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PHOSPHORUS SUPPLEMENTATION FOR INCREASING REPRODUCTION IN CATTLE*

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Feed phosphate consumption in the United States increased from 340,000 tons in 1951 to 1.3 million tons in 1970. The requirements for feed phosphate supplements have been estimated at 1.8 million tons by 1985. This is an indication of the need and importance of feed phosphates in livestock production systems.

In ruminants, symptoms of phosphorus deficiency include loss of appetite, lowered performance and lowered reproductive rates. Severely affected animals may chew various objects and eat soil. Such symptoms may be confused with those of other nutrient deficiencies or management problems. A prolonged phosphorus deficiency reduces blood inorganic phosphorus. Normal plasma values are 4-6 mg/100 ml for adult animals and 6-8 mg/100 ml for young animals.

During the 1973-74 shortage of phosphorus supplements a report on Levels and Sources of Phosphorus Recommended for Livestock and Poultry was prepared by a Task Force on Phosphorus Requirements of Livestock and Poultry and published by the NRC-National Academy of Science. An abbreviated table of dietary phosphorus requirements of beef cattle is presented in Table 1. The phosphorus requirement depends on the age of animal and the biological function which it is performing. The lowest NRC recommendation is 0.18% phosphorus in the diet of non-lactating pregnant cows. Recommended dietary levels during periods of phosphorus shortage for this same animal are minimal levels of 0.16% and emergency levels of 0.15%. Most recommended phosphorus levels are from 0.21% up to 0.38%. In the Latin American Tables of Feed Composition the phosphorus levels of 1129 forage entries were studied. Fourteen percent of the forages contained less than 0.10% phosphorus, 48% of the forages contained less than 0.20% phosphorus and nearly 75% of the forages contained less than 0.30% phosphorus. These data support the conclusion, that for grazing cattle, the most prevalent mineral element deficiency throughout the world is lack of phosphorus. Furthermore, nineteen Latin American countries have reported a deficiency.

*Presented at the Ruminant Livestock Production System Seminar, Georgetown, Guyana, March 1, 1976.

Table 1. Abbreviated Table of Dietary Phosphorus Requirements for Beef Cattle

Weight		Daily Gain[a]		Present NRC Recommendation[b]		Recommended during Phosphorus Shortage: Minimal Level		Recommended during Phosphorus Shortage: Emergency Level	
Kg.	lb.	Kg.	lb.	(g/day)	(% in ration)	(g/day)	(% in ration)	(g/day)	(% in ration)
Growing Finishing Steer Calves and Yearlings									
250	550	0.7-1.3	1.5-2.9	16-23	0.28-0.38	14-21	0.25-0.34	14-20	0.24-0.33
400	880	1.0-1.4	2.2-3.1	20-23	0.21-0.26	18-21	0.19-0.23	17-20	0.18-0.22
Pregnant Yearling Heifers - Last 3-4 Months of Pregnancy									
375	825	0.4-0.8	0.9-1.8	15-22	0.21-0.19	14-20	0.19-0.17	13-19	0.18-0.17
Dry Pregnant Cows - Middle Third of Pregnancy									
454	1000	---	---	12	0.18	11	0.16	10	0.15
Dry Pregnant Cows - Last 2-3 Months of Pregnancy									
454	1000	0.4	0.9	15	0.18	14	0.16	13	0.15
Cows Nursing Calves - Average Milking Ability									
400	880	---	---	25	0.28	23	0.25	21	0.24
Cows Nursing Calves - Superior Milking Ability									
400	880	---	---	41	0.38	37	0.34	35	0.33
Bulls, Growth and Maintenance									
400	880	0.9	2.0	23	0.21	21	0.19	20	0.18
800	1760	---	---	19	0.18	17	0.16	16	0.15

a/ Ranges in recommendations correspond to ranges in daily gain.

b/ Based on Nutrient Requirements of Beef Cattle 6th Revised Edition (In Press).

