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Full Research Article

A STUDY ON KID MORTALITY – FOCUSING ON NUTRITIONAL MYOPATHY

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Abstract

Nutritional myopathy, or white muscle disease, is a common condition in livestock caused by deficiencies in selenium and vitamin E. This study aimed to investigate the incidence of nutritional myopathy in caprine kids, focusing on its role as a cause of mortality in the Trás-os-Montes region.

A post-mortem study was conducted over one year on 111 young goats, less than three months old, originating from autochthonous breeds of Trás-os-Montes and Alto Douro (Bravia and Serrana breed). Necroscopy was performed to examine for macroscopic findings. Collected tissue was fixed in 10 % buffered formalin and examined histopathologically. Parasitological analysis was also performed. The clinical history, post-mortem lesions, and histological examination were used to establish cause of each kid's death.

The primary lesions were enteritis and pneumonia. The findings revealed that 22.5 % of the necropsied goats exhibited lesions consistent with nutritional myopathy, macroscopically detectable in the limb and heart muscles. The study underscores the importance of implementing preventive measures and nutritional management practices to mitigate the occurrence of nutritional myopathy in goat herds in Trás-os-Montes.

Key Words: kid, nutritional myopathy, selenium, vitamin E

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INTRODUCTION

Goats rank among the earliest domesticated animals, having been connected with humans for at least 10,000 years (Monteiro et al., 2017). There are over 1,153 breeds of goats worldwide, differing in size, shape, and production types (F W Haenlein, 2017).

Goat farming has become an increasingly important economic and social activity in various regions worldwide. This is mainly due to goats' ability to thrive in challenging climatic conditions and their relatively short gestation period. However, the success of goat rearing hinges on the identification and selection of suitable breeds for the local environment. Also, the health and well-being of the animals are crucial to ensuring productivity and the quality of derived products (Lohani and Bhandari, 2020; Modi et al., 2024; Roy and Patbandha, 2024).

Kid preweaning mortality is a significant cause of economic loss to goat farmers. Several factors influence the kid mortality rate in goat farming. These include the type of birth (single or multiple), the sex of the kid, birth weight, the parity of the doe, and the season in which kidding occurs (Balasopoulou et al., 2022; Chauhan et al., 2019; Joshi et al., 2018; Ngongolo and Mmbaga, 2022).

The causes of death in young goats are diverse, and they can act individually or in combination. These causes include stress, nutritional deficiencies, neonatal infections, such as enteritis and pneumonia, maternal factors, and environmental factors leading to starvation. Many of these causes can be mitigated, and mortality rates can be reduced through improved management and feeding practices for the kidding flock (Roy and Patbandha, 2024).

Nutritional myopathy stands out due to its impact on muscle function and overall animal performance. Often referred to as white muscle disease, it is primarily caused by deficiencies in essential nutrients such as selenium and vitamin E. These nutrients maintain cellular integrity and protect muscle tissue from oxidative damage. Young goats are particularly susceptible to this condition due to their rapid growth rates and higher nutritional requirements (Pugh, 2023; Rammell et al., 1989; Ross et al., 1989).

The clinical signs of nutritional myopathy can range from mild to severe and include muscle weakness, stiffness, and an inability to stand or walk. In severe cases, affected animals can exhibit respiratory distress due to the involvement of the diaphragm and intercostal muscles. Early detection and appropriate dietary management are essential to prevent significant morbidity and mortality in affected herds (Donoghue and Kronfeld, 1990; Reilly et al., 2002).

Mortality in young goats in the Trás-os-Montes region is high, but no comprehensive study has identified the specific causes of death in this region. Understanding these factors is critical for developing effective strategies to reduce mortality rates and improve the overall health and productivity of the herds. To improve herd productivity, thereby mitigating economic losses and enhancing the sustainability of goat farming in the

region, this study aims to identify the primary causes of mortality in young goats under three months old in Northern Portugal, specifically focusing on nutritional myopathy.

