Prevalence of Rift Valley fever in domestic ruminants in the central and northern regions of Burkina Faso

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H. Boussini [(1)*], C.E. Lamien [(2)], O.G. Nacoulma [(3)], A. Kaboré [(4)], G. Poda [(4)] & G. Viljoen [(2)]

(1) African Union–Interafrican Bureau for Animal Resources, Kenindia Business Park, Museum Hill, Westland Rd, P.O. Box 30736, 00100 Nairobi, Kenya

(2) Animal Production Unit, Food and Agriculture Organization of the United Nations/International Atomic Energy Agency Agriculture and Biotechnology Laboratory, Department of Nuclear Sciences and Applications, International Atomic Energy Agency, Wagramer Strasse 5, P.O. Box 100, A-1400 Vienna, Austria

(3) Laboratoire de Biochimie et Chimie Appliquées, UFR/SVT, Université de Ouagadougou, 03 BP 7021 Ouagadougou 03, Burkina Faso

(4) Laboratoire National d'Élevage, Ministère des Ressources Animales, 03 BP 7026 Ouagadougou 03, Burkina Faso

*Corresponding author: boussini@hotmail.com

Summary

The seroprevalence of Rift Valley fever was determined in cattle, sheep and goats in selected areas of northern and central Burkina Faso. A total of 520 serum samples were screened for anti-Rift Valley fever virus immunoglobulin G (IgG) antibodies using an inhibition enzyme-linked immunosorbent assay (ELISA). An average seroprevalence of 7.67% (range 5% to 20%) was found in ruminants in Seno and Soum provinces, and prevalences of 20% and 22.5% in cattle in Yatenga and Oubritenga provinces, respectively. The

location, species and age of the animals was found to influence the seroprevalence. All the ELISA IgG-positive samples were tested for IgM in a competitive ELISA and were found negative, thus ruling out recent infections. The IgG-positive samples, including weak positives, were further tested in a serum neutralisation test for neutralising antibodies and 54.5% of these samples tested positive. The results show that the virus is in circulation in central and northern regions of Burkina Faso, suggesting the need for improved surveillance and control systems to prevent future outbreaks and the consequent economic impact of the disease in Burkina Faso livestock.

Keywords

Antibodies – Burkina Faso – Cattle – ELISA – Enzyme-linked immunosorbent assay – Goat – Immunoglobulin G – Immunoglobulin M – Neutralisation – Ovine seroprevalence – Rift Valley fever – Serum neutralisation test – Sheep seroprevalence – Virus.

Introduction

Rift Valley fever (RVF) is a zoonotic disease caused by a *Phlebovirus* in the family *Bunyaviridae* and is a World Organisation for Animal Health (OIE) notifiable disease that mainly affects sheep, cattle, goats and camels, although wildlife ruminants can also be infected (1). The RVF virus (RVFV) was first isolated in 1931, close to Lake Naivasha in the Kenyan Rift Valley (2). It is, however, thought that the disease may have occurred earlier, as an outbreak fitting the description of RVF and associated with heavy mortality in sheep was reported in the Kenyan Rift Valley in 1913 (1, 3). In ruminants, the main symptoms are abortion and mortality in young animals, with abortion and mortality rates being highest in sheep and goats (4, 5).

Outbreaks of RVF in livestock on the African continent have been described many times, but the first outbreaks among human and livestock populations outside the continent were reported in the Arabian Peninsula in 2000 (6, 7). In West Africa, several outbreaks associated with human deaths have been described in Mauritania and Senegal (8, 9). Humans are usually infected by contact with the blood

and body fluids of infected animals during handling and slaughtering or from contact with contaminated meat during the preparation of food, or from the bites of infected mosquitoes (1, 10). In humans, the main clinical symptoms of the disease are those of an acute febrile illness, leading in the majority of cases to a haemorrhagic fever (11).

Rift Valley fever virus is transmitted by mosquitoes, usually of the genus *Aedes*, acting as vectors of the disease. Epizootics of the fever occur periodically after heavy rainfall and in flooded areas (6, 12), which allow the mosquito eggs to hatch.

