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Environmental Impact On The Health Of Mongolian Pastoral Livestock

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Abstract
The objective of this study was to evaluate key indicators of innate resistance in livestock by species (ruminants and small ruminants) and age groups (juvenile and mature animals) during the spring and autumn seasons in Mongolia. Blood samples were collected from animals grazing in mining regions of the country. Parameters such as total white blood cell (WBC) count, neutrophil phagocytic activity (via the Nitroblue Tetrazolium [NBT] test), and malondialdehyde (MDA) levels were determined using both manual and automated methods.
The study revealed the following findings:
- *Juvenile animals exhibited relatively lower innate resistance compared to mature animals, indicating reduced immune activity, which may adversely affect productivity and hinder normal growth and development.*
- *Small ruminants demonstrated lower resistance compared to large ruminants, possibly due to species-specific physiological differences, feed availability, and metabolic characteristics.*
- *Seasonal comparison showed that innate resistance declined significantly in spring across all livestock types, likely due to feed scarcity, exposure to cold stress, and adverse environmental factors. In contrast, resistance improved during autumn, correlating with better pasture quality and improved body condition. However, some animals still showed lower-than-normal biochemical and immune parameters, indicating individual variability in adaptive capacity.*

In conclusion, the innate resistance of livestock is strongly influenced by age, species, and seasonal conditions. These factors play a vital role in overall animal health, productivity, and immune competence. The results suggest that age-specific and seasonally adapted feeding and management strategies should be implemented to maintain and enhance animal resilience.

Keywords: *Innate resistance, Livestock species, Seasonal variation, White blood cells (WBC), NBT test, Malondialdehyde (MDA)*

INTRODUCTION

In recent years, climate change, environmental degradation, and the exploitation of natural resources have led to significant disruptions in Mongolia's rangeland ecosystem [1,2]. These changes have negatively impacted the health and innate resistance of livestock, resulting in reduced productivity and stunted growth [1, 3]. In particular, livestock grazing in mining zones are increasingly exhibiting weakened adaptability and diminished natural immunity, highlighting the urgent need to assess the innate resistance capacity of Mongolian livestock.

Innate resistance is a vital indicator that reflects the animal's physiological and immunological ability to resist external environmental stressors and pathogenic agents [1]. This study aimed to assess the innate resistance of livestock grazing in areas surrounding gold, fluorspar, and coal mining operations by evaluating specific hematological and biochemical indicators [5, 10, 12, 13].

The core indicators used in the study include:

- **White blood cell count (WBC):** A marker of natural defense capacity and responsiveness to environmental stress.
- **Neutrophil phagocytic activity (NBT test):** An essential parameter measuring the primary immune response and phagocytosis activity against infectious agents.
- **Malondialdehyde (MDA) levels:** An indicator of oxidative stress associated with lipid peroxidation of cell membranes, reflecting internal regulatory status and antioxidant defense levels.

By analyzing these indicators in combination, this study offers an objective evaluation of immunobiochemical changes in livestock and their overall innate resistance under unfavorable environmental conditions.

MATERIALS AND METHODS

This study was conducted on pasture-raised livestock grazing in areas surrounding mining operations in Mongolia, specifically the Zaamar gold mining region of Tuv province, Bor-Undur fluorspar deposit in Khentii province, and the Nalaikh coal mining district of Ulaanbaatar city.

The animals included in the study were categorized by species as cattle, horses, sheep, and goats. Each species was further subdivided into two age groups: juvenile (young) and adult (mature).

From each group, three animals were selected using random sampling based on the principle of analogy. A summary table was prepared to clearly present the species, age classification, and sampling locations of the studied animals.

