OPEN ACCESS
DOI: 10.5455/javar.2014.a12

J. Adv. Vet. Anim. Res., 1(2): 42-49, June 2014
Available at- *http://bdvets.org/JAVAR*

JAVAR Journal of Advanced Veterinary and Animal Research

RESEARCH ARTICLE

Seroprevalence and risk factors of Peste des Petits Ruminants in sheep and goats in Sudan

Huyam Ahmed MohammedElamin Salih[1*], Abdelhamid Ahmed Mohammed Elfadil[2], Intisar Kamil Saeed[3] and Yahia Hassan Ali[3]

[1]General Directorate of Animal Health & Epizootic Diseases control, Khartoum, Soba, Sudan;
[2]Department of Preventive Medicine and Public Health, College of Veterinary Medicine, Sudan University of Science & Technology, Sudan;
[3]Virology Department, Veterinary Research Institute, P.O. Box No. 8067, Alamarat, Khartoum, Sudan.
[*]Corresponding author's e-mail: huyamamin@yahoo.com

ABSTRACT

The seroprevalence and risk factors of Peste des Petits Ruminants (PPR) were determined in unvaccinated sheep and goats in Sudan. A total of 480 sera samples were collected from the sheep (n=261) and goats (n=219) of Sennar, Gedarif, River Nile, and North Kordofan states during May, June, and October 2012 and February 2013, respectively. The sera were tested for the presence of antibodies against PPR using competitive Enzyme Linked Immunosorbent Assay. The overall seroprevalence of PPR was recorded as 45.6% (n=219/480); whereas, 57.2% in Sennar, 46.2% in Gedarif, 34.9% in River Nile and 39.8% in North Kordofan. A total of 14 risk factors were investigated using structured questionnaire, of which 9 were found to be associated with PPR seroprevalence ($p \leq 0.05$). Among the localities, Abozabad located in North Kordofan had the highest prevalence (91.7%) of PPR followed by Barbar in River Nile. PPR seroprevalence was higher in pastoralists, animals housed in scarp fences, females, and Kwahla sheep. In addition, PPR was higher in the states that had high rainfall and wind-speed. The associated 9 factors were further analyzed multivariably by logistic regression, and finally 5 of them (states, localities, husbandry system, gender, and age) were found to be associated with PPR seroprevalence ($p \leq 0.05$).

Keywords:

cELISA, PPR, Risk factor, Seroprevalence, Small ruminant

Received : 03 March 2014, **Revised**: 01 April 2014,
Accepted : 10 April 2014, **Published online**: 30 April 2014.

INTRODUCTION

Peste des Petits Ruminants (PPR) is a highly contagious transboundary animal disease affecting both wild and domestic small ruminants. The disease was first described in 1942 in Cote Devoir (Ivory Coast), and subsequently it spread over large areas in Africa. PPR is now prevalent in broad belt in Sub–Saharan Africa. In Africa, serological evidence of this disease was detected in Niger; however, the existence of PPR virus was confirmed in Ethiopia and Eritrea (Gopilo, 2005). In 2007, PPR was confirmed in Kenya and Uganda, and in 2008, the disease was reported in Tanzania (Karimuribo et al., 2011).

In Sudan, PPR was first reported during 1971 in Southern Gedarif state (Eastern Sudan), then in Central Sudan during 1971-1972. After these reports, PPR outbreaks continued to be reported in Darfur, Central Sudan and Khartoum (Saeed et al., 2004). At present, the disease is considered as an endemic disease in Sudan, similar to other countries of East Africa, with a seroprevalence rate varying from 58.1% to 93.8% (Shuaib, 2011).

