

Pathomorphological and Haematobiochemical Changes in PPR Affected Goats of Malwa Region

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Abstract— The study was carried out to determine the pathomorphological and haematobiochemical changes in PPR affected goats of Malwa region, Madhya Pradesh. During six months duration, 500 goats were screened irrespective of age, sex and breed with 100 goats showing clinical symptoms similar to PPR were taken for study. Haematobiochemical analysis revealed significantly decreased haematological parameters, leukocytosis with significant neutrophilia and lymphopenia. On biochemical analysis, significant changes were observed in total protein and ALT values. Gross and microscopic lesions suggestive of PPR were observed in respiratory, digestive and lymphoid system in lungs, abomasum and mesenteric lymph nodes and presence of intracytoplasmic and intranuclear inclusion bodies evident in epithelial cell lining of bronchi and bronchioles, respectively.

Keywords— Goats, Gross and Microscopic changes, Haematobiochemical changes, Histopathological changes, PPR.

I. INTRODUCTION

PPR is a highly contagious viral disease that primarily affects small ruminants, with goats showing higher susceptibility to infection and disease manifestation (Ezeokoli et al., 1986). The disease has been consistently reported across various regions of the country and is now recognized as endemic, leading to significant economic losses in the small ruminant sector. In areas where PPR is endemic, the virus poses a major barrier to the development of a sustainable small ruminant industry. Gross pathological findings includes watery, mucopurulent ocular and nasal discharge, erosions and ulceration of the oral mucosa, diarrhoea with encrustations of the nostrils (Mabdoli and Ali, 2012). Pneumonic lungs with congestion and consolidation of the cardiac lobe is present. The intestinal mucosa is usually congested, haemorrhagic and covered with mucus (Rahman et al., 2011). Histopathological findings shows syncytial cells and eosinophilic intracytoplasmic inclusion bodies in bronchial epithelium cells (Patel et al., 2017) and variable degrees of lymphoid cell depletion especially in mesenteric lymph nodes (Chauhan et al., 2011). Marked haemoconcentration, neutrophilic leucocytosis with lymphopenia, eosinophilia, and monocytosis and biochemical analysis showed consistent increase in BUN, albumin and fibrinogen associated with the pattern of pneumonia (Emikpe et al., 2013). Controlling PPR in endemic regions will be more easier and effective with the support of patho-haematobiochemical findings and to study the incidence of Peste-des-petits-ruminants in goats of Malwa region, Mhow (M.P.).

II. MATERIAL AND METHODS

2.1 Screening and Selection of Animals

A total of 500 goats were screened irrespective of sex, age and breed brought at slaughter house, Cantonment board, Mhow for the duration of six months. Among 500 screened goats, 100 goats showing clinical symptoms similar to PPR disease were selected for the present study and detailed antemortem and post-mortem examinations were performed and approved by Institutional Animal Ethics Committee.

2.2 Sample collection

2.2.1 Ante-mortem sampling

Five mL of blood were collected from the jugular vein of affected goats in blood-collecting vials containing EDTA (@2mg/mL) for conducting hematobiochemical studies. Two mL of blood was kept for manual haematology and three mL for biochemical studies.

2.2.2 Post mortem sampling: For Gross and Histopathological examination

Goats after slaughtered were examined grossly for any lesions associated with PPR and representative samples of lung, abomasum and mesentric lymph nodes were collected in 10% neutral buffered formalin for histopathological examination.

2.3 Haematobiochemical parameters:

- Haemoglobin concentration (Hb, g/dL)
- Packed cell volume (PCV, %)
- Total Erythrocyte Count (TEC, million / μ L)
- Total Leukocyte Count (TLC, thousand/ μ L)
- Differential Leukocyte Count (DLC, %)
- Total protein (g/dL)
- Aspartate amino transferase (AST, IU/L)
- Alanine amino transferase (ALT, IU/L)

2.4 Tissue Processing

After gross examination representative tissue samples were collected in 10% neutral buffered formalin as fixative for 24 - 48 hrs. After fixation, the tissues were cut into pieces of 2 to 3 mm thickness and then subjected to routine histopathological technique. Conventionally paraffin embedded tissue sections (5 μ thick) are stained with H and E stain and examined under microscope for interpretation of tissue changes.

2.5 Statistical analysis of data

The data was analyzed by Z-test as per the standard procedure described by Snedecor and Cochran (1994).

