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Data-driven assessment of gastrointestinal parasitism in zero-grazed goats: Influence of age, gender, and body weight

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Abstract: Gastrointestinal parasite (GIP) infections are a primary constraint on health and productivity in intensive caprine production, yet their impact in zero-grazing systems is frequently underestimated. This study aimed to quantify the prevalence and intensity of GIP infections in a research herd and to identify host-specific demographic drivers of parasite shedding. A cross-sectional study was conducted on 50 Katjang goats at the Livestock Research Unit, Universiti Malaysia Sabah. Faecal egg counts (FEC) were quantified using standardised methods, and the resulting data were analysed using Negative Binomial (NB) regression to account for high overdispersion. Results revealed an exceptionally high herd prevalence of 98%. Parasite intensity was highly aggregated, characterised by a small percentage of "super-shedders," including one extreme high-leverage individual exceeding 26,000 eggs per gram (EPG). The NB model ($\alpha = 0.656$, $p < 0.001$) identified age and gender as the most significant predictors of infection intensity. Younger goats (<1 year) exhibited the highest mean FEC (2,640 EPG), suggesting increased susceptibility due to physiological immaturity. Furthermore, gender was a primary driver of variation ($p = 0.034$), with males exhibiting significantly higher mean FEC and greater shedding variance than females. While body weight showed high variability among mid-weight individuals, lower body weight often coincided with peak shedding in younger cohorts. These findings demonstrate that within confined, zero-grazing systems, infection intensity is heavily influenced by host-specific factors rather than environmental exposure alone. Ultimately, identifying these host-specific demographic drivers provides a vital framework for transitioning from traditional, non-selective herd-wide treatments to precision-based, data-driven interventions.

Keywords: data-driven risk assessment, faecal egg count, gastrointestinal parasite, goat host demographic, katjang goats

1. Introduction

Goat production is an important segment of the global livestock industry, making significant contributions to rural livelihoods, particularly in developing and tropical regions (Lu, 2023). As demand for animal protein rises and human and animal populations grow rapidly, small ruminants are attracting renewed interest due to their adaptability to various agro-ecological conditions, efficient feed conversion, and low production costs (FAO, 2024). Goats, in particular, can utilise unproductive land and low-quality forages to produce meat and dairy

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products rich in key micronutrients such as iron, zinc, and vitamin B12 (Ripoll *et al*., 2020). In Southeast Asia, including Malaysia, goat production has gained increased emphasis in national agro-food strategies to reduce reliance on imported red meat and improve national self-sufficiency. However, despite their biological adaptability, goats are highly susceptible to parasitic infections, which negatively impact productivity and profitability (Sontigun *et al.,* 2025).

One of the most widespread biological challenges to sustainable goat production systems is infection by gastrointestinal parasites (GIP). GIP shown in Figure 1, primarily caused by strongylid nematodes such as *Haemonchus contortus*, *Teladorsagia circumcincta*, and *Trichostrongylus* spp., continues to have significant economic and welfare impacts on small ruminant production systems worldwide (Bautista-Garfias *et al*., 2022; Maurizio *et al*., 2023). GIP infection impairs nutrient utilisation efficiency, causes chronic inflammation, and, in the case of *H. contortus*, leads to significant blood loss and potentially anaemia, reduced growth rates, and mortality, particularly in young or physiologically stressed animals (Mpofu *et al*., 2022). The impact of GIP infection is often exacerbated in tropical climates, characterised by warm temperatures and humidity, which favour the survival and transmission of these parasites throughout the year.

Controlling GI parasitism is the subclinical nature of the infection. Infected goats may appear healthy while experiencing increasing physiological impairment. As a result, parasite infection is often not detected until clinical signs appear or there is a marked decline in animal performance (Saha *et al*., 2026). This subclinical nature of GI parasitism underscores the need for surveillance approaches that quantify parasite infection rather than merely identify its presence. In this context, faecal egg count (FEC), expressed as eggs per gram (EPG) of faeces, has been established as the basis of parasitological surveys in small ruminants.

Faecal egg counting is an objective method for quantifying worm burden in adults and assessing the risk of environmental contamination, thereby supporting evidence-based decision-making in herd health management. Unlike qualitative diagnostic methods, faecal egg counting enables the detection of individual differences in parasite shedding, which is important given the well-documented phenomenon of parasite over-dispersion. Identifying these “super-shedders” is therefore critical for implementing Targeted Selective Treatment (TST), a precision-based approach to worm control that reduces chemical use, maintains refugia, and delays the onset of anthelmintic resistance (Besier *et al.,* 2010).

The McMaster technique remains the most widely used method for FEC determination due to its simplicity, reproducibility, and cost-effectiveness (Whitlock, 2009; Boareki *et al*., 2021). The method has been extensively validated and refined, becoming common method in determining EPG in many research in veterinary pathology. Recent research continues to highlight the value of McMaster-derived FEC data in monitoring infection dynamics, evaluating treatment efficacy, and informing sustainable parasite control programmes, particularly in resource-limited settings (Playford & Besier, 2025).

