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Paper

Enzootic Ovine Abortion among small ruminants in Southern Benin

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Abstract

The advancement of small ruminant farming in Benin has encountered challenges associated with health issues and agricultural practices. This study aimed to provide the initial documentation of the prevalence of enzootic ovine abortion and evaluate the health status of animals concerning various recurring diseases on traditional small ruminant farms in Benin. In 2023, a semi-structured survey of 450 farms was carried out in two agricultural development centers in Benin. Additionally, 385 sera samples (200 sheep and 185 goats) from 77 farms, selected from the 450 surveyed farms, where animals exhibited signs of reproductive loss, underwent testing using the indirect Elisa method for Chlamydia abortus species. Among the 385 sera samples tested, 30 (7.79%) from pole 1 and 25 (6.49%) from pole 2 were positive for Chlamydia abortus. The survey results unveiled that small ruminants were primarily raised for savings and, to a lesser extent, for meat production and socio-cultural reasons, predominantly in Pole 1. During the rainy season, the common practice among farmers is to let their animals run free, although some opt to tie them to a fixed stake or keep them in loose confinement, the latter being more common in pole 2. The primary animal diseases reported by farmers included peste des petits ruminants, scabies, verminous digestive diseases, pasteurellosis, Rift Valley fever, sheep pox, agalactia, and trypanosomosis. The incidence of these diseases varied between the poles.

Enzootic Ovine Abortion emerges as a substantial threat to both animal well-being and public health. This research sheds light on the overlooked nature of this perilous disease, aiming to contribute to the enhancement of small ruminant livestock.

Keywords

Benin, Chlamydia abortus, Pathologies, Survey, Small Ruminant

Introduction

Diseases causing abortion in animals, caused by infections or parasites, constitute serious economic and public health problems. Their negative consequences, including developmental delays, infertility, and reduced milk production, lead to significant economic losses. Furthermore, these diseases have an indirect impact on animal products, resulting in significant veterinary expenses and herd reconstitution costs. The demand for animal proteins has substantially increased in the Republic of Benin over the past two decades due to population growth, resulting in a significant rise in the society's digital production 1.

Moreover, zoonoses such as toxoplasmosis, brucellosis, Q fever, and especially enzootic ovine abortion caused by *Chlamydia abortus*, a disease-causing abortion, deaths, premature deliveries, and miscarriages in pregnant women, require in-depth studies and preventive actions to reduce risks to public health 2. This disease was first documented in West Africa, notably in Mali, where the overall prevalence was 3.55% (3, and in Ethiopia with a prevalence of 9.88% (4.

In animals (small ruminants), *C. abortus* can be acquired through inhalation, ingestion, direct inoculation into the eye, and venereal transmission. Sources of these organisms include birth products, vaginal discharges, faeces, urine, semen, and ocular and nasal secretions 5. Shedding in vaginal fluids can commence more than 2 weeks before an abortion, particularly in goats, and may persist intermittently for a few weeks afterward. Some sheep and goats can become carriers of *C. abortus*, with persistent infections reported for at least 2 to 3 years in some cases 6. However, due to the neglected nature of this zoonosis, the available data on this subject in the sub-region in general, and particularly in the Republic of Benin, are incomplete, making it challenging to establish the disease's prevalence in all countries. In order to decrease the risks associated with these diseases, in-depth research and preventive actions must be conducted.

The aim of this study is to assess the health of small ruminant livestock in southern Benin, draw up a surveillance plan to identify the predominant diseases, and examine for the first time the health status and prevalence of enzootic abortion in these animals (sheep and goats).

Materials and methods

Study environment

The study was conducted in Benin's southern region, which encompasses six departments and is home to three of the country's seven Agricultural Development Poles (PDA). These poles, which are key elements of the agricultural development strategy, were planned taking into account the agro-climatic conditions and specific potential of each region of the country. Among the poles in this region, pole 1 is located in the south of the country and is mainly dedicated to food tree cultivation. This area is also home to transhumant herds, requiring careful management of the agro-salvo-pastoral space. Pole 1 is dedicated to crop diversification, with a particular focus on oil palm, food crops, cassava, and rice plantations. Finally, Pole 2 focuses more on fishing and market gardening activities in the river-lagoon regions of southern Benin, as well as in the Mono and Ouémé valleys. These two poles (Pole 1 and Pole 2) were chosen in the southern part of Benin, which has a subtropical climate with two rainy seasons (April to July and September to October) interspersed with two dry seasons. March is the hottest month, while August is the mildest.

