

Print ISSN : 0972-8813  
e-ISSN : 2582-2780

[Vol. 21(3) September-December 2023]

# Pantnagar Journal of Research

(Formerly International Journal of Basic and  
Applied Agricultural Research ISSN : 2349-8765)



G.B. Pant University of Agriculture & Technology, Pantnagar



## **ADVISORYBOARD**

### **Patron**

Dr. Manmohan Singh Chauhan, Vice-Chancellor, G.B. Pant University of Agriculture and Technology, Pantnagar, India

### **Members**

Dr. A.S. Nain, Ph.D., Director Research, G.B. Pant University of Agri. & Tech., Pantnagar, India  
Dr. Jitendra Kwatra, Ph.D., Director, Extension Education, G.B. Pant University of Agri. & Tech., Pantnagar, India  
Dr. S.K. Kashyap, Ph.D., Dean, College of Agriculture, G.B. Pant University of Agri. & Tech., Pantnagar, India  
Dr. S.P. Singh, Ph.D., Dean, College of Veterinary & Animal Sciences, G.B. Pant University of Agri. & Tech., Pantnagar, India  
Dr. K.P. Raverkar, Ph.D., Dean, College of Post Graduate Studies, G.B. Pant University of Agri. & Tech., Pantnagar, India  
Dr. Sandeep Arora, Ph.D., Dean, College of Basic Sciences & Humanities, G.B. Pant University of Agri. & Tech., Pantnagar, India  
Dr. Alknanda Ashok, Ph.D., Dean, College of Technology, G.B. Pant University of Agri. & Tech., Pantnagar, India  
Dr. Alka Goel, Ph.D., Dean, College of Community Science, G.B. Pant University of Agri. & Tech., Pantnagar, India  
Dr. Malobica Das Trakroo, Ph.D., Dean, College of Fisheries, G.B. Pant University of Agri. & Tech., Pantnagar, India  
Dr. R.S. Jadoun, Ph.D., Dean, College of Agribusiness Management, G.B. Pant University of Agri. & Tech., Pantnagar, India

