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IMPACT OF GASTROINTESTINAL PARASITES ON IMMUNOCOMPROMISED RUMINANTS

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Abstract

Gastrointestinal (GI) parasitic infections are a significant threat to ruminant health, with more serious effects in animals with suppressed immune systems. This study investigated the effects of GI parasites on immunodeficient ruminants by comparing parasitological burden, clinical severity, hematobiochemical profiles, immune parameters, and productivity performance with those of their immunocompetent counterparts. Sixty ruminants (30 immunocompromised and 30 controls) were included in this study. Immunosuppressed animals had higher strongyle fecal egg counts (1370.3 ± 428.4 vs 504.3 ± 130.6 EPG; $p < 0.001$) and increased Eimeria oocyst scores (1607.0 ± 1133.2 vs 734.3 ± 476.4 OPG; $p < 0.001$). Hematological and biochemical parameters reflected significant disease influence as packed cell volume (22.13 ± 2.50% vs 29.79 ± 2.61%; $p < 0.001$), serum albumin (2.37 ± 0.25 vs 3.30 ± 0.22 g/dL; $p<0.001$) and total protein (5.70 ± 0.40 vs 7.04 ± 0.32 g/dL; $p<0·001$) were significantly lower in immunocompromised group animals than the control counterparts, respectively). Multiple parasitic infections were identified in 90.0% of immunocompromised ruminants, compared to 0% in the controls ($\chi^2 = 45.52$, $p < 0.001$), and Haemonchus had a significantly higher prevalence (70.0% vs 13.3%; $p < 0.001$). Productive performance was seriously impaired in immunocompromised animals, with lower mean daily gain (66.8 ± 36.7 vs 117.7 ± 44.9 g/day; $p < 0.001$). There was a significant correlation between the parasite burden and anemia ($\rho = -0.994$), diarrhea severity ($\rho = 0.936$), and diminished body weight gain ($\rho = -0.798$) (all $p < 0.001$). The results of the present study show that immunosuppressed ruminants suffer from significantly greater parasite loads and

attendant clinical and productivity losses when infected, indicating a clear need for specific parasite control strategies within populations at risk.

1. INTRODUCTION

Gastrointestinal (GI) parasitic diseases are one of the most limiting factors to ruminant health and productivity throughout the world, especially in areas with intensive or semi-intensive production systems. The adult worms of helminths such as strongyle nematodes, *Haemonchus spp.*, *Trichostrongylus spp.*, *Eimeria* and *Fasciola spp.* are ubiquitous and their economic cost is considerable attributed to growth rate reduction, lack of feed conversion efficiency, anemia, protein wasting and increased mortality [1]. Besides their direct pathogenic consequences, GI parasites are a welfare problem and become promotion consortia of secondary infections on the host. While significant intervention has been achieved with respect to endoparasites, gastrointestinal parasitism remains an endemic problem in many ruminant populations, illustrating the significance of gaining improved insights into host–parasite interactions under field circumstances [2].

The immunity of the host is determinant for the susceptibility and intensity of clinical manifestations caused by intestinal parasites. Immunocompromised Appropriate immune response is critical to prevent parasite establishment and reproduction in the host, immuno-deficient ruminants (periparturient, malnutrition, chronic disease or immunomodulation) have a dismal capacity to control this phenomenon. This defect may result in higher parasite burdens, sustained egg excretion and a higher frequency of mixed infections. Periparturient immunosuppression is a well-documented phenomenon that results in transient impaired protective immunity and increased parasite transmission. Immune dysfunction combined with the lack of essential nutrient have a synergistic or vicious effect in which nutritional parasitism sucks up, and begets poor nutriture that further erodes health status and productivity [3].