Despite extensive global research on gastrointestinal parasitism in goats, knowledge gaps remain, particularly at regional and production system levels. In Malaysia, there is limited published information on the prevalence and infection intensity of gastrointestinal parasites, especially under zero-grazing management systems. It is assumed that zero-grazing management can minimise parasite infection in goats. However, emerging evidence indicates that various host factors, such as age, body weight, and gender, can cause significant variation in parasite infection, even in controlled environments (Saha *et al*., 2026). Additionally, indiscriminate deworming practices are common, leading to the emergence of anthelmintic resistance, particularly in Southeast Asian countries (Maurizio *et al*., 2023). For this reason, the present study aims to address this knowledge gap by investigating the prevalence of gastrointestinal parasitic eggs in zero-grazing goats and exploring the relationship between host demographic characteristics and infection intensity. By generating high-resolution individual-level EPG data, this study seeks to provide a foundation for evidence-based precision livestock parasite management. Ultimately, improved knowledge of GIP epidemiology in zero-grazing goat production will be instrumental in enhancing animal welfare, sustaining anthelmintic efficacy, and increasing the productivity of small ruminants.

Figure 1. Morphological appearance of a gastrointestinal parasite in goats as observed under low-light microscopy at 10× magnification. Presumptive diagnosed based on their structural shape as *Nematodirus spp.* (A, B) and *Haemonchus contortus* (C).

2. Materials and Methods

2.1 Faecal samples collection and preparation

This faecal samples were collected from Katjang goats in a zero-grazing production system at the Livestock Research Unit, Faculty of Sustainable Agriculture (FSA), Universiti Malaysia Sabah (UMS). A cross-sectional sampling approach was adopted to collect the faeces sample of the goats to ensure that the prevalence rates derived reflect the true position of the herd. A total of 50 faecal samples was collected directly from the rectum of 50 goats to avoid any environmental contamination. The aseptically collected sample was taken by restraining the animal before taking about 10-20 grams of the fresh material using a lubricated disposable glove. For every animal that was sampled, the relevant information of age, sex, pen number, and body weight was documented. Every stool sample was placed in a new, labelled, airtight plastic container. The faecal samples were packed in a cooler box with ice blocks (at 4 °C) to prevent the further development of eggs and larvae of the parasite organisms, and to maintain their morphologic characteristics intact. These samples would then be transported to the Parasitology Laboratory in FSA for further analysis within 24 hours post-sampling time. Potential confounders such as anthelmintic history and physiological status were not controlled in this study due to the recording limitation.

2.2 Faecal analysis

The level of gastrointestinal parasite infection was estimated by using the modified McMaster counting technique (Basripuzi *et al.*, 2013). Such a well-established technique was chosen for the calculation of eggs per gram (EPG) of faeces. EPG of faeces was a highly significant quantitative estimate for the helminthic load present in the hosts. Two grams of each 50 faecal samples were processed within 24 hours of sampling timeframe. Fresh faeces were accurately weighed (2 g) and homogenised with 28 mL of saturated sodium chloride solution. Saturated sodium chloride was selected as the flotation medium due to its high specific gravity (approximately 1.20), which facilitates the buoyancy and flotation of common nematode eggs. The resulting mixture provided a 1:15 dilution ratio (2 g of faeces in a total suspension of 30 mL). The mixture was then agitated to ensure a uniform suspension and strained through a fine sieve (or double-layered gauze) to remove coarse debris while allowing parasite eggs to pass freely into the filtrate for further analysis.

2.3 Quantitative analysis and EPG

Faecal suspension was promptly aspirated into a pipette and used to inoculate the chambers of a McMaster counting slide. The slide was allowed to sit for 5 to 10 minutes to allow the less dense parasitic eggs to float to the surface of the coverslip. Eggs in the grid chambers of the counting slide were counted under a low-light microscope at a 10× power magnification. Counting was performed based on the total number of eggs of the parasites present in the grid chambers of the two counting chambers and was not specifically in regard to morphological types of parasitic eggs, to obtain a total infection intensity.

Calculation of the EPG for each sample was performed using the following formula, with consideration of the 1:15 dilution and the counted eggs observed on the slide (Basripuzi *et al.*, 2013):

$$\text{EPG} = \frac{\text{Total number of eggs counted}}{\text{Volume counted (mL)}} \times \frac{\text{Total volume of suspension (mL)}}{\text{Weight of faeces (g)}}$$

For a standard McMaster slide, the counted sample volume will be 0.30 mL for the two grids (often referring to two chambers of 0.15 mL each). With the standardised values (counted sample: 0.30 mL, total suspension: 30 mL, sample of faeces: 2 g).

These EPG counts give the necessary values for the assessment of parasite load to form the basis of statistical analysis concerning the influence of the host factors (age, gender, weight).

2.4 Experimental design and statistical analysis

Descriptive statistics were performed for all variables, with parasite prevalence calculated as the proportion of positive samples to the total number of goats sampled. Measures of central tendency for FEC, including mean, standard deviation (SD), and range, were used to characterise the parasite burden. The statistical analysis followed a two-stage approach using Minitab version 2026. Initially, a General Linear Model (GLM) and standard Ordinary Least Squares (OLS) Regression were performed to determine the effects of gender, age, and body weight on FEC. However, diagnostic checks of the initial model, including the Test for Equal Variances and residual analysis, indicated significant heteroscedasticity and non-normal distribution of residuals. The FEC data exhibited high aggregation and overdispersion, a common trait in parasitological counts where a few "super-shedders" skew the distribution.