## **EDITORIALBOARD**

### **Members**

Prof. A.K. Misra, Ph.D., Chairman, Agricultural Scientists Recruitment Board, Krishi Anusandhan Bhavan I, New Delhi, India  
Dr. Anand Shukla, Director, Reefberry Foodex Pvt. Ltd., Veraval, Gujarat, India  
Dr. Anil Kumar, Ph.D., Director, Education, Rani Lakshmi Bai Central Agricultural University, Jhansi, India  
Dr. Ashok K. Mishra, Ph.D., Kemper and Ethel Marley Foundation Chair, W P Carey Business School, Arizona State University, U.S.A  
Dr. B.B. Singh, Ph.D., Visiting Professor and Senior Fellow, Dept. of Soil and Crop Sciences and Borlaug Institute for International Agriculture, Texas A&M University, U.S.A.  
Prof. Binod Kumar Kanaujia, Ph.D., Professor, School of Computational and Integrative Sciences, Jawahar Lal Nehru University, New Delhi, India  
Dr. D. Ratna Kumari, Ph.D., Associate Dean, College of Community / Home Science, PJTSAU, Hyderabad, India  
Dr. Deepak Pant, Ph.D., Separation and Conversion Technology, Flemish Institute for Technological Research (VITO), Belgium  
Dr. Desirazu N. Rao, Ph.D., Professor, Department of Biochemistry, Indian Institute of Science, Bangalore, India  
Dr. G.K. Garg, Ph.D., Dean (Retired), College of Basic Sciences & Humanities, G.B. Pant University of Agric. & Tech., Pantnagar, India  
Dr. Humnath Bhandari, Ph.D., IIRRI Representative for Bangladesh, Agricultural Economist, Agrifood Policy Platform, Philippines  
Dr. Indu S Sawant, Ph.D., Director, ICAR - National Research Centre for Grapes, Pune, India  
Dr. Kuldeep Singh, Ph.D., Director, ICAR - National Bureau of Plant Genetic Resources, New Delhi, India  
Dr. M.P. Pandey, Ph.D., Ex. Vice Chancellor, BAU, Ranchi & IGKV, Raipur and Director General, IAT, Allahabad, India  
Dr. Martin Mortimer, Ph.D., Professor, The Centre of Excellence for Sustainable Food Systems, University of Liverpool, United Kingdom  
Dr. Muneshwar Singh, Ph.D., Project Coordinator AICRP- LTFE, ICAR - Indian Institute of Soil Science, Bhopal, India  
Prof. Omkar, Ph.D., Professor, Department of Zoology, University of Lucknow, India  
Dr. P.C. Srivastav, Ph.D., Professor, Department of Soil Science, G.B. Pant University of Agriculture and Technology, Pantnagar, India  
Dr. Prashant Srivastava, Ph.D., Cooperative Research Centre for Contamination Assessment and Remediation of the Environment, University of South Australia, Australia  
Dr. Puneet Srivastava, Ph.D., Director, Water Resources Center, Butler-Cunningham Eminent Scholar, Professor, Biosystems Engineering, Auburn University, U.S.A.  
Dr. R.C. Chaudhary, Ph.D., Chairman, Participatory Rural Development Foundation, Gorakhpur, India  
Dr. R.K. Singh, Ph.D., Director & Vice Chancellor, ICAR-Indian Veterinary Research Institute, Izatnagar, U.P., India  
Prof. Ramesh Kanwar, Ph.D., Charles F. Curtiss Distinguished Professor of Water Resources Engineering, Iowa State University, U.S.A.  
Dr. S.N. Maurya, Ph.D., Professor (Retired), Department of Gynecology & Obstetrics, G.B. Pant University of Agric. & Tech., Pantnagar, India  
Dr. Sham S. Goyal, Ph.D., Professor (Retired), Faculty of Agriculture and Environmental Sciences, University of California, Davis, U.S.A.  
Prof. Umesh Varshney, Ph.D., Professor, Department of Microbiology and Cell Biology, Indian Institute of Science, Bangalore, India  
Prof. V.D. Sharma, Ph.D., Dean Academics, SAI Group of Institutions, Dehradun, India  
Dr. V.K. Singh, Ph.D., Head, Division of Agronomy, ICAR-Indian Agricultural Research Institute, New Delhi, India  
Dr. Vijay P. Singh, Ph.D., Distinguished Professor, Caroline and William N. Lehrer Distinguished Chair in Water Engineering, Department of Biological Agricultural Engineering, Texas A&M University, U.S.A.  
Dr. Vinay Mehrotra, Ph.D., President, Vinlax Canada Inc., Canada

### **Editor-in-Chief**

Dr. Manoranjan Dutta, Head Crop Improvement Division (Retd.), National Bureau of Plant Genetic Resources, New Delhi, India

### **Managing Editor**

Dr. S.N. Tiwari, Ph.D., Professor, Department of Entomology, G.B. Pant University of Agriculture and Technology, Pantnagar, India

### **Assistant Managing Editor**

Dr. Jyotsna Yadav, Ph.D., Research Editor, Directorate of Research, G.B. Pant University of Agriculture and Technology, Pantnagar, India

### **Technical Manager**

Dr. S.D. Samantray, Ph.D., Professor, Department of Computer Science and Engineering, G.B. Pant University of Agriculture and Technology, Pantnagar, India

