Lead poisoning in a calf from the mining area of Sierra Madrona and Alcudia Valley

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Abstract: We notify the first reported case of lead (Pb) poisoning in a calf from the old mining district of Sierra Madrona and Alcudia Valley (Spain), which appeared in a farm with visible signs of historic mining activity in the surrounding land. The blood Pb level found in this calf was 311 µg/dL, and was associated to several symptoms of clinical Pb poisoning, including severe paralysis, loss of sensitivity from hip to the hind legs and incoordination. Soils, plants and water points inside the farm showed Pb levels above the threshold values to be classified as highly polluted soils, toxic pastures for livestock and non-potable water for humans. This report indicates that Pb pollution denotes a health risk for cattle reared in the mining area of Sierra Madrona and Alcudia Valley.

Keywords: Livestock, lead, plumbism, heavy metals, soil contaminantion.

Resumen: Intoxicación por plomo en un ternero de la zona minera de Sierra Madrona y el Valle de Alcudia. Se notifica el primer caso registrado de intoxicación por plomo (Pb) en un ternero del antiguo distrito minero de Sierra Madrona y el Valle de Alcudia (España), que apareció en una finca ganadera con restos visibles de antiguas activides mineras en los terrenos circundantes. El nivel de Pb en sangre detectado en el animal fue de 311 µg/dL, y estuvo asociado a diversos síntomas de intoxicación clínica por Pb, que incluyen parálisis severa, pérdida de sensibilidad en los cuartos traseros e incoordinación. Los suelos, las plantas y los puntos de agua presentes en la finca mostraron niveles de Pb por encima de los valores umbral, siendo considerados como suelos altamente contaminados, pastos tóxicos para el ganado y agua no potable para el consumo humano. Estos datos indican que la contaminación por Pb implica un riesgo para la salud del ganado criado en la zona minera de Sierra Madrona y el Valle de Alcudia.

Palabras clave: Ganado, plomo, plumbismo, metales pesados, contaminación del suelo.

Introduction

Despite there has been a large reduction in lead (Pb) use over the past three decades, environmental Pb contamination is still a serious health problem. Lead poisoning is one of the most frequently reported causes of poisoning in livestock, with cattle as the most commonly affected species. Among the sources of Pb that have been found to cause Pb poisoning in livestock, the presence of large quantities of Pb in soils, sediments and/or water courses in areas of old mine workings has been frequently identified in cases diagnosed in grazing cattle [1].

The old mining district of Sierra Madrona and Alcudia Valley (province of Ciudad Real, South-Central Spain) is situated in a geologically rich area in argentiferous galena, which constituted the major Pb producing district in Spain during the second half of the 19th century. Because of intensive mining, refining and smelting activities, around 484 abandoned mines and prospects, which have never been remediated, are currently scattered throughout an area spanning 2500 km^2. High levels of Pb can still be found in soils, plants and river sediments around the disused metalliferous mines and dumps [2,3], affecting the pasture and arable lands [4,5]. Nowadays, extensive livestock farming for meat production is the most important land use within this old mining district. Animals from these farms graze year round on pasture and in Mediterranean forests surrounding the Pb mines and dumps, thus they are potentially exposed to the remaining Pb pollution.

In a previous work within this mining area, it has been found that 91.4% of cattle had blood Pb levels corresponding to subclinical exposure (6-35 µg/dL) [6]. Elevated blood Pb levels were accompanied by δ-aminolevulinic acid dehydratase (δ-ALAD) activity inhibition in blood, which confirmed that measurable effects of Pb poisoning were taking place in the cattle reared in this mining area [6].

Here it is reported the first case of clinical Pb poisoning in a beef calf from this abandoned mining area, which appeared in a farm of extensive farming production with visible signs of historic mining activity (old mines and buildings, spoils heaps and dumps) in the surrounding land.

