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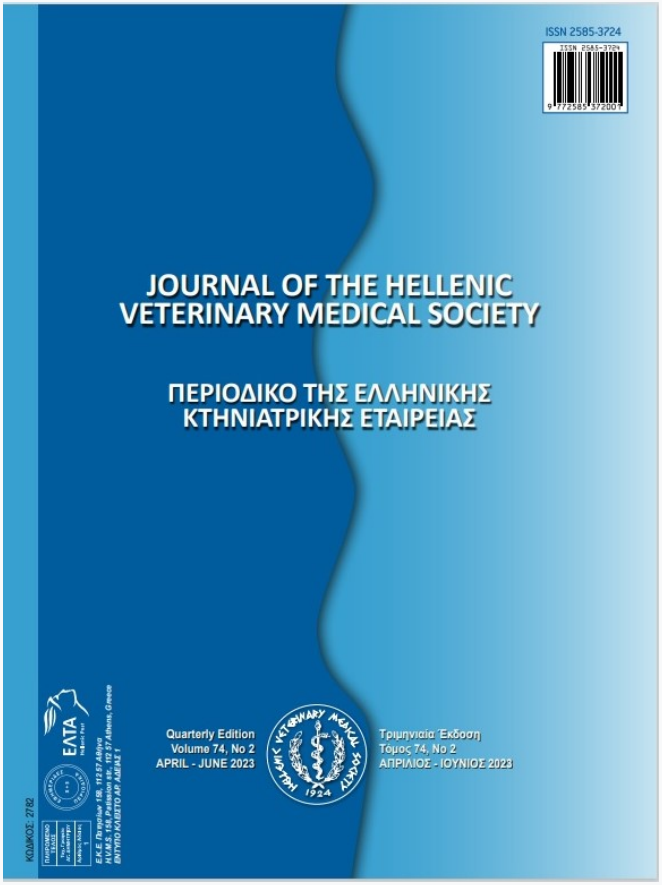

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Research article
Ερευνητικό άρθρο

Assessment of Peste Des Petits Ruminants (PPR) in Turkey Between 2017-2019

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ABSTRACT: Peste des petits ruminants (PPR) is a viral disease affecting small ruminants and causing significant agricultural damage. The World Organization for Animal Health (OIE) has classified PPR as an animal disease that must be reported immediately. This study aimed to understand of spatial and seasonal epidemiology of PPR in Turkey and provide information by using Geographical Information Systems (GIS). Descriptive and analytical statistics were used in the study, and logistic regression analysis was applied to assess the effect of season and species factors on PPR outbreaks occurring in Turkey. Data were obtained from the World Animal Health Information System (WAHIS) database of OIE. Between 2017-2019, 337 outbreaks, 18467 cases, and 11526 deaths were reported in 57 provinces of Turkey and the highest number of PPR outbreaks, cases, and deaths were reported in The Central Anatolia Region. On time-wise examination, the PPR risk areas revealed changes with different levels of endemicity. The Central Anatolia Region was the top outbreaks reported region during 2017-2018, whereas The Marmara Region reported more outbreaks during 2019. PPR outbreaks occurred throughout the year in all seasons but were most frequently encountered during the winter season (December to February) and the results showed that seasonal and species factors are important in the spread of the disease. PPR has been widely distributed throughout the country, and the epidemiological picture suggests that the disease has become an endemic infection in the country. The spatial and seasonal distribution of PPR in Turkey gives useful information on hotspot areas, allowing managers to make informed decisions about prevention and control in different parts of the country. In accordance with the PPR Global Control and Eradication Strategy, the study also outlines when and where extensive surveillance, vaccination, and biosecurity measures are required for the control and eradication of the disease in Turkey.

Keywords: Epidemiology; Peste des petits ruminants (PPR); Risk; Spatial Analysis; Turkey.

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INTRODUCTION

Peste Des Petits Ruminants (PPRV) is a highly contagious viral disease that is economically important and has a high mortality and morbidity rate (Mapaco et al., 2019). PPRV is characterized by high fever, cough, anorexia, nasal and lacrimal discharge that changes from initially serous to pus in later stages, diarrhea, stomatitis, enteritis and bronchopneumonia (Balamurugan et al., 2014; Gao et al., 2021). PPR virus belongs to the Morbillivirus genus of the family Paramyxovirinae, a subfamily of the Paramyxoviridae family of the order Mononegavirales (Ma et al., 2019; Mariner et al., 2016). PPR was initially discovered in Cote d'Ivoire in the early 1940s, then spread to Africa, the Middle East, parts of Asia, and Europe (Balamurgan et al., 2021). Today, more than seventy countries have reported infection, and many countries are at risk of introducing the disease (Fathelrahman et al., 2021). PPR outbreaks are known to cause serious socioeconomic issues and the annual economic loss caused to PPR is estimated to be US$1.45-2.10 billion (Jones et al., 2016). Also, sheep and goat industries are important food supplies and economic bases in many countries. As a result, the World Organisation for Animal Health (OIE) and the Food and Agriculture Organization (FAO) launched the PPR Global Control and Eradication Strategy (PPR GCES) in 2015. The purpose of the strategy is to eradicate PPR globally by 2030. The strategy is divided into four stages: (i) assessment, (ii) control, (iii) eradication, and (iv) post eradication (The World Organisation for Animal Health, 2015).

