RESEARCH ARTICLE

Haemato-Epidemiological Study of Peste des Petits Ruminants in Goats

Mayank A. Patel[1], Sudhir A. Mehta[1]*, Manish D. Patel[1], Saurabh M. Parmar[2], Rajesh J. Bhojani[1], Shruti D. Bhoya[1]

Abstract

The study, conducted from January to September 2024 at the Veterinary Clinical Complex, Kamdhenu University, Navsari, investigated peste des petits ruminants (PPR) in goats, with a 6.38% (29/454) overall incidence, and 40.27% (29/72) hospital-based incidence among suspected cases. Twenty-nine goats out of 454 were confirmed positive using rapid antigen diagnostic test or c-ELISA and s-ELISA. Non-descript breeds exhibited the highest incidence (58.62%), followed by Surti (20.68%), Sojat (10.34%), Phantom (6.89%), and Sirohi (3.44%) breeds. Male goats (75.86%) and those aged 1-2 years (55.17%) were predominantly affected. Seasonal trends showed a peak incidence during the monsoon (41.38% in June), with significant influence of age, breed, and sex on disease occurrence. Haematological evaluation revealed macrocytic hypochromic anaemia with elevated mean corpuscular volume and reduced mean corpuscular haemoglobin concentration. Other notable findings included thrombocytopenia, leukopenia, lymphopenia and increase in neutrophil and eosinophil counts, alongside moderate reductions in haemoglobin, total erythrocyte count and packed cell volume in 29 PPR affected goats as compared to 6 healthy control goats.

Keywords: Anaemia, Goat, Leukopenia, PCV, PPR, Prevalence.

Ind J Vet Sci and Biotech (2025): 10.48165/ijvsbt.21.3.19

Introduction

Goats are highly susceptible to various viral diseases, which can significantly impact their growth and productivity (Nath *et al.,* 2014). As a low-cost, resource-efficient livestock option, they are widely reared by marginal farmers and landless labourers who rely on them for meat and milk production. Often referred to as the "poor man's cow" and regarded as an "Any Time Money-ATM," goat farming supports the socioeconomic development of rural families due to its versatility in providing meat, milk, and fibre (Sapcota *et al.,* 2017). Despite being a valuable asset that enhances the financial stability of farmers, the burden of diseases, morbidity, and mortality often results in substantial economic losses.

Peste des petits ruminants (PPR) is a highly contagious transboundary viral disease primarily affecting sheep and goats. This OIE (Office International des Epizooties) notifiable disease is characterized by its acute nature and significant economic impact due to high morbidity and mortality rates (Diallo *et al.,* 2007). Infected goat herds have reported morbidity and mortality rates of 100% and 80-90%, respectively, resulting in substantial financial losses. Globally, the annual economic impact is estimated to range from US$ 1.4 billion to US$ 2.1 billion. In India, the projected economic burden due to morbidity, mortality, productivity losses, and trade restrictions is approximately INR 1,800 million (US$ 39 million) (Govindaraj *et al.,* 2016), highlighting the significant financial implications of disease outbreaks (Balamurugan *et al.,* 2014). This communication reports on haemato-epidemiological study of peste des petits ruminants in goats in and around Navsari district in Gujarat.

[1]Department of Veterinary Medicine, College of Veterinary Science and Animal Husbandry, Kamdhenu University, Navsari-396450,Gujarat, India

[2]Department of Veterinary Clinical Complex, College of Veterinary Science and Animal Husbandry, Kamdhenu University, Navsari-396450, Gujarat, India

***Corresponding author**: Dr. S.A. Mehta, Assistant Professor, Department of Veterinary Medicine, College of Veterinary Science and AH, Kamdhenu University, Navsari-396450, Gujarat, India, E-mail: samehta@kamdhenuuni.edu.in; ivetmayank08@gmail.com

How to cite this article: Patel, M. A., Mehta, S. A., Patel, M. D., Parmar, S. M., Bhojani, R. J., & Bhoya, S. D. (2025). Haemato-Epidemiological Study of Peste des Petits Ruminants in Goats. Ind J Vet Sci and Biotech, 21(3), 95-99.

