Research Article

Seroprevalence and Risk Factors of Peste des Petits Ruminants in Goats from Khipro, District Sanghar, Sindh

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Abstract | This study aimed to determine the seroprevalence of Peste des Petits Ruminants (PPR) in goats of Khipro District, Sanghar, and assess associated risk factors. A total of 180 serum samples were randomly collected from goats of varying age groups and categorized based on clinical, para-clinical, and gross pathological postmortem findings. Samples were analyzed using competitive ELISA at the Central Veterinary Diagnostic Laboratory (CVDL), Tandojam, Sindh. The overall seroprevalence of PPR was highest in non-irrigated areas (72.54%) compared to irrigated regions (45.73%). Gender-wise, females exhibited higher infection rates (59.85%) than males (34.88%). Age significantly influenced prevalence, with goats >12 months showing the highest Seropositivity (73.33%) and those aged 4–12 months the lowest (32.72%). Seasonal variation was evident, with August recording the highest prevalence (67.39%) and October the lowest (31.88%). Clinically positive samples demonstrated markedly higher seroprevalence (61.97%) than para-clinical cases (21.05%). Clinical monitoring revealed peak body temperature (105.38°F) and pulse rate (120 BPM) on days 5 and 4, respectively, while respiratory rates peaked at 50 RPM on day 4. Severe clinical manifestations included oculo-nasal discharge (day 10), diarrhea (day 7), dehydration (day 7), necrotic stomatitis (day 9), and cough (day 10). Postmortem analysis identified stomatitis, tracheal froth, pneumonic lungs, splenomegaly, mesenteric lymphadenopathy, intestinal hemorrhages, and pathognomonic "zebra striping" lesions in the gastrointestinal tract. This study concludes that PPR seroprevalence in Khipro District is alarmingly high, particularly in non-irrigated zones, female goats, and older animals (>12 months). The findings underscore the need for targeted vaccination campaigns, enhanced surveillance, and farmer education to mitigate PPR's impact on goat populations and local livelihoods.

Keywords | PPR, Seroprevalence, C-ELISA, Goats, Khipro, Sindh, Risk factors

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INTRODUCTION

The domestic goat (Capra hircus), a member of the family Bovidae and subfamily Caprinae, is one of the earliest domesticated livestock species, with origins tracing back to wild goats in the Fertile Crescent of the Near East around 10,000 years ago (Zeder, 2008). Goats are raised globally in various production systems, with over 1 billion

animals, and are especially important in tropical and sub-tropical regions (Escareño *et al.*, 2012).

Goat farming plays a vital role in the livelihood of smallholder farmers, particularly in low-income countries, where goats are often referred to as the poor man's cow due to their ability to thrive in harsh environments and provide meat, milk, fiber, and income (Peacock, 2005; Kosgey and Okeyo, 2007).

Worldwide population of goat is about one billion, and the goat population globally more than double during the last four decades. According to the Food and Agriculture Organization, over 90% of goats are found in developing countries; Asia has the largest proportion of the world's goat population, followed by Africa (Utaaker *et al.*, 2021). Pakistan ranks third globally, with an estimated goat population of about 80 million (Abdullah *et al.*, 2024). Despite their resilience, goats are vulnerable to numerous infectious diseases that significantly hinder productivity. Among these, Peste des Petits Ruminants (PPR) is considered one of the most devastating viral diseases affecting small ruminants, causing substantial economic losses due to high morbidity and mortality, decreased productivity, and restricted trade (Munir, 2014; OIE, 2021).

PPR is a transboundary viral disease caused by PPR virus (PPRV), a negative-sense, single-stranded RNA virus belonging to the genus Morbillivirus, family Paramyxoviridae (Parida *et al.*, 2015). The disease was first described in Côte d'Ivoire in 1942 and has since spread extensively throughout Africa, the Middle East, and Asia (Baron *et al.*, 2016; Gargadennece and Lallanne, 1942). It was first reported in Pakistan in 1991, and since then, it has become endemic across the country, with recurrent outbreaks particularly in Punjab, Sindh, and Khyber Pakhtunkhwa (Abubakar *et al.*, 2015; Khan *et al.*, 2008).

