2025 SCIENCELINE

Online Journal of Animal and Feed Research

Volume 15, Issue 1: 15-20; January 30, 2025

ISSN 2228-7701

DOI: https://dx.doi.org/10.51227/ojafr.2025.3

SARCOCYSTOSIS IN ALPACAS AND LLAMAS: REGIONAL, MARKET, AND MUSCLE-SPECIFIC PREVALENCE PATTERNS

Edgar GARCIA-OLARTE[1], Jordan NINAHUANCA[1]✉, Wilder SUAREZ-REYNOSO[1], Yakelin MAURICIO-RAMOS[2], Maria Flores GUILLEN[1], Ide Unchupaico PAYANO[1], Armando Aquino TACZA[1], and Wilhelm Guerra CONDOR[3]

[1]*Departamento Académico de Zootecnia, Universidad Nacional del Centro del Perú, Av. M.C. 3909, Huancayo, 12000, Perú*
[2]*Laboratorio de Sanidad Animal, Universidad Nacional del Centro del Perú, Av. M.C. 3909, Huancayo, 12000, Perú*
[3]*Facultad de Ciencias de la Salud, Universidad Peruana Los Andes, Huancayo, 12002, Perú*

✉Email: jninahuanca@uncp.edu.pe

Supporting Information

RESEARCH ARTICLE

PII: S222877012500003-15

Received: April 20, 2024

Revised: January 15, 2025

Accepted: January 17, 2025

ABSTRACT: The objective of this study was to determine the effect of species (alpacas and llamas), markets in the city of Huancayo (Ferrocarril Commercial Center, Nueva Esperanza, and Nazareth), and muscle groups on the prevalence of *Sarcocystis* sp. Between January and October 2023, a total of 2,211 carcasses were inspected, comprising 1,716 alpacas and 495 llamas. The results indicated a prevalence of 21% (104/495 carcasses) in llamas and 8% (138/1,716 carcasses) in alpacas. By region of origin, the prevalence in alpacas was reported as follows: Huancavelica (7.7%) with 14/181 carcasses, Junín (6.7%) with 55/820 carcasses, and Lima (9.7%) with 69/715 carcasses. For llamas, the Lima region exhibited the highest prevalence of sarcocystosis (33.9%) with 72/212 carcasses, followed by Huancavelica (14.7%) with 14/102 carcasses, and Junín (9.8%) with 18/181 carcasses. Regarding the markets, the Ferrocarril market presented the highest risk of contamination, serving as the reference group for comparison. In contrast, the Nazareth and Nueva Esperanza markets showed significantly lower odds of *Sarcocystis* sp. presence, with Odds Ratios (ORs) of 0.38 and 0.25, respectively. For muscle groups, the anatomical distribution of *Sarcocystis* sp. cysts revealed a preferential localization in the leg (OR = 1.65) and neck (OR = 1.20) compared to the shoulder. This investigation provides significant data on the prevalence of *Sarcocystis* sp. in alpacas and llamas, highlighting a higher prevalence in llamas despite their smaller sample size. These findings emphasize the need for targeted interventions to address this parasitic infection in camelid production systems.

Keywords: Animal products, Camelids, Carcass quality, Mantaro valley, Parasite.

INTRODUCTION

Peru boasts a diverse range of climatic conditions, coupled with ample availability of natural pastures (Estremadoyro et al., 2024), which serve as the primary food source for South American camelids. These animals exhibit remarkable efficiency in converting feed, requiring only 1.5 - 2% of dry matter (DM) relative to their body weight for survival (Coleman et al., 2010). With approximately 4.3 million alpacas and 1.2 million llamas, Peru sustains a substantial population of these valuable species (Catoa et al., 2016).

