



# Epidemiological Study of Peste Des Petits Ruminants in Sheep and Goat During 2005-2017 in Palestine

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## ABSTRACT

The objective of this study was to analyze the epidemiological occurrence of Peste des petits ruminants in sheep and goat in Palestine during 2005-2017. Data were collected from the annual agricultural census released by the Palestinian central bureau of statistics and the reports of world organization for animal health, submitted by the general directorate of veterinary services and animal health between 2005 and 2017. The study indicated that Peste des petits ruminants is enzootic in Palestine, reported in each year of the study period. The incidence rate ranged from 1.78 to 14.36% with an average of 6.39% per year and per 104 animals. The average morbidity, morbidity and case fatality rate were 8.89%, 2.89%, and 33.57% respectively. Temporal analysis obtained that Peste des petits ruminants is more epizootic in the dry season between April and August with a significant peak on June. The Peste des petits ruminants vaccination rate in Palestine was low and not well organized, ranged from 0.77-34.39% with an average rate of 9%. The appropriate data recording, improving owner awareness, expand the use of the Peste des petits ruminants vaccine and a systematic disease monitoring program are required to control the spread of the disease.

**Keywords:** Epidemiology, Goat, Palestine, Peste des petits ruminants, Sheep

## INTRODUCTION

Peste Des Petits Ruminants (PPR) is a contagious acute viral disease of sheep and goats, characterized by fever, stomatitis, enteritis, pneumonia, and high morbidity and mortality rate (Kozat and Sepehrizadeh, 2017). The disease causes abortion in pregnant animals, increase neonatal mortality and exacerbate the economical losses (Jones et al., 2016). Sheep and goats are the usual targets, besides, cattle and other wild ruminants have been infected most often experimentally (Kumar et al., 2014). The causative agent of PPR belongs to the family *Paramyxoviridae*, genus *Morbillivirus* under order *Mononegavirales*. PPR virus exists as a single serotype but at the genetic level is divided into four distinct lineages (I-IV) based on the fusion (F) protein gene sequence (Banyard, 2010). The virus is present in the secretions of infected animals. Close contact between animals enhance inhalation of droplets that are released into the water, feed, and bedding from the affected animals are the main sources of infection. However, the virus does not survive for a long time outside the body of a host animal (Baron et al., 2016).

There is no effective drug for the treatment of the PPR disease. The control of the disease is limited by using antibacterial drugs to prevent secondary bacterial infection. It is also of importance that the animal should be vaccinated with the commercially available attenuated vaccine as the main control measure in endemic regions (Banyard et al., 2010). The disease occurs worldwide, commonly located in the developing country particularly Asia, the Middle East, and Africa (Özkul et al., 2002; Saeed et al., 2010; Banyard et al., 2014), where veterinary services and resources are inadequate to control or eradicate. Information on the occurrence, prevalence and characterization of PPR disease is available from a number of countries in which the disease has been reported such as Asian countries (Al-Dubaib, 2009; Zahur et al., 2009; Balamurugan et al., 2011). However, the pattern of PPR disease in Palestine has not been investigated before. Also, no systematic study of PPR infection has been done in small ruminants in Palestine. Therefore, the current study was performed to analyze the epidemiological situation of PPR in Palestine over a period of 12 years. This information would be necessary to understand the disease dynamics, mortality, incidence, and temporal distribution and other factors responsible for the persistence of infection in Palestine. In addition, it will help assess the risks, of the disease in order to formulate the appropriate preventative and reactive measures to decrease the infection or to eradicate the disease.

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## MATERIALS AND METHODS

### Sheep and goat livestock in Palestine 2005–2017

The available numbers of sheep and goat populations in Palestine between 2005 and 2017 were collected from different sources, the primary source was the annual agricultural census released by the Palestinian central bureau of statistics conducted in Palestine (PCBS, 2010). The numbers of sheep and goat populations for the year 2017 has not published yet.

### Peste des petits ruminants vaccination, annual and temporal trends

The quantitative data on PPR outbreaks, cases, deaths and vaccinations were collected for the period from 2005 to 2017. Data was extracted from the published annual reports on the world animal health information system of the period between 2005 and 2017 (Jebara et al., 2012).

