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Article

Epidemiological Investigation of Peste des Petits Ruminants in Bahrain

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Simple Summary: Peste des petits ruminants is a transboundary animal disease that causes huge direct and indirect economic losses and affects severely the livelihood of vulnerable livestock owners. The initial step in controlling and eradicating this disease in a country or a region is to understand the distribution scheme, prevalence and risk factors associated with infection. In this investigation, we describe the different epidemiologic features of this disease in Bahrain.

Abstract: Peste des petits ruminants (PPR) is one of the major transboundary animal diseases that severely impact livestock production and trade worldwide. An investigation was carried out into the seroprevalence and risk factors of PPR in small ruminants, camels, and wild ruminants in Bahrain. A total of 1240 serum samples were collected from 119 sheep flocks and 1224 serum samples from 125 goat herds. In addition, 100 sera from camels and 38 sera from wild ruminants, were collected. Serum samples were tested for the presence of PPR specific antibodies using a competitive ELISA. Flock management and health information of the flocks and herds were collected using a semi-structured questionnaire. The individual prevalence of PPR in sheep and goats was 26% and 25.5%, respectively. The flock or herd level prevalence of PPR was 22.7% and 29.6% in sheep and goats, respectively. None of the tested camels or wild ruminants were positive for PPR-specific antibodies. Sheep and goats from the Northern governorate were more likely to be seropositive to PPR than in other governorates. On the individual animal level, the univariate analysis suggested; age (<12 months), sex (male), and health status (weak animals) as risk factors for PPR seropositivity. On the flock/herd level, the multivariable logistic regression analysis identified large flock/herd size and semi-intensive farming as risk factors for PPR seropositivity.

Keywords: small ruminants; peste des petits ruminants; epidemiology; Bahrain

1. Introduction

Peste des petits ruminants (PPR) is a major transboundary animal disease that causes significant direct and indirect economic losses due to high mortalities and impairment of livestock trading [1–3]. PPR is an acute viral disease that affects mainly domesticated and wild small ruminants. Clinically, PPR is characterized by fever, pneumonia, necrosis and ulceration of the mucous membranes, especially in the buccal cavity, and inflammation of the gastro-intestinal tract leading to severe diarrhoea [4].

The PPR virus is an RNA virus that belongs to the *Morbillivirus* genus and is antigenically related to the Rinderpest virus, which infect large ruminants [5,6]. Based on the partial sequence of the Fusion

(F) protein gene, PPRV isolates are grouped into 4 lineages. Lineage III form of PPRV was mainly reported in Africa, while most of the isolates from Asia, mainly the Middle East, were of Lineage IV [7–12].

The first case of PPR outbreak was reported in West Africa in the early 1940s, and later recognized as an endemic disease in all countries in the West and Central Africa [13]. PPR is endemic in most of the Middle East countries and is mainly controlled by yearly vaccination with a modified live vaccine containing the Nig75/1 isolate [4,15,16].

The first and the only outbreak of PPR reported in two governorates (the Northern and Al-Muharraq governorates) of Bahrain was in imported sheep flocks in 2012 [17]. Vaccination has never been practiced and not allowed by law in Bahrain. Bahrain like other GCC States follows the Progressive Control Pathway for PPR (PCP-PPR) agreed under the FAO-WOAH Global Framework for the Progressive Control of Transboundary Animal Diseases (GF-TADs) and currently ranked at Level 3.

The objectives of this study were to investigate the prevalence of PPR in sheep, goats, camels and wild ruminants in Bahrain and to determine risk factors associated with seropositivity to PPR.

2. Materials and Methods

2.1. Study design and population

A cross-sectional design was used in this investigation. The target population was all livestock (sheep, goats, camels and small wild ruminants) holdings in Bahrain. Bahrain has 4 governorates: the Capital, Muharraq, Northern and Southern governorates. Two livestock production systems have been identified in the country: traditional and semi-intensive. The livestock are kept indoors (zero grazing) with minimum interaction with other herds/flocks. As for camels and wild ruminants, the whole country was considered as one cluster. Vaccination of livestock against PPR is prohibited by law in Bahrain.