Sarcocystosis is a parasitic disease caused by protozoa of the genus *Sarcocystis* sp. (Fayer et al., 2015), this protozoan belongs to the domain Protozoa, phylum Apicomplexa, class Sporozoa, suborder *Eimeriorina*, and family *Sarcocystidae* (Yang et al., 2005), which affects a wide range of intermediate hosts, including domestic and wild animals (Amalfitano et al., 2017). In camelids, particularly alpacas (*Vicugna pacos*) and llamas (*Lama glama*), this parasitosis is of growing concern due to its significant impact on meat quality (Gareh et al., 2020), food safety, and public health (Fernandez-F et al., 2022; Rodríguez et al., 2023). The life cycle of *Sarcocystis* sp., involves both definitive and intermediate hosts, with the parasite undergoing asexual reproduction in the musculature of the intermediate host (Lucas et al., 2019; Wu et al., 2022), forming cysts that can compromise meat suitability for human consumption. Definitive hosts, such as domestic and wild canids, play a crucial role in the dissemination of the parasite, perpetuating its cycle (Lindsay and Dubey, 2020). Despite the cultural and economic importance of alpacas and llamas in the Andean regions, there is limited information on the prevalence and distribution of sarcocystosis in their carcasses (Shams et al., 2022), particularly in commercial markets. Previous studies have documented prevalence rates varying widely between regions and production systems, suggesting that environmental conditions, animal management practices, and market dynamics may significantly influence the epidemiology of this disease (Valentine and Martin, 2007; Condori-Quispe et al., 2019). However, these studies often lack granular insights into the role of specific factors, such as geographic location, market practices, and anatomical distribution of cysts, which are essential for designing targeted control strategies.

This study addresses a critical gap in knowledge by evaluating the prevalence of *Sarcocystis macrocysts* in alpaca (*Vicugna pacos*) and llama (*Lama glama*) carcasses marketed in three key regions of Peru: Lima, Junín, and Huancavelica

Citation: Garcia-Olarte E, Ninahuanca J, Suarez-Reynoso W, Mauricio-Ramos Y, Guillen MF, Payano IU, Tacza AA, and Condor WG (2025). Sarcocystosis in alpacas and llamas: regional, market, and muscle-specific prevalence patterns. *Online J. Anim. Feed Res.*, 15(1): 15-20. DOI: https://dx.doi.org/10.51227/ojafr.2025.3

(Bartl et al., 2023). These regions are not only pivotal for livestock production but also showcase diverse environmental and commercial dynamics, which may influence the epidemiology of sarcocystosis (Ayala Vargas, 2018). Additionally, this research explores the association between the prevalence of *Sarcocystis* sp., and specific commercial markets, as well as the distribution of cysts across different muscle groups, providing a nuanced understanding of this parasitic disease. In recent years, the province of Huancayo has experienced a marked increase in the consumption of alpaca and llama meat (Caulfield et al., 2022). However, the scarcity of authorized slaughterhouses and suboptimal sanitary conditions in animal processing has created significant information gaps. These include limited data on the prevalence of *Sarcocystis* sp., as well as the economic losses associated with carcass seizures due to parasitic contamination.

In this context, the objective of this study was to determine the prevalence of *Sarcocystis* sp. in llama and alpaca carcasses marketed in Huancayo. Furthermore, it sought to evaluate the economic implications of carcass seizures caused by this parasitosis. The findings aim to provide valuable insights for the better management of camelid resources and to support the implementation of effective strategies for controlling this parasitic disease.

MATERIALS AND METHODS

Area study

The study was conducted in three markets located in the city of Huancayo, situated in the southern part of the Mantaro Valley at an altitude of 3,200 meters above sea level. The selected markets were Centro Comercial Ferrocarril (12°4'18.80"S, 75°12'17.47"W), Nueva Esperanza (12°4'12.28"S, 75°12'16.35"W), and Nazaret (12°4'12.94"S, 75°12'16.18"W) (Senamhi, 2023). These markets primarily offer llama and alpaca carcasses, which are sourced from various regions, including Lima, Huancavelica, and Junín. The climate of the study area is characterized by an average annual temperature of 11°C and a total annual rainfall of 625 mm. A map indicating the location of the markets is presented in Figure 1.