MATERIALS AND METHODS

This study included young goats under three months old from herds of the autochthonous Bravia and Serrana breeds (under extensive production systems) over one year. The animals were submitted to the necropsy service of the Histology and Pathological Anatomy Laboratory at the University of Trás-os-Montes e Alto Douro (UTAD) to determine the cause of death. The necropsy was always requested by a veterinarian clinician (FS), who ensured the owner's written informed consent during ambulatory clinic visits initiated by the owner's call. These calls were due to animal mortality or illnesses affecting other animals. In cases where a dead animal was found whose death had occurred less than 24 h earlier, a necropsy was requested. The animals underwent necropsy, with the interval between death and necropsy ranging from 1 to 48 h. Each animal was accompanied by a record detailing breed, age, sex, and as complete a clinical history as possible, including the location and size of the flock, the number of sick animals, and the number of deceased animals.

Necropsies were always conducted by the same pathologist (IP) following this species' safety procedures and standard techniques, as utilized in the Necropsy Service of the Laboratory of Histology and Pathological Anatomy, UTAD. All macroscopic findings were documented using a written protocol and photographs. For histopathological examinations, representative samples were collected from each animal. In all cases, samples were taken from organs with lesions and systematic samples from the diaphragm, heart, and right Triceps brachii muscle. Samples were fixed in 10 % buffered formalin, embedded in paraffin wax, sectioned at 3 μm, and stained with hematoxylin-eosin for histopathological examination. Samples for parasitological analysis were also collected.

The main causes of death were determined by considering the clinical history, post-mortem lesions, and histological examination.

RESULTS

Clinical data

This study included 111 young goats, of which 104 were Bravia breed (93.7 %), and seven were Serrana breed (6.3 %). The clinical data showed diarrhea was the most common clinical sign (n=29; 26.1 %). Additionally, one or more of the following signs were observed: weight loss, growth retardation, anorexia, prostration, cough, or poor general condition. Sudden death occurred in 44 cases (39.6 %) without any prior

clinical signs being detected. In some instances, the number of affected animals was high, with mortality rates exceeding 50 %.

Nutritional myopathy-compatible lesions

As described in Table 1, the main lesions observed during the necropsy of 111 goat kids were enteritis, pneumonia, and white muscle disease-compatible lesions. Some animals presented with multiple lesions, including enteritis and pneumonia, muscle necrosis, and other conditions.

Of the 111 necropsied animals, 25 (22.5 %) presented with skeletal and cardiac muscle lesions, both macroscopic and microscopic, compatible with nutritional myopathy. In these animals, the clinical history included sudden death, muscle weakness, and growth retardation.

Table 1. Major lesions observed in kids necropsy of the Trás-os-Montes region.

Lesions observed	N	%
Enteritis	54	48.65
Pneumonia	37	33.33
Nutritional myopathy compatible lesions	25	22.52
Abomasal bezoars	5	4.55
Peritonitis	3	2.70
Abomasal ulceration	4	3.6
Hepatitis/Omphalophlebitis	4	3.6
Arthritis	2	1.8

Macroscopically, thirteen cases showed pale-colored skeletal muscles, bilaterally affecting limb muscles (Figure 1), intercostals, and the diaphragm. Cardiac lesions in 21 animals exhibited heterogeneous coloration with pale areas of variable extent, corresponding to myocardial degeneration and necrosis confirmed by histopathological examination.