The effect of gastrointestinal parasitism in immune depressed ruminants has implications not only for parasite parameters but also for systemic hematological, biochemical, and immunological responses. Anemia, hypoalbuminemia, and shifts in the leukogram are frequent findings and are important markers of disease severity in animals with heavy parasitemia. These alterations, which are usually associated with clinical signs of the disease such as diarrhea and low body weight, lead to poor growth rates and economic losses [4]. While literature reports are abundant on GI parasitism in ruminants in general, fewer address the examination of immunosuppressed hosts and the combined effects of parasite burden and immune compromise. Accordingly, the study aimed to assess the effects of gastrointestinal parasites on immunocompromised ruminants by comparing parasite load and clinical/immunological parameters and productivity indicators with those of immunocompetent counterparts. By clarifying these associations, the present study aims to provide evidence to tailor parasite control measures for high-risk ruminant populations [5].

2. METHODOLOGY

A prospective observational study design was used to compare the effects of GI parasitic infection in immunosuppressed and immunocompetent ruminants. The study was designed as a cross-sectional investigation, using production-related parameters as short-term outcome proxies to reflect the clinical and productive effects of parasitism.

The test population was sampled from representative production premises and from domesticated ruminant animals (cattle, goats, and sheep). Animals were divided into two categories: immunocompromised or control (immunocompetent). Immunologic impairment was categorized by known, commonly accepted conditions that impair immune function (the periparturient state, malnutrition, chronic disease, or recent corticosteroid treatment). Control animals were healthy, with no identifiable immunosuppressive agents. Animals of various

ages and both genders were also considered to represent the usual herd population.

Fecal examinations determined the intensity of gastrointestinal parasites. For strongyle fecal egg counts, they were expressed as eggs per gram (EPG), whereas those of Eimeria infection intensity were oocysts per gram (OPG). The status of three major GI parasites, such as *Haemonchus*, *Trichostrongylus*, and *Fasciola* species, was recorded as binomial data. Mixed-infection status was characterized by the concurrent detection of at least two parasitic taxa in any single animal.

Clinical condition was scored based on body condition (as assessed by BCS on a standard scale of 1–5) and fecal consistency [0 = normal; 3 = severe]. Hematological and biochemical indexes were used to assess anemia, protein status and immune response. These were packed red cell volume (PCV), serum albumin, total protein, total WBC count, eosinophil percentage and concentration of IgG. Average daily weight gain was also taken as a short-term productivity parameter, describing the functional consequences of parasitism and immune condition on host performance. This provided an indirect estimate of growth efficiency and general condition.

All variables were measured per individual animal and compiled into a dataset. Continuous variables were left on their original measurement scales, and categorical variables collapsed for analysis. Data completeness and plausibility were checked before statistical analysis. Data was analyzed using IBM SPSS Statistics. Parasitological, clinical, and immunological variables were summarized by groups using descriptive statistics. Group differences in immunocompromised and control animals were analyzed using independent-samples t-tests or the Mann–Whitney U test, as appropriate for the data distribution. Correlations between parasite load and hematobiochemical parameters were assessed. Parasite prevalence and co-infection rates were compared between groups using chi-square tests. The independent influence of parasite load and immunity on clinical and productivity outcomes was evaluated by fitting multivariable regression models. Statistical significance was established at 0.05 using two-sided tests.

3. RESULTS

A total of 60 ruminants: 30 immunosuppressed and 30 control animals, consisting of cattle, goats, and sheep. There was no significant difference in age distribution between the groups (29.8 months, mean for both). Table 1: Descriptive summaries of selected parasitological, clinical, hematobiochemical, and performance parameters.

Table 1: Descriptive Statistics by Immune Status (Mean ± SD)

Variable	Immunocompromised (n=30)	Control (n=30)
Body condition score (1–5)	2.13 ± 0.25	3.08 ± 0.15
Strongyle FEC (EPG)	1370.3 ± 428.4	504.3 ± 130.6
Eimeria OPG	1607.0 ± 1133.2	734.3 ± 476.4
PCV (%)	22.13 ± 2.50	29.79 ± 2.61
Albumin (g/dL)	2.37 ± 0.25	3.30 ± 0.22
Total protein (g/dL)	5.70 ± 0.40	7.04 ± 0.32
WBC ($\times 10^9$/L)	9.66 ± 0.87	8.11 ± 0.46
Eosinophils (%)	8.77 ± 2.62	5.41 ± 1.25
IgG (g/L)	12.18 ± 0.92	15.89 ± 0.83
Average daily gain (g/day)	66.8 ± 36.7	117.7 ± 44.9

Immunocompromised animals were infected with markedly more parasites compared to controls based on both FEC ($t = 10.59$, $p < 0.001$) and Eimeria OPG ($t = 3.89$, $p < 0.001$) (Table 2).