III. RESULTS AND DISCUSSION

In the present study goats showing catarrhal nasal discharge, lacrimal discharge, congested mucous membranes, erosive ulcerative lesions on gums, lips and tongue with profuse diarrhoea (depicted in Plate 01 to 05) were studied and samples were taken from 100 PPR suspected goats out of 500 screened and subjected to systematic necropsy examination. During the study period, following significant gross and microscopic pathological changes associated with PPR disease were found:



PLATE 01: Photograph of goat showing white bran deposits in the mucosa of gums



PLATE 02: Photograph showing nodular lesions around mouth of PPR affected goat



PLATE 03: Photograph of goat showing serous nasal discharge



PLATE 04: Photograph of goat showing purulent lacrimation



PLATE 05: Photograph of goat showing matting of eyelids due to purulent ocular discharge

3.1 Respiratory system

On gross examination, serosanguinous fluid was found in the thoracic cavity of affected goats (Plate 06). Lungs showed pneumonic lesions, with areas of red hepatization, congestion, emphysema and firm consistency. Areas of consolidation, patchy congestion and ecchymotic haemorrhages were found particularly around the apical and cardiac lobes of lung (Plate 07, 08 and 09). The cut surface of more than 50% of the lungs revealed frothy exudate indicating pulmonary oedema. Tracheal mucosa were found inflamed, congested and filled with frothy exudate along with the presence of haemorrhages (Plate 10 and 11). Above findings of respiratory system were found similar with the findings of Chauhan et al. (2011); Khan et al. (2018); Islam et al. (2023); Emkipe et al. (2010) and Toplu (2004), where they observed frothy tracheal exudate, consolidation, hydrothorax and pneumonic lesions in lungs. The pneumonic tract and haemorrhagic trachea are probably due to descending upper respiratory tract infections in PPR complicated by secondary bacterial infection. Moreover, congestion and red hepatization of the lungs were suggestive of PPRV involvement. The involvement of the respiratory system in PPR is remarkable and pneumonia is a predominant gross lesion of PPR disease.

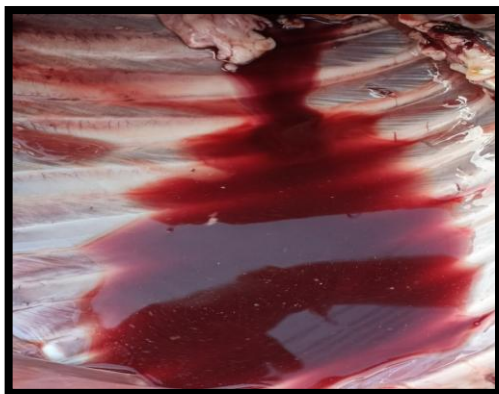


PLATE 06: Photograph of goat showing serosanguinous fluid in thoracic cavity

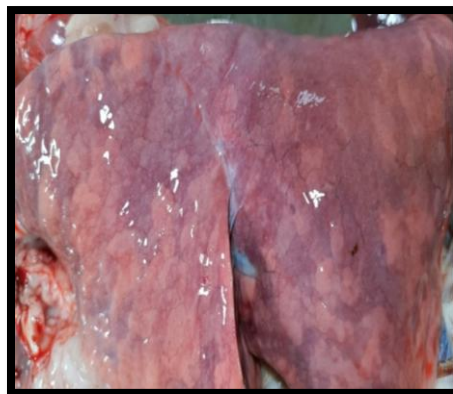


PLATE 07: Photograph of lung showing severe patchy congestion and area of emphysema in different lobes of lung



PLATE 08: Photograph of lung showing patchy areas of consolidation and congestion



PLATE 09: Photograph showing congestion and ecchymotic haemorrhages on cardiac lobe of lung



PLATE 10: Photograph of trachea showing congestion in tracheal mucosa



PLATE 11: Photograph of tracheal lumen filled with frothy exudate

3.2 Digestive and lymphoid system

Grossly, white necrotic bran like erosions along with sanguinous fluid were present in the abomasal folds of affected goats (Plate 12). Also, congestion with catarrhal discharge were found in the abomasum (Plate 13). Liver of affected goats was slightly yellowish in colour with pale areas of necrosis and hepatic congestion (Plate 14 and 15). Gall bladder were found engorged with bile and congested (Plate 16). Intestinal lesions revealed hyperaemic changes, serosal congestion and slightly thickened mucosa with streaks of linear haemorrhages characteristic of PPR (Plate 17 and 18). The mesenteric lymph nodes were found enlarged, congested and oedematous (Plate 19, 20 and 21). Similar findings were also observed by Shaila et al.