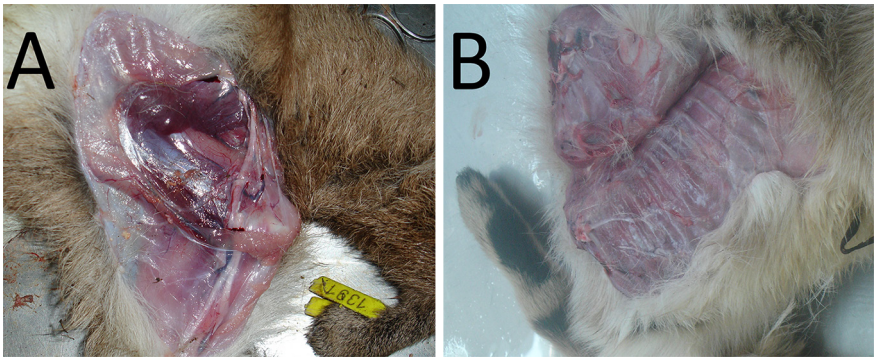

Figure 1: Macroscopic images of nutritional myopathy-compatible lesions. **A** - Pale coloration of the muscles (forelimb). **B** - Pale coloration of the intercostal muscles.

Lesions were observed in both ventricles, which were more advanced in the left ventricle and interventricular septum, sometimes with extensive necrosis and calcification (Figure 2). Other lesions included hydrothorax, hydropericardium, pulmonary edema, ascites, and congestive hepatomegaly, indicating possible death from heart failure (n=4). Other lesions, such as enteritis and pneumonia (n=15), abomasal ulceration (n=2), and abomasum (n=5), were also observed in many animals with evident muscle and myocardial necrosis.

