

# DISEASES CAUSED BY MINERAL DEFICIENCIES IN CATTLE RAISED UNDER RANGE CONDITIONS IN BRAZIL, A REVIEW

CARLOS HUBINGER TOKARNIA and JÜRGEN DÖBEREINER

In cattle kept under range conditions are known to occur deficiencies of phosphorus, magnesium, sodium, chlorine, copper, cobalt, iodine, manganese, zinc and selenium. These may vary from severe deficiencies, with more or less characteristic disorders, to slight deficiencies with non-specific symptoms, such as slow development, low fertility, low body weight at slaughter and low milk yield.

Mineral deficiencies are confined to certain areas. When they are severe they may be responsible for the general poverty which exists in these regions. Mild deficiencies may also cause serious economic loss as they reduce the productivity of the animals and provide an obstacle to improvement of the cattle population over large areas.

## *Diagnosis of Diseases caused by Mineral Deficiencies in Cattle raised under Range Conditions*

In diagnosing mineral deficiencies, as in the diagnosis of any disease, it is necessary to study the different manifestations of the condition, so that conclusions may be drawn from all the available data.

In most of the more severe mineral deficiencies the history of the herd may give an indication of a specific deficiency. In some mineral deficiencies clinical examination of the cattle reveals characteristic manifestations. Post-mortem examinations and histopathological studies also help in the establishment of the diagnosis. Phosphorus deficiency can be safely diagnosed by the very characteristic osteophagia, the severity of which may indicate the degree of the deficiency, and by the occurrence of rickets and osteomalacia. Iodine deficiency can easily be diagnosed by the observation of endemic goitre in calves. The definitive diagnosis of the other mineral deficiencies has to be confirmed by chemical analysis and experimentation. Chemical determinations must be done on tissues and body fluids of animals from the region involved. Information on the mineral levels in soil and pasture are useful in aiding the investigation of mineral deficiencies in animals. Analyses of animal material will allow the direct identification of the existing deficiencies with the use of relatively few samples. The results of pasture and soil analyses generally are not so easy to interpret as there are many factors in the soil and in the pasture which may influence the assimilation of mineral elements by the plant and the animal. Beside this, in many regions the collection of representative pasture samples of material actually eaten by the animals is difficult or even impossible, and moreover the mineral content of pasture samples varies considerably according to the growing stage of the plants.

Experiments with mineral supplementation may seem to be the easiest method of diagnosing a mineral deficiency, but often it is difficult to conduct well performed experiments in cattle under range conditions, because of the many natural limitations in deficient areas.

## *Studies on Mineral Deficiencies affecting Range Cattle in Brazil*

In Brazil, mineral deficiencies were suspected as the cause of several diseases of unknown etiology in cattle. In many of these diseases mineral deficiency have been confirmed. In this review the diseases due to mineral deficiencies are grouped together under the mineral involved. In the etiology of some of the diseases there is more than one mineral involved. These conditions are included under the mineral which is responsible for the most conspicuous symptoms observed in that diseases.

For the purpose of this review the results of chemical analyses of plant and soil samples made independently of studies of possible mineral deficiency diseases in cattle are omitted, because this isolated data is difficult to interpret.

## *Phosphorus Deficiency*

Giovine (1943) made a clinical study of phosphorus deficiency in cattle in Minas Gerais. He concluded that phosphorus deficiency affected a great number of cattle in different areas, mainly in the northern, central and western regions of this state. The more severely affected animals were cows after the first and second calving. The clinical signs were depraved appetite, manifested mainly by osteophagia, skeletal defects ("caranga"), emaciation, decreased milk yield, temporary suppression of oestrus, decreased fertility, and slow growth of the calves. There was a significant decrease in serum inorganic phosphorus levels. But calcium levels were normal or slightly decreased. Administration of phosphorus supplements resulted in a clinical recovery.

In a supplementary paper Menicucci (1943) gave the results of phosphorus determinations on blood samples (probably serum) from cattle in Minas Gerais. He considered 3.5 mg of inorganic P/100 ml of blood (serum) as a normal value, and found that only 39.6 per cent of the animals were normal, and that all the other animals suffered from varying degrees of phosphorus deficiency. Unfortunately the author did not give information on the season of the year when the blood samples were taken, the procedure of sampling, or the age and sex of the animals sampled. One hundred and forty-three soil analyses were made and these showed a maximum value of 0.41 per cent (%) of  $P_2O_5$ , just traces as a minimum value, and a mean of 0.09% of  $P_2O_5$ . Based on data obtained from other countries suggesting that phosphorus deficiency occurs in cattle when

<sup>1</sup> Animal Pathologists of the Instituto de Pesquisas Agropecuárias do Centro-Sul, EMBRAPA, Km 47, 20000 Rio de Janeiro, GB, ZC-28, Brazil, and fellows of the Brazilian National Research Council (CNPq).



the soil values are below 0.27% of  $P_2O_5$ , and that there is no such deficiency when the values are above 0.55% of  $P_2O_5$ , he concluded that phosphorus deficiency probably occurs in most of the cattle population in Minas Gerais.

