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Lead poisoning of calves pastured in the target area of a military shooting range

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Bleivergiftung von Rindern nach Weiden im Zielbereich eines Schiessgeländes

Fünf Jungrinder im Alter von 7–9 Monaten wurden anfangs Mai auf eine Weide im Zielbereich einer Schiessanlage gebracht. Nach 5 Tagen erkrankte das erste Tier an akuter Bleivergiftung. Die weiteren Tiere erkrankten 6–8 Tage nach Weideaustrieb. Die wichtigsten Symptome bestanden in zentralnervösen Störungen wie Zwangsbewegungen, Opisthotonus, Speicheln, Verdrehen der Augen, Konvulsionen, leerem Kauen, Zähneknirschen, Lecken, Durchbrechen der Weideumzäunung und Brüllen. Alle Tiere gingen innerhalb von wenigen Stunden nach Auftreten der ersten Symptome ein. Die bei einem Tier vorgenommene Bleibestimmung in Blut, Leber und Nieren ergab stark erhöhte Werte von 940 µg/l Vollblut, 38 mg/kg Leber Frischgewicht und 30 mg/kg Niere Frischgewicht. Bei der Sektion dieses Rindes wurden akute Blutungen in Herz, Nieren und Lunge, eine akute Tubulonephrose und ein hochgradiges akutes Lungenemphysem festgestellt. Die Bleibestimmung in je einer Boden- und Grasprobe aus dem Zielbereich des Schiessgeländes ergab Bleigehalte von 29'550 mg/kg TS Erde und 3900 mg/kg TS Gras. Weitere Abklärungen ergaben, dass das betroffene Gebiet seit vielen Jahren als Schiessgelände benutzt wird und dass im Vorjahr ca. 20'000 Schüsse mit einem Bleigehalt von 3.05 und 8.55 g pro Geschoss abgegeben wurden. Die Untersuchungen lassen den Schluss zu, dass das Zielgelände von Schiessanlagen nicht beweidet und auch nicht anderweitig für die tierische Futter- bzw. die menschliche Nahrungsmittelproduktion genutzt werden darf.

Schlüsselwörter: **Rind – Bleivergiftung – Weiden – Schiessgelände**

Summary

Five calves, seven to nine months of age, were put on pasture in the target area of a shooting range in early May. Acute lead poisoning occurred in one of the calves after five days of grazing; the remainder became ill one to three days later. The most important symptoms consisted of neurological disturbances and included maniacal movements, opisthotonus, drooling, rolling of the eyes, convulsions, licking, champing of the jaws, bruxism, bellowing and breaking through fences. All but one calf, which was euthanatized, died within several hours of the occurrence of the first symptoms. In one calf, the concentration of lead in samples of whole blood (940 µg/l), liver (38 mg/kg wet weight) and kidney (30 mg/kg wet weight) were markedly increased. Post mortem examination of this calf revealed acute cardiac, renal and pulmonary haemorrhage, acute tubulonephrosis and acute severe pulmonary emphysema. The concentration of lead in the dry matter of a grass and a soil sample from the target zone of the shooting range were 29'550 mg/kg and 3900 mg/kg, respectively. Further investigation revealed that this area had been used as a military shooting range for many years, and in the previous year, approximately 20'000 bullets with lead contents of either 3.05 g or 8.55 g had been fired. The results of this study indicate that the target area of shooting ranges must not be used for pasture or for food production for animals or humans.

Key words: **cattle – lead poisoning – shooting range**

Introduction

The ingestion of lead is one of the most common causes of poisoning in cattle (Jubb and Huxtable, 1993; Radostits et al., 1994). The major sources of lead include anti-rust agents containing red lead (minium), lead-bearing paint, grease, used motor oil, lead batteries, shotgun pellets and bullets. A number of reports pertaining to lead poisoning in cattle have been published recently (Bubwy et al., 1990; Baars et al., 1992; Schlerka and Schuh, 1992; Wunderlin et al., 1992; Gudmundson, 1993; McEvoy and McCoy, 1993); however, none of these reports concern lead poisoning in association with pasturing in a shooting range. Recent studies indicate, however, that the soil and vegetation in the target area of shooting ranges are heavily contaminated with lead (Siegrist, 1994; Affolter and Enggist, 1995). Contamination of soil and vegetation by lead, in amounts that exceed the official tolerance level, should be expected in the target area proper as well as in a 20 m radius around it. This report describes fatal lead poisoning in five calves that were pastured in the target area of a military shooting range.