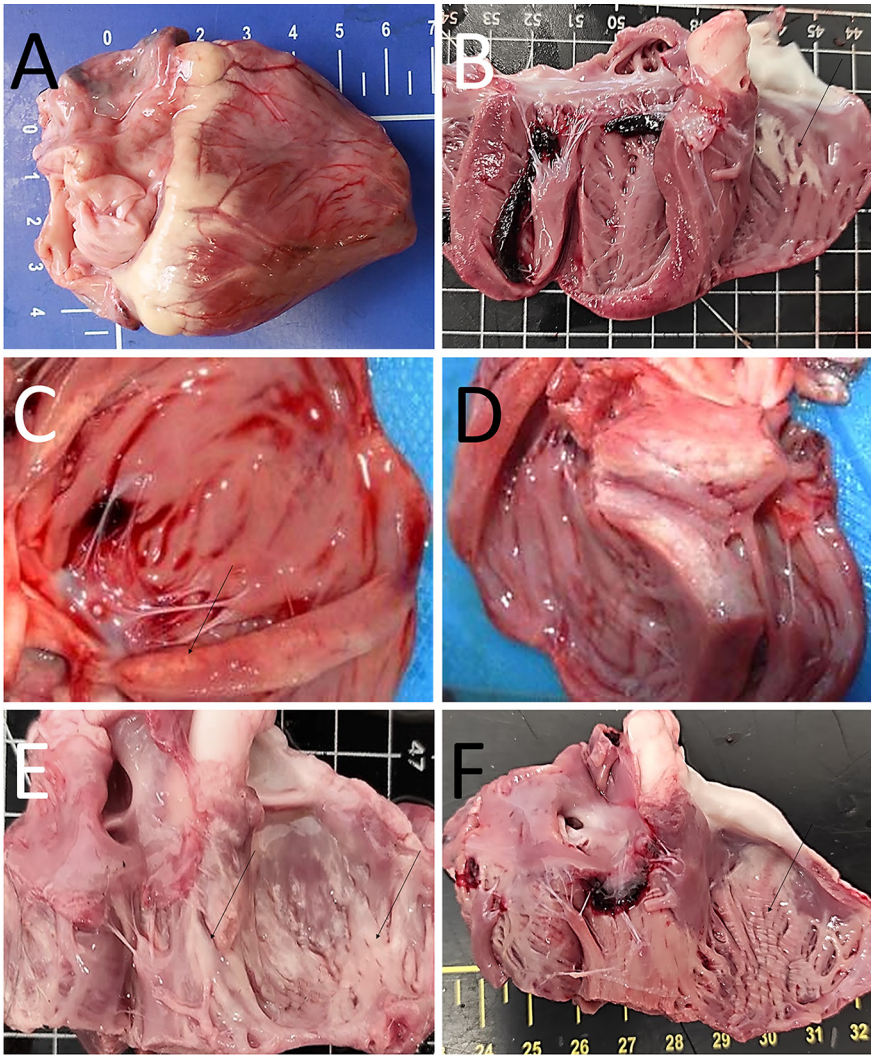

Figure 2: Macroscopic images of nutritional myopathy-compatible lesions. **A** - Pale coloration of the myocardium, subepicardial myocardium. **B** - Pale area of necrosis in the right ventricle (arrow). **C** - Myocardial necrosis, more evident in the interventricular septum (arrow). **D** - Section of the interventricular septum: necrosis and calcification in the interventricular septum. **E** - White coloration of the subendocardial myocardium – diffuse myocardial necrosis (arrow)). **F** - Diffuse myocardial necrosis with striation areas (myocardial calcification - arrow).

Histological analysis showed variable lesions, including hyaline degeneration and myocardial necrosis. Cardiac muscle cells exhibited hyperchromatic acidophilic cytoplasm with loss of striation and pyknotic nuclei. Some areas showed basophilic granulation corresponding to mitochondrial calcification, macrophage invasion, and fibroblast proliferation (Figure 3).

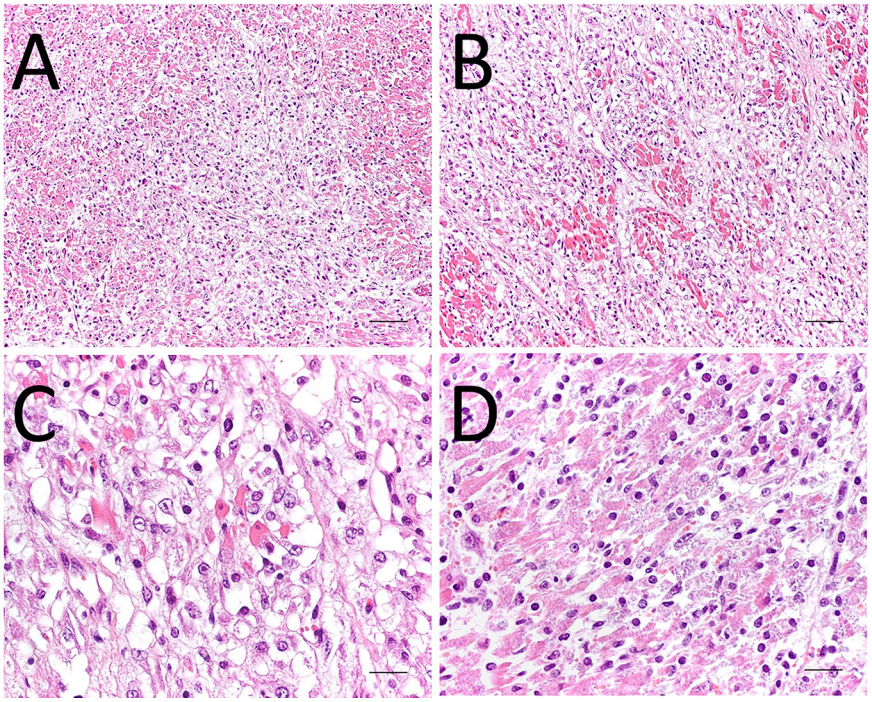

Figure 3: Microscopic images of nutritional myopathy-compatible lesions (hematoxylin-eosin staining). **A** - Myocardial necrosis, showing connective tissue proliferation (scale bar=60 μm). **B** - Diffuse hyaline necrosis of the subepicardial myocardium of the right ventricle. Note the proliferation of fibroblasts and macrophage infiltration (scale bar=60 μm). **C** - Enlargement of the previous image. The cardiac muscle cells appear hyper-eosinophilic, with loss of striation and pyknotic nuclei (scale bar=20 μm). **D** - Necrosis of the subendocardial myocardium of the interventricular septum; basophilic granulation of cardiac muscle cells - calcification of mitochondria (scale bar=30 μm).

