

Full Length Research Paper

Sero-prevalence of *peste des petits ruminants virus* (PPRV) in small ruminants in Blue Nile, Gadaref and North Kordofan States of Sudan

A. S. Abdalla¹, A. A. Majok², K. H. El Malik³ and A. S. Ali^{4*}

¹General Directorate of Animal Health and Epizootic Disease Control, Federal Ministry of Animal Resources and Fisheries, Khartoum, Sudan.

²Dr. John Garang Memorial University of Science and Technology, Bor, Sudan.

³Department of Preventive Medicine and Public Health, Faculty of Veterinary Medicine, University of Khartoum, Sudan.

⁴Department of Microbiology, Faculty of Medicine, King Khalid University, Abha, Saudi Arabia.

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The present cross-sectional survey was conducted in Blue Nile, Gadarif and North Kordofan states of Sudan. The study was conducted during the period May 2005 to September 2006 to provide an overview of the most important diseases affecting small ruminants' productivity. Results of interviews with small ruminants' keepers indicated that *peste des petits ruminants* (PPR) was found to be one of the most important diseases in all the study areas, with minor variations in importance at individual state level. Analyses of the sera collected from small ruminants gave an overall sero-prevalence of PPR as 61.8%. However, PPR had a slightly higher ranking in importance in Gadarif and Blue Nile states, while respondents in North Kordofan did not report PPR as the most important disease, but reported a syndrome with diarrhea, pneumonia and sudden death. This syndrome was considered by the pastoralists as the most important condition which reduced their small ruminants' numbers and denied them market access.

Key words: *Peste des petits ruminants* (PPR), seroprevalence, small ruminants, Sudan.

INTRODUCTION

Peste des petits ruminants (PPR) is an acute or sub-acute viral disease of small ruminants. Other names commonly used includes, pseudo rinderpest of small ruminants; pest of small ruminants; goat plague; pest of sheep and goat; stomatitis pneumoenteritis syndrome; contagious pustular stomatitis and pneumoenteritis complex (Alillo et al., 1998). It is a highly contagious, infectious and fatal viral disease of domestic and small ruminants (Roeder et al., 1999; Ozmen et al., 2009). The disease is characterized by fever, necrotic stomatitis, gastroenteritis and pneumonia. Defra (2005) described it as a rinderpest-like contagion of goats and sheep characterized by erosive stomatitis, enteritis, pneumonia.

The first report of an outbreak of a rinderpest-like disease in sheep and goats in Sudan was in 1971 in the southern part of Gadarif State near Dindir River (Elhag, 1973). The disease was diagnosed as Rinderpest (RP) on clinical signs. However, RP precipitinogens were demonstrated by agar gel precipitation test (AGPT) (Elhag, 1973). Subsequent isolates from an outbreak of a 1972 RP-like disease in Sennar and Meilig in Sudan were found to be closely related antigenically to the Nigerian *peste des petits ruminants* (PPRV). The isolates were considered as PPR and termed as SUD 72/ 1(Sinnar) and SUD 72/ 2 (Meilig) (Elhag and Talor, 1984). Other outbreaks of PPR in the Sudan include the ones from Elhilalia in Gezira state (Awad Elkarim et al., 1994) and Elfashir in North Darfur (Elsheikh, 1992). Sero-surveillance results demonstrated the prevalence of the disease in Khartoum (Zeidan, 1994), Southern Sudan states (Osman, 2005), and Khartoum, Gezira, River Nile, Kordofan, Eastern

*Corresponding author. E-mail: abumalaz2002@gmail.com. Tel: +966 (07)-241-8589, +966-56-146-9977. Fax: +966-72718194.

states (Intisar et al., 2010).

Various laboratory techniques and serological tests were employed to diagnose the PPRV antigens or antibodies in sera of infected animals including AGPT and hemagglutination test (HA) (Nusseiba et al., 2008) and experimental infection (Nusseiba et al., 2009a).

The purpose of this study was to determine the prevalence of PPR by serology in small ruminants in Blue Nile, Gadarif and North Kordofan States of Sudan.

MATERIALS AND METHODS

Study area

The study area include Blue Nile State, Gadarif State and Elkhowie area in North Kordofan State which were selected according to predetermined criteria, namely, diversity in terms of production systems, market outlets, prevalence of poverty, dominance of sheep and goats and prevalence of major trans-boundary diseases. Information on small ruminants' health and market constraints was collected through a structured questionnaire

Questionnaire survey

The questionnaires were designed by the Small Ruminant Project Scientists (ILRI/ICARDA), discussed with the national research team and agreed upon to be used for data collection from households/flocks. The structured questionnaire comprised of 262 for households [116 from Blue Nile, 101 from North Kordofan (Elkhowie administrative unit) and 45 from Gadarif States]. Occupation and main sources of family income were included in the questionnaire.

