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Research article

Seroprevalence of Bluetongue and Schmallenberg viruses in ruminants in Al-Batinah Governorates, Oman

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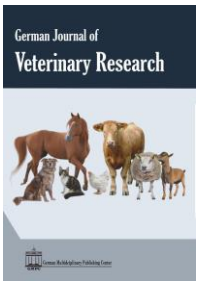

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Abstract

Bluetongue (BTV) and Schmallenberg viruses (SBV) are the causative agents of Bluetongue and Schmallenberg diseases, respectively. Both BTV and SBV are vector-borne viruses that are transmitted mainly by *Culicoides* (Diptera; *Ceratopogonidae*) and infect domestic, wild ruminants, and camelid species. Bluetongue virus belongs to the genus *Orbivirus*, family *Reoviridae*, whereas Schmallenberg virus belongs to the genus *Orthobunyavirus*, family *Bunyaviridae*. In this study, we used enzyme-linked immunosorbent assay (ELISA) to determine the seroprevalence of both viruses in ruminants in Al-Batinah Governorates, Sultanate of Oman. A total of 529 serum samples were randomly collected from 207 sheep, 265 goats, and 57 cattle from five wilayat of Al-Batinah North and Al-Batinah South Governorates. The serum samples were screened for the presence of BTV-specific antibodies against the BTV VP7 protein using ID Screen® Bluetongue Competition (cELISA) and screened for the presence of SBV-specific antibodies against the recombinant SBV nucleoprotein antigen using ID Screen® Schmallenberg virus Indirect Mult (iELISA). The overall seroprevalence of BTV and SBV infections was 69.8% and 44.8%. In cattle, the prevalence of BTV and SBV antibodies was comparatively higher (94.7% and 82.5%) than in goats (83% and 43%) and sheep (45.9% and 36.7%). The highest BTV seroprevalence was recorded in Nakhal (85.5%), followed by Wadi Al-Maawil (81%), and was lowest in Barka (59.6%). However, the highest seroprevalence of SBV was observed in Wadi Al-Maawil (50%), followed by Barka (48.7%), and lowest in Sohar (34.2%). Overall, the seroprevalence of BTV and SBV in domesticated ruminants was higher in adults than in young animals. Females showed a higher seroprevalence of BTV and SBV compared to males. The study provides an update on the epidemiological status of BTV, and to our knowledge, this is the first study on the seroprevalence of SBV in ruminants in Oman. Future studies are required for the isolation and identification of BTV and SBV along with other potential biological vectors in Oman.

Keywords: Bluetongue virus, Schmallenberg virus, ruminants, Oman, Seroprevalence.

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Introduction

Bluetongue and Schmallenberg diseases are non-contagious, vector-borne viral diseases that infect both domestic and wild ruminants, including but not limited to sheep, goats, cattle, camels, and deer (Gubbins et al., 2014; Hassani & Madadgar, 2021). Both viruses are mainly transmitted by midges of the *Culicoides* species (Diptera; *Ceratopogonidae*) (Ali et al., 2012; Collins et al., 2018; Gubbins et al., 2014). Bluetongue disease is caused by BTV, a non-enveloped, double-stranded RNA (dsRNA) virus belonging to the *Orbivirus* genus from the *Reoviridae* family. BTV is classified into serotypes, classical serotypes 1-24 (BTV1-24) and atypical BTV serotypes (BTV 25, 26, 27, 28, and 36) that are phylogenetically distinct from the classical serotypes as suggested by (Givens, 2018). On the other hand, Schmallenberg disease is caused by SBV, an enveloped virus with single-stranded RNA (ssRNA) (Collins et al., 2019), belongs to the *Orthobunyavirus* genus from the *Bunyaviridae* family (Veldhuis et al., 2014). Diseases can differ greatly in their severity depending on the host species, virus strain,

