Small Ruminant Research 178 (2019) 111–116

Contents lists available at ScienceDirect

Small Ruminant Research

journal homepage: www.elsevier.com/locate/smallrumres

Short communication

Cross-sectional seroprevalence study of peste des petits ruminants in goats in Andaman and Nicobar Islands, India

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ARTICLE INFO

Keywords:
PPR
Goats
Seroprevalence
Cross-sectional study
Andaman Nicobar Islands
India

ABSTRACT

This cross-sectional study describes the seroprevalence of peste des petits ruminants (PPR) in goats in Andaman and Nicobar (AN) Islands, India during 2017–2018. A total of 392 goat serum samples were collected from 36 epidemiological units (epi-units) using a stratified random sampling procedure and were screened for PPR virus (PPRV) antibody using an indigenously developed PPR monoclonal antibody-based competitive enzyme-linked immunosorbent (ELISA) assay. The results showed that the overall 1.28% (0.01-0.03 at 95% confidence interval) and 1.39% apparent and true prevalence of PPRV antibodies in goats in the studied region. Further, a few samples from five epi-units have only shown marginal positive (percentage inhibition (PI) value ranged from 40.4 to 48.0) for PPRV antibodies with less than 30% seroprevalence in all the tested epi-units in the study region. The finding infers that the goat population in the region are generally free from PPRV antibodies, as there were neither PPR outbreaks reported nor PPR vaccination strategies practiced in goats in AN Islands. Further, the PPR immune protection in goats is almost nil, when compared with the mainland of India, where the disease is enzootic with varying percentage of seroprevalence and population immunity is being reported. This is first of its kind on the prevalence study of the PPRV antibodies in goats in a unique niche of AN archipelago of India.

1. Introduction

Peste des petits ruminants (PPR), otherwise called as 'Small Ruminant Plague' or 'Goat Plague', is an acute, highly contagious, World Organization for Animal Health (OIE) notifiable and an economically important transboundary viral disease of domestic (goats and sheep) and wild small ruminants. The disease is caused by the small ruminant morbillivirus (SRMV), formerly known as PPR virus (PPRV), a member of genus *Morbillivirus* of the family *Paramyxoviridae* (http://ictvonline.org/virusTaxonomy.asp). Clinically, PPR is characterized by pyrexia, oculonasal discharges, stomatitis, gastroenteritis, diarrhoea, and bronchopneumonia. PPR is associated with high morbidity (ranges from 10% to 100%) and mortality (usually ranges from 50% to 90%) in susceptible sheep and goats and poses a heavy threat to the national economy of the enzootic countries (Balamurugan et al., 2014a; Govindaraj et al., 2016). PPR is a major constraint and affects the productivity of sheep and goats and it is considered enzootic in Africa, Arabian Peninsula, Middle East, Central, and South-East Asia. The disease significantly impacts the small ruminant sector and affects food security in enzootic countries. Following the worldwide eradication of Rinderpest in 2011, a global consensus on PPR Global Control and Eradication Strategy (GCES) was reached on the need to eradicate PPR with the vision of a PPR-free world by 2030. An initial PPR Global Eradication Programme (PPR-GEP) for the period 2017–2021 was launched by the Food and Agriculture Organization and OIE to put the GCES into action (OIE, FAO, 2015).

Moreover, some of the UTs and states including AN Islands has not implemented the vaccination programme, due to the low incidence or no outbreaks of PPR reported from their respective UT/States. At present, the disease has been brought under control in some of the states of India and the occurrence and severity have been progressively and substantially declined in areas under regular vaccination (Balamurugan et al., 2016; Govindaraj et al., 2019). In India, several PPR outbreaks have not been recorded properly, owing to inadequate animal disease

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https://doi.org/10.1016/j.smallrumres.2019.08.013
Received 15 May 2019; Received in revised form 24 August 2019; Accepted 24 August 2019
Available online 25 August 2019
0921-4488/