Sample size and serum samples collection

The following criteria were adopted for sampling as below:

- 1) The target population was defined as including all small ruminants in the study sites.
- 2) The study population was identified to include the small ruminants that had not been vaccinated against PPR.

The three study states were taken as clusters with known population of small ruminants. Sampling with probabilities proportional to number of small ruminants in each state (that is, probability sampling) was used to determine the number of small ruminants (sample size, n) to be included in the study in each state. The sample size determined, thus for each state was, Blue Nile, 280, Gadarif 105 and W. Kordofan, 215 samples, giving a total of 600 animals (sheep and goats).

Within each state number of small ruminants in each locality was selected conveniently (convenient sampling). Thus, the distribution within each state was (280) in Blue Nile State, (105) in Gadarif state and (215) in North Kordofan State (Elkhowie Administrative Unit). The total number sampled and bled for sera for all the three states was 600.

Competitive enzyme immunosorbent assay for detection of antibodies to PPRV

Competitive enzyme-linked immunosorbent assay (c- ELISA) was used to test 600 serum samples collected from small ruminants from all study sites to determine PPR sero-prevalence. The test

was carried out firmly as described by Nusseiba et al. (2009b). The Assay procedure followed the restricted steps mentioned in the PDSL protocol and was applied in the Central Veterinary Research Laboratory (CVRL), Khartoum.

Data analysis

SPSS software version 11.5 was used to analyze the data.

RESULTS

The survey revealed that the most dominant livestock (small ruminants) production system was seasonal movement in Gadarif and Blue Nile states; while sedentary system was the dominant in North Kordofan (Elkhowie area) (Table 1).

Information about small ruminants' diseases obtained from the respondents through interviews differed from year to year and by study areas. Thus, for 2005 study year 17.1, 64.2 and 0% of the respondents reported that PPR was the most important disease in Gadarif, Blue Nile and North Kordofan (Elkhowie area) states respectively; while 22.7% of the respondents reported that diarrhea and pneumonia conditions were the most important conditions in 2005. PPR, diarrhea and pneumonia had 33.98, 57.41 and 41.44% case fatality rate respectively during this year.

For the study year 2004, 43.6, 46.4 and 0% of the respondents reported that PPR was the most important disease in Gadarif, Blue Nile and North Kordofan States, respectively; while 20.6% of the respondents reported diarrhea and pneumonia to be the most important conditions in 2004. PPR, diarrhea and pneumonia had 48.23, 95.74 and 11.86% case fatality rate respectively during that year.

In the study year 2003, however, 21.4, 22 and 0% of the respondents reported PPR to be the most important disease in all the study states (Gadarif, Blue Nile and North Kordofan), respectively. However, 3.6% of the respondents reported diarrhea and pneumonia as the most important conditions in that year.

A Considerable number of respondents (58.9%) stated that both sheep and goats were affected equally with PPR, although goats appeared to be the most affected with PPR (57.1%) when compared to other diseases.

Further analysis revealed significant association between prevalence of PPR and winter season ($p < 0.05$). There was a strong correlation between the number of animals affected with PPR and the number of sick animals that could not be sold in Blue Nile state (Pearson correlation coefficient (r) = 0.819, r^2 = 0.671). Similarly, there were positive correlations (Pearson correlation coefficients, 0.327 and 0.622 for Blue Nile and Gadarif states respectively) between the number of goats born during the year and the number that died due to PPR during the same year.

PPR gave an overall sero-prevalence of 61.8%;

Table 1. Production systems of small ruminants in each study site as a percentage of the total population engaged in each system in each State.

State	Production system			Total (%)
	Sedentary (%)	Seasonal movement (%)	Permanent movement (%)	
Gadarif	13 (28.9)	29 (64.4)	3 (6.7)	45 (100)
Blue Nile	33 (28.5)	78 (67.2)	5 (4.3)	116 (100)
N. Kordofan	65 (64.3)	33 (32.7)	3 (3.0)	101 (100)
Total	111 (42.4)	140 (53.4)	11 (4.2)	262 (100)

Table 2. Sero-prevalence of PPR in sheep and goats tested with an indirect c-ELISA in the study areas.