To address this, a Negative Binomial (NB) Regression was implemented as a more suitable alternative to the linear and Poisson models. The NB model utilised a logarithmic link function to account for the count-based nature of the data and incorporated a dispersion parameter (α) to handle the variance-to-mean relationship. The final model evaluated the influence of host demographic factors (age, gender, and weight) on infection intensity, with the level of significance set at $p < 0.05$. This data-driven modelling approach ensured a more precise risk assessment by capturing the exponential nature of parasite shedding patterns within the intensive zero-grazing system.

3. Results and Discussion

Data from 50 sampled goats revealed substantial inter-herd variation in parasite shedding. To ensure the statistical stability of the final regression model, Observation 39 (ID 086; Female, 26,550 EPG) was analysed independently and excluded from the main regression computation. This extreme value - exceeding the average male EPG by more than 11-fold; exerted an excessively high leverage that would mathematically distort the regression coefficients and mask the subtle demographic trends of the remaining 98% of the herd (Appendix - Table A1). However, from an epidemiological standpoint, this individual represents a critically meaningful biological phenomenon rather than statistical noise: a classic "super-shedder" contributing disproportionately to potential environmental contamination within a zero-grazing system. Separating this extreme point allowed for a more stable interpretation of baseline herd dynamics while highlighting the urgent practical need for Targeted Selective Treatment (TST) strategies on the farm. Within the remaining model population, observations 15, 18, and 49 were flagged as having large residuals, indicating instances where actual faecal egg counts (FEC) deviated notably from model predictions. For instance, mature animals such as ID 001 (8 years old) and ID 160 (5 years old) both reached peak burdens of 3,750 EPG, demonstrating that high-intensity shedding can still manifest in older cohorts under intensive management conditions.

The EPG counts showed utmost variation ranging from as low as 150 EPG to as high as 3462.5 (Table 1). The parasite distribution is highly skewed (1.13 for females, -1.05 for males), where a few individuals (the high-risk shedders) contributed to most of the eggs.

Table 1: Descriptive Analysis of Gastrointestinal Parasite Infection (N=49).

Variable	Gender	N	Mean	SE Mean	StDev	Minimum	Q1	Median	Q3	Maximum	Skewness
EPG	F	41	1182.93	142.095	909.850	150	500	1000	1550	3750	1.13
	M	8	2412.5	477.507	1350.60	0	1137.5	2875	3462.5	3750	-1.05

Note: EPG: Faecal egg count expressed in egg per gram; SE: Standard Error; StDev: Standard deviation.

3.1 Effect of gender on parasite count

The present findings indicated that male goats exhibited a higher mean faecal (EPG = 2,412.50) than female goats (EPG = 1,182.93) as shown in the Table 1. The regression model was used to evaluate the impact of gender on parasite shedding. Highly significant gender influence (p = 0.007), where on average, male goats had an EPG that was 1,010 units higher than females when other factors were constant. This suggests that under this zero-grazing conditions, males may be more susceptible to high parasite burdens or may act as primary contributors to environmental contamination. Male goats are frequently reported to harbour greater parasite burdens, a pattern commonly attributed to the immunosuppressive effects of androgens, particularly testosterone (Grear *et al.*, 2009; Sellau *et al.*, 2024). Elevated testosterone levels are known to modulate immune function, directing physiological resources toward growth and reproductive investment at the expense of parasite resistance (Hellard *et al.*, 2013). In the present study, most male goat have maintained EPG values exceeding 2,000, indicating moderate to high infection intensity. Such variability is characteristic of gastrointestinal parasite (GIP) infections in small ruminants and reflects the inherently over-dispersed distribution of helminth populations rather than uniform host susceptibility (Maurizio *et al.*, 2023).

Notably, one male goat (Tag 196) was recorded zero EPG, suggesting potential genetic resistance or enhanced immunocompetence or could be an outlier result, provided if there is no anthelmintic treatment or prevalence in place. Such inter-individual variation has been widely reported and supports the role of host genetics in regulating parasite susceptibility, offering opportunities for selective breeding for parasite resistance (Notter, 2013).

In contrast, one female goats (ID 086) exhibited extreme variation in parasite burden could be a critical ‘super-shedder’ (the highest EPG; 26,550). Even this data was excluded from the statistical analysis as deemed to be outlier, in most population, even a small percentage of ‘high-risk shedders’ could be responsible for the vast majority of environmental contamination and the exclusion may bias epidemiological interpretation. In zero-grazing environment, this single individual could potentially contaminate the entire pen area far more than the rest of the herd combined. This animal represents a classic “super-shedder,” contributing disproportionately to environmental contamination.

In females, such elevated egg output is frequently associated with the periparturient rise

(PPR), during which immunological relaxation happened during late pregnancy and early lactation. This can result in increased worm fecundity and egg shedding. In contrast with study by Hassanen *et al*, (2020), GIT parasites prevalent was higher in male (75.4%) than female (62.4%) goat reared in Egypt. This study observed that the infection pattern strongly supports the 80/20 rule, whereby approximately 20% of hosts account for 80% of parasite transmission (Cooper *et al*., 2019). These findings highlight the limitations of blanket anthelmintic treatment and strongly support the adoption of faecal egg count–based TST. Targeting high-shedding individuals such as Tags 086 and 100 would substantially reduce overall parasite pressure while preserving refugia and mitigating the development of anthelmintic resistance (Besier, 2012).