### Data analysis

The frequency of the outbreaks, incidence rate, incidence rate upon exposed, mortality rate, case fatality and vaccination rate of PPR diseases considered in each month of the year according to standard methods (Thrusfield, 2018). These epidemiological parameters were calculated according to the following formulae:

Incidence rate per  $10^4$  animals = number of cases per year/ total population of sheep and goat during that year  $\times 10^4$ , infectious mortality rate = number of deaths /number of susceptible animals during the outbreak at the same year  $\times 100$ , mortality rate per  $10^4$  animals = number of deaths /total population of sheep and goat during the same year  $\times 10^4$ , case fatality rate = number of deaths /number of cases, vaccination rate = total number of vaccinated animals / average population of sheep during that year  $\times 100$ . The data collected were analyzed using Microsoft office excel (2007) and figures were performed using GraphPad Prism 5 software (GraphPad Software Incorporatio, San Diego, USA).

## RESULTS

### Cumulative profiles

The retrospective quantitative data of PPR for the past 13 years in Palestine are shown in the table 1 included the following information: An average annual sheep population was 1.18 million. An average immunization coverage rate was 9%. A total of 856 outbreaks, 8972 cases, and 2942 deaths were indicated. The average incidence rate was 6.4% per year and per  $10^4$  animals. The average morbidity rate was 8.9%. The average morbidity rate was 2.9%. The average case fatality rate was 33.6%. Data for numbers of vaccinated animals during years 2005-2011 and 2013 were not reported.

### Peste des petits ruminants annual trends

The finding obtained that outbreaks occurred in all years (Figure 1), with the highest number occurring in 2012 (n=312), followed by 2013 (n=96). The lowest number reported in 2017 (n=31) and 2014 (n=46). The increase in the number of outbreaks during 2012–2013 is interesting (Figure 1). The highest incidence rate per 10000 animals was observed in 2005 (14.36%), followed by 2013 (14.08%) and 2015 (8.31%), while the lowest incidence rate occurred in 2016 (1.78%). Morbidity rate ranged from 3.50% in 2007 to 14.63% in 2005. The highest mortality rate per 10000 animals occurred in 2015 (4.94%), followed by 2012 (4.30%). The lowest mortality rate was observed in 2008 (1.31%) (Table 1). The highest case fatality occurred in 2013 (48.25%) followed by 2008, and the lowest occurred in 2015.

### Temporal distribution

Data for various parameters were collated by month for the period from January 2005 to December 2017. During this period, the disease occurred in all months of the year, but the highest number of outbreaks occurred on June (Table 2 and Figure 2). The highest numbers of reported outbreaks occurred in summer season between May and August (Figure 2). The lowest outbreaks and the lowest mortality occurred on November and October (Table 2). The greatest mortality rate was reported on November. The disease trend tends to be more severe on December and April with the highest case fatality rate (Table 2).

### Trends in vaccine utilization

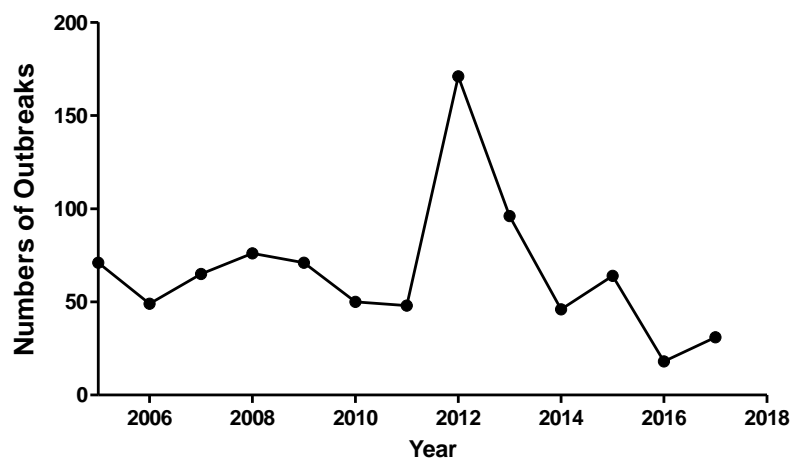
The total utilization of the Peste des petits ruminants vaccine was compared across different years. There is some limitation about the numbers of vaccinated animals in 2012 and 2014-2017 years. The vaccine used is a live attenuated vaccine. The total of immunization coverage was 845762 animals with an average vaccination rate of 9.0%. The annual utilization data showed that the highest number of doses (250228 doses) utilized with a vaccination rate of 21.31% achieved in 2005, whereas in 2012 only 34,769 doses were utilized, and the vaccination rate was 4.08% (Figure 3). With

regards to vaccination rate, the highest vaccination percentage was achieved in 2011 (21.54%), followed by 2005, 2010 and 2006. The lowest vaccination percentage was in 2013 (4.08%) (Table 1). The vaccination rate was not available for the 2012, 2015-2017 years.

