Enzootic geophagia of calves and lambs in the Northern Cape and North-West Provinces of the Republic of South Africa, and the possible role of chronic manganese poisoning

J.A. Neser
Pathology Section, Onderstepoort Veterinary Institute, Private Bag X05, Onderstepoort 0110, RSA
e-mail: johann@moon.ovi.ac.za

Enzootic geophagia

Geophagia, the deliberate ingestion of soil, has been classified as a form of pica. Geophagia in mammals has been associated with deficiencies of elements such as phosphorus, sodium, magnesium, sulphur, copper, cobalt and manganese (Kreulen & Jaeger, 1984). Geophagia may also be an instinctive behavioural response to gastro-intestinal disturbances (Kreulen, 1985; Johns & Duquette, 1991; Reid, 1992). In this presentation a specific enzootic form of geophagia is described which occurs in young beef calves and lambs born under ranching conditions at very specific locations in the Northern Cape and North-West Provinces of South Africa.

Symptoms, age susceptibility and incidence

Young calves display an insatiable appetite for the manganese-rich soil. Some calves lick iron poles. Severe constipation and dehydration develop and death occurs within 7 to 14 days of age. Calves older than ± 2 months are rarely affected. However, morbidity and mortality rates have been difficult to determine accurately.

The farmers managed to control the occurrence of the geophagia by keeping their cows with young calves on deep litter in pens, allowing cows limited grazing during the day. They were also successful in suppressing the symptoms by injecting their calves shortly after birth with commercial iron-dextran compounds.

Geographical distribution, geology and topography

The Enzootic geophagia occurs on a limited number of farms in the Vryburg, Postmasburg and Barkley West districts of the Northern Cape and North-Western Provinces. The affected farms are found in an arid region of the provinces, known as the Ghaap Plateau. All farms have one characteristic in common, a manganese-rich soil with superficial outcrops of manganese-rich dolomite rock.

According to the Official Geological Map (1:1000000) of South Africa (Council for Geoscience, Private Bag X112, Pretoria 0001, RSA), the affected area is underlain by manganese-rich dolomitic or carboniferous rock of the Reivilo Formation (Astrup & Tsikos, 1998). The area has a unique geological composition of limestone, dolomite and chert.

The affected areas are characterized by wide, shallow pans. Rainwater tends to drain slowly from the pans. The soil contains numerous densely distributed, round to ovoid, black-grey carboniferous concretions of ca. 1-10 mm, derived from the superficial weathering of parent rock under warm moist conditions in the pans. The soil contains an average of 8% manganese, 3% iron and 0.0024% cobalt.

Ingestion of manganese-rich concretions by calves and lambs

The stimuli prompting the ingestion of the manganese-rich soil by calves and lambs are unknown. Evidence of the ingestion of small quantities of soil by calves and lambs is frequently observed during routine post mortem examinations. Graham et al. (1994) associated consumption of soil by calves with a deficiency of minerals especially iron in their dams’ milk. It may also be a displaced reaction to hunger when the calves are temporarily deserted by their dams when grazing. Such calves were observed to start licking soil.

In our investigations calves and lambs reared in confinement voluntarily ingested small quantities of soil from both affected and unaffected farms in the affected area, as well as soils from experimental farms where geophagia is unknown. In all cases the dams were not deficient in phosphorus or sodium, thus excluding these as possible causes of geophagia in their calves. The ingestion of the manganese-rich soil was
found to aggravate the initial ingestion of this soil and produced severe geophagia experimentally in a high proportion of young calves. The tendency apparently disappears when the rumen becomes functional.

The mechanism through which the intake of manganese initiates geophagia in calves and lambs is unclear and apparently rather complex. It is known that manganese interferes with iron absorption by competitively binding to sites for absorption (Thomson & Valberg, 1972; Hurley & Keen, 1987). Manganese has been shown to interfere with the availability of zinc in the digestive tract, as well as with the uptake of cobalt by micro-organisms in the rumen (Pfander et al., 1966). A deficiency in cobalt has been associated with pica in cattle (Keulen & Jaeger, 1984; Valli & Parry, 1993) and a zinc deficiency has been implicated as a cause of geophagia in children (Hambidge et al., 1987).

It is hypothesized that the ingestion of manganese-rich soil has a perpetual effect in the gastrointestinal tract of the calf, thereby causing progressive deficiencies of iron and/or zinc. This prompts a vicious cycle of increasing consumption of the manganese-rich soil that ultimately leads to the demise of the calf. In our investigation geophagia could be prevented in the calves exposed to manganese-rich soil from the affected area by prophylactic injections of commercial iron- and vitamin B\textsubscript{12} compounds at birth, and at 10 days of age.

Hepatotoxic effect of manganese

The main characteristic of the problem is liver damage. Macroscopical pathological changes consist of moderate to severe jaundice and a marked enlargement and yellow discolouration of the liver. The ingestion of soil leads to varying degrees of constipation and colic. This probably causes the cessation of suckling which contributes to occurrence of death within 7 – 14 days after the commencement of geophagia. Dark-brown to black soil, largely consisting of manganese-rich concretions, is usually found in the abomasum and small intestine of the animal. Liver specimens from calves and a lamb with soil in their digestive tracts or a history of geophagia revealed high concentrations of manganese, ranging from 10 – 1800 mg/kg wet liver mass compared to the normal range of 2 – 3 mg/kg wet mass (Hurley & Keen, 1987). A preliminary investigation showed that the concentrations of manganese and iron in the livers of yearlings and culled cows from two severely affected farms were within normal ranges for cattle.