So far, several studies have been reported on seroprevalence of PPR and isolation of PPR virus in Sudan. However, there are very few reports on epidemiological and environmental factors related to PPR

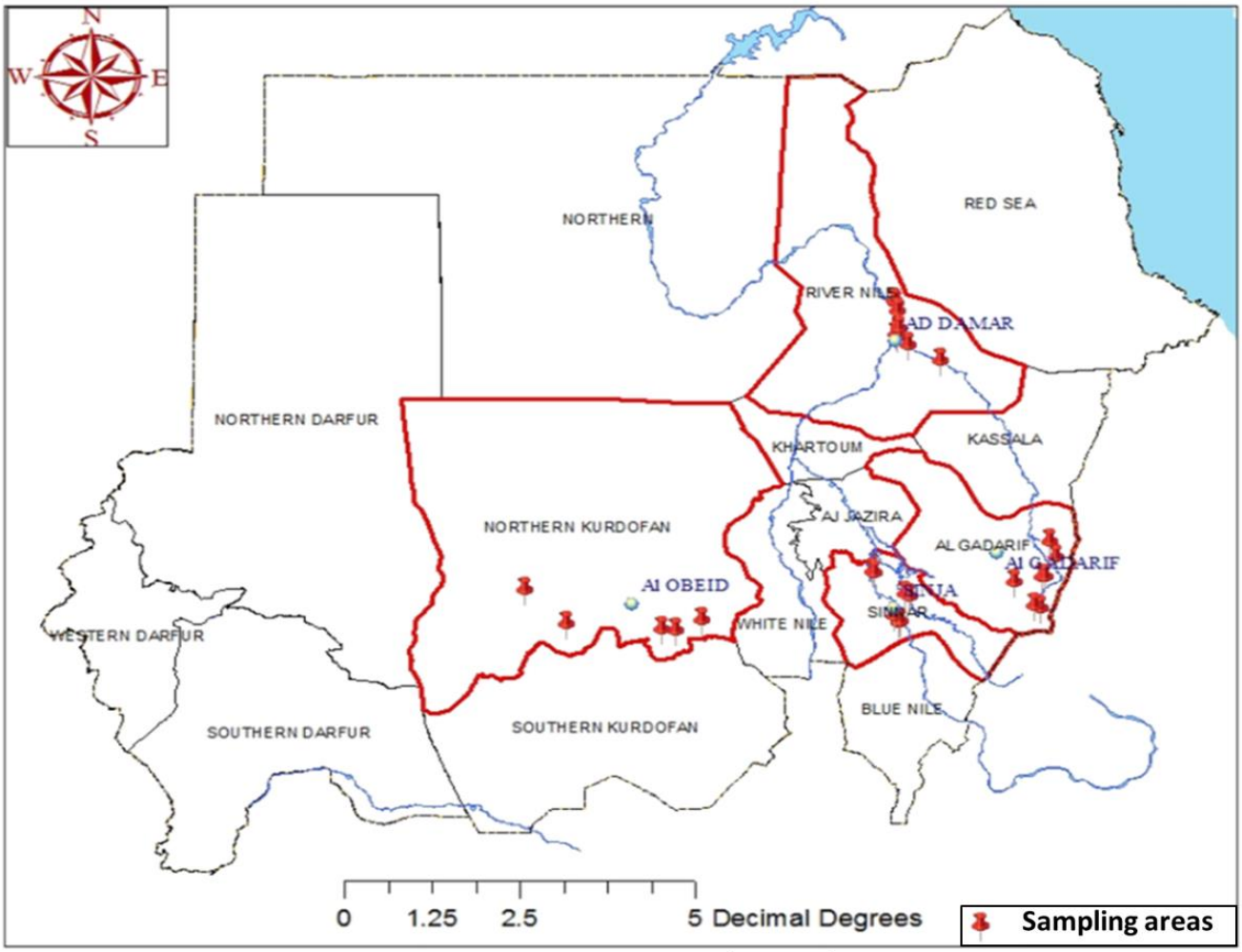

Figure 1: Sampling areas for investigating PPR seroprevalence in Sennar, Gedarif, River Nile and North Kordofan states of Sudan during 2012-2013.

outbreak in small ruminants in Sudan. Also, limited works have been conducted to investigate the risk factors which contribute in the spreading of PPR virus. Therefore, the present study was designed to investigate the seroprevalence of PPR in sheep and goats of Sudan; and to rule out different risk factors that might be associated with PPR seroprevalence in Sudan.

MATERIALS AND METHODS

Study area: The study was conducted in four different states of Sudan; River Nile (in the north), Gedarif (in the east), Sennar (in the center), and North Kordofan (in the west) (Figure 1).