The choice of poles and communes included in the study was based on the concentration of small ruminant livestock in these areas, with reference to the 2021 report by the Agricultural Statistics Directorate.

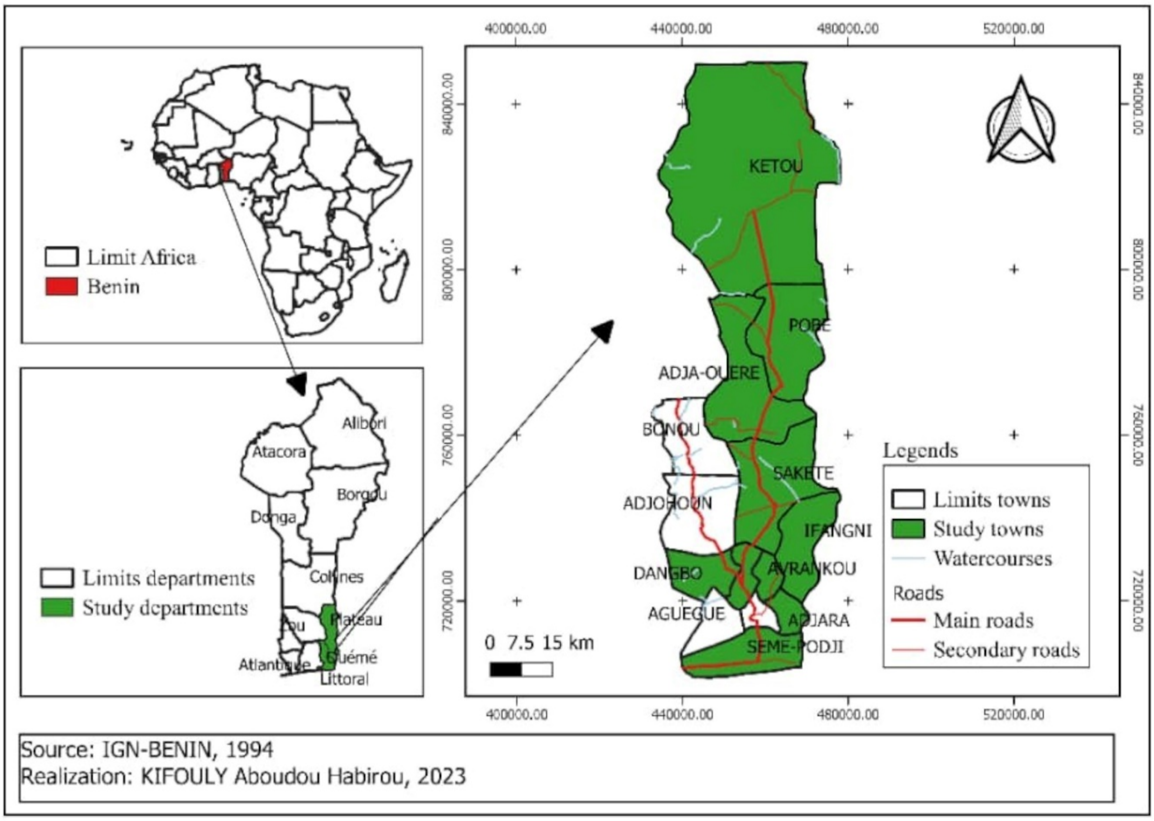

Figure 1. Map of collected samples zones.

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Data collection plan, sample collection and preparation

The study was carried out in two stages: first, an exploratory phase, followed by an in-depth data collection phase. The aim of the exploratory phase was to make contact with the stakeholders involved in sheep and goat production in the study areas while raising their awareness of the survey objectives. Data was collected through focus group discussions and individual interviews, involving a variety of resource people such as farm managers, butchers, livestock managers, members of the transhumance and livestock market management committees, small ruminant traders, agents specializing in animal production and health, local elected representatives and rural development officials.