## CONTENTS

<b>Studies on genetic diversity and character association analysis in wheat (<i>Triticum aestivum</i> L. em. Thell)</b>	<b>337-344</b>
P. SINGH, B. PRASAD, J. P. JAISWAL and A. KUMAR	
<b>Study of Genetic Variability for yield and yield contributing characters in Bread Wheat (<i>Triticum aestivum</i> L.)</b>	<b>345-348</b>
SHIVANI KHATRI, RAKESH SINGH NEGI and SHIVANI NAUTIYAL	
<b>To assessment about the combining ability and heterosis studies in pea [<i>Pisum sativum</i> L. var. <i>hortense</i>]</b>	<b>349-355</b>
AKASH KUMAR, BANKEY LAL, P. K. TIWARI, PRANJAL SINGH and ASHUTOSH UPADHYAY	
<b>Effect of integrated nutrient management on growth, yield, and quality traits in garden pea (<i>Pisum sativum</i> L.) under sub-tropical conditions of Garhwal hills</b>	<b>356-364</b>
SUMIT CHAUHAN, D. K. RANA and LAXMI RAWAT	
<b>To study of correlation and path coefficients analysis for pod yield in garden pea [<i>Pisum sativum</i> L. var. <i>hortense</i>]</b>	<b>365-370</b>
CHANDRAMANI KUSWAHA, H. C. SINGH, BANKEY LAL, PRANJAL SINGH and ASHUTOSH UPADHYAY	
<b>Black gram (<i>Vigna mungo</i> L.) response to plant geometry and biofertilizers in western Himalayan Agroecosystem</b>	<b>371-375</b>
SANDEEPTI RAWAT, HIMANSHU VERMA and J P SINGH	
<b>Integrated effect of natural farming concortions, organic farming practices and different fertilizer doses on productivity and profitability of wheat in western Himalayan zones of India</b>	<b>376-382</b>
PRERNA NEGI, HIMANSHU VERMA, MOINUDDIN CHISTI, J. P. SINGH, PRIYANKA BANKOTI, ANJANA NAUTIYAL and SHALINI CHAUDHARY	
<b>Economics of paddy cultivation in the salinity affected regions of Alappuzha district, Kerala</b>	<b>383-390</b>
NITHIN RAJ. K, T. PAUL LAZARUS, ASWATHY VIJAYAN, DURGA A. R, B. APARNA and BRIGIT JOSEPH	
<b>Persistent toxicity of insecticides, fungicides, and their combinations against <i>Spodoptera litura</i> (Fab.) on soybean</b>	<b>391-395</b>
GUNJAN KANDPAL, R.P. SRIVASTAVA and ANKIT UNIYAL	

<b>Productive and reproductive performance of dairy animals in district Varanasi of Uttar Pradesh</b> RISHABH SINGH , YASHESH SINGH and PUSHP RAJ SHIVAHRE	396-400
<b>Role of nanotechnology in environmental pollution remediation</b> A.K. UPADHYAY, ANUPRIYA MISRA, YASHOVARDHAN MISRA and ANIMESH KUMAR MISHRA	401-408
<b>Effects of chemical industry effluents on humoral immune response in mice</b> SEEMA AGARWAL and D.K. AGRAWAL	409-415
<b>Correlation between sero-conversion and clinical score in Peste des petits ruminants disease in goats</b> AMISHA NETAM, ANUJ TEWARI, RAJESH KUMAR, SAUMYA JOSHI, SURBHI BHARTI and PREETINDER SINGH	416-419
<b>Length weight relationship and condition factor of Bengal corvina, <i>Daysciaena albida</i> (Cuvier, 1830) from Vembanad Lake</b> KITTY FRANCIS C. and M. K. SAJEEVAN	420-424
<b>Temporal changes in per capita consumption of meat in different countries of South East Asia region</b> ABDUL WAHID and S. K. SRIVASTAVA	425-431
<b>Temporal analysis of milk production and consumption in the Central Asian countries</b> ABDUL WAHID and S. K. SRIVASTAVA	432-436
<b>Development and quality evaluation of jackfruit rind incorporated vermicelli <i>Payasam</i></b> ATHIRA RAJ, SHARON, C.L., SEEJA THOMACHAN PANJIKKARAN., LAKSHMI, P.S., SUMAN, K.T., DELGI JOSEPH C. and SREELAKSHMI A. S	437-443
<b>Optimizing pre-drying treatments of kale leaves for enhanced processing quality</b> BINDVI ARORA, SHRUTI SETHI, ALKA JOSHI and AJAY NAROLA	444-452
<b>Effect of training and visit (T &amp; V) system on fish production (Aquaculture) in Ogun State, Nigeria</b> UWANA G.U. and V.E OGBE	453-459
<b>Use of social media by rural and urban youths: A study in Uttarakhand</b> ANNU PARAGI and ARPITA SHARMA KANDPAL	460-465
<b>Assessment of traditional knowledge of therapeutic potential of native crops among population of Udham Singh Nagar, Uttarakhand</b> A. DUTTA, A. BHATT, S. SINGH and K. JOSHI	466-472
<b>Modernizing dairy operations: A comprehensive case study of mechanization in Bhopal farms</b> M. KUMAR	473-477