Sample collection: A total of 480 blood samples were collected from sheep (n=261) and goats (n=219) from Sennar, Gedarif, River Nile, and North Kordofan states in Sudan during the months of May, June and October 2012, and February 2013, respectively (Table 1).

Detection of PPR antibodies using competitive Enzyme Linked Immunosorbent Assay (cELISA): Sera samples were separated from the blood samples by centrifugation (5,000 rpm) at room temperature, and stored at -20^{0}C until used. The sera were tested for PPR antibodies using cELISA kit (CIRAD EMVT, Montpellier, France). The test was performed according to the instructions of the manufacturer.

Data collection: Data on PPR outbreaks, animal census, vaccination and animal movement were collected from the General Directorate of Animal Health and Epizootics Disease Control, and the General Administration of Animal Resources located in the above mentioned four states. Meteorological data were collected from the Sudan Meteorological Authority. The data included rainfall, temperature, wind-speed and relative humidity records during the sampling period. A structured questionnaire was used to collect data during the period of sampling. The questionnaire

was designed to record the risk factors via direct questioning to the herd owners, and also some factors were taken from the direct notices and calculations, the Latitude and Longit-ude were taken using Global Positioning Service (GPS).

Data analysis: Categories of all data have been presented in Table 2. The collected data were analyzed by the Statistical Package for Social Sciences (SPSS) version 17.0. First, an analysis by using 2-tailed Chi-square test was conducted to find out the association between the investigated 14 risk factors and the ELISA positive and negative animals. In the second step, a logistic regression model was used to assess the association between the 9 significant risk factors ($p \leq 0.05$) in the univariate analysis and the PPR Abs (+ve) and PPR Abs (-ve). Data and results displayed in tables and Map were produced using GIS software ArcMap 9.3.

RESULTS

Seroprevalence of PPR: The overall seroprevalence for PPR in the tested samples was 45.6% (n=219/480); 43.7% (114/261) in sheep and 47.9% (105/219) in goats. Considering different states, 79 (57.2%) samples of Sennar were found to be positive for PPR. Similarly, 66 (46.2%) in Gedarif, 37 (34.9%) in River Nile, and 37 (39.8%) in North Kordofan were positive for PPR antibodies (Table 1).

Risk factors associated with PPR seropositivity:

Univariate analysis using Chi-square: Fourteen risk factors were assessed using structured questionnaire for every sampled herd. Nine different factors were found to be associated with PPR seroprevalence ($p \leq 0.05$). In univariate analysis when analyzed by Chi-square (χ^2), Sennar state was found to have the highest prevalence (57.2%), and within localities, Abozabad in Northern Kordofan had the highest prevalence (91.7%) followed by Barbar in River Nile state (70%). PPR was found to be highly prevalent among pastoralists (68.1%) as compared to other husbandry systems. Among the animal housing types, the animals kept in scrap fence houses had the highest PPR seropositivity (100%). Females were found to be more affected with PPR (54.5%). Regarding age groups, animal >12 months had the highest prevalence (57.2%) of PPR (Table 2). Kwahla sheep was mostly affected (83.3%) by PPR as compared to other sheep breeds. Some climatic conditions were found to be associated with PPR prevalence; the states with high rainfall and high wind-speed were found to have the highest PPR prevalence (51.6% and 50.2%, respectively) as shown in Table 2.

Multivariate analysis using Logistic regression: The significant 9 factors, found from univariate analysis, were further subjected to multivariate analysis using Logistic Regression model, and finally 5 risk factors were found to be associated with PPR seroprevalence ($p \leq 0.05$); these were states, localities, husbandry system, sex and age as shown in Table 3.

DISCUSSION

Assessment of risk factors is important for effective control and eradication of PPR. Besides climatic factors, seasonal and geographical variations influence PPR outbreak. Our study showed that the overall prevalence (45.6%) of PPR in four states of Sudan was

Table 1: PPR seroprevalence in Sennar, Gedarif, River Nile, and North Kordofan states of Sudan using cELISA.