Source of support: Nil

Conflict of interest: The author(s) declare that there is no conflict of interest.

Submitted 01/02/2025 **Accepted** 28/02/2025 **Published** 10/05/2025

Materials and Methods

Selection Criteria

A total of 454 goats were presented at Veterinary Clinical Complex (VCC), under the Veterinary Medicine, Veterinary College, Kamdhenu University, Navsari (Gujarat, India) during February to September 2024. Of these 72 goats showed clinical signs of pyrexia (>103.5°F), necrotic stomatitis, enteritis, catarrhal inflammation of nasal and ocular mucosa, open mouth breathing etc. that were preliminary suspected for PPRV infection and further subjected for detailed clinico-diagnostic examinations. Besides, six apparently healthy goats were included as a healthy control from the AICRP

goat unit, Livestock Research Station, Kamdhenu University, Navsari.

Sample Collection

Nasal swabs for rapid antigen detection test and viral identification (n=72), blood samples (n=72) for haematology and serum samples for analysis of oxidative stress index as well as serological confirmation of PPR virus were collected from goats presented at VCC, Navsari.

Diagnosis through Rapid Antigen Test Kit and Sandwich ELISA (s-ELISA)

The immuno-chromatographic assay provides a direct field-based method for the detection of Peste des Petits Ruminants Virus (PPRV) antigen across all four lineages using swab samples. It is a pen-side test based on reagents. The nasal swabs of 25 suspected goats were screened through ID Rapid® PPR Antigen Test Kit (FAO/OIE reference laboratory, CIRAD, France).

All the collected samples including nasal swabs, whole blood and serum samples were sent to NIVEDI, Bengaluru for detection of PPR virus by Sandwich ELISA (s-ELISA) method.

Statistical Analysis

The data was suitably tabulated and analysed using IBM SPSS Statistics, Version 27.0, following standard statistical methods. Descriptive statistics were employed to calculate Means ± SEs, and an independent sample t-test to compare means of various parameters between two groups of goats. Further, risk ratios of transportation and system influence in occurrence of PPR were analysed using MedCalc Statistical Software. Above all the calculations were determined at the 5% ($p \leq 0.05$) significance level.

Results and Discussion

The overall incidence of peste des petits ruminants (PPR) was 6.38% (29/454), while the hospital-based incidence among suspected cases was 40.27% (29/72).

Breed-wise Incidence

The incidence of PPR found in different breeds is presented in Table 1. Among 29 PPR-positive goats, the highest incidence was observed in non-descript breeds (58.62%), followed by Surti (20.68%), Sojat (10.34%), Phantom (6.89%) and Sirohi (3.44%). The significant differences in susceptibility to peste des petits ruminants (PPR) found among goat breeds might be attributed to more sample size of specific breed presented in study and geographical diversity. Additionally, the innate and adaptive immune responses differ across breeds, impacting their morbidity and mortality rates during outbreaks.

Management practices also play a critical role; goats raised in traditional systems may face higher exposure to the virus, while environmental factors, such as nutrition and climate, can further influence their health. Moreover, breeds with historical exposure to PPR may develop a level of herd immunity that makes them more resilient (Ahaduzzaman, 2020). Our findings of higher incidence in ND breed corroborated with Chauhan *et al*. (2012), but were in contrast to Chitradevi *et al*. (2021), who recorded maximum occurrence in Jamunapari breed. While, Sarker and Islam (2012), Rahman *et al*. (2016) and Shahabuddin *et al*. (2017) reported a higher incidence in Black Bengal breed.