Table 1. Livestock species, sample size and study location

season	Parameter analysis	age	Livestock species				Location (Mine type, Province & District)
			cattle	horse	sheep	goat	
Spring	WBC, MDA, Neutrophil phagocytic activity	adult	3	3	3	3	Zaamar gold mining region of Tuv province
		Juvenile	3	3	3	3	
autumn	WBC, MDA, Neutrophil phagocytic activity	adult	3	3	3	3	
		Juvenile	3	3	3	3	
Spring	WBC, MDA, Neutrophil phagocytic activity	adult	3	3	3	3	Nalaikh coal mining district of Ulaanbaatar city
		Juvenile	3	3	3	3	
autumn	WBC, MDA, Neutrophil phagocytic activity	adult	3	3	3	3	
		Juvenile	3	3	3	3	
Spring	WBC, MDA, Neutrophil phagocytic activity	adult	3	3	3	3	Bor-Undur fluorspar deposit in Khentii province
		Juvenile	3	3	3	3	
autumn	WBC, MDA, Neutrophil phagocytic activity	adult	3	3	3	3	
		Juvenile	3	3	3	3	

Sample Collection and Laboratory Analysis

Blood samples were collected from animals grouped by species and age. To rapidly assess white blood cell count (WBC), one of the key indicators of innate resistance, manual counting techniques were applied directly in the field (herding site) using simple hematological methods. After collection, samples were transported to the laboratory under proper conditions for further testing, including neutrophil phagocytic activity (NBT test) and malondialdehyde (MDA) concentration. Seasonal variation was assessed by sampling in spring and autumn over a two-year period.

NBT Test for Neutrophil Phagocytic Activity

Neutrophil phagocytic activity was determined using the Nitroblue Tetrazolium (NBT) reduction test. Venous blood was drawn from the study animals into vacuum tubes containing heparin, then transported to the laboratory for processing.

For the assay, equal volumes (0.1 mL) of 0.2% NBT solution and whole blood were mixed in microtubes and incubated at 37°C for 20–30 minutes. After incubation, blood smears were prepared, air-dried, and stained with Giemsa stain. Using a light microscope with 1000x magnification, 100 neutrophils were examined, and cells showing positive NBT reaction (containing blue formazan granules) were counted.

The following indicators were calculated:

- **Phagocytic activity** (%) = (NBT-positive neutrophils / total neutrophils) × 100
- **NBT Index** – the average number of formazan granules per neutrophil

Determination of MDA Concentration

The concentration of malondialdehyde (MDA), a marker of lipid peroxidation and oxidative stress, was measured using the thiobarbituric acid (TBA) reaction method. Venous blood samples were centrifuged at 3000 rpm for 10 minutes to separate the serum.

TBA reagent was prepared using sulfuric acid (H_2SO_4), thiobarbituric acid, and appropriate buffer solutions following standard protocols. Equal volumes of serum and TBA reagent were mixed and heated in a water bath at 95–100°C for 30–60 minutes, during which an MDA–TBA complex formed, producing a pink chromogen. The reaction mixture was then cooled, and absorbance was measured at 532 nm using a spectrophotometer. MDA concentration was expressed in micromoles per liter (µmol/L).

RESULT & DISCUSSION

Blood samples collected from the study animals were analyzed to determine key indicators of innate resistance, including white blood cell (WBC) count, neutrophil phagocytic activity, and malondialdehyde (MDA) concentration. The results were compared by species, age group, and seasonal variation, revealing differences in physiological and immune resilience among livestock types.

Table 1. Analytical results of blood samples collected from livestock in the spring & the autumn season

Livestock species (symbol)	age	Parameter (Mean Value)			Location (Mine type, Province & District)
		WBC	MDA (µmol/L)	Neutrophil phagocytic activity (%)	
the spring season					
cattle * horse* sheep * goat *	adult	3,66*, 10,86*, 7,17*, 7.93*,	2,045*, 1,87*, 2,87*, 3,56*	42*, 45*, 30*, 25*	Zaamar gold mining region of Tuv province, Bor-Undur fluorspar deposit in Khentii province, Nalaikh coal mining district of Ulaanbaatar city.
	Juvenile	4,86*, 9,48*, 11,8*, 8,56*	1,84*, 1,27*, 2,13*, 2,56*	48*, 50*, 32*, 26*	
the autumn season					
cattle * horse* sheep * goat *	adult	9,7*,8,14*, 7,80*, 7,93*	0,89*, 0,78*, 1.536*, 1.67*	56*, 62*, 40*, 38*	Zaamar gold mining region of Tuv province, Bor-Undur fluorspar deposit in Khentii province, Nalaikh coal mining district of Ulaanbaatar city.
	Juvenile	10,5*, 8,37*, 8,63 *, 11,8 *	0,67*, 0,56*, 0.876*, 0.724*	58*, 65*, 42*, 40*	

According to the test results, sheep exhibited the lowest level of innate resistance among the studied livestock species. This finding is illustrated in the corresponding diagram.