Turkey, located in the Eastern Mediterranean, is a bridge between Europe and Asia. Against the approximately 2.1 billion world sheep and goat population (Balamurugan et al., 2021), approximately 48.5 million (37.3 million sheep and 11.2 million goats) small ruminants were recorded in Turkey in 2019 (Turkish Statistical Institue, 2021). Although PPR virus infection was first detected serologically in 1992 in Mardin/Kızıltepe (Aylan, 2003) and in 1993 based on pathomorphological and immunohistological findings in infected lambs (Alcigir et al., 1996), it was officially reported for the first time in 1999 in Southeastern and Eastern Anatolia. Many researchers have looked at serological virus detection, and diverse studies in various regions of Turkey have revealed the existence of PPR throughout the country (Albayrak and Alkan, 2009; Alcigir et al., 1996; Altan et al., 2019; Guler et al., 2014; Tatar and Alkan, 1999; Ozkul et al., 2002; Saglam and Temur, 2009). However, much of the information is still inadequate.

There has been no nationwide research to understand the spatial distribution and seasonal changes of the PPR in Turkey so far. Furthermore, understanding disease dynamics, disease hotspot areas/zones, and outbreak timing are critical to assisting policymakers in making proper control and eradication decisions. For this reason, the current study was carried out to determine the spatial distribution and seasonal pattern of PPR outbreaks in sheep and goats using passive surveillance information recorded across the country, as well as to assess the state of the ongoing PPR control effort in Turkey.

MATERIALS AND METHODS

Study location

Turkey is located between 36° 42′ north latitudes and 26° 45′ east longitudes, surrounded by the Black Sea on the north, the Aegean Sea on the west and the Mediterranean Sea on the south. Turkey, which is part of Asia and the northern hemisphere, is a country with an area of 780,580 km^2 (Dizman and Mukhtarli, 2021). Turkey is located at the crossroads of Europe and Asia, forming a link between the two continents. Thrace is the name of the European section of the country, whereas Anatolia is the name of the Asian part. Greece and Bulgaria border it on the northwest, the former Soviet Union (Georgia, Armenia, and Azerbaijan Republics) and Iran on the east and Iraq and Syria on the south.

Turkey is made up of 7 geographic regions; Marmara, Aegean, Mediterranean, Black Sea, Central Anatolia, Eastern Anatolia and Southeastern Anatolia region. These regions are divided into 81 provinces, 922 districts, 18293 villages, and 32207 neighborhoods in Turkey.

Outbreak Data

PPR is a disease that requires all cases to be reported to the national veterinary authority of each OIE member country and to OIE on an international level. PPR outbreak and case data for the period 2017-2019 were obtained from WAHIS database, which was published publicly.

Data analysis

At the provincial and regional levels, passive surveillance data was compiled, and cumulative monthly outbreaks/cases of PPR were calculated to determine the disease's seasonal occurrence in different regions.

The state of the disease in sheep and goats, disease burden, host susceptibility, spatial distribution, risk areas, and other aspects of the disease in Turkey have all been examined based on cumulative reports. Maps have long been used to investigate the relationship between location, environment, and animal disease (Gesler, 1986). Because of its spatial analysis and visualization capabilities, GIS is used in this study to analyze the spatial distribution and interaction of diseases. Recently GIS with, spatial analysis has become popular in animal disease risk analysis (Niu et al., 2021). Provincial-level shapefile (.shp extension) data were used to be used in a GIS software for spatial analysis and mapping of outputs. All maps were generated using the open-source GIS software (QGIS version 3.10.2). The scale of cumulative outbreaks that occurred in the area (province) per year during the analysis period (Balamurugan et al., 2021) was categorized into various risk categories (if the outbreak numbers as 0- no risk, 1- very low, 2- low, 3- medium, 4- high and >4 very high-risk districts) and was shown on the map. A logistic regression analysis was applied to assess the effect of the season (spring, summer, autumn, winter) and species (sheep, goat) factors on PPR outbreaks occurring in Turkey. The odds ratio (OR), and confidence levels at 95% were calculated, and a value of $P < 0.05$ was accepted as statistically significant. The passive disease surveillance data available in the WAHIS database was analyzed in SPSS 23.0 software.