The virus is transmitted primarily via aerosols, direct contact with infected secretions (nasal, ocular, oral), and contaminated feed or water (Albina *et al.*, 2013). Clinical signs of PPR include high fever, nasal and ocular discharges, stomatitis, pneumonia, severe diarrhea, and often death within a few days (Kabir *et al.*, 2019). Morbidity may cross 90%, while mortality typically ranges between 50% and 80% in naïve populations (Kabir *et al.*, 2020; Abubakar *et al.*, 2008). Although both sheep and goats are susceptible, goats tend to exhibit more severe clinical signs and higher case fatality rates (Abubakar *et al.*, 2015; Truong *et al.*, 2014; Ahmed, 2020). The disease is most prevalent during periods of climatic stress, such as the rainy season or during winter when animals are housed closely together (Ahmed, 2020; Salih *et al.*, 2014; Tenuche *et al.*, 2023).

Post-mortem lesions often include Ulcerative to necrotic stomatitis, bronchopneumonia, and "zebra-striping" of the colon due to hemorrhagic lesions (Parida *et al.*, 2015; Yousaf *et al.*, 2023). These findings, along with clinical history and laboratory testing, help differentiate PPR from diseases such as bluetongue, Foot and Mouth Disease, contagious caprine pleuropneumonia (CCPP), contagious Ecthyma, contagious pustular stomatitis and sheep/goat pox (Yousaf *et al.*, 2023; Kamal and El-Sayed, 2019).

Diagnosis is confirmed using laboratory tests such as competitive ELISA (cELISA), real-time PCR, and virus isolation, antigen and antibody detection, and molecular approaches all are used in diagnosis (Yousaf *et al.*, 2023; Kamal and El-Sayed, 2019). Although no antiviral treatment exists, supportive therapy and the control of secondary bacterial infections can reduce mortality (Kabir *et al.*, 2019; Ayaz *et al.*, 1997; Abubakar and Irfan, 2014). Vaccination remains the most effective control measure, with live attenuated vaccines offering long-lasting immunity (Zhao *et al.*, 2021; Liu *et al.*, 2014).

The socioeconomic burden of PPR is significant. In Pakistan alone, estimated annual losses exceed PKR 20.5 billion due to deaths, reduced production, and trade limitations (Abera, 2023). As a result, the FAO and OIE have launched a global eradication program aiming to eliminate PPR by 2030 (Njeumi *et al.*, 2015).

MATERIALS AND METHODS

Study area and experimental design

This study was conducted in Khipro Tehsil of Sanghar District, Sindh Province, Pakistan. A total of 180 blood serum samples were randomly collected from goats exhibiting clinical signs suggestive of PPR Goats were selected using simple random sampling from various herds across the Union Councils. The samples were obtained from goats across 14 Union Councils, namely Khipro, Hathungo, Bhopi, Qazi Faiz Muhammad, Khori, Hafizabad, Dhilyar, Hamzo Dars, Khahi, Roonjho, Kamil Hingoro, Bilal Hingorjo, Banko Chanihon, and Ranak Dahar.

Goats were categorized based on clinical condition (clinical, para-clinical, and gross pathological) and demographic characteristics including age and sex. The age groups included: 0–4 months (suckling), 4–12 months (young), and >12 months (adults), further divided into males and females. Clinical signs observed in suspected animals included fever, diarrhea, oculo-nasal discharge, coughing, dehydration, oral lesions, and respiratory distress. Dead animals were subjected to postmortem examination with focus on respiratory and gastrointestinal lesions.

Sample collection and transport

From each goat, 5 mL of blood was aseptically collected from the jugular vein using disposable syringes. The blood samples were transferred to sterile vacutainer tubes without anticoagulant. After clotting, serum was separated by allowing the tubes to stand for 3 hours at ambient temperature and then stored at 4 °C. All serum samples were maintained under cold chain and submitted to the Central Veterinary Diagnostic Laboratory (CVDL), Tandojam, for PPRV antibody detection.