## Correlation between sero-conversion and clinical score in Peste des petits ruminants disease in goats

AMISHA NETAM, ANUJ TEWARI\*, RAJESH KUMAR, SAUMYA JOSHI, SURBHI BHARTI and PREETINDER SINGH

*Department of Veterinary Microbiology, College of Veterinary and Animal Sciences, G. B. Pant University of Agriculture and Technology, Pantnagar (U. S. Nagar, Uttarakhand)*

*\*Corresponding author's email id: anuj474@gmail.com*

**ABSTRACT:** A correlation analysis was conducted to evaluate the relationship between clinical signs and seroconversion. The results of the correlation analysis demonstrated a positive association between clinical signs and seroconversion in cases of PPR infection. Conversely, no correlation was observed between seroconversion and clinical score in PPR negative animals tested via RT-PCR. Therefore, it can be concluded that a combination of high clinical scores and high seroconversion serves as an indicator of the current ongoing PPRV infection, which can be valuable for surveillance purposes in areas where PPR is endemic.

**Key words:** Clinical score, sero-conversion, RT-PCR, PPRV, Infection

Peste des petits ruminants (PPR) is caused by *Peste des petits ruminants virus* (PPRV) belonging to the genus *Morbillivirus* of the family *Paramyxoviridae* within the order *Mononegavirales* (Amarasinghe *et al.*, 2019). PPR mostly affects goats and sheep, but it also affects wild ruminants, pigs, dogs, and camels; cattle and buffaloes are infected asymptotically with seroconversion, but other wild ruminants, pigs, dogs, and camels may show clinical signs and mortality (Albina *et al.*, 2013; Rahman *et al.*, 2016; Schulz *et al.*, 2018). Goats are more susceptible than sheep with high mortality (Hussain, *et al.*, 2003). The annual global economic losses are estimated to be USD 1.4 to more than 2.1 billion (Agrawal *et al.*, 2023) and losses in India are estimated to be USD 2 million to USD 18 million which may go up to USD 1.5 billion (Bardhan *et al.*, 2017) owing to morbidity, mortality, and productivity losses with trade limitations (Balamurugan *et al.*, 2014). The goal of the global PPR eradication program, set to be accomplished by 2030, can be attained through timely diagnosis, limited movement of infected animals, and the strategic separation of sick animals from their herds (Agrawal *et al.*, 2023). Hence, the regular screening of PPR in regional goats is needed. Therefore, the clinical samples from the suspected goats of Pantnagar were collected and screened for

PPRV in the present study.

### MATERIALS AND METHODS

#### Clinical samples for PPRV isolation and identification

The identification of these goats as suspected cases was based on the presence of specific clinical indications such as nasal discharge, sticky eyes, foul-smelling diarrhea, elevated body temperature (105 °F), and a considerable mortality in-contact goat. Each individual clinical sign was assigned a corresponding clinical score. The particulars regarding the animals, their exhibited clinical signs, the assigned clinical scores, and the outcome of the tests conducted can be found in Table 1.

The nasal, oral, and rectal swabs from PPR suspected goats were collected. The swabs were collected from the clinical outbreaks in 3 ml of PBS followed by gentle swirling and squeezing. The content was then filtered through a 0.22 µm Millipore syringe filter under aseptic conditions. The filtrate was used for RNA extraction and as inoculum for virus isolation. Anticoagulated blood in EDTA (Levram life sciences, India) and swabs (nasal, oral and rectal) in 3 ml of phosphate-buffered

saline (PBS) (pH 7.4) for virus identification were collected from the clinical outbreaks. The samples were immediately put inside the ice box and transferred to the lab. The clinical samples were stored at -30°C until used. Serum samples for testing anti-PPRV antibodies by c-ELISA were also collected from these suspected cases.

