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Acute nutritional muscular dystrophy and mortality associated with selenium deficiency in artificial rearing of dairy calves in Salta, Argentina

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ABSTRACT

Selenium (Se) is a trace element important for performance and immune functions in cattle. The deficiency of this mineral is widely distributed in northwestern Argentina and it is usually associated with intensive production systems. Calves seem more susceptible due to the metabolic regulation failures produced by this deficiency. This paper aims to describe a case of acute muscular dystrophy associated with Selenium deficiency in seven calves from a dairy farm in Salta, Argentina between March and May 2022. Selenium levels in the animals' whole blood revealed that 66% of the calves ($68,31 \pm 10,52$ ppb) and approximately 90% of the cows (post-partum= $71,24 \pm 10,04$ ppb, and pre-partum $97,68 \pm 36,35$ ppb) presented severely deficient values. The animals showed dehydration, weakness, prostration, respiratory signs, and even death without perceptible clinical signs. Macroscopically, diffuse pallor was found in the muscles of the hind limbs and in the myocardium in certain cases. Microscopically, severe polyphasic degeneration and necrosis of the muscle fibers were found, consistent with acute muscular dystrophy.

Keywords: nutritional muscular dystrophy, white muscle disease, perinatal mortality, deficiency disease, selenium.

RESUMEN

El selenio (Se) es un oligoelemento importante para que el ganado mantenga sus funciones inmunológicas adecuadamente y logre un correcto desempeño productivo. La deficiencia de este mineral está ampliamente distribuida en el noroeste de Argentina y suele estar asociada con sistemas de producción intensivos. Los animales jóvenes parecen ser más susceptibles debido a fallas en la regulación metabólica producidas por esta deficiencia. Este artículo tiene como objetivo describir un caso de distrofia muscular aguda asociada con la deficiencia de selenio en terneros de un establecimiento lechero ubicado en Salta, Argentina, entre marzo y mayo de 2022. Los niveles de selenio en la sangre total de los animales revelaron que el 66% de los terneros ($68,31 \pm 10,52$ ppb) y aproximadamente el 90% de las vacas (postparto = $71,24 \pm 10,04$ ppb y preparto $97,68 \pm 36,35$ ppb) presentaban valores de deficiencia severa. Los animales mostraban deshidratación, debilidad, postración, signos respiratorios o incluso muerte sin signos clínicos perceptibles. Macroscópicamente, se encontró una palidez difusa en los músculos de las extremidades posteriores y del miocardio en ciertos casos. Microscópicamente, se encontraron degeneración polifásica severa y necrosis de las fibras musculares, consistente con la distrofia muscular aguda.

Palabras clave: distrofia muscular nutricional, enfermedad de músculo blanco, mortalidad perinatal, enfermedad carencial, selenio.

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INTRODUCTION

Selenium (Se) is a trace element that plays a significant role in the health and performance of cattle (Sapkota, 2020). The incidence of selenium deficiency is distributed in various regions worldwide and has become more important in recent years because of the intensification of the systems (Mehdi and Dufresne, 2016). In cattle, this deficiency affects both performance (Hall *et al.*, 2013b) and immune functions (Hall *et al.*, 2013a; Hujejiletu *et al.*, 2013).

Young animals are more susceptible to clinical disorders associated with selenium deficiency because the metabolic pathways in developing organisms are more easily deregulated than those in adult cattle (Hall *et al.*, 2014). In newborn calves, weakness at birth and high perinatal mortality rates associated with secondary infections can be observed (Bostedt and Schramel, 1990). In cases where the deficiency is severe, cases of nutritional muscular dystrophy may occur (Ammerman and Miller, 1975). The transfer of selenium from cows to newborn calves is done through the placenta and milk (Enjalbert *et al.*, 1999). For this reason, it is essential to ensure the correct supplementation of pregnant cows during the last third of pregnancy (Bayril *et al.*, 2015).

This paper describes an acute case of muscular dystrophy associated with high mortality rates in dairy calves in an intensive dairy farm in northwestern Argentina. Clinical, pathological, epidemiological, and biochemical aspects are highlighted.