Under the guidance of a competent guide, the discussion topics covered various aspects, including abortive chlamydia, production objectives, the main animal diseases encountered and their symptoms, and animal health and hygiene practices. Based on the group discussions, a sample of forty-five farmers per commune was selected for individual interviews, using a paper or electronic survey form (entered in KoboCollect) depending on the availability of the stakeholders and the specific features of each zone. In all, 450 interviews were carried out. The farmers were informed in advance of the visit so that they could prepare the information requested. These individual interviews focused on various aspects, including production objectives (which could be multiple), herd management, animal health practices and knowledge of *Chlamydia abortus* and its symptoms. In addition, five communes in each cluster were selected on the basis of the number of small ruminant farmers in each. For example, in Pole 1 (governorate of Plateau), the communes of Kétou, Adja-Ouèrè, Pobè, Sakété and Ifangni were taken into account; as for Pole 2 (governorate of Ouémé), it is composed of Sèmè-Kpodji and Dangbo, as well as Avrankou, Adjarra and Akpro-Missérété.

A suction tube was used to collect approximately 5 mL of blood from each animal's jugular vein. The sera were isolated from the clotted blood by centrifugation at 3000 rpm for 05 minutes and stored at -20 degrees Celsius, not to degrade the constituents of the blood so as not to destroy the infectious or non-infectious nature of the sample until serological analysis. The samples were collected by respected the institutional and national guide for the care and use of laboratory animals.

Study design

During 2022-2023, a cross-sectional study was conducted with owner's consent, approved by the Ethics Review Committee of the University of Abomey-Calavi. Sample size was calculated using Cochran's formula:

$n = Z^2 p (1 - p)/e^2$

where n is the sample size, Z is the statistic for 95% confidence interval, p is expected prevalence (50% due to Benin Republic's unaffected status regarding *C. abortus* infection), and e is precision (5%). 385 samples were collected from 77 ruminant flocks in five municipalities of each Ouémé and Plateau governorates, Southern Benin. Samples were randomly collected from both species (200 ewes and 185 goats) aged between <2 to >3 years, across four seasons. Some examined animals had a history of abortion (n = 345).

Laboratory analysis

Diagnostic work done at Bohicon Veterinary Laboratory's serology unit using IDVET's (Montpellier, France) indirect ELISA kits for *Chlamydia abortus*. Tests followed manufacturer's guidelines and were read at 450 nm using Chromate Inc's ELISA reader. Validation criteria for this zoonotic disease: mean optical density of positive controls > 0.350 and mean optical density ratio (DO pc/OD nc) > 3.

Statistical analysis

The information collected was entered into an Excel spreadsheet and analysed using SAS software (SAS Institute, Cary, NC, USA). Observed frequencies were determined using the Proc FREQ procedure in SAS software, and the chi2 test was used to assess the significance of the pole factor on the variables studied. To compare the relative frequencies between the different poles, the two-tailed Z test was applied. Each relative frequency was assigned a 95% confidence interval (CI), calculated according to the usual formula: CI = 1.96 * (square root of (P * (1 - P)) / N), where P represents the relative frequency and N the sample size.

Results

Clinical manifestation of Chlamydia abortus into the herds

Questioned farmers provided answers concerning the presence of Enzootic Ovine Abortion disease on the farms visited, focusing on *Chlamydia abortus* (table IV). In poles 1 and 2, respectively 65% and 74% of farmers reported frequent cases of premature birth ($p < 0,002$) and birth weight loss in newborns (62% in pole 1 and 71% in pole 2) ($p < 0,005$). Weight loss in pregnant ewes and goats was mainly observed at the end of gestation according to 59.56% of breeders in pole 1 and 51.11% in pole 2, although it could also occur at other times ($p < 0,004$). With regard to cases of retained placenta, 58% and 66% of farmers indicated that this was common on farms in pole 1 and 2 respectively ($p < 0,011$). Furthermore, a majority of abortion waves were observed in the third trimester of gestation (47% in pole 1 and 53% in pole 2), although significant cases of this wave were also observed in the first two trimesters ($p < 0,022$). With regard to cases of metritis, 42% and 33% of farmers in pole 1 and 34% and 40% in pole 2 respectively reported cases of udder inflammation and milk losses on their farms ($p < 0,03$). In addition, 56% and 50% of farmers reported cases of reddish-brown vulval discharge in pregnant goats and ewes during parturition ($p < 0,007$) (table I).