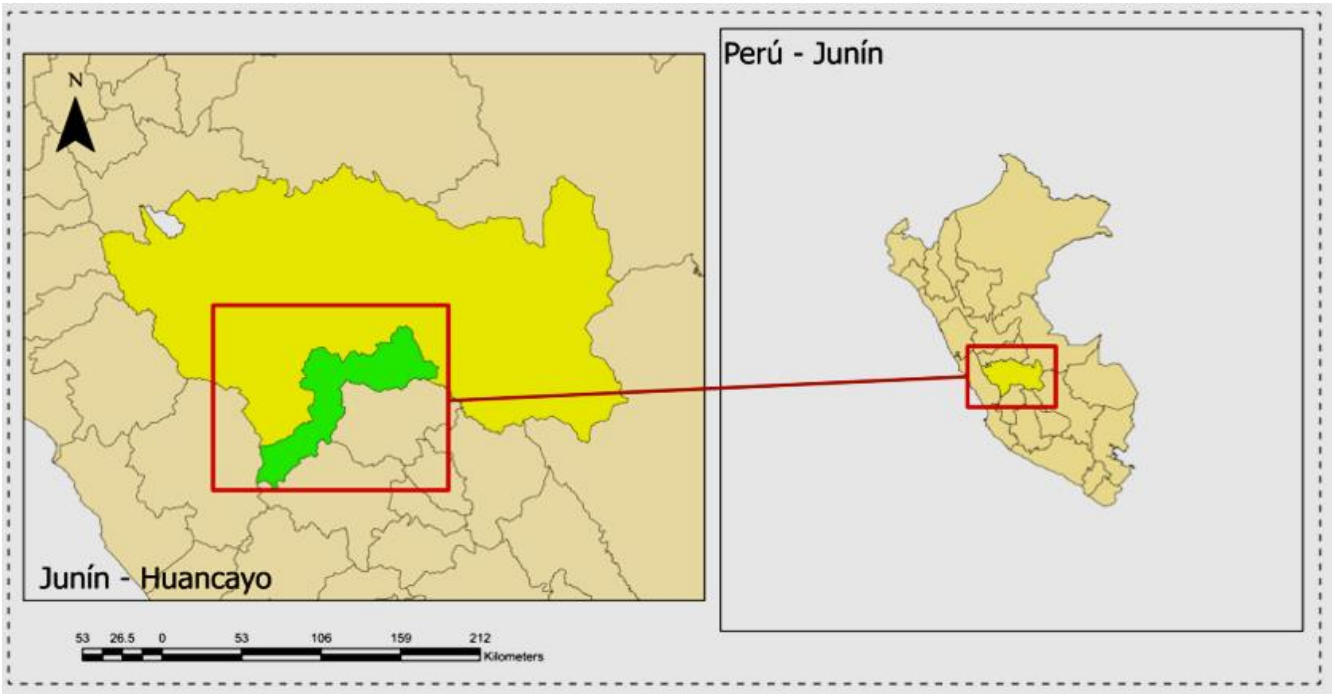

Figure 1- Location of the study

Samples

During the period from January to October 2023, a total of 2211 carcasses were collected, of which 1716 corresponded to alpacas and 495 to llamas. These were from 3 regions: Huancavelica (181/alpaca and 95/llama), Junín (820/alpaca and 108/llama), and Lima (715/alpaca and 292/llama). These carcasses from the 3 regions were received by 3 markets: Centro Comercial Ferrocarril (n = 572 alpaca, with 223, 126, and 223 for the neck, shoulder, and leg muscles, respectively; and 160 llama, with 52, 61, and 47 for the same muscles, respectively), Nazareth (n = 482 alpaca, with 154, 149, and 179 for the neck, shoulder, and leg muscles, respectively; and 182 llama, with 58, 68, and 56 for the same muscles, respectively), and Nueva Esperanza (n= 662 alpaca, with 249, 168, and 245 for the neck, shoulder, and leg muscles, respectively; and 153 llama, with 53, 52, and 48 for the same muscles, respectively). This collection was carried out in collaboration with the sanitary control personnel from the Bromatology area of the Provincial Municipality of Huancayo.