Background

The five calves in this study belonged to a farm in a hilly area of the Swiss Lower Alps. There were 25 Swiss Braunvieh cows, 7 heifers and 7 calves on the farm. In early May, five calves, seven to nine months old and weighing between 250 and 300 kg, were put on a small pasture near the farmhouse (day 0). The calves remained on pasture day and night and were monitored several times a day by the owner, who noted nothing abnormal during the first few days.

On the morning of day 5, the owner noticed that two calves were apathetic and had stopped grazing. By early afternoon, one of the calves (No. 1) had opisthotonus and was circling and as a result, broke through the electric fence. The calf went down 150 m outside of the pasture; it was frothing excessively at the mouth and rolling its eyes. The referring veterinarian treated the calf symptomatically, but it died several minutes later.

On day 6, the owner noticed that calf No. 2 was missing and the fence had been broken again. The calf was found dead approximately 100 m outside of the pasture in a gully. Post mortem examination of this calf by the referring veterinarian revealed no remarkable findings. The three remaining calves, which were still clinically healthy, were immediately stabled and fed hay.

On the morning of day 7, calf No. 3 had a reduced appetite, a rectal temperature of 38.5°C and appeared apathetic. Other abnormal signs included bruxism, champing of the jaws and drooling. The calf died within several hours of the occurrence of the initial symptoms.

On day 8, symptoms including anorexia, pushing against the front of the stall, arching of the back, staring haircoat, chewing movements and drooling were observed in calf No. 4. The calf was then referred to our clinic. On the afternoon of day 8, calf No. 5 died after exhibiting symptoms similar to those observed in calf No. 4.

Clinical examination of calf No. 4

Calf No. 4 weighed 266 kg and was down in sternal recumbency. General behaviour and attitude were markedly abnormal. The most important symptoms included bellowing, rolling of the eyes, convulsions, licking, drooling and champing of the jaws. The scleral vessels were slightly congested, the capillary refill time was three seconds and the oral mucosa was pale pink. The calf had a rectal temperature of 39.3°C, a heart rate of 160 beats/min and a respiratory rate of 60 breaths/min. Auscultation of the lungs revealed no abnormal sounds. There was ruminal and intestinal atony, and the amount of feces was severely reduced. The feces were olive green, well digested and had a porridge-like consistency. The urine, obtained via a catheter, was light yellow, clear and had a pH of 7. A semi-quantitative urine strip test revealed ++ glucose and ++ erythrocytes (range +, ++, +++)

Based on history and clinical symptoms, a tentative diagnosis of lead poisoning was made. The differential diagnosis included cerebrocortical necrosis and hypomagnesaemia. Serum and EDTA blood samples were collected for haematological, biochemical (Table 1) and blood-gas analysis (Table 2). The most important findings were haemoconcentration (PCV, 46%), moderate to severe increase in serum electrolytes, and severe acidosis with a

Table 1: Results of the haematological and biochemical examinations in calf No. 4 with lead poisoning

Variable	Calf No. 4	Normal range
Haematocrit (%)	46	33–36
RBC count (10^6/µl)	10.9	5–9
WBC count (10^3/µl)	4.3	4–10
Plasma protein (g/l)	84	60–80
Fibrinogen (g/l)	6	5–7
Urea (mmol/l)	5.4	<7.5
Bilirubin (µmol/l)	8.7	0.8–8.6
AST (U/l)	327	40–80
GLDH (U/l)	15.6	10–25
γ-GT /U/l)	11	6–17
SDH (U/l)	19.4	3–7.5
Calcium (mmol/l)	3.46	2.00–2.60
Magnesium (mmol/l)	1.68	0.70–1.10
Inorganic phosphate (mmol/l)	5.22	1.30–2.25
Sodium (mmol/l)	167	135–155
Potassium (mmol/l)	11.2	3.5–5.5
Chloride (mmol/l)	106	96–110

Table 2: Results of analysis of venous blood in calf No. 4 with lead poisoning

Variable	Calf No. 4	Normal range
pH	6.59	7.35–7.50
pCO_2 (mmHg)	76.1	35–45
HCO_3^-(mmol/l)	2.8	20–30
Base excess (mmol/l)	-33.2	-2 to +2

blood pH of 6.59 and a base excess of -33.2 mmol/l. In addition, analysis of an EDTA blood sample revealed a lead concentration of 940 µg/l (Table 3).
A diagnosis of acute lead poisoning was made. After the examination, the calf was euthanatized and necropsied. All organs were examined macroscopically and histologically. There was acute, nonspecific cardiac and renal haemorrhage and acute tubulonephrosis involving the proximal renal tubules. Acid-fast inclusions were not observed in the renal and hepatic epithelium. The concentration of lead in samples of liver and kidney were 38 mg/kg wet weight and 30 mg/kg wet weight, respectively (Table 3).