**Table 1.** Annual statistics of Peste des petits ruminants in sheep and goat in Palestine (2005-2017)

| Year | Total No. Outbreaks | No. Susceptible | No. Cases | No. Deaths | Morbidity rate (%) | Mortality rate (%) | Incidence rate/10 <sup>4</sup> | Case fatality rate (%) | Vaccination rate (%) |
|------|---------------------|-----------------|-----------|------------|--------------------|--------------------|--------------------------------|------------------------|----------------------|
| 2005 | 71                  | 11523           | 1686      | 359        | 14.63              | 3.12               | 14.36                          | 21.29                  | 4.21                 |
| 2006 | 49                  | 7946            | 349       | 124        | 4.39               | 1.56               | 2.96                           | 35.53                  | 6.99                 |
| 2007 | 65                  | 9251            | 324       | 132        | 3.50               | 1.43               | 2.98                           | 40.74                  | 3.37                 |
| 2008 | 76                  | 11070           | 494       | 145        | 4.46               | 1.31               | 5.21                           | 29.35                  | 6.08                 |
| 2009 | 71                  | 8730            | 441       | 170        | 5.05               | 1.95               | 3.77                           | 38.55                  | 7.67                 |
| 2010 | 50                  | 6794            | 664       | 180        | 9.77               | 2.65               | 3.65                           | 27.11                  | 10.35                |
| 2011 | 48                  | 6412            | 692       | 175        | 10.79              | 2.73               | 7.12                           | 25.29                  | 34.39                |
| 2012 | 171                 | 9599            | 1054      | 413        | 10.98              | 4.30               | 5.26                           | 39.18                  | NA                   |
| 2013 | 96                  | 15441           | 1200      | 579        | 7.77               | 3.75               | 14.08                          | 48.25                  | 0.77                 |
| 2014 | 46                  | 9395            | 690       | 200        | 7.34               | 2.13               | 7.29                           | 28.99                  | NA                   |
| 2015 | 64                  | 4923            | 785       | 243        | 15.95              | 4.94               | 8.31                           | 30.96                  | NA                   |
| 2016 | 18                  | 1892            | 200       | 75         | 10.57              | 3.96               | 1.78                           | 37.50                  | NA                   |
| 2017 | 31                  | 3791            | 393       | 147        | 10.37              | 3.88               | NA                             | 37.40                  | NA                   |