State	Sheep		Goats		Total	
	No. tested	+ve (%)	No. tested	+ve (%)	No. tested	+ve (%)
Gadarif	58	15 (25.9)	47	15 (31.9)	105	30 (28.58)
Blue Nile	152	99 (65.1)	128	95 (74.2)	280	194 (69.3)
N. Kordofan	189	137 (72.5)	26	10 (38.5)	215	147 (68.4)
Total	399	251 (62.9)	201	120 (59.7)	600	371 (61.8)

Table 3. Prevalence of PPR antibodies in small ruminants by sex in the study areas.

State	Males		Females	
	No. tested	+ve (%)	No. tested	+ve (%)
Gadarif	20	2 (10.0)	85	28 (32.9)
Blue Nile	73	43 (58.9)	207	151 (72.9)
N. Kordofan	51	33 (64.7)	164	114 (69.5)
Total	144	78 (54.2)	456	293 (64.2)

(371/600); while individual study states had (69.3 %) in Blue Nile, (68.4%) in North Kordofan and 28.6% in Gadarif states. On species basis, an overall sero-prevalence in all study sites was 62.9% for sheep and 59.7% for goats with major fluctuation at state level (Table 2).

On sex basis, an overall sero-prevalence in all study sites was 54.2% for males and 64.2% for females with major fluctuation at state level (Table 3). The difference in overall sero-prevalence between sex among study states was significant when chi square was used ($p < 0.05$) and the odds ratio was found to be 1.52 which means that the female had a risk factor 1.5 times that of males, while within State significant difference was observed in Blue Nile state and Gadarif only.

Using chi-square statistics, there was significant association in the overall sero-positivity among different age groups for both species (sheep and goats) ($p < .005$). Likewise, there was significant positive correlation between percent inhibition (PI) which was used to measure the cut-off points for c-ELISA and the age of samples at the 0.01 level (2-tailed).

Economic importance of PPR

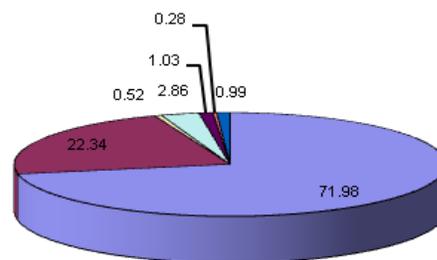
The total cost of small ruminants that died of PPR disease reported by respondents during the study years (2005, 2004 and 2003) was valued at Sudanese Dinnar (SD) 13,674,500, 10,811,950 and 1,370,000, with the equivalent values, in US Dollars being, estimated at \$ 56,977.1, 43,247.8 and 5,269.2 respectively, giving a total value of total death of SD 25,856,450, equivalent to a total value of \$ 105,494.10 for the study period (2003 to May, 2005). The approximate value of total losses other than deaths (Abortion, milk loss and emaciation) due to PPR for the same study period (2003 to May, 2005) was SD 6,321,600 (equivalent to \$ 25,838.2).

Cost of drugs for treatment against PPR over the same period (2003 to 2005) was SD 5,447,050 (or 22,146.9 US Dollars). Fees levied for services for PPR over the same period of three years was SD 6,500 (or, \$ 26.8). The combined cost due to deaths, losses other than deaths, drugs and services attributable to the PPR disease was SD 37,631,600 (\$ 153,479.2). Losses due to PPR accounted for 29.1% of the losses from all diseases

Table 4. Value of losses resulting from deaths and other costs due to PPR as reported by respondents.

Value of losses and costs	The total losses and costs of the 1 st and 2 nd most important diseases reported (SD)	PPR (SD)
Value of dead small ruminants	101,381,750	25,856,450
Value of production losses (milk, abortions lost of weight, etc.)	11,350,100	6,321,600
Cost of drugs and vaccines	16,669,510	5,447,050
Fees for services	19,500	6,500
Total (SD)	129,420,860 (100%)	37,631,600 (29.1%)

- Livestock rearing
- Crop production
- Service
- Livestock trade
- Other trade/business
- Remittance from family members working away from household
- Other (specify)

**Figure 1.** Occupation and main sources of family income reported.

studied during the same study period (2003 to 2005) Table 4.

Occupation and main sources of family income reported

71.98% of the respondents depend on livestock rearing, 22.34% on crop production, 2.86% on livestock trade, 1.03% on other/trade and business, 0.52% on services and 0.28% on remittance from family members working away from household Figure 1.