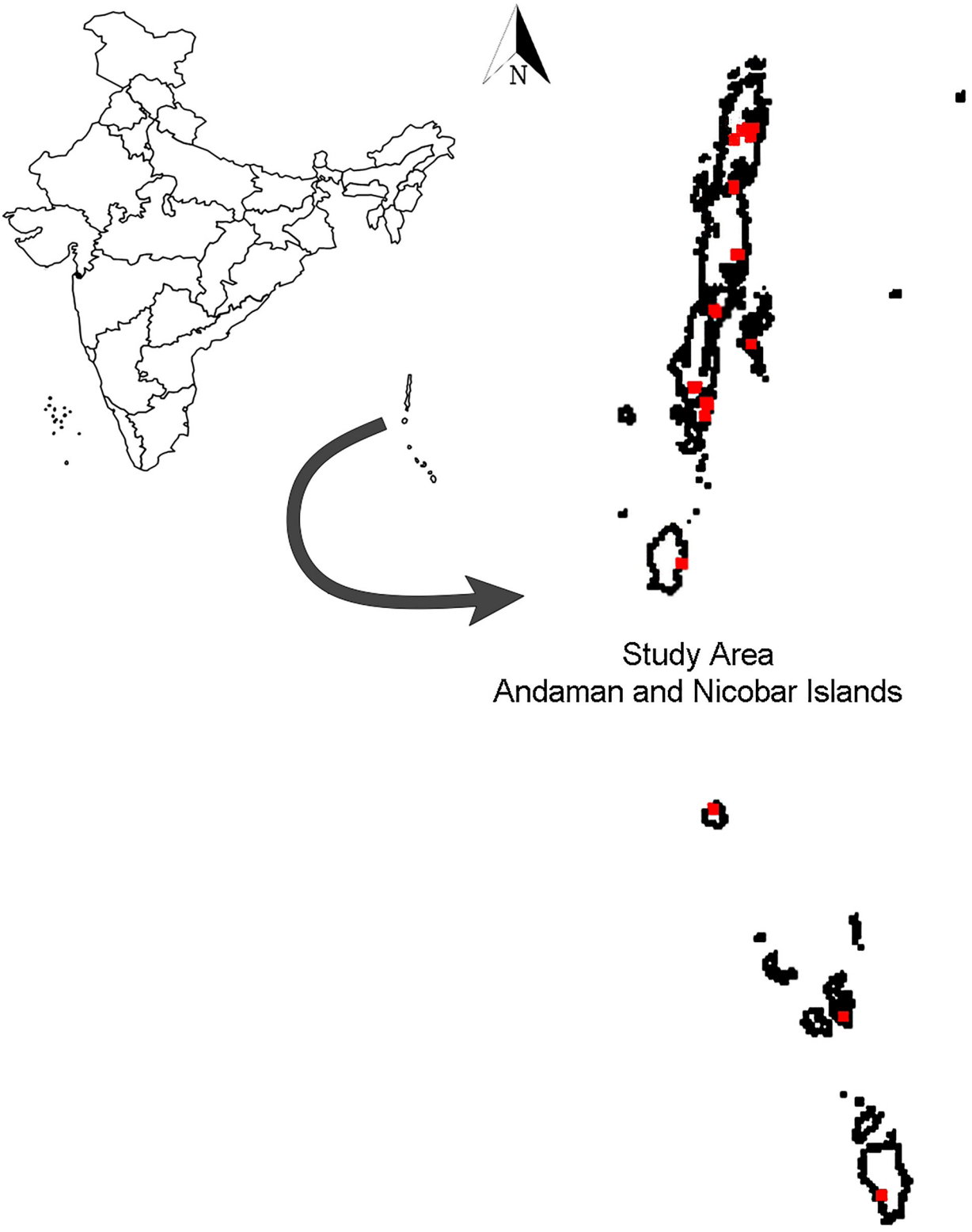

Fig. 1. The surveyed epi-unit (village) places are depicted (as ■ a dot) in GIS Map of AN islands of India.

reporting and surveillance systems. Hence, measurement of the prevalence of antibodies to PPRV in different geographical locations of the country with varying agro-climatic conditions may be helpful in developing disease control strategies. Organized surveys of the nation- or region/zone- or state-wide, the prevalence of PPR in India have not been conducted except a few isolated studies. A small number of reports published since 1994, from various states of India, have generally indicated that most positive animals have migrated from neighbouring states (Sunilkumar et al., 2005; Balamurugan et al., 2011, 2012). Furthermore, prevalence study is paramount important for formulating effective disease control measures to prevent the disease incursion or infiltration especially in isolated environments such as distant islands as well as to make or acquire disease-free status by implementing the comprehensive active intensive surveillance and monitoring

programme. This would help in sustainable livestock production and management for the livelihood of farmers in the limited demographical condition of islands, and even it paves a way for export trade in the disease-free status of niche. Therefore, a cross-sectional prevalence study of PPR in goats in AN Islands, India was carried out to understand /determine the seroprevalence status of goats reared under unique niche isolated archipelago settings.