Table 2. Analysis of variance (ANOVA) of faecal egg count (EPG) distribution in intra-population variation and gender influences under zero grazing conditions.

Source	**DF**	**Adj SS**	**Adj MS**	**F-Value**	**p-Value**
Regression	3	19387034	6462345	7.94	0.000
Weight, Kg	1	97053	97053	0.12	0.731
Age	1	4923960	4923960	6.05	**0.018***
Gender	1	6601221	6601221	8.11	**0.007***
Error	**45**	**36614905**	**813665**		

* p < 0.05

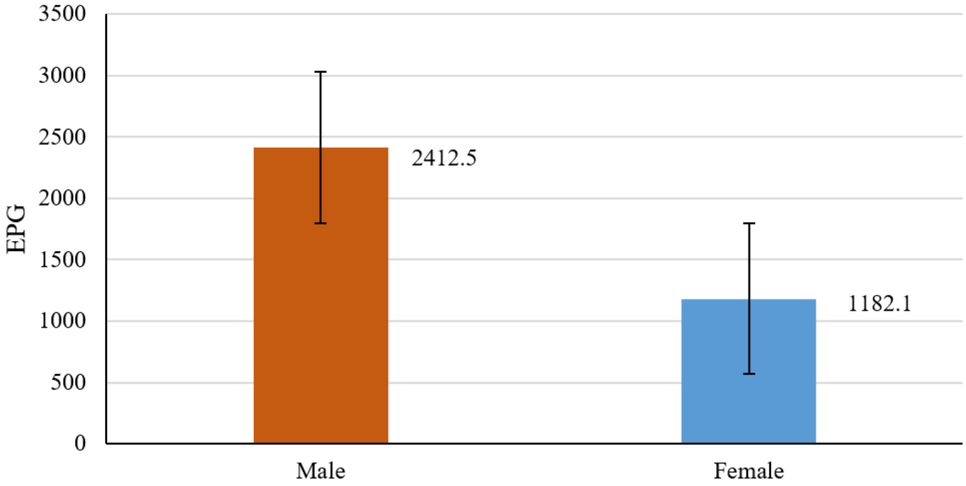

Figure 2. Comparative distribution of mean faecal egg count (counted in egg per gram; EPG) between male and female goats, revealing pronounced intra-population variation and elevated parasite shedding patterns among male goats in a zero-grazing system ($p < 0.05$). Error bars represent standard deviation.

3.2 Effect of body weight on parasite count

The regression indicates that weight and age are non-linear predictors. While young, low-weight goats (like IDs 104, 106, 100) were vulnerable, the presence of high-EPG adults suggests that age-conferred immunity may be incomplete or compromised by other stressors in this zero-grazing system. The sampled population was stratified into six body weight categories to evaluate the relationship between body mass and gastrointestinal parasite burden (Table 3). The analysis revealed marked variation in faecal egg counts (FEC) across the weight ranges, with the highest number of animals in the 22.1-27.0 kg category (n = 13). Figure 3 further highlights the substantial intra-group variability, showing a wide spread of EPG values across all weight categories.

Interestingly, the lowest weight category (1.0-7.0 kg) also recorded a high mean EPG of 1,800, reflecting the increased susceptibility of young goats. This study aligns with established findings that younger and lighter goats are generally more susceptible to gastrointestinal nematode infections, largely due to immature immune systems and limited exposure. Conversely, the heaviest goats (35.1-62.0 kg) showed the lowest coefficient of variation (44.82%), indicating more consistent parasite burdens likely due to acquired immunity and physiological robustness. Despite these trends, statistical analysis confirmed no significant association between body weight and parasite burden ($p > 0.05$), emphasising that body weight alone is an unreliable predictor of infection intensity.

These findings reinforce the importance of individual-level monitoring using faecal egg counts rather than relying on weight or general group averages. Weight can be affected by several factors such as genetics, feed, rear practices and feed conversion ratio (Lim *et al.,* 2022; Davison *et al.,* 2023; Ojo *et al.*, 2024). The presence of "super-shedders" underscores the necessity of TST, which focuses interventions on high-risk individuals, reducing pasture contamination while preserving refugia and mitigating anthelmintic resistance (Arthur *et al.,* 2010; Tan *et al*., 2017). Collectively, Table 3 and Figure 3 demonstrate that infection dynamics in goats are highly heterogeneous and influenced by multiple interacting factors, including age, genetics, and immune status, rather than body weight alone.

Table 3. Influence of body weight on parasite load as measured by faecal egg count (in egg per gram, EPG).

Weight Range (kg)	Sample Size (n)	Mean EPG±SD	CV (%)
1.0 - 7.0	5	1,800.00 ±1,496.99	83.17
7.1 - 18.0	8	571.43 ± 419.18	73.36
18.1 - 22.0	12	850.00 ± 482.89	56.81
22.1 - 27.0	11	3,470.83 ±1,326.15	211.08
27.1 - 35.0	6	1,825.00 ±1,230.75	67.44
35.1 - 62.0	7	2,392.86 ±1,072.55	44.82

Note: CV: coefficient of variantion.