2.2. Sampling

Each governorate in Bahrain was considered a cluster and each of those governorates were treated as an epidemiological unit. According to herd/flock size, three strata (for sheep flocks: < 50 heads, 50-200 heads and > 200 heads; for goats: < 50 heads, 50-100 heads and >100 heads) were considered and representative samples for each stratum were collected from each governorate. As for camels and wild ruminants, the whole country was considered as one unit and stratification was not performed. Sample size was calculated for each of the 4 governorates (for sheep and goats' populations) separately, using the following parameters (a confidence interval of 95%, confidence level (margin of error) of 5% and a response level of 50%). A total of 1,240 and 1,224 sheep and goat serum samples, respectively, were collected from 119 and 125 sheep and goats' flocks/herds, respectively. As for camels and wild ruminants, a total of a 100 camel and 38 small wild ruminants were sampled from different locations in Bahrain. Herds/flocks to be sampled were randomly selected using the computation function of the SPSS software (SPSS v 25, IBM, USA). Blood was collected from the jugular vein of the selected animal and transported in cold box to the laboratory where the sera were isolated and stored at -20°C until further analysis. A pre-tested semi-structured questionnaire was administered to collect health and management information about each sampled herd/flock. The health information included were the presence of PPR clinical signs, mortality rate, abortion rate, and vaccination history. The management information included were the source of water, disinfection and cleaning practices, and workers' farming behaviours.

2.3. Serological analysis

All the collected sera were screened for the presence of PPR antibodies using commercially available competitive ELISA (cELISA) kit (Innovative Diagnostic, Lyon, France). Controls (strong positive, weak positive and negative controls) were provided with the kit. The sensitivity and

specificity of this competitive ELISA are 94.5 and 99.4%, respectively, as compared to virus neutralization assay [18].

2.4. Statistical analysis

All data, information and results of the individual sera, and information collected by the semi-structured questionnaire, were coded and entered into an SPSS spreadsheet. Frequency tables were produced using cross-tabulation. Univariate analysis was performed using χ^2 and multivariable analysis was performed using regression analysis. All analysis was performed using SPSS v 25 (SPSS, IBM, USA).

3. Results

3.1. Prevalence of PPR

Out of the 1,240 tested sheep sera, 323 (26%) were seropositive by the PPR cELISA. In goats, 312 out of 1224 (25.5%) tested goats sera, were seropositive by the PPR cELISA (Figure 1). No significant difference was found in the individual animal PPR seroprevalence between sheep and goats. The herd PPR seroprevalence in goats (29.6%) was found to be slightly higher than the flock PPR seroprevalence in sheep (22.7%) (Figure 1).

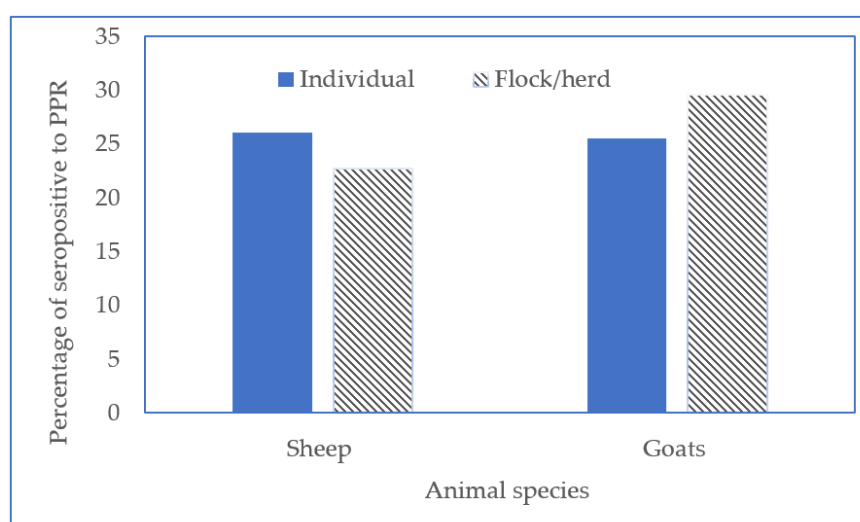


Figure 1. Percentage of PPR seropositive sheep and goats (individual and flock) in Bahrain.

The distribution of prevalence in the different governorates are shown in Figure 2. The Northern governorate showed the highest prevalence ($p < 0.05$) of PPR seropositive sheep and goats. None of the screened camels or wild ruminants were positive by cELISA suggesting the absence of PPR infection in these animal species.