RESULTS

Between 2017 and 2019, 337 PPR outbreaks were reported in Turkey, with an average of 112,33 outbreaks per year respectively, with 280 (83.09%) outbreaks in sheep and 57 (16.91%) outbreaks in goats. PPR was recorded multiple times in 70,37% of provinces (n = 57) and all geographical regions (n = 7) during this time period. Among different geographical regions the proportion of reported outbreaks respectively; Central Anatolia (88 outbreaks; 26.11%), followed by the Black Sea (71 outbreaks; 21.07%), Aegean (63 outbreaks; 18.69%), Marmara (54 outbreaks; 16.02%), Eastern Anatolia (36 outbreaks; 10.68%), while the Mediterranean (19 outbreaks; 5.64%) and Southeastern Anatolia (6 outbreaks; 1.78%) regions. On the other hand, when the number of cases in PPR was evaluated, a total of 18.467 cases were detected, with an average of 6156 cases per year, 15502 (83.94%) in sheep and 2965 (16.06%) in goats. The majority of the cases are in the Central Anatolia (38.96%) region. On analysis of 3 years of data, it was observed that 11.526 deaths were reported, of which 17.74% in goats (n = 2045) and 82.26% in sheep (n = 9481). Also, in comparison, Central Anatolia (38.24%) showed the highest rate of reported deaths, followed by Black Sea (19.84%), Marmara (15.81%), Aegean (12.59%), Eastern Anatolia (6.98%), Mediterranean (5.60%), Southeastern Anatolia (0.94%). The details of the PPR outbreaks, cases, and deaths in sheep and goats in different periods and in different regions of analysis are presented in Figure 1.

Although the case fatality rate of PPR reports in sheep and goats from different regions varies by year, it was determined that the case fatality rate was higher in goats. The region-wise detail of the case fatality rate of PPR reports in sheep and goats in different re-

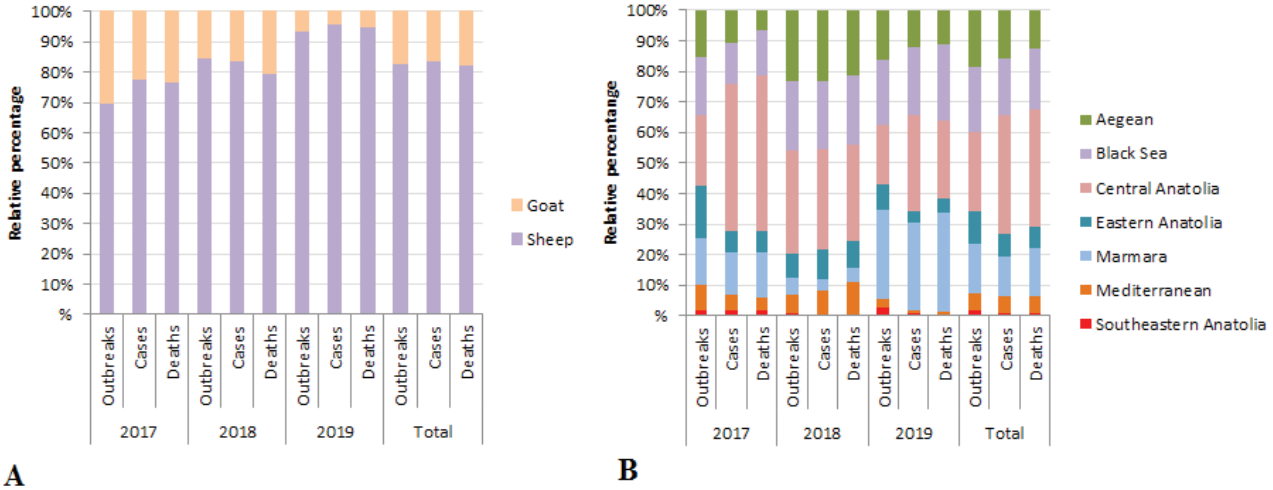

Figure 1: Analysis of cumulative PPR reports in different periods (2017-2019). (A).Species-wise (B).Region-wise

gions is presented in Figure 2.

Further, the mean cases per outbreak were calculated and different regions vary by year, it was determined that was higher in Central Anatolia (Figure 3).

