Sero-epidemiology of peste des petits ruminants in Oromia and Afar regional states of Ethiopia

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V.N. Rume [1, 2], S.C. Bodjo [2]*, B. Gurja [1], J.D.D. Baziki [2], D. Adama [2], P. Ankeli [2], N.D. Nwankpa [2], D. Yebchaye [2] & T.S. Tessema [3]

(1) Department of Microbial Cellular and Molecular Biology, Addis Ababa University, P.O. Box 1176, Addis Ababa, Ethiopia

(2) African Union–Pan African Veterinary Vaccine Centre (AU–PANVAC), P.O. Box 1746, Debre Zeit, Ethiopia

(3) Institute of Biotechnology, Addis Ababa University, P.O. Box 1176, Addis Ababa, Ethiopia

*Corresponding author: charlesbodjo@gmail.com

Summary

Peste des petits ruminants (PPR) is a severe non-zoonotic viral disease of small ruminants caused by a morbillivirus closely related to rinderpest virus (RPV). The disease is widespread in Africa, the Middle East and Southern Asia. It is one of the priority animal diseases whose control is considered important for poverty alleviation in those regions because of the associated high economic losses. A sero-epidemiological study of PPR was conducted in Oromia and Afar regional states of Ethiopia. A total of 800 serum samples from sheep and goats were collected between October 2015 and March 2016 in Afar and Oromia, where no vaccination history has been recorded. These two regions are known to have a large population of small ruminants. The levels of PPR antibodies obtained in the two regions using the competitive enzyme-linked immunosorbent assay

(cELISA) ID Screen® PPR Competition from IDvet (Montpellier, France) were similar, at 12.7 and 13.0% for Afar and Oromia, respectively. A seroprevalence of 12.9% for the two regions was obtained. The study also linked seropositivity to risk factors such as sex, age and species with a *p*-value of less than 0.05 ($p = 0.0001$, $p = 0.0001$ and $p = 0.004$, respectively).

Keywords

Afar – cELISA – Ethiopia – Oromia – PPR – Risk factor – Seroprevalence.

Introduction

Peste des petits ruminants (PPR) is a highly contagious viral disease of small ruminants (sheep and goats) first described in Côte d'Ivoire (1). The disease is now widespread globally and is reported across Africa, the Middle East, Eurasia (Bulgaria, Georgia and Turkey) and Asia (2, 3, 4). It causes high economic losses, which lead to increased poverty and threaten food security in the infected regions. Morbidity and mortality rates can rise up to 100% and 90%, respectively, in newly infected regions. The disease constitutes a threat to livestock production in many developing countries, particularly in Africa and Asia. Sheep and goats contribute significantly to the nutrition and cash income of farmers in Africa and Asia, and these countries account for about 72.9% of the world's poorest people (5). The control of PPR is, therefore, considered important for poverty reduction because the disease is a major constraint to the production of small ruminants.

In consideration of the importance of sheep and goats in the livelihoods of the poor populations in these regions, the international veterinary community decided to focus on global efforts towards the control and eradication of PPR by the endorsement of the PPR Global Control and Eradication Strategy (PPR–GCES) at the international conference for the control and eradication of PPR jointly organised by the Food and Agriculture Organization of the United Nations (FAO)

and the World Organisation for Animal Health (OIE) in Abidjan, Côte d'Ivoire, in 2015 (6).

The first clinical suspicion of PPR in Ethiopia was raised in 1977 and serological evidence of its presence was reported by Taylor in 1984 (7); PPR was later confirmed in lymph nodes and spleen specimens collected from an outbreak on a holding near Addis Ababa in 1991 using a complementary deoxyribonucleic acid (cDNA) probe (8).

After the first official report of PPR in Ethiopia in 1996, several studies have reported a high prevalence of PPR in sheep and goats within the country (9, 10).

Small ruminants in Ethiopia mainly thrive on free-range pastureland, shrubs and forest cover. Owing to the shrinkage in pastureland and forest area, these animals travel long distances for fodder and water during the dry season. Seasonal movement of animals has been shown to be a factor in the spread of PPR virus (PPRV); this partly explains the occurrence of the disease in areas where it was never previously reported (11, 12). Eventually, PPR became one of the most economically important livestock diseases in Ethiopia (10).

In accordance with the current PPR global eradication strategy put in place by the FAO/OIE (6), it became necessary to determine the current seroprevalence of PPR in each region of Ethiopia and to identify the risk factors associated with the disease in those areas. This paper reports the results of a PPR seroprevalence study obtained from some selected zones of Oromia and Afar regional states of Ethiopia, where no vaccination programmes have been conducted.