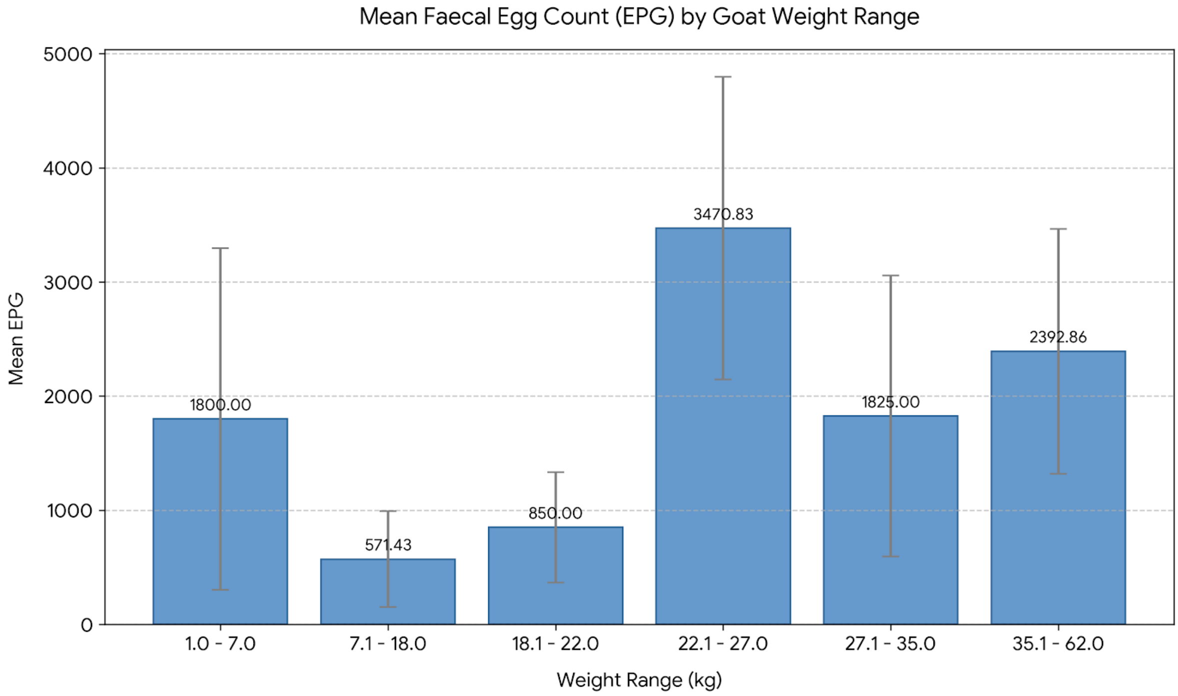

Figure 3. Influence of body weight on mean faecal egg count (in egg per gram; EPG) and associated variations in infection intensity. P value was more than 0.05, thus there was no significant difference among the weight groups. Error bars represent standard deviation.

3.3 Effect of age on parasite count

The influence of host age on gastrointestinal parasite (GIP) burden demonstrated distinct patterns across the four study cohorts: Group 1 (<1 year), Group 2 (1–2 years), Group 3 (3–4 years), and Group 4 (≥5 years). Regression analysis confirmed that age significantly impacts EPG ($p = 0.018$), with the highest mean parasite count observed in Group 1 (Mean EPG = 2,640) (Table 4 and Figure 4). This peak suggests that young kids are most susceptible to infection due to immunological immaturity and a lack of prior exposure to GIP.

Interestingly, the lowest burden was recorded in Group 2 (Mean EPG = 977.6), which may represent a transient "immunity honeymoon" period where initial exposure has triggered a protective response, but long-term environmental accumulation hasn't yet peaked. In contrast, the oldest cohort (Group 4) exhibited the least variability in shedding. This stability suggests a state of host-parasite equilibrium, where mature goats have developed a consistent, albeit not necessarily "zero," level of resilience that keeps shedding within a predictable range. However, the high overall counts across all groups, frequently exceeding the recommended clinical threshold of 1,000 EPG, suggest that the current deworming program is either ineffective or inconsistently applied. To mitigate this, frequent monitoring and TST are essential, particularly for Group 3.

Identifying and treating "high-risk" breeders before they enter the reproductive cycle is critical; if an animal consistently fails to manage its GIP burden, it should be culled to prevent the propagation of susceptible genetics within the herd.

To accurately model these patterns, a Negative Binomial (NB) Regression was utilised to account for the over dispersed nature of the count data Figure 5). The model identified gender as a primary driver of shedding ($p = 0.034$), while the significant overdispersion parameter ($\alpha = 0.656$, $p < 0.001$) validated the NB model over standard linear methods. Unlike linear models that assume constant change, the NB model captures the exponential relationships and "super-shedder" dynamics (e.g., ID 001 and ID 160) typical of biological systems. By focusing management efforts on these high-intensity shedders and protecting the vulnerable young kids in Group 1, the farm can effectively reduce pasture contamination and enhance overall herd immunity.