(1996); Kumar et al. (2004); Rahman et al. (2011) and Bharti et al. (2020) in the digestive system of PPR positive goats. Begum et al. (2018) observed congested liver, atrophied spleen and enlarged, congested mesenteric lymph nodes were concomitant to the above results.

Histopathological lesions suggestive of PPR were seen in 73 tissue samples including 24 lungs, 28 abomasum and 21 mesenteric lymph nodes. Microscopic examination of lungs revealed congestion and haemorrhages in interstitium with infiltration of monocyctic cells (Plate 22). Areas of emphysema and infiltration of inflammatory cells in the alveolar walls, bronchi and bronchioles were also found (Plate 23 and 24). Accumulation of serofibrinous exudate and infiltration of inflammatory cells in the lung parenchyma indicated bronchopneumonia (Plate 25). Presence of intracytoplasmic and intranuclear inclusion bodies also evident in epithelial cell lining of bronchi and bronchioles (Plate 26 and 27). Similar lung lesions were also observed by Patel et al. (2017); Pawaiya et al. (2004) and Chauhan et al. (2011). Interstitial pneumonia was evident and in agreement with findings of Mahajan et al. (2017). On the contrary, Kumar et al. (2004); Aytekin et al. (2011) and Malik (2016) were observed eosinophilic intracytoplasmic inclusion bodies in the hyperplastic bronchiolar and alveolar epithelium that were not observed in present study. Sections of the abomasum showed hyperplasia of abomasal folds with presence of inflammatory exudate, congestion, haemorrhages and infiltration of inflammatory cells (mononuclear cells and neutrophils) (Plate 28 and 29). Similar findings were reported by Pope et al. (2013), who observed significant diffuse lymphoid infiltration and oedema in the abomasum. Mesenteric lymph nodes showed severe depletion of lymphocytes in germinal follicles in cortex and medulla region (Plate 30), along with haemorrhages, oedema and distension of lymphatics in cortico-medullary region (Plate 31). Similar findings were also observed by Maina et al. (2015); Patel et al. (2017) and Kul et al. (2007).



PLATE 12: Photograph showing white necrotic bran like erosions on abomasal folds along with sanguinous fluid



PLATE 13: Photograph showing congestion of abomasal folds with catarrhal discharge



PLATE 14: Photograph showing haemorrhages and necrotic foci on liver surface



PLATE 15: Photograph showing hepatic congestion of liver surface

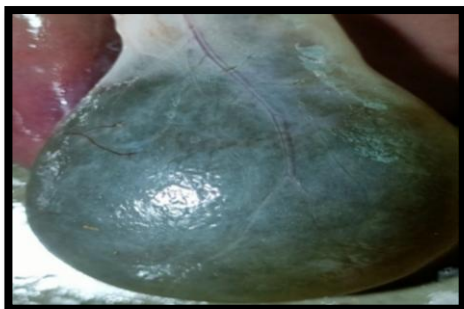


PLATE 16: Photograph showing engorged gall bladder in goat



PLATE 17: Photograph showing serosal congestion of intestine



PLATE 18: Photograph of intestine showing streaks of linear haemorrhages (Zebra stripping)



PLATE 19: Photograph showing oedematous, enlarged mesenteric lymph node

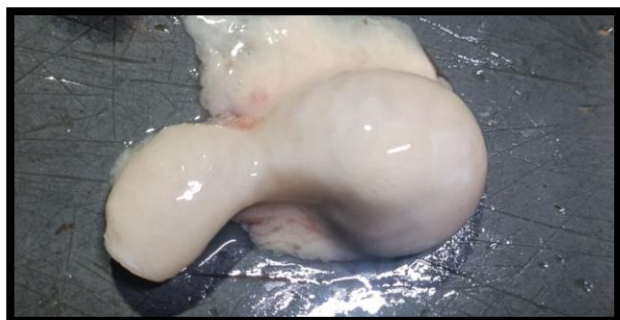


PLATE 20: Photograph showing enlarged, swollen mesenteric lymph node of goat suffering from PPR



PLATE 21: Photograph showing congested, oedematous lymph node

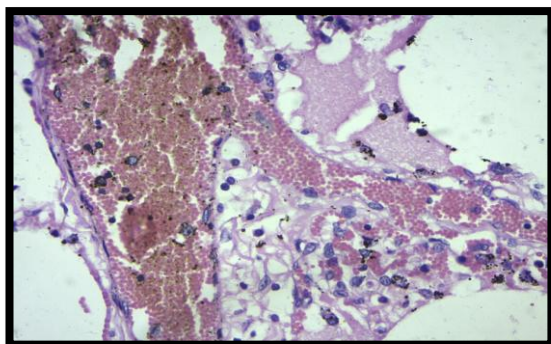


PLATE 22: Photomicrograph showing congestion and haemorrhages along with infiltration of monocytic cells in interstitium (H&E, 100X)