DISCUSSION

Diarrhea and pneumonia, together with unknown conditions, leading to sudden deaths, dullness and abortion in animals were observed. Such symptoms and laboratory results led to suspicion that PPR might have been the cause of deaths, but misdiagnosed by small ruminants' producers. Mariner and Paskin (2001) had reported that it was usual for communities to recognize one or two major diseases for which they had no name or names in the local languages. These researchers suggested that such unknown ill-health conditions

become major problems and may often be considered as new diseases.

Generally, ranking of diseases' importance by the respondents tends to agree with our laboratory results, confirming observation of Mariner et al. (2009) on farmers' rich practical agricultural knowledge and its relationship to the degree of economic dependence a society has on that activity. Moreover, the study revealed that 72% of the respondents reported livestock rearing as their main occupation and the main source of income.

The observation that case fatality rate of PPR in goats was (53.3%) compared to only (39.7%) in sheep indicates that goats are more susceptible to PPR than Sheep. This finding is in agreement with Lefèvre and Diallo (1990) and Roeder et al. (1994) observation that PPRV exhibits different levels of virulence between sheep and goats. It is also in agreement with Radostits' (2000) findings, which indicated that case fatality rates are much higher in goats than in sheep.

On the economic impact of PPR, this study has determined the total value of losses from deaths, losses other than deaths (abortion, emaciation and milk loss), and cost of drugs and fees for services during the three successive study years (2003, 2004, 2005) to be \$ 525,774. PPR accounted for 29.10% of these losses. Since 72% of the respondents depend entirely on livestock rearing, these losses could be taken to be of considerable economic impact on the livelihoods of small ruminants' keepers in the project areas. Additionally, small ruminants' producers are not able to access markets for their animals because of these identified diseases. Therefore, although the total losses and economic impact may have been underestimated, PPR is an economically significant disease of small ruminants as observed by Dhar et al. (2002).

Major ecological changes, which certainly affected the distribution of diseases, have occurred due to overgrazing, insecurity, tribal conflict and raiding, leading to extensive animal movement. Moreover, the newly established quarantine in Elkhwei (North Kordofan) where more animals from far areas (e.g. Darfur region), are held together without vaccination against PPR (RM Hassan, Community Animal Health Delivery services, Unpublished) could be one of the possible reasons for higher prevalence of PPRV in North Kordofan. Although the study showed higher prevalence of PPR in North Kordofan, the pastoralists are not familiar with clinical signs of PPR and have no local name for it. Pastoralist misdiagnosis is, therefore, a possibility and the higher proportion of small ruminants positive for antibodies to the disease in this site would therefore imply that PPR may have been newly introduced into the area.

This study revealed that PPR sero-prevalence in small ruminants was the highest in Blue Nile state (69.3%), which agrees with the findings of Osman (2005). This observation may be attributed to the characteristics of PPR as a trans-boundary disease and the frequent

movements of animals (small ruminants) within the state and to other parts of the country. Blue Nile and Gadarif States border Ethiopia at areas where insecurity makes veterinary services inaccessible to small ruminants' producers. Gadarif state had lower sero-prevalence (28.6%) compared to Blue Nile, which may be an indication of good PPR vaccination coverage in this state

The study revealed that the overall (all three study states) sero-prevalence for female was 64.3% while that for males was 54.2%. There was significant difference in sero-positivity between females and males of small ruminants tested ($p < 0.05$). This significance has no biological plausibility and does disagree with Osman (2005) findings that the sex of animals had no effect on the development of PPRV antibodies. The fact that small ruminants' producers keep more females for breeding purposes may explain this observation. Hence, the probability for females getting exposed to PPRV throughout their life time is more, than for males. However, association between PPR sero-positivity and sex of tested animals in Elkhwei area was not significant ($p > 0.05$), putting doubt on this assumption.

Likewise, there was significant difference in the prevalence of antibodies to PPRV in Blue Nile and Gadarif states among different age groups. This finding disagrees with observation of Osman (2005). This can be justified by the fact that the older animals have greater probability of exposure to the PPRV throughout their life time than younger ones. Interviewees stated that they usually keep older animals for breeding purposes.

The fact that there was significant correlation between Percent Inhibition (PI) average (used to measure the cut-off point) and different age groups confirms the findings of Radostits et al. (2000) that the percentage of antibodies to PPRV in small ruminants raises with age.

The conclusion from this study is that a PPR is probably more prevalent in the Sudan than is known so far. Moreover, homologous PPR attenuated vaccine is highly recommended to be used to protect against virulent virus challenge in the country for control of PPR.

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