#### Identification of PPRV from clinical outbreaks

The RNA was extracted from clinical samples using TRIzol-S Reagent (SRL, India). The extracted RNA was stored at -20°C until further use. For the RNA extraction, the protocol of Chomczynski and Sacchi (1987) was followed with slight modification. The detection of PPRV nucleic acid in the clinical samples (whole blood, nasal swab, oral swab, and rectal swab) was done by using a one-step RT-PCR kit (HIMEDIA) and amplicon was analyzed by agarose gel electrophoresis.

#### Competitive-ELISA for detection of anti-PPRV antibodies

Serum samples were tested by c-ELISA kit (ID Screen® PPR Competition, France) for detection of anti-PPRV antibodies in terms of competition percentage (S/N %). The test was performed as per

the manufacturer's guidelines.

The results were expressed as competition percentage (S/N %) which was calculated as follows:

$$S/N\% = \frac{OD \text{ sample}}{OD \text{ negative control}} \times 100$$

The results were interpreted as follows-

Positive : S/N %  $\leq$  50 %

Doubtful : S/N %  $>$  50 % or  $\leq$  60%

Negative : S/N %  $>$  60 %

Samples categorized as doubtful were retested by the above-mentioned c-ELISA kit

**Statistical analysis:** The correlation between clinical signs and seroconversion was estimated by correlation coefficient using GraphPad Prism 9.

## RESULTS AND DISCUSSION

Apparently healthy goats (Animal number 1, 5, 6, 18, 19) did not show any clinical sign. Out of 19 animals tested, 8 animals turned out to be positive by RT-PCR (Table 1). All RT-PCR positive animals showed a strong seroconversion except animal number 6 which did not show sero-conversion.

**Table 1: Details of clinical samples, their clinical signs, clinical score, one step RT-PCR and c-ELISA results of clinically suspected goats for PPR**

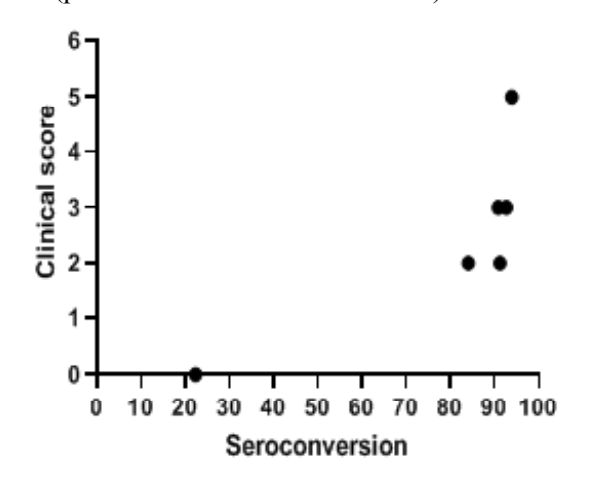
Animal number	RT-PCR	c-ELISA (S/N %)	Health status	Clinical score
1	negative	73.98	apparently healthy	0
2	negative	76.31	nasal discharge, diarrhoea,	2
3	negative	43.16	nasal discharge, diarrhoea,	2
4	negative	3.47	nasal discharge, diarrhoea,	2
5	negative	36.04	apparently healthy	0
6	positive	77.69	apparently healthy	0
7	negative	69.5	Diarrhoea	1
8	positive	15.91	nasal discharge, off-fed	2
9	positive	9.12	nasal discharge, lacrimation, diarrhoea	3
10	negative	74.15	nasal discharge	1
11	positive	9.32	nasal discharge, sticky eyes, diarrhoea	3
12	positive	8.77	nasal discharge, off-fed	2
13	negative	8.38	nasal discharge, off-fed	2
14	positive	6.1	nasal discharge, off-fed, fever, ulcer on mouth, diarrhoea	5
15	negative	75.22	nasal discharge, dull	2
16	positive	7.2	nasal discharge, dull	2
17	positive	7.29	fever, nasal discharge, coughing	3
18	negative	51.2	apparently healthy	0
19	negative	84.91	apparently healthy	0

Mean value of clinical score in RT-PCR positive animals=2.50, Mean value of clinical score in RT-PCR negative animals=1.09