Furthermore, the highest (38.28%) proportion of reported outbreaks (n = 129) were during 2018 followed by 32.34% (n = 109) during 2019 and 29.38% (n = 99) during 2017. Nevertheless, outbreaks were reported during 2017-2018 with the least in Southeastern Anatolia and the highest in Central Anatolia, whereas outbreaks were reported during 2019 with the lowest in Southeastern Anatolia and the Mediterranean and the highest in the Marmara. Further, in each year separately the region-wise analysis revealed that the Central Anatolia region reported the highest cases (Figure 4).

Although PPR outbreaks were seen throughout the year in Turkey between 2017-2019; 22 outbreaks (6.53%) from March to May, 62 outbreaks (18.40%) from June to August, 123 outbreaks (36.50%) from September to November, and 130 outbreaks (38.58%) were observed from December to February. From this perspective, the winter season had the most outbreaks, while the spring season had the fewest. Between 2017 and 2019, the months with the most epidemics were January and December, and the months with the fewest outbreaks were April and May. The monthly distribution of PPR outbreaks is presented in Figure 5.

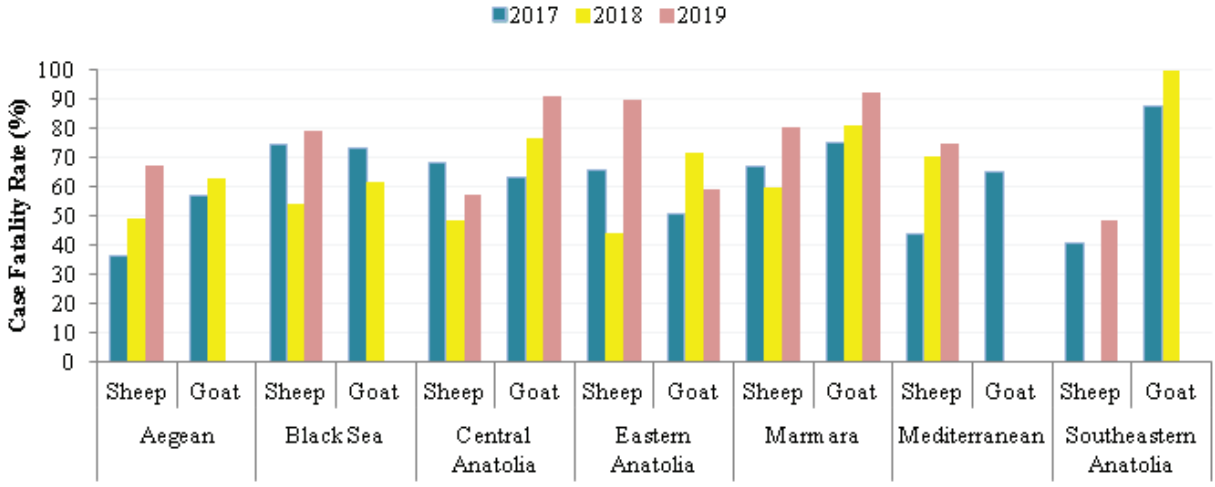

Figure 2: Region-wise case fatality rate of PPR in sheep and goats in different zones of the country (2017-2019)

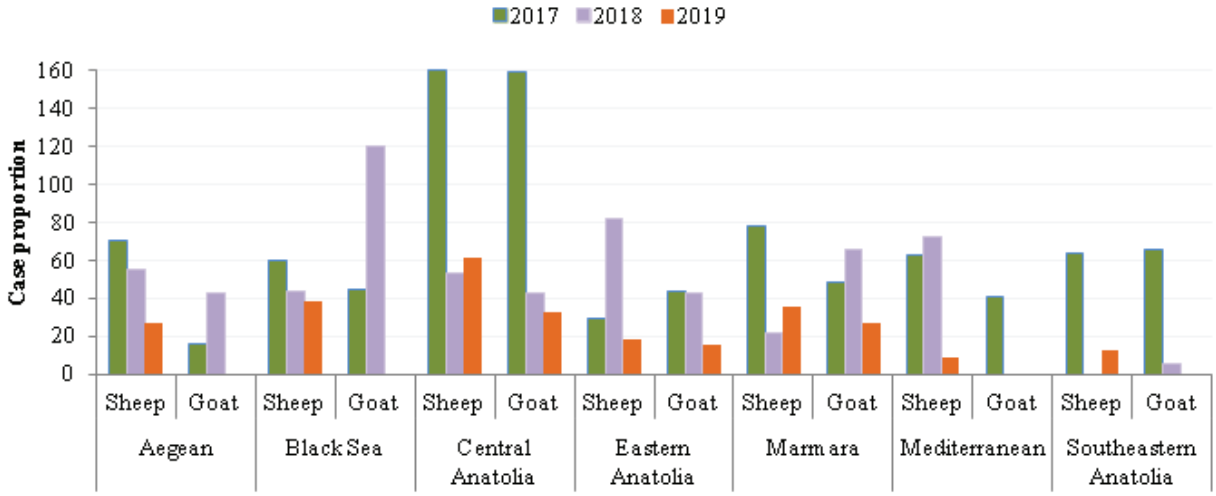

Figure 3: Region-wise the mean cases per outbreak of PPR in sheep and goats in different zones of the country (2017-2019)