Parameters		Pole 1 (225)		Pole 2 (225)		
		No of farmers (%)	95% CI	No of farmers (%)	95% CI	P value
Premature births	Yes	147 (65)	57,64 ± 73,03	167 (74)	67,59 ± 80,86	0,002
	No	78 (35)	24,11 ± 45,23	58 (26)	14,52 ± 37,04	
		225		225		
Newborns' weight loss at birth	Yes	140 (62)	54,19 ± 70,25	159 (71)	63,59 ± 77,74	0,005
	No	85 (38)	27,47 ± 48,08	66 (29)	18,35 ± 40,32	
Weight loss at the end of gestation	At beginning	57 (25)	14,04 ± 36,62	55 (24)	13,09 ± 35,80	0,004
	At middle	34 (15)	3,07 ± 27,15	55 (24)	13,09 ± 35,80	
	End of gestation	134 (60)	51,25 ± 67,87	115 (51)	41,97 ± 60,25	
Placenta Retained	Yes	130 (58)	49,29 ± 66,27	148 (66)	58,13 ± 73,42	0,011
	No	95 (42)	32,29 ± 52,15	77 (34)	23,62 ± 44,82	
Abortion waves	First semester	44 (20)	7,84 ± 31,28	49 (22)	10,22 ± 33,33	0,022
	Second semester	75 (33)	37,61 ± 56,61	57 (25)	14,04 ± 36,62	
	Third semester	106 (47)	22,66 ± 44,00	119 (53)	43,92 ± 61,86	
Metritis	Agalactia	56 (25)	13,56 ± 36,21	59 (26)	15,00 ± 37,45	0,031
	Milk losses	75 (33)	22,66 ± 44,00	90 (40)	29,88 ± 50,12	
	mastitis	94 (42)	31,81 ± 51,75	76 (34)	23,14 ± 44,41	
Cases of discharges	Brown vulvar	45 (20)	8,31 ± 31,69	37 (16)	4,50 ± 28,39	0,007
	Brown-red vulvar	127 (56)	47,82 ± 65,07	113 (50)	41,00 ± 59,44	
	Red vulvar	53 (24)	12,13 ± 34,98	75 (33)	22,66 ± 44,00	

* The result is significant at $p < 0,05$.

Table I. Clinical manifestation of Chlamydia abortus into the herds.

Seroprevalence and factors associated with C. abortus infection in the Pole 1 and Pole 2

The investigation centred on the prevalence of *C. abortus* infection in small ruminants inhabiting five municipalities within the Pole 1 and Pole 2, located in Southern Benin. The findings have unveiled noteworthy disparities among these distinct geographical areas at a significance level of $p < 0.05$. The prevalence of *C. abortus* infection was notably elevated in the municipalities of Sakété and Kétou in Pole 1 (Table II). Most notably, the municipality of Akpro-Missérété exhibited the highest prevalence, closely trailed by Sèmè-Kpodji (Table III), both situated within the Pole 2. It is essential to highlight those animals in Sakété (with an Odds Ratio of 1.641) and Akpro-Missérété (with an Odds Ratio of 2.022) bore a significantly higher risk of *C. abortus* infection when contrasted with their counterparts in other municipalities.

The variables linked to the prevalence of *C. abortus* infection underwent rigorous scrutiny employing the logistic regression methodology, documented in Table IV and Table V. Notably, seropositivity was significantly more pronounced in ewes compared to goats, across both departments, bearing p-values of 0,010 and 0,025, respectively. An intriguing facet of this study is the considerable impact of the season, with p-values of 0,021 and 0,002, on the prevalence of *C. abortus* infection across the surveyed regions. The prevalence of *C. abortus* infection in small ruminants exhibited higher rates during the short rainy season and the long dry season within the Ouémé department, while the primary rainy season and minor dry season prevailed within the Plateau department. Interestingly, the results did not substantiate a robust correlation between abortion events and *C. abortus* infection (p = 0,213).

Turning our attention to the management systems adopted on the scrutinized farms, the prevalence rate attained its zenith on farms where abortion incidents had been recorded and where animals were subjected to intensive rearing practices, a statistical significance of p = 0.032 was noted in both departments. Additionally, farms featuring a herd size ranging from 10 to 30 animals or those neglecting post-abortion hygiene measures exhibited significantly higher prevalence rates in both departments.