2. Materials and methods

2.1. Study area

AN Islands was purposively selected as the disease has not been reported (http://www.dahd.nic.in/), though the disease is reported since 1987 and enzootic in the mainland of India. The AN Archipelago is a unique niche consisting of more than 500 Islets situated between 6 °N and 14 °N latitude and 92 °E and 94 °E longitude ~1200 km south-east of the Indian peninsula in the Bay of Bengal and is spread over a linear distance of > 550 km and geographical area of 8,249 km^2. As per 19th Livestock Census, 2012, AN Islands, has only 65324 goat population among the small ruminants (http://www.dahd.nic.in/) and five breeds (Andaman local, Barren or Feral/semi-feral, Teressa, Malabari, and its crosses and Boer crosses) of goats are being reared (Chand et al., 2013). The rural communities resided in the village consisting of a group of households that pursue similar animal husbandry and socio-economic activities. Hence, the village is a distinct unit and considered as the epi-unit in this study.

2.2. Sampling plan

Indian Council of Agricultural Research (ICAR)- National Institute of Veterinary Epidemiology and Disease Informatics (NIVEDI), conducts regular surveys to monitor the status of livestock diseases in the country. As a part of that activity, a cross-sectional study was conducted between April 2017 and March 2018 to ascertain the prevalence status of PPRV antibodies in the goat population in AN Islands. The sampling strategy was determined based on the goat population and the sample size was determined by using the formula $N = Z^2 [p (1-p/e^2)$ (Cochran, 1963) through epitools, where N = sample size, Z = 95% confidence level, p = 50% proportion (at maximum estimated true proportion), e is the precision of the sample size estimate (5%). Based on these input parameters, a total sample size of 383 were determined (http://epi-tools.ausvet.com.au/content.php?page = 1Proportion), for the goat population in AN islands.

A list of revenue villages and their goat population in AN Islands was prepared and in order to have a sizeable population, when approached for sampling, the villages (epi-units) having more than 30 goats were shortlisted for the sampling frame. The number of secondary units (animal) samples within an epi-unit were calculated by the hypergeometric distribution as per GCES guidelines with the unit prevalence of 30% (OIE, FAO, 2015) and a maximum of 9–11 samples to be collected based on the goat population in the each epi-units. (https://nivedi.res.in/Nadres_v2/Epical/herd_level_sample_size.php). Accordingly, the number of required primary sampling epi-units (35–42) arrived and the estimated epi-units were allocated randomly to blocks or tehsils in all the three districts of AN islands using R software (R Core Team, 2014).

2.3. Serum samples

In each epi-unit, animals are selected by the simple random method and a maximum of 11 unit samples based on the available goat population from each selected epi-units with a total of 392 serum samples from 36 epi-units were collected through collaborating center of ICAR-NIVEDI, AICRP on ADMAS, Animal Science Division, ICAR- CIARI, Port Blair. The sample surveyed village places are depicted in GIS Map (Fig. 1) based on their geo-coordinates using QGIS Software 2.18.6 version. Collected blood sample in vacutainer tubes was labeled and placed in a cool shipment box with ice packs and separated sera in the laboratory were transported to the ICAR-NIVEDI, Bengaluru. The samples upon received were stored at −20 °C until further use.

2.4. Sample testing

The collected serum samples were tested by indigenously developed PPR competitive ELISA for detection of antibodies against PPRV, which were measured in terms of percentage inhibition (PI) according to the protocol described by Singh et al. (2004b). Samples with PI of ≥40% were considered positive for the presence of PPRV specific antibodies and the overall percentage positivity was calculated.