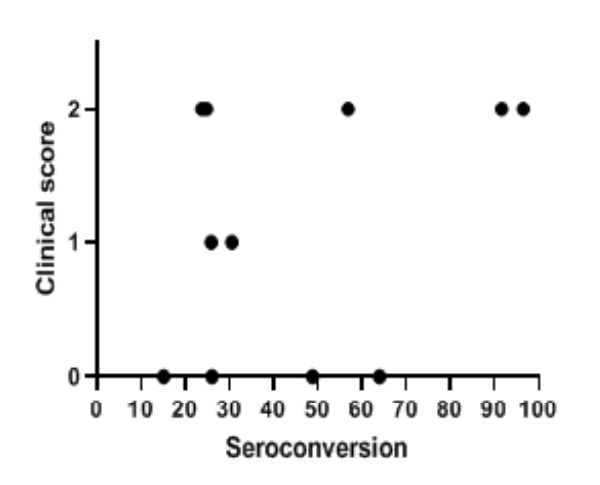
**Correlation analysis between clinical signs and seroconversion**

Correlation analysis between clinical signs and seroconversion was done on the basis of:

1. Correlation between clinical signs and seroconversion in RT-PCR positive animals (infected) randomly taken samples on the basis of clinical signs versus sero-conversion.
2. Correlation between clinical signs and seroconversion in RT-PCR negative animals (past infection or never infected).



**Fig. 1: Correlation between clinical score and seroconversion in RT-PCR positive animals ( $r=0.799$ ,  $p=0.0172$ ). A weak correlation with  $r$  value  $0.35$  ( $p$  value= $0.2903$ ) between clinical signs versus seroconversion in RT-PCR negative animals was obtained.**



**Fig. 2: Correlation between clinical score and seroconversion in RT-PCR negative animals ( $r=0.35$ ,  $p=0.2903$ ).**

When correlation between clinical signs versus seroconversion in RT-PCR positive animals (PPRV infected animals) was made, a strong correlation of  $0.799$  was obtained which signifies that PPRV infected animals (ongoing infection) showed clinical signs which was positively associated with sero-conversion ( $p$  value= $0.0172$  significant).

One animal No 6 was found RT-PCR positive but negative in clinical score and seroconversion, which could be because either the animal was sub-clinically infected or due to the early stage of infection the clinical signs and antibodies were not developed.

Thus, the correlation analysis shows that in an ongoing PPR infection, clinical signs and seroconversion are positively associated and both are strong indicators of the ongoing infection. At the same time in RT-PCR negative animals no correlation was found between seroconversion and clinical score. Moreover, the RT-PCR positive animals showed higher clinical score (Mean value= $2.5$ ) than the non infected animals (Mean value= $1.09$ ) (Table 1).

The study established a strong positive correlation ( $r = 0.799$ ) between clinical signs and seroconversion in PPR- infected goats, reinforcing their interdependence. Notably, the absence of correlation in non-infected animals highlights the specificity of these indicators. The observed higher mean clinical score in RT-PCR positive animals ( $2.50$ ) compared to non-infected ( $1.09$ ) counterparts underscores the combined importance of visible symptoms and immune response as robust markers of active PPR infection. This correlation analysis provides valuable insights for designing targeted surveillance strategies, contributing to the global goal of PPR eradication by 2023.

**CONCLUSION**

Thus, it is concluded that high clinical scores with high seroconversion is an indicator of ongoing PPRV infection which can be used during surveillance of PPR in an endemic setting.