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Figure1. Comparative analysis of baseline resilience among different animal species

The study revealed that juvenile animals exhibited a more pronounced decrease in immune activity and greater oxidative imbalance compared to adult animals. In other words, juveniles demonstrated lower resilience than mature individuals. The results are illustrated in the accompanying graph.

Figure2. Age-wise variation in resilience parameters in livestock

Based on the natural and climatic conditions of Mongolia, a seasonal assessment of livestock resilience was conducted. The findings indicated that during the autumn season, all types of livestock demonstrated relatively high levels of physiological resilience. This is likely attributable to improved nutritional status due to abundant forage, increased body condition, and optimal metabolic and immune system activity.

In contrast, during the spring season, a general decline in resilience was observed across all livestock. This deterioration may be directly related to nutrient deficiency accumulated over the winter, cold stress, wind exposure, dryness, and increased herding pressure. Notably, juvenile animals and small ruminants such as sheep and goats exhibited significant reductions in immune function indicators—including phagocytic activity, white blood cell count (WBC), and malondialdehyde (MDA) levels—suggesting that these groups are more vulnerable during this period. The data reflecting seasonal effects are depicted in the accompanying figure

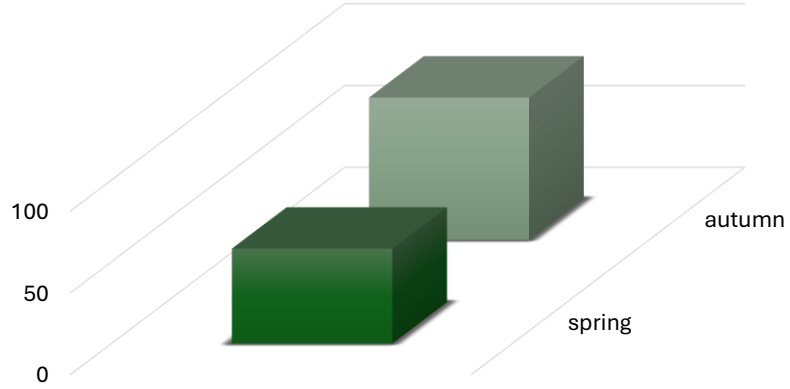

Figure3. Seasonal Variation in Livestock Resilience Indicators

The natural resilience of livestock refers to the animal's innate capacity to defend itself, respond to external environmental stressors, and adapt to changing conditions. This trait is directly linked to productivity and developmental performance.

Specifically, animals with well-balanced immune and homeostatic regulation systems, and consequently higher resilience, tend to:

- Exhibit more consistent growth and development with reduced physiological stress;
- Demonstrate higher reproductive performance, milk, and meat yields;
- Show lower susceptibility to diseases, resulting in reduced veterinary and treatment costs.

Therefore, resilience should not be viewed solely as a health indicator but also as a foundational determinant of livestock productivity and sustainable performance.

Similar trends have been observed in international studies. For instance, research conducted in the central pastoral zones of Turkey (Yilmaz et al., 2018) reported a decline in immune parameters and an increase in oxidative stress in sheep and goats during the spring season, negatively affecting their resilience. Likewise, studies from southern Russia's pastoral regions (Ivanov et al., 2021) found that juvenile calves experienced a decline in immune activity and growth during the spring, further indicating seasonal vulnerability.

These findings align with results observed under Mongolian conditions, emphasizing that factors such as seasonality, animal species, age, and pasture quality are key determinants of livestock resilience.

CONCLUSION

1. The reduced resilience of juvenile animals is likely due to the incomplete development of their immune system, which may lead to decreased productivity, delayed growth during maturation, and ultimately stunted physical development.
2. The study results indicate that the natural resilience of small ruminants is relatively lower than that of large livestock. This difference may be attributed to species-specific physiological characteristics.
3. Under pastoral livestock production systems, seasonal changes directly affect resilience indicators. In particular, negative impacts are more pronounced during the spring season.

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