Burkina Faso's economy is primarily based on agriculture and about 80% of the population rely on it for their livelihoods. Animal production contributes significantly to economic growth and in 2010 represented 18% of the national gross domestic product. Moreover, the livestock value chain plays a crucial role in fighting poverty by boosting incomes in rural areas. In 2009, the number of domestic ruminants in Burkina Faso was estimated at 28 million head, comprising 8 million cattle, 8 million sheep and 12 million goats (approximate numbers) (13). More than 80% of these domestic ruminants are raised in the extensive/pastoral production system, which experiences numerous and multifaceted constraints, including repeated droughts and a high prevalence of parasitic and infectious diseases that lead to low productivity and affect food security.

Some earlier studies have demonstrated evidence of the circulation of the virus in Burkina Faso and highlighted the need for continuous disease surveillance as a tool for early detection and control (9, 14, 15). The aim of the present study was to screen animals for antibodies to the virus in two high-risk areas of the country in order to justify the establishment of regular serological and molecular surveys in sentinel herds, together with clinical, virological and epidemiological follow-up of cases of fever of unknown origin in both human and animal populations.

Materials and methods

Study areas

Areas in central and northern Burkina Faso were selected for the study, based on the distribution of dams, swamps and ponds, and on rainfall data collected between 2005 and 2007. The study areas were the provinces of Oubritenga (12° 61′ N, 1° 32′ W) and Ganzourgou (12° 34′ N, 0° 84′ W) in the central region, and the provinces of Yatenga (13° 60′ N, 2° 46′ W), Seno (14° 05′ N, 0° 20′ W) and Soum (14′ N, 1° 67′ W) in the northern regions (Fig. 1).

Sampling and sera

Blood samples for serology were collected from herds that grazed around the following water reservoirs: the hydroelectric dam of Ziga (Oubritenga); Mogtedo dam (Ganzourgou); Koumbri and Ouahigouya dams (Yatenga); the pond of Djibo (Soum); the pond of Dori and Yakouta dam (Seno). These areas were considered a major risk for vector-borne infectious diseases.

Sampled animals were classified according to age: <1 year, 1 to 3 years, 3 to 5 years, >5 years. Blood samples were randomly collected in dry vacutainer tubes, allowed to clot at room temperature for 24 h and thereafter stored at +4°C. Sera were separated and stored at –20°C until used for serological testing. Each sample was labelled according to animal species, sex, age, herd holder and location.

Analyses

An inhibition enzyme-linked immunosorbent assay (ELISA) (Biological Diagnostic Supplies Limited, United Kingdom, www.bdsl2000.com) was used to screen for anti-RVFV immunoglobulin G (IgG) antibodies in accordance with the procedure described by the manufacturer (16).

All IgG-positive samples, including any weak positives, were further tested using an IgM competitive ELISA to identify possible recent infections.

The serum neutralisation test, which is the accepted gold standard for anti-RVFV antibody detection, was used to determine the virus-neutralising ability of the antibodies (7). In this assay, a serum sample is serially diluted and incubated with a standard dose of virus. If there are enough antibodies in the serum the viruses are neutralised. In order to evaluate the neutralisation effect, Vero cells are added to the serum/virus mixture and if neutralisation has occurred (titre ≥ 1/20) the cells remain intact without any cytopathic effect. In comparison with ELISA, the test is a sensitive and specific technique; however, the disadvantages are that it is time consuming and requires cell culture (17).

The logistical regression model in Software R.2.0.0 (Language and Environment, 2004) was used for an analysis of variance on the classification criteria. Differences were considered significant at probability thresholds of 5% or <1%.

Results

Table I shows the species and origin of the 520 sera that were analysed.

Detection of anti-RVFV IgG antibodies in an inhibition enzyme-linked immunosorbent assay

All 520 serum samples were screened for anti-RVFV IgG antibodies in an inhibition ELISA. Taking the northern and central regions of Burkina Faso together, the overall seroprevalence was 7.69% (40/520): the prevalence in the northern region was 9.37% and, in the central region, 5% (Table II).