Findings	Sennar	Gedarif	River Nile	North Kordofan
Samples tested (n=480)	138	143	106	93
cELISA positive (n=219)	79	66	37	37
Overall seroprevalence (%)	**57.2**	**46.2**	**34.9**	**39.8**
Number of sheep tested	83	93	42	43
Positive (+ve)	47	36	11	20
Seroprevalence in sheep (%)	**56.6**	**38.7**	**26.1**	**46.5**
Number of goats tested	55	50	64	50
Positive (+ve)	32	30	26	17
Seroprevalence in goat (%)	**58.1**	**60**	**40.6**	**34**
Number of females tested	123	104	70	37
Positive (+ve)	74	60	29	19
Female seroprevalence (%)	**60.1**	**57.6**	**41.4**	**51.3**
Number of males tested	15	38	36	56
Positive (+ve)	5	6	8	18
Male seroprevalence (%)	**33.3**	**15.7**	**22.2**	**32.1**

Table 2: Univariate analysis for risk factor associated with PPR seropositivity using Chi-square (χ^2) test.

Risk factor		No. of tested animals	No. of positive samples	Seroprevalence %	χ^2	df	*p*-value
State							
	Sennar	138	79	57.2	**13.717**	**3**	**0.003***
	Gedarif	143	66	46.2			
	River nile	106	37	34.9			
	North kordofan	93	37	39.8			
Locality							
Sennar	Abuhugar	68	43	63.2	**46.017**	**13**	**0.000***
	East sennar	44	25	56.8			
	Dindir	26	11	42.3			
Gedarif	Elfashga	29	11	37.9			
	Basonda	23	15	65.2			
	Elgorisha	61	29	47.5			
	Western glabat	30	11	36.7			
River Nile	Atbra	50	14	28			
	Barbar	10	7	70			
	Eldamar	46	16	34.8			
North Kordofan	Elkhiwai	15	4	26.7			
	Abozabad	12	11	91.7			
	Umrwaba	10	1	10			
	Elrahad	56	21	37			
Husbandry system							
	Open-grazing	322	137	42.5	**17.656**	**2**	**0.000***
	Pastoralists (Nomadic)	72	49	68.1			
	Intensive	86	33	38.4			
Housing							
	No house	175	73	50.3	**24.038**	**5**	**0.000***
	Building of bricks	73	35	47.9			
	Metal	11	0	0			
	Mud	58	18	31			
	Shrub fence	186	86	46.2			
	Wood& scrap	7	7	100			
Herd Composition							
	sheep &goats	327	157	48	**3.461**	**2**	0.177
	Sheep	82	30	36.6			
	Goats	71	32	45.1			
Species							
	Sheep	261	114	43.7	**0.874**	**1**	0.200
	Goats	219	105	47.9			
Breed							
	Rufaa	43	27	62.8	**23.193**	**13**	**0.039***
	Ashgar	14	5	35.7			
	Gwasma	5	4	80			
	Kenana	1	0	0			
	Kwahla	6	5	83.3			
	Baladi	241	108	44.8			
	Ethio-baladi	20	6	30			
	Garag-baladi	15	5	33.3			
	Hamary	43	20	46.5			
	Saaneen	11	2	18.2			
	Shami	4	0	0			
	Nubian-shami	1	0	0			
	Nubi	48	24	50			
	Baladi- saaneen	28	13	46.4			

To be continued in the next page

Table 2: Univariate analysis for risk factor associated with PPR seropositivity using Chi-square (χ^2) test. ***(Continued)***

Risk factor		No. of tested animals	No. of positive samples	Seroprevalence %	χ^2	df	*p*-value
Sex							
	Female	334	182	54.5	**34.793**	**1**	**0.000***
	Male	146	37	25.3			
Age (month)							
	1-3	51	10	19.6			
	4-12	186	43	37.6	**31.829**	**2**	**0.000***
	>12	243	139	57.2			
Herd size (no. of animal)							
	≤ 60	213	87	40.8			
	61-120	208	100	48.1	**7.330**	**3**	**0.062***
	121-200	27	18	66.7			
	> 200	32	14	43.8			
Annual Rainfall							
	Low rainfall	199	74	37.2	**9.758**	**1**	**0.001***
	High rainfall	281	145	51.6			
Wind-speed							
	Slow wind speed	249	103	41.4	**3.784**	**1**	**0.032***
	High wind speed	231	116	50.2			
Monthly Day Max temperature							
	Moderate	236	103	43.6	**0.734**	**1**	0.222
	High	244	116	47.5			
Monthly Relative Humidity							
	Low humidity	337	153	45.4	**0.023**	**1**	0.479
	High humidity	143	66	46.2			