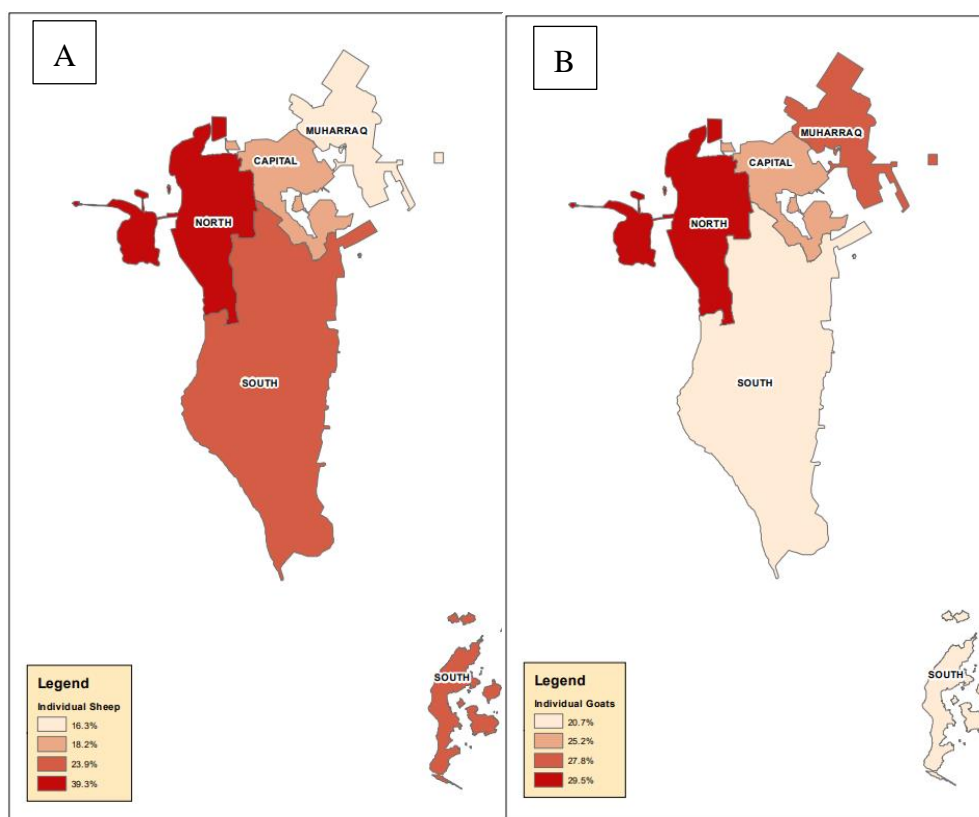


Figure 2. A map showing the distribution of PPR seropositive sheep (A) and goats (B) in the different governorates of Bahrain.

3.2. Risk factors analysis

The initial univariate analysis using the Chi-square test revealed 3 factors that influence seropositivity of sheep to PPRV. Sheep located in the Northern governorate and of female sex and of weak health are more likely to be seropositive to PPRV (Table 1).

Table 1. Univariate analysis of seropositivity to PPR in individual sheep in Bahrain.

<i>Variable</i>		<i>No. Negative (%)</i>	<i>No. Positive (%)</i>	<i>Odd ratio</i>
<i>Governorate</i>	Capital	279 (81.8)	62 (18.2)	3.3
	Muharraq	113 (83.7)	22 (16.3)	
	Northern	230 (60.7)	149 (39.3)*	
	Southern	295 (76.6)	90 (23.9)	
<i>Age</i>	< 12 months	210 (76.9)	63 (23.1)	----
	12 – 36 months	234 (74.5)	80 (25.5)	
	> 36 months	473 (72.4)	180 (27.6)	
<i>Sex</i>	Male	140 (69.7)	61 (30.3)*	1.4
	Female	765 (76.3)	238 (23.7)	
<i>Health status</i>	Excellent	288 (83.7)	56 (16.3)	1.9
	good	257 (77.2)	76 (22.8)	
	Weak	117 (64.3)	65 (35.7)*	
	Poor	40 (81.6)	9 (18.4)	

*Statistically significant by chi-square ($p < 0.05$).

In goats, the univariate analysis suggested the location (northern governorate), age of less than 12 months of age, Sex (males) and of weak health as risk factors associated with seropositivity to PPR (Table 2).

Table 2. Univariate analysis of seropositivity to PPR in individual goats in Bahrain.