Competitive enzyme-linked immunosorbent assay (C-ELISA)

Detection of PPRV-specific antibodies in serum samples was performed using a commercial competitive ELISA kit (ID Screen® PPR Competition, IDvet, Grabels, France) following the manufacturer's instructions. In brief, 25 µL of dilution buffer and 50 µL of each test serum, positive control, and negative control were added to appropriate wells in a pre-coated microtiter plate. The plate was incubated at 37±3°C for 45±4 minutes to facilitate binding. After incubation, the wells were washed three times with 300 µL of wash buffer to remove unbound substances.

Subsequently, 100 µL of anti-PPRV monoclonal antibody conjugated to peroxidase was added to each well and incubated for 30 minutes at 21±5°C. A second wash step was performed to remove excess conjugate. Then, 100 µL of substrate solution (TMB) was dispensed into each well and incubated in the dark at 21±5°C for 15±2 minutes. The enzymatic reaction was stopped by adding 100 µL of stop solution, and the optical density (OD) was measured at 450 nm using a microplate reader.

Results were interpreted based on the competition percentage (S/N%). Samples with S/N% ≤ 50% were considered positive, those >60% were negative, and those between 51% and 59% were considered doubtful and retested for confirmation.

Statistical analysis

Data were analyzed using the Statistical Package for the Social Sciences (SPSS), version 24.0 (IBM Corp., Armonk, NY, USA). Descriptive statistics were used to summarize the prevalence of PPRV antibodies across different age groups, sex, and clinical categories.

RESULTS

Seroprevalence of PPRV in goats

A total of 180 serum samples were tested to determine the seroprevalence of Peste des Petits Ruminants Virus (PPRV) in goats from 14 union councils of Khipro, District Sanghar, Sindh. The sampled areas included Khipro, Hathungo, Bhopi, Qazi Faiz Muhammad, Khori, Hafizabad, Dhilyar, Hamzo Dars, Khahi, Roonjho, Kamil Hingoro, Bilal Hingorjo, Banko Chanihon, and Ranak Dahar. Goats exhibiting clinical signs of PPR, such as coughing, diarrhea, stomatitis, pyrexia, and oculo-nasal discharge, were selected for sampling. Each animal was bled via jugular venipuncture, and serum was separated and stored at –20 °C until testing. All serum samples were submitted to the Virology Section of the Central Veterinary Diagnostic Laboratory in Tandojam, where competitive ELISA (c-ELISA) was used for the detection of PPRV antibodies.

Area-wise seroprevalence

The analysis revealed that the highest seroprevalence (72.54%) was recorded in non-irrigated areas, whereas irrigated regions showed a lower prevalence (45.73%) (Figure 1). This suggests an influence of environmental and management conditions on disease exposure.

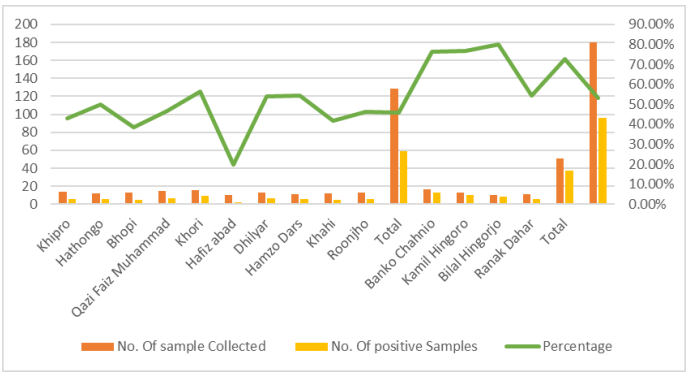

Figure 1: Area wise Sero-prevalence of peste des petits ruminants in goats.

Gender-wise seroprevalence

Among the tested animals, female goats demonstrated a higher seroprevalence rate (59.85%) compared to males (34.88%) (Figure 2). This discrepancy may reflect differences in exposure, immunity, or management practices between sexes.