Hematological and biochemical parameters revealed a higher disease burden in immunosuppressed animals, with significantly lower PCV ($t = -11.59$, $p < 0.001$), albumin ($t = -15.22$, $p < 0.001$), and total protein ($t = -14.34$, $p < 0.001$) compared to controls. (Table 2). Increased WBC ($t = 8.65$, $p < 0.001$) and a significant percentage of eosinophils ($t = 6.34$, $p < 0.001$) were found in immunocompromised animals, but IgG was significantly lower than that in normal rats ($t = -16.42$, $p < 0.001$) (Table 2). Immunocompromised animals exhibited decreased performance, indicated by average daily gain ($t = -4.81$, $p < 0.001$) (Table 2). The severity of diarrhea was significantly greater in the immunocompromised group (median 2 vs 0 on a scale from 0 to 3 for controls) (Mann–Whitney $U = 877.5$, $p < 0.001$).

Table 2: Group Comparison (Welch t-Tests) of Key Continuous Outcomes

Outcome	Test statistic	p-value
Body condition score	$t = -17.98$	<0.001
Strongyle FEC (EPG)	$t = 10.59$	<0.001
Eimeria OPG	$t = 3.89$	<0.001
PCV (%)	$t = -11.59$	<0.001
Albumin (g/dL)	$t = -15.22$	<0.001
Total protein (g/dL)	$t = -14.34$	<0.001
WBC ($\times 10^9$/L)	$t = 8.65$	<0.001
Eosinophils (%)	$t = 6.34$	<0.001
IgG (g/L)	$t = -16.42$	<0.001
Average daily gain (g/day)	$t = -4.81$	<0.001

Prevalence contrasts indicated significantly more Haemonchus-infected animals in the immunosuppressed group (70.0%) than in the control group (13.3%) ($\chi^2 = 17.55$, $p < 0.001$) (Table 3). The parasite Fasciola was diagnosed exclusively in immunocompromised animals (20.0% vs 0.0%; $\chi^2 = 4.63$, $p = 0.031$). Mixed infection was highly prevalent in immunocompromised patients (90.0%) and absent in controls (0.0%) ($\chi^2 = 45.52$; $p < 0.001$). There was no significant difference in the prevalence of Trichostrongylus infection between groups ($\chi^2 = 1.17$, $p = 0.279$) (Table 3).

Table 3: Parasite Prevalence by Group (Chi-Square Tests)

Parasite/Outcome	Immunocompromised n/N (%)	Control n/N (%)	χ^2	p-value
Haemonchus positive	21/30 (70.0%)	4/30 (13.3%)	17.55	<0.001
Trichostrongylus positive	22/30 (73.3%)	17/30 (56.7%)	1.17	0.279
Fasciola positive	6/30 (20.0%)	0/30 (0.0%)	4.63	0.031
Mixed infection	27/30 (90.0%)	0/30 (0.0%)	45.52	<0.001

Correlation analysis showed strong associations between parasite intensity and clinical/production indices (Table 4). Strongyle FEC had a strong negative relationship with PCV ($\rho = -0.994$, $p < 0.001$) and albumin ($\rho = -0.989$, $p < 0.001$), whereas it had the strongest significant positive correlation with diarrhea score ($\rho = 0.936$, $p < 0.001$). The average daily gain was highly negatively correlated with FEC ($\rho = -0.798$, $p < 0.001$). Eimeria OPG was also associated with lower PCV and levels of albumin and increased diarrhea severity (all $p < 0.001$) (Table 4).