In the northern region, the highest prevalences were 22.5% in cattle in Yatenga province, followed by 20% in sheep and 17.5% in goats in Soum province. The lowest prevalence in cattle was in Seno province (7.5%). These areas of the northern region had significantly higher ($p \leq 0.001$) prevalences of anti-RVFV antibodies in small ruminants than in other locations. In the central region, Oubritenga province had

the second-highest RVFV seroprevalences: 15% in cattle and 10% in sheep (Table II).

Serology results by region and by species

In the Northern provinces, the highest RVF seroprevalence for cattle was recorded in Yatenga (22.5%) and the lowest in Seno (7.5%). For goats, the highest seroprevalence was found in Soum (17.5%) and the lowest in Seno (2.5%). For sheep, the highest seroprevalence was recorded in Soum (20%) and the lowest in Seno (5%).

In the central region, seropositivity was found in cattle (15%) and sheep (10%) in Oubritenga; the overall seroprevalence for small ruminants in Ganzourgou province was 0%.

In the northern region, the overall seroprevalences were 15%; 8.33% and 6.66% for cattle, sheep and goats, respectively; in the central region overall seroprevalences were 15%, 5% and 0% respectively (Table III).

Taking the two regions together, the highest seroprevalence was found in cattle (15%), followed by sheep (7%) and goats (4%). Thus, the RVFV seroprevalence varied significantly between species ($p \leq 0.05$).

Serology results by age group

Seroprevalence varied by age group (Table IV). The highest seroprevalences were found in animals 3 to 5 years old (8.60%) and in those >5 years old (8%). Animals <1 year old and between 1 and 3 years old had significantly lower seroprevalences at 4.54% and 6.4%, respectively ($p \leq 0.001$).

Detection of anti-RVFV IgM antibodies in competitive enzyme-linked immunosorbent assay

The 40 samples that tested positive for anti-RVFV IgG antibodies were retested in a competitive ELISA for IgM antibodies and all were found negative.

Detection of neutralising anti-RVFV antibodies in the serum neutralisation test

A total of 55 sera (40 testing positive for IgG by ELISA, 15 giving an inconclusive result) were tested in the neutralisation test. Of these, 30 (54.5%) were found to be positive for specific anti-RVFV antibody. The breakdown by species was as follows: sheep 75%, goats 72.2% and cattle: 11.8% (Table V).

Discussion

The study has demonstrated serological evidence of RVFV circulation among domestic ruminant populations in both northern and central Burkina Faso. There remains a need, however, to isolate and characterise the circulating viruses. The relatively high overall seroprevalence of 7.69% (9.37% in the northern region, 8.33% in Oubritenga province in the central region) clearly indicates that RVF could be a major health concern, thus warranting thorough investigation in this country. Data recorded 30 years ago (14) support the present finding that RVFV is circulating among domestic ruminant populations, with significant epidemiological importance, in Burkina Faso (1). However, the overall recorded seroprevalences of anti-RVFV antibodies of 15% in cattle, 7% in sheep and 4% in goats were lower than those reported earlier, which ranged between 12.3% and 14.8% (14, 15).

The serological results in this study are compatible with earlier works in Cameroon (18), Togo (4), Kenya (2, 19) and Senegal (8). However, in comparison with other studies in East, West and Central Africa, the prevalence of anti-RVFV antibodies in small ruminants was lower at 5.5% than that reported in the Senegal River basin (19.3%) (8), Côte d'Ivoire (9.71%) (20), Mauritania (85%), Cameroon (12.2%) Togo (6.1%) (15) and Chad (10.7%) (21), although it was higher than in Benin (1.71%) (4). In cattle, the observed seroprevalence was lower than previously reported in Benin (20.8%) and the Senegal River basin (27.4%) but higher than in Cameroon (9.35%) (15) and Madagascar (25.8%) (22).