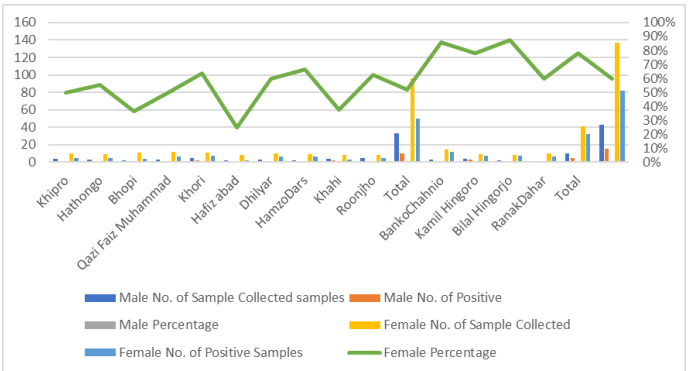

Figure 2: Gender wise sero-prevalence of peste des petits ruminants in goats.

Age-wise seroprevalence

Seroprevalence was assessed across three age groups. Goats older than 12 months had the highest seropositivity (73.33%), followed by those aged 0–4 months (46.00%) and 4–12 months (32.72%) (Figure 3). The results indicate increased exposure with age.

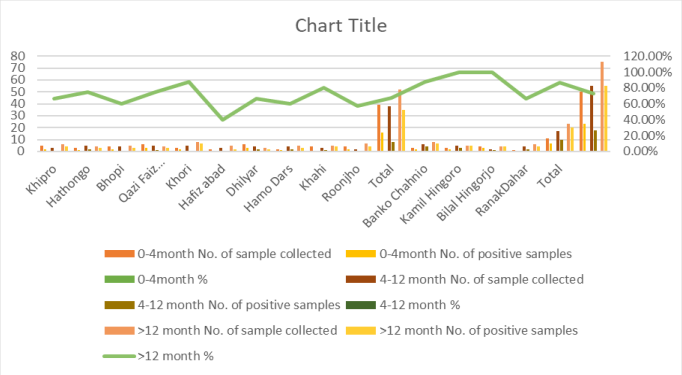

Figure 3: Age wise sero-prevalence of peste des petits ruminants in goats.

Month-wise seroprevalence

Seasonal variation was observed, with the highest seroprevalence recorded in August (67.39%) and the lowest in October (31.88%) (Figure 4), Seasonal variation suggests potential links with climatic factors or animal movement patterns influencing PPRV prevalence.

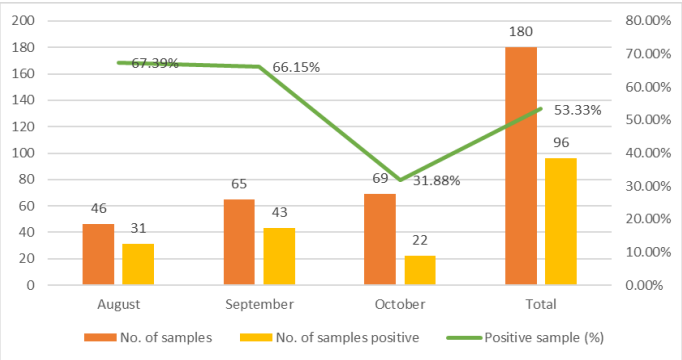

Figure 4: Month wise sero-prevalence of peste des petits ruminants in goats.

Clinical vs. para-clinical sero-positivity

Clinically suspected animals exhibited a higher seropositivity rate (61.97%) compared to para-clinical (subclinical) cases (21.05%) (Figure 4 and Table 1). Clinically positive animals were closely monitored for 14 days, and symptoms such as depression, nasal discharge, and diarrhea were recorded.

Table 1: Clinical and para-clinical sero-prevalence of PPR in goats of Khipro, district Sanghar.

Clinical			Para-clinical		
No. of samples	**No. of positive samples**	**Percentage**	**No. of sample**	**No. of positive sample**	**Percentage**
142	88	61.97%	38	8	21.05%

Clinical findings

Detailed clinical monitoring was performed on a herd of nine goats in Khori village, which tested positive for PPRV. Over a two-week period, clinical signs were scored on a severity scale (0–3). A progressive increase in body temperature was noted from day 1 (104.44 °F) to a peak on day 5 (105.38 °F), followed by a gradual decline to 103.18 °F by Day 10 (Figure 5).