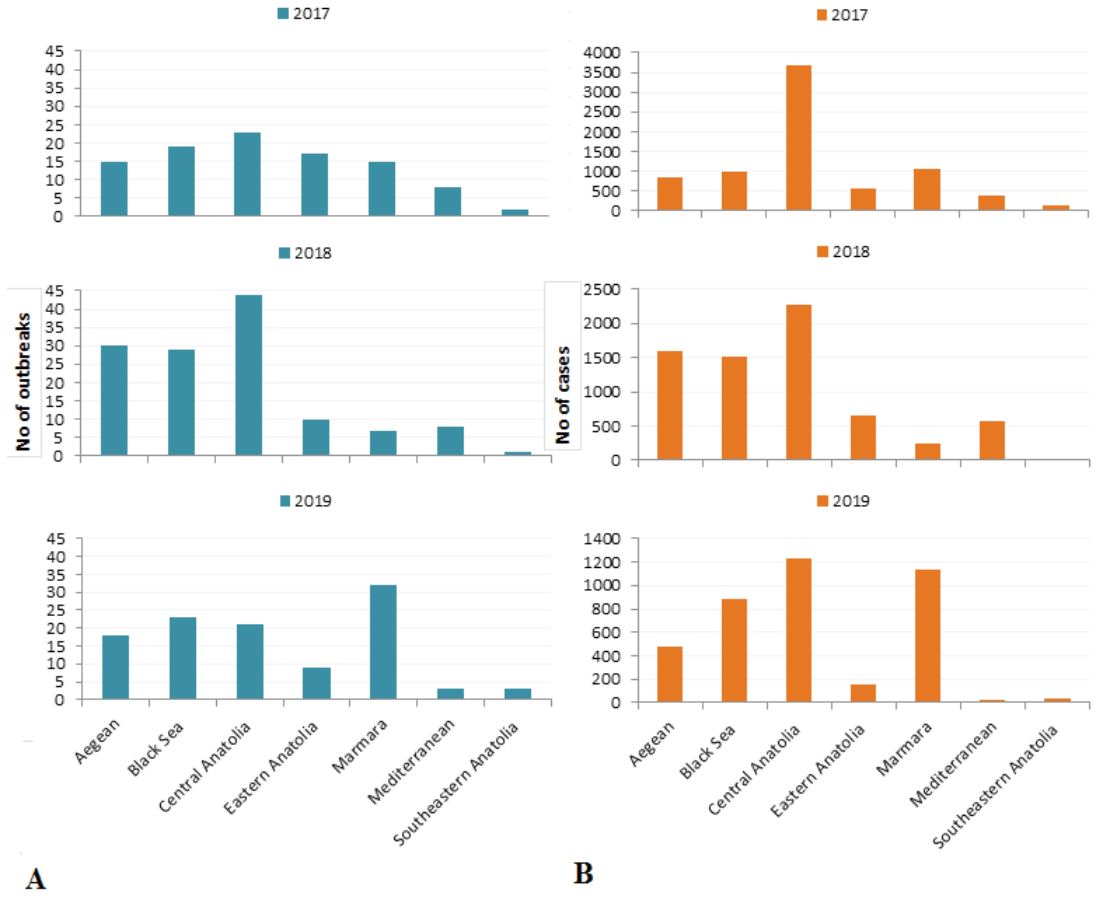

Figure 4: Region-wise occurrence of cumulative PPR reports in Turkey (2017-2019). (A). Outbreaks (B). Cases