Material and methods

The calf (Limuosin) was found by the farmer on May 2012 with visible signs of neurological impairment. It was 2.5 months old, and was still unweaned. His mother was 26 months old, was also born and raised on the same farm, and this was his first birth. The calf was subjected to routine clinical examination by the local veterinary practitioner, and a blood sample was taken with a syringe from the coccygeal vessel and collected in a heparinised tube to be analysed for Pb. To establish potential sources of Pb exposure, eight samples of soils (500-1000 g at a depth of 0-5 cm) and ten pooled samples of plants (40-50 g, mostly Gramineae with minor proportions of Brassicaceae, Fabaceae and Malvaceae) were collected from the area of the farm where this calf was reared. Moreover, four water samples (50 ml) were collected at different sites where livestock use to drink. These sites were a drinking trough (site B) and three points of a stream (site C, see Figure 1). Water of the trough is being pumped from the mine shaft and the stream flows from the mine dump.

Blood Pb level was analysed using a graphite furnace-atomic absorption spectroscopy system (AAnalyst 800, Perkin Elmer)

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following the methodology described by Rodríguez-Estival et al. [6]. Certified reference samples of blood (Bovine blood ERM-195, European Reference Materials) were analyzed to ensure the quality of the methodology. The recovery (mean ± SE) was 107.5 ± 2.8% (n = 6). The detection limit was 0.89 μg/dL of Pb.

Soil, plants and water samples were prepared, oven-dried to constant weight, and acid-digested as described by Reglero et al. [2] before being analyzed for Pb also by atomic absorption spectroscopy. Certified reference samples of soil (CRM025-050, Resource Technology Corporation, USA) and bush branches and leaves (NCS DC 73349A, China National Analysis Center for Iron and Steel) were also analyzed. The recoveries (mean ± SE) were 107.6 ± 15.2% (n = 2) and 113.2 ± 4.8% (n = 2), respectively. The detection limits for Pb analysis were 0.06 μg/L in water, 0.009 μg/g dry weight (d.w.) in plant and 0.09 μg/g d.w. soil samples.

Results

The blood Pb level found in this calf reached a value of 311 μg/dL. Clinical signs detected in the calf included severe paralysis, loss of sensitivity from hip to the hind legs and incoordination. The presence of normal heart rate and corporal temperature, no depression and lack of appetite loss were, however, observed during the clinical examination. No other possible causes of illness (such as infectious diseases, trauma or neoplasia) were diagnosed to explain the clinical symptoms presented by the calf. The animal had to be euthanized to prevent suffering.

Lead levels detected in soils from this farm ranged from 414 to 65858 μg/g d.w. (mean Pb level=8897 μg/g d.w.) (Table 1). Lead levels found in plants used by cattle from this area for feed ranged from 2.3 to 182.7 μg/g d.w. (mean Pb level=52.6 μg/g d.w.). Lead levels in water points used by cattle from this area for drink ranged from 12.9 to 43.8 μg/L (mean Pb level=26.6 μg/L) (Table 1). A schematic representation of this farm is provided in Figure 1 over an aerial photograph obtained from SigPac. The cattle herd to which the intoxicated calf and his mother belonged move and graze freely along this area, which include two dumps (C and D) and a fenced plot (commonly used to stable cattle) whose floor is covered with chat from a dump located close to a mine shaft (A) (Fig. 1).

Table 1. *Total Pb concentrations in soils, plants and water points inside the farm and criteria for its classification according to total Pb content (μg/g d. w. for soil and plants, and μg/L for water).*

Sample	N	Pb concentration		Classification
		Mean	Range	
Soils	8	8897	414-65858	Soils highly polluted (>300 μg/g) [8]
Plants (mostly Gramineae)	10	52.6	2.3-182.7	Plants potentially toxic to livestock (>30 μg/g dw) [9]
Water	4	26.6	12.9-43.8	Exceeds the maximum level destined for human consumption (>25 μg/L) [10]