In this study, location had a significant influence on RVFV seroprevalence. The highest seroprevalence was found in the northern region of Burkina Faso, which is an arid area that often has extensive stagnant water in ponds and dams during the rainy season. These conditions enable the hatching of transovarially infected *Aedes* in flood water and initiate local transmission (10, 12, 23). Other studies have also reported a high seroprevalence in arid regions and low seroprevalence in tropical regions (3, 6, 9, 22), and this is consistent with findings indicating a relationship between the timing and location of RVF epidemics and climatic indicators (9, 24, 25). In the present study, sheep and goats in the northern region had a higher seroprevalence of anti-RVFV antibodies than ruminants in the central region (5%), although in cattle the prevalence was the same (15%) in both regions. In the northern region in Seno and Soum provinces, all the tested animal species were affected by the virus, whereas in Yatenga province, only cattle were affected. In central Burkina Faso, anti-RVFV antibodies were detected only in Oubritenga province, where there is a hydroelectricity dam. The seroprevalence variation between locations may be secondary to the variation attributed to multiple other factors, including environmental ones (2, 19). The transmission of RVFV is closely related to flooding events and can also be widespread during periods of excessive rainfall (10, 18, 19).

The present study also showed that the seroprevalence of anti-RVFV antibodies differed not only between the northern and central regions of Burkina Faso but also differed from pond to pond within the same province. The dams in Yatenga province and the hydroelectric dam in Oubritenga province had the highest anti-RVFV antibody rates for cattle at 22.5% and 15%, respectively, whereas the pond in Soum province had the highest seroprevalence rates for small ruminants (sheep: 20%, goats: 17.5%). These findings corroborate previous findings in Senegal River basin (8). The impact of both natural and artificial water sources on human and animal health should be carefully investigated to identify risk factors and facilitate the prediction of RVF epidemics, because the risk of human epidemics appears to be associated with prevalences of 15% to 20% in animals (21).

Cultural differences can also influence RVF risk. In the northern areas of Burkina Faso, people are nomadic pastoralists who practise transhumance during the dry season, where the animals could be in contact with RFV (2, 9, 11). This may explain the seropositivity in the cattle of Yatenga province, where only cattle are involved in transhumance. In contrast, both small ruminants and cattle are moved for transhumance in Soum and Seno provinces. The differences between species within the locations studied could be explained by the difference in production systems, where cattle and sheep are grazed together and goats are chained in the central region. Further investigations are needed to assess the effect of transhumance on the risk of RVFV transmission.

The anti-RVFV antibody prevalence varied according to the animal species. In both the northern and central regions, cattle appeared more affected than sheep and goats. These findings corroborate earlier studies reporting that the first amplification cycle of the virus was mainly observed in cattle and humans (26). However, previous surveys in Chad (21), Saudi Arabia (6), Somalia (23), Madagascar (27) and Côte d'Ivoire (28) have shown that small ruminants were more affected than cattle.

Age group also has a significant effect on RVFV seroprevalence. In the present study, an increased seroprevalence was recorded in older animals, and similar findings have been reported in Kenya (2), Chad (21), Togo (4), Somalia (23) and Madagascar (27). The relatively high prevalence in animals under one year of age, in association with abortion and stillbirth, indicates that there was recent and significant RVF circulation in the relevant regions, though without virus isolation. The high seroprevalence in this young age group could also be due to the presence of maternally derived antibodies. This is critical information, because it shows that there could be considerable RVFV activity in the country without any clinical signs of the disease. This situation has been confirmed in numerous studies in many other African countries (1). In 1985 and 2006 there were reports of animals being infected with the virus without visible signs of the disease in the animals or in humans (6, 10). Thus, the disease could exist in a

subclinical form similar to that reported in 2006 in Kenya and Tanzania (19), and in Mauritania and Senegal in 1987 (15, 29).

