International Journal of Environmental Sciences
ISSN: 2229-7359
Vol. 11 No. 16s, 2025
https://www.theaspd.com/ijes.php

Emerging Threat Of Gastrointestinal Parasites In Juvenile Sheep From Quisapincha Parish, Tungurahua: Prevalence And Health Implications

Miguel Tisalema Shaca[1], Juan Llivi Marcatoma[1], Marco Flores Blacio[1], Santiago Valle Baldeón[1], Santiago Alexander Guamán Rivera[2*]

[1]Escuela Superior Politécnica de Chimborazo, (ESPOCH), Riobamba, Ecuador, Grupo de Investigación en Ciencias Veterinarias
[2 *]Universidad Autónoma de Barcelona, Grupo de Investigación en Rumiantes (G2R), Belletarra, Barcelona, España
*Corresponding author: Santiago Alexander Guamán Rivera
*E-mail: santyalex.guaman@hotmail.com

Abstract
Gastrointestinal parasites represent a major health threat to juvenile sheep, especially in tropical highland regions such as Quisapincha Parish in Tungurahua, Ecuador, where sheep farming is a crucial livelihood for indigenous communities. This study aimed to determine the prevalence, diversity, and degree of gastrointestinal parasitic infection in sheep under 12 months of age, while exploring environmental and management factors contributing to their distribution. A total of 222 fecal samples were collected directly from the rectum of sheep in various rural communities and analysed using flotation techniques and optical microscopy to identify parasitic forms. Statistical analysis was conducted using SAS software, including descriptive statistics and Pearson correlation to assess relationships between parasite burden and anemia severity. The results revealed a high overall prevalence of gastrointestinal parasites at 74.77%, with Eimeria spp. (38.95%), Strongyloides spp. (13.48%), and Haemonchus spp. (9.74%) being the most common. Most infections were classified as mild (78.67%) or moderate (21.33%), with no cases of heavy infestation. Creole sheep had the highest prevalence (83.51%), followed by crossbreeds (67.65%) and Merino sheep (24.18%). Males showed higher infection rates than females (79.17% vs. 71.43%), and sheep over 12 months exhibited slightly higher parasitism than younger groups. The high prevalence suggests deficiencies in pasture management, irregular implementation of deworming protocols, and limited veterinary support. These findings underscore the need for integrated parasite management strategies that include improved sanitary practices, regular monitoring, targeted anthelmintic use, and farmer education. Strengthening local animal health programs is essential to reduce parasitic burdens and enhance productivity in smallholder sheep systems in the Ecuadorian highlands.

Keywords: *Gastrointestinal parasites, juvenile sheep, parasite prevalence, Eimeria spp., Strongyloides spp., FAMACHA method, Quisapincha Parish, Ecuadorian highlands.*

Introduction

Gastrointestinal parasites pose significant challenges to sheep populations globally, influencing both animal health and agricultural productivity (Mendoza et al., 2015; Van Metre, 2010). The prevalence and impact of these parasites are known to vary with environmental conditions, including climate, which affects the lifecycle and transmission dynamics of the parasites (Gorski et al., 2004; Mehedi, B et al., 2020; Pinilla et al., 2020). Studies have documented that parasite infections often exhibit seasonal patterns, influenced by factors such as temperature, moisture, and the availability of naïve hosts (Calderon et al., 2018; Gorski et al., 2004). For instance, temperature and humidity have been shown to directly impact the survival and development of strongyle larvae and coccidian oocysts in the external environment (Guamán-Rivera et al., 2024; Malik et al., 2019; Tomley & Shirley, 2009). In recent years, research has focused on understanding the effects of climate change on the epidemiology of gastrointestinal parasites in livestock (De-Jongh et al., 2022; Rojas-Downing et al., 2017; Toulkeridis et al., 2020). The mean temperature in regions like St. Kilda has increased by approximately 0.03°C per year since the commencement of longitudinal studies in 1985, leading to shifts in parasite dynamics. Additionally, environmental variations can alter the physiological state of hosts, thereby affecting their exposure, susceptibility, and resistance to infections (Cheng et al., 2022; De-Jongh et al., 2022; Joy et al., 2020; Rojas-Downing et al., 2017; Toulkeridis et al., 2020). Reduced food availability during winter months, for example, may limit the nutritional resources necessary for maintaining immune function in sheep (Gerber et al., 2013; Rojas-Downing et al., 2017). Specifically, in the context of Tungurahua province in Ecuador, the prevalence of ectoparasitic arthropods, such as Melophagus ovinus, has shown significant variability across different municipalities, suggesting that localized environmental factors play a crucial role in parasite dynamics. Understanding these patterns is essential, particularly given the high economic and nutritional importance of sheep to the local population. The demand for sheep products has been on the rise, and ensuring the health of livestock is vital to meet this growing need. As such, addressing the emerging threats posed by gastrointestinal parasites is crucial for the sustainability of sheep farming in the region.