Parasitological analysis

Macroscopic examinations were conducted on the neck, shoulder, and legs of each camelid (alpacas and llamas) to assess infection rates of macroscopic cysts (Regensburger et al., 2015). The detection of cysts involved meticulous and thorough visual inspections of the carcasses, ensuring accuracy and consistency in observations (Apaza Jimenez and Chipana Mendoza, 2021). These examinations were performed in designated markets and at the processing center managed by the National Agricultural Health Service (SENASA), adhering to standardized protocols to ensure the reliability of the results.

Statistical analysis

The prevalence of macrocysts in alpacas and llamas were calculated using the equation:

$$Prevalence\ (\%) = \frac{\#\ positive\ cases}{Total\ number\ of\ individuals} x100$$

A generalized linear mixed model (GLMM) with binomial distribution was applied, with the response variable being the presence of the parasite (macrocysts). Random effect variables included Species (Alpaca and Llama), Region (Huancavelica, Junín and Lima) and arm (BRAZO), neck (CUELLO) and leg (PIERNA) muscles. Additionally, the logit function was used to calculate Odds Ratios (OR), providing a measure of association between the variables of interest. All statistical analyses and calculations were performed using Excel (Microsoft Office® v2013) and the open-source software R (Team et al., 2018), using the packages descTools, ROCR, agricolae and stats to ensure accurate and reproducible results.

RESULTS AND DISCUSSION

Table 1 presents the total number of carcasses examined per camelid. The results showed the presence of *Sarcocystis* sp. in both species, with a prevalence of 8.0% (138 carcasses) for alpacas and 21.0% (104 carcasses) for llamas. The results of this study provide valuable insights into the prevalence and distribution of *Sarcocystis* sp. in alpaca and llama carcasses, emphasizing species, regional, and market-specific differences, as well as muscle-specific predilections. These findings highlight critical epidemiological patterns and their implications for food safety and public health. Table 2 shows that the highest prevalence of sarcocystosis in alpacas was recorded in the Lima region (9.7%) with 69 out of 715 carcasses, followed by Huancavelica (7.7%) with 14 out of 181 carcasses, and Junín (6.7%) with 55 out of 820 carcasses. Similarly, concerning llamas, the Lima Region exhibited the highest prevalence of sarcocystosis (33.9%) with 72 out of 212 carcasses, followed by Huancavelica (14.7%) with 14 out of 102 carcasses, and Junín (9.8%) with 18 out of 181 carcasses. A significant difference ($p < 0.05$) in the prevalence of sarcocystosis was observed between Lima and Junín, as well as between Lima and Huancavelica in the case of alpacas. Similarly, significant differences ($p < 0.05$) in the prevalence of sarcocystosis were found between the Huancavelica region and the Lima and Junín regions in llama carcasses. It was observed that the regions of Lima are the most at-risk places for consumption. These results are similar to those reported by Castro and Leguía (1992) in Lima and by Santiago and Leguía (2018) in the Junín region. These findings highlight that, despite being recognized as prominent livestock areas, the measures implemented for the management and prevention of parasitosis have not yielded satisfactory results in terms of food safety. In this situation, it is imperative to prioritize control efforts, such as health education and implementing authorized slaughterhouses for more effective resource management, thus ensuring food safety and public health.

Table 1 - Prevalence of *Sarcocystis* sp. in alpaca and llama carcasses.

Carcasses	Total examined	Positive infected	
		N	%
Alpaca	1716	138	8.0
Llama	495	104	21.0

Table 2 - Prevalence of *Sarcocystis* sp. in alpaca and llama carcasses.