breed, and environmental conditions. Clinical signs appear following the infection with BTV, where viremia leads to fever, cyanotic tongue, facial edema, excessive salivation, nasal discharges, hemorrhages, and congestion (Maan et al., 2011), as well as abortions, stillbirths, and death (Ilango, 2006) in sheep, and can be asymptomatic in cattle and goats. While SBV-infected animal develops very short viremia (1 to 5 days) usually, SBV infections are asymptomatic in adult ruminants and may show mild non-specific clinical signs, including pyrexia, diarrhea and a drop in milk production (Kęsik-Maliszewska et al., 2019; Rasekh et al., 2018). Infection with SBV during early pregnancy can cause stillbirths, musculoskeletal and central nervous system abnormalities, and congenital malformations in lamb and goat kids as well as newborn calves (Veldhuis et al., 2014; Wernike et al., 2015; Givens, 2018). Both BTV and SBV induce huge economic losses. Stanciu & Sarbu (2014) estimated the total global economic losses due to BTV to be approximately 3 billion US$ annually. These losses are the result of either direct causes that include animal deaths, abortions, loss of weight, a decrease in meat or milk production, or indirect causes such as live animals and animal products export restrictions such as semen and fetal bovine serum (Hassani & Madadgar, 2021; Stanciu & Sarbu, 2014; Veldhuis et al., 2014). In Belgium, the cost of individual symptomatic treatment for SBV-infected animals was about 65 or 107 Euros in case of a fatal outcome or apparent recovery, respectively (Martinelle et al., 2014). According to the World Organization for Animal Health (WOAH), BTV is considered a transboundary notifiable disease due to the high morbidity and mortality rates in the infected animals and its ability to spread across national borders (Hassani & Madadgar, 2021). According to (Leask et al., 2013), although the SBV virus is not currently a notifiable disease in the UK or Europe, farmers and veterinarians are encouraged to report stillbirths, deformities, and nervous symptoms.

Generally, the global spreading of BTV and SBV overlaps with the distribution of competent *Culicoides* spp insect vectors and warm or hot climatic conditions (Rasekh et al., 2018; Endalew et al., 2019). BTV is found in most tropical and temperate regions around the world (Qin et al., 2020). The disease was repeatedly reported in Africa, Turkey, and Europe as well as in Middle East countries like Oman, Saudi Arabia, Syria, Yemen, Iran, Pakistan (Mehlhorn et al., 2007), Kuwait (Maan et al., 2011), and Iraq (Shlash et al., 2012). Taylor et al. (1991) found that BTV is widespread and enzootic in Northern Oman. The high BTV seroconversion occurred in Barka and Nakhal during the rainy season and was characterized by a peak of *C. imicola,* and the seroconversion of Al-Batinah north provinces along the coast was low. Taylor et al. (1991) used the AGID assay test and noted that the bluetongue was present in all parts of Oman, and the seroprevalence varied between Oman's regions: 35.7% in Al-Batinah, 37.2% in the Interior, 25.7% in Sharqiyah, 90.6% in Heima, and 40.4% in Salalah. According to Al-Busaidy & Mellor (1991), sixteen *Culicoides* species were identified in Northern Oman, including *C. imicola,* which acted as the classical Old World BTV vector and were correlated to spring rains in that area, *C. schultzei* group midges, and low proportion of other species like *C. arabiensis*, *C. azerbajdzhanicus, C. badooshensis, C. leucostictus, C. mesghali, C. odai, C. odiatus, C. pycnostictus, C. ravus, C. wardi, C. buettikeri,* and *C. ibriensis.*

As for SBV, the infection spread very rapidly after the epidemic in 2011 over large parts of Western Europe, and SBV cases were reported from 27 countries such as Germany, the Netherlands, and Belgium, followed by the UK, France, Italy, Luxembourg, Spain, Denmark, and, Switzerland (Doceul et al., 2013). Later, SBV spread as far as the Middle East and was reported in Iran (Rasekh et al., 2018), Saudi Arabia (Taha et al., 2015), Lebanon (Abi-Rizk et al., 2017), and Northern Jordan (Abutarbush et al., 2017). SBV was also detected in African countries, such as Nigeria (Oluwayelu et al., 2018), Tanzania (Mathew et al., 2015), South Africa (Snyman et al., 2021), and Namibia (Molini et al., 2018).

Different serological and molecular techniques are used to monitor the spread of BTV and SBV in ruminants, such as enzyme-linked immunosorbent assay (ELISA) (Oryan et al., 2014; Daly et al., 2015; Sibhat et al., 2018) agar gel immunodiffusion assay (AGID) test (Taylor et al., 1991), virus neutralization test (VNT) and rRT-PCR (Bosnić et al., 2015; Wernike et al., 2014). Taylor et al. (1991) studied the BTV distribution throughout Oman in domestic animals (goats, sheep, and cattle) using the AGID test and identified BTV serotypes using the virus neutralization test. All these tests lack the specificity and cross-reactivity with other arboviruses that are provided by the current commercially available ELISA assays anti-VP7 competitive ID Screen® Bluetongue cELISA kit and ID Screen® Schmallenberg virus Indirect Multi-species screening test (iELISA kit). To our knowledge, no studies were conducted to

investigate the presence of SBV in Oman. This study aims to investigate the seroprevalence of BTV and SBV in sheep, goats, and cattle in Al-Batinah Governorates, Sultanate of Oman, using ELISA.

