance of 0.16. In the second a negative balance of 0.41 was reduced to 0.20, and in the third a negative balance of 0.26 was reduced to 0.01. In Exps. 1 and 3 these reduced net losses of calcium occurred concurrently with increased secretion of milk. The gain in calcium absorption and retention is almost entirely accounted for by reduced excretion in the faeces, as is shown in the following table.

Table V. *Ca intake minus excretion in faeces (average per day in g.).*

Period	Exp. 1	Exp. 2	Exp. 3
Pre-period	1.01	-0.03	0.35
Irradiation period	1.42	0.14	0.73

Thus, under the influence of irradiation, there is either increased absorption from the intestine or decreased excretion into the intestine. The same result was obtained by us in growing pigs subjected to irradiation [Orr, Henderson and Magee, 1924]. This decreased excretion of calcium in the faeces under the influence of irradiation has since been noted by Hart, Steenbock and Elvehjem [1924] in goats, and by Webster and Hill [1925] in rats.

It has been generally believed that calcium is excreted chiefly by the large intestine. The work of Telfer [1923], however, makes it appear doubtful whether, normally, calcium is excreted into the intestine in appreciable amounts. In his experiments he regards the calcium of the faeces as chiefly, if not entirely, unabsorbed residue. The work of our colleagues and ourselves

on the factors affecting the retention of calcium and phosphorus in growing animals tends to confirm Telfer's conclusion. The results of the above experiments, therefore, afford further evidence in favour of the view previously put forward, that the beneficial effect of ultra-violet light and also of oils on the assimilation of calcium is probably due chiefly to their influence in increasing the percentage of calcium which is absorbed from the intestine [Husband, Godden and Richards, 1923; Orr, 1924; Henderson, 1925].

There was a slight increase in the percentage of calcium in the milk during the period of irradiation. The data are too meagre to warrant any definite conclusion. They are interesting, however, in the light of results obtained by Hess, Unger and Supplee [1920]. These workers found a marked difference between the percentage composition of the ash of milk of stall-fed cows on an antiscorbutic-free diet and that of the same cows on pasture. The percentage of calcium in the former case was 0.138 (as CaO) and in the latter 0.165. These workers, while not expressing any definite opinion, suggested that the difference might possibly be due to the antiscorbutic vitamin of the pasture. In view of our results it is probable that the difference noted by them may have been due, partly at least, to the influence of sunlight while the cows were on pasture.

SUMMARY.

In three balance experiments on lactating goats it was found that irradiation of the animals by the carbon arc lamp reduced the loss of calcium from the body.

Leaving out of consideration the amounts contained in the milk secreted, the reduction was entirely accounted for by decreased excretion in the faeces; the urinary excretion remaining practically constant.

It is suggested, therefore, that irradiation by the carbon arc lamp caused an increased absorption of calcium from the intestine.

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