J Vet Sci. 2024 Jul;25(4):e57
https://doi.org/10.4142/jvs.24086
pISSN 1229-845X·eISSN 1976-555X

Journal of Veterinary Science

Research Report
Virology

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Seroprevalence and risk factors of sheep and goat pox virus in selected districts of Wolaita Zone, Southern Ethiopia

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OPEN ACCESS

Received: Mar 18, 2024
Revised: Jun 14, 2024
Accepted: Jul 8, 2024
Published online: Jul 19, 2024

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ABSTRACT

Importance: Sheep and goat pox (SGP) virus infection is a highly fatal viral infection of small ruminants that causes major production losses in sheep and goats in Ethiopia while also limiting international trade.
Objective: This study aimed to estimate the seroprevalence of SGP infection and assess related risk variables.
Methods: A cross-sectional study was conducted from February to August 2023 on 384 serum samples taken from sheep and goats. A serum neutralization test was conducted to detect the presence of antibodies against the SGP virus in Wolaita Sodo Regional Laboratory.
Results: The overall seroprevalence rate of SGP was 4.95%. Factors such as sheep (8.26%), female sheep and goats (7.45%), older sheep and goats (8.33%), larger flock size of sheep and goats (10.47%), poorly conditioned sheep and goats (31.58%), sheep and goats with a tick on their skin (10.38%), and animals that had not been vaccinated (5.17%) were found to have higher seroprevalence. Furthermore, the seropositivity in sheep was five times greater than in goats (adjusted odds ratio [AOR], 4.73; 95% confidence interval [CI], 1.39–15.99). Additionally, large-sized flocks of sheep and goats were more likely to be seropositive to pox disease than small-sized flocks (AOR, 6.73; 95% CI, 1.58–28.67).
Conclusions and Relevance: Thus, the study revealed the prevalence of SGP in the Wolaita zone. Additional research should be conducted to estimate the extent of the disease at the regional level, and management measures should be implemented to reduce the economic losses associated with this condition.

Keywords: Ethiopia; goat pox virus; sheep pox virus; risk factors; seroprevalence

INTRODUCTION

Ethiopia is home to one of the largest populations of small ruminants worldwide with 42.9 million sheep and 52.5 million goats [1]. FAOSTAT's livestock population figures indicate that this represents around 10% of Africa's total livestock population and 4% of the global small ruminant population [2]. Despite having vast small ruminant resources, the country is unable to expand the sector due to widespread livestock diseases, a lack of an effective disease control strategy, and a lack of government attention [3,4]. After contagious caprine

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Conflict of Interest
The authors declare no conflicts of interest.

Data Availability Statement
The data will be provided upon the request of the corresponding author.

Funding
This paper was published with special support from the Korean Society of Veterinary Science.

pleuropneumonia and Peste des petits ruminants (PPR), sheep pox (SP) and goat pox (GP) are two of the most serious diseases affecting sheep and goats in Ethiopia [5]. According to a study by Gelaye et al. [6], the Capripox outbreaks in small ruminants in several locations of Ethiopia were caused by GP.

Sheep and goat pox is a fatal systemic contagious viral disease that mostly affects small ruminants. The disease's most common symptoms include broad skin eruptions, fever, generalized papules or nodules, vesicles (rarely) on non-wool skin, internal lesions in the lungs, pulmonary and gastrointestinal mucosa, and death [7]. Diseases are designated as OIE-notifiable because they play a significant role in the agricultural economy [8,9]. The disease is mainly spread by direct contact with diseased animals or through coming into contact with contaminated feces or mucous secretions [10].

The viruses that cause these illnesses belong to the capripoxvirus (CaPV) genus, *Chordopoxvirinae* subfamily, and *Poxviridae* family. The CaPV isolates are closely related genetically. The illnesses caused by SP virus, GP virus, and lumpy skin disease virus strains cannot be distinguished clinically or serologically, including with a virus neutralization test. However, significant host preferences exist, with most strains of SP virus and GP virus generating more severe disease in the homologous hosts [5].