Materials and Methods

Investigation Sites

Five districts (Figure 1A) were investigated from Al-Batinah Governorates, Northern Oman, which is divided into Al Batinah South and Al Batinah North, located between (23.4315° N, 57.4240° E) and (24.3420° N, 56.7299° E), respectively. The study area sits on the coast and experiences a hot, humid climate for most of the year, typically from April to October. Temperatures and humidity then decrease significantly from November to March. During this period, occasional heavy rain showers usually occurred (Zurigat et al., 2007).

Serum Samples

A total of 529 serum samples were randomly collected across five districts (Saham, Sohar, Wadi Al-Maawil, Nakhal, and Barka) of the Al-Batinah Governorates in 2016. The samples were obtained from 207 sheep, 265 goats, and 57 cattle between November and March. Animals were reared in small farms where mixed animal flocks ranged between 10 and 100 heads and fed on Rhodes-grass hay, grains, dates, alfalfa, and house leftovers. The species, gender, age, breed, date of sampling, and health status of the animal were recorded for all samples. Blood samples were collected from the jugular veins of cattle, sheep, and goats on vacuum collection tubes (serum tubes). The samples were centrifuged for five minutes at 3500 rpm to extract pure sera. Finally, the samples were stored at -80 °C until further analysis. The research was performed following the relevant guidelines and regulations of the ethical and animal welfare code of Sultan Qaboos University, Oman, and the Ministry of Agriculture, Fisheries, and Water Resources, Oman. Oral consent was obtained from the farm owner before drawing animals' blood by a licensed veterinarian.

Serological Detection

A commercially available ID Screen® Bluetongue Competition ELISA (cELISA) (IDvet, France) was used for the detection of antibodies against the BTV VP7 protein according to the manufacturer's instructions. The signal-to-noise ratio was calculated as follows (S/N% = OD Sample/OD NC × 100). The serum samples were considered positive if they produced an optical density that was less than 40%, and samples with a ratio greater than or equal to 40% were considered negative when the results of positive and negative controls were valid.

The ID Screen® Schmallenberg virus Indirect Multi-species screening test (iELISA) (IDvet, France) was used for the detection of antibodies against the SBV in serum samples according to the manufacturer's protocol. The sample-to-positive ratio was calculated as follows ($S/P(\%) = 100 \times \frac{(OD\ sample - OD\ NC)}{(OD\ PC - OD\ NC)}$). The serum samples were considered positive if they presented S/P (%) that was greater than 60%, whereas samples with a ratio less than or equal to 50% were considered negative. Samples with a ratio greater than 50% and less than or equal to 60 were considered doubtful when the results of positive and negative controls were valid. The doubtful results of data analysis were considered negative.

Statistical Analysis

The seroprevalence of BTV and SBV was calculated based on the seropositive samples divided by the total population at risk. The associations of seroprevalence with potential risk factors with two levels were tested using the Pearson Chi-square or Fisher Exact test. Potential risk factors with more than two categorical levels were investigated individually using univariate logistic regression. All statistical tests were conducted using SPSS version 20 (SPSS Inc., Chicago) at a = 0.05 significance level.

Results and Discussion

This study was conducted to estimate the seroprevalence and distribution of antibodies to BTV and SBV in different domesticated animals (sheep, goats, and cattle) in the Al-Batinah Governorates of Oman. In the present study, 529 serum samples from sheep (n=207), goats (n=265), and cattle (n=57) were collected and screened for the presence of BTV and SBV-specific antibodies by cELISA and iELISA, respectively. The overall BTV and SBV antibodies prevalence were 69.8% and 44.8%, respectively, in all five districts of the Al-Batinah Governorates (Table 1). Several assays have been previously employed for investigating BTV and SBV seroprevalence globally (Taylor et al., 1991; Oryan et al., 2014; Daly et al., 2015; Bosnić et al., 2015; Sibhat et al., 2018); some of which showed cross-reactivity with other arboviruses. Both ELISA assays that were used in this study are highly specific for the targeted antibodies.