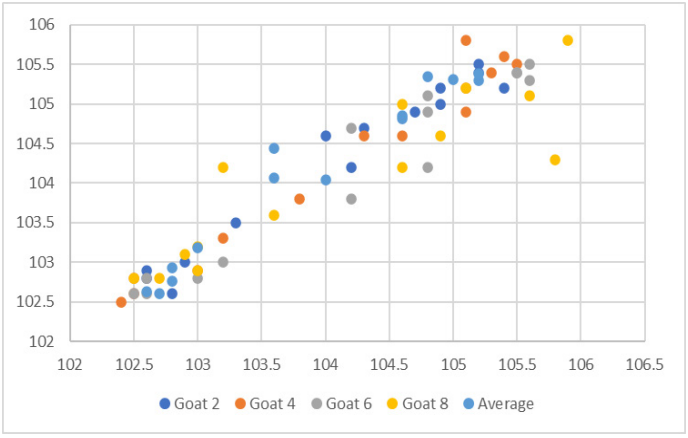

Figure 5: Temperature in goats was observed in clinical study in union council Khori of Khipro, district Sanghar.

Pulse and respiration rates peaked on Day 4 at 120 BPM and 50 RPM, respectively (Figures 6, 7). Serous to mucopurulent nasal discharge intensified by Day 10, with complete nostril obstruction observed (Figure 12). Mucoid diarrhea was prominent between Days 6 and 11 (Figure 9), dehydration peaked from Days 6 to 10 (Figure 10), and stomatitis with labial scabs was most severe from Days 8 to 11 (Figure 8). Coughing intensified between Days 6 and 13 (Figure 11).

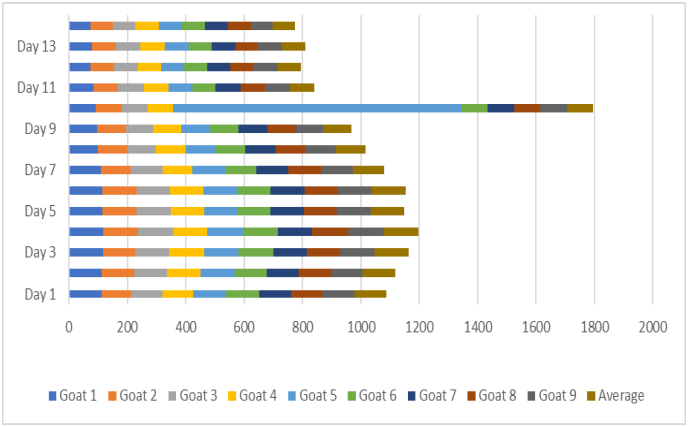

Figure 6: Pulse rate in goats was observed in clinical study in union council Khori of Khipro, district Sanghar.

Gross pathological lesions

Postmortem examination of four PPRV-positive goats revealed 45% mortality among clinically affected animals. Lesions included excoriation of lips, nasal and oral erosions, tracheal exudates, and pneumonic lungs with

fibrous adhesions to the rib cage. Three animals showed right anterior lobe consolidation, while one showed left lobe involvement. One goat had a focal lung abscess. Splenic congestion and atrophy were common, along with intestinal hemorrhages and congested mesenteric lymph nodes. Erosions of the vulval mucosa were seen in two cases that died in the acute phase of disease (Table 2).

Table 2: Postmortem findings of died animals during study.

Postmortem findings	Goat 1	Goat 2	Goat 3	Goat 4	Average
Necrotic stomatitis	2	2	1	1	1.5
Hyperemia and froth in trachea and bronchi	3	1	2	2	2
Pneumonic lungs	2	3	3	2	2.5
Enlarged spleen	2	1	2	2	1.75
Enlarged mesenteric lymph nodes	1	1	2	0	1
Hemorrhages in intestine	1	2	1	0	1

Pathological findings were scored as nil (0), light (1), moderate (2) and severe (3) according to its severity.