Gastrointestinal parasites pose significant health risks to juvenile sheep, particularly in regions like Quisapincha Parish, Tungurahua. Among these parasites, gastrointestinal worms are the most concerning, including roundworms (nematodes), tapeworms (cestodes), and flukes (trematodes). Each of these parasites has a unique life cycle and mode of infection, often leading to malnutrition and increased susceptibility to other diseases due to their ability to feed on the host's blood or tissues. In particular, certain species of nematodes, such as Nematodirus battus, are notably pathogenic in specific temperate areas, causing significant morbidity in young lambs during spring when infective larvae are abundant. Other prevalent gastrointestinal parasites include the brown stomach worm (Teladorsagia circumcincta) and the barber pole worm (Haemonchus contortus), which is particularly damaging in tropical and subtropical regions, contributing to anaemia and nutrient depletion in affected sheep. The prevalence of these parasites is influenced by environmental factors, especially rainfall, which affects the availability of infective larvae in pastures (Chhabra & Mafukidze, 1992; Maharjan et al., 2006; Siddiquee et al., 2014). Infection rates tend to peak in late winter, subsequently declining in the spring and reaching their lowest levels during the summer months. Notably, different feeding practices also impact parasite prevalence, with ground feeding modes associated with higher rates of gastrointestinal parasite infections compared to high bed feeding. With this objective, a study was developed to evaluate the prevalence and diversity of gastrointestinal parasites in sheep under one year of age in Quisapincha parish, province of Tungurahua, determining their relationship with environmental and management factors, in order to generate relevant information for control and mitigation strategies to improve the health and productivity of sheep in the region.

Materials and methods

Ethical Considerations

All animal procedures were conducted in accordance with the ethical guidelines set by (St-Pierre, 2007). Fecal sampling and clinical assessments were non-invasive, and all sheep were monitored for any signs of distress. The owners of the sheep farms provided informed consent for participation in the study.

Study Area and Animal Selection

The present research was conducted in the Quisapincha Parish of the Ambato canton in the Tungurahua province, Ecuador. The canton is situated at coordinates X = 9865921, Y = 753559, with an altitude of 3670 meters above sea level. Quisapincha Parish has a population that is 70% indigenous, with agriculture being the traditional livelihood of its inhabitants. Over the past 20 years, Quisapincha has experienced the highest population growth among rural parishes in the region. The local agricultural production is largely marketed through intermediaries, which is a key part of the production chain that disadvantages farmers by resulting in low payment for their products. The communities within Quisapincha Parish include: San José de Ambayata, Cachilvana Chico, Cachilvana Grande, Calhuasig Chico, Calhuasig Grande, Chumalica, Condezán, and El Galpón.

Sample size

Since the sheep population in Quisapincha Parish and its communities is unknown, and there are no demographic data available, the sample size required for the validation of the study can be calculated using the formula for an infinite population. The formula is as follows:

$$n = \frac{Z^2 \times p \times (1-p)}{E^2}$$

$$n = 222$$

Where:
n = is the sample size
Z = is the Z-value corresponding to the desired confidence level (for example, for a 95% confidence level, Z=1.96),
p = is the estimated proportion of the population that has the characteristic of interest (in the case of parasites, it could be estimated as 50%, i.e., P = 0.5 if no prior information is available),
E = is the margin of error (commonly set to 5%, i.e., E = 0.05).

Sample recollection and laboratory analysis

The sample collection procedure was done with the animals enclosed in a funnel and, with the glove on, the sample of approximately 50 grams of faeces was taken directly from the rectum of the sheep.