Bluetongue Virus

The overall seroprevalence of BTV antibodies in goats was 83% in the present study (Table 1), while lower seropositive rates of 28.0%, 53.3%, and 39.5% were recorded in China (Qin et al., 2020), Saudi Arabia (Yousef et al., 2012) and Iraq (Shlash et al., 2012), respectively.

Out of the 207 sheep that were tested, 95 (45.9%) animals were found positive for IgG antibodies against BTV (Table 1). The rate of seropositivity in sheep in Ethiopia (Gizaw et al., 2016), Iran (Khezri et al., 2013), Iraq (Shlash et al., 2012), and Saudi Arabia (Yousef et al., 2012) was 69.1%, 40.9%, 44%, and 54.1%, respectively.

The seroprevalence was statistically significant among animal species (x^2= 94.82, $p < 0.05$). The seroprevalence of BTV antibodies in cattle (94.7%) was higher than that in goats (83%) and sheep (45.9%) (Table 1). It is much higher than the reported seroprevalence of 44.5% and 44.8% in China and Saudi Arabia, respectively, probably due to the smaller sample size in our study (Yousef et al., 2012; Qin et al., 2020).

There was a significantly higher seroprevalence of BTV in caprine (83.0%) than that in ovine (45.9%) in our study (Table 1). Similarly, higher seroprevalence of BTV in goats (100%) than in sheep (84.5%) was reported by (Elmahi et al., 2021) in Sudan. A higher prevalence of BTV in goats (85.3%) than in sheep (74.4%) has also been reported in southern Iran (Oryan et al., 2014). In contrast to our findings, higher seroprevalence in sheep (69.1%) was reported in Ethiopia (Gizaw et al., 2016). This could be related to a difference in how ovine and caprine animals react to the BTV vector. The higher seroprevalence of BTV in goats than in sheep indicates that goats may play a key role in BTV epidemiology as a carrier. Sheep, on the other hand, are more susceptible to BTV and show evident clinical indications and mortalities, whereas goats are more resistant and can survive the infection. It's known that goats with the fewest clinical symptoms have a higher BTV titer, making them a possible source of infection for other animals (Elmahi et al., 2021). Similar observations were reported by (Qin et al., 2020) that cattle had higher anti-BTV antibodies (44.5%) compared to goats (28.0%) in China using cELISA. (Elmahi et al., 2021) demonstrated that cattle are the main reservoir and carrier of the virus due to their long viremia and attractiveness to the *Culicoides spp* vector. However, the present results contradict the results of a study conducted by (Mahmoud et al., 2019) where they found that the seroprevalence of BTV in sheep and goats was higher (50.3%) compared with cattle (40.1%) using cELISA.

Regarding different regions, seropositive goats, sheep, and cattle were found in all five districts of the Al-Batinah Governorates, where samples were collected, indicating that BTV infection was extensive in these districts. The highest prevalence was recorded in Nakhal (85.5%) and Wadi Al-Maawil (81.0%), while the lowest prevalence was recorded in Barka (59.6%) (Table 1) (Figure 1B). The seroprevalence among districts was significantly different (x^2 = 23.67, $p < 0.05$). As there is no BTV vaccine being used in Oman, the seroprevalence is the result of natural infections.

The prevalence of BTV infection was higher in females than males, as shown in Table 2, although the difference was non-statistically significant. It was 84.6%, 97.1%, and 45.5% in females of goats, cattle, and sheep, respectively. Similar results were reported by (Elmahi et al., 2021; Mahmoud et al., 2019) that the BTV infection rate was significantly higher in females (49.3%) than in males (23.2%) in Libyan provinces. However, the authors declared difficulties in interpreting the result which could be due to the bias of male and female sample size originating from farm animal availability or due to differences in husbandry practices (Elmahi et al., 2020). The chi-square analysis indicated that there were no significant differences ($p > 0.05$) among gender groups.