Other lesions

Other lesions were also observed. Enteritis was observed in 54 cases (48.6 %), pneumonia in 37 cases (33.3 %), peritonitis in 3 cases (2.7 %), abomasal ulceration in 4 cases (3.6 %), hepatitis/omphalophlebitis in 4 cases (3.6 %), and arthritis in 2 cases (1.8 %). It is noteworthy that some animals presented with multiple lesions, including enteritis and pneumonia, muscle necrosis, and other conditions.

Regarding digestive lesions, enteritis was present in approximately half of the animals. Parasitic etiology was confirmed in 16 cases: 12 cases by *Eimeria* sp., 1 by *Moniezia expansa*, and in 3 cases, enteritis was attributed to *Cryptosporidium* sp. Regional lymph

node reaction was evident in most cases. In six animals, lesions indicating enteritis and pneumonia were observed. Besides enteritis, one case showed lesions compatible with ruminal acidosis, with a dark rumen wall and a large amount of corn grains. Four animals had abomasal ulcers, and 5 had bezoars in the abomasum.

The observed respiratory system lesions varied. In 16 animals, pulmonary edema, congestion, and consolidation were seen, mainly affecting cranio-ventral areas. Histopathological analysis confirmed lesions compatible with bronchopneumonia. Fibrinous pneumonia and pleurisy were also noted, with variable amounts of fibrin forming masses or adhesions to the pleura.

Two animals showed hepatic abscesses associated with omphalophlebitis and peritonitis. One case had focal necrotic hepatitis compatible with necrobacillosis. Another case showed lesions compatible with parasitic hepatitis. Articular lesions (fibrinopurulent or purulent arthritis) were observed in two animals, one of which also had pleuropneumonia.

DISCUSSION

High mortality rates in the extensive production of small ruminants compromise the viability of goat farms in various countries. Neonatal mortality rates in goats raised in extensive systems range from 10 to 60 %, reaching 100 % in some farms (Medeiros, 2005; Pinheiro et al., 2000).

Nutritional muscular dystrophy, commonly known as white muscle disease, is the most common manifestation of selenium and vitamin E deficiency in goats. This condition is described in various animal species, with goats being the most susceptible ruminants. The clinical form of the disease is more common in young goats up to six months old and, in some regions, is recognized as the leading cause of death in goats aged 1 to 9 weeks (McGavin and Zachary, 2007; Smith and Sherman, 2009).

In this study, necropsies were performed on 111 caprine kids of autochthonous breeds raised in an extensive grazing system to understand the impact of nutritional muscular dystrophy on the mortality of kids in the northern region of Portugal. In 25 cases, muscle lesions were observed in skeletal and cardiac muscles, similar to those described in nutritional myopathy. The cardiac form was sometimes associated with sudden death and heart failure lesions, as reported by other authors (Beytut and Aksakal, 2003; Pehrson, 1993; Surai, 2006).

Levels below the daily required intake of selenium and vitamin E compromise cellular oxidative reactions, leading to hyaline and granular degeneration of muscle fibers, necrosis, and replacement of muscle with connective tissue, as observed in histological examinations of our samples (McGavin and Zachary, 2007; Wesolowski et al., 2022; Zarczynska et al., 2013).

However, the consequences of selenium-deficient diets include other diseases beyond white muscle disease, and it is not always evident to associate this with etiology. In young animals, they include poor viability of newborns, inability to suckle, growth retardation, and progressive weight loss. Additionally, selenium, whether or not in conjunction with vitamin E, affects the immune response and, consequently, disease susceptibility and resistance to diseases such as pneumonia and diarrhea (Díaz-Sánchez et al., 2017; Smith and Sherman, 2009), which were the main causes of death in our study. Additionally, the host's nutritional status influences the virulence of pathogens, as viruses can mutate their genotype, altering from their non-virulent phenotype in even well-nourished hosts on selenium-deficient diets (Beck, 2007), with implications for herd diseases. So, the incidence of selenium deficiency estimated by white muscle lesions could be underestimated in our study. The occurrence of other lesions, such as enteritis (48.6 %) and pneumonia (33.3 %), that could be linked to poor hygiene, inadequate housing, and suboptimal management practices could also be associated with immune system deficiencies and possible mineral deficiencies, such as selenium (Ratsep, 2020). It is, thus, urgent to conduct studies with laboratory analyses to understand the real impact of nutritional myopathy.