Animal	Region	Total	Infected	%
Alpaca	Huancavelica	181	14	7.7[a]
	Junin	820	55	6.7[a]
	Lima	715	69	9.7[a]
P-value				NS
Llama	Huancavelica	102	14	14.7[a]
	Junín	181	18	9.9[a]
	Lima	212	72	33.9[b]
P-value				**

Equal letters in the same column do not differ significantly ($p > 0.05$).

Table 3 - Prevalence of *Sarcocystis* sp. in alpaca and llama carcasses.

Variable		N	Odds ratio	References	P values
SPECIES	ALPACA	1716		Ref.	
	LLAMA	495		2.82 (2.06, 3.84)	<0.001
REGION	HUANCAVELICA	276		Ref.	
	JUNIN	928		1.45 (0.85, 2.52)	0.179
	LIMA	1007		3.79 (1.68, 8.69)	0.001
MARKET	FERRO	732		Ref.	
	NAZA	664		0.38 (0.22, 063)	<0.001
	NESPE	815		0.25 (0.12, 0.51)	<0.001
MUSCLES	ARM	624		Ref.	
	NECK	789		1.20 (0.81, 1.79)	0.364
	LEG	798		1.65 (1.17, 2.35)	0.005

The OR (Odds ratio) is a statistical indicator that measures the probability of an event occurring in one group compared to another (Reference).

In Table 3, the Odds Ratios (OR) are observed, with the Llama species obtaining a value of 2.82, indicating that llamas have a higher chance of the presence of *Sarcocystis* sp. macrocysts compared to Alpacas. Regarding the region, Lima shows the highest chance of reporting macrocysts, reaching an OR of 3.79. This suggests a significantly higher presence compared to other regions. The higher prevalence of *Sarcocystis sp*. in llamas (21.0%) compared to alpacas (8.0%) reflects significant differences in susceptibility between the two species. This discrepancy may be attributed to llamas' greater exposure to definitive hosts, such as domestic and wild canines, and their distinct grazing behaviors, which may increase the risk of infection (Rosenthal, 2021). Additionally, management practices, herd density, and environmental conditions likely play a role in the higher parasitic burden observed in llamas. These findings align with existing literature, which suggests that llamas are often more vulnerable to parasitic infections due to less intensive management systems compared to alpacas (Wu et al., 2022). A notable finding of this study is the significant regional disparity in the prevalence of *Sarcocystis* sp. Lima exhibited the highest prevalence among regions, with an OR of 3.79 compared to other locations, such as Junín and Huancavelica. This suggests that factors specific to Lima, including urbanization, higher population density, and suboptimal slaughterhouse conditions, may contribute to the elevated risk of contamination, an idea also shared by Rene et al. (2019). Moreover, the environmental conditions in Lima, characterized by more intensive camelid trade and market activity, likely exacerbate the exposure of animals to parasitic contamination (Raymond et al., 2020). The lower prevalence observed in Junín and Huancavelica may be explained by differences in climatic conditions, such as cooler temperatures and reduced rainfall, which may limit the survival of *Sarcocystis* sp. in the environment (Baitzel et al., 2022). The results also highlight significant differences in prevalence within regions for alpacas and llamas. For instance, Lima showed a prevalence of 9.7% in alpacas and 33.9% in llamas, compared to Junín, which had lower rates for both species. These regional variations underscore the need for tailored interventions that account for the specific epidemiological and environmental characteristics of each location (Jauregui et al., 2024).