Villares and Silva (1956), between 1951 to 1953, determined the inorganic phosphorus content of whole blood from 37 Guzerá cows held on ~~range~~ range conditions at the Fazenda Experimental de Criação, Sertãozinho, São Paulo. The average inorganic phosphorus content was 4.17 ( $\pm 1.56$ ) mg per 100 ml of blood (694 analyses). This annual average is almost at the lower limit of the normal physiological variation. The inorganic phosphorus content varied during the year and clearly showed a rhythmical curve which had a normal segment with an average of 5.19 ( $\pm 1.41$ ) mg and a deficient segment with an average of 3.30 ( $\pm 1.05$ ) mg. The 1.89 ( $\pm 0.54$ ) mg difference between these means is highly significant and indicates a periodic phosphorus deficiency. The phosphorus deficient period corresponded to the dry season and the period of adequate phosphorus to the wet season. Lactating cows had phosphorus deficiency both in the dry and rainy seasons, with blood values of 2.58 ( $\pm 0.89$ ) and 3.30 ( $\pm 1.03$ ) mg of inorganic phosphorus, but at the end of lactation phosphorus levels rapidly rose to normal. The non-milking cows were deficient only during the dry season.

Bauer *et al.* (1964), studying a disease of cattle with neuromuscular signs in the county of Vitória do Palmar, Rio Grande do Sul — which may be botulism according to the description given — performed phosphorus analyses on blood serum, and copper and cobalt determinations on liver samples of cattle from this region. All phosphorus values were low; of the 40 samples analysed, 77.5% had values below 4.0 mg of inorganic P/100 ml of blood serum. From six liver samples analysed, four were deficient or marginally deficient for copper and three marginally deficient for cobalt.

Grunert and Santiago (1969) studied the influence of supplemental bone meal on the fertility in beef cattle in Rio Grande do Sul. The test was performed on 7,590 heifers and cows grazing on pasture. A total of 2,511 control animals received only salt in addition to pasture. An increase in the conception rate was noted, especially in lactating cows. In the control group only 25.6% of the lactating cows conceived, whereas 33.4% of all cows suckling a calf became pregnant after a small addition of bone meal and 47.3% after a larger amount. Non-lactating animals showed an improvement of 6.0% in fertility when the proportion of bone meal was more than 50% in the bone meal-salt mixture. It was not possible to demonstrate any influence of the bone meal on the fertility of the heifers.

Tokarnia *et al.* (1970a) studied a disease of cattle which occurs in the "chapadas" or "agreste" (cerrado) regions of Piauí, in northeastern Brazil. The clinical signs of the disease are stunted growth, rough haircoat, low carcass weight at slaughter, reduced calf production, low milk yield, a weak and deformed skeleton as enlarged joints, lordosis and frequent bone fractures; the animals show osteophagia which causes choking of the mouth and throat. "Entreva" is the popular term for the most severe form of the disease, in which the skeletal lesions are so pronounced that the animal has a stiff gait. The main post-mortem findings were softening of bones, which could be broken more easily than

normal bones and sometimes could even be cut with a knife. On histological examination rickets and osteomalacia were diagnosed. Calcium analyses on blood serum from 51 bovines were normal. The inorganic phosphorus values were low. Twenty five bovines had less than 4.0 mg inorganic P/100 ml of blood serum, in 14 others, the phosphorus values were between 4.0 and 5.0 mg, and in only 12 animals were the values above 5.0 mg. The blood samples were taken in March, during the rainy season when there was plenty of green pasture. Based on the history, the clinical picture, post-mortem findings, histopathological changes and inorganic phosphorus determinations on the blood serum, a diagnosis of phosphorus deficiency was made. Secondly to phosphorus deficiency, there is the occurrence of epizootic botulism (Tokarnia *et al.* 1970b). In addition copper deficiency was also found in this region; from 26 liver samples collected from cattle and sheep it was found that 9 were deficient<sup>2</sup> and 8 marginally deficient in copper, whilst only one marginally deficient cobalt values was found (Tokarnia *et al.* 1971).