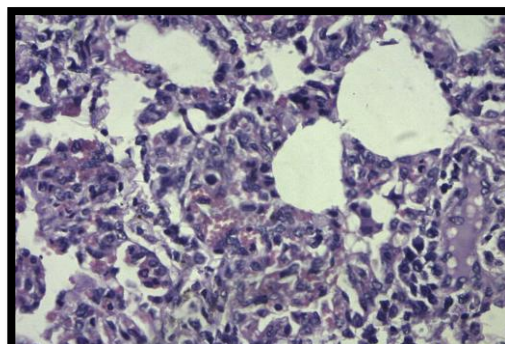


PLATE 23: Photomicrograph showing areas of emphysema in lung tissue (H&E, 100X)

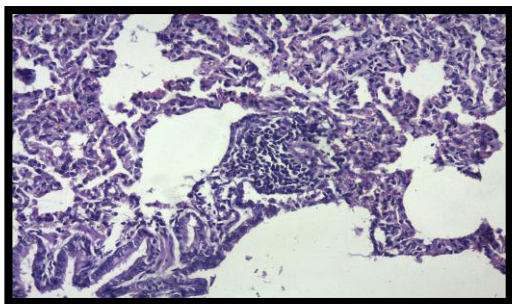


PLATE 24: Photomicrograph of lung showing infiltration of inflammatory cells in bronchiolar walls (H&E, 100X)

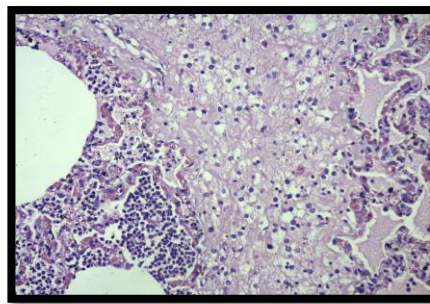


PLATE 25: Photomicrograph showing serofibrinous exudate accumulation in lung parenchyma (H&E, 400X)

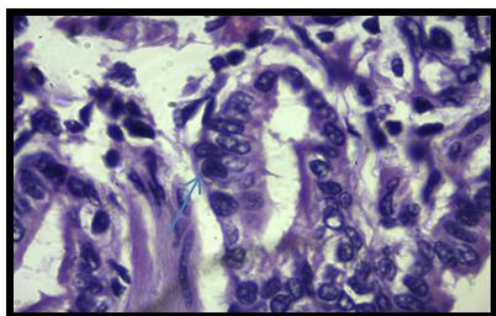


PLATE 26: Photomicrograph of lung showing intracytoplasmic inclusion body in lining epithelium of bronchiole (H&E, 100X)

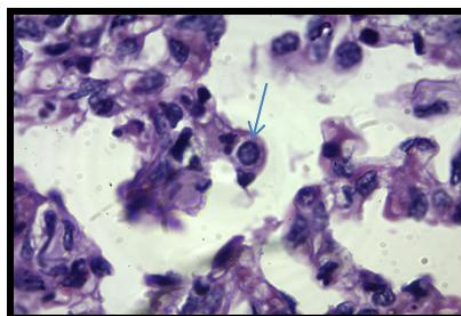


PLATE 27: Photomicrograph showing intranuclear inclusion body in lining epithelium of bronchiole (H&E, 100X)

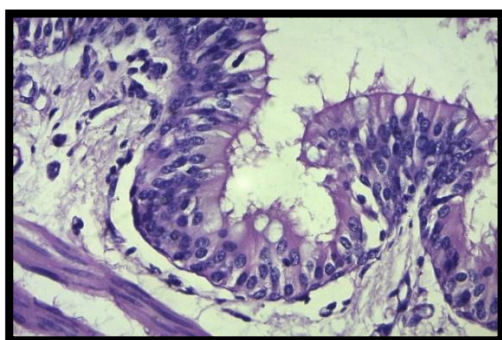


PLATE 28: Photomicrograph showing hyperplasia of abomasal mucosa with presence of inflammatory exudate (H&E, 400X)