The laboratory procedure starts with the preparation of the sugar solution (1.280 g) in 1 litre of purified water. In coding order, each sample is weighed about 5 g of faeces and placed in the bottles with the addition of 30 ml of saturated sugar solution. This is then filtered through the gauze (sieve) to remove fibre particles and organic matter and the filtered solution is centrifuged at 2500 rpm in the test tubes for 10 minutes. A drop of the supernatant was placed on the slide, covered to avoid bubble formation and observed under the microscope at 10 × and 40 × field of view to identify and quantify the parasites in their different stages found from the upper end to the lower end, in a straight line to shift the image slightly to the left side and start from the lower end to the upper end.

Prevalence rate

Prevalence refers to the number of existing cases of a disease and is considered a measure of disease status; it represents the proportion of individuals in a population affected by the disease (Noordzij et al., 2010).

$$Prevalence = \frac{Number\ of\ subjects\ having\ the\ disease\ at\ a\ time\ point}{Total\ number\ of\ subjects\ in\ the\ population}$$

Statistical analysis

All statistical analyses were performed using SAS version 9.1 (SAS Institute Inc., Cary, NC, USA). Demographic variables of the sampled sheep (age, sex, and breed), recorded in the field, were analyzed using descriptive statistics including measures of central tendency, dispersion, and frequency distributions with the PROC MEANS procedure.

Additionally, an analysis of molecular variance (AMOVA) was conducted using the General Linear Model (GLM) procedure to evaluate the effect of categorical factors (breed, age group, and sex) on the degree of gastrointestinal parasitism. This allowed for the identification of statistically significant differences among groups and the quantification of their relative contributions to variation in parasite burden.

Results

Figure 1 shows the data as positive (+) when at least one type of parasite was detected, and negative (—) when no parasites were observed in the 222 samples analysed in the laboratory. A high frequency of parasitic infection was identified in sheep from the communities, with a prevalence rate of 74.77% in the sampled animals. These results correspond to sheep production systems located in the rural communities of Quisapincha parish, in the Ambato canton.

International Journal of Environmental Sciences
ISSN: 2229-7359
Vol. 11 No. 16s, 2025
https://www.theaspd.com/ijes.php

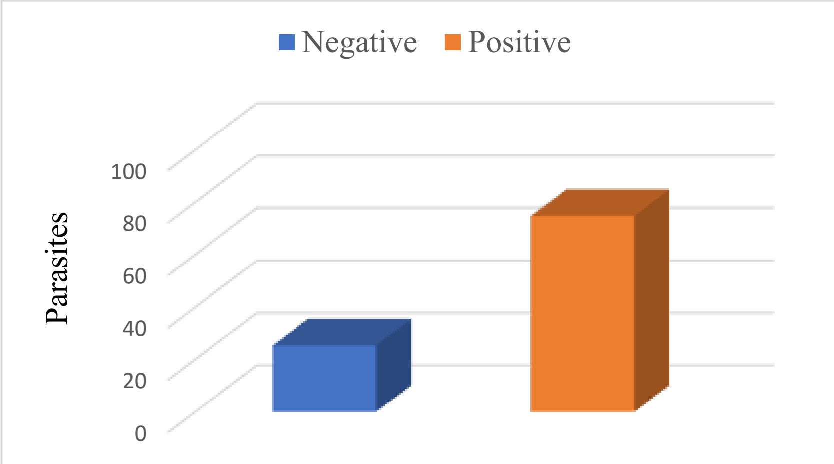

Figure 1. Presence of gastro-intestinal parasites

The qualitative analysis identifies the types of gastrointestinal parasites in the samples by direct microscopic observation by concentration. Table 1. describes the frequencies of each of the parasites recognised, with 10 types of parasites observed.

Table 1. Types of gastrointestinal parasites

Parasite Type	Frequency (%)
Strongyloides spp.	13.48%
Eimeria spp.	38.95%
Nematodirus spp.	10.49%
Trichostrongylus spp.	8.99%
Ostertagia spp.	3.00%
Haemonchus spp.	9.74%
Trichuris spp.	2.62%
Chabertia spp.	8.61%
Amoeba spp.	2.62%
Giardia spp.	1.50%
Total	**100.00%**

The prevalence rate is defined as the relative frequency of all cases of a disease occurring within a given population over a specific period of time, and it is calculated by relating the number of positive cases confirmed through laboratory results to the total number of individuals studied. The corresponding results are presented in Table 2. The prevalence rate of parasitic infections in sheep from the communities of Quisapincha was found to be 74.77%, as it indicates that nearly two-thirds of the ovine population is affected. This high prevalence may reflect poor pasture and pen management practices, as well as a lack of adherence to established deworming schedules. Although interviews and field observations revealed the presence of sanitary calendars in some enclosures, these protocols are often not followed or enforced. Furthermore, the prevalence rate by breed revealed that Creole sheep exhibited the highest parasitic burden (83.51%), followed by crossbreeds (67.65%), while Merino sheep had the lowest prevalence (24.18%). These findings are consistent with insights obtained from interviews with local farmers, who indicated that Merino sheep, often managed under technical assistance from rural development organizations, are dewormed more frequently. Crossbreeds are somewhat prioritized due to their superior phenotype and market value, whereas Creole sheep, typically undervalued in local markets, receive minimal veterinary care and are often excluded from structured health management programs.