Clinical pictures of severe phosphorus deficiency with pronounced osteophagia were observed in western and southern Minas Gerais (Megale 1949a, b), in the "fronteira" and "serra" areas of Rio Grande do Sul (Santos & Pereira Neto 1963, and personal observations), on the "chapadas" of Maranhão and northern Goiás, on the "campos altos" of Marajó Island, on the "lavrados" of the Roraima Territory, on the sandy soils of the eastern pantanal and in certain other areas in southern Mato Grosso (personal observations). In southern Maranhão and northern Goiás secondary epizootic botulism was diagnosed, and in some of the southern Mato Grosso areas the disease also appears to occur (personal observations).

Dayrell *et al.* (1973) studied young male cattle kept under range conditions in four "cerrado" areas of Brasília (Sobradinho, Planaltina, Formosa and Luziânia) for a period of 14 to 21 months. Serum inorganic phosphorus values were determined at monthly intervals during this period. Analyses of phosphorus levels in grass samples of *Melinis minutiflora*, *Hyparrhenia rufa* and *Aristida* sp., and soil analyses were also carried out. The results of the serum inorganic phosphorus estimations from cattle in the areas of Sobradinho and Planaltina were in agreement with the herd histories, which indicated that the Sobradinho area was not deficient in phosphorus. But the Planaltina area was deficient. In the areas of Formosa and Luziânia, the serum inorganic phosphorus levels were intermediate, and were in agreement with the herd histories, which indicated a moderate phosphorus deficiency. There was a significant correlation between the phosphorus values in the blood serum and the values of the three grass species with the exception of the area where there was the most severe phosphorus deficiency. There was

<sup>2</sup> In the papers published by Tokarnia and co-workers the following criteria, based on data found in the literature (Tokarnia *et al.* 1968), was adopted in the interpretation of analytical data of liver copper and cobalt values. Liver copper values from 0 to 50 parts of the element per million (ppm) of dry matter indicate deficiency, from 50 to 100 ppm marginal deficiency, and above 100 ppm adequate copper in cattle and sheep of all ages. Liver cobalt values below 0.05 ppm indicate deficiency, from 0.05 to 0.12 ppm marginal deficiency, and above 0.12 ppm adequate cobalt in cattle, 9 months and older, and in sheep, 3 months and older, below 0.08 ppm indicate deficiency, from 0.08 to 0.10 ppm marginal deficiency, and above 0.10 ppm adequate cobalt.



a correlation between the phosphorus values of the soil and the yearly average serum inorganic phosphorus value of the cattle from all four areas. No correlation was found between the rainfall and inorganic phosphorus levels in the blood serum in phosphorus deficient areas, but in areas where there was not a phosphorus deficiency there was a close correlation between increased rainfall and increased inorganic phosphorus in the blood serum.

### Iodine Deficiency

Megale (1949b) described cases of congenital goitre in calves, in western and southern Minas Gerais. Histopathological examinations revealed a diffuse parenchymatous goitre. The administration of mineral mixtures containing iodine to the cows prevented the birth of goitrous calves. Calves treated with iodine recovered.

Iodine deficiency in cattle was also diagnosed on observation of goitre in newborn calves in many areas of central and southern Mato Grosso (personal observations).

### Cobalt Deficiency

Corrêa (1955, 1957) studied a disease in cattle with the popular names "peste de secar", "sablose", "mal da areia", "mal das cabeceiras" and "mal do colete", in the State of São Paulo. It was characterised by lack of appetite, slow and progressive loss of condition, cachexia, lethargy, pica, anaemia, long and rough haircoat, decreased milk yield and low fertility. It occurs more frequently from December to May, i.e., during the rainy season. Liver samples from 22 healthy cattle from an area considered to be sufficient in minerals and from 20 sick cattle from a deficient area, were analysed for cobalt and copper. In the healthy animals the average value for cobalt was  $0.201 (\pm 0.016)$  and for copper  $198.24 (\pm 23.72)$  parts per million of dry matter. In the sick animals the average value for cobalt was  $0.058 (\pm 0.006)$  and for copper  $175.00 (\pm 24.07)$  ppm. The cobalt values of the sick animals indicated cobalt deficiency. Analyses of pasture and soil samples confirmed the cobalt deficiency. In pasture samples from areas where the disease does not occur average levels of cobalt were  $0.334 (\pm 0.030)$  and of copper  $14.36 (\pm 0.96)$  ppm of dry matter, whereas in samples from areas where the disease occurs, the values were  $0.046 (\pm 0.005)$  and  $14.23 (\pm 2.23)$  respectively. Soil samples gave average values of  $20.37 (\pm 3.16)$  and  $22.77 (\pm 2.98)$  ppm of dry matter for cobalt and copper respectively in areas where the disease does not occur, whereas in areas where it occurs the values were  $0.797 (\pm 0.246)$  and  $18.25 (\pm 1.05)$  ppm.