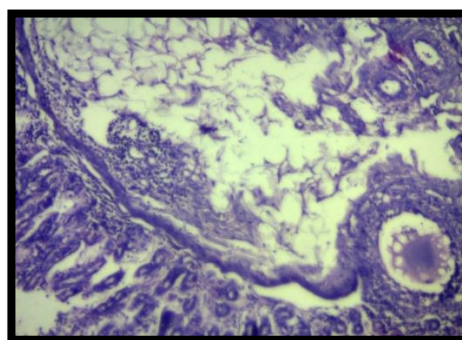


PLATE 29: Photomicrograph showing congestion and lymphoid aggregate in abomasal submucosa (H&E, 200X)

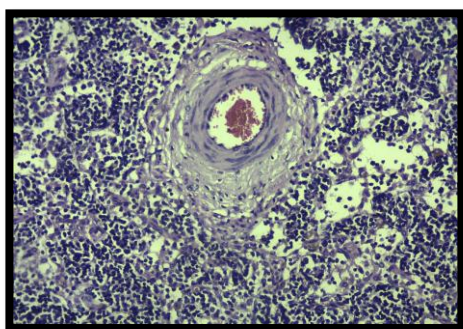


PLATE 30: Photomicrograph of lymph node section showing severe depletion of lymphocytes in germinal follicles (H&E, 200X)

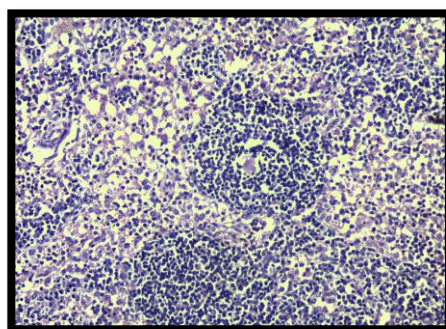


PLATE 31: Photomicrograph of lymph node section showing oedema in sparsely populated areas of lymph node (H&E, 200X)

3.3 Haematological analysis

The mean values ($\pm$ SE) of haematological parameters are presented in Table 1 and 2. In present study, a significant reduction in the mean values of all the three haematological parameters were observed. This may be attributed to erosions, necrosis, congestion and widespread haemorrhages causing blood loss and possibly due to secondary bacterial infection causing toxemia. Reduced values of haematological parameters were also studied by various co-workers viz. Aziz et al. (2019); Dimri et al. (2002); Bari et al. (2018); Das et al. (2015); Begum et al. (2018); Toplu (2004); Sharma et al. (2012) and Chitradevi et al. (2021).

TABLE 1

HAEMATOLOGICAL VALUES OF PPR POSITIVE AND NEGATIVE GOATS ON THE BASIS OF HISTOPATHOLOGY

S.No.	Parameters	PPR positive goats	PPR negative goats
1	Hb* (g/dL)	7.40 $\pm$ 0.40	8.49 $\pm$ 0.35
2	PCV* (%)	22.20 $\pm$ 1.21	25.47 $\pm$ 1.07
3	TEC* (million/ μ L)	3.70 $\pm$ 0.20	4.24 $\pm$ 0.17

**P $\leq$ 0.05*

3.3.1 Total Leukocyte Count (TLC, thousand/ μ L)

Statistically, significantly increased ($P\leq 0.05$) TLC values were observed in goats positive for PPR as compared to goats found negative, given in Table 2. The increased TLC values were in agreement with the findings of Maina et al. (2015); Begum et al. (2018); Emikpe et al. (2013) and Das et al. (2015) in PPR affected goats. Significant leukocytosis could be due to acute inflammation or due to stress caused by secondary bacterial infection.

3.3.2 Differential Leukocyte Count (DLC, %)

Statistically, blood smear examination showed significant increase ($P\leq 0.05$) in the mean values of neutrophil count (%) in PPR positive goats. This may be due to inflammation in tissues which leads to migration of neutrophils in response of infection while significantly decreased ($P\leq 0.05$) lymphocyte count may be attributed to immunosuppressive and lymphotropic nature of virus causing necrosis of lymphocytes in lymph nodes, spleen and peyers patches. There was non significant differences observed in the monocyte, eosinophil and basophil count in PPR positive goats as compared to negative goats.

These findings regarding differential leukocyte count corellates with the reports of Maina et al. (2015); Emikpe et al. (2014); Balogun et al. (2017); Yarim et al. (2006); Sahinduran et al. (2012) and Ugochukwu et al. (2018) where they studied significant increase in neutrophil values, decreased lymphocyte count with no significant difference in monocyte, eosinophil and basophil values in PPR positive goats. Das et al. (2015) and Begum et al. (2018) observed a significant increase in neutrophil value similar to the present study but a significant increase in lymphocyte count was also observed contrary to the present study. The difference between these haematological parameters may be due to the different phases of the disease, the presence of secondary bacterial infections, nutritional status and severe diarrhoea leading to dehydration.