Table 1: Breed wise incidence among the affected cases of PPR in goats

Breeds	No. of positive goatsa	Percentage	χ^2 value	p value
Non-descript	17	58.62	12.25	0.01*
Surti	06	20.68		
Sojat	03	10.34		
Phantom	02	06.89		
Sirohi	01	03.44		
Total	**29**	--		

*p≤0.01, highly significant between breeds

Sex-wise Incidence

The sex-wise incidence of PPR was significantly higher in male (82.75%, 24/29) than in female (17.24%, 5/29). Similar findings were noted by Thakor *et al*. (2016), Shahabuddin *et al*. (2017) and Sakhare *et al*. (2019), but in contrast to this, Mahajan *et al*. (2012), Nizamani *et al*. (2015) and Rath *et al*. (2020) found higher incidence in female goats. Moreover, Afera *et al*. (2014) found non-significant differences between male and female goats. It is hypothesized that a higher number of male goats presented to the clinic during the study period, coinciding with an increased demand for males during the festive season, resulted in higher incidence of PPR in males. Additionally, male goats may exhibit a greater susceptibility to PPR infection compared to females, potentially due to genetic predisposition (Sarker and Islam, 2011).

Age-wise Incidence

The incidence of PPR in the different age groups presented in Table 2 varied highly significantly. Among 29 positive goats, the highest incidence was observed in 1-2-years old goats (55.17%), followed by 6-12 month (31.03%). The lowest cases were found in goats aged less than 6 months (10.34%) and more than 2 years (3.44%) of age.

Table 2: Age wise incidence among the affected cases of PPR in goats

Age	No. of positive goats	Percentage	χ^2 value	p value
<6 month	3	10.34	18.86	0.00*
6-12 month	9	31.03		
1-2 year	16	55.17		
>2 year	1	03.44		

*p ≤0.01, highly significant between the age groups

The findings were closer to those reported by Bello *et al*. (2016) and Sakhare *et al*. (2019), who found higher incidences of PPR in middle age groups of 1-2 years. In contrast to this study, Mahajan *et al*. (2012), Thakor *et al*. (2016), Shahabuddin

et al. (2017) and Rath *et al*. (2020) found the highest incidence in less than 1 year of age. However, Chauhan *et al*. (2012), Nizamani *et al*. (2015) and Rahman *et al*. (2016) found higher incidence in more than 2 years aged goats. Mature animals are more likely to test seropositive for PPR than younger animals, possibly due to factors such as poor nutrition and a higher burden of parasitic infections from frequent grazing in contaminated pastures alongside other animals (Sarker and Islam, 2011; Munibullah *et al*., 2022).

Month-wise Incidence

Based on the data from January to September (Spring, Summer and Monsoon seasons), the prevalence of PPR in the goat population differed non-significantly across months (Table 3). The occurrence of PPR remained low in the spring season (February to March) with a prevalence of 6.90% in February and 3.45% in March. As the summer season progressed (April to May), infection rates gradually increased, reaching 17.24% in May. The highest incidence observed during the monsoon season (June to September), particularly 41.38% in June followed by 24.14% in July. Tajpara *et al*. (2021) also found similar non-significant outcome for months/ seasons.

Parvez *et al*. (2014) also recorded higher incidence in monsoon season. In contrary, Thakor *et al*. (2016) and Shahabuddin *et al*. (2017) found more incidences in winter season. High incidence in monsoon might be due to seasonal shift, high humidity (Shahabuddin *et al*., 2017) and different geographical region of study period (Parvez *et al*., 2014). The incidence of PPRV infection has been linked to seasonal shifts, such as the onset of the rainy season or cold, dry periods. Therefore, it could be concluded that seasonal variation appears to play a significant role in PPR occurrence in goats.

Table 3: Month-wise incidence among the affected cases of PPR in goats

Months	Total case	No. positive	%	χ^2 value	p value
January	04	00	00.00	8.84	0.36
February	02	02	06.90		
March	06	01	03.45		
April	13	01	03.45		
May	12	05	17.24		
June	17	12	41.38		
July	15	07	24.14		
August	02	01	03.45		
September	01	00	00.00		
Total	**72**	**29**	--		

Non-significant at p>0.05

Haematological Alterations in PPRV Affected Goats

The means ± SEs of haemoglobin (Hb), total erythrocyte count (TEC) and packed cell volume (PCV) in goats affected with Peste des Petits Ruminants virus (PPRV) and healthy control group did not differ significantly on the day of presentation. These results suggested that all the goats were presented with acute phase of infection with minor alteration in haematology. However, the platelet count in PPRV-affected goats (338.14 ± 31.59 × 10^3/µL) was significantly decreased ($p \leq 0.01$) compared to healthy control goats (566.67 ± 92.43 × 10^3/µL). Similarly, the total leukocyte count (TLC) was also significantly reduced in PPRV-affected goats compared to healthy controls (Table 4). Chukwudi *et al*. (2021) and Al Saad (2023) also reported leukopenia in their studies.