No: Number, NA: data not available

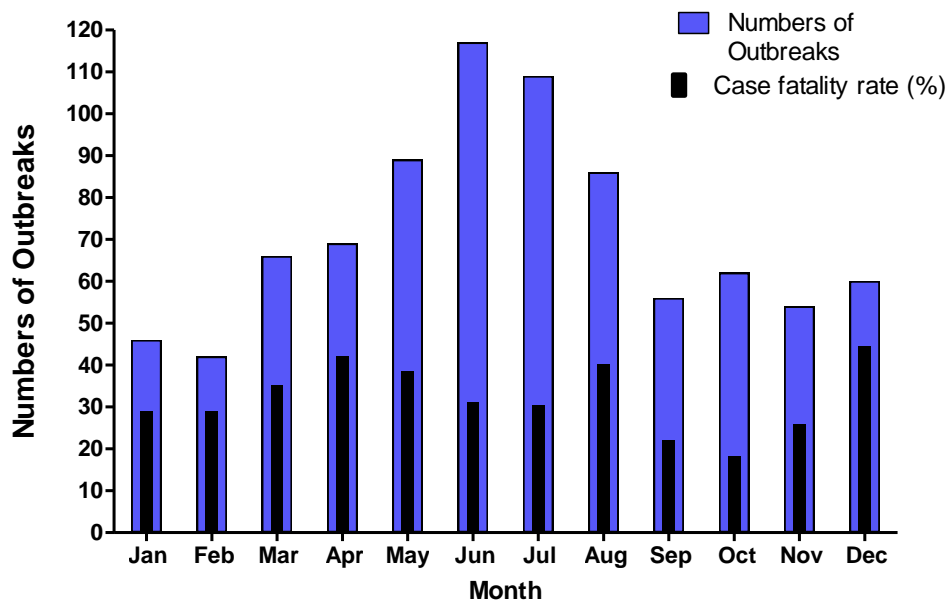


**Figure 1.** Numbers of Peste des petits ruminants outbreaks in sheep and goat in Palestine during 2005-2017.

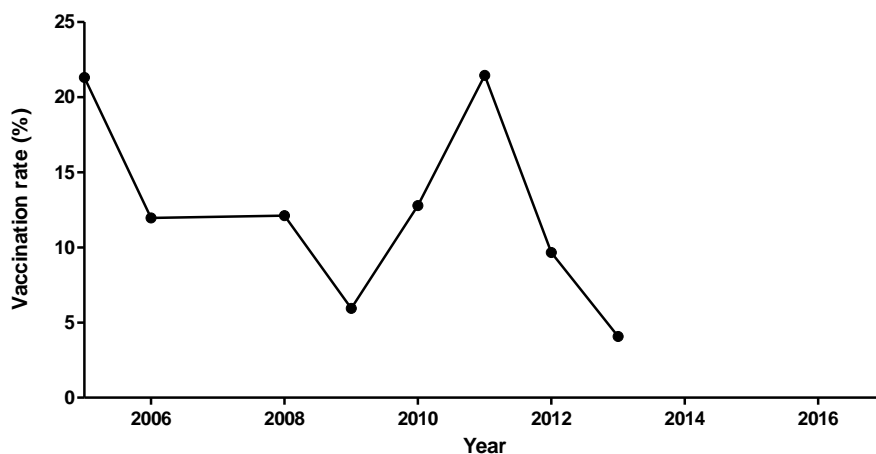
**Table 2.** Seasonality of PPR in sheep and goat in Palestine (January 2005 to December 2016)

| Month     | No. Outbreak | No. Susceptible | No. Case | No. Deaths | Morbidity rate (%) | Mortality rate (%) | Case fatality rate (%) |
|-----------|--------------|-----------------|----------|------------|--------------------|--------------------|------------------------|
| January   | 46.0         | 5165            | 397      | 115        | 7.7                | 2.2                | 29.0                   |
| February  | 42.0         | 5018            | 517      | 149        | 10.3               | 3.0                | 28.8                   |
| March     | 66.0         | 9318            | 923      | 325        | 9.9                | 3.5                | 35.2                   |
| April     | 69.0         | 10913           | 765      | 322        | 7.0                | 3.0                | 42.1                   |
| May       | 89.0         | 13208           | 1104     | 424        | 8.4                | 3.2                | 38.4                   |
| June      | 117.0        | 15835           | 1320     | 409        | 8.3                | 2.6                | 31.0                   |
| July      | 109.0        | 16665           | 1765     | 534        | 10.6               | 3.2                | 30.3                   |
| August    | 86.0         | 8972            | 594      | 238        | 6.6                | 2.7                | 40.1                   |
| September | 56.0         | 5929            | 589      | 129        | 9.9                | 2.2                | 21.9                   |
| October   | 62.0         | 4589            | 414      | 75         | 9.0                | 1.6                | 18.1                   |
| November  | 54.0         | 5518            | 201      | 52         | 3.6                | 0.9                | 25.9                   |
| December  | 60.0         | 5637            | 383      | 170        | 6.8                | 3.0                | 44.4                   |

No: Number



**Figure 2.** Seasonality of Peste des petits ruminants in sheep and goat in Palestine (January 2005 to December 2017)



**Figure 3.** Vaccination rate of Peste des petits ruminants in sheep and goat in Palestine during 2005-2017

## DISCUSSION

PPR is an extremely contagious viral disease of sheep and goats. Due to the massive economic impacts of PPR in Palestine, it is essential to perform the analysis of epidemiological data of this disease. Understanding the disease epidemiology is necessary for effective control in the aim to the eradication of the disease. The present study was performed to provide epidemiological information in Palestine about the available confirmed PPR outbreaks among sheep and goats during 2005 and 2017.