CASE DESCRIPTION

Between March and May 2022, the Specialized Veterinary Diagnostic Service from INTA Salta (SDVE-INTA Salta) provided diagnostic assistance to a dairy farm in the town of "Campo Quijano" in Salta province due to a gradual increase in the perinatal and neonatal mortality rates of calves in an artificial rearing system. In the mentioned period, fifteen deaths out of forty-five births were registered. The newborn animals were immediately separated from their mothers and taken to a calf barn where they were offered three liters of colostrum each (by voluntary intake or by tube). Injectable iodine was applied to them too. On average, protein determination in the serum of colostrated animals using a refractometer ranged from 6.8 to 7.1 mg/mL. Before admission, the floor of the rearing area was incinerated, and each calf was

housed in an individual pen with bedding and shelter. A total of seven complete necropsies were performed, including sampling for microbiological and histopathological studies. Additionally, blood samples were collected from prepartum and postpartum females and newborn calves.

RESULTS

Clinical findings and epidemiological findings

The affected calves were less than 10 days old. The animals died within one to two days after the onset of signs; a moderate degree of dehydration, extreme weakness, prostration, respiratory signs, and vocalizations were observed. In four animals, death occurred without previous signs. Only three of the affected calves showed diarrhea. The monthly mortality data recorded are shown in fig. 1.

Microbiological findings

Lung, spleen and liver samples were taken and cultured from all necropsied animals. All samples were negative for relevant pathogens.

Pathological findings

Pathological findings consistent with muscular dystrophy were present in three of the seven dead calves (42%). In the remaining four calves, no lesions were detected in the muscles evaluated. The findings are shown in fig. 2. The macroscopic lesions were characterized by a diffuse pallor in extensive muscle areas, especially in the muscles of the hind limbs. The most severely affected muscles were the semimembranosus, semitendinosus, and quadriceps. In two animals, whitish lesions were observed at the level of the myocardium. A histopathology study revealed severe polyphasic degeneration and necrosis of the muscle fibers, consistent with acute muscular dystrophy. The muscle fibers were hyper-eosinophilic, fragmented, and vacuolated and showed loss of cross-striation with the influx of macrophages and hypertrophy of satellite cells. A small number of muscle fibers retained some striation, showed increased basophilia and centrally localized nuclei, suggesting regeneration.

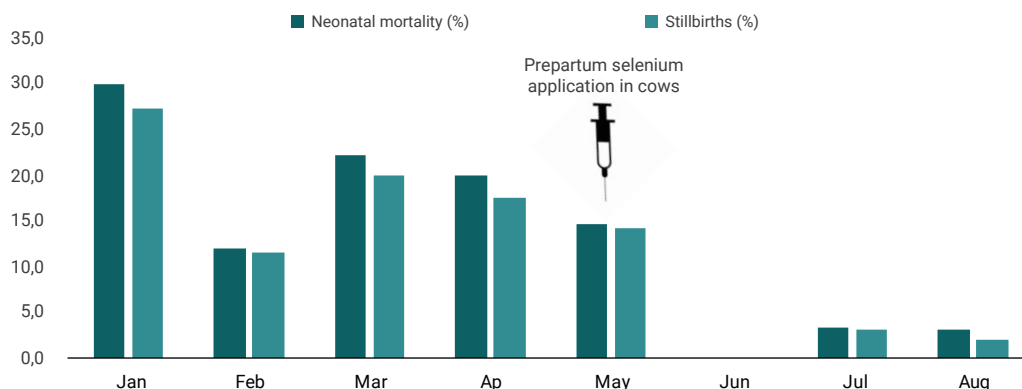


Figure 1. Epidemiological data. Neonatal mortality (%) and Stillbirths (%) rates in calves between the periods Jan-Aug 2022.