Effect of Phosphorus Deficiency on Reproduction

Early research in the United States and South Africa showed the dramatic effect of phosphorus supplementation on reproductive performance. More recent studies have substantiated these early results.

Black et al. (1943) conducted an investigation from 1937 to 1941 inclusive to determine what mineral elements were deficient in the vegetation of southern Texas and the methods of correcting such deficiencies. Comparatively few samples of vegetation contained more than 0.13 percent of phosphorus, but most of them contained more than 0.23 percent of calcium (Table 2). The indication, therefore, is that cattle grazing such forage would not get sufficient phosphorus to meet their requirements, but that the calcium would be ample. A low protein content of the forage was usually found to be associated with a low phosphorus content. One hundred Brahman x Shorthorn and Brahman x Hereford heifers about 18 months of age were used. The control groups received no mineral supplement. The three remaining groups were hand-dosed, six times a week, with the following mineral supplements: Group 2, bonemeal; Group 3, disodium phosphate; and Group 4, bonemeal with small quantities of iron, manganese, copper, cobalt, zinc, and boron. Groups 2 and 3, bonemeal and disodium phosphate were fed in such quantities as to supply 6.5 grams to lactating cows, per head daily. Group 4 cows, whether dry or in lactation, were kept at the 6.5 gram level. Except for several months at the beginning and end of the experiment, the average weights of the cows in each of the mineral fed groups were significantly higher than those of the control group cows. Differences between the supplement-fed groups were not significant at any time during the experiment.

The primary advantage in feeding a phosphorus supplement to cows under the conditions of this experiment is the increased percentage of the calf crops and greater weights attained by the offsprings (Table 3). Based on a 2-year average, only 64 percent of the control cows produced calves as compared with 85 percent for those supplement-fed. This difference was highly significant. For the 2-year period, also, the control cows weaned only a 58 percent calf crop, whereas the supplement-fed cows weaned 81 percent. Only slightly more than 30 percent of the control cows calved in 2 consecutive years, whereas the supplement-fed cows averaged about 73 percent. The difference was highly significant. The feeding of phosphorus supplements to cows had no influence on the birth weights of calves. However, on the average for 2 years, the weaning weight per calf in the supplement-fed groups was 69 pounds more than in the control group, which was a considerable advantage.

Differences in weaning weights of the calves in the supplement-fed groups were not statistically significant.

At 12 months of age, the difference in average weight between the heifers in the supplement-fed and control groups was essentially the same as at weaning time, but, at 18 months of age, the former heifers averaged 126 pounds heavier than the latter.

Table 2. Average protein, calcium, and phosphorus content, on an air-dry basis, of some of the more important forage plants in southern Texas.