Table 4. Influence of age on parasite load as measured by faecal egg count (counted in egg per gram, EPG)

Variable	Age Group	N	Mean	SE Mean	StdDev	Minimum	Q1	Median	Q3	Maximum
EPG	1 (<1y)	6	2640.00	633.92	1417.48	200	1525	2900	3625	3750
	2 (1-2y)	29	977.59	127.49	686.55	150	475	750	1300	2750
	3 (3-4y)	6	1433.33	459.29	1125.02	300	450	1125	2588	3150
	4 (>4y)	8	2206.25	387.81	1096.89	800	1113	2125	3275	3750

Note: SE: Standard error; StdDev: Standard Deviation.

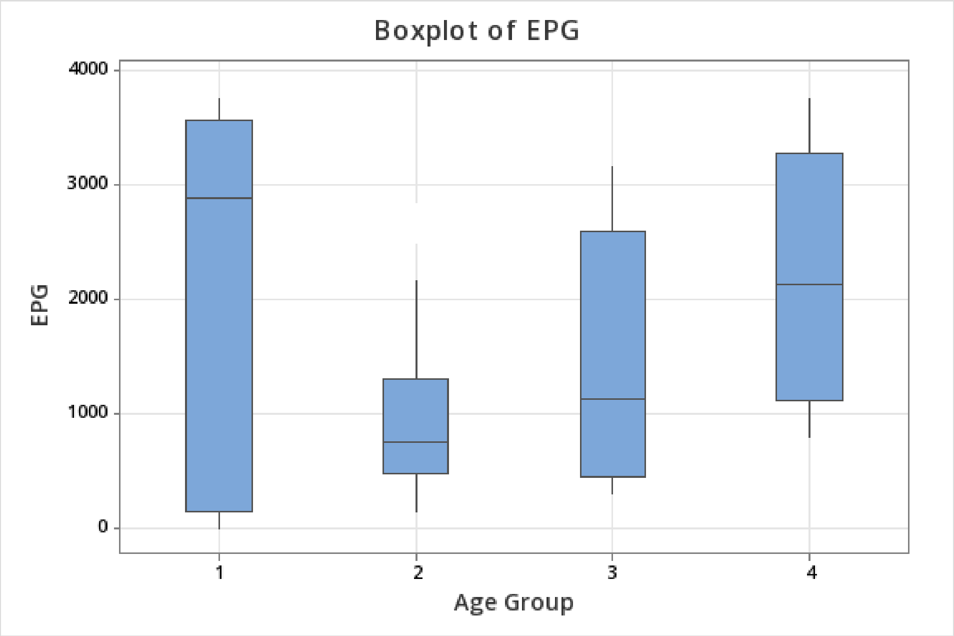

Figure 4. Influence of age on parasite burden - evidenced by variations in mean egg per gram (EPG) ($p < 0.05$). Bars represent data range.
Note: Age group: 1 (< 1 year); 2 (1-2 years); 3 (3-4 years); 4 (> 4 years).

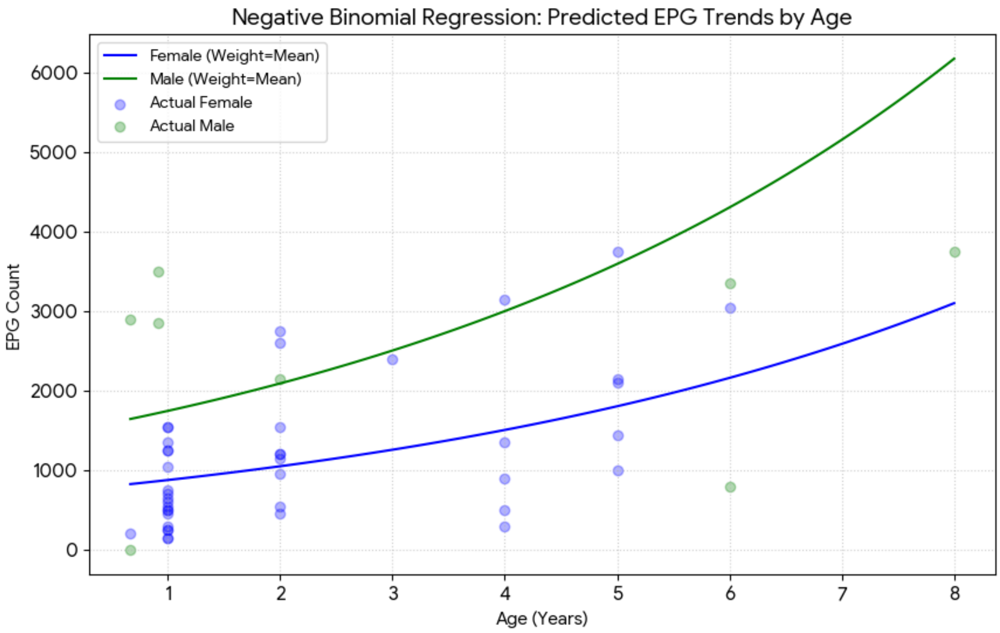

Figure 5. Negative binomial regression: Predicted faecal egg (measured in egg per gram; EPG) trends by age - illustrated an increasing trend.