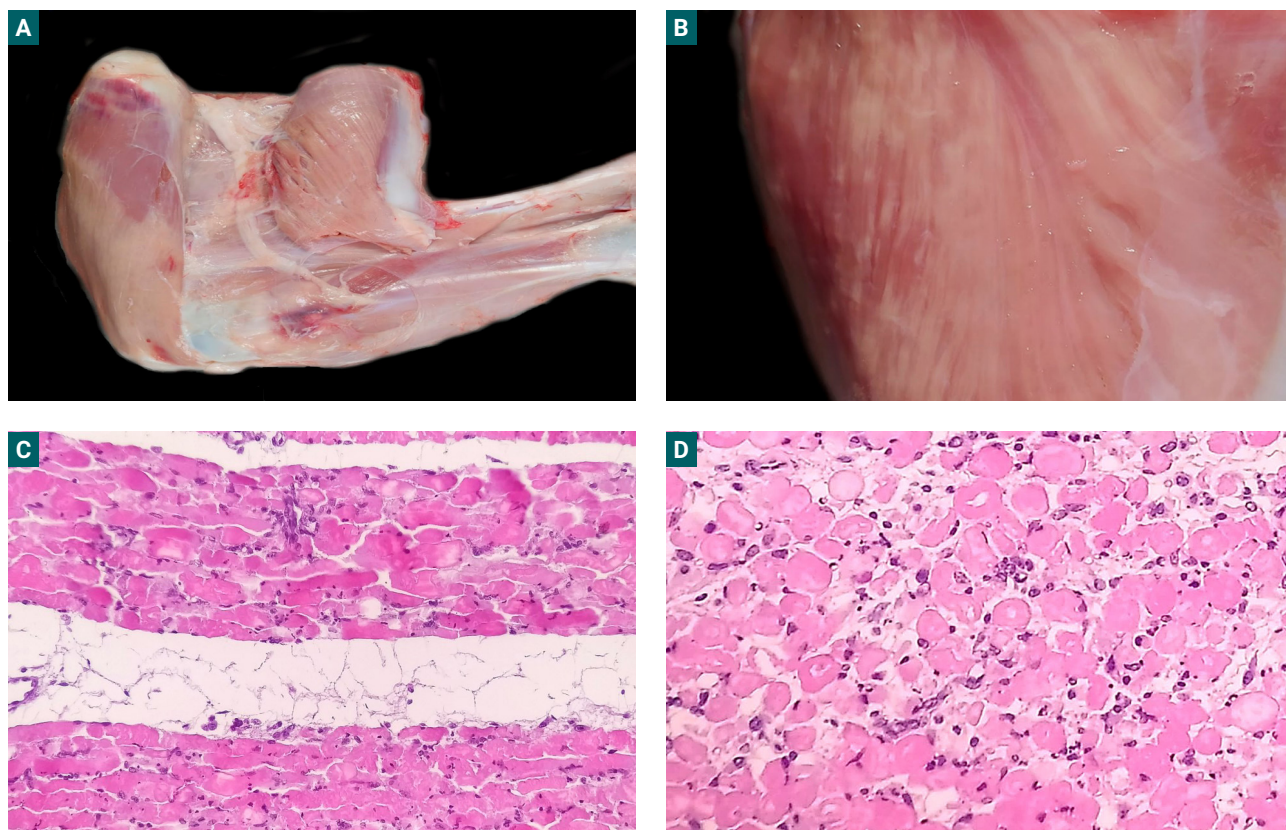


Figure 2. A. Macroscopic finding in muscular dystrophy due to Se deficiency in the limbs. Note the pale areas interspersed with normal areas. B. Muscular dystrophy in hind limbs muscle. C, D. Longitudinal and transverse cut sections of striated skeletal muscle, respectively. Hypereosinophilia, fragmentation, and vacuolization of the myofibrils (10X, H&E).

Category	(n)	Se in whole blood	% of selenium-deficient animal
Pre-partum cows	9	97,68±36,35	45% (4/9)
Post-partum cows	9	71,24±10,04	89% (8/9)
Newborn calves	6	68,31±10,52	66% (4/6)

Table 1. The concentration of Se (ppb) in the whole blood of different categories from the affected dairy farm.