2.5. Statistical analysis

The seroprevalence with 95% confidence intervals (CI) was estimated from the formula described by Thrushfield (2005) based on the sensitivity (92.4%) and specificity (98.4%) of the indigenously developed PPR C-ELISA (Singh et al., 2004b) employed. Apparent prevalence = number of positive animals/numbers of tested animals. True prevalence (TP) was estimated with the Rogan-Gladen estimator, TP = (Apparent Prevalence + [specificity − 1]) / (Specificity + [Sensitivity-1]) as described earlier (Thrushfield, 2005).

3. Results and discussion

In AN Islands, goats constitute 37.67% of the total livestock and an important productive asset of settlers, landless, marginal, and small landholders of these islands and it generates a flow of income and employment throughout the year. Majority of goats in these islands resemble Black Bengal and were brought from mainland Bengal state and adjacent states in different phases of inhabitation and rehabilitation of migrated/settled people (Kundu et al., 2010). In Andaman local black Bengals are well adapted and are widely distributed throughout the Andaman Islands, whereas, Malabari goat, which was introduced from Kerala and Tamil Nadu during 7th five-year plan for up-gradation of indigenous goats (Kundu et al., 2010).

The present study provides prevalence data on PPRV antibodies in goats in AN Islands during the year 2017–2018, based on the screening of the 392 serum samples, with observed the apparent and true seroprevalence of 1.28% and 1.39%, respectively. The details of serum samples collected during the survey and its test results are summarized in Table 1. Only a few samples in five epi-unit villages have shown marginal positive (PI value ranges from 40.4 to 48. 0) for PPRV antibodies except one weak positive sample with overall less than 30% prevalence in all the tested epi-units of AN Islands. Moreover, if the cutoff of the PI ≥ 50% were considered positive for the presence of PPRV antibodies based on the PPR endemicity in India (Balamurugan et al., 2011), none of the serum samples from all the epi-unit villages found to be positive, except for only one sample from Hanspuri village, which showed weak positive reaction (PI value of 77.5). The few positive samples might be due to the introduction of earlier vaccinated or recovered infected animals from the mainland of India as stated earlier (Kundu et al., 2010). The susceptibility of a host to PPRV infection also varies with the breed of the animal, which also plays an important role in the epidemiology of PPR (Lefevre and Diallo, 1990). This study, needs to be visualized with certain limitations viz. the collection of serum samples over a period of a year, the associated variable/risk factors such as host factors (breed, age, sex, etc.) and vaccination status of animals was not available for further multi-factorial analysis.

Furthermore, none of the selected epi-units of AN islands had neither seroprevalence of > 30% nor protective population immunity of > 70%, which implies that no circulation of the PPRV in the goats, which are free from PPRV antibodies, as there were neither PPR

Table 1
Epidemiological unit -wise details of samples tested and its results for PPRV antibodies in goats in AN Islands.