Table 7. Prevalence Rate of Parasitic Infections in Sheep

Prevalence rate	Characteristic	Observed Value (%)
Breed	Creole	83.51%
	Crossbred	67.65%
	Merino	24.18%
Sex	Male	79.17%
	Female	71.43%
Age	1 to 6 months	76.36%
	7 to 12 months	69.84%
	Over 12 months	77.55%

Regarding the sex of the animals sampled in the present study, the average prevalence rates showed slight differences between males (79.17%) and females (71.43%). Males exhibited a higher percentage of parasitic infection compared to females. In relation to age, the present study conducted in Quisapincha–Tungurahua revealed a higher prevalence rate in adult sheep (over 12 months of age), with 77.55%, followed closely by nursing lambs and young animals (1 to 6 months) with a parasitism rate of 76.36% within their respective category. This close relationship may be attributed to the fact that young lambs remain constantly with their mothers, which could facilitate parasite transmission. In contrast, fattening sheep are managed in separate groups, reducing their exposure to certain sources of infection.

The laboratory reports also provide qualitative results indicating the level of parasite infestation (i.e., mild, +; moderate, ++ and abundant, +++; Figure 3) for each type of parasite found. In general, no parasite type has a high infestation degree (+++), while the moderate degree (++) is presented by 4 types of gastrointestinal parasites: Strongyloides spp, Eimeria spp, Trichostrongylus spp and Amoebas spp. As for the mild degree (+), they have a low presence in each sample analysed of at least one of the ten types of parasites identified.

Table 3. Type of parasite and degree of infestation

Parasite	Mild (+)	%	Moderate (++)	%	Abundant (+++)	%
Strongyloides spp.	16	44.44%	20	55.56%	0	0.00%
Eimeria spp.	34	32.69%	70	67.31%	0	0.00%
Nematodirus spp.	28	100.00%	0	0.00%	0	0.00%
Trichostrongylus spp.	16	66.67%	8	33.33%	0	0.00%
Ostertagia spp.	8	100.00%	0	0.00%	0	0.00%
Haemonchus spp.	26	100.00%	0	0.00%	0	0.00%
Trichuris spp.	7	100.00%	0	0.00%	0	0.00%
Chabertia spp.	23	100.00%	0	0.00%	0	0.00%
Amoeba spp.	3	42.86%	4	57.14%	0	0.00%
Giardia spp.	4	100.00%	0	0.00%	0	0.00%
Average	–	**78.67%**	–	**21.33%**	–	**0.00%**

The parasitological analysis revealed differential prevalence and intensity of gastrointestinal parasites among the sampled population. The most frequently identified species were Eimeria spp and Strongyloides spp. Eimeria spp was the most prevalent parasite, detected in 104 animals (representing 100% of Eimeria positive cases), with 67.31% (n = 70) exhibiting a moderate level of infection and 32.69% (n = 34) showing a mild infection. No animals showed an abundant infestation level. Strongyloides spp was also highly prevalent, found in 36 animals,

International Journal of Environmental Sciences
ISSN: 2229-7359
Vol. 11 No. 16s, 2025
https://www.theaspd.com/ijes.php

with 55.56% (n = 20) having a moderate infection and 44.44% (n = 16) a mild infection. Similarly, no cases of abundant infestation were recorded.
Other gastrointestinal parasites were detected at lower frequencies and generally at mild or moderate intensities. In this sense, Nematodirus spp, Trichostrongylus spp, Ostertagia spp, Haemonchus spp, Trichuris spp, Chabertia spp, Amebas spp, and Giardia spp were identified but in proportions below 20%, with most infestations categorized as mild. Importantly, no cases of abundant parasitic infestation were reported across all species, which may suggest a moderate parasitic burden within the population and the possible effectiveness of partial anthelmintic control or good host immune response. The dominance of Eimeria spp and Strongyloides spp indicates these genera are of significant epidemiological importance in the current management and environmental conditions.