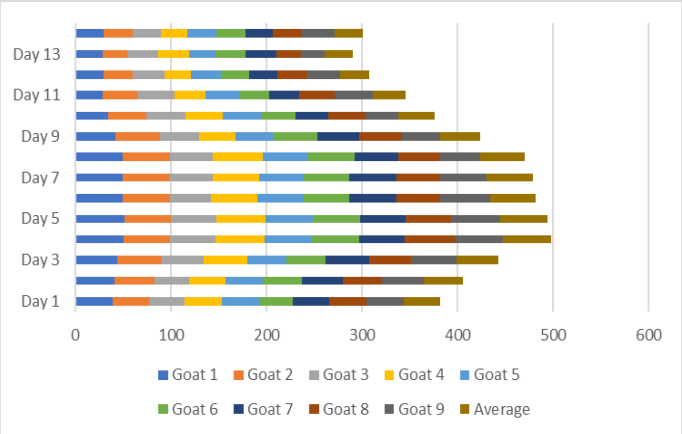

Figure 7: Respiration rate in goats was observed in clinical study in union council Khori of Khipro, district Sanghar.

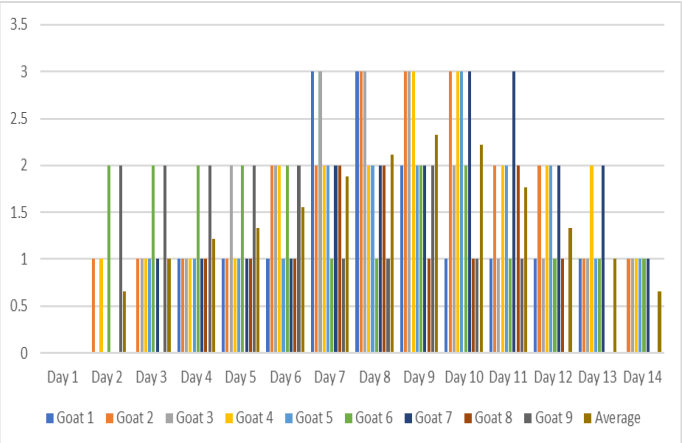

Figure 8: Stomatitis in goats was observed in clinical study in union council Khori of Khipro, district Sanghar.

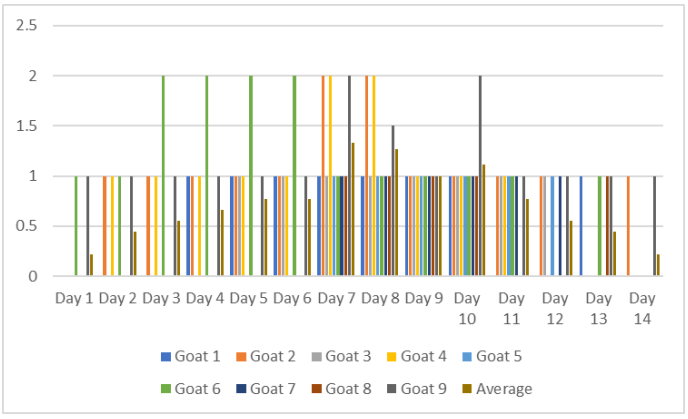

Figure 9: Diarrhea in goats was observed in clinical study in union council Khori of Khipro, district Sanghar

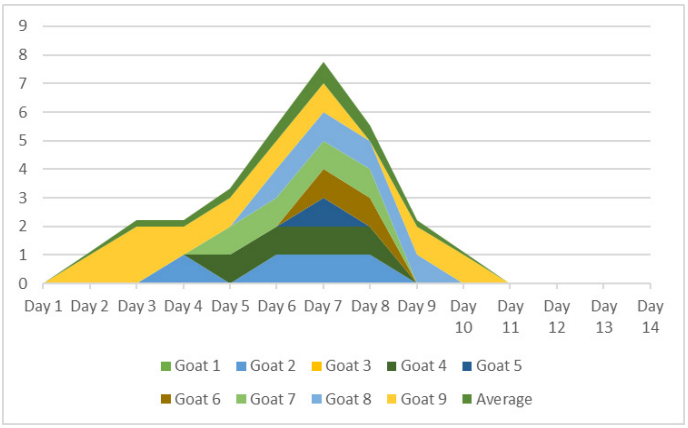

Figure 10: Dehydration in goats was observed in clinical study in union council Khori of Khipro, district Sanghar.