The prevalence of *Sarcocystis* sp. also varied significantly among markets (Table 3). The Ferrocarril market showed the highest risk of contamination, serving as the reference group with which other markets were compared. Conversely, the Nazareth and Nueva Esperanza markets demonstrated significantly lower odds of *Sarcocystis* sp. presence, with ORs of 0.38 and 0.25, respectively. These differences may be attributed to variations in sourcing practices, transportation conditions, and sanitary measures implemented at each market (Fernandez-F et al., 2022; Rodríguez et al., 2023). Markets with better infrastructure and stricter quality control measures are likely to exhibit lower prevalence rates of parasitic infections (Baitzel et al., 2022). The findings suggest that market-specific factors, such as hygiene standards and meat handling protocols, play a critical role in determining the risk of contamination. The anatomical distribution of *Sarcocystis* sp. cysts revealed a preferential localization in the leg (OR = 1.65) and neck (OR = 1.20) compared to the shoulder. This finding is consistent with previous studies that report a higher prevalence of macrocysts in muscle groups with greater vascularization and proximity to infected tissues (Regensburger et al., 2015). The preferential accumulation of cysts in the leg and neck muscles may reflect physiological differences in blood flow or tissue composition, which facilitate parasite development and cyst formation (Lucas et al., 2019; Wu et al., 2022). From a practical standpoint, this information is essential for meat inspection processes, as it highlights the importance of focusing on high-risk anatomical sites during routine examinations.

CONCLUSION

The research reveals significant data on the prevalence of *Sarcocystis* sp. in alpacas and llamas, highlighting a higher presence in llamas despite their smaller number of examined samples. This finding suggests a potential risk to public

health, especially in areas like Lima, where the prevalence is notably high. The results also underscore the importance of addressing risk factors such as extreme weather conditions and commercial practices that may influence the spread of parasitosis. There is a clear need to implement effective control and resource management measures to ensure food safety and public health in these regions. These findings provide a solid foundation for future research and preventive actions in the region.

DECLARATIONS

Corresponding author

Correspondence and requests for materials should be addressed to Jordan Ninahuanca Carhuas. E-mail: jninahuanca@uncp.edu.pe; ORCID: https://orcid.org/0000-0002-0137-0631

Authors' contribution

Edgar Garcia-Olarte: Execution of the research; Jordan Ninahuanca Carhuas: Statistical analysis and editing; Wilder Suarez-Reynoso and Wilhelm Guerra Condor: laboratory analysis; Yakelin Maurico-Ramos: data collection; María Flores Guillen: macroscopic analysis of cysts; Ide Unchupaico Payano: macroscopic analysis of cysts; Armando Aquino Tacza: carcasses non-monitoring.

Acknowledgments

The authors would like to thank the staff involved, the laboratory employees.

Ethical approval

The procedures and ethics of this research work were based on the international and national guidelines for the care and use of animals in the scientific research.

Consent to publish

All authors agree to the publication of this manuscript.

Competing interests

The authors have not declared any competing interest.

REFERENCES

Amalfitano G, Petrigh R, Loos J and Fugassa M (2017). New parasites information to camelids increase the knowledge about Cerro Casa de Piedra 7 archaeological site, Santa Cruz province, Argentina. Anales del Instituto de la Patagonia. Universidad de Magallanes, pp. 101-108. https://www.cabidigitallibrary.org/doi/full/10.5555/20183079497

Apaza Jimenez YK and Chipana Mendoza GJ (2021). Types of methodologies for the diagnosis of Trichinella speralis in pork (*Sus scrofa domesticus*). Revista Estudiantil Agro-Vet 5: 49. https://agrovet.umsa.bo/index.php/AGV/article/view/61

Ayala Vargas C (2018). Sarcocistiosis (Arrocillo, Falsa triquina, Falso cisticercos, Sarcosporidiosis); Revisión literaria. Revista de Investigación e Innovación Agropecuaria y de Recursos Naturales 5(ESPECIAL): 193-206. http://www.scielo.org.bo/pdf/riiarn/v5nEspecial/v5_a21.pdf

Baitzel SI, y La Borda MP, Konecky BL, Sae-Lim J and Rivera Infante AF (2022). RETRACTED ARTICLE: Pastoral Paleoclimate Palimpsests of the South-Central Andes: High-Altitude Herder Dwellings in the 2nd Millennium ad. Journal of Field Archaeology 47(5): 341-359. https://doi.org/10.1080/00934690.2022.2072161

Bartl K, Mogrovejo P, Dueñas A and Quispe I (2023). Cradle-to-grave environmental analysis of an alpaca fiber sweater produced in Peru. Science of The Total Environment 905: 167023. https://doi.org/10.1016/j.scitotenv.2023.167023