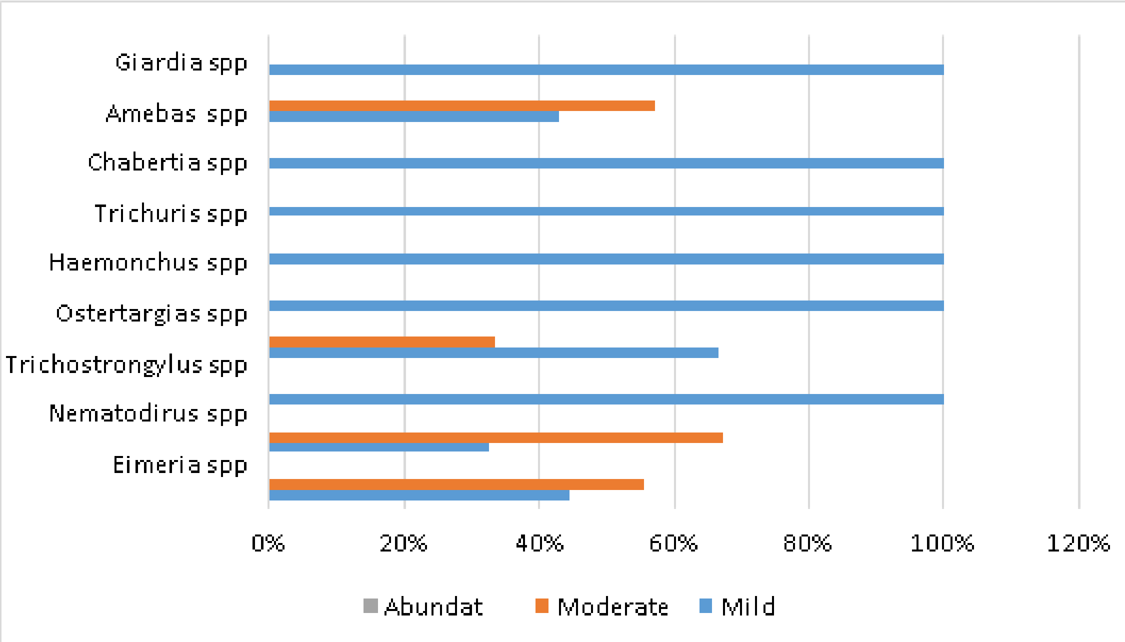

Figure 2. Extent of infestation by type of parasite

Discussion

The prevalence of gastrointestinal (GI) parasites in juvenile sheep is significantly influenced by environmental conditions, particularly rainfall patterns, temperature, and humidity. These factors affect the availability of infective larvae (L3) in pastures, which tend to peak in late winter and diminish during the warmer summer months (Roeber et al., 2013). The seasonal variations in parasite availability and infection are critical, as certain species thrive under specific climatic conditions. For instance, Nematodirus battus is particularly pathogenic in temperate regions, causing substantial disease in young lambs during the spring mass-hatching of its infective larvae (Melville et al., 2024). Among the common GI nematodes affecting sheep, the barber pole worm (Haemonchus contortus) is noted for its pathogenicity, especially in tropical and subtropical areas, leading to significant protein loss and anemia due to its blood-feeding behavior. Other significant parasites include the brown stomach worm (Teladorsagia circumcincta) and the nodular worm (Oesophagostomum columbianum), both associated with parasitic gastroenteritis in sheep. The potential for increased prevalence due to these factors raises concerns about the health implications for juvenile sheep, emphasizing the need for ongoing monitoring and management strategies to mitigate the impact of GI parasites on sheep health and productivity. In the context of Quisapincha Parish, the specific types and prevalence of GI parasites remain under-researched, but there are indications that environmental and management factors similarly affect infection rates as observed in other regions (Van Metre, 2010). The potential for increased prevalence due to these factors raises concerns about the health implications for juvenile sheep, emphasizing the need for ongoing monitoring and management strategies to mitigate the impact of GI parasites on sheep health and productivity. In this sense, the emerging threat of gastrointestinal parasites in juvenile sheep, particularly in Quisapincha Parish, Tungurahua, has significant implications for animal health and agricultural productivity. Gastrointestinal parasites, including species such as Haemonchus contortus and Nematodirus battus, pose considerable risks to the well-being of young sheep, leading to clinical symptoms like weight loss, anemia, and even death if left untreated (Hayward et al., 2022).