3.4 Linking age and gender dynamics

Building upon the age-related trends, the interaction between host age and gender further defines the susceptibility landscape of the herd. The Test for Equal Variances (Figure 6) confirms that while age dictates the average burden, gender significantly influences the spread and predictability of that burden. Specifically, male goats not only exhibited higher mean EPG counts but also displayed a significantly larger variance compared to females. This indicates that while female goats tend to cluster around a moderate infection level, the male population is more prone to harbouring "super-shedders" with extreme EPG values. By identifying these high-variance groups through ANOVA, it becomes clear that gender-specific physiological or behavioural factors likely exacerbate the age-related vulnerabilities previously discussed.

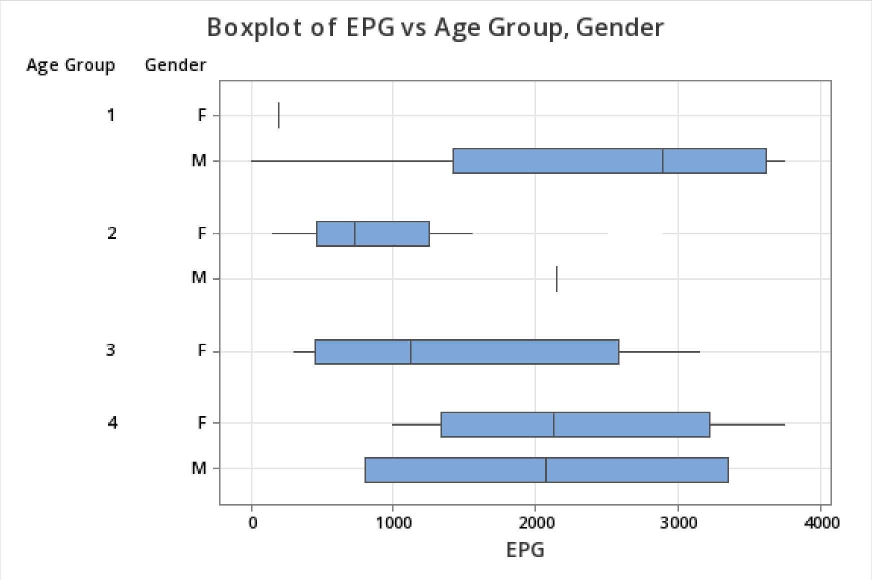

Figure 6. Effect of age group and gender to parasite burden (mean egg per gram (EPG)) using ANOVA -Test for Equal Variance. Bars represent data range.

Note: Age group: 1 (< 1 year); 2 (1-2 years); 3 (3-4 years); 4 (> 5 years); Gender: F: female; M: male goat.

3.5 Prevalence of gastrointestinal parasites (GIP)

The overall prevalence of GIP in the study population was found to be exceptionally high, with 98% of the goats (49 out of 50) testing positive for parasite eggs. This near-universal prevalence is characteristic of tropical goat farming systems where the warm, humid climate facilitates year-round larval development. In this zero-grazing environment, the high prevalence suggests that despite the lack of traditional pasture grazing, the animals are consistently exposed to infective larvae, likely through contaminated bedding, floor slats, or shared feeding troughs. The prevalence did not significantly vary between age groups, indicating that while the intensity of shedding changes as the animal matures, the risk of infection remains constant across the entire herd. However, the findings are limited to a single herd and may not represent broader production systems in Malaysia.

3.6 Dynamics of infection intensity and parasite overdispersion

In Malaysian smallholder and commercial livestock enterprises, existing literature demonstrated that herd prevalence frequently reaches 100%, with mean FECs often exceeding 2,000 EPG in untreated populations. Due to sustained high temperatures and humidity in tropical environments, *Haemonchus contortus* can progress from egg to infective third-stage larvae (L3) in as little as 4 days. Consequently, even within zero-grazing systems, the risk of reinfection remains substantial if environmental factors, such as un-aged manure application on adjacent fodder crops, allow for larval survival.

In contrast, parasite burdens in temperate climates are highly seasonal, characteristically dropping to near-zero values during winter periods. Small ruminant parasitism in those regions is heavily influenced by the "spring rise," a sudden elevation in FEC among peri-parturient does driven by the reactivation of hypobiotic larvae. Malaysian caprine production faces an entirely different epidemiological paradigm: a "constant rise" facilitated by a perennial tropical climate that lacks a cold season capable of reducing environmental larval populations. This constant exposure places local herds within a perpetual high-risk threshold, where parasite-induced production losses, such as depressed weight gain and annual mortality rates between 10% and 40%, significantly escalate.

While zero-grazing housing limits direct pasture contact, it does not fully eliminate parasite transmission. Infective larvae of gastrointestinal strongyles can survive within moist manure on slotted pen floors for up to 22–23 days. Given that a single female H. contortus can deposit 5,000 to 10,000 eggs per day under optimal tropical conditions, environmental contamination accumulates rapidly (Basripuzi *et al.,* 2013; Carson *et al*., 2023). This reproductive capacity directly contextualises the extreme shedding intensity observed in this study, exemplified by a single female "super-shedder" (ID 086) with an FEC of 26,550 EPG.

While prevalence outlines the epidemiological distribution of infection, the intensity of shedding reveals the severe underlying physiological burden within the flock. The overall mean FEC for this research herd stood at 1,418 EPG, surpassing the standard clinical threshold at 1,000 EPG established for severe infection in tropical regions. The individual-level data from this study strongly illustrate the phenomenon of biological overdispersion, wherein a highly skewed minority of the population, predominantly young kids and breeding males, is responsible for the vast majority of the total environmental egg output.