In endemic areas, SGP viruses produce significant production losses due to lower milk yield, weight gain, higher abortion rates, wool and hide damage, increased susceptibility to pneumonia and fly bite, and direct mortality [11]. Morbidity in these susceptible flocks ranges from 75% to 100%, with mortality ranging from 10% to 85% depending on the virus's virulence [12]. The most recent small ruminant seroprevalence has been reported as 15.5% and 15.36% in the western part of the Amhara region and Afar region of Ethiopia, respectively [10,13].

Moreover, the introduction and trading of exotic sheep and goat breeds are severely hampered by SP and GP, which also makes it more difficult to import superior breeds to increase the quality of sheep and goats domestically [14,15]. Because of the diseases' direct link to mortality as well as their effects on wool and hide deterioration, reduced weight gain, increased premature birth rates, increased susceptibility to pneumonia, and fly strikes, the diseases are linked to severe production losses [16].

Despite its significant economic importance and trade concerns, statistics on pox infection seroprevalence and risk factors in the study districts, as well as the southern Ethiopian region as a whole, are scarce. A better understanding of the disease's seroprevalence and associated characteristics would lead to more effective disease control approaches. As a result, the current study aims to estimate the seroprevalence of SGP viruses and associated factors in small ruminants in selected districts of the Wolaita Zone, southern Ethiopia.

METHODS

Ethics approval and consent to participate

The best practice guidelines for veterinary care were followed and those sheep and goat owners were informed as to the purpose of the study, and that the Wolaita Sodo University of Research Ethics and Review Committee approved the protocol of the study with the reference number WSU/41/23/2241. Verbal consent was also obtained from the owners to

take samples and for further research use of the samples. The samples were collected during routine veterinary practice in adherence to a high standard of veterinary care, and after the permission of the animal owners and informed consent was obtained from owners for animal use. The authors would confirm that manipulations on animals were conducted by research animal guidelines and regulations of the School of Veterinary Medicine of Wolaita Sodo University which was in line with ARRIVE guidelines.

Study area

The study was conducted in the selected district Wolaita Zone in southern Ethiopia (**Fig. 1**). The districts were selected based on a history of SGP outbreaks, a livestock population, and a high amount of livestock exchanges via marketing with surrounding zones. The research site is at 6°54′N 37°45′E, with an elevation ranging from 1,600 to 2,100 m.a.s.l. The climate in the region is well-moderated subtropical highland, with distinct rainy summers and dry winters. The area has bimodal rainfall from March to October. The average yearly rainfall has been 1,014 mm. Temperatures vary from 17.7°C in July to 22.1°C in February and March [17].

Study animals and study design

The study animals were sheep and goats of different age groups, both sexes, and breeds, and kept under different management systems. The age category of study animals was classified as young (6 months to 1.5 years); adult (1.5 < X ≤ 2.5 years) and old age (Y > 2.5 years) based on their dentation pattern [13]. Sheep and goats older than 5 months who were reared in a large farming system were considered for seroprevalence testing. District animal husbandry departments and livestock owners were interviewed for information about Capri pox vaccination protocols.

The study included kebeles or areas that had not received Capri pox vaccine in the previous year. The districts and kebeles were chosen based on their agroclimatic zones and prior