In differential leukocyte count, the neutrophils and eosinophils were significantly ($p \leq 0.01$) increased, while lymphocytes were decreased ($p \leq 0.01$) in PPRV-affected goats compared to healthy controls. Monocytes however showed a non-significant increase between two groups. The mean ± SE values of MCV, MCH and MCHC (Table 4) revealed a significant increased MCV and decreased MCHC values in the PPR affected goats. Morphologically it could be classified as a macrocytic and hypochromic anaemia and such type of anaemia usually is observed in immune mediated RBC losses and recovery following haemorrhages due to endothelial injury, which is also a consistent finding of PPR (Brar *et al*., 2019).

Leukopenia observed in the present study could be attributed to the lymphotropic activity of the PPR virus as the virus has an affinity for the lymphoid organ and replicates within lymphoid organs, causing extensive necrosis of lymphocytes. This destruction leads to a significant reduction in the number of circulating leukocytes counts. Further, the variability in these parameters among reports may be associated with presentation of goats in various stages of PPR (acute, sub-clinical and chronic). Decreased WBCs lead to marked immuno-suppression of the host immunity, which might promote the establishment and aggravates the course or severity of secondary bacterial infection or other underlying diseases. Thus, this complicates the management of the disease (Chukwudi *et al*., 2021). Additionally, PPRV can cause myelosuppression, impairing the bone marrow's capacity to generate new blood cells, which intensifies leukopenia (Bamouh *et al*., 2019).

Table 4: Haematological parameters of PPR affected and healthy control groups of goats

Parameter	Healthy group (n=6)	Affected group (n=29)	p value
Hb (g/dL)	10.42±0.53	10.01±0.26	0.53
TEC (10^6/µL)	12.48±0.31	11.88±0.21	0.23
PCV (%)	33.68±1.33	35.02±0.75	0.45
Platelets (10^3/µL)	566.67±92.43	338.14±31.59**	0.00
TLC (cells/µL)	8650±581.23	4538±372.66**	0.00
Neutrophils (%)	30.67±1.68	63.76±1.83**	0.00
Lymphocytes (%)	65.50±1.61	30.41±1.77**	0.00
Monocytes (%)	02.67±0.21	03.24±0.15	0.11
Eosinophils (%)	01.17±0.16	02.59±0.18**	0.00
MCV (fL)	27.04±1.20	29.14±0.45*	0.03
MCH (pg)	08.36±0.44	8.42±0.14	0.87
MCHC (g/dL)	30.92±0.84	28.56±0.38*	0.01

*p≤ 0.05, **p ≤0.01 between groups

Relative Risk of Transportation in the Occurrence of PPR in Goats

In this study, transportation history was analysed for its association with the risk of PPR occurrence, with relative risk ratios calculated to compare recently transported and non-transported goats among the 72 suspected ones. As shown in Table 5, the incidence of PPR was significantly higher ($p \leq 0.05$) in transported goats, with a relative risk >1, indicating greater susceptibility to PPRV infection following transportation. Similar findings were reported by Hussain (2021), who highlighted the role of animal movement in exacerbating PPR prevalence and it also corroborated with Mahajan *et al*. (2012) and Ishag *et al*. (2023). Post-transportation, inflammatory responses in the respiratory tract, characterized by oxidative stress, mucus hypersecretion, vascular barrier dysfunction and bronchial wall edema, likely exacerbate infection risks (Santus *et al*., 2014; Zheng *et al*., 2021). In India, long-distance travel during lean periods, compounded by nutritional deficits, increases the stress and susceptibility to infections, facilitating the spread of PPR along migration routes. This vulnerability, particularly in nutritionally compromised animals, has been documented by Singh *et al*. (2004) and Balamurugan *et al*. (2012), further associating transportation with heightened PPR outbreaks.