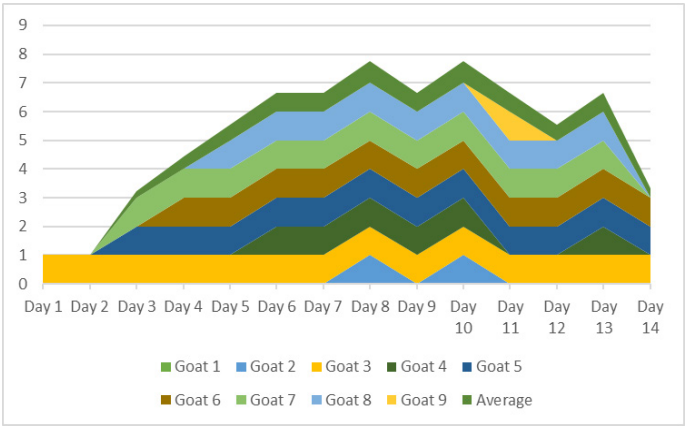

Figure 11: Cough in goats was observed in clinical study in union council Khori of Khipro, district Sanghar.

DISCUSSION

This study investigated the seroprevalence of Peste des Petits Ruminants (PPR) in goats from Taluka Khipro, District Sanghar, using a competitive ELISA (c-ELISA). The results revealed a high seroprevalence in non-irrigated areas (72.54%) compared to irrigated zones (45.73%), indicating a significant influence of environmental conditions on the spread of PPR.

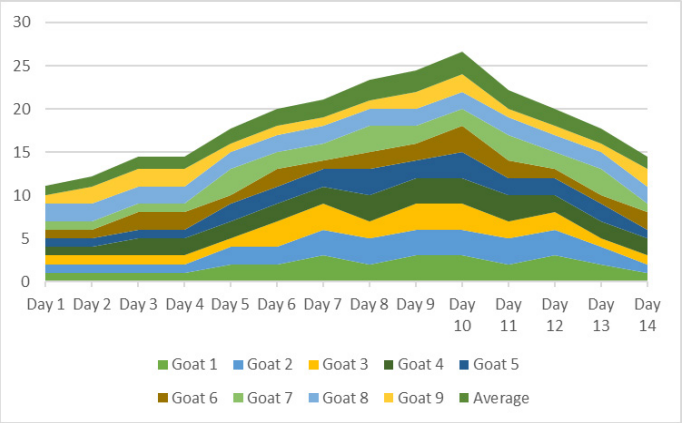

Figure 12: Occulo-nasal discharge in goats was observed in clinical study in union council Khori of Khipro, district Sanghar.

Our findings align with the study by Nizamani *et al.* (2015), who reported a seroprevalence of 69.3% in the non-irrigated, hilly regions of Kohistan, District Dadu. In contrast, lower rates were reported in irrigated areas such as Hyderabad (47.1%) and Khairpur (40.7%). This difference may be due to arid climates, reduced nutritional availability, and greater mobility of animals in desert areas, all of which contribute to increased disease transmission.

Vaccination is widely recognized as the primary tool for PPR prevention and control. However, a major challenge in Pakistan is inadequate vaccine coverage, especially in remote pastoral communities. According to Khan *et al.* (2007), nearly 70–80% of the goat population remains at Risk due to limited immunization campaigns and lack of regular vaccination schedules. Environmental factors such as humidity, rainfall, and stressful conditions caused by seasonal migrations also contribute significantly to outbreak occurrences (Khan *et al.*, 2007).

The movement of animals across long distances, often in search of food and water, increases exposure to the virus. The resultant fatigue and stress compromise immunity and create ideal conditions for viral transmission (Rahman *et al.*, 2004). Introducing new animals into existing herds especially those sourced from endemic regions has also been shown to accelerate the spread of the disease (Zahur *et al.*, 2011).