All the samples in this study that tested positive for anti-RVFV IgG antibodies were found to be negative for IgM antibodies, therefore information on acute RVFV infection could not be obtained. Although this aspect has been less well studied, there are suggestions that anti-RVFV IgM antibody is lost in 50% of animals by 45 days after infection and is absent in 100% at the fourth month after infection (12, 30). Another limitation in detecting active infections was that the serum samples were collected two months after the end of the rainy season.

The results of the neutralisation test confirmed the presence of specific anti-RVFV antibodies (17), showing that the virus is in circulation in both central and northern regions of Burkina Faso, although without any outbreaks. These results demonstrate that RVFV can, without doubt, be added to the complex aetiology of domestic ruminant abortions in Burkina Faso livestock (4, 31), and also in other regions in which the disease is enzootic (21, 23, 27, 32).

Virus isolation studies and entomological surveys are needed to better understand these high levels of seroprevalence. Despite the absence of officially reported outbreaks of RVF in Burkina Faso, with clinical signs in animals, the national veterinary authorities need to develop strategies for the prevention and control of RVF, which take into account changes in the distribution of this climate-change-associated transboundary disease, including potential disease outbreaks (33).

Conclusion

This study in Burkina Faso showed that RVFV was present in livestock populations in the northern and central regions of the country, although anti-RVFV IgM antibodies were not detected. The highest seroprevalence was found in the northern region around temporary ponds and dams. Although the public health importance is unknown, the economic and epidemiological significance of RVF in Burkina Faso is of interest. Sentinel herds could be used to evaluate

recent infections and better predict possible outbreaks. Veterinarians and public health professionals should work together to ensure early detection of RVF in both animals and humans, in line with the One Health approach. The disease appears to be one of the main climate-change-associated diseases, therefore the climate should be regularly monitored to prevent and detect the invasion of mosquito populations, particularly after heavy rainfalls and flooding, which influence the disease dynamic and its impact on animal and human health.

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Table I
Species and origin of the sera analysed

Province	Species			Total
	Cattle	Sheep	Goats	
Seno	40	40	40	120
Soum	0	40	40	80
Yatenga	40	40	40	120
Oubritenga	40	40	40	120
Ganzourgou	0	40	40	80
Total	120	200	200	520

Table II
Distribution of the prevalence of immunoglobulin G antibodies against Rift Valley fever virus, by species and province

Region	Province	Species	No. of sera tested	No. of positive sera	Percentage positive
Northern	Seno [a]	Cattle	40	3	7.5
		Goats	40	1	2.5
		Sheep	40	2	5
	Soum [b]	Goats	40	7	17.5
		Sheep	40	8	20
	Yatenga [c]	Cattle	40	9	22.5
		Goats	40		0
		Sheep	40		0
Central	Oubritenga [d]	Cattle	40	6	15
		Goats	40		0
		Sheep	40	4	10
	Ganzourgou [e]	Goats	40		0
		Sheep	40		0
Total			520	40	7.69

a) Dori pond and Yakouta dam

b) Djibo pond

c) Koumbri dam and Ouahigouya hydroelectric dam

d) Ziga hydroelectric dam

e) Mogtedo dam

Table III
Distribution of the prevalence of immunoglobulin G antibodies against Rift Valley fever virus, by species and region

Region	Species	No. of sera tested	No. of positive sera	Percentage positive
Northern	Cattle	80	12	15
	Goats	120	8	6.66
	Sheep	120	10	8.33
Total		320	30	
Central	Cattle	40	6	15
	Goats	80	0	0
	Sheep	80	4	5
Total		200	10	