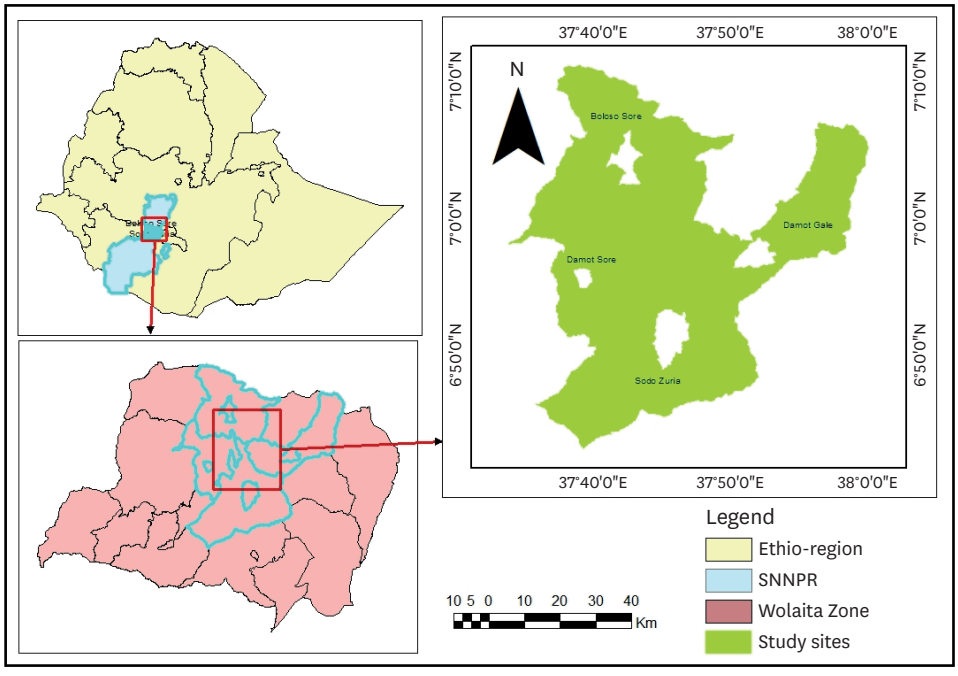

Fig. 1. Map of the study sites (ArcGIS, 2022).

https://doi.org/10.4142/jvs.24086

Capri pox vaccination records. Individual animals in selected kebeles were sampled using a systematic random sampling technique. From February to August 2023, a cross-sectional study was done to investigate the seroprevalence of the Capri pox virus and associated risk factors in a selected district of Wolaita zone, southern Ethiopia.

Sample size determination and sampling strategy

A Thrusfield [18] formula was used to establish the required sample size for the study animals, therefore 384 sheep and goat sera were collected based on a 50% expected prevalence (P), 95% confidence interval (Z), and 5% desired precision.

$$N = \frac{Z^2 \times P_{exp}(1 - P_{exp})}{d^2}$$

The kebeles in the study districts were selected in proportion to the overall small ruminant population. The number of sheep and goats collected in each research district was proportional to the size of the flock. Accordingly, a total of 384 sheep and goats from four districts were included in this study.

The study districts were purposefully chosen based on factors such as livestock population, road accessibility, a history of not having received a vaccination in the previous year, and owners' willingness to take part in the research. The districts, peasant association/kebeles, and village/flock were the first, second, and third stages selected in this study. Lastly, during sample collection, a systematic random sampling procedure was used to choose specific animals from the target population.

Sample collection, transportation, and laboratory techniques

For the seroprevalence investigation, 10 mL of blood was taken aseptically from the jugular veins of seemingly healthy animals using ordinary vacutainer tubes and transported to the Wolaita Sodo Regional Laboratory. The blood was then allowed to coagulate overnight at room temperature. The sera were separated and labeled in a separate tube. The sera were then placed into sterile cryovials, carried in an icebox, and stored at −20°C till laboratory examination was completed [19,20].

Serological test

Antibody detection against SGP infection

The serum samples were tested in the Wolaita Sodo Regional Laboratory for the presence of antibodies against sheep and goat infection using a viral neutralization test (VNT) [21]. Because the VNT cannot distinguish between SGP antibodies, the serological result is referred to as "sheep and goat pox antibody."

Associated risk factors

The associated risk factors were recorded during sampling. Individual sheep and goat owners from each district were randomly selected and interviewed to assess SGP disease-related factors such as species, sex, age, body condition score, flock size, vaccination history, and study areas. All epidemiological data was gathered for each animal.