Name of the District	Name of the Tehsil/ Block	Name of the Village /Epi-Unit	Goat population in the Epi-unit	No. of the samples collected and tested	No. of the samples Positive for PPRV antibodies in ELISA (PI Value)	Apparent Prevalence % positivity	Confidence Intervals at 95 % level	True Prevalence % positivity
Nicobar	Car Nicobar	Kinmai	88	11	0	–	0.0– 0.26	–
Nicobar	Great Nicobar	Sastri Nagar	136	10	1 (42.8)	10.00	0.02– 0.40	11.00
Nicobar	Nancowry	Meenakshi Ram Nagar	83	11	0		0.0– 0.26	
North & Middle Andaman	Diglipur	Durgapur (RV)	78	11	0	–	0.0– 0.26	–
North & Middle Andaman	Diglipur	Haridas Kattai (EFA)	83	11	0	–	0.0– 0.26	–
North & Middle Andaman	Diglipur	Hoari Bay (EFA)	148	11	0	–	0.0– 0.26	–
North & Middle Andaman	Diglipur	Keralapuram (RV)	93	11	0	–	0.0– 0.26	–
North & Middle Andaman	Diglipur	Krishnapuri (RV)	89	11	0	–	0.0– 0.26	–
North & Middle Andaman	Diglipur	Mohanpur (RV)	42	11	0	–	0.0– 0.26	–
North & Middle Andaman	Diglipur	Narayan Tikri (EFA)	71	11	0	–	0.0– 0.26	–
North & Middle Andaman	Diglipur	Smith (EFA)	52	11	0	–	0.0– 0.26	–
North & Middle Andaman	Mayabunder	Chuglum Gum (EFA)	156	10	0	–	0.0– 0.28	–
North & Middle Andaman	Mayabunder	Hanspuri (RV) (including JPP Camps)	93	11	1 (77.49)	9.09	0.02– 0.38	9.99
North & Middle Andaman	Mayabunder	Kanchi Nallaha (EFA) & Bamboo Nallaha (EFA)	114	11	0	–	0.0– 0.26	–
North & Middle Andaman	Mayabunder	Webi (RV)	96	11	0	–	0.0– 0.26	–
North & Middle Andaman	Rangat	Boreham Valley (FS)	47	10	0	–	0.0– 0.28	–
North & Middle Andaman	Rangat	Kalsi (RV)	113	11	0	–	0.0– 0.26	–
North & Middle Andaman	Rangat	Kanchangarh (RV)	72	11	0	–	0.0– 0.26	–
North & Middle Andaman	Rangat	Khatta Khari (EFA)	78	11	0	–	0.0– 0.26	–
North & Middle Andaman	Rangat	Mithila (RV)	80	11	0	–	0.0– 0.26	–
North & Middle Andaman	Rangat	Nilambur (RV)	118	11	0	–	0.0– 0.26	–
North & Middle Andaman	Rangat	Sippi Tikry (EFA)	130	11	0	–	0.0– 0.26	–
North & Middle Andaman	Rangat	Wrafter's Creek (RV)	73	11	0	–	0.0– 0.26	–
South Andaman	Ferrargunj	Hashmatabad (RV)	59	11	0	–	0.0– 0.26	–
South Andaman	Ferrargunj	Knapuram (RV)	109	11	0	–	0.0– 0.26	–
South Andaman	Ferrargunj	Lohabarrack (WLS)	152	11	0	–	0.0– 0.26	–
South Andaman	Ferrargunj	Muslim Basti (RV)	70	11	0	–	0.0– 0.26	–
South Andaman	Ferrargunj	Namunaghar (RV)	102	11	0	–	0.0– 0.26	–
South Andaman	Ferrargunj	Tirur (RV)	152	11	0	–	0.0– 0.26	–
South Andaman	Little Andaman	Butler Bay Forest Camp 4-III (FDCA)	44	10	1 (40.7)	10.00	0.02– 0.40	11.00

(*continued on next page*)

Table 1 (*continued*)

Name of the District	Name of the Tehsil/ Block	Name of the Village /Epi-Unit	Goat population in the Epi-unit	No. of the samples collected and tested	No. of the samples Positive for PPRV antibodies in ELISA (PI Value)	Apparent Prevalence % positivity	Confidence Intervals at 95 % level	True Prevalence % positivity
South Andaman	Little Andaman	Butler Bay Forest Camp 4-IV (FDCA)	77	11	0	–	0.0– 0.26	–
South Andaman	Port Blair	Bejoy Nagar (RV)	123	11	0	–	0.0– 0.26	–
South Andaman	Port Blair	Bimilitan (RV) & Kodiyaghat	33	11	1 (40.36)	9.09	0.02– 0.38	9.99
South Andaman	Port Blair	Pahargaon part (RV)	77	11	0	–	0.0– 0.26	–
South Andaman	Port Blair	Rutland (RV)	126	11	1 (47.9)	9.09	0.02– 0.38	9.99
South Andaman	Port Blair	Sitapur (RV)	86	11	0	–	0.0– 0.26	–
		Total	**3343**	**392**	**5**	**1.28**	**0.01–0.03**	**1.39**

outbreaks reported nor vaccination strategies practiced in AN Islands. Further, the immune protection against PPR in goats in AN islands is almost nil, when compared with the mainland of India, where the disease is enzootic with the fluctuating percentage of seroprevalence and population immunity is being reported (Singh et al., 2004a; Sunilkumar et al., 2005; Balamurugan et al., 2011, 2014a, 2014b). In other words, susceptible goat population is in high risk of the chance of acquiring PPRV infection, if close contact of infected animals is there in the AN islands, however, so far, no PPR outbreaks have been reported from these AN islands. This could be due to an ecological unique niche of islands, the topology of the region causes restricted migration of animals from the nearby region, low population density of goats, availability of low grazing area, with reduced transmission of the virus between animals, as close contact of small ruminants is needed for acquiring and spread of infection.