Table 3: Lead concentration in samples of blood, liver and kidney of calf No. 4 with lead poisoning and in a grass and a soil sample from the target area of a shooting range

Specimen	Lead content	Interpretation
Whole blood (µg lead/l)[1]	940	> 350 µg/l indicative of poisoning [4]
Liver (mg lead/kg dry matter)[2]	38	> 20 mg/kg wet weight indicative of poisoning [4]
Kidney (mg lead/kg wet weight)[2]	30	> 25 mg/kg wet weight indicative of poisoning [4]
Soil (mg lead/kg dry matter) [3]	29550	< 50[5]
Grass (mg lead/kg dry matter) [3]	3900	< 30[5]

[1] Determination using a mass spectrometer in the laboratory of the Department of Veterinary Internal Medicine, University of Zurich
[2] Determination using atomic absorption in the UFAG Laboratories, CH-6210 Sursee
[3] Determination using atomic absorption in the SOLVIT Laboratory, Korner & Laczkó, CH-6010 Kriens, according to the regulations of the FAC, Liebefeld.
[4] Radostits et al., (1994)
[5] Lindt et al., (1990): Values measured in soil specimens of not contaminated areas.

Investigation of the farm

In order to locate the source of lead, the farm and pasture were investigated. The pasture had a surface area of approximately 2000 m^2 and was found to include the target area of a shooting range (Fig. 1). The shooting range consisted of a rifle house with eight places for shooting at targets placed 300 m away. The bullets penetrated the targets and lodged in a mound of earth (backstop) behind the targets. The backstop was covered with rubber mats to prevent the bullets from ricocheting. The calves had access to a grass strip, approximately 2 m wide and situated between the targets and the backstop. Interestingly, the grass on this strip had been completely eaten, whereas the pasture surrounding the target area had barely been grazed. The lead content of a grass and a soil sample obtained from the middle of the grass strip was 3900 and 29'550 mg/kg dry matter (DM), respectively. Other possible sources of lead, such as lead batteries or minium-coated iron objects, were found neither on the pasture nor in the barn. Further investigation revealed that the affected area had been used as a shooting range

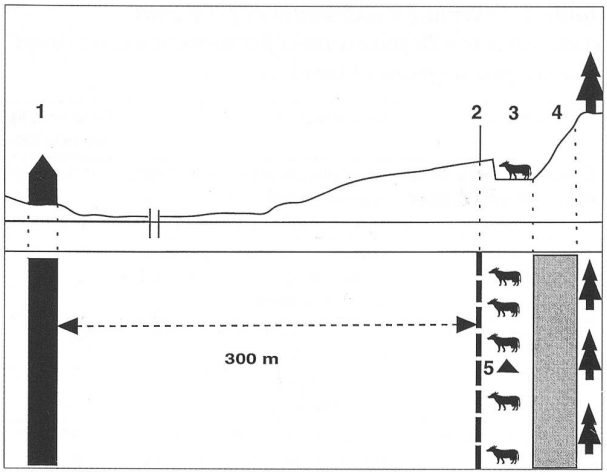

Figure 1: Schematic representation of the military shooting range in profile and from above. 1 = rifle house, 2 = targets, 3 = strip of grass between targets and backstop, 4 = backstop, 5 = site where a grass and a soil sample were obtained for determination of lead concentration.

for many years, and approximately 20'000 bullets had been fired in the previous year. The types of bullets used were 7.5 mm (GP 11) and 6.5 mm (Gw Pat 90) rifle cartridges. These bullets have a hard lead core composed of 98% lead and 2% antimony (Siegrist, 1994). The bullet core weighed 8.55 g in the GP 11 cartridge and 3.05 g in the Gw Pat 90 cartridge. The bullet core also contained 0.001% cadmium, 0.001% copper, 0.002% zink and 0.005% arsenic. The actual amount of lead fired in the previous year was estimated to be between 61 and 171 kg.