TABLE 2

MEAN ($\pm$ SE) LEUKOGRAM VALUES IN PPR POSITIVE AND NEGATIVE GOATS

S.No.	Parameters	PPR Positive	PPR Negative
1	TLC*(thousand/ μ L)	15.32 $\pm$ 1.49	11.42 $\pm$ 0.18
2	Neutrophils* (%)	63.00 $\pm$ 1.79	36.76 $\pm$ 0.95
3	Lymphocytes* (%)	33.13 $\pm$ 1.76	38.44 $\pm$ 1.61
4	Eosinophils (%)	1.04 $\pm$ 0.30	1.34 $\pm$ 0.20
5	Monocytes (%)	2.25 $\pm$ 0.30	2.14 $\pm$ 0.16
6	Basophils (%)	0.00 $\pm$ 0.00	0.00 $\pm$ 0.00

**Significant (P $\leq$ 0.05)*

3.4 Biochemical analysis

The mean values ($\pm$ SE) of biochemical parameters i.e. total protein, aspartate aminotransferase (AST) and alanine aminotransferase (ALT) in goats are presented in Table 3 and Figure 1 and 2, respectively. In the present study, significant reduction in the mean values of total protein were observed in goats positive for PPR as compared to negative goats. Reduction in total protein might be due to damage to the glomeruli walls that causes increased permeability of capillary walls leading to the leakage of proteins from blood to urine. Studies have also shown that feed intake, nutritional variations, and environmental and hormonal factors are associated with a decrease in total protein levels. There was non significantly increased AST values and significantly increased ALT values were observed in PPR positive goats as compared to PPR negative goats which correlated with liver damage caused by the virus. Any damage to hepatic tissues leads to a significant rise in the levels of ALT and AST, as these enzymes are present in various body tissues and are abundant stores that can be released and elevated during pathological damage to tissues. Similar findings were observed by Das et al. (2018); Yarim et al. (2006); Bari et al. (2018); Begum et al. (2018); Kataria et al. (2007); Islam et al. (2018) and Aziz et al. (2019). They reported significant decrease in the mean values of total protein in PPR positive goats in comparison to PPR negative goats. Chitra Devi et al. (2021) reported a significant increase in ALT levels with no significant difference in the AST value of PPR positive goats.

TABLE 3
MEAN ($\pm$ SE) BIOCHEMICAL VALUES OF PPR POSITIVE AND NEGATIVE GOATS

S.No.	Parameters	PPR Positive	PPR Negative
1	TP* (g/dL)	6.93 $\pm$ 0.21	7.48 $\pm$ 0.06
2	AST (IU/L)	86.84 $\pm$ 5.03	76.25 $\pm$ 2.53
3	ALT*(IU/L)	133.02 $\pm$ 5.41	70.93 $\pm$ 2.41

**Significant ($P \leq 0.05$)*

IV. CONCLUSION

The present study was carried out to determine the pathomorphological and haematobiochemical changes in PPR affected goats of Malwa region, Madhya Pradesh. During the six-month study period, 500 goats were screened irrespective of age, sex and breed, among which 100 goats showing clinical symptoms similar to PPR were selected and subjected to detailed antemortem, post-mortem, histopathological and haematobiochemical examinations. The diagnosis of PPR disease in goats of Malwa region was based on clinical examination, post-mortem changes, histopathological and haematobiochemical changes that were suggestive of PPR virus infection.

Gross and microscopic lesions suggestive of PPR were observed in the respiratory, digestive and lymphoid systems, particularly in the lungs, abomasum and mesenteric lymph nodes, along with the presence of intracytoplasmic and intranuclear inclusion bodies in the epithelial cell lining of bronchi and bronchioles, respectively. Haematological analysis revealed significantly decreased haematological parameters, leukocytosis with significant neutrophilia and lymphopenia, while biochemical analysis showed significant changes in total protein and ALT values. The present findings confirm that PPR in goats is associated with characteristic pathomorphological and haematobiochemical alterations that can aid in the diagnosis of the disease and will be helpful in formulating effective control and preventive strategies against this economically important disease in endemic regions

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CONFLICT OF INTEREST

The authors declare no conflict of interest.