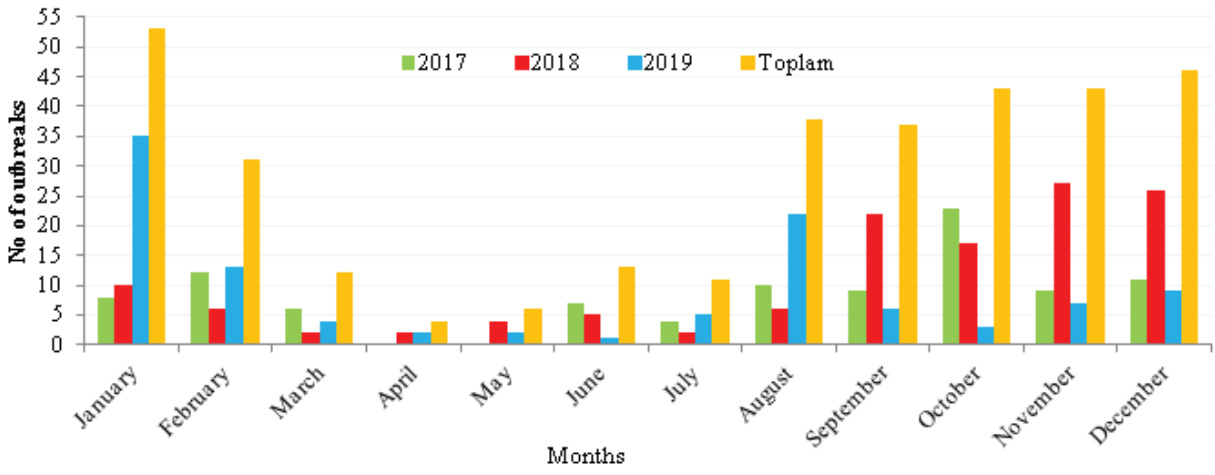

Figure 5: Month-wise analysis of cumulative PPR outbreaks in different period in Turkey (2017-2019)

The logistic regression analysis showed season and species factors as a significant risk factors. Significantly higher odds of PPR were observed in autumn [OR 6.37(95% CI 3.27-12.40)] and winter [OR 3.86 (95% CI 1.98-7.50)] than the spring season and showed statistical significance. The odds of PPR were significantly higher in sheeps [OR 5.05 (95% CI 3.18-8.03)] than goats (Table 1).

On analysis of outbreaks data, PPR endemic risk areas showed a variation in the different provinces/ regions of Turkey. Endemic provinces are shown according to the number of epidemics occurring in dif-

Table 1: Logistic regression results of the relationship between season and species factors and PPR outbreak in Turkey

Risk factor	Categories	Estimate	SE	OR (95% CI)	p-value
Season	Spring (March-May)	1.00	Reference	-	-
	Summer (Jun-Aug)	0.49	0.35	1.64 (0.82-3.29)	0.16
	Autumn (Sept-Nov)	1.85	0.34	6.37(3.27-12.40)	0.00
	Winter(Dec-Feb)	1.35	0.34	3.86(1.98-7.50)	0.00
Species	Goat	1.00	Reference	-	
	Sheep	1.62	0.24	5.05(3.18-8.03)	0.00