Data management and analysis

All data collected from field and laboratory analyses was entered into a Microsoft Excel sheet 2019 and analyzed using STATA version 14. Descriptive statistics were used to determine the seroprevalence of antibodies against sheep and goat natural pox virus infection. Pox virus

infection seroprevalence was calculated by dividing the number of pox-positive animals by the total population at risk of contracting the disease. Multiple logistic regression analyses included explanatory variables with a p value ≤ 0.25 (maximum likelihood ratio test) from univariable analysis. The final multiple logistic regression models were built manually with a forward stepwise selection strategy. A variable was considered a confounder if it changed the coefficient of a significant variable by more than 25%. Kruskal gamma statistics were used to assess the predictors' multicollinearity, and variables with gamma values ranging from −0.6 to +0.6 were included in a multivariable logistic regression model. The final multivariate logistic regression models provided the odds ratio (OR) and 95% confidence interval (CI) for the factors associated with the outcome variables. A p value of less than 0.05 indicated a significant difference.

RESULTS

Seroprevalence of SGP infection

Blood samples from sheep and goats at the study sites were tested for previous exposure to SGP viruses using a VNT. Of the 384 blood serum samples examined (275 goats and 109 sheep), 19 (9 sheep and 10 goats) were positive for SGP antibodies. The total seroprevalence rate of SGP was 4.95% (95% CI, 3.17–7.64) (**Fig. 2**).

Seroprevalence and associated factors of pox infection in sheep and goats

In the current study finding, the association between seropositivity and hypothesized risk factors revealed that sheep (8.26%; 95% CI, 4.32–15.18), female sheep and goats (7.45%; 95% CI, 3.57–14.89), older age group of sheep and goats (8.33%; 95% CI, 1.05–43.71), large flock size of sheep and goats (10.47%; 95% CI, 5.50–19.00), poorly conditioned sheep and goats (31.58%; 95% CI, 18.72–48.06), sheep and goat with a tick on their skin (10.38%; 95% CI, 5.81–17.85), and those animals that have not vaccinated (5.17%; 95% CI, 3.28–8.08) were observed to have higher seroprevalence rate comparatively (**Table 1**).

Logistic regression analysis of risk factors with SGP seropositivity

Univariable logistic regression analysis of risk factors with SGP seropositivity

The univariable logistic regression analysis shows that seropositivity differs by kebeles, with Abela Zegre having higher seropositivity than the others; however, this difference is not

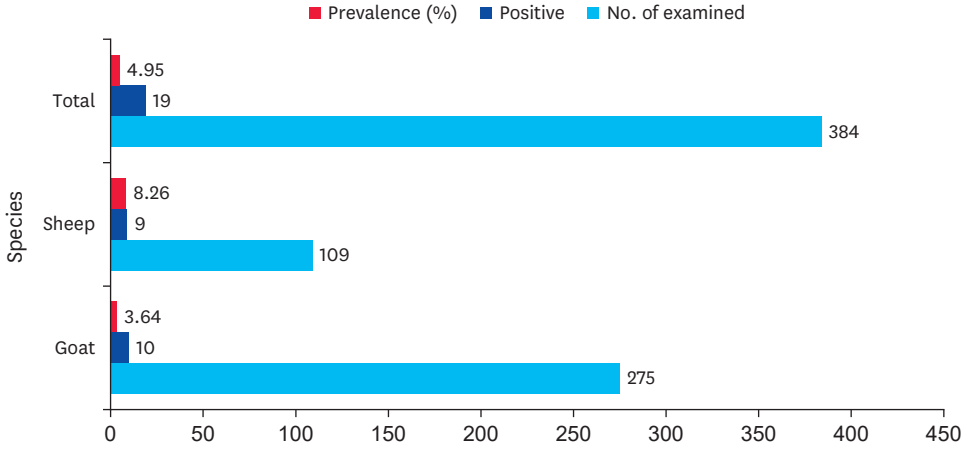

Fig. 2. Seroprevalence of sheep and goat pox infection in the study districts.