Materials and methods

Study areas

This study was undertaken between October 2015 and March 2016 in Oromia and Afar regions of Ethiopia (Fig. 1) where PPR vaccination programmes were not conducted, according to the Veterinary Services. The small ruminant population in the two regions is larger

than in other regions. The Oromia region is the largest state of Ethiopia, with a population of small ruminants estimated at 9,401,844 sheep and 7,685,529 goats (13). Samples for this study were collected from four districts: Arero (4°44′N 38°45′E), Miyo (3°30′N 39°27′E), Teltele (4°50′N 37°25′E) and Yabello (4°53′N 38°5′E) in the Borena subdivision zone (5°00′N 38°15′E) which is bordered on the south by Kenya.

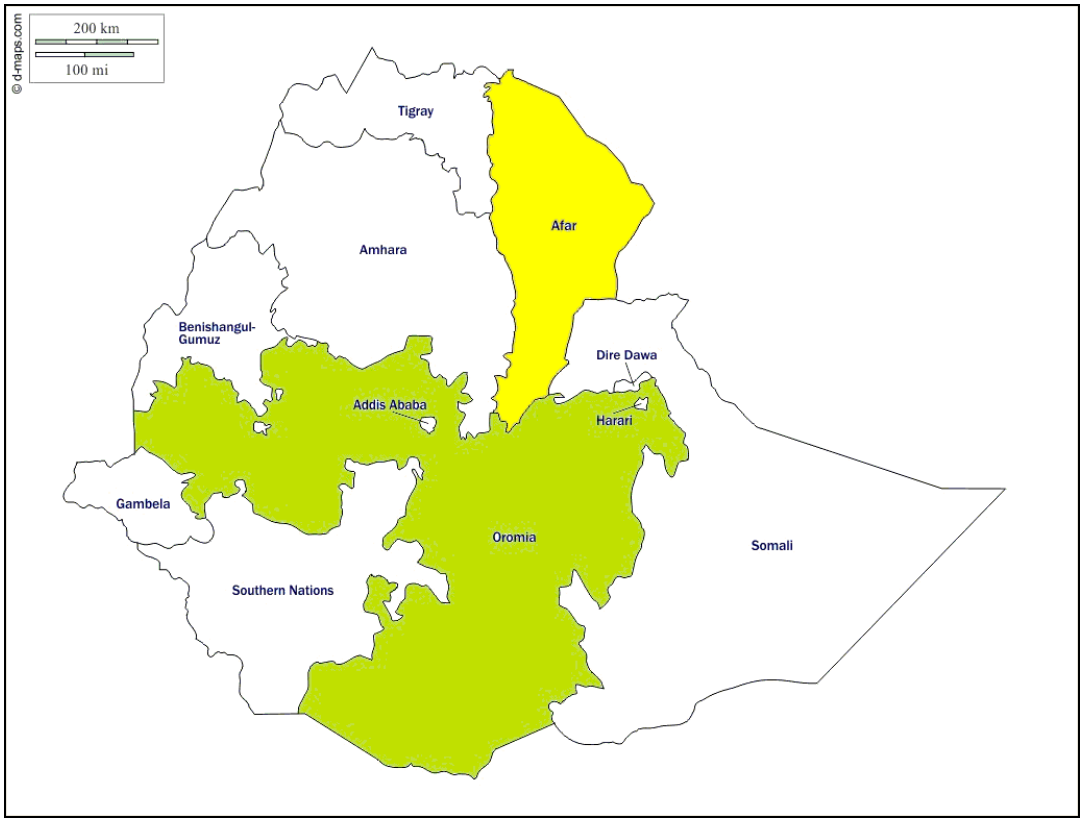

Fig. 1

Map of the study area (adapted from www.d-maps.com)

The Afar region is located in the eastern part of Ethiopia. The sheep and goat populations are estimated at 353,418 and 599,828, respectively (13). Samples were collected from four districts: Abala (13°22′N 39°45′E), Mille (12°20′N 42°02′E), Dubti (11°50′N 41°0′E) and Asayta (11°45′N 41°30′E) (Fig. 1).

Sampling method and sample size

The cross-sectional sampling method was used for this study. The two study regions were selected based on a large population of small ruminants. Eight districts within the regions were selected based on accessibility to farmers, farmers' cooperation, peace and security of the area and logistics. At least 10 herds or flocks were selected from each district for sampling. The sample sizes for these districts were determined by the formula recommended by Thrusfield (14):

$$N = 1.962 \times PQ/D2$$

Where N is the required sample size, P is the expected prevalence based on previous preliminary surveys, Q is $1 - P$ and D is the level of precision (5%). Given that there was no previous report of the seroprevalence in the specific study location, 50% expected prevalence was used in the formula. To increase the precision, 384 was rounded up to 400.