Interestingly, four animals had gastric ulcers, which some authors associate with nutritional deficiencies, such as selenium deficiency (Lebreton and Mathevet, 2003). Half of the animals (n=2) with gastric ulcers also had evident muscle and cardiac lesions.

Selenium deficiency could stem from poor-quality feed or lack of supplementation, both preventable issues. Implementing routine dietary supplementation could significantly reduce the incidence of nutritional myopathy and improve overall herd health. The high mortality rates observed in the study, with some herds experiencing over 50 % loss, are alarming. This points to systemic issues in herd management that need urgent addressing. Improved veterinary care, better housing conditions, and enhanced biosecurity measures are essential to reducing the incidence of these diseases. Additionally, farmer education on timely intervention and regular health monitoring could play a vital role in mitigating these losses.

Despite mortality following birth being considered normal, the importance of necropsy should not be overlooked. In fact, this study highlights the importance of thorough necropsy and histopathological examination in identifying the causes of death in young goats. Necropsy is an easily performed method, and identifying lesions can be crucial in implementing measures to reduce economic losses and detect selenium-deficient areas in soil and feed. Preventive strategies, particularly for nutritional myopathy, should focus on ensuring adequate selenium and vitamin E intake. Based on the results, this could involve regular soil and forage testing to determine nutrient content and appropriate supplementation. Additionally, routine health checks and early detection of clinical signs can help prevent disease occurrence.

CONCLUSION

This study revealed a high mortality rate in young goats in the Trás-os-Montes region, with 22.5 % of the animals that underwent necroscopy exhibiting lesions consistent with nutritional myopathy. These results emphasize the importance of necropsy and underscore the urgent need to implement preventive and nutritional management strategies, including adequate selenium and vitamin E supplementation, to reduce mortality and improve the health and productivity of goat herds in selenium-deficient regions.

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Authors' contributions

F.S. – Clinical monitoring of the herds, study design, performance of necropsies, manuscript writing; I.P. – Conducted necropsies and histopathological examinations, manuscript writing.

Competing interests

No competing interests.

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UTICAJ NUTRITIVNE MIOPATIJE NA MORTALITET JARADI U REGIONU TRÁS-OS-MONTES

Filipe SILVA, Isabel PIRES

Kratak sadržaj

Nutritivna miopatija, takođe poznata kao bolest belih mišića, uobičajeno je stanje kod stoke uzrokovano nedostatkom selena i vitamina E. Ova studija je imala za cilj da istraži učestalost nutritivne miopatije jaradi, fokusirajući se na njenu ulogu kao uzrok smrtnosti u regionu Trás-os-Montes.

Postmortalna studija sprovedena je tokom jedne godine na 111 mladih koza, mlađih od 6 meseci, poreklom iz autohtonih rasa Trás-os-Montesa i Alto Douro (Bravia i Serrana rase). Prikupljeni materijal je fiksiran u 10 % puferovanom formalinu i obrađen za histopatološki pregled.

Glavne lezije bile su enteritis i pneumonija. Nalazi su pokazali da je 22,5 % obdukovanih koza imalo lezije koje su bile konzistentne sa nutritivnom miopatijom, makroskopski otkrivenom u mišićima udova i srca. Studija naglašava važnost primene preventivnih mera i praksu nutritivnog upravljanja, kako bi se smanjila pojava nutritivne miopatije u kozjim stadima u Trás-os-Montesu.

Ključne reči: jarad, nutricionistička mijopatija, selen, vitamin E