Discussion

This report serves to demonstrate that fatal lead poisoning in calves may occur after only a few days of grazing on a heavily contaminated area. In Switzerland, the official tolerance level for heavy metal contamination of soil is 50 mg/kg. The lead content of soil with an average contamination corresponds to approximately half the tolerance level (Siegrist, 1994). The lead content of the soil sample in this study was an astonishing 600 times higher than the official tolerance level (Table 4). Similar findings were reported in two extensive studies of other shooting ranges (Siegrist, 1994; Affolter and Enggist, 1995). Siegrist (1994) investigated the lead contamination of soil in seven military shooting ranges in the canton of St. Gallen. Lead concentrations in the soil from the backstop area of the two largest shooting ranges were 30'000 and 60'000 mg/kg DM. The extent of the contamination was surprising, because the soil in an area greater than 20 metres in front of and 25 metres behind the targets was contaminated with lead.
The determination of lead concentration in the grass sample in this study indicated that the vegetation was

Table 4: Criteria for assessment of the lead concentration in plants used for human and animal consumption (from Lindt et al., 1990)

Classification	Comments	Lead (mg/kg dry matter)
Normal, area not directly contaminated	This concentration may occur in areas outside of the influence of emissions	< 0.5
Normal, area contaminated	This concentration may occur in areas outside of a 2 km radius from the emissions	0.5–1
Slightly increased	This concentration is below tolerance limit for humans; vegetation can be used for consumption.	1–10
Greatly increased	This concentration is above the tolerance limit for humans, but below the tolerance limit for animals; use of vegetation is restricted.	10–30
Extremely increased	This concentration is above the tolerance limit for animals; vegetation must not be used for feed.	> 30

also heavily contaminated. The maximum tolerance level for lead in cattle feed is 25 to 30 mg/kg DM (Kessler, 1993). The lead concentration in this sample of grass was 100 times the suggested limit of 30 mg/kg DM for animals (Lindt et al., 1990) and 300 times the tolerance level of 10 mg/kg DM for humans. Affolter and Enggist (1995) demonstrated a clear correlation between the lead contents of the soil and the vegetation. Lead may enter the plant through the roots and/or through the leaf stomata. The major portion of lead in samples of grass is probably found in the dust on the surface of the plant; washing may remove 30 to 80% of the total amount of lead (Merian, 1984). The main source of lead that pollutes vegetation is probably contaminated soil and dust from bullets, which is stirred up by the wind or by the impact of bullets and carried over a distance of several metres to be deposited on the surface of plants. When the grass is eaten by animals, the sum of the lead concentrations in the plant tissue and the amount deposited on its surface will determine total intake.

The ingestion of forage plants containing lead is usually the major source in cases of lead poisoning of cattle. In calves, ingestion of 400 to 600 mg of lead per kg of body weight results in fatal poisoning (Radostits et al., 1994). In the case of calf No. 4, which weighed 266 kg, this corresponded to 106 to 160 g of lead. This amount was contained in 27 to 41 kg of grass DM. With a daily intake of approximately 6 kg of DM, fatal lead poisoning would occur in 5 to 7 days. A similar effect would be expected in cattle consuming feed contaminated with 300 to 450 mg of lead per kg of DM for a period of greater than two weeks (Affolter and Enggist, 1995). Chronic lead poisoning in ruminants can be expected when feed containing more than 50 mg of lead per kg of DM is ingested over a period of several months. No negative effects have been observed in ruminants that received a daily dose of 0.2 mg of lead per kg of body weight or that consumed feed containing less than 10 mg of lead per kg of DM (Merian, 1984). In addition to plant material, varying amounts of soil are always ingested by grazing cattle or those fed grass; in dairy cows, this may amount to between as much as 1 and 10% of the ingested dry matter (Healy, 1972; Thornton and Abrahams, 1983). This corresponds to 0.2 to 2 kg of soil per day in a cow consuming 20 kg of DM. In areas where the soil is heavily contaminated, the ingestion of soil may affect the animal more than the consumption of grass.