Castro J and Leguía G (1992). Prevalence of *Sarcocystis* sp. in cattle, sheep and goats slaughtered in Lima's animal feedlots. Revista Peruana de Biología 4(1-2): 21-24. https://doi.org/10.15381/rpb.v4i1-2.8336

Catoa RM, Gallegos R, Mamani TH and García JPGJRIA (2016). Estructura Genética de la Población de Llamas (*Lama glama* del Banco de Germoplasma del Instituto Nacional de Innovación Agraria-Perú. 18(1): 55-60. http://doi.org/10.1827/ria.2016.178

Caulfield ME, Vanek SJ, Meza K, Huaraca J, Loayza JL, Palomino S, Olivera E, Ccanto R, Scurrah M and Vigil LJEA (2022). Drivers of farmer involvement in experimental forage trials in the Peruvian Andes and implications for participatory research design. 58: e39. https://doi.org/10.1017/S0014479722000357

Coleman J, Berry D, Pierce K, Brennan A and Horan B (2010). Dry matter intake and feed efficiency profiles of 3 genotypes of Holstein-Friesian within pasture-based systems of milk production. Journal of Dairy Science, 93(9): 4318-4331. https://doi.org/10.3168/jds.2009-2686

Condori-Quispe R, Loza-Murguía MG, Gutiérrez-Ramírez L and Condori-Condori C (2019). Prevalence of Sarcocystis spp. in cardiac muscle of llamas (*Lama glama*) and alpacas (*Vicugna pacos*). Journal of the Selva Andina Anima 6(2): 39-46. https://doi.org/10.36610/j.jsaas.2019.060200039

Estremadoyro LJG, Salome PH, Carhuas JN, Guzman SO, Tacza AA, Guillen MAF and Garcia-Olarte E (2024). Effects of Different Seasons on Milk Quality: A Study on Two Cattle Breeds in Rainy and Drought Contexts. World's Veterinary Journal 14(2): 213-219. https://doi.org/10.54203/scil.2024.wvj26

Fayer R, Esposito DH and Dubey JP (2015). Human infections with *Sarcocystis* species. Clinical microbiology reviews 28(2): 295-311. https://doi.org/10.1128/cmr.00113-14

Fernandez-F F, Gutiérrez-A R, Pacheco-S V, Chirinos-T J, Lombardo DM, Olivera LV, Bernabe-Ortiz JC and López-Casaperalta P (2022). Determination of Sarcocystis lamacanis microcysts in the cardiac muscle of alpacas (*Vicugna pacos*) and their correlation with troponin cTnI. A study performed in the high Andean region of southern Peru. Veterinary and Animal Science 18: 100270. https://doi.org/10.1016/j.vas.2022.100270

Gareh A, Soliman M, Saleh AA, El-Gohary FA, El-Sherbiny HM, Mohamed RH and Elmahallawy EK (2020). Epidemiological and histopathological investigation of *Sarcocystis* spp. in slaughtered dromedary camels (Camelus dromedarius) in Egypt. Veterinary Sciences 7(4): 162. https://doi.org/10.3390/vetsci7040162

Jauregui Z, Salas-Fajardo MY, Puicón V and Lucas JR (2024). Prevalence and distribution pattern of *Sarcocystis* spp. in slaughtered cattle from the Peruvian tropical Andes, Peru. Veterinary Parasitology: Regional Studies and Reports 48: 100990. https://doi.org/10.1016/j.vprsr.2024.100990

Lindsay DS and Dubey JP (2020). Neosporosis, toxoplasmosis, and sarcocystosis in ruminants: an update. Veterinary Clinics: Food Animal Practice 36(1): 205-222. https://doi.org/10.1016/j.cvfa.2019.11.004