https://doi.org/10.4142/jvs.24086

Table 1. Seroprevalence of sheep and goat pox in the study area

Variables	Category	No. of examined	No. of positive	Prevalence (%)	95% CI
Species	Goat	275	10	3.64	1.96–6.64
	Sheep	109	9	8.26	4.32–15.18
Sex	Male	290	12	4.14	2.36–7.16
	Female	94	7	7.45	3.57–14.89
Age	Adult	190	8	4.21	2.11–8.22
	Old	12	1	8.33	1.05–43.71
	Young	182	10	5.49	2.97–9.94
Flock size	Large	86	9	10.47	5.50–19.00
	Medium	101	7	6.93	3.31–13.90
	Small	197	3	1.52	0.48–4.64
Body condition scores	Good	233	1	0.43	0.06–3.01
	Medium	113	6	5.31	2.39–11.38
	Poor	38	12	31.58	18.72–48.06
Presence of tick	Yes	106	11	10.38	5.81–17.85
	No	278	8	2.88	1.44–5.67
Vaccination history	Vaccinated	36	1	2.78	0.37–17.76
	Not vaccinated	348	18	5.17	3.28–8.08
Study sites	Abela Zegre	117	7	5.98	2.86–12.08
	Abela Kolishobo	108	6	5.56	2.50–11.89
	Abela Mareka	84	3	3.57	1.14–10.59
	Abela Shoya	75	3	4.0	1.28–11.79

CI, confidence interval.

Table 2. Univariable logistic regression analysis of risk factors seroprevalence of sheep and goat pox

Variables	Category	OR	95% CI	*p* value
Species	Goat	Ref	Ref	Ref
	Sheep	2.385	0.94–6.04	0.067
Sex	Male	Ref	Ref	Ref
	Female	1.86	0.71–4.88	0.205
Age	Adult	Ref	Ref	Ref
	Old	2.07	0.24–18.04	0.511
	Young	1.32	0.51–3.42	0.565
Flock size	Large	7.56	1.99–28.66	0.003
	Medium	4.82	1.21–19.04	0.025
	Small	Ref	Ref	Ref
Body condition scores	Good	Ref	Ref	Ref
	Medium	13.01	1.54–109.40	0.018
	Poor	107.08	13.38–856.98	0.0001
Presence of tick	Yes	3.91	1.53–10.01	0.004
	No	Ref	Ref	Ref
Vaccination history	Vaccinated	Ref	Ref	Ref
	Not vaccinated	1.909	0.25–14.73	0.535
Study sites	Abela Mareka	Ref	Ref	Ref
	Abela Kolishobo	1.59	0.38–6.54	0.522
	Abela Zegre	1.72	0.43–6.85	0.443
	Abela Shoya	1.12	0.22–5.75	0.887

OR, odds ratio; CI, confidence interval.

statistically significant ($p > 0.05$). Flock size, body condition scores, and tick presence were all associated with SGP seropositivity (**Table 2**).

The current study found that the seroprevalence rate of pox virus infection was 7.56 times higher in large flock size (95% CI, 1.99–28.66) and 4.82 times higher in medium flock size (95% CI, 1.21–19.04) than in small flock size, with a statistically significant difference between flock size. When the current study's pox virus infection results were compared among different body condition scores of the study animals, an increasing seroprevalence

Table 3. Multivariable logistic regression analysis of associated risk factors of pox seropositivity in sheep and goats in the study area

Variables	Category	AOR	95% CI	*p* value
Species	Goat	Ref	Ref	Ref
	Sheep	4.73	1.39–15.99	0.013
Flock size	Large	6.73	1.58–28.67	0.01
	Medium	3.74	0.83–16.77	0.085
	Small	Ref	Ref	Ref
Body condition scores	Good	Ref	Ref	Ref
	Medium	14.67	1.71–125.74	0.014
	Poor	139.19	15.89–1,218.65	0.0001
Presence of ticks	Yes	3.209	0.99–10.32	0.051
	No	Ref	Ref	Ref

AOR, adjusted odds ratio; CI, confidence interval.

trend was observed with poor ($p = 0.0001$; OR, 107.08; 95% CI, 13.38–856.98) and medium ($p = 0.018$; OR, 13.01; 95% CI, 1.54–109.40) conditioned sheep and goats. The difference in body condition score and seropositivity of SGP was statistically significant (**Table 2**).

Multivariable logistic regression analysis of risk factors with SGP seropositivity

Consequently, among the related risk factors considered, species, body condition score, sex, and flock size were then fitted to the final multivariable logistic regression model ($p \leq 0.25$) to check the true significant association of these associated risk factors without confounding effect on the others with an adjusted odds ratio (AOR), and thus, species, body condition score, and flock size were identified as associated factors for the occurrence of SGP infection (**Table 3**).