In order to get a good epidemiological picture of the prevalence of PPR within the study regions, probability proportional to size was used; therefore, the sample size was calculated by dividing the number of small ruminants in each district by the total number of small ruminants in the selected districts and multiplying by 400.

$$\text{Sample size} = \left(\frac{\text{Number of small ruminants in each district}}{\text{Total small ruminants in selected districts}}\right) \times 400$$

The sample size was determined for a confidence interval (CI) at 95% and is presented in Table I.

Approximately 10 ml of blood was collected from each animal into a plain sterile vacutainer and labelled with date, sex, age and location. The samples were placed in a cold chain and transported within 1 h 30 min to the laboratory of the African Union–Pan African Veterinary Vaccine Centre (AU–PANVAC). Serum was separated and stored at –20°C until analysis.

Serological analysis

Serum samples were tested for PPR antibodies using the competitive enzyme-linked immunosorbent assay (cELISA) ID Screen® PPR Competition from IDvet (Montpellier, France) (15). The test was performed according to the manufacturer's instructions. Results were expressed as percentage inhibition of the optical density (% OD) reading of the sample, calculated as % OD = 100 × (S – N)/(P –N), with the tested sample (S) and OD of the negative (N) and positive (P) controls, respectively. Samples with percentage inhibition less than or equal to 50% were considered positive for PPR antibodies. Samples with OD greater than 50% and less than or equal to 60% were considered doubtful, while samples with OD greater than 60% were negative.

Data analysis

The data obtained from this study were analysed using the Statistical Package for the Social Sciences (SPSS) software version 20 (IBM SPSS Statistics Premium 20.0, IBM Corp., Armonk, NY, USA). Descriptive statistics, chi-square tests and multivariate and univariate regression analyses were used to determine the association of risk factors with seroprevalence.

Results

Overall seroprevalence

Out of the 800 sera samples collected from the study regions and analysed by cELISA, 103 samples were positive for PPR antibodies, with an overall prevalence of 12.9% (Table I).

Seroprevalence by region

The seroprevalence found in Oromia and Afar regional states was similar, with 52 and 51 positives out of 400 samples collected from each region, respectively (Table I).

Table I

Seroprevalence of peste des petits ruminants by region, district, sex, species and age

Variable	Location	Sample number	Number positive	Percentage positive	*p*-value
Region	Oromia	400	52	13	
	Afar	400	51	12.7	
District	Arero	153	26	16.9	
	Teltele	124	6	4.8	
	Yabello	53	9	16.9	
	Miyo	70	11	15.7	
	Milli	205	29	14.1	
	Abela	123	13	10.5	
	Dubti	45	5	11.1	
	Asayta	27	4	14.8	0.106
Sex	Male	361	27	7.5	
	Female	439	76	17.3	0.0001
Species	Goats	396	64	16.2	
	Sheep	404	39	9.7	0.004
Age (years)	Adult	516	93	18.0	
	Young	284	10	3.5	0.0001

Seroprevalence by district

Prevalence was similar within the districts of Oromia (16.9% and 16.9% for Arero and Yabello) and Afar (14.8% and 14.1% for Asayta and Milli) (Table I). The multivariate regression analysis showed that there was no significant difference among the districts: the *p*-value was greater than 0.05 ($p = 0.106$).

Analysis of risk factors associated with peste des petits ruminants

Districts

The data analysed indicated that there is no significant difference in the prevalence of PPR between the districts in Oromia and Afar. Even though there was a slight variation between the two regions, statistical analysis of the prevalence in the different districts showed that the disease is circulating equally in the regions because the *p*-value was greater than 0.05 ($p = 0.106$) (Table I).

Sex

Out of the 439 female and 361 male animals screened, females had a higher prevalence (17.3%; 76/439 positive) when compared with males (7.4%; 27/361 positive). The analysis showed that there is a significant difference in prevalence between the sexes as the *p*-value was less than 0.05 ($p = 0.001$) (Table I).

Species

Out of 396 goats and 404 sheep analysed, goats had a higher seroprevalence of 16.1% (64/396 positive) when compared with 9.6% (39/404 positive) in sheep. The statistical analysis showed a significant difference in prevalence ($p = 0.004$) (Table I). These results indicate that goats are almost twice as likely to be seropositive for PPR as sheep.