Identifying these high-intensity demographic cohorts provides a clear alternative to traditional, non-selective blanket anthelmintic treatments, which are known to accelerate the development of drug resistance. Furthermore, because parasite resistance is a heritable trait, quantifying individual variations in FEC offers a reliable phenotypic metric for selective breeding programmes aimed at progressively improving herd-level resilience over subsequent generations (Notter, 2013). However, certain microenvironmental factors inherent to intensive zero-grazing practices, including slotted floor designs, localised manure accumulation rates, and humidity levels at the pen floor interface, were not evaluated in the present study due to operational limitations.

4. Conclusion

This study highlights the significant impact of host age and gender on the shedding patterns of gastrointestinal parasites within a Malaysian zero-grazing goat farm. The results demonstrate that younger goats (<1 year) and male goats represent the most vulnerable demographic cohorts, exhibiting both the highest mean FEC and the greatest variability in shedding intensity. The statistical validation provided by the Negative Binomial Regression and ANOVA Test for Equal Variances underscores that parasite distribution across the herd is highly non-uniform and heavily driven by specific high-risk individuals. Ultimately, these findings demonstrate that quantifying infection intensity and identifying host-specific demographic drivers are essential for transitioning from traditional, non-selective herd-wide treatments to precision-based, data-driven interventions. The marked overdispersion observed confirms that controlling internal parasites in intensive tropical systems relies on identifying highly susceptible cohorts rather than assuming uniform environmental exposure. Focusing monitoring efforts on these high-risk demographics, specifically through the strategic management of persistent super-shedders and the rigorous surveillance of breeding males, provides a robust framework for reducing environmental parasite loads, optimising herd health, and mitigating the rising threat of anthelmintic resistance within the tropical livestock industry.

Data Availability

Data partially presented in this paper. For further data information, available upon request.
The data that support the findings of this study are available from the corresponding author upon reasonable request.

Author Contributions

Md Safiul Alam Bhuiyan: Conceptualisation, Methodology, Supervision. **Rayhan Firdaus Rusly:** Data curation, Original draft preparation. **Fatin Naazira Along:** Editing, Laboratory work. **Su Chui Len Candyrine:** Writing, Reviewing. **Mohamad Asrol Kalam:** Writing, Reviewing. **Rohaida Abdul Rasid:** Writing, Reviewing. **Rovina Kobun:** Writing, Reviewing. **Mohammad Mijanur Rahman:** Writing, Validating. **Norafizah Abdul Rahman:** Software, Writing, Reviewing, Editing, Corresponding author.

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Conflicts of Interest

The authors declare that they have no conflicts of interest.

Ethics Statement

Only minimal faecal sampling involving animals and the procedures were reviewed and conducted in accordance with relevant institutional and national guidelines. The care and use of farm animals were with present of university's veterinarian. No ethical approval is required.

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Appendix

Table A1. Comprehensive Parasitological Data for the Study Population (N=50).

No	ID	Age (month)	Pen	Weight, kg	Gender	Parasite	EPG
1	006	12	1	25.5	F	10	500
2	043	12	1	23	F	21	1050
3	054	12	1	30	F	11	550
4	104	03	1	3.5	F	4	200
5	106	03	1	3.5	F	27	1350
6	016	12	2	22	F	31	1550
7	027	12	2	27	F	31	1550
8	051	12	2	26	F	25	1250
9	057	12	2	13	F	25	1250
10	009	12	3	19	F	13	650
11	013	12	3	22	F	9	450
12	014	12	3	22	F	5	250
13	030	12	3	25	F	12	600
14	039	12	3	21	F	15	750
15	001	90	4	62	M	75	3750
16	022	48	5	38	F	63	3150
17	082	72	5	24.5	F	61	3050
18	160	60	5	35	F	75	3750
19	174	60	5	32	F	43	2150
20	189	36	5	27	F	48	2400
21	002	72	6	44.5	M	67	3350
22	080	48	6	27	F	10	500
23	100	11	6	11	M	70	3500
24	138	48	6	22	F	6	300
25	044	12	7	18	F	6	300
26	059	12	7	10	F	3	150
27	105	03	7	3.5	M	58	2900
28	024	60	8	37	F	29	1450
29	102	60	8	42	F	42	2100
30	164	48	8	28	F	18	900
31	194	48	8	21	F	27	1350
32	196	08	8	7	M	0	0
33	012	12	9	14	F	10	500
34	045	12	9	25	F	5	250
35	053	12	9	10.5	F	3	150
36	066	12	9	12	F	14	700
37	136	24	10	25.5	F	55	2750
38	148	24	10	24	F	24	1200
39	086	48	10	27	F	531	26550
40	088	60	10	28	F	20	1000
41	021	24	11	18	F	19	950
42	031	24	11	20	F	11	550
43	047	24	11	22	F	23	1150
44	050	24	11	20	F	9	450
45	110	03	11	3.5	M	57	2850
46	200	24	11	40	M	43	2150
47	003	24	12	18.5	F	31	1550
48	011	24	12	27.5	F	52	2600
49	040	24	12	22	F	24	1200
50	171	72	12	53	M	16	800

Note: F = Female M = Male