Furthermore, sheep had 4.73 times the probability of seropositivity as goats ($p = 0.013$; 95% CI, 1.39–15.99). Likewise, large-sized flocks of sheep and goats were seven times more likely to be seropositive to pox disease than small-sized flocks (AOR, 6.73; 95% CI, 1.58–28.67), which means the study population that was found in large flock size was seven times more likely to develop pox virus infection as shown in **Table 3**. Besides, the Hosmer-Lemeshow goodness-of-fit test suggested that the model fit the data ($\chi^2 = 81.52$; $p = 0.1847$) and multicollinearity was found not to violate the assumption (AUC = 90.35%) (**Fig. 3**).

DISCUSSION

In Ethiopia, SGP viruses cause major production losses in their respective endemic regions. The diseases stymie international trade and have significant fiscal implications. The World Organization for Animal Health classifies pox infection as a notifiable disease due to its rapid transboundary spread and significant financial impact on the livestock sector [18,19,22,23]. SGP is a highly contagious viral virus that hinders sheep and goat production and productivity in Ethiopia. SGP was identified in almost many regions of Ethiopia [7,14,19,20].

The current study found that the disease is common and circulating in the study areas, with an overall seroprevalence rate of 4.95%, with 8.26% of sheep and 3.64% of goats exposed to pox virus infection. However, this finding disagreed with which indicated 15.5% in the western Amhara region [10], and which indicated 15.36% in the Afar region, Ethiopia [13]. Similarly, the findings study was lower than which reported 63.55% in Sudan [24] and which reported 17.24% in Pakistan [25]. Several study findings imply that regional differences in seroprevalence may be caused by changes in animal mobility and the introduction of new

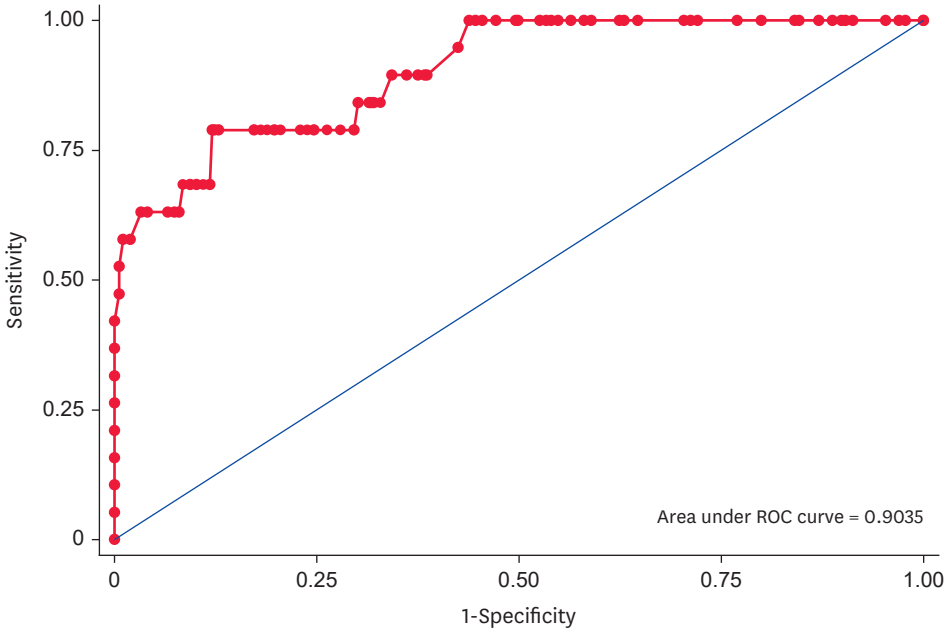

Fig. 3. Multicollinearity test.
ROC, receiver operating characteristic.

diseased animals into the flock [13].

Clinical signs of sheep and goats include nodules and papules on various thin or hairless regions of the body. These clinical results were consistent with those reported in Algeria [26] and in India [9,12,27].