The results of this study support those of Siegrist (1994) and Affolter and Enggist (1995), who demanded that the use of heavily contaminated areas for agricultural purposes should be urgently reconsidered. In particular, the use of such areas for pasturing cattle or for harvesting hay and grass for animal feed should be prohibited to prevent poisoning of the animals and lead from entering the human food chain. Vegetation must be cut and left to decay on site. It is evident that vegetables must not be planted on such sites and that the harvesting of berries and mushrooms must be prohibited. Furthermore, access to the backstop area by the public, in particular by children, must be prevented by fences or hedges. The groundwater must be monitored in those zones that are located near a shooting range. The dismantling of a shooting range poses special problems. It is recommended that in such ranges, the soil be left on site, or removed and handled according to environment protection law (Siegrist, 1994). The latest advances in technology must be used when building new shooting ranges in order to minimize contamination of the environment with lead.

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Intoxication au plomb chez des jeunes bovins lors de pacage dans le voisinage des cibles d'un terrain de tir

Cinq jeunes bovins âgés de 7 à 9 mois ont été amenés au début de mai sur un pâturage dans le voisinage des cibles d'un terrain de tir. Après 5 jours, le premier animal a présenté des symptômes aigus d'intoxication au plomb. Les autres animaux ont été atteints 7 à 8 jours après la mise en pâturage. Les symptômes les plus importants ont été des troubles du système nerveux central tels que mouvements contraints, opisthotonos, hypersalivation, rotation des yeux, convulsions, mâchage à vide, grincement des dents, léchage, enfoncement des clôtures et beuglements. Tous les animaux sont décédés dans l'espace de quelques heures après l'apparition des premiers symptômes. La détermination dans le sang, le foie et le rein d'un animal a révélé des valeurs élevées de 940 µg/l de sang, 38 mg/kg de poids frais de foie et 30 mg/kg de poids frais de rein. Lors de l'autopsie de cet animal, des hémorragies aiguës dans le cœur, les reins et les poumons, une tubulonéphrose aiguë, et un emphysème pulmonaire aigu grâve ont été constatés. La détermination de la quantité de plomb dans des échantillons de sol et d'herbe de la zone des cibles du terrain de tir a révélé des contenus en plomb de 29 550 mg/kg MS de terre et 3900 mg/kg MS d'herbe. D'autres investigations ont indiqué que le territoire concerné avait été utilisé depuis plusieurs années comme terrain de tir et qu'au cours de l'année précédente environ 20 000 coups avec un contenu en plomb de 3,05 à 8,55 g par coup avaient été tirés. L'enquête a permis de conclure que le voisinage des cibles du terrain de tir ne devait plus être pâturé et ne plus être utilisé pour la production de nourriture destinée aux animaux et aux humains.

Avvelenamento da piombo in manzi che avevano pascolato nell'area d'obiettivo di un poligono di tiro

Cinque manzi giovani di età compresa fra i 7 e 9 mesi sono stati portati al pascolo all'inizio di maggio nell'area di obiettivo di un poligono di tiro. Dopo 5 giorni si manifestava nel primo animale l'avvelenamento acuto da piombo. Gli altri animali si ammalarono 6–8 giorni dopo la fuoriuscita al pascolo. I sintomi più importanti consistevano in disturbi nervosi centrali tali che, movimenti forzati, poistotono, salivazione, rotazione degli occhi, convulsioni, masticazione a vuoto, digrignamento dei denti, leccare, sfondamento dello steccato del pascolo et muggire. Tutti gli animali morirono poiche ore dopo l'apparizione dei primi sintomi. La determinazione del contenuto di piombo in sangue, fegato e reni in uno degli animali, mise alla luce valori molto elevati: 940 µg/l di sangue, 38 mg/kg di fegato fresco e 30 mg/kg di rene fresco. Durante la sezione di questo manzo si constatarono emorragie acute in cuore, reni e polmoni, una tubulonefrosi acuta ed un enfisema polmonare acuto e di alto grado. La determinazione del piombo in una prova del terreno e dell'erba rivelava dei contenuti di piombo di 29 550 mg/kg di terra e 3900 mg/kg di sostanza secca d'erba. Ulteriori ricerche confermavano che l'area incriminata viene usata da tanti anni come area di tiro e che l'anno precedente erano stati sparati circa 20 000 colpi con un contenuto di piombo per colpo di 3.05g e 8.55 g. La ricerca conclude che l'area di un poligono di tiro non è utilizzabile come pascolo e che essa non si adatta per la produzione di alimenti sia per l'uomo e che per l'animale.