Lucas JR, Barrios-Arpi M, Rodríguez J, Balcázarnakamatsu S, Zarria J, Namiyama G, Taniwaki N and Gonzales-Viera O (2019). Ultrastructural description of *Sarcocystis* sp. in cardiac muscle of naturally infected alpacas (*Vicugna pacos*). Iranian Journal of Parasitology 14(1): 174-179. https://doi.org/10.18502/ijpa.v14i1.733

Raymond C, Horton RM, Zscheischler J, Martius O, AghaKouchak A, Balch J, Bowen SG, Camargo SJ, Hess J and Kornhuber K (2020). Understanding and managing connected extreme events. Nature Climate Change 10(7): 611-621. https://doi.org/10.1038/s41558-020-0790-4

Regensburger CD, Gos ML, Ctibor J and Moré GA (2015). Morphological and molecular characteristics of *Sarcocystis aucheniae* isolated from meat of guanaco (*Lama guanicoe*). vailable online: https://ri.conicet.gov.ar/handle/11336/55022

Rene C-Q, Gregorio L-MM, Luis G-R and Cirilo C-C (2019). Prevalence of *Sarcocystis* spp. in cardiac muscle of llamas (*Lama glama*) and alpacas (*Vicugna pacos*). Journal of the Selva Andina Animal Science 6(2): 39–46. https://doi.org/10.36610/j.jsaas.2019.060200039.

Rodríguez A, Quispe-Solano M, Rodríguez J-L and Lucas JR (2023). The occurrence of *Sarcocystis* spp. in the myocardium of alpacas (*Vicugna pacos*) with associated risk factors in the Peruvian Andes. Tropical Animal Health and Production 55(2): 66. https://doi.org/10.1007/s11250-023-03498-3

Rosenthal BM (2021). Zoonotic *Sarcocystis*. Research in veterinary science 136: 151-157. https://doi.org/10.1016/j.rvsc.2021.02.008

Santiago B and Leguía G (2018). Prevalencia de *Sarcocystis* en alpacas (*Lama pacos*) y en perros pastores de una ganadería de la Sierra central del Perú. Biotempo 15(1): 59-62. https://doi.org/10.31381/biotempo.v15i1.1696

Senamhi (2023). Hydrometeorological Data at the national level in Peru. Datos Hidrometeorológicos a nivel nacional en Perú. Retrieved 28 de abril, 2023, from https://www.senamhi.gob.pe/?&p=estaciones

Shams M, Shamsi L, Asghari A, Motazedian MH, Mohammadi-Ghalehbin B, Omidian M, Nazari N and Sadrebazzaz A (2022). Molecular epidemiology, species distribution, and zoonotic importance of the neglected meat-borne pathogen *Sarcocystis* spp. in cattle (*Bos taurus*): a global systematic review and meta-analysis. Acta parasitologica 67(3): 1055-1072. https://doi.org/10.1007/s11686-022-00563-z

Team RC, Team MRC, Suggests M and Matrix S (2018). Package stats. The R Stats Package. https://prs.ism.ac.jp/~nakama/Rjp/stats-manual.pdf

Valentine BA and Martin JM (2007). Prevalence of neoplasia in llamas and alpacas (Oregon State University, 2001–2006). Journal of Veterinary Diagnostic Investigation 19(2): 202-204. https://doi.org/10.1177/104063870701900213

Wu Z, Sun J, Hu J, Song J, Deng S, Zhu N, Yang Y and Tao J (2022). Morphological and Molecular Characterization, and Demonstration of a Definitive Host, for *Sarcocystis* masoni from an Alpaca (*Vicugna pacos*) in China. Biology 11(7): 1016. https://doi.org/10.3390/biology11071016

Yang Z-Q, Wei C-G, Zen J-S, Song J-L, Zuo Y-X, He Y-S, and et al. (2005). A taxonomic re-appraisal of *Sarcocystis* nesbitti (Protozoa: Sarcocystidae) from the monkey Macaca fascicularis in Yunnan, PR China. Parasitology international 54(1): 75-81. https://doi.org/10.1016/j.parint.2004.12.004