REFERENCES

- [1] Aytekin, İ., Mamak, N., Ulucan, A., & Kalinbacak, A. (2011). Clinical, haematological, biochemical and pathological findings in lambs with Peste-des-petits-ruminants. *Kafkas Universitesi Veteriner Fakultesi Dergisi*, *17*(3), 49-55.
- [2] Aziz, R. P., Sharma, S. K., Kuldeep, S. K., Yadav, H. S., & Kuntal, N. (2019). Hemato-biochemical and electrolyte alterations in a flock of goats affected with Peste-des-petits-ruminants. *Journal of Pharmaceutical Innovation*, *8*(4), 18-21.
- [3] Balogun, F. A., Fasanmi, O. G., Oladipo, T. A., Popoola, M. A., Olona, J. F., & Adeoye, Y. D. (2017). Field evaluation and confirmation of acute Peste-des-petits-ruminants outbreak in a flock of West African dwarf goats in Ibadan, Nigeria. *International Journal of Veterinary Science and Medicine*, *5*(2), 75-80.
- [4] Bari, M. S., Rana, E. A., Ahaduzzaman, M., Al Masud, A., Das, T., & Hasan, T. (2018). Haemato-biochemical parameters of Pesti-des-petits-ruminants (PPR) affected goats in Chittagong, Bangladesh. *Journal of Advanced Veterinary and Animal Research*, *5*(2), 11-17.
- [5] Begum, S., Nooruzzaman, M., Parvin, M., Mohanto, N., Parvin, R., Islam, M. R., & Chowdhury, E. H. (2018). Peste-des-petits-ruminants virus infection of Black Bengal goats showed altered haematological and serum biochemical profiles. *Onderstepoort Journal of Veterinary Research*, *85*(1), 1-10.
- [6] Chauhan, H. C., Lambade, P. S., Sen, A., Dadawala, A. I., Ranaware, P. B., Chandel, B., Joshi, D. V., Patel, S. S., Pankaj, K., Shah, N. M., & Kher, H. N. (2011). The use of pathological and histopathological techniques in the diagnosis of Peste-des-petits-ruminants in India. *Veterinaria Italiana*, *47*(1), 41-47.
- [7] 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), 37-41.
- [8] Das, S., Nath, R., Balamurugan, V., Choudhury, R., & Devi, M. (2015). Haematobiochemical analysis of goats naturally infected with Peste-des-petits-ruminants. *International Journal for Research in Emerging Science and Technology*, *2*(9), 19-24.
- [9] Dimri, U., Mishra, S., Mishra, N., Shinde, A. K., Bhagwan, P. S. K., & Sharma, M. C. (2002). An outbreak of Peste-des-petits-ruminants in goats in an organised farm of semi-arid India. *Intas Polivet*, *3*(1), 96-100.
- [10] Emikpe, B. O., Sabri, M. Y., Akpavie, S. O., & Zamri-Saad, M. (2010). Experimental infection of Peste-des-petits-ruminants virus and *Mannheimia haemolytica* A2 in goats: Immunolocalisation of *Mannheimia haemolytica* antigens. *Veterinary Research Communications*, *34*, 69-78.
- [11] Emikpe, B. O., Ezeasor, C. K., Sabri, M. Y., & Anosa, V. O. (2013). Clinicopathological evaluation of intranasal, subcutaneous and intramuscular routes of vaccination against intratracheal challenge of Peste-des-petits-ruminants virus in goats. *Small Ruminant Research*, *113*(1), 290-296.
- [12] Islam, M., Pathak, D. C., Das, S., Raman, T., Sarma, S., Nath, R., & Sultana, A. (2023). Pathological and molecular studies of Peste-des-petits-ruminants in goats of Assam. *International Journal of Advanced Biochemistry Research*, *7*(2), 81-86.
- [13] Khan, A., Saleemi, M. K., Ali, F., Abubakar, M., Hussain, R., Abbas, R. Z., & Khan, I. A. (2018). Pathophysiology of Peste-des-petits-ruminants in sheep (Dorper and Kajli) and goats (Boer and Beetal). *Microbial Pathogenesis*, *117*, 139-147.
- [14] Kul, O., Kabakci, N., Atmaca, H. T., & Ozkul, A. Y. K. U. T. (2007). Natural Peste-des-petits-ruminants virus infection: Novel pathologic findings resembling other morbillivirus infections. *Veterinary Pathology*, *44*(4), 479-486.
- [15] Kumar, P., Tripathi, B. N., Sharma, A. K., Kumar, R., Sreenivasa, B. P., Singh, R. P., Dhar, P., & Bandyopadhyay, S. K. (2004). Pathological and immunohistochemical study of experimental Peste-des-petits-ruminants virus infection in goats. *Journal of Veterinary Medicine, Series B*, *51*(4), 153-159.
- [16] Madboli, A. A., & Ali, S. M. (2012). Histopathological and immunohistochemical studies on the female genital system and some visceral organs in sheep and goat naturally infected by Peste-des-petits-ruminants virus. *Global Veterinaria*, *9*(6), 52-60.
- [17] Mahajan, V., Filia, G., Bal, M. S., Kaur, G., Sharma, S., Dantotia, A., & Singh, C. K. (2017). Outbreaks of Peste-des-petits-ruminants (PPR) in goats in Punjab, India. *International Journal of Current Microbiology and Applied Sciences*, *6*(8), 5-10.
- [18] Maina, S. M., Gitao, C. G., & Gathumbi, P. K. (2015). Hematological, serological and virological findings in sheep and goats experimentally infected with lineage III Peste-des-petits-ruminants virus isolates in Kenya. *Journal of Experimental Biology and Agricultural Sciences*, *3*(1), 1-8.
- [19] Malik, M. (2016). *Molecular pathomorphology and immunodiagnosis of PPR in goats in Assam* [Doctoral dissertation, Assam Agricultural University].
- [20] Patel, Y. R., Patel, J. M., Vihol, P. D., Kalyani, I. H., Solanki, J. B., & Panchal, P. P. (2017). Pathomorphological studies of Peste-des-petits-ruminants (PPR) in goats of Navsari and Valsad Districts, India. *International Journal of Current Microbiology and Applied Science*, *6*(12), 38-44.
- [21] Pawalya, R. V. S., Misra, N., Bhagwan, P. S. K., & Dubey, S. C. (2004). Pathology and distribution of antigen in goats naturally infected with Peste des petits ruminant virus. *Indian Journal of Animal Sciences*, *74*(1), 35-40.
- [22] Pope, R. A., Parida, S., Bailey, D., Brownlie, J., Barrett, T., & Banyard, A. C. (2013). Early events following experimental infection with Peste-des-petits ruminant virus suggest immune cell targeting. *PLoS One*, *8*(2), e55830.
- [23] Rahman, M. A., Shadmin, I., Noor, M., Parvin, R., Chowdhury, E. H., & Islam, M. R. (2011). Peste-des-petits-ruminants virus infection of goats in Bangladesh: Pathological investigation, molecular detection and isolation of the virus. *Bangladesh Veterinarian*, *28*(1), 1-7.
- [24] Sahinduran, S., Albay, M. K., Sezer, K., Ozmen, O., Mamak, N., Haligur, M., Karakurum, C., & Yildi, R. (2012). Coagulation profile, haematological and biochemical changes in kids naturally infected with Peste-des-petits-ruminants. *Tropical Animal Health and Production*, *44*, 53-57.