Gastrointestinal parasites significantly affect the health of juvenile sheep, leading to a range of clinical signs and potential economic losses in the livestock industry. Common symptoms associated with these infections include weight loss, diarrhea, anemia, and generalized weakness, which can eventually culminate in death if not treated promptly (Hoste et al., 2008). Specific signs such as pale mucous membranes, "bottle jaw (edematous swelling under the jaw), and varying degrees of lethargy are often observed (Blackburn et al., 1991). The transmission of these parasites primarily occurs through environmental exposure, with particular emphasis on the role of intermediate hosts and vectors. For instance, certain parasites are transmitted by sand flies of the Phlebotomus and Lutzomyia species, while others can spread through less common routes such as blood transfusion, transplacental transmission, and venereal contact (Vasileiou et al., 2015). This highlights the multifaceted nature of transmission and the need for comprehensive management strategies. Infected animals may also exhibit a range of nonspecific clinical signs, including fever, cough, and chronic gastrointestinal issues, which can lead to complications such as chronic kidney disease and systemic infections in immunocompromised individuals (Gorski et al., 2004).

Therefore, an Integrated Parasite Management (IPM) program combines multiple strategies to reduce parasite burdens effectively (Maqbool et al., 2017). Key components of an IPM program for sheep include regular deworming, effective pasture management, and the incorporation of both chemical and natural treatments (Clausen et al., 2015). This approach helps to delay the development of resistance among parasites by reducing selective pressure through strategies such as drug rotation and pasture rotation (Emery, 2021). For this reason, effective pasture management is crucial in controlling sheep parasites. Rotating grazing areas helps prevent overuse and reduces the sheep's exposure to parasite-infested pastures (Haenlein & Park, 2020). Additionally, allowing pastures to rest and considering mixed-species grazing can disrupt the life cycles of parasites, thereby reducing their prevalence. Continuous monitoring, including fecal egg counts, is essential for assessing treatment efficacy and adapting management strategies accordingly (Donald, 1994).

Consequently, future research should prioritize the long-term monitoring of gastrointestinal parasites in juvenile sheep to better understand their prevalence and the factors influencing their dynamics. Seasonal patterns in parasite infections have been well-documented, indicating that climatic variables significantly impact parasite development and host susceptibility (Chagas et al., 2022). Conducting longitudinal studies similar to those undertaken in wildlife populations could yield invaluable insights into how environmental changes affect parasite burdens in livestock (Hayward et al., 2022). Such studies should consider the role of anthelminthic treatments and age-related immunity, which are known to influence parasite prevalence among different demographic groups within sheep populations.

Conclusions

The study revealed a high prevalence (74.77%) of gastrointestinal parasites in juvenile sheep from Quisapincha, indicating a critical animal health concern. Eimeria spp. and Strongyloides spp. were the most prevalent taxa, particularly in Creole sheep with limited veterinary oversight. These findings highlight the urgent need for structured parasite surveillance and targeted control programs. Integrated parasite management strategies are essential to improve health outcomes and productivity in smallholder sheep systems.

References

1. Blackburn, H. D., Rocha, J. L., Figueiredo, E. P., Berne, M. E., Vieira, L. S., Cavalcante, A. R., & Rosa, J. S. (1991). Interaction of parasitism and nutrition and their effects on production and clinical parameters in goats. Veterinary Parasitology, 40(1), 99–112. https://doi.org/https://doi.org/10.1016/0304-4017(91)90086-B
2. Calderon, A., Guzman, C., Salazar-Bravo, J., Figueiredo, L. T., & Mattar, S. (2018). Viral Zoonoses That Fly with Bats: A Review. MANTER: Journal of Parasite Biodiversity. https://doi.org/10.13014/k2bg2kwf
3. Chagas, A. C. de S., Tupy, O., Dos Santos, I. B., & Esteves, S. N. (2022). Economic impact of gastrointestinal nematodes in Morada Nova sheep in Brazil. Revista Brasileira de Parasitologia Veterinaria, 31(3), 1–10. https://doi.org/10.1590/S1984-29612022044