Table 5: Relative risk of transportation in the occurrence of PPR in goats

Particulars	(n=72)	Affected animals	%	p value	Relative risk
Recently Transported	27	Positive 17** Negative 10	62.96	0.00	2.36
Non-transported	45	Positive 12 Negative 33	26.66		

**$p \leq 0.01$ highly significant

Table 6: Influence of systemic involvement in the occurrence of PPR in goats

Particulars	Suspected goats	PPR positive goats	Percent
RTI	08	01	12.50
Enteritis	13	03	23.07
Both	51	25	49.02
Total	**72**	**29**	**--**

Influence of Systemic Involvement in the Occurrence of PPR in Goats

Table 6 outlines the occurrence of PPR among suspected goats categorized by the affected system: respiratory tract infections (RTI), enteritis, or a combination of both. Out of 72 suspected cases, 12.50% (1/8) with respiratory symptoms and 23.07% (3/13) with enteric symptoms were confirmed positive for PPRV. Notably, 49.02% (25/51) of goats exhibiting both respiratory and enteric symptoms tested positive, highlighting a higher prevalence in cases with combined clinical manifestations.

The association between systemic involvement and PPR occurrence in goats was examined based on the calculated relative risk (RR 2.57). Goats with both respiratory and enteric symptoms (n=51) were compared to those with either respiratory tract infections (RTI) or enteritis alone (n=21), and 25/51 and 4/12, respectively ($p=0.04$), were found affected with PPR. A relative risk of 2.57, *i.e.* >1 indicated a higher likelihood of PPR in goats with combined symptoms. These findings aligned with studies by Rahman *et al*. (2021) and Ishag *et al*. (2023).

Conclusion

The hospital-based overall incidence of peste des petits ruminants (PPR) in goats was observed to be 6.38% (29/454) and among the suspected cases it was found 40.27% (29/72). Non-descript goat breeds, males, and goats aged 1-2 years were most affected. Peak incidence occurred from June to September, with significant associations noted for breed, age, and sex, though not for seasonality. Haematological findings revealed macrocytic hypochromic anaemia. Recent transportation and combined respiratory and enteric symptoms significantly increased infection risk.

Acknowledgements

Author(s) are grateful to the Principal of Veterinary College, and Head of the Department of Veterinary Medicine, Navsari for providing necessary facilities to conduct aforesaid research work.

References

Afera, B., Hussien, D., & Amsalu, K. (2014). Seroprevalence of Peste des petits ruminants in goats of southern parts of Tigray region. *Global Veterinaria*, *12*(4), 512-516.

Ahaduzzaman, M. (2020). Peste des Petits Ruminants (PPR) in Africa and Asia: A systematic review and meta-analysis of the prevalence in sheep and goats between 1969 and 2018. *Veterinary Medicine and Science*, *6*(4), 813-833.

Al Saad, K.M. (2023). Investigation of the clinical and diagnostic aspects of peste des petits ruminants (PPR) in sheep from the Southern Region of Iraq. *Archives of Razi Institute*, *78*(2), 561.

Balamurugan, V., Hemadri, D., Gajendragad, M.R., Singh, R.K., & Rahman, H., (2014). Diagnosis and control of peste des petits ruminants: A comprehensive review. *Virus Disease*, *25*, 39-56.

Balamurugan, V., Saravanan, P., Sen, A., Rajak, K.K., Venkatesan, G., Krishnamoorthy, P., & Singh, R.K. (2012). Prevalence of peste des petits ruminants among sheep and goats in India. *Journal of Veterinary Science*, 13(3), 279-285.

Bamouh, Z., Fakri, F., Jazouli, M., Safini, N., Omari Tadlaoui, K., & Elharrak, M. (2019). Peste des petits ruminants pathogenesis on experimental infected goats by the Moroccan 2015 isolate. *BMC Veterinary Research*, *15,* 1-8.