Parameter	No of examined animals	No of positive (%)	95% CI	P value	Odd Ratio
Kétou	85	6 (7,06)	1,61 ± 12,50	2E-05	1,159
Sakété	90	8 (8,89)	3,01 ± 14,77		1,641
Pobè	64	2 (3,13)	-1,14 ± 7,39		0,421
Adja-Ouèrè	72	4 (5,56)	0,26 ± 10,85		0,829
Ifangni	74	5 (6,76)	1,04 ± 12,48		1,076
Total	385	25 (6,49)	4,03 ± 8,95		

Table II. Prevalence of C. abortus infection across the sites of Pole 1. * The result is significant at P < 0,05.

Parameter	No of examined animals	No of positive (%)	CI (95%)	p value	Odd ratio (OD)
Sèmè-Kpodji	85	9 (10,59)	4,05 ± 17,13		1,573
Akpro-Missérété	90	11 (12,22)	5,46 ± 18,99		2,022
Dangbo	70	5 (7,14)	1,11 ±13,18	1,28E-05	0,892
Adjarra	65	3 (4,62)	0,49 ±9,72		0,525
Avrankou	75	2 (2,67)	0,98 ±6,31		0,276
Total	385	30 (7,79)	5,11 ±10,47		

Table III. Prevalence of C. abortus infection across the sites of Pole 2. * The result is significant at p < 0,05.

Breeding methods and management of small ruminants

All the farmers surveyed (100% of respondents) practice different management methods for their animals throughout the year, adapting these practices according to the season. Roaming is the most common method, accounting for 42% in pole 1 and 46% in pole 2. Other methods such as semi-claustration, mobile stakes and fixed stakes are also used on other farms, in proportions of 31%, 16% and 11% respectively for pole 1, and 35%, 13% and 7% for pole 2. These management methods were the most commonly observed on the farms visited (p < 0,03) in both poles. Most farmers (68% for pole 1 and 61% for pole 2, p < 0,04) periodically took their animals to pasture. Unfortunately, a majority of these farmers (61% and 70% respectively for pole 1 and pole 2, p < 0,004) share the pasture with other animals whose health status is unknown.

In both poles, the majority of farmers observed that their animals scraped the ground with their teeth at certain times (74% in pole 1 and 67% in pole 2), without being able to explain this behaviour, although it was common among their animals (p < 0,02). With regard to the management of abortion products such as aborted foetuses, placentas, etc., over 41% and 44% of farmers in pole 1 and pole 2 respectively said they threw them away, while 31% and 35% chose to burn them. On the other hand, 28% and 21% of farmers interviewed in pole 1 and 2 respectively preferred to bury them. These different management practices for aborted products are the most common in these two regions of the southern zone (p < 0,01).

As for the supply of water for the animals, 44% and 42% of farmers indicated that their main source was wells, while 32% and 26% relied on a pump. Groundwater is the source of water for 24% and 32% of farmers surveyed in pole 1 and pole 2 respectively. These sources of water varied according to the area in which the farmers lived (p < 0,02). Finally, most farmers (72% for pole 1 and 64% for pole 2, p < 0,006) declared that they had close contact with their animals, which was unavoidable (Table VI).

Parameters	No of examined animals	No of positive (%)	CI (95%)	P value	Odd ratio (OD)
Species					
Sheep	210	16 (7,62)	4,03 ± 11,21	0,025	1,668
Goat	175	9 (5,14)	1,87 ± 8,42		0,688
	385	25 (6,49)			
Age					
<2	86	4 (4,65)	0,20 ± 9,10	0,014	0,655
2–3	167	13 (7,78)	3,72 ± 11,85		1,541
>3	132	8 (6,06)	1,99 ± 10,13		0,926
	385	25 (6,49)			
Season					
Main rain	121	10 (8,26)	3,36 ± 13,17	0,002	1,556
Main dry	94	3 (3,19)	-0,36 ± 6,74		0,408
Minor rain	105	7 (6,67)	1,90 ± 11,44		1,067
Minor dry	65	5 (7,69)	1,21 ± 14,17		1,271
	385	25 (6,49)			
Management system					
Intensive	187	14 (7,49)	3,71 ± 11,26	0,032	1,479
Semi - Extensive	133	8 (6,02)	1,97 ± 10,06		0,915
Extensive	65	3 (4,62)	-0,49 ± 9,72		0,662
	385				
History of abortion					
Yes	344	22 (6,40)	3,81 ± 8,98	0,213	1,366
No	41	3 (7,32)	-0,65 ± 15,29		1,166
	385				
Flock Size					
<10	208	11 (5,29)	2,25 ± 8,33	0,046	0,694
10–30	102	9 (8,82)	3,32 ± 14,33		1,669
>30	75	5 (6,67)	1,02 ± 12,31		1,054
	385				
Exchange of breeding male with neighbours					
Yes	346	23 (6,65)	4,02 ± 9,27	0,214	2,136
No	39	2 (5,13)	-1,79 ± 12,05		0,764
	385				
Post abortion measures					
Isolation and disinfection	165	7 (4,24)	1,17 ± 7,32	0,039	0,514
No measures	220	18 (8,18)	4,56 ± 11,80		2,24
	385				