4. Cheng, M., McCarl, B., & Fei, C. (2022). Climate Change and Livestock Production: A Literature Review. Atmosphere, 13(1). https://doi.org/10.3390/atmos13010140
5. Chhabra, R. ., & Mafukidze, R. . (1992). Prevalence of coccidia in pigs in Zimbabwe. Veterinary Parasitology, 41:1-5.
6. Clausen, J. H., Madsen, H., Van, P. T., Dalsgaard, A., & Murrell, K. D. (2015). Integrated parasite management: path to sustainable control of fishborne trematodes in aquaculture. Trends in Parasitology, 31(1), 8–15. https://doi.org/10.1016/j.pt.2014.10.005
7. De-Jongh, E. ., Harper, S. ., Yamamoto, S. ., Wright, C. ., Wilkinson, C. ., Ghosh, S., & Otto, S. J. . (2022). One Health, One Hive: A scoping review of honey bees, climate change, pollutants, and antimicrobial resistance. PLoS ONE, 17:e0242393e. https://doi.org/10.1371/journal.pone.0242393
8. Donald, A. D. (1994). Parasites, animal production and sustainable development. Veterinary Parasitology, 54(1), 27–47. https://doi.org/https://doi.org/10.1016/0304-4017(94)90082-5
9. Emery, D. L. (2021). Approaches to integrated parasite management (Ipm) for theileria orientalis with an emphasis on immunity. Pathogens, 10(9). https://doi.org/10.3390/pathogens10091153
10. Gerber, P. J., Steinfeld, H., Henderson, B., Mottet, A., Opio, C., Dijkman, J., Falcucci, A., & Tempio, G. (2013). Tackling climate change through livestock – A global assessment of emissions and mitigation opportunities. Food and Agriculture Organization of the United Nations (FAO), Rome.
11. Gorski, P., Niznikowski, R., Strzelec, E., Popielarczyk, D., Gajewska, A., & Wedrychowicz, H. (2004). Prevalence of protozoan and helminth internal parasite infections in goat and sheep flocks in Poland Prevalence of protozoan and helminth internal parasite infections in goat and sheep flocks in Poland Abstract Zusammenfassung Introduction Goats and sheep. Arch. Tierz., Dummerstor, February 2014.
12. Guamán-Rivera, S. ., Figueroa-Saavedra, H. ., Méndez Zambrano, P. ., Herrera-Feijoo, R. ., Carrillo Riofrío, F. ., Baquero Tapia, M. ., Cajamarca Carrazco, D. ., & López Paredes, C. . (2024). Animal Diseases Reported by Livestock Farmers in Orellana Province , Ecuador : A Retrospective Observational Study from 2011 to 2019. DJ Nat Sc Biol Med, 15, 535–545.
13. Haenlein, G. F. W., & Park, Y. W. (2020). Fighting the Deadly Helminthiasis without Drug Resistance. Dairy, 1(3), 177–186. https://doi.org/10.3390/dairy1030012
14. Hayward, A. D., Behnke, J. M., Childs, D. Z., Corripio-Miyar, Y., Fenton, A., Fraser, M. D., Kenyon, F., McNeilly, T. N., Pakeman, R. J., Pedersen, A. B., Pemberton, J. M., Sweeny, A. R., Wilson, K., & Pilkington, J. G. (2022). Long-term temporal trends in gastrointestinal parasite infection in wild Soay sheep. Parasitology, 149(13), 1749–1759. https://doi.org/DOI: 10.1017/S0031182022001263
15. Hoste, H., Torres-Acosta, J. F. J., & Aguilar-Caballero, A. J. (2008). Nutrition-parasite interactions in goats: Is immunoregulation involved in the control of gastrointestinal nematodes? Parasite Immunology, 30(2), 79–88. https://doi.org/10.1111/j.1365-3024.2007.00987.x
16. Joy, A., Dunshea, F. R., Leury, B. J., Clarke, I. J., Digiacomo, K., & Chauhan, S. S. (2020). Resilience of small ruminants to climate change and increased environmental temperature: A review. Animals, 10(5). https://doi.org/10.3390/ani10050867
17. Maharjan, M., Joshi, V., Joshi, D. ., & Manandhar, P. (2006). Prevalence of Salmonella Species in Various Raw Meat Samples of a Local Market in Kathmandu. Ann. N.Y. Acad. Sci, 256:249-256. https://doi.org/10.1196/annals.1373.031
18. Malik, Y. S., Singh, R. K., & Yadav, M. P. (2019). Recent advances in animal virology. In Recent Advances in Animal Virology. https://doi.org/10.1007/978-981-13-9073-9
19. Maqbool, I., Wani, Z. A., Shahardar, R. A., Allaie, I. M., & Shah, M. M. (2017). Integrated parasite management with special reference to gastro-intestinal nematodes. Journal of Parasitic Diseases, 41(1), 1–8. https://doi.org/10.1007/s12639-016-0765-6
20. Mehedi, B, H., Nahar, A., RAHMAN, A. K. M. ., & Ehsan, M. . (2020). Prevalence of gastro-intestinal parasitic infections of cats and efficacy of antiparasitics against these infections in Mymensingh sadar, Bangladesh. Bangl. J. Vet. Med, 18: 65-73.
21. Melville, L. A., Innocent, G., Dijk, J. Van, Mitchell, S., & Bartley, D. J. (2024). Refugia, climatic conditions and farm management factors as drivers of adaptation in Nematodirus battus populations. Veterinary Parasitology, 327(October 2023), 110120. https://doi.org/10.1016/j.vetpar.2024.110120
22. Mendoza, M. F., Pulido, A., Barbosa, A., & Aranda, M. (2015). Presence of gastrointestinal parasites in swine and human of four swine production farms in Cundinamarca- Colombia. Revista MVZ Cordoba, 20, 5014–5027. https://doi.org/10.21897/rmvz.15
23. Noordzij, M., Dekker, F. W., Zoccali, C., & Jager, K. J. (2010). Measures of Disease Frequency: Prevalence and Incidence. Nephron Clinical Practice, 115(1), c17–c20. https://doi.org/10.1159/000286345
24. Pinilla, J. ., Morales, E., Delgado, N. ., & Florez, A. . (2020). Prevalence and risk factors of gastrointestinal parasites in backyard pigs reared in the bucaramanga metropolitan area, Colombia. Revista Brasileira de Parasitologia Veterinaria,