## REFERENCES

- Agrawal, A., Varshney, R., Gattani, A., Hira Khan, M., Gupta, R., Solanki, K.S., Patel, S.K., Singh, R.P., Singh, P. (2023). Development of Hemagglutinin-Neuraminidase Homologous Peptides as Novel Promising Therapeutic Agents Against Peste des Petits Ruminants Virus. *Protein J.* Dec;42(6):685-697. doi: 10.1007/s10930-023-10134-4. Epub 2023 Jul 8. PMID: 37421558.
- Agrawal, A., Varshney, R., Gattani, A., Kirthika, P., Gupta, R., Kumar, D. and Singh, P. (2023). SLAM (CD150) receptor homologous peptides block the peste des petits ruminants virus entry into B95a cells. *Proteins: Structure, Function, and Bioinformatics.*, 2023: 11-17.
- Albina E., Kwiatek O., Minet C. and Lancelot R., Servan de Almeida R. and Libeau G. 2013. Peste des petits ruminants, the next eradicated animal disease? *Vet. Microbiol.*, 165: 38-44.
- Amarasinghe, G.K., Ayllón, M.A., Bào, Y., Basler, C.F., Bavari, S., Blasdel, K.R., Briese, T., Brown, P.A., Bukreyev, A., Balkema-Buschmann, A., Buchholz, U.J., Chabi-Jesus, C., Chandran, K., Chiapponi, C., Crozier I, de Swart, R.L., Dietzgen, R.G, Dolnik, O., Drexler, J.F., Dürrwald, R., Dundon, WG, Duprex WP, Dye JM, Easton AJ, Fooks AR, Formenty PBH, Fouchier RAM, Freitas-Astúa J, Griffiths A, Hewson R, Horie M, Hyndman TH, Jing D, Kitajima EW, Kobinger GP, KondM H, Kurath G, Kuzmin IV, Lamb RA, Lavazza A, Lee B, Lelli D, Leroy EM, LÐ J, Maes P, Marzano SL, Moreno A, Mühlberger E, Netesov SV, Nowotny N, Nylund A, Økland AL, Palacios G, Pályi B, Paw'ska JT, Payne SL, Prosperi A, Ramos-González PL, Rima BK, Rota P, Rubbenstroth D, Sh+ M, Simmonds P, Smither SJ, Sozzi E, Spann K, Stenglein MD, Stone DM, Takada A, Tesh RB, Tomonaga K, Tordo N, Towner JS, van den Hoogen B, Vasilakis N, Wahl V, Walker PJ, Wang LF, Whitfield AE, Williams JV, Zerbini FM, Zhng T, Zhang YZ, Kuhn JH (2019). Taxonomy of the order Mononegavirales: update 2019. *Arch Virol.* 2019 Jul;164(7):1967-1980. doi: 10.1007/s00705-019-04247-4. PMID: 31089958; PMCID: PMC6641539.
- Balamurugan, V., Krishnamoorthy, P., Raju, D.S.N., Rajak, K.K., Bhanuprakash, V., Pandey, A.B., Gajendragad, M.R., Prabhudas, K., Rahman, H. 2014. Prevalence of Peste-des-petits-ruminant virus antibodies in cattle, buffaloes, sheep and goats in India. *Virus Disease*, 25(1): 85-90.
- Bardhan, D., Kumar, S., Anandsekaran, G., Chaudhury, J.K., Meraj, M., Singh, R.K., Verma, M.R., Kumar, D., Kumar P.T., N., Ahmed Lone, S., Mishra, V., Mohanty, B.S., Korade, N., De U.K. (2017). The economic impact of peste des petits ruminants in India. *Rev Sci Tech*, 36: 245–263.
- Chomczynski, P. and Sacchi, N. (1987). Single-step method of RNA isolation by acid guanidinium thiocyanate-phenol-chloroform extraction. *Anal. Biochem.*, 162: 156–159.
- Hussain, M., Muneer, R., Jahangir, M., A. H. Awan, Khokhar, M.A., Zahur, A.B. et al. 2003. Chromatographic Strip Technology: A Pen-side Test for the Rapid Diagnosis of Peste Des Petits Ruminants in Sheep and Goats. *Journal of Biological Sciences.*, 1 January 2003. , 10.3923/jbs.2003.1.7.
- Rahman, A.U., Abubakar, M., Rasool, M.H., Manzoor, S., Saqalein, M., Rizwan, M., et al. (2016). Evaluation of Risk Factors for Peste des Petits Ruminants Virus in Sheep and Goats at the Wildlife-Livestock Interface in Punjab Province, *Pakistan. BioMed Res Int*, 2016:7826245.
- Schulz, C., Fast, C., Schlottau K., Hoffmann, B. and Beer, M. (2018). Neglected Hosts of Small Ruminant Morbillivirus. *Emerg Infect Dis.*, 24:2334–2337.

Received: October 23, 2023  
Accepted: December 21, 2023