The histopathological changes in the liver were consistently characterized by a chronic cholangiohepatitis with marked portal fibrosis and bile duct proliferation. Similar histopathological changes could be induced in the liver of laboratory rodents through the experimental dosing of manganese compounds (Findlay, 1924; Witzleben et al., 1968).

The concentrations of the other elements in the liver did not show any specific pattern which could be related to soil ingestion. The manganese concentration in the livers of full-term bovine foetuses from cows in the affected areas as well as from new-born calves before milk was ingested, were within the normal range. Transplacental transmission of manganese with its accumulation in the livers of calves, rabbits and mice has been reported where the dams were supplemented with manganese (Hurley & Keen, 1987). However, our observations were based on a limited number of animals, and further cases will have to be examined to arrive at more definite conclusions on the possible role of transplacental transmission of manganese on the occurrence of geophagia in calves in the affected area. The contribution of a possible manganese-induced vitamin B\textsubscript{12} deficiency in the mothers which is transferred to their offspring has not been investigated. This seems unlikely because the geophagia could be induced in calves at experimental stations where their mothers were not subjected to an overexposure of manganese.

Final conclusions

The ultimate cause of the geophagia is still uncertain. The characteristic lesions in the liver can be attributed to a subacute to chronic form of manganese poisoning caused by an abnormally high intake of manganese-rich soil. Our findings suggested that the accumulation of manganese in their livers occurs mainly after birth. Therefore, the occurrence of geophagia in the calf seems to be independent of the habitation of their mothers in the affected area, though the beef production practices on the farms seem to contribute to the occurrence of the problem.

References


2. SYMPTOMS, AGE SUSCEPTIBILITY AND INCIDENCE

2.1. ENZOOTIC GEOPHAGIA

Enzootic geophagia occurs in young calves and lambs on affected farms. It is characterized by wide, low-lying shallow pans in which rainwater takes longer to drain. The pans are up to 2 metres in diameter and 0.1-0.2 metres deep, with a shallow sloping floor of fine white sand. The characteristic lesions in the liver can be attributed to a subacute to chronic form of manganese poisoning.

3. GEOGRAPHICAL DISTRIBUTION

Geophagia occurs on a limited number of farms in the Vryburg, Postmasburg and Barkley West districts of the Northern Cape and Northern Transvaal. Affected farms are situated in an extensive area known as the Glass Plateau.

4. GEOLOGY OF THE AFFECTED AREA

According to the official Geological Map (1:100000) of South Africa (Council for Geosciences, P/B X 122, Pretoria, 2001), the area is underlain by manganese-rich dolomite or carboniferous rock of the Rustfontein Formation (Astrup & Tokars 1993). This area has a unique geological composition of limonite, dolomite and chert.

The area is characterized by a peculiar blue-grey colour and the letter codes of XG7.

5. TOPOGRAPHICAL FEATURES

The affected area is also characterized by wide, low-lying shallow pans in which rainwater takes longer to drain. The soil contains numerous densely distributed small, round to void black-gray carboniferous concretions of dolomite rock. This area has a unique geological composition of limonite, dolomite and chert.

On analysis, the soil contains an average of 1.8% manganese, 3% iron and 0.024% cobalt.

6. INGESTION OF MANGANESE-RICH CONCRETIONS BY CALVES AND LAMBS

The initial stimulus for the ingestion of manganese-rich soil by calves and lambs is not known. The ingestion of relatively small quantities of soil by calves and lambs from diverse discoloured areas has been observed frequently during routine post-mortem examinations. Soil licking may be an instinctive mechanism to secure necessary mineral levels in the diet.

7. THE TOXIC EFFECT OF MANGANESE

The main feature of the disease is liver damage, although the ingestion of soil also leads to a sudden increase in the concentration of manganese in the liver, pancreas and kidneys.

8. HISTOPATHOLOGICAL CHANGES IN THE LIVER

The histopathological changes in the liver were consistently characterized by a chronic cholangiohepatitis with portal fibrosis and bile duct proliferation. Similar histopathological changes could be induced in the liver of laboratory rats by the experimental feeding of manganozoic compounds (Findlay 1924, Pillicek).

9. EXPERIMENTS WITH SOIL FEEDING AND MINERAL SUPPLEMENTATION

9.1. FEEDING EXPERIMENTS

Fails geophagia could be caused in young calves at the PVL and at the OVI by offering manganese-rich soil from the affected area to calves purchased from locations other than the affected area.

9.2. MINERAL SUPPLEMENTATION

Geophagia could be prevented in calves exposed to manganese-rich soil by the prophylactic injection of commercial iron- and vitamin B12 compounds at birth and at 10 days of age on farms in the affected area, as well as at the OVI.

11. REFERENCES