ar and Month	Paspalum plicatulum			Andropogon litoralis			Elyonurus tripsacoides			Aristida purpurea			Rainfall
	Protein	Calcium	Phosphorus	Protein	Calcium	Phosphorus	Protein	Calcium	Phosphorus	Protein	Calcium	Phosphorus	
1939	%	%	%	%	%	%	%	%	%	%	%	%	Inches
nuary	5.70	.43	.06	4.03	.27	.05	4.15	.26	.04	5.51	.29	.06	1.75
bruary	7.73	.44	.09	5.75	.28	.06	4.26	.25	.05	7.03	.24	.07	.56
rch	9.53	.54	.08	7.26	.36	.10	6.85	.29	.08	7.64	.25	.08	.31
ril	8.32	.51	.08	6.20	.34	.07	6.07	.30	.07	6.37	.23	.06	1.84
y	9.26	.50	.10	7.14	.31	.10	6.70	.26	.09	7.92	.24	.10	5.62
ne	6.48	.46	.07	6.22	.29	.08	5.74	.24	.08	----	---	---	1.74
ly	4.35	.51	.06	4.53	.34	.06	3.62	.22	.05	5.70	.29	.05	.40
gust	3.97	.49	.05	3.45	.30	.04	3.43	.32	.04	4.41	.24	.07	.56
ptember	7.92	.51	.07	7.01	.41	.09	5.85	.29	.07	7.17	.26	.07	4.02
tober	7.02	.44	.08	7.19	.30	.09	----	---	---	8.06	.26	.10	.51
vember	4.62	.36	.04	2.88	.26	.05	4.60	.23	.05	5.63	.22	.06	.00
cember	3.30	.41	.03	4.69	.24	.03	2.91	.23	.03	3.23	.19	.03	.14
1940													
nuary	3.20	.34	.03	3.44	.24	.03	3.18	.24	.04	3.09	.21	.02	.40
bruary	3.85	.38	.03	3.38	.27	.03	3.24	.21	.03	3.67	.21	.02	.31
rch	4.15	.36	.03	3.90	.29	.04	3.48	.20	.03	3.96	.22	.03	2.25
ril	9.85	.54	.11	7.69	.39	.10	9.22	.36	.11	11.29	.23	.11	.00
y	5.82	.47	.05	4.06	.26	.04	4.75	.31	.04	----	---	---	.15
ne	8.72	.58	.09	6.94	.34	.08	7.13	.33	.10	7.46	.31	.08	1.52
ly	9.84	.49	.10	6.87	.29	.08	6.76	.29	.07	----	---	---	3.75
gust	5.73	.20	.08	7.41	.54	.08	----	---	---	----	---	---	2.38
ptember	9.63	.41	.11	----	---	---	5.27	.27	.06	7.79	.31	.10	2.92
tober	3.83	.30	.05	3.94	.24	.05	3.38	.26	.04	----	---	---	1.01
vember	2.39	.49	.03	3.40	.25	.03	3.66	.33	.04	3.38	.23	.03	1.10
cember	4.76	.33	.04	3.67	.25	.03	4.32	.26	.04	----	---	---	2.46

rce: Black et al., 1943.

Table 3. Effect of Phosphorus Supplements on Cattle Production data for the 2 calf crops, 1939 and 1940.

Item	Group 1. Control fed no supplement		Group 2 fed bonemeal		Group 3 fed disodium phosphate		Group 4 fed bonemeal and trace minerals	
	1939	1940	1939	1940	1939	1940	1939	1940
No. cows	25	23	25	24	24	23	25	22
Calves born	22	9	25	16	22	18	23	18
Calves weaned	19	9	23	14	21	18	22	18
% calf crop	88	39.1	100	66.7	91.7	78.3	92	81.8
% calf crop weaned	76	39.1	92	58.3	87.5	78.3	88	81.8
Avg. weaning wt. calves	421	429	486	503	513	501	460	503
Avg. wt. cows at weaning	701	832	878	885	864	889	859	884
% cows calving 2 consecutive, %	30.4		58.3		78.3		81.8	
Cost of supplement per weaned calf	0		3.81		4.36		3.80	
Net increased return per calf due to supplement	0		5.91		6.55		4.89	

Source: Black et al., 1943, Calves were valued at $8.00 per hundred weight.

Reynolds et al. (1953) report the results of P supplementation experiment on range cattle breeding performance. This experiment was carried out in southern Texas over a five-year period, during a prolonged drought. The purpose of it was to find the effect of three different methods of providing P to breeding cattle.

Group 1 received no supplement, Group 2 was fed bonemeal in self-feeders, Group 3 received disodium phosphate in drinking water, and Group 4 cattle grazed on a range which was fertilized with triple superphosphate.

Table 4. Effect of Phosphorus on Calf Production in Texas.

Item	Group 1 Control	Group 2 Bonemeal	Group 3 Disodium Phosphate	Group 4 Fertilizer
Weight of calves at weaning, lb.	489	535	542	551
No. of days between calvings	459	365	367	364
Weaned calf weight per acre, lb.	21	31	33	47
Calf crop weaned, %	64	88	92	96

Source: Reynolds et al., 1953.

Conrad and Mendes (1965) reported the results of an experiment which was conducted on a private ranch near Aquidauana, Mato Grosso, Brazil. This ranch had about 10,000 Brahman crossbred cattle on 70,000 acres and had an average annual calf crop of about 55%.