The BTV seroprevalence in cattle younger than two years was 100.0% (18/18) and 92.3% (36/39) in animals two years and older (Table 2), and there were no significant differences ($p > 0.05$). Sheep and goats aged one year and older were more likely to be infected with BTV (51.1% and 87.5%), respectively, compared to animals younger than one year (Table 2), with statistically significant differences ($p < 0.05$). This finding is in agreement with the results of Abera et al. (2018), who reported high seropositivity to BTV in adult animals (≥ 1 yr) in Ethiopia. The increased BTV antibody seroprevalence, along with the increase in age, is attributable to a series of years in which a widespread infection with bluetongue occurred or could happen either from the virus's ongoing presence or annual re-infections from an external source (Gizaw et al., 2016). Furthermore, adult animals are frequently let into the pasture to graze, where they are likely to be exposed to infected *Culicoides spp.* vectors and, therefore, infected with BTV. In contrast, young animals are typically kept indoors and well cared for by their owners to protect them from infectious diseases,

particularly insect and tick-borne infections (Khair et al., 2014).

Schmallenberg Virus

The overall seroprevalence of SBV infection in Al-Batinah ranged from 34.3% to 50.1% in the five Wilayat (Table 1). The highest seroprevalence was observed in Wadi Al-Maawil at 50.1%, followed by Barka (48.8%). However, the lowest seroprevalence was recorded in Sohar at 34.3% (Table 1) (Figure 1C). The difference in seroprevalence among wilayats was non-statistically significant ($x^2 = 5.32$, $p > 0.05$). High percentages of SBV seroprevalence in Al-Batinah Governorates could be due to the widespread distribution of vector *Culicoides spp.* midges that transmit the virus and the absence of specific vaccination in Oman.

About 43.0% of total tested goat samples were found positive for anti-SBV antibodies (Table 1). The SBV seropositive rate in goats was 95% in Germany (Helmer et al., 2013) and 1.1% in Turkey (Luttikholt et al., 2014). The seroprevalence of SBV antibodies in sheep was 36.71% in the present study (Table 1), while lower seropositive rates of 12.8% and 16.26% were recorded in Portugal (Esteves et al., 2016) and Lebanon (Abi-Rizk et al., 2017), respectively. On the other hand, a much higher seropositive rate of 80.2% was recorded in sheep in the Netherlands (Luttikholt et al., 2014).

The overall seroprevalence of SBV antibodies in cattle was 82.5% in the present study (Table 1), which is much higher than the reported seroprevalence of 56.6% in Ethiopia (Sibhat et al., 2018), 21% in Iraq (Al-Baroodi, 2021), and 32.2% in Portugal (Tavares, 2017). This probably is attributed to the small cattle sample size in the present study. The seroprevalence of SBV was statistically significant among animal species ($x^2 = 38.49$, $p < 0.05$)

Similar to the present results, the seroprevalence of SBV was higher among goats (47%) compared with sheep (39%) in Tanzania (Levin, 2015). In Nigeria, cattle had a higher SBV seropositive percentage (91.2%) than sheep (65.4%) (Oluwayelu et al., 2018). However, the results of the present study contradict (Helmer et al., 2015), who reported a higher SBV seroprevalence in sheep (58.7%) than in goats (43.8%). Also, antibodies against SBV were highly prevalent in cows (99%) and sheep (94%) but much lower in goats (36.4%) in the Netherlands (Loeffen et al., 2012). The differences in seroprevalence between domesticated ruminants could be related to a difference in how animals react to the virus vector. *Culicoides spp.* feed on a variety of vertebrate hosts, but cattle are the most common and preferable host (Barrett et al., 2015; Helmer et al., 2015). Sheep and goats have a two-layer coat, one with a coarse topcoat and the other with a fine woolen undercoat, which could hinder the midges from penetrating the skin (Helmer et al., 2015).

Table 1: Summary of the numbers of the tested samples for each species and the prevalence of anti-VP7 antibodies against BTV and anti-SBV antibodies in 5 districts of Al-Batinah Governorates.

Variable	No. of samples	BTV			SBV		
		No. of Positive (%)	Chi-square (x^2)	p-value	No. of Positive (%)	Chi-square (x^2)	p-value
Species							
Sheep	207	95 (45.9)	94.82	0.001*	76 (36.7)	38.5	0.001*
Goat	265	220 (83.0)			114 (43.0)		
Cattle	57	54 (94.7)			47 (82.5)		
Wilayat							
Saham	133	90 (67.7)	23.67	0.001*	58 (43.6)	5.32	0.256
Sohar	73	47 (64.4)			25 (34.3)		
Wadi Al-Maawil	84	68 (81.0)			42 (50.0)		
Nakhal	83	71 (85.5)			36 (43.4)		
Barka	156	93 (59.6)			76 (48.8)		
Total	529	369 (69.8)			237 (44.8)		

* Statistically significant

Table 2: Univariate analysis of anti-VP7 antibodies against BTV and anti-SBV antibodies in relation to animal sex and age.