29(4), 1–10. https://doi.org/10.1590/S1984-29612020094

25. Roeber, F., Jex, A. R., & Gasser, R. B. (2013). Impact of gastrointestinal parasitic nematodes of sheep, and the role of advanced molecular tools for exploring epidemiology and drug resistance - An Australian perspective. Parasites and Vectors, 6(1), 1–13. https://doi.org/10.1186/1756-3305-6-153
26. Rojas-Downing, M. M., Nejadhashemi, A. P., Harrigan, T., & Woznicki, S. A. (2017). Climate risk management climate change and livestock: impacts , adaptation, and mitigation. Climate Risk Management, 16:145-163. https://doi.org/10.1016/j.crm.2017.02.001
27. Siddiquee, N., Tripura, T., Islam, M., Bhuiyan, S., Rahman, A., & Bhuiyan, A. (2014). Prevalence of sub-clinical mastitis in high yielding crossbred cows using Draminski mastitis detector. Bangladesh Journal of Veterinary Medicine, 11(1), 37–41. https://doi.org/10.3329/bjvm.v11i1.17731
28. St-Pierre, N. R. (2007). Design and Analysis of Pen Studies in the Animal Sciences. Journal of Dairy Science. https://doi.org/10.3168/jds.2006-612
29. Tomley, F. M., & Shirley, M. W. (2009). Livestock infectious diseases and zoonoses. Philosophical Transactions of the Royal Society B: Biological Sciences, 364(1530), 2637–2642. https://doi.org/10.1098/rstb.2009.0133
30. Toulkeridis, T., Tamayo, E., Simón-Baile, D., Merizalde-Mora, M. ., Reyes -Yunga, D. ., Viera-Torres, M., & Heredia, M. (2020). Climate change according to ecuadorian academics-perceptions versus facts. Granja, 31:21-49. https://doi.org/10.17163/lgr.n31.2020.02
31. Van Metre, D. (2010). Gastrointestinal Parasites in Sheep and Goats : Frequently Asked Questions. University, Colorado State. 1(8), 8–19. https://extension.colostate.edu/topic-areas/agriculture/gastrointestinal-parasites-in-sheep-and-goats-frequently-asked-questions-8-019/
32. Vasileiou, N. G. C., Fthenakis, G. C., & Papadopoulos, E. (2015). Dissemination of parasites by animal movements in small ruminant farms. Veterinary Parasitology, 213(1), 56–60. https://doi.org/https://doi.org/10.1016/j.vetpar.2015.04.031