Table IV. Variables associated with C. abortus infection in small ruminants of Pole 1. * The result is significant at p < 0,05.

Parameter	No of examined animals	No of positive (%)	CI (95%)	Odd ratio (OD)	p value
Species					
Sheep	200	17 (8,50)	4,63 ± 12,37	1,229	0,01
Goat	185	13 (7,03)	3,34 ± 10,71	0,814	
	385	30 (7,79)	5,11 ± 10,47		
Age					
<2	96	5 (5,21)	2,80 ± 13,86	0,591	0,008
2–3	157	14 (8,92)	3,49 ± 11,80	1,297	
>3	132	11 (8,33)	3,06 ± 12,09	0,955	
	385				
Management system					
Intensive	194	17 (8,76)	4,38 ± 12,12	1,421	0,031
Semi-extensive	115	8 (6,96)	2,92 ± 12,73	0,871	
Extensive	76	5 (6,58)	1,01 ± 12,15	0,814	
	385				
Seasons					
Main rain	175	14 (8)	3,54 ± 11,31	1,13	0,021
Main dry	67	5 (7,46)	1,17 ± 13,76	0,945	
Minor rain	97	8 (8,25)	3,50 ± 15,05	1,119	
Minor dry	46	3 (6,52)	-0,61 ± 13,66	0,806	
	385	30 (7,79)	2,36 ± 6,47		
History of abortion					
Yes	345	26 (7,54)	4,99 ± 10,66	1,263	0,214
No	40	4 (10)	-0,66 ± 15,66	0,955	
	385				
Flock Size					
<10	195	8 (4,10)	1,67 ± 7,56	0,342	0,038
10–30	104	15 (14,42)	6,90 ± 20,02	3,157	
>30	86	7 (8,14)	2,36 ± 13,92	1,063	
	385	30			
Exchange of breeding male with neighbours					
Yes	336	26 (7,74)	4,39 ± 9,90	1,489	0,204
No	49	4 (8,16)	3,07 ± 21,42	1,073	
	385				
Post abortion measures					
Isolation and disinfection	188	10 (5,32)	2,50 ± 9,21	0,525	0,001
No measures	197	20 (10,15)	5,52 ± 13,77	2,237	
	385				

Table V. Variables associated with C. abortus infection in small ruminants of Pole 2. * The result is significant at p < 0,05.

	Pole 1		Pole 2		P value
Parameters	**No of farmers (%)**	**95% CI**	**No of farmers (%)**	**95% CI**	
Animal management practices					
Roaming	95 (42)	32,29 ± 52,15	103 (46)	36,16 ± 55,40	
Semi-wildlife	70 (31)	20,27 ± 41,96	78 (35)	24,11 ± 45,23	0,025
Fixed stake	35 (16)	3,55 ± 27,56	29 (13)	0,69 ± 25,08	
Mobile stake	25 (11)	-1,21 ± 23,43	15 (7)	-5,96 ± 19,29	
Total	225		225		
Grazing animals					
Yes	153 (68)	60,61 ± 75,39	138 (61)	53,21 ± 69,46	0,04
No	72 (32)	21,22 ± 42,78	87 (39)	28,43 ± 48,90	
Sharing grazing with other animals					
Yes	137 (61)	52,72 ± 69,06	157 (70)	62,59 ± 76,96	0,004
No	88 (39)	28,92 ± 49,31	68 (30)	19,31 ± 41,14	
Soil scraping by animals					
Yes	167 (74)	67,59 ± 80,86	151 (67)	59,62 ± 74,60	0,023
No	58 (26)	14,52 ± 37,04	74 (33)	22,18 ± 43,59	
Water source					
Well	98 (44)	33,74 ± 53,37	95 (42)	32,29 ± 52,15	
Ground water	54 (24)	12,61 ± 35,39	71 (32)	2075 ± 42,37	0,024
Pump	73 (32)	21,70 ± 43,18	59 (26)	15,00 ± 37,45	
Aborted products					
Burn	69 (31)	19,79 ± 41,55	79 (35)	24,59 ± 45,64	
Landfill	64 (28)	17,39 ± 39,50	47 (21)	9,27 ± 32,51	0,019
Throw away	92 (41)	30,84 ± 50,94	99 (44)	34,22 ± 53,78	
Contact between farmer and animals					
Yes	163 (72)	65,59 ± 79,30	143 (64)	55,67 ± 71,44	0,006
No	62 (28)	16,43 ± 38,68	82 (36)	26,03 ± 46,86	