Gender-wise, a higher seroprevalence was observed in female goats (59.85%) compared to males (34.88%). This result is consistent with the findings of Kihu *et al.* (2015) and Aziz-ul-Rahman *et al.* (2016), who also reported a greater susceptibility in females, possibly due to stress from reproductive cycles, pregnancy, and lactation all of which suppress immune responses.

Age was also a significant factor. Adult goats (>12 months) showed the highest seroprevalence (73.33%), followed by kids aged 4–12 months (32.72%), and suckling kids (0–4 months) at 46.0%. These findings are consistent with those of Zahur *et al.* (2011) and Aziz-ul-Rahman *et al.* (2016), who observed that adults often test positive due to prior exposure to the virus or vaccination, whereas younger animals are more likely to be negative.

Seroprevalence was highest during August (67.39%), followed by September (66.15%), and declined in October (31.88%). These results align with observations by Sarker and Islam (2011), who found PPR outbreaks to be more frequent during the monsoon season due to increased humidity, muddy conditions, and poor ventilation in animal shelters. Similar seasonal patterns were mentioned by Kabir *et al.* (2019).

The nutritional status and socio-economic conditions of farmers also influence the spread and impact of PPR. In Khipro, poor fodder availability, limited veterinary outreach, and low awareness levels among livestock keepers likely contributed to high infection rates (Khan *et al.*, 2007).

Clinically infected animals showed hallmark symptoms including high fever, mucopurulent nasal discharge, ocular exudate, oral lesions, respiratory distress, and diarrhea. Clinical signs peaked between days 4 to 9 post-infection, which is consistent with findings by Balamurugan *et al.* (2014) and Radostits *et al.* (2000). These signs reflect the virus's affinity for epithelial tissues, resulting in inflammation and necrosis.

Serologically, clinically infected animals showed higher antibody levels (61.97%) compared to para-clinical cases (21.05%), corroborating the observations of (Haji *et al.*, 2007), who found stronger seropositive responses in symptomatic goats.

Overall, our study confirms the endemicity of PPR in desert regions like Khipro and highlights the urgent need for targeted vaccination campaigns, farmer education, and improved veterinary outreach. Factors such as gender, age, seasonal variations, and migration patterns must be considered in designing effective control programs.

CONCLUSIONS

This study highlights a high seroprevalence of Peste des Petits Ruminants (PPR) in goats from Taluka Khipro, District Sanghar, with significant variations based on ecological zone, age, sex, and season. Goats in non-irrigated desert areas showed a higher seroprevalence, suggesting that arid environmental conditions, animal mobility, and limited veterinary access contribute to increased

disease transmission. Female and adult goats were more frequently seropositive, likely due to longer exposure times and physiological stressors. Clinical, para-clinical, and pathological observations confirmed that PPR remains a pressing health threat, particularly during the monsoon season when the risk of outbreaks is elevated. The study also confirms that c-ELISA is an effective diagnostic tool for detecting PPR antibodies in both symptomatic and asymptomatic animals. Given the endemic nature of PPR in the region, there is an urgent need for sustained and targeted vaccination campaigns, farmer education on disease prevention, and improved veterinary outreach services especially in remote desert zones. These efforts are essential to prevent economic losses, safeguard animal health, and move toward the global goal of PPR eradication by 2030.

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NOVELTY STATEMENT

This is the first documented study assessing the seroprevalence and clinical pathology of Peste des Petits Ruminants (PPR) in goats from Taluka Khipro, District Sanghar, a semi-arid region of Sindh, Pakistan. The research uniquely combines serological evidence using c-ELISA with clinical, para-clinical, and pathological findings, offering comprehensive insights into disease dynamics. The study also identifies ecological zone-specific risk patterns, emphasizing higher PPR occurrence in non-irrigated desert areas, which has not been previously reported in the literature. These findings are crucial for designing area-specific control strategies and vaccination policies in dryland pastoral systems.

AUTHOR'S CONTRIBUTION

AK and AR have equal contribution to this research work. Additionally, AK analysed the data and wrote the paper. MU, AAL and NAS have completed the sampling and performed the CMT test. AK, and MZ have performed the biochemical tests. MIM and SUJ, FAA has designed the study and funded the research work.

Conflict of interest

The authors have declared no conflict of interest.

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