<i>Variable</i>		<i>No. Negative (%)</i>	<i>No. Positive (%)</i>	<i>Odds ratio</i>
<i>Governorate</i>	Capital	243 (74.8)	82 (25.2)	1.2
	Muharraq	114 (72.2)	44 (27.8)	
	Northern	263 (70.5)	110 (29.5)*	
	Southern	292 (79.3)	76 (20.7)	
<i>Age</i>	< 12 months	172 (66.9)	85 (33.1)*	1.3
	12 – 36 months	228 (73.1)	84 (26.9)	
	> 36 months	512 (78.2)	143 (21.8)	
<i>Sex</i>	Male	148 (63)	87 (37)*	2.0
	Female	742 (77.5)	215 (22.5)	
<i>Health status</i>	Excellent	229 (75.3)	75 (24.7)	1.2
	good	267 (73.6)	96 (26.4)	
	Weak	106 (66.3)	54 (33.8)*	
	Poor	32 (71.1)	13 (28.9)	

*Statistically significant by chi-square ($p < 0.05$).

On the flock/herd level, the univariate analysis revealed two risk factors for sheep flocks seropositivity to PPR (Location “Northern governorates” and Herd size) (Table 3). For goat herds, farming type (semi-intensive farming) was identified as risk factor for seropositivity to PPR (Table 4).

Table 3. Univariate analysis of seropositivity to PPR at sheep flock level in Bahrain.

<i>Variable</i>		<i>No. Negative (%)</i>	<i>No. Positive (%)</i>	<i>Odds ratio</i>
<i>Governorate</i>	Capital	35 (83.3)	7 (16.7)	3.5
	Muharraq	25 (83.3)	5 (16.7)	
	Northern	4 (44.4)	5 (55.6)*	
	Southern	28 (73.7)	10 (26.3)	
<i>Herd size</i>	< 50	74 (84.1)	14 (15.9)	1.6
	50 – 200	13 (61.9)	8 (38.1)	
	> 200	5 (50)	5 (50)*	
<i>Farming</i>	Traditional	90 (77.6)	26 (22.4)	---
	Semi-intensive	2 (66.7)	1 (33.3)	
<i>Purpose</i>	Trading and meat	0 (0.0)	1 (100)	---
	Breeding	92 (78)	26 (22)	
<i>Source of water</i>	Ground water	22 (73.3)	8 (26.7)	---
	Municipality water	70 (79.5)	18 (20.5)	
<i>Presence of dogs</i>	Yes	7 (70)	3 (30)	---
	No	85 (78)	24 (22)	
<i>Use of disinfectants</i>	Yes	4 (100)	0 (0.0)	---

<i>Disposal of dead</i>	No	88 (76.5)	27 (23.5)	
	Call municipality	77 (81.1)	18 (18.9)	---
	Incineration	2 (50)	2 (50)	
<i>Presence of abortion</i>	Burial	13 (65)	7 (35)	
	Yes	33 (78.6)	9 (21.4)	---
	No	59 (76.6)	18 (23.4)	

*Statistically significant by chi-square ($p < 0.05$).

Table 4. Univariate analysis of seropositivity to PPR at goat herd level in Bahrain.

<i>Variable</i>	<i>No. Negative (%)</i>	<i>No. Positive (%)</i>	<i>Odd ratio</i>	
<i>Governorate</i>	Capital	30 (71.4)	12 (28.6)	---
	Muharraq	23 (76.7)	7 (23.3)	
	Northern	31 (72.1)	12 (27.9)	
	Southern	4 (40)	6 (60)	
<i>Herd size</i>	< 50	72 (72)	28 (28)	---
	50 – 100	10 (71.4)	4 (28.6)	
	> 100	6 (54.5)	5 (45.5)	
<i>Farming</i>	Traditional	84 (73)	31 (27)	4.0
	Semi-intensive	4 (40)	6 (60)*	
<i>Purpose</i>	Trading and meat	0 (0.0)	4 (100)	---
	Breeding	88 (72.7)	33 (27.3)	
<i>Source of water</i>	Ground water	23 (65.7)	12 (34.3)	---
	Municipality water	65 (73)	24 (27)	
<i>Presence of dogs</i>	Yes	9 (75)	3 (25)	---
	No	79 (69.9)	34 (30.1)	
<i>Use of disinfectants</i>	Yes	5 (71.4)	2 (28.6)	---
	No	79 (73.1)	29 (26.9)	
<i>Disposal of dead</i>	Call municipality	68 (67.3)	33 (32.7)	---
	Incineration	5 (83.1)	1 (16.9)	
	Burial	15 (83.3)	3 (16.7)	
<i>Presence of abortion</i>	Yes	28 (70)	12 (30)	---
	No	60 (70.6)	25 (29.4)	

*Statistically significant by chi-square ($p < 0.05$).