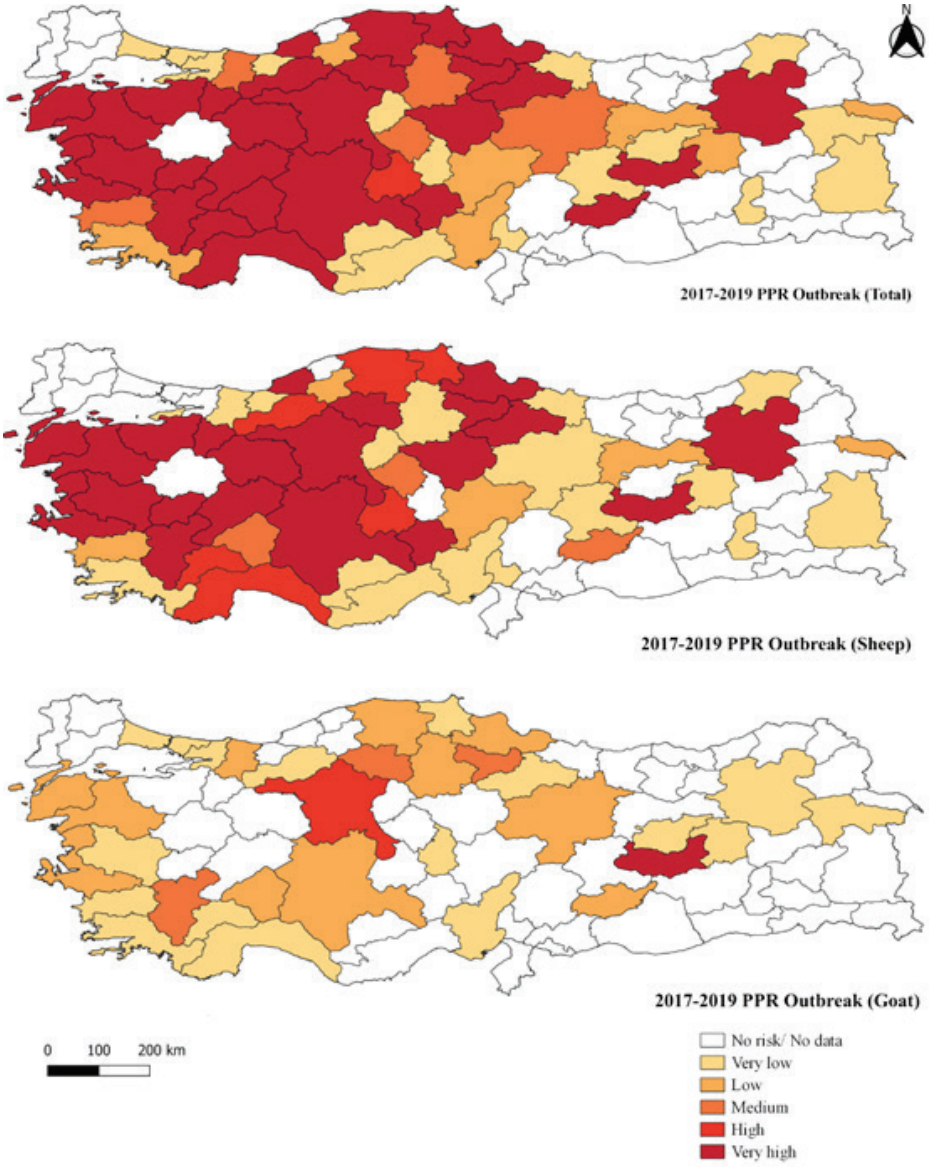

Figure 6: The species-wise endemic provinces of PPR in different regions of Turkey (2017-2019)

ferent provinces of Turkey using a six-scale analysis classification. Many provinces of Aegean, Central Anatolia, Central Black Sea, and Marmara fall under the highly hyperendemic risk areas categories, whereas some provinces in the states of Eastern, Southeastern Anatolia, and Mediterranean have low endemic risk areas. It has been shown that PPR outbreaks in sheep are higher than in goats in Turkey. When the PPR outbreak was evaluated throughout Turkey between 2017-2019, it was detected in 57 provinces. The province with the highest number of epidemics was Ankara (22, 6.53%), located in the Central Anatolia Region. Species-wise analysis, it was determined that the most epidemic in sheep was in Konya province

(19, 6.79%) in Central Anatolia and Elazig province (6, 10.53%) located in Eastern Anatolia in goats. On the other hand, while 21 provinces are hyperendemic for sheep, only one province is hyperendemic for goats. An outbreak of PPR in goats was reported in Istanbul in 2018 in the Thrace region (part of the Marmara region), which is a key point in the spread of the epidemic to Europe (Figure 6).

DISCUSSION

The OIE has classified PPR, a highly contagious disease, as an animal disease. Animal surveillance, immunization, antibiotic treatment, animal isolation, and harmless treatment are the mainstays of its prevention and management at the moment (Spiegel and Havas, 2019). Latent animals are still infectious due to PPR's acute infectivity and extensive transmission pathways and is difficult to eliminate due to variances in preventative and control strategies in different countries and PPR still occurs often (Zhao et al., 2021). Vaccination is a suggested significant method in the fight against PPR control and eradication. Immunity to PPR obtained from the mother lasts for 3-4 months in usually. Therefore, vaccination is usually suggested at the age of 4-5 months. Vaccination has been carried out in nearly all PPRV-infected nations in recent years. Countries have utilized a variety of vaccination techniques, according to epidemiological conditions, the level to which they have effectively targeted immunization based on disease situations, and National Strategic Plans (Rony et al., 2017; Zhao et al, 2021).

The existence of PPR in Turkey is significant due to the country's unique geographical location and the greatest threat to neighboring countries with huge populations of naive animals (Parida et al., 2016). First discovered in Turkey in the 1990s, PPR has become one of the most common viral diseases in ovine animals in the 2000s and has been reported in all regions of Turkey. After a series of outbreaks in Turkey, a mass vaccination program was implemented throughout the country with an EU-supported project. The project, aimed to (a) identify and register all sheep and goat populations across the country, and (b) control PPR through effective vaccination strategies. Small ruminants were ear-tagged and registered in a database as part of this project in order to track their movements in accordance with EU criteria; and small ruminants were vaccinated against PPR. Despite the fact that these efforts did not completely eradicate PPR from the country, they did help decrease PPR outbreaks in Turkey (Altan et al., 2019; Guler et al., 2014).