*$p \leq 0.05$ was considered as significant; df = degree of freedom

lower as compared to some other previous studies; for example, 54% by Haroun et al. (2002), 50.6% by Osman et al. (2009), 61.8% by Abdalla et al. (2012), 62.8% by Saeed et al. (2010), and 70.2% by Shuaib (2011). This variation might be due to the wide-coverage of vaccination against PPR that reached 5,200,190 doses (animals) in 2011 as compared to 2,799,299 doses (animals) in 2010 (Anonymous, 2010 & 2011). The PPR prevalence was found to be significantly higher in Sennar (57.2%) followed by Gedarif (46.2%) in Eastern Sudan, and North Kordofan (39.8%) in western Sudan; whereas, the lowest prevalence was recorded in River Nile (34.9%) in Northern Sudan. The highest prevalence of PPR in Sennar and Gedarif might be due to the difference in climatic factors as these two states had the highest annual rainfall rates among the states. These findings were agreed with the reports of Saeed et al. (2010), while differed from the findings of Abdalla et al. (2012), and Shuaib (2011). This state variation of PPR prevalence might be due to variation in rainfall, humidity and wind-speed among the states. In our study, we found that the states with high rate of rainfall and high wind-speed were significantly affected as compared to the states having low rainfall and slow wind-speed. High rainfall cools weather that contributes to PPR spreading, as described by Elnoman et al. (2011), Elhassan et al. (1994), and Saeed et al. (2010).

On the other hand, based on locality, highest prevalence of PPR was found at Abozabad (91.7%) in Northern Kordofan state, followed by Barbar in River Nile state (70%). From these findings, it can be speculated that the prevalence of PPR was varied significantly among the states of Sudan as well as within a state in the country due to the geographical difference; these findings are agreed with the results reported by Shuaib (2011) and Muse et al. (2012). However, the observation reported by Ozkul et al. (2011) differed to our findings.

Sheep and goats of >12 months had a significantly higher seroprevalence, followed by animals with age from 4 to 12 months, while the low prevalence was found in kids aging 1 to 3 months. These results are in support to the findings of Abubakar et al. (2009), who reported that highest PPR seroprevalence was seen in animals aged >2 years. Therefore, adult animals might be more vulnerable to PPR infections as compared to younger animals. However, Sarker and Islam (2011) reported the highest PPR prevalence in young animals reasoning the poor immunity and poor nutrition as

Table 3: Multivariate analysis for the association between PPR seropositivity status and the potential risk factors resulting from the univariate analysis using Logistic regression.

Risk Factor	Seroprevalence (%)	Exp (B)	95% C.I. for Exp (B)		*p*-value
			Lower	Upper	
States					**0.038***
Sennar	57.2	0.205	0.025	1.658	0.137
Gedarif	46.2	1.104	0.186	6.560	0.913
North Kordofan	39.8	0.018	0.001	0.427	0.013
River Nile (Ref.)	**34.9**				
Localities					**0.001***
Abuhugar	63.2	12.949	2.025	82.794	0.007
East Sennar	56.8	11.217	1.562	80.536	0.016
Elfashga	37.9	1.528	0.300	7.786	0.610
Basonda	65.2	5.731	1.221	26.906	0.027
Elgorisha	47.5	3.662	0.761	17.631	0.106
Atbara	28	1.376	0.274	6.899	0.698
Barbar	70	11.184	0.892	140.233	0.061
Elkhiwai	26.7	0.448	0.014	4.920	0.511
Abuzabad	91.7	9.567	0.530	172.768	0.126
Elrahad	37	0.080	0.005	1.355	0.080
Umrwaba (Ref.)	**10**				
Husbandry system					**0.007***
Open grazing	42.5	0.061	0.011	0.348	0.002
Pastoralists (Nomadic)	68.1	0.073	0.008	0.633	0.018
Intensive (Ref.)	**38.4**				
Sex					**0.000***
Female	54.5	0.414	0.219	0.782	0.007
Male (Ref.)	**25.3**				
Age					**0.000***
> 12 months	57.2	0.295	0.178	0.492	0.000
4 to 12 months	37.2	0.161	0.064	0.408	0.000
1 to 3 months (Ref.)	**19.6**				

*$p \leq 0.05$ was considered as significant; C.I. = confidence interval; Exp (B) = exponent B, representing the odds ratio

responsible factors for the disease prevalence.