A total of 381 cows which had weaned at least three calves were divided into four experimental groups. Each group was kept in separate pastures of similar conditions and were fed trace mineralized salt ad libitum. The duration of the experiment was from August 10, 1963, to February 28, 1965.

Treatments were as follows:

Group A - Molasses - urea, 9:1, 2 kg. head daily
Group B - Disodium phosphate, ad libitum
Group C - Bonemeal, ad libitum
Group D - Control

Results are outlined in Table 5.

They show that the control group had an average calf crop of 55% as compared to 77% for those fed bonemeal, an increase of 22% from the feeding of bonemeal. Cows receiving any of the three supplements also calved earlier than those receiving only trace mineralized salt.

Table 5. Effect of Phosphorus on Calf Production in Brazil.

	No. of cows	No. births by 10/22/64	No. births by 02/28/65	Total calf crop	% births
Group A Urea - Molasses	98	48	20	68	69
Group B Disodium Phosphate	94	62	4	66	70
Group C Bone Meal	90	59	10	69	77
Group D Control	99	22	32	54	55

Source: Conrad and Mendes, 1965.

Proof that large numbers of grazing cattle are not receiving adequate phosphorus supplementation and that mineral supplementation will produce an economical return of two to one on mineral investment is shown in two reports from research conducted by ICA-CIAT in the eastern Llanos of Colombia.

The Preliminary Implications of the ICA-CIAT Herd from Stonaker et al., 1974.

The early and currently operating strategy in the ICA-CIAT Herd Systems Project has been to introduce, under the challenge of an inhospitable environment, a series of existing inputs to increase beef production economically. The opportunity to study a wide range of interactions of inputs has been provided.

With grade Zebu heifers purchased in the Carimagua area by ICA, effects of several variables on reproductive rate, growth, mortality and disease, and total beef produced are being investigated. These variables are complete mineral supplement, improved molasses grass pasture and urea-molasses supplementation. On a hierarchical basis, it will be possible to study the effects of early weaning and crossbreeding within the groups. Thus several variables in the project are concurrently being examined at two levels: the prevailing or existing level versus an estimated or improved level.

Salt and mineral supplementation. Complete mineral supplementation has been proven to affect reproductive capacity markedly, increasing reproductive rates across a wide range of soil and climatic conditions. The prevailing question is why this mineral supplementation is not widely used in the Llanos. Current indications are that pregnancy rates in first-calf heifers may be greatly increased by mineral supplementation (CIAT Annual Report 1973). The effect on nursing cows is almost certain to be less; ICA data indicated that except for the North Coast station at Montería, wet cows are not bred, even though they receive minerals.

The increased reproduction of first-calf heifers alone will more than pay for mineral supplementation of the entire cow herd (Tables 7 7 and 8). The mineral response in cows at Carimagua is not yet known, but it will probably be less than in others because of other more limiting stress factors for the nursing cow.

An additional advantage is that these heifers reach a breeding weight at least four months sooner than those that do not receive mineral supplementation.

Table 6. Preliminary results from ICA-CIAT Herd Systems Project (1972-1974).

	Herd	Heifer Weight (kg) Dec. 73	Feb. 74	Percentage Pregnant Oct. 73		Feb. 74	
Native	1	307	316	63		66	
Savanna-salt	2	289	289	31	24	57	50
Savanna-salt	3	270	275	17		43	
Savanna-minerals	4	334	343	68	70	88	84
Savanna-minerals	5	332	335	71		79	
Savanna-molasses grass-minerals	6	325	338	58	60	89	86
Savanna-molasses grass-minerals	7	326	347	63		83	
Molasses grass-minerals	8	328	333	78	80	86	88
Molasses grass-minerals	9	335	333	81		89	

Table 7. Summary of salt and mineral consumption per cow at Carimagua (1973).