Variable	No. of samples	BTV			SBV		
		No. of Positive (%)	Chi-square (x^2)	p-value	No. of Positive (%)	Chi-square (x^2)	p-value
Sex							
Sheep							
Male	31	15 (48.4)	0.09	0.763	10 (32.4)	0.32	0.577
Female	176	80 (45.5)			66 (37.5)		
Goat							
Male	38	28 (73.7)	2.74	0.098	10 (26.3)	5.05	0.025*
Female	227	192 (84.6)			104 (45.8)		
Cattle							
Male	23	21 (91.3)	0.91	0.990	19 (82.6)	0.001	0.980
Female	34	33 (97.1)			28 (82.4)		
Age							
Sheep			17.99	0.001*			
<1 yr	23	1 (4.4)			4 (17.4)	4.16	0.041*
≥1 yr	184	94 (51.1)			72 (39.1)		
Goat							
<1 yr	49	31 (63.3)	16.64	0.001*	11 (22.5)	10.38	0.001*
≥1 yr	216	189 (87.5)			103 (47.7)		
Cattle							
<2 yr	18	18 (100.0)	1.46	0.544	12 (66.7)	4.53	0.846
≥2 yr	39	63 (92.3)			35 (89.7)		
Total	529	369 (69.8)			237 (44.8)		

* Statistically significant

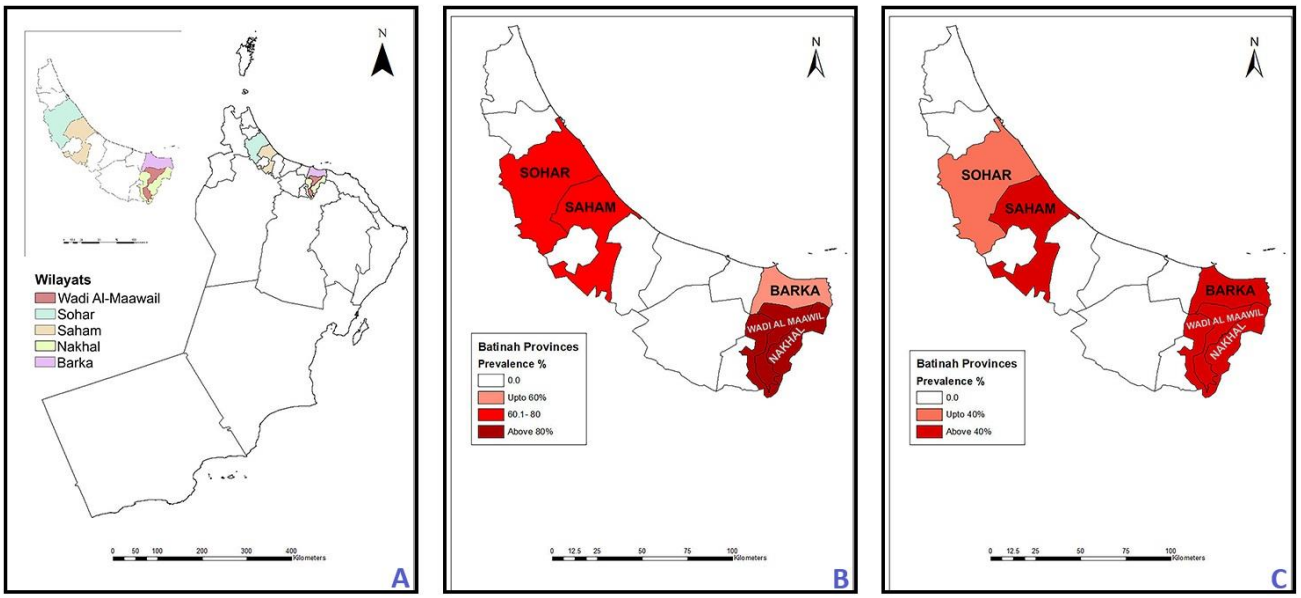

Figure 1: A) Distribution map of the samples in the provinces of Al Batinah Governorates; B) Seroprevalence map of BTV in domesticated ruminants in provinces in Al-Batinah Governorates using c-ELISA; C) Seroprevalence map of SBV in domesticated ruminants in provinces in Al-Batinah Governorates using i-ELISA.