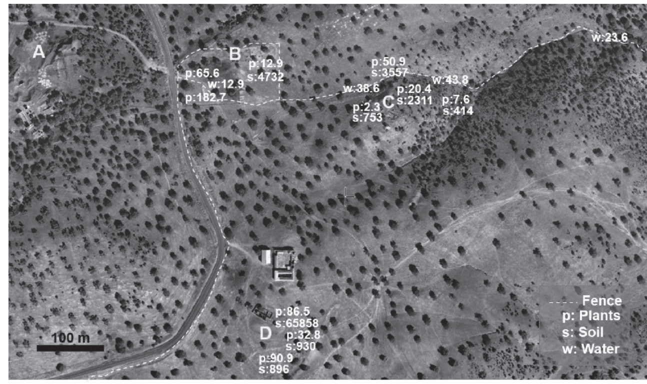

Figure 1. Photograph of the sampled farm (SigPac). Lead concentrations for soils and plants at each sampling point are expressed in μg/g (d. w.) and for water in μg/L. Chat from the dump located close to a mine shaft (A) was used in the past to cover the floor at the fenced plot where the calf was found with signs of neurological impairment (B). Adult cows can move around the farm, including two other dumps located inside (C and D).

Discussion

Lead is a multitargeted toxicant that affects a range of different physiological systems, including central nervous system, immune function, reproduction, bone metabolism, kidney, haematopoiesis, cardiovascular system and gastrointestinal system [7]. The blood Pb level found in this calf (311 μg/dL) widely exceed the blood Pb concentration indicative of clinical poisoning (>35 μg/dL) [7]. The clinical signs accompanying this blood Pb level are similar to those observed in other cases of Pb poisoning in livestock. Blood Pb levels between 10 and 80 μg/dL have been related with neurobehavioral impairments and deficits in motor function, paralysis, ataxia and convulsive episodes [1,7]. Other typical clinical symptoms of Pb poisoning observed with blood Pb levels higher than 40 μg/dL include anemia, hypertension, nephropathy, encephalopathy, peripheral neuropathy, excessive salivation, vomiting, and intestinal colic, as well as abnormal behaviour patterns such as insomnia, lost of appetite, and lassitude [1,7], but they were not detected in this case.

Although adult cattle are primarily affected by clinical Pb poisoning through the ingestion of polluted soils, plants and water, suckling calves are particularly vulnerable to suffer its clinical symptoms. Mean Pb levels detected in soils, plants and water were above the threshold values to be classified as highly polluted soils [8], toxic pastures for livestock [9], and non-potable water for humans [10], suggesting that cattle reared herein may be exposed to high levels of Pb pollution (Table 1). Since the poisoned calf reported here was still unweaned, the transfer of Pb during the period of pregnancy and lactation could explain its high blood Pb level, together with the enhanced rates of Pb absorption and retention observed in juveniles respect to adults [7]. Moreover, according to the information provided by the farmer, calves frequently stay in the dumps, where they often lick Pb polluted soils and plants directly. The farmer also declared that similar symptoms to those detected in this calf have been observed in other three calves that died in the last two years in the same farm. Rodríguez-Estival et al. [6] also detected the highest blood Pb levels in the two calves that they sampled from this mining area (45.2 and 80.7 μg/dL, respectively), in both cases corresponding to clinical poisoning levels, and suggested that the risk of Pb poisoning could be specially marked in younger animals.

The exposure of livestock to environmental Pb pollution in farms affected by old mining activities is of greater significance to animal welfare and public health, since livestock known to have been poisoned by Pb may accumulate sufficient Pb to render their milk, offal and meat unfit for human consumption [11]. This is especially relevant, because Pb poisoning is among the most common toxic incidences diagnosed in bovine livestock in Spain [12,13] and elsewhere [14]. Miranda et al. [12] studied the case of ten heifers affected by Pb poisoning after the exposure to pasture contaminated by a broken battery. These heifer initially developed anorexia, blindness, ataxia, muscular twitching, teeth-grinding and head-pressing, and elevated blood Pb levels (>10 µg/dL) were still observed 205 days after Pb exposure [12].

The management of sources of mining polluted sites and their residues is therefore important for animal health and food safety. Soler Rodríguez et al. [15] highlighted the risk for human health of the uncontrolled management of mining residues after the diagnose of the intentional poisoning of calves in Spain with mining residues containing elevated levels of arsenic. Apart of the risk of lethal poisoning, abnormal exposure to toxic heavy metals may have consequences on the homeostasis of other essential elements [16-18]. The present report, together with previous studies [6], indicates that Pb pollution denotes a health risk for cattle reared in the mining area of Sierra Madrona and Alcudia Valley. There are clear research needs to identify the scope of this environmental problem, to study the potential health effects on livestock reared in this mining area, and the potential indirect effects on human health, and to develop management strategies in order to reduce Pb exposure in livestock.