Generally, animal husbandry practices, seasonality, and geographical locations affect PPR occurrence (Balamurugan et al., 2021; Iglesias et al., 2016; Lefèvre and Diallo, 1990; Singh et al., 2004). This study aimed to understand the spatial and seasonal epidemiology of PPR in Turkey. Different species endemic risk areas were shown in different regions of Turkey by spatial analysis of outbreak data. As a result of the spatial pattern of PPR, except for the Southeastern Anatolia region, was seen intensely especially in sheep in all regions (Figure 6). This could be because sheep outweigh goats by roughly 4 to 1 in Turkey's 20th livestock census. In addition, as a result of logistic regression analysis, it was determined that the odds ratio of PPR in sheep [OR 5.05 (95% CI 3.18-8.03)] was significantly higher than in goats. This result is consistent with the information that in some studies, the seroprevalence of PPR in sheep is higher than that of goats at both herd and individual levels (Mahajan et al., 2012).

The importance of animal movements on epidemic diseases is widely accepted and there are international regulations exist to reduce the risks. Despite these rules, epidemics occur on a regular basis as a result of both legal and illegal animal movements (Fèvre et al., 2006). The increased animal trade and the history of sheep and/or goats of different ages coming together with or without related changes in housing and feeding might be associated with the occurrence of PPR. Because animals are usually under stress due to long-distance traveling and the nutritional deficiency (Balamurugan et al., 2021). In our study, a serious increase in outbreaks was observed as a result of the movement and gathering of animals for Eid al-Adha in August after July, which is compatible with this information. Animal movements in Turkey should be carried out in a very controlled manner. Because, a considerable number of small ruminants are transferred inside Turkey, particularly from areas with high endemicity to the Marmara region of Turkey, there is a possibility of PPR spreading to Europe (Altan et al., 2019).

PPR occurs in all seasons but is encountered most frequently either in the wet season/summer or during the cold dry season. In this study, seasonal variations in PPR outbreaks have been recorded in different years of Turkey. The risk evaluation has been found to be significantly higher in the winter and post-mon-

soon seasons than in the monsoon season. During the winter season, animals are in close contact with each other, making the potentially highly contagious PPR virus more contagious. Similar results have been reported from different countries'studies conducted (Chowdhury et al., 2014; Rony et al., 2017; Sarker et al., 2011). As a result of the evaluation of the number of outbreaks, the highest number of outbreaks was recorded in winter. Consistent with our study, the increased frequency of PPR in winter has also been reported by others (Abubakar et al., 2015; Khan et al., 2008). The temperature has a variety of effects on the spread of contagious diseases. Lower temperatures may allow the virus to survive longer in the environment, leading to outbreaks in the small ruminant population. The risk has been determined lower in the summer season, according to logistic regression analysis. In many studies evaluating climatic factors, similarly, it has been reported that the risk of PPR decreases as the temperature increases. Because high temperature has a negative effect on the virus (Niu et al., 2021).

On the other hand between 2017-2019, the highest precipitation rate in Turkey was reported in December and January (Turkish State Meteorological Service, 2020). As a result of a month-wise analysis of cumulative PPR outbreaks (Figure 6), the highest outbreaks in December and January to be seen it is compatible with the information that PPR occurs more in wet-cold. Similarly, many studies have reported that the prevalence of PPR is higher in rainy-cold (Mahmoud et al., 2016) and rainy seasons (Molla and Delil, 2015; Mondal and Yamage, 2014), and precipitation is positively associated with the formation of PPR in studies evaluating climatic factors (Ma et al., 2019; Niu et al., 2021).

This study had some limitations; primarily, information was limited regarding the focus of the outbreak for epidemiological analysis. Collected PPR data was from the OIE database and there are some issues such as data updates. For further study, there is no information on the breed, sex, or age of the animals involved in the outbreaks. These limitations may have resulted in insufficient results.

CONCLUSIONS

The current study provides information on the spatial distribution and seasonal patterns of PPR in Turkey, as well as the burden of diseases, control program status, and time of outbreaks/cases, to assist policymakers in making informed decisions. It also may be identified when and where intense surveillance, vaccination, and effective control strategies for the control and eradication of PPR in different regions/provinces of Turkey might be performed more efficiently. Currently, the disease is controlled by an effective and safe live attenuated PPR vaccine, but complete control and eradication of the disease from Turkey is only achievable with the proper implementation of a strategic vaccination program. In conclusion, this study will be added significantly to the current understanding of the epidemiology of PPR in Turkey.

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CONFLICT OF INTEREST

The authors declare no conflict of interest.

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