Biochemical findings

The concentrations of Se in the whole blood of prepartum and postpartum cows and newborn calves are shown in table 1. Briefly, low levels of selenium were observed in a high percentage of pre-partum (97,7±36,4 ppb) and post-partum (71,2±10,0 ppb) cows, and in newborn calves (68,3±10,5 ppb). In cattle, selenium values greater than 210 ppb are considered normal. In this case, the levels were much lower than those established in the bibliography (Kinkaid, 2000).

DISCUSSION AND CONCLUSIONS

Nutritional muscular dystrophy (NMD), or “white muscle disease”, is a pathological entity associated with severe Se and/or vitamin E deficiency (Anderson *et al.*, 1977; Maas, 1984). In the present work, the clinical and pathological findings associated with the low levels of Se detected in calves and cows suggest

that the deficiency of this mineral was the trigger for the high mortality rates observed. It should be noted that NMD is a late expression of selenium deficiency (Mehdi and Dufresne, 2016). Other diseases can cause similar muscle injuries, including poisoning by ingesting *Senna occidentalis* (Carmo *et al.*, 2011) or ionophore toxicity, such as monensin poisoning (Brito *et al.*, 2016). Those causes were ruled out based on the anamnestic and epidemiological data. On the other hand, no studies could be conducted on blood tocopherol levels. Because of this, the possibility of a combined deficiency of Se and vitamin E could not be excluded. The response to the treatment with Se reaffirmed the origin of the disease.

The severity of the pathological changes produced by selenium deficiency depends on age, which also determines whether the consequences are fatal or not (Sapkota, 2020). Pathological conditions and deaths owing to selenium deficiency occur primarily in newborn animals and those in the early and last

postnatal stages of development. The reasons why selenium deficiency results in such a diverse range of unusual pathological conditions are still unclear (Mehdi and Dufrasne, 2016). Because vitamin E and selenium have interdependent antioxidant functions, a deficiency of one of these compounds may increase the requirements of the other needed to prevent abnormalities (NRC 2000). It is likely that the cause of selenium-deficient animals manifesting one or any of the other symptoms depends on the concomitant vitamin E deficiency (Sapkota, 2020).

Kinkaid (2000) mentions that values of selenium in blood below 60 ppb indicate "severe deficiency", values between 60 and 200 ppb are "marginally deficient", values between 210 and 1200 ppb are "adequate" and greater than 1200 ppb are highly adequate. In this report, the results of selenium in the whole blood obtained from cows and calves showed low levels of this micro-mineral. About 66% of the calves and approximately 90% of the cows showed severe Se deficiency.

In Argentina, cases of nutritional muscular dystrophy have been registered in cattle (Rodríguez *et al.*, 2018) and sheep (Micheloud *et al.*, 2018), although information about that disease in dairy herds is scarce. However, selenium deficiency is widespread throughout the country (Lizárraga, 2021). In this regard, in a study conducted by Cseh *et al.* (2013) in which the level of glutathione peroxidase (GPx) was determined in 3621 blood samples of beef cattle from different farms in Argentina, it was found that 36% of the animals presented values below 30 IU/g of hemoglobin, which were compatible with Se deficiency.

Another author (Minatel *et al.*, 2004) conducted a study in the northwestern region of Buenos Aires province, Argentina, and observed that 77% and 68.5% of the beef cattle blood samples presented compatible levels with deficiency of Se during winter and summer, respectively.

Several studies have suggested an immunosuppressive effect of selenium deficiency in ruminants (MacPherson, 1994). For example, this deficiency has been associated with sepsis in young cattle and mastitis in adult cows (Dalir-Naghadeh *et al.*, 2006). It has been suggested that marginal selenium deficiency may be associated with general morbidity and/or poor performance in calves (Waltner-Toews *et al.*, 1986). Consistent with this, Spears *et al.* (1986) show a lower incidence of neonatal diarrhea and a reduction in mortality in beef calves supplemented with this mineral, and how stillbirths and neonatal mortality were significantly reduced following the application of injectable selenium to prepartum cows.

Finally, due to the productive and reproductive importance of this micromineral, selenium deficiency must be considered when addressing morbidity or mortality issues in artificially fed calves.

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