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References

1. Payne J, Livesey CT (2010) Lead poisoning in cattle and sheep. In Pract 32: 64-69.
2. Reglero MM, Monsalve-González L, Taggart MA, Mateo R (2008) Transfer of metals to plants and red deer in an old lead mining area in Spain. Sci Total Environ 406: 287-297.
3. Higueras P, Oyarzun R, Iraizoz JM, Lorenzo S, Esbrí JM, Martínez Coronado A (2012) Low-cost geochemical surveys for environmental studies in developing countries: Testing a field portable XRF instrumental under quasi-realistic conditions. J Geochem Explor 113: 3-12.
4. Rodríguez L, Ruiz E, Alonso-Azcárate J, Rincón J (2009) Heavy metal distribution and chemical speciation in tailings and soils around a Pb-Zn mine in Spain. J Environ Manag 90: 1106-1116.
5. Ruiz E, Alonso-Azcárate J, Rodríguez L, Rincón J (2009) Assessment of metal availability in soils from a Pb-Zn mine site of South-Central Spain. Soil Sediment Contam 18: 619-641.
6. Rodríguez-Estival J, Barasona JA, Mateo R (2012) Blood Pb and δ-ALAD inhibition in cattle and sheep from a Pb-polluted mining area. Environ Pollut 160: 118-124.
7. Ma WC (2011) Lead in mammals. In: Beyer NW, Meador JP (eds.) Environmental contaminants in biota – Interpreting tissue concentrations. 2nd ed. CRC Press. Boca Raton, FL (USA). 595-608.
8. Directive 86/728/EEC, of 12 June 1986 on the protection of the environment, and in particular of the soil, when sewage sludge is used in agriculture.
9. Chaney RL (1989) Toxic element accumulation in soils and crops: Protecting soil fertility and agricultural food-chains. In: Bar-Yosef B, Barrow NJ, Goldshmid J (eds.) Inorganic Contaminants in the Vadose Zone. Springer-Verlag. Berlin (Germany). 140-58.
10. Directive 98/83/EEC, of 3 November 1998 on the quality of water intended for human consumption.
11. Sharpe RT, Livesey CT (2006) Lead poisoning in cattle and its implications for food safety. Vet Rec 159: 71-74.
12. Miranda M, López-Alonso M, García-Partida P, Velasco J, Benedito JL (2006) Long-term follow-up of blood lead levels and haematological and biochemical parameters in heifers that survived an accidental lead poisoning episode. J Vet Med A 53: 305–310.
13. Novoa MC, Melgar MJ, García MA, Alonso J, Pérez-López M (2012) Análisis de la casuística del servicio de atención toxicológica veterinaria (SATVe) en el período 2001-2007. Rev Toxicol 29: 29-35.
14. Guitart R, Croubels S, Caloni F, Sachana M, Davanzo F, Vandenbroucke V, Berny P (2010) Animal poisoning in Europe. Part 1: Farm livestock and poultry. Vet J 183: 249-254.
15. Soler Rodríguez F, Hernández Moreno D, Oropesa Jiménez AL, Pérez López M (2012) Riesgos de los residuos de minería: Intoxicación intencional en vacuno por arsénico inorgánico. Rev Toxicol 29: 36-39.
16. Blanco Penedo I, Cruz JM, López-Alonso M, Miranda M, Castillo C, Hernández J, Benedito JL (2005) Influencia del estatus de cobre sobre la acumulación de metales tóxicos y esenciales en ganado vacuno. Rev Toxicol 22: 200-204.
17. López Alonso M, Miranda M, Castillo C, Hernández J, Benedito JL (2002) Interacción entre metales tóxicos y esenciales en ganado vacuno de Galicia. Rev Toxicol 19: 69-72.
18. Reglero MM, Taggart MA, Castellanos P, Mateo R (2009) Reduced sperm quality in relation to oxidative stress in red deer from a lead mining area. Environ Pollut 157: 2209-2215.