Our study revealed that females were affected significantly as compared to males, agreeing with Shuaib (2011), and Abdalla et al. (2012). The present breeding system in Sudan could be the reason as female animals were kept longer time for reproduction purpose. But, it was disagreed with Sarker and Islam (2011) who stated that males are mostly affected by PPR, and this might be due to genetic variation of the animals.

In our study, animals reared with pastoralist system (Transhumance) were mostly infected (68.1%). Low prevalence was found in the animals reared in intensive system. This was similar to the findings of Shuaib (2011). Also, the interaction between sheep and goats in pastoralist system especially in the states with high density of wild animals like Sennar and North Kordofan could affect the PPR prevalence; as the infectivity and role of PPR transmission through wild ruminants is mentioned by Housawi et al. (2004), Zahur et al. (2008) and Gopilo (2005).

PPR seroprevalence was found to be differed significantly between housing categories; animals in scrap fences were mostly affected, followed by animals with no houses. The low prevalence was found in animals kept in modern houses with metal fences.

We also checked the seroprevalence of PPR among the breeds, and we found that Kwahla breed of sheep was significantly affected followed by Gwasma sheep. These two breeds belong to trans-human tribes and trans-human was shown for the highest seroprevalence among husbandry systems.

The association between the positive cases against PPR and the 9 potential risk factors found through univariate analysis was assessed with a multivariate analysis using logistic regression; with confidence interval 95% and $p \leq 0.05$. The multivariate analysis revealed an association between the PPR seropositivity and the geographical location in state and locality levels, and that was in line with Shuaib (2011). Sheep and goats from three localities were at high risk for

PPR infections; Basonda in Gedarif state (Exp (B)=5.731), Abuhugar (Exp (B)=12.949) and East Sennar (Exp (B)=11.217) in Sennar state.

Regarding the husbandry system, logistic regression revealed significant association between the systems and PPR seropositivity. The animals owned by nomadic pastoralists were at high risk for PPR with Exp (B)=0.073 and p=0.018 as compared to other systems. This could be due to vulnerability of small ruminant herds in pastoralists and open grazing systems to infected herds in pastures, and water points. These herds might be arrived from other states particularly, from the states located at country borders like Sennar and Gedarif with high PPR prevalence. This finding is in agreement with the observations of Kihu et al. (2010).

CONCLUSIONS

The overall seroprevalence for PPR was 45.6%. Prevalence of PPR was mostly associated with high rainfall and high wind-speed. Pastoralists and open grazing among the different husbandry systems were most important for PPR outbreaks. On the other hand, PPR was mostly prevalent in female animals, and the animals of >12 months of age.

ACKNOWLEDGEMENTS

The authors are thankful to the Director and the staffs of the GDs of Animal Health and Epizootic Diseases Control, Khartoum-Soba, and Animal Resources Sennar, Gedarif, River Nile and North Kordofan for their generous supports in the sampling, trips and data collection. The cELISA kits were kindly supplied by Geneviève Libeau of CIRAD, France.

REFERENCES

Abdalla AS, Majok AA, Elmalik KH, Ali AS (2012). Sero-prevalence of Peste des Petits ruminants virus (PPRV) in small ruminants in Blue Nile, Gadaref and North Kordofan States of Sudan. Journal of Public Health and Epidemiology, 4: 59-64.

Abubakar M, Jamal SM, Arshad MJ, Hussain M, Ali Q (2009). Peste des petits ruminants virus (PPRV) infection; its association with species, seasonal variations and geography. Tropical Animal Health and Production, 41: 197-202.