Bello, A.M., Lawal, J.R., Dauda, J., Wakil, Y., Lekko, Y.M., Mshellia, E.S., & Mani, A.U. (2016). Research for peste des petits ruminants (PPR) virus antibodies in goats, sheep and gazelle from Bauchi

and Gombe States, North Eastern Nigeria. *Direct Research Journal of Agriculture and Food Science*, *4*(8), 193-198.

Brar, R.S., Sandhu, H.S., & Singh, A. (2019). *Veterinary Clinical Diagnosis by Laboratory Methods*. 2nd edn., Kalyani Publishers, India, pp. 27-70.

Chauhan, H.C., Dadawala, A.I., Chandel, B.S., Kalyani, I.H., Patel, S.S., & Kher, H.N. (2012). Seroprevalence of Peste des petits ruminants in small ruminants under different managemental conditions. *Indian Journal of Veterinary Sciences and Biotechnology*, *7*(3), 37-39.

Chitradevi, S., Sivaraman, S., & Madheswaran, R. (2021). Molecular confirmation of Peste des petits ruminants (PPR) disease outbreak in cross bred Jamunapari goats in Tamil Nadu. *The Pharma Innovation Journal*, *10*(11), 2237-2241.

Chukwudi, I.C., Ugochukwu, E.I., & Chah, K.F. (2021). Comparative analysis of haemo-biochemical profile of peste des petits ruminants infected sheep and goats in south east Nigeria. *Nigerian Journal of Animal Production*, 1079-1083.

Diallo, A., Minet, C., Le Goff, C., Berhe, G., Albina, E., Libeau, G., & Barrett, T. (2007). The threat of peste des petits ruminants: Progress in vaccine development for disease control. *Vaccine*, *25*(30), 5591-5597.

Govindaraj, G., Balamurugan, V., & Rahman, H. (2016). Estimation of economic loss of PPR in sheep and goats in India: An annual incidence-based analysis. *British Journal of Virology*, *3*(3), 77-85.

Hussain, K. (2021). Seo-prevalence with risk factors for peste des petits ruminants (ppr) in sheep and goats using competitive ELISA in Mosul, Iraq. *Basrah Journal of Veterinary Research*, *20*(1), 160-171.

Ishag, H.Z.A., Terab, A.M.A., Eltahir, Y.M., El Tigani-Asil, E.T.A., Khalil, N.A.H., Gasim, E.F.M., &Khalafalla, A.I. (2023). A clinical, pathological, epidemiological and molecular investigation of recent outbreaks of peste des petits ruminants virus in domestic and wild small ruminants in the Abu Dhabi Emirate, United Arab Emirates. *Veterinary Sciences*, *10*(1), 56.

Islam, M.S., Khan, M.S.I., Kader, H.A., Begum, M.R., & Asgar, M.A. (2012). Prevalence of PPR of goat and their response to antibiotic treatment at Mirzaganj Upazila of Patuakhali District. *Journal of Environmental Science and Natural Resources*, *5*(2), 181-184.

Mahajan, S., Agrawal, R., Kumar, M., Mohan, A., & Pande, N. (2012). Risk of seroconversion to peste des petits ruminants (PPR) and its association with species, sex, age and migration. *Small Ruminant Research*, *104*(1-3), 195-200.

Munibullah, M., Li, Y.M., Munib, K., & Zhang, Z.D. (2022). Regional epidemiology and associated risk fators of peste des petits ruminants in Asia- A review. *Slovenian Veterinary Research*, *59*(2), 75-87.

Nath, T.C., Bhuiyan, M.J.U., Mamun, M.A., Datta, R., Chowdhury, S.K., Hossain, M., & Alam, M.S. (2014). Common infectious diseases of goats in Chittagong district of Bangladesh. *International Journal of Scientific Research in Agricultural Sciences*, *1*(3), 43-49.

Nizamani, A.R., Nizamani, Z.A., Umrani, A.P., Dewani, P., Vandiar, M.A., Gandahi, J.A., & Soomro, N.M. (2015). Prevalence of Peste des petits ruminants virus antibodies in small ruminants in Sindh, Pakistan. *The Journal of Animal and Plant Sciences*, *25*(6), 1515-1519.