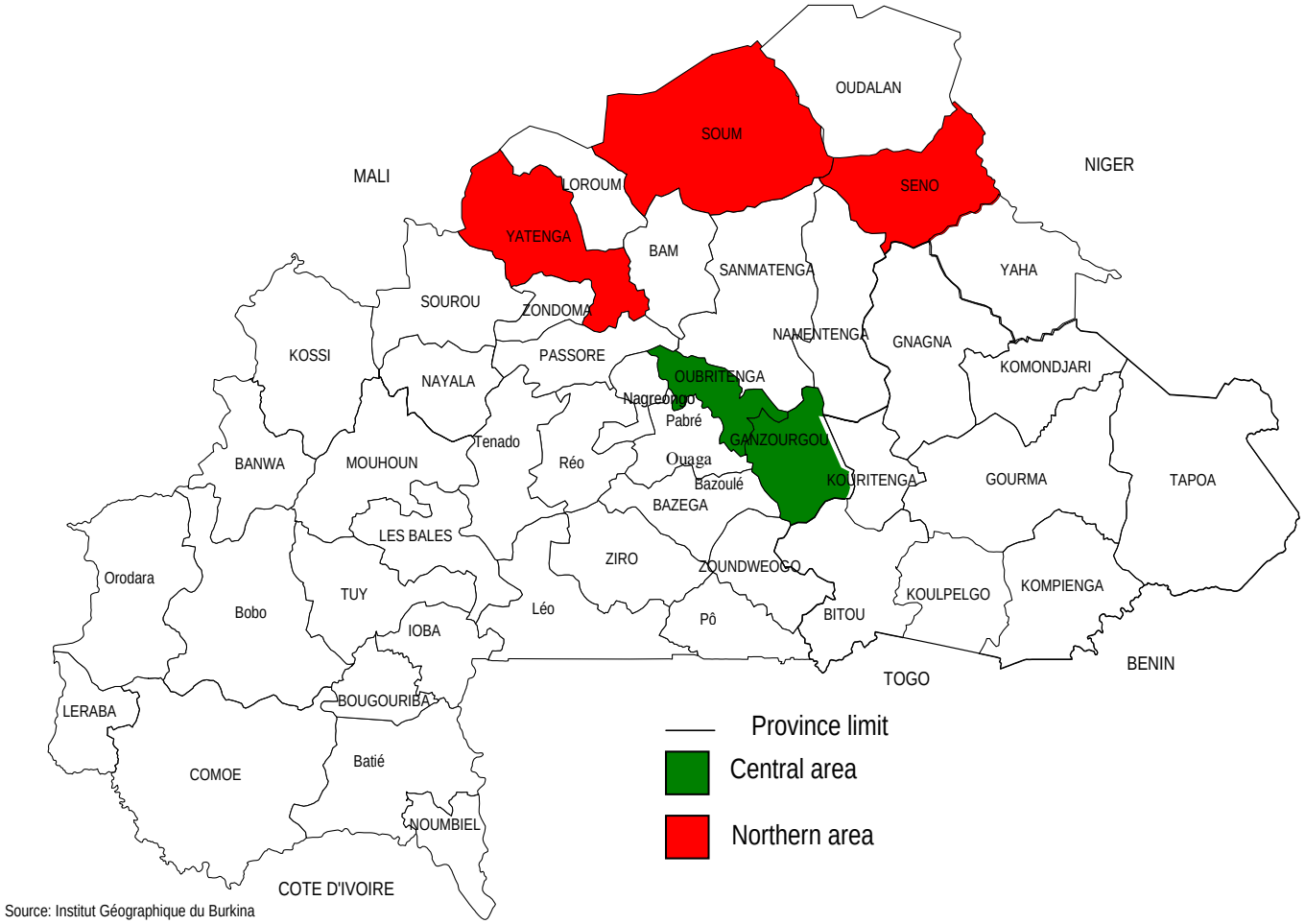
Table IV
Global prevalence of immunoglobulin G antibodies against Rift Valley fever virus, by age group

Animal age group (years)	No. of sera tested	No. of positive sera	Percentage positive
<1	44	2	4.54
1 to 3	125	8	6.4
3 to 5	186	16	8.60
>5	175	14	8
Total	520	0	7.69

Table V
Detection of neutralising antibodies in the serum neutralisation test

Species	No. of sera tested	No. of positive sera	Percentage positive
Cattle	17	2	11.8
Goats	18	13	72.2
Sheep	20	15	75
Total	55	30	54.5

Fig 1
Rift Valley fever study areas, 2005 to 2007



Source: Institut Géographique du Burkina