Further, the observed low seroprevalence might be because of the collected samples from goats, which were not suspected for PPR and were randomly from apparently healthy animals from 36 different epi-units in nine taluks by stratified random sampling method, representing the target goat population in the studied area (Table 2). In general, the regional difference in the prevalence of antibodies is also based on the relative populations of small ruminants. Earlier, the seroprevalence ranging between 0 and 2.1% in geographically isolated states of India (Himachal Pradesh and North-Eastern states) having a relatively small population of sheep and goats, were also reported (Singh et al., 2004a; Balamurugan et al., 2011, 2014b). Similarly, the low seroprevalence of 2.11% in goats was reported in Tripura state having ˜0.70 million small ruminants in the North East Region of India (De et al., 2016). Moreover, different studies in India and their results demonstrate the widespread nature of the disease in mainlands (Singh et al., 2004a; Raghavendra et al., 2008; Balamurugan et al., 2011). Generally, variation in seroprevalence could be due to differences in sample size, prevailing management practices, humidity or season as reported earlier (Singh et al., 2004a). However, in the present study, as per sampling plan, cross-sectional study was conducted to estimate apparent prevalence with a specified level of confidence (95%) and desired precision (5%), with the maximum statistical sample size of 385 number of unit samples for the finite or large population representing the target population from different epidemiological units of the studied area.

4. Conclusions

In conclusion, the present survey provides evidence of the seroprevalence of PPR, in non-vaccinated and no PPR outbreak reported AN Islands of India. Further, the study implies that the goat population in the villages (epi-units) were having less than 30% seroprevalence or free from PPRV antibodies, which necessitate the comprehensive active intensive surveillance programme. This is imperative for monitoring of the occurrence of sporadic outbreaks in different clinical forms of the diseases in the islands to make disease-free Islands by implementing effective disease control measures /strategies for PPR. Moreover, at the time of declaring India is provisionally free from PPR, surveillance of PPR in AN islands also need to be carried out as per GCEP guidelines to support the demonstration of freedom from disease in unvaccinated populations.

Ethical standards

The manuscript does not contain animal experimental trial

Declaration of Competing Interest

The authors declare that they have no conflict of interest.

Table 2
District-wise details of samples tested and its results for PPRV antibodies in goats in AN Islands.

Name of the District	No. of the Block in each district	No. of the villages in each district	No. of the sample tested	No. of the samples positive for PPRV antibodies in ELISA	Apparent Prevalence % positivity	Confidence Interval value (CI at 95 %)	True prevalence % positivity	Prevalence % status No. of Epi-units		
								< 30%	30–70%	>70%
Nicobar	3	3	32	1	3.13	0.01–0.16	3.42	3	0	0
North and Middle Andaman	3	20	218	1	0.46	0.00–0.03	0.49	20	0	0
South Andaman	3	13	142	3	2.11	0.01–0.06	2.31	13	0	0
Total	**9**	**36**	**392**	**5**	**1.28**	**0.01–0.03**	**1.39**	**36**	**0**	**0**

Acknowledgments

Authors wish to thank the Indian Council of Agricultural Research (ICAR), New Delhi, India, and the ICAR-Natonal Institute of Veterinary Epidemiology and Disease Informatics (NIVEDI) for providing funding and their staff for constant encouragement and support. The authors also thank the collaborating center of ICAR-NIVEDI, AICRP on ADMAS, Animal Science Division, ICAR-Central Island Agricultural Research Institute (CIARI), Port Blair for collecting and sending the serum samples as a part of regular disease monitoring. The authors are thankful to the Directorate of Animal Husbandry and Veterinary Services, Andaman and Nicobar Islands, and their officials, field veterinarians, para-veterinarians for their assistance during samples collection in the survey and for their kind help and co-operation.

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