Table 4: Spearman Correlations Between Parasite Burden and Outcomes (Overall, n=60)

Predictor	Outcome	ρ (Spearman)	p-value
Strongyle FEC (EPG)	PCV (%)	−0.994	<0.001
Strongyle FEC (EPG)	Albumin (g/dL)	−0.989	<0.001
Strongyle FEC (EPG)	Average daily gain (g/day)	−0.798	<0.001
Strongyle FEC (EPG)	Diarrhea score (0–3)	0.936	<0.001
Eimeria OPG	PCV (%)	−0.748	<0.001
Eimeria OPG	Albumin (g/dL)	−0.751	<0.001
Eimeria OPG	Average daily gain (g/day)	−0.910	<0.001
Eimeria OPG	Diarrhea score (0–3)	0.711	<0.001

4. DISCUSSION

The present study demonstrates that, under field conditions, immunocompromised ruminants carry significantly higher gastrointestinal parasite burdens than immunocompetent ruminants, as demonstrated by increased strongyle fecal egg count values, significant *Eimeria* oocyst shedding, and much higher prevalences of mixed infections. These results are also in accordance with the classical work that has demonstrated that a degraded quality of host immunity promotes better recrudescence and longevity, as well as fecundity, of gastrointestinal parasites [6, 7]. Nutrition stress and chronic disease were prevalent immunosuppressive factors in the current population, both of which are known to potentiate parasite susceptibility by impairing the host's ability to mount effective immune responses [8, 9]. The high prevalence of mixed infection could also suggest that immunosuppression creates a favorable environment for multiple parasite species to co-infect and increase disease severity [9, 10].

The hematological and biochemical alterations recorded in immunosuppressed animals clearly indicate the systemic effect of gastrointestinal parasitism. These striking decreases in PCV and serum albumin are consistent with parasite-mediated blood loss and protein degradation, classic consequences of heavy nematode infections, including abomasal infestations [11]. Decreased total protein levels may also reflect failure to uptake nutrients and chronic inflammation due to parasitism [11]. These findings were in consistence with the already known hematological profile of parasitized ruminants and highlighted that PCV, albumin and eosinophils could be used as valuable diagnostic indicators for disease severity after parasite infestation [12].

Immunological indices varied significantly among groups showing how the host immune response correlates with its parasitemia status. Excessive eosinophil levels in immunosuppressed animals identify helminth responsive immune mediating while lowered level of IgG suggests the failure of chronic humoral immunity under the high parasite challenge [13, 14]. It is well documented that by parturition animals undergo a period of temporary immuno-suppression leading to increased output/transmission of parasite eggs particularly as commonly seen in sheep and goats [3, 15]. Such immune trade-offs are thought to reflect the costs of immunity in energy terms, which might otherwise be invested elsewhere, for example into growth and development [16].

The reduced average daily gain and higher diarrhea scores in immuno-suppressed animals were indicative of the adverse effect of gastrointestinal parasitism on productivity. These performance losses impact the economic results of pig production, because modest decreases in the growth rate can cause enormous monetary losses on a herd basis [17, 18]. In total, the results reinforce that immunosuppressed ruminants carry a higher load of GI parasitic infections which are characterized by serious clinical and production implications as well as immunological repercussions. These results highlight that host-immune status dependent appropriate parasite control strategies should be considered particularly among the risk groups such as

malnourished and periparturient animals to reduce morbidity and improve productivity.

5. CONCLUSION

The findings underline the effect of GI parasitism in immunosuppressed ruminants, which appears to be related to depressed immune response that results from greater parasite burdens and higher prevalence and severity of mixed infections regardless of their clinical or subclinical course. Immuno-compromised mice developed severe anemia, along with moderate hypoproteinemia and increased susceptibility to infection. Growth rates were also lower than those of the controls indicating, that the systemic impact of GI parasites was not restricted to local intestinal pathology. The strong correlations of parasite challenge with degree of diarrhea and lost productivity are significant and quantify the economic and welfare impact that parasitism has on vulnerable populations of ruminants. These results highlight the role of host immunity on top of parasite susceptibility and disease severity. Targeted chemoprophylaxis, nutritional support and intensive monitoring of high-risk groups like malnourished or periparturient subjects are the key to alleviate helminth impact. Immunization approaches combined with parasite control are expected to improve the efficacy of control, animal health and sustainability of small ruminants' production systems.

6. FUNDING

Not applicable.

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