Anonymous (2010 & 2011). Annual and monthly reports of The General Directorate of Animal Health and Epizootic Diseases Control (AHEDC), Ministry of Animal resources, Fisheries and Pastures, Sudan.

Elhassan AM, Osman AY, Suliman BH, Omer AF, Ahmed EH (1994). Observations on the Epidemiology of PPR in Sudan. The Sudan Journal of Veterinary Research, 13: 29-34.

Elnoman M, Shaikat A, Nath B, Shil S, Hussain M (2011). Incidence and modulating effects of environmental factors on infectious diseases of black Bengal goat in Cox's Bazaar district of Bangladesh. Yüzüncü yıl Üniversitesi Veteriner Fakültesi Dergisi, 22: 163-167.

Haroun M, Hajer I, Mukhtar M, Ali BE (2002). Detection of antibodies against Peste des petits ruminants in sera of cattle, camels, sheep and goats in Sudan. Veterinary Research Communications, 26: 537-541.

Housawi FMT, Abu Elzain EME, Mohammed GE, Gameel AA, AlFaleg AIA, Hegazi A, Albashir B (2004). Emergence of Peste des petits ruminants virus in sheep and goats in Eastern Saudi Arabia. Revue d'elevage et de Medecine Veterinaire des pays Tropicaux, 57: 31-34.

Gopilo A (2005). Epidemiology of peste des petits ruminants virus in Ethiopia and molecular studies on virulence. PhD thesis, Institute National Polytechnique, Toulouse, France.

Karimuribo ED, Loomu PM, Mellau LSB, Swai ES (2011). Retrospective study on sero-epidemiology of PPR before its official confirmation in northern Tanzania in 2008. Research Opinions in Animal & Veterinary Sciences, 1: 184-187.

Kihu SM, Gitau CG, Bebora LC, Njenga MJ, Wairire GG, Maingi N, Wahoma RG, Ndiwa NN (2010). Risk factors associated with spread of PPR in Turkana district, kenya, Third forum meeting Entebbe, Uganda, Research Application summary; pp 529-535.

Muse EA, Karimuribo ED, Gitao GC, Misinzo G, Mellan SB, Msoffe PLM, Swai ES, Albano MO (2012). Epidemiological investigation into the introduction and factors for spread of Peste des Petits Ruminants, southern Tanzania. The Onderstepoort Journal of Veterinary Research, 79: 457-462.

Osman NA, Ali AS, Rahman-Mahasin EA, Fadol MA (2009). Antibody seroprevalence against PPR virus in sheep and goats in Sudan. Tropical Animal Health and Production, 41: 1449-1453.

Ozkul A, Akca Y, Alkan F, Barrett T, Karaoglu T, Deglap SB, Anderson J, Yesilbag K, Cokcaliskan C, Gencay A, Burgu I (2002). Prevalence, distribution, and host Range of Peste des petits ruminants virus, Turkey. Emerging Infectious Diseases, 8: 709-712.

Saeed IK, Khalfalla AI, ElHassan SM, ElAmin MA (2004). PPR in the Sudan: investigation of recent outbreaks, virus isolation and cell culture spectrum. Journal of Animal and Veterinary Advances, 3: 361- 365.

Saeed IK, Ali YH, Khalfalla AI, Rahman-Mahasin EA (2010). Current situation of Peste des petits ruminants (PPR) in the Sudan. Tropical Animal Health and Production, 42: 89-93.

Sarker S, Islam H (2011). Prevalence and risk factors assessment of PPR in goats in Rajshahi, Bangladesh. Veterinary World, 4: 546-549.

Shuaib YA (2011). Peste des petits ruminants in Sheep in Sudan: A study on sero-prevalence and risk factors, MSc thesis, Graduate School of Addis Ababa university, Department of Public health, Faculty of Veterinary Medicine, Freie unversitat Berlin and Sudan University of Science and Technology, Sudan.

Zahur AB, Irshad H, Hussain M, Ullah A, Jahangir M, Qasim Khan M, Sabirfaroog M (2008). The epidemiology of peste des petits ruminants in Pakistan. Revue Scientifique et Technique, 27: 877-884.