Age

The seroprevalence values in two age groups were compared: adult and young animals (young indicating those still suckling and under the guidance of their mother). A seroprevalence of 18.0% (93/516 positive) was recorded for adults as against 3.5% (10/284 positive) for young animals. The difference is significant ($p = 0.0001$), as shown in Table I, indicating that adults are more likely to be seropositive for PPR than young animals.

Discussion

This study determined the seroprevalence of PPRV antibodies in small ruminants in Oromia and Afar regions of Ethiopia between October 2015 and March 2016, and highlighted possible risk factors associated with susceptibility to the disease.

The study revealed the seroprevalence of PPRV among young and adult sheep and goats of both sexes. The prevalence of PPRV antibodies in these categories agrees with the studies conducted by Khalafalla *et al.* in Sudan, where they indicated that animals of all ages and both species and sexes were susceptible, and that naturally infected animals were shown to remain seropositive for a long time (16).

In the current study, females were found to have a higher risk of being seropositive than males. The multivariate analysis revealed that females were 2.3 times more likely to be seropositive than males. This finding is similar to those of the studies conducted by Waret-Szkuta *et al.* (17) and Rahman *et al.* (18), in which females showed higher seroprevalence than males. The case fatality rate has been shown to be higher in females than in males (16), and this variation could be attributed to alterations in the physiological condition of female animals, especially those due to the immunosuppressive effects of pregnancy and lactation (19, 20, 21). Females are kept longer than the males in a herd or flock, for reproduction purposes, which increases the likelihood for female animals to be exposed to PPRV over time and to be sampled (18, 19). Sex has previously been described as a risk factor for PPR where females are shown to have greater risk of being positive (22, 23, 24); however, studies by Mbyuzi *et al*. and Sarkar and Islam found that males have higher risk of being seropositive than females (25, 26). This difference could be attributed to varying external factors which can affect the outcome of any study.

This study also revealed a difference in species susceptibility to PPR because the result of the univariate regression analysis showed that goats were 1.6 times more likely to be seropositive than sheep. This is similar to the findings of previous epidemiological studies that show

that PPR is predominantly a disease of goats rather than sheep (27, 28). This finding is also in agreement with studies by Rahman *et al.*, Kihu *et al.* and Al-Majali *et al.* (18, 19, 29), who indicated that goats were more likely to be seropositive for PPR than sheep. The PPRV is said to exhibit different levels of virulence in sheep and goats. Goats are severely affected while sheep generally undergo a mild form (30, 31). However, Abubakar *et al.* have indicated that in some cases sheep are shown to have higher prevalence than goats. They attributed this to a higher recovery rate (lower case fatality rate) and/or a greater longevity of sheep versus goats because sheep are kept for wool production (31).

A comparison between adult and young animals indicated that age may be a risk factor for PPR, because the prevalence was higher in adults than in the young. Adults were 5.1 times more likely to be seropositive than young animals. This is similar to the results obtained by Mahajan *et al.* and Torsson *et al.* (24, 32), who demonstrated that adult animals have a high level of seropositivity to PPR. This difference is likely to be due to the fact that adults have had a longer period of exposure to the virus (23), or that the young die more rapidly during infection, hence fewer young animals are available for sampling (16). The findings of these studies are also similar to those of the studies conducted by Khalafalla *et al.*, Gari *et al.* and Awa *et al.* (16, 33, 34), who indicated that adults have a higher risk of being infected than the young. Similarly, other studies, conducted by Waret-Szkuta *et al.* in Ethiopia (17) and Abubakar *et al.* in Pakistan (31), also indicated that age is a risk factor for PPR.

The only factor that was not shown to have a significant association with seropositivity to PPRV in the current study is location. This is contrary to a report by Abubakar *et al.*, who determined that occurrence of infection varied substantially by geographical location (31). The multivariate regression analysis in the current study showed no significant difference in seropositivity among the study districts, which indicated that PPR is persistent and equally distributed in the study area. These results suggest that PPR is endemic and that PPRV is extensively circulating within these districts.

Conclusion

The results of this study suggest that PPRV is circulating in the study regions and that the risk of exposure is related to the age, sex and species of the animal. This study is a confirmation of the endemicity of PPR in Ethiopia because it was conducted in the two major regions of Ethiopia with very large populations of small ruminants.

Despite the availability of good vaccines, PPR continues to spread. The ongoing strategy for eradication of PPR in Ethiopia should take into consideration the seroprevalence of the disease in the different regions of the country, as presented in this study.

Recommendation

In order to control and eliminate PPR effectively, there is a need to: *i)* have comprehensive PPR seroprevalence data to allow better national vaccination management through regular surveillance and updates; *ii)* revisit the continental and national strategies, based on current epidemiological data on the spread of the disease, for emergency preparedness.

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