"Mal do fastio", a disease of cattle which occurs in the sugar cane plantation area of the Serra da Ibiapaba, in Ceará, was studied (Tokarnia *et al.* 1961, 1968). Every year during the rainy season all the cattle are taken to the lower "sertão" area, and are taken back to the Serra only at the beginning of the dry season. If this is not done, the animals are affected by "mal do fastio". This happened in 1958, when because of severe drought in all northeastern Brazil, and especially in the "sertão", very few cattle could be moved down from the Serra. Five sick and three healthy animals which had been in the region for

over a year, were examined. The signs of the disease were lack of appetite, rough body hair coat, dry faeces, loss of condition, anaemia and finally death. Post-mortem examinations and histopathological studies revealed lipoidosis of the liver and haemosiderosis of the spleen and kidney. Liver cobalt values of four animals with "mal do fastio" were deficient, and in a fifth marginally deficient. Liver copper was deficient in one of them, and marginally deficient in two others, and normal in two. In two of the three healthy animals liver cobalt was deficient and in one there was a marginally deficient copper value. It was concluded from the history, clinical picture, post-mortem and histopathological findings and from liver analyses, that "mal do fastio" is a disease primarily due to cobalt deficiency and that there is also copper deficiency.

A cattle disease causing mortality in the forest area of the region of Macapá, in Amapá, was studied and the main characteristics of the diseased animals were their poor condition and lack of appetite (Tokarnia *et al.* 1971). Liver cobalt values were deficient in one and marginally deficient in four animals, liver copper values were deficient in three, marginally deficient in two and normal in one animal. It was concluded that there is a combined cobalt and copper deficiency.

Tokarnia *et al.* (1971) studied a chronic disease of cattle, which occurs north of the Doce river, in Espírito Santo, and which is called "toque" or "toca". The disease is observed when animals stay for a period longer than 60 to 180 days on certain pastures. Sick animals isolate themselves from the rest of the herd, are apathetic, show loss of appetite, rough haircoat, dry faeces, and they loose body condition. If the animals are not moved from this pasture, they will die; but if they are taken to a pasture where the disease does not occur, the animals will recover quickly. Clinical examination of three bovines affected by "toque" revealed poor condition and rough haircoat. At post-mortem and histopathological examinations liver lipoidosis was found in one animal. Cobalt values in liver samples from two animals were deficient and marginally deficient in a third; copper values were normal. In four animals from the same region, not affected by "toque", the liver cobalt values were deficient in one and marginally deficient in a second; copper values were only marginally deficient in one animal. It was concluded that "toque" or "toca" is a disease primarily caused by cobalt deficiency.

### Copper Deficiency

Tokarnia *et al.* (1960, 1968) investigated the cause of a poor condition of cattle, and specifically of a disease called "ronca" (roaring disease), in the Parnaíba delta, in Piauí and Maranhão. The animals were undernourished and had rough and often scarce body haircoat, which in some animals seemed bleached. Most of the animals were easily excitable, many had diarrhoea which was neither due to lush pasture growth at the beginning of the rainy season or to worm infestation. The animals with "ronca" had in addition a noisy respiration, similar to roaring. A normocytic and hypochromic anaemia was found in both sick and apparently healthy animals. Post-mortem examinations and histopathological studies revealed haemosiderosis in the livers of all animals with

"ronca" and in the spleen and lymph nodes of most of them. In animals not affected by "ronca" haemosiderosis of the spleen and lymph nodes was rare and was not seen in the liver. Liver copper values were deficient in three animals with "ronca" and in five others not affected by "ronca" from which liver samples were collected. Liver cobalt values were normal with the exception of one which was marginally deficient. It was concluded that there was a copper deficiency in the Parnaíba delta, but the simultaneous occurrence of other deficiencies or factors could not be excluded, especially as no explanation could be found for the roaring.

Near the coast of Piauí, on sandy soils, there occurs a disease in newborn or young lambs which is locally known as "escancho" (Tokarnia *et al.* 1960, 1963). Incoordination of the hind quarters is the most characteristic symptom. In severe cases paraplegia is observed. The disease is non-febrile, the appetite remains normal, and the condition may be either acute or chronic. Most of the affected lambs die. In nine animals post-mortem examinations revealed no abnormalities but histopathological studies revealed demyelination of the spinal cord. Copper determinations on liver samples revealed deficient values in all nine animals, whereas cobalt values were normal. It was concluded that "escancho" is iden-



FIG. 1. Cobalt (Co), copper (Cu), iodine (I) and phosphorus (P) deficiencies in cattle in Brazil, not confirmed cobalt deficiency (CO?).



tical to "enzootic ataxia", a disease associated with copper deficiency, described in other countries.