Parvez, M.A., Khatun, R., & Al Noman, M.A. (2014). Prevalence and associated risk factors of Peste des Petits Ruminants (PPR) in goats in Chittagong district, Bangladesh. *Research Journal for Veterinary Practitioners*, *2*(1s), 14-17.

Rahman, A.A., Islam, S.S., Sufian, M.A., Talukder, M.H., Ward, M.P., & Martínez-López, B. (2021). Peste des Petits Ruminants risk factors and space-time clusters in Bangladesh. *Frontiers in Veterinary Science*, *7,* 572432.

Rahman, M.M., Alam, K.J., Alam, M.S., Hasan, M.M., & Moonmoon, M. (2016). A study on prevalence of peste des petits ruminant (PPR) in goat at Bagmaraupazilla at Rajshahi district in Bangladesh. *Research in Agriculture Livestock and Fisheries*, *3*(2), 339-344.

Rath, P.K., Panda, S.K., Mishra, B.P., Karna, D.K., Sahoo, G., Mishra, U.K., & Patra, R.C. (2020). Epidemiological risk factor analysis in goats and sheep naturally infected with Peste des petits ruminants virus. .*Journal of Entomology and Zoology Studies, 8*(3), 546-549.

Sakhare, P., Kalyani, I., Vihol, P., Sharma, K., Solanki, J., Desai, D., & Makwana, P. (2019). Seroepidemiology of Peste des Petits Ruminants (PPR) in sheep and goats of southern districts of Gujarat, India. *International Journal of Current Microbiology and Applied Science, 8*(11), 1552-65.

Santus, P., Corsico, A., Solidoro, P., Braido, F., Di Marco, F., & Scichilone, N. (2014). Oxidative stress and respiratory system: pharmacological and clinical reappraisal of N-acetylcysteine. *Journal of Chronic Obstructive Pulmonary Disease*, *11*(6), 705-717.

Sapcota, S., Gairhe, S., Kolakshyapati, M., Upadhaya, N., Acharya, Y., & Ghimire, Y.N. (2017). Role of women in goat farming in mid hills of Nepal. In: *Proceeding of the 10th National Workshop on Livestock and Fisheries Research in Nepal, 5*(7), 351-354.

Sarker, S., & Islam, H. (2011). Prevalence and risk factor assessment of Peste des petits ruminants in goats in Rajshahi, Bangladesh. *Veterinary World*, *4*, 546-549.

Shahabuddin Ahmed, M.R.H., Hossain, M.A., Uddin, F., Rashid, H., Talha, M.H., & Rahman, M.M. (2017). Clinical prevalence and influencing factors analysis for the occurrence of Peste Des Petits Ruminants (PPR) disease of goat at Sylhet Region, Bangladesh., *Veterinary Clinical Science*, *5*(1),1-5.

Singh, R.P., Saravanan, P., Sreenivasa, B.P., Singh, R.K., & Bandyopadhyay, S.K. (2004). Prevalence and distribution of peste des petits ruminants virus infection in small ruminants in India. *Revue Scientifique Technique*, *23*(3), 807-819.

Tajpara, M.M., Kanani, A.N., Savsani, H.H., Kathiriya, J.B., Gohil, P.V., Patel, D.R., & Shah, N.M. (2021). Incidence of Peste Des Petits Ruminants virus infection in small ruminants of Saurashtra region of Gujarat State. *International Journal of Current Microbiology and Applied Sciences*, *10*(07), 257-269.

Thakor, R.B., Patel, M.D., Patel, R.M., & Kalyani, I.H. (2016). Seroprevalence of peste des petits ruminants in goats of South Gujarat. *Indian Journal of Small Ruminants*, 22(2), 252-254.

Zheng, W., Liu, B., Hu, W., & Cui, Y. (2021). Effects of transport stress on pathological injury and main heat shock protein expression in the respiratory system of goats. *Journal of Animal Physiology and Animal Nutrition*, *105*(1), 1-13.