The multivariable logistic analysis for sheep seropositivity to PPR suggested that sheep in the Northern governorate are more likely (OR 3.07) to be seropositive than those in the other governorates. However, the multivariable analysis for goats revealed that goats from the Northern governorate (OR 2.02), of age less than 12 months (OR 2.06), and of a male sex (OR 2.20) are more likely to be seropositive to PPR (Table 5).

Table 5. Logistic regression/multivariable analysis* of individual sheep and goats seropositivity to PPR.

<i>Animal Species</i>	<i>Variable</i>	<i>B</i>	<i>S.E.</i>	<i>Sig.</i>	<i>Odd ratio</i>
<i>Sheep</i>	Constant	19.010	0.402	0.000	

	Southern	-0.055	0.429	0.898	
	Northern	1.121	0.349	0.001	3.07
<i>Goats</i>	Constant	-1.939	0.482	0.000	
	Southern	0.590	0.320	3.398	
	Northern	0.705	0.341	4.264	2.02
	< 12 months	0.724	0.237	9.371	2.06
	> 36 months	0.476	0.235	4.092	
	Male	0.789	0.191	17.059	2.20

*Variable(s) entered on step 1: Governorate, Age, Sex, Health condition.

4. Discussion

Epidemiology of PPR is not well understood in the Middle East region since the available vaccines do not have the capacity to differentiate between infected and vaccinated animals when performing serological screening. This study is the first in addressing the prevalence of PPR and risk factors associated with seropositivity to the PPRV in small ruminants, camels and wild ruminants in Bahrain. In this study, the individual prevalence of PPR antibodies in goats and sheep was similar, while the herd prevalence in goats was significantly higher than that in sheep flocks. Similar findings were reported by several authors from the Middle East and Africa [7,14,19–23]. The prevalence of PPR in Bahrain was lower than that reported in some of the neighboring countries. In Saudi Arabia, where vaccination is practiced, the prevalence ranged from 37.7% to 86.1% [15,24,25]. In Yemen, the prevalence of antibodies against PPRV (15% in sheep and 18% in goats) was slightly lower than that reported in Bahrain [26]. Our findings and reports on PPR prevalence from other countries in the region further suggest that PPR is endemic and regional approach for the control and prevention is paramount.

The seroprevalence of PPR was significantly higher in the Northern governorate than other governorates in Bahrain. The only land port of Bahrain with Saudi Arabia is located in the Northern governorate. It is believed that PPR vaccines in these areas are illegally used as they may have been brought from Saudi Arabia in private cars and shared or sold to small ruminant farmers. In addition, PPR vaccination is widely practiced in countries from which Bahrain imports sheep (especially Awassi breed) and goats, which explains why the Northern governorate showed the highest prevalence of PPR. Strengthening the control against illegal veterinary vaccines trafficking may positively impact the PPR surveillance in the Bahrain.

The findings of this study suggest that goats younger than 12 months of age have a better chance to be seropositive to PPR. Similar findings were reported previously [14,19,27,28]. In addition, males in both sheep and goats were more likely to be seropositive to PPR and could be attributed to the importation of Awassi sheep and Baldi goats from Saudi Arabia, Syria, Lebanon, Oman and Jordan that are practicing PPR vaccination. Sheep and goats health conditions were strongly associated with seropositivity to PPRV. Weak animals were more likely to be seropositive than healthy animals which corroborates with previous reports elsewhere [14,29,30]. On the flock/herd level, our findings were in agreement with previous studies in which semi-intensive farming (for goat herds) and flock size (for sheep flocks) were identified as risk factors for seropositivity in sheep flocks and goat herds [14,19,20,27,31,32].

5. Conclusions

This first study revealed the seroprevalence of PPR in sheep and goats in Bahrain as similar to that in other countries of the region. As official vaccination is not practiced in Bahrain, illegal use of PPR vaccination is practiced and thus explains in partial the presence of PPR antibodies.

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Conflicts of Interest: The authors declare that they have no conflicts of interest.

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