Abela Zegre kebele had the greatest seroprevalence rate of SGP (5.98%), which could be ascribed to a lack of strategic vaccinations. The variation in seroprevalence by location could be due to differences in animal mobility and the introduction of additional animals (potentially infected) [19,28]. Besides, a researcher inquired about information regarding the annual vaccination practices in the studied kebele from relevant stakeholders like veterinary professionals of districts, and zonal head offices and they reported the absence of sheep and goat vaccination practices.

In Ethiopia, a live attenuated SPPV Kenya O-180 vaccine strain (KS1-O180) is used to immunize small ruminants against SGP, as well as cattle against lumpy skin diseases. It is considered that sheep and goats who have been naturally infected with SGP viruses and recovered from the sickness are protected for the rest of their lives [27]. However, there have been repeated reports of the vaccine providing poor protection against the lumpy skin disease virus in Ethiopia. This vaccination failure was most likely driven by inadequate vaccine handling in areas where energy supply is limited for maintaining the cold chain [19]. Furthermore, due to the warm climate, biting flies (*Stomoxys* species) were present in this kebele, which is consistent with [11,16,25,29], who said that vectors with large mouthparts and frequent feeding habits are the key variables favoring mechanical transmission.

Furthermore, due to the kebele's or study sites' geographical location, there are different uncontrolled sheep and goat movements by local merchants from surrounding markets, extensive grazing and movement patterns of sheep and goat in the kebele and between

markets (animals are transported from different districts of the Wolaita zone and adjacent zones (Gamo Gofa) to Humbo market; which involves uncontrolled movements; leads to cross-contamination), and local trading of infected sheep and goats between the kebeles. This study agreed with previous studies—Achour and Bouguedour [26] stated that the spread of Capri pox virus into new areas is primarily associated with an increase in unrestricted animal movement through trade; Singh et al. [27] and Babiuk et al. [30] stated that insufficient quarantine measures and cross-border trade of live animals may contribute to disease spread.

The lowest morbidity and mortality in sheep and goats in Abela Mareka kebele may be attributed to targeted vaccinations with both live attenuated vaccine strains and combined SGP and PPR vaccines for both sheep and goats than other kebeles.

The current study revealed a morbidity of 3.64% in goats, which is lower than previously published values of 12.88% in goats and 8.26% in sheep in Ethiopia's Adama area [31]; 12.9% in goats and 9.5% in sheep in Ethiopia's Dibate districts, Benishangul Gumuz regional state [32]. This could be attributed to the unrestricted grazing and watering of sheep and goats, as well as their free movement by uncontrolled local traders [33]. Traditional animal husbandry approaches increase disease transmission. However, the current seroprevalence level was lower than that reported by Molla et al. [34] in sheep and goats in the Gamo Gofa zone, Southwestern Ethiopia and by Elshafie and Ali [24] in sheep in Sudan. This could be because animals vaccinated in endemic areas develop lifelong immunity. Sheep and goats in endemic areas were more resistant because of previous illnesses or vaccinations [33,35-38].

This study also found lower morbidity and mortality in goats than previously reported by Babiuk et al. [36], with a morbidity of 60% and a mortality rate of 45%. Because European sheep and goat breeds are highly susceptible to Capri pox virus, and wildlife can infect domestic sheep and goat populations, mortality in the study areas could be 100% when compared to local Dangela, Washera, and Farta sheep and Gumuz, Agew, and Begia-Medir goats [29,35].

A multivariate logistic regression analysis model revealed that body condition scores (p = 0.0001), species (p = 0.013), and flock size (p = 0.01) were all significantly associated with diseases. The seroprevalence rate of pox infection was 3.64% in goats and 8.26% in sheep and it was statistically significant, showing that sheep are more prone to contracting pox virus infection than goats' animals. The odds of having pox infection seropositivity in sheep were five times higher than in goats (OR, 4.73; 95% CI, 1.39–15.99%). This finding contrasted previous research [36]. According to Assefa et al. [38], a statistically significant difference in pox virus was observed between sheep and goats. Assefa and colleagues stated that the disease is more important in sheep due to genetic differences, which contradicts they stated that Capri pox virus is not host-specific and the majority of strains cause disease in both sheep and goats.