- [25] Shaila, M. S., Shamaki, D., Forsyth, M. A., Diallo, A., Goatley, L., Kitching, R. P., & Barrett, T. (1996). Geographic distribution and epidemiology of Peste-des-petits-ruminants viruses. *Virus Research*, *43*(2), 49-53.
- [26] Sharma, C. S., Mehta, H. K., Prakash, M. M., & Shukla, P. C. (2012). Studies on clinico-haemato-biochemical changes in Peste-des-petits-ruminants in goats. *Veterinary Practitioner*, *13*(2), 22-25.
- [27] Singh, R., Singh, R., Singh, S., Kamdi, B., Kumari, S., Singh, R., & Husain, A. (2018). Patho-morphological based diagnosis of Peste-des-petits-ruminants (PPR) in goats. *Journal of Animal Research*, *8*(3), 45-48.
- [28] Snedecor, G. W., & Cochran, W. G. (1994). *Statistical methods* (8th ed., pp. 312-317). The Iowa State University Press Publishing Co.
- [29] Toplu, N. (2004). Characteristic and non-characteristic pathological findings in Peste-des-petits-ruminants (PPR) of sheep in the Ege district of Turkey. *Journal of Comparative Pathology*, *131*(2-3), 35-41.
- [30] Ugochukwu, I. C. I., Ugochukwu, E. I., & Chukwu, C. C. (2018). Haematological parameters and serum biochemical assay of West African dwarf goats infected with Peste-des-petits-ruminants virus in Nsukka, Enugu State. *Comparative Clinical Pathology*, *27*, 13-19.
- [31] Yarim, G. F., Nisbet, C., Yazici, Z., & Gumusova, S. O. (2006). Elevated serum total sialic acid concentrations in sheep with Peste-des-petits-ruminants. *Medycyne Weterinaryjna*, *62*(12), 75-77.