Sutmöller *et al.* (1966) found low liver copper values in cattle from the Marajó Island, the coast of Amapá Territory and the low-lands of the Lower Amazon Region.

Nine of ten liver samples collected from cattle on the Marajó Island, Pará, had deficient values for copper. Cobalt values were all normal. (Tokarnia *et al.* 1968.)

In the coastal area of the northern part of the State of Rio de Janeiro, the same roaring disease of cattle as occurs in the Parnaíba delta, is observed. The clinical data, post-mortem and histopathological findings are identical. In two animals affected by the disease the liver copper values were deficient, and in one of them a deficient cobalt value was also found. Another bovine, not affected by the disease, and one sheep from that area also had deficient copper values. (Tokarnia *et al.* 1971.)

It was thought that the cattle should be in better condition in the southern part of the State of Rio de Janeiro than they actually were, so a mineral deficiency was suspected. Seven deficient and seven marginally deficient liver copper values out of a total of 35 animals examined were obtained; as for cobalt there were only three marginally deficient values (Tokarnia *et al.* 1971.)

In <sup>northern</sup> Santa Catarina, Tokarnia *et al.* (1971) found deficient copper values in 12 of 14 bovines examined. The cobalt values were all normal. These animals were from higher areas between the Serra do Mar and the Atlantic coast. Here, "enzootic haematuria" and carcinomas of the upper digestive tract of cattle are prevalent and overshadow all other problems (Tokarnia *et al.* 1969). In southern Santa Catarina between the Serra do Mar and the Atlantic, there were no "enzootic haematuria" but where cases of carcinomas of the upper digestive tract occur, there is a disease characterized by loss of condition and weakness. Two animals examined were cachectic and anaemic. Liver copper values were deficient in both, whereas the cobalt values were normal. In another animal, an apparently healthy sheep, the liver copper value was deficient, and in two bovines, one was marginally deficient and the other normal. Liver cobalt values were normal with the exception of one which was marginally deficient.

In the region of Rondonópolis, in central Mato Grosso, there is a chronic disease called "cara inchada". It affects up to 50 per cent of the calves around weaning time and mineral deficiency was thought to be the cause. There were periodontal lesions, particularly in the premolar regions. Liver copper values from six affected calves were deficient, whereas cobalt values were normal. The cause of the disease, and the role of copper deficiency in its pathogenesis are unknown. (Tokarnia *et al.* 1971.)

#### Sodium and Chlorine Deficiencies

Imai *et al.* (1965/66) did not observe any significant difference in growth rate between eight heifers with access to salt supplementation and eight others without this supplement during 851 days on *Panicum maximum* pasture at the Experimental Station in Sertãozinho, São Paulo.

#### DISCUSSION

From the existing studies on diseases caused by mineral deficiencies in cattle in Brazil (Fig. 1), one can conclude that mineral deficiencies are important in this country.

Phosphorus deficiency is certainly the most important mineral deficiency of cattle in Brazil. In addition to the areas where pronounced phosphorus deficiency has been diagnosed, there probably occurs in large parts of Brazil a seasonal phosphorus deficiency, as studied by Villares and Silva (1956) in Sertãozinho, São Paulo.

Cobalt deficiency seems to come second in importance. Diseases called "toque" or "toca", which have the same or similar history as a condition with the same names identified as cobalt deficiency in northern Espírito Santo (Tokarnia *et al.* 1971), occur in other regions of Brazil; so in the São Francisco river valley in western Bahia (Macedo 1952), in the Uruçuí and Gurguéia river valleys in southeastern Piauí (Iglesias 1951) and in the "chapada" regions of Maranhão (Tokarnia *et al.* 1968). There is also an indication of cobalt deficiency in the Bragança region in Pará (Soares 1963), and in several areas of central and southern Mato Grosso (personal observations).

Copper deficiency seems also to be quite common, but the presence of this mineral deficiency cannot be ascertained from disease histories and by the collection of clinical data. Copper deficiency in cattle is less characteristic than the other mineral deficiencies mentioned above and it can be seen from this review that it sometimes occurs associated with other deficiencies which dominate the clinical and pathological picture of copper deficiency.

Iodine deficiency in cattle has been observed only in Minas Gerais and Mato Grosso.

As yet there are no data on the occurrence of deficiencies of sodium, chlorine, magnesium, manganese, zinc and selenium in cattle in Brazil.

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