The seroprevalence rate of SGP in different age groups revealed that old animals (8.33%) were more likely to be seropositive than young and adult animals, but this difference was not statistically significant (p > 0.05). Lower immunity in old female sheep and goats due to the lambing/kidding period or a depleted physiological state may also contribute to increased seroprevalence in these species, as maternal immunity only lasts up to 3 months. However, this was disagreed with Domenech et al. [29], who reported that recovered animals developed lifetime immunity and immunological conditions.

According to the current study's findings, flock size had a significant impact on the seroprevalence rate of SGP infections. In this study, multivariable logistic regression analysis revealed that flock size seropositivity to pox virus infection was statistically significant (p = 0.01), implying that large flocks of sheep and goats were seven times more likely to develop pox infection when all other factors were held constant (OR, 6.73; 95% CI, 1.58–28.67%). This direct link may indicate the disease's infectious nature and mechanism of transmission, which is attributed to the animal densely population, which may increase the frequency of direct contact and thus the risk of transmission. In general, the current study revealed that the disease rate was higher (OR, 3.74; 95% CI, 0.83–16.77) and p value 0.085 when the flock size increased from 86 to 101 and 6.73 times higher (OR, 6.73; 95% CI, 1.58–28.67) and p = 0.01 when the flock size was greater than 101 individual animals, which is consistent with previous reports [30], which revealed that large flock size and flocking of sheep and goats together predispose to Capri pox virus.

According to the current study findings, the seroprevalence rate of SGP infection was also considerably affected by body conditions score. Moreover, multivariable logistic regression analysis revealed that body condition score and seropositivity of pox virus infection were statistically significant (p = 0.0001), which implies poor body conditioned sheep and goats were 140 times more likely to develop pox infection than counterparts (OR, 139.19; 95% CI, 15.89–1,218.65). Furthermore, medium-body conditioned animals were 15 times more likely to be affected than good body conditions (OR, 14.67; 95% CI, 1.71–125.74). This direct association could indicate the disease's infectious nature and transmission mechanism, which are linked to malnourished animals and may enhance the frequency of direct contact, hence promoting disease development. Without ticks and vaccines, diseases were more likely to occur. Thus, the absence of tick management and sheep and goat vaccinations was suggested to be contributory factors to the pox virus outbreak [39].

These findings indicated that Capri pox virus affected both sexes equally, however, female sheep and goats had more severe illnesses. Female sheep and goats may have a poorer immune system during pregnancy and lactation compared to male sheep and goats [30].

The current study's multivariate regression analysis found no statistically significant variation in seropositivity among the sample kebeles. This could be because pox virus infection is chronic and uniformly distributed in the research sites, implying that pox virus infection is widespread in these districts. Additionally, the research areas may have similar agroecological settings. It is crucial to emphasize that, due to the relatively small sample size, risk factor analyses may lack sufficient power to identify differences between risk factors. Thus, these findings must be interpreted with caution.

In this study, we did not perform molecular characterizations of SGP, which would have provided a better clue in further explaining the SGP virus circulating in the area and aided in the development of vaccines for disease prevention and control. However, our findings provide insights into SGP occurrences in the research area and alert concerned stakeholders to the disease's impact.

In conclusion, this study found that the SGP is prevalent in the study area, and resulted in severe morbidity and mortality. The uncontrolled mobility of animals with diseases, and a lack of strategic vaccinations, may contribute to its spread. Only species, body condition score, and flock size were found to be statistically significant risk factors for SGP virus

seropositivity. Thus, prevention and control measures, and surveillance procedures, should be implemented. Furthermore, it is strongly urged that when animal mobility is uncontrolled, annual mass vaccination is recommended as the most practicable, cheap, and realistic method of controlling SGP. In addition, detailed investigations into the prevalence of diseases, epidemiology of disease outbreaks, CaPV host specificity, and molecular characterizations were recommended.

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