	Salt only			Salt - mineral mix*					
Herds	1	2	3	4	5	6	7	8	9
	8.9	6.6	13.4	17.0	18.2	28.8	25.2	27.0	27.0
Avg consumption, kg.	9.6			17.6		27.0		27.2	
Cost/year (Col$)	9.65			70.48		108.00		108.80	

*Salt 47%, dicalcium phosphate 47%, trace minerals 6%; approximate cost Col$ 4 per kg, salt only Col$ 1 per kg (1$US = 25$ Col)

Table 8. Projected returns from mineral supplementation in herd of 80 cows and 20 heifers.

Herds	2	3	4	5	6	7	8	9
	%	Nb*	%	Nb*	%	Nb*	%	Nb*
Calf crop from heifers	50	10	84	17	85	17	88	18
Assumed calf crop from cows	50	40	50	40	50	40	50	40
Total calves		50		57		57		58
Value of calves at Col$1,600		$ 80,000		$ 91,200		$ 91,200		$ 92,800
Increase in calf value from minerals		—		$ 11,200		$ 11,200		$ 12,800
Salt or mineral cost		$ 965		7,048		10,800		10,800
Increased value of minerals		—		6,083		9,835		9,835
Net increase from minerals				$ 5,117 (84%)		$ 1,365 (14%)		$ 2,965 (30%)

*Nb=number of births.

Minerals from Annual Report, 1974, CIAT. Up to February, 1974, about 18 months after the experiment began and before the first calving, mineral-supplemented heifers weighed 1.20 times more than heifers receiving only salt. On a gain basis, mineral-supplemented heifers gained 1.63 times more than the heifers on salt only. In contrast to African results, mineral-supplemented heifers actually responded more to minerals in the dry season than during the wet season. It might be inferred from this that the lowland pasture used in the dry season was of somewhat higher nutritive value than the upland pasture grazed in the rainy season. The mineral comparison was limited to native pasture.

First-year calving and pregnancy rates were greatly different for the mineral-supplemented group. This amounted to 34 more calves born or predicted to be born per 100 cows; that is, 1.49 times more for the mineral-supplemented herd.

These early results reinforced the recommendations for feeding complete minerals, advocated for so long by all agricultural advisory agencies, public and private. It is difficult to understand why there has been so little adoption of mineral feeding. Perhaps an explanation such as that of Bauer (1968)* pertains. He found in the Beni region of Bolivia that the economics of mineral supplementation in cow herds was not favorable. However, in the present study with heifers, return on mineral investment is at least two to one. Comparative results with cows will become available in future years.

Consumption was about 10 kg/year/heifer for salt-only herds, 20 kg of complete mineral mix on native pasture, 30 kg of complete mineral mix on molasses grass pasture year round, and 25 kg of complete mineral mix per cow per year for herds on molasses grass only during the rainy season. The mineral formula was: 47% salt, 47% dicalcium phosphate, 6% trace mineral mix. The trace mineral mix was copper sulfate 1.95%, ferrous sulfate 5.0%, zinc oxide 1.24%, manganese sulfate 3.09%, cobalt sulfate .2%, potassium iodide .07%, wheat middlings 88.45%.

Summary

One of the major advantages from phosphorus supplementation under range conditions is the increase in percent calf crop and the resulting increase in the percent of calves weaned. Phosphorus supplementation as bonemeal in a two year study in Texas resulted in a weaned calf crop of 81% as compared to 58% for the controls. In a later study, the weaned calf crop was 88% for those fed bonemeal compared to 64% for the controls. A study conducted in Brazil resulted in a 77% calf crop when bonemeal was fed compared to 55% for the controls. Recent trials in Colombian llanos demonstrated that the pregnancy rate was increased from 50% for the controls up to 84% when complete minerals were fed. Economical returns on mineral investment has been at least two to one in some studies.

In view of the current information on low phosphorus levels in Rupununi and intermediate savannah soils and forages and the results of the survey in the Rupununi cattle producing area (only 2 of 42 producers feeding minerals), mineral supplementation, especially phosphorus, appears to be an economically sound practice which has tremendous potential for increasing the precent calf crop in the major cattle producing areas of

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