These results are in agreement with the present study, which recorded the highest seroprevalence of both BTV and SBV in cattle, followed by goats and sheep samples.

The SBV seroprevalence of female sheep and goats was 37.5% and 45.8%, respectively, which was higher than males (32.4% and 26.3%), respectively (Table 2). Females and males of cattle recorded close percentages of seropositivity at 82.4% and 82.6%, respectively (Table 2). The chi-square analysis revealed no significant differences ($p > 0.05$) among gender groups of sheep and cattle but significant differences ($p < 0.05$) among gender groups of goats. The high prevalence of SBV in females compared to males may be due to the higher number of female tested samples than males. Similarly, (Jiménez-Ruiz et al., 2021) reported that the SBV seroprevalence

was 33.8% in females and 28.4% in males. On the other hand, the present results disagreed with (Jesse et al., 2022), who found that males of small ruminants had a higher SBV prevalence of 27.1% than females (19.2%).

According to age groups, (Table 2) shows that the highest seroprevalence was observed in sheep and goats in those aged one year and older (39.1% and 47.7%), respectively, and lower in goats younger than one year (17.4% and 22.5%) of age, respectively. In cattle, those older than two years recorded higher seroprevalence (89.7%) than those younger than two years (66.7%) (Table 2). The age-specific parameter indicated that the seroprevalence of SBV infection varied with age and was statistically different ($p < 0.05$). This agrees with the previously published results that indicate a higher prevalence of SBV antibodies in older animals compared to younger ones (Sibhat et al., 2018; Jesse et al., 2022). According to (Veldhuis et al., 2014), adult stock of cattle had a higher SBV prevalence (80.1%) than young stock (75.5%). In adult cows, the natural SBV infection leads to the persistence of antibodies against SBV for at least two years (Elbers et al., 2014; Varol, 2022). However, by ingestion and absorption of antibodies contained in colostrum, newborn calves gain passive immunity from their dams, and they lose their maternally derived antibodies after 5–6 months. The presence of antibodies against SBV in animals aged over six months is probably associated with active immunity, which indicates SBV circulation (Elbers et al., 2014; García-Bocanegra et al., 2017; Sibhat et al., 2018). As a result of SBV infection at an early stage of gestation, that leads to virus overwintering by transplacental infection of offspring, which could potentially lead to economic loss related to death or culling of offspring (Claine et al., 2013; Esteves et al., 2016). Higher seroprevalence in adult cows may be the result of the accumulation of exposure over several seasons (called age-cohort), as well as the fact that odor attractants from adult cows are more efficient in attracting *Culicoides* midges than those from young cattle (Sibhat et al., 2018).

In line with other similar studies, the high overall seroprevalence of BTV and SBV infections in domestic ruminants in Al-Batinah governorates could be due to the widespread distribution of vector midges (Elmahi et al., 2021). The considerable variations in BTV and SBV antibodies seroprevalence between Al-Batinah governorates and the countries compared in this study could be attributable to a variety of factors, including geographic variances, sample sizes, diagnostic procedures, feeding circumstances, species, breeds, and the different animal population which make it difficult to pinpoint a specific cause for these variances (Qin et al., 2020). Furthermore, the onset of BTV and SBV are influenced by a variety of natural conditions like temperature, rainfall, and altitude. The distribution of the Culicoides vector was not investigated in this study, although, previously, 16 different types of Culicoides midges were found in northern Oman, and the peak season for *C. imicola* coincided with the spring rains (Al-Busaidy & Mellor, 1991). The interaction of temperature and rainfall has an impact on vector dispersal and abundance, which are crucial factors that determine the prevalence and spread of the infection (Qin et al., 2020).

Conclusion

In conclusion, this study evaluated the prevalence of BTV and SBV antibodies in ruminants in Al-Batinah Governorate, Oman. The results showed that seropositive goats, sheep, and cattle were found in the Al-Batinah governorate, indicating a wide exposure to BTV and SBV infections in all five studied districts. As vaccination programs for BTV and SBV are not implemented in Oman, seropositive results indicate BTV and SBV infections among the domestic population. A well-defined BTV and SBV prevention and control strategy could include vaccination schedules, vector eradication, and restrictions on animal movement within the country. Further studies are required for the isolation and identification of BTV and SBV currently circulating in ruminants in Oman for proper disease prevention and control.

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