The first report of PPR in the country was in 1993 (Parida et al., 2015). Since a large number of outbreaks have occurred and documented, these documentations were based on the confirmation of the World Organization for Animal Health (OIE) (Jebara et al., 2012). Indeed, other outbreaks, deaths and other data based on clinical observations were not accurately recorded due to inadequate animal disease diagnosis, reporting, and surveillance systems. The findings indicated that PPR in Palestine is present in an enzootic form with a low morbidity and mortality rate, however, the prevalence rate needs to be investigated by a national surveillance campaign. There is a limitation of reports regarding the incidence of PPR from other countries, most of the studies described PPR prevalence in a selected population at a certain time. For example, in Saudi Arabia, the prevalence rate was 2.3% in a total of 1035 serum samples from sheep and goat in 2004 (Adel et al., 2004). In 2010 in Pakistan, about 10% out of 2723 samples tested by ELISA were positive (Munir et al., 2010). In a survey performed by Al-Majali et al. (2008), a high prevalence rate was detected in sheep (29%, n= 929) and goat (49%, n= 400) tested in Northern Jordan in 2007 (Al-Majali et al., 2008). Outbreaks also most frequently being characterized in Iraq with high morbidity and low mortality rates (Banyard et al., 2010), while 22.4%

out of 1607 samples were positive in Turkey in 2002 (Özkul et al., 2002). These studies confirmed that PPR is enzootic in this region of the world. In the enzootic area, the mortality rates may be as low as 20% with outbreaks occurring at a regular interval (Dhar et al., 2002). These similar estimates confirmed that PPR is a regional problem and countries in the Middle East. The variations in PPR incidence between these countries are mostly related to the different density of the flocks in the studied area, animal husbandry systems, flock size, vaccinations, humidity, rainfall, temperature and the technique used for detection of the disease (Sharma et al., 2015; Ma et al., 2017). The disease in Palestine is circulating quietly during the season. The findings revealed that the PPR outbreaks numbers increase in the dry season from April to August with a peak in June. The disease then expresses itself in epizootic outbreaks that appear with a seasonal frequency. These results are in agreement with other studies (Singh et al., 2004; Foltise et al., 2017), who observed higher prevalence in the dry season. This increase could be related to animal movement, animals flocked from one place to another that favor the spread of the virus (Dhar et al., 2002). Sheep and goats from different places are brought into close contact during spring and summer seasons at the marketplaces, this could also promote PPR virus transmission (Das et al., 2007). In contrast other studies reported that PPR is mostly epizootic during the wet season (Balamurugan et al., 2011), this could be due to the limited availability of feed during this period of time and close confinement of the animals in farm buildings, as well as to the increased introduction of susceptible young animals in the flocks rather than a seasonal surge in viral activity (Balamurugan et al., 2011; Ban-Bo et al., 2014). The findings revealed that PPR mortality rate range from 0.9 to 3.5%, in agreement with other studies that the mortality rate in endemic areas may be as low as 20%, with outbreaks occurring at a regular interval (Dhar et al., 2002). PPR tends to be more severe in the change in weather such as the late dry season and the onset of the rainy season (hot and humid) or dry, cold periods (Dhar et al., 2002). A nation-wide program vaccination against PPR has been practiced in Palestine to control the disease. Currently, the available PPR vaccine is a live attenuated prepared from a reference strain Nig. 75/1 from Jordan bio-industries center (JOVAC, Jordan). The PPR vaccination in Palestine is not well organized, the findings indicated that the rate of vaccinated animals is too low and will not lead to effective containment and control of PPR. It is important to note that the Israeli measures defy access to perform veterinary services of animals in Palestine (MoA, 2015). The difficulties to reach animals holdings near the Israeli Settlements and the “closed military zone” by Israeli military barriers also contribute to the low vaccination rate (PCBS, 2011). The restriction of vaccine administration by the veterinary service at the ministry of agriculture as well as the unawareness of owners about the benefits of vaccination could be probable explanations of this low rate of vaccination.

## CONCLUSION

In conclusion, based on present findings, PPR is enzootic in sheep and goat in Palestine. Outbreaks occurred during the year; more epizootic with low morbidity and mortality, and sever in wet cold seasons. Proper and effective record keeping is essential for tracking and evaluation of the disease status in Palestine. A sero-surveillance plan should be taken up particularly in the unvaccinated areas to estimate the prevalence. Besides, a vaccination campaign must be applied at the level of the state to control the disease followed by a systematic monitoring program should be initiated to assess the efficacy of the vaccination campaign.

## DECLARATIONS

### Competing interests

The author has declared that no competing interest exists.

### Consent to publish

The author gives the consent for information and images concerning the article to be published in the World's Veterinary Journal.

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