Table VI. Livestock farming methods and animal management. p 0.05 = Not significant difference

Main symptoms and suspected diseases in small ruminant reported by farmers

The discussions in the discussion groups revealed that the main pathologies encountered in the livestock were PPR, digestive verminoses, scabies, agalactia, pasteurellosis, and trypanosomiasis. Participants reported that these diseases, especially PPR, caused mortalities. Unanimously, they also affirmed that most of them occurred during the rainy season.

Table VIII shows the main observed symptoms and the suspected diseases based on these symptoms by the farmers and veterinary agents present during the discussion groups. Similarly to the discussions, individual surveys revealed that the suspected pathologies in the livestock were PPR (55.11% and 45.33% in pole 1 and 2, respectively), Rift Valley fever (19.11% and 28.44% in pole 1 and 2, respectively), scabies (15.56% and 19.56% in pole 1 and 2), digestive verminoses (51.11% and 43.11% in pole 1 and 2, respectively), agalactia (51.11% and 42.67% in pole 1 and 2, respectively), brucellosis (20% and 25.33% in pole 1 and 2, respectively), trypanosomiasis, and coccidiosis (12% and 11% in pole 1 and 2, respectively), contagious ecthyma (9.78% and 10.22% in pole 1 and 2, respectively), and echinococcosis (9.33% in pole 1 and 2, respectively) (table VIII). These different diseases were most frequently mentioned, although some had a greater impact than others (p=0.009, p=0.042, and p=0.045, respectively, for diseases of viral, bacterial, and parasitic origin).

Diseases	Type	Clinical signs
Peste des petits ruminants (PPR)	Viral	Fever, runny nose and eyes, conjunctivitis, mouth lesions, diarrhoea, breathing difficulties, abortions, high mortality.
Rift Valley fever (RVF)	Viral	Fever, abortions in pregnant ewes, stillbirths, mortality in young lambs, neurological damage in adults.
Clabber	Viral	Fever, skin eruptions (papules and vesicles) on udders, muzzle and feet.
Pasteurellosis (Pneumonia)	Bacterial	Fever, cough, purulent nasal discharge, breathing difficulties, depression, loss of appetite.
Ecthyma	Viral	Skin lesions around the mouth, nose, eyes and feet, causing painful scabs.
Scabies (Pseudoscabiosis)	Parasitic	Itching, skin lesions, wool loss, frequent scratching
Coccidiosis	Parasitic	Diarrhoea, weight loss, anaemia, dehydration
Verminosis	Parasitic	Anaemia, weight loss, diarrhoea, presence of worms in the faeces
Ovine brucellosis	Bacterial	Repeated abortions, inflammation of testicles in rams.
Tuberculosis	Bacterial	Emaciation, chronic cough, breathing difficulties, abortions in pregnant females.
Tetanus	Viral	Agitation, screaming, trembling, neck stretched backwards.
Mastitis	Bacterial	Inflammation of the udder, udder hard to the touch, refusal to breastfeed.
Echinococcosis	Parasitic	Nodule under the skin containing, when the incision is made, a sac filled with liquid and numerous small white "eggs

PPR : Peste des Petits Ruminants ; RVF : Rift Valley Fever.

Table VII. Main symptoms and suspected diseases in small ruminant.

Parameters	Pole 1 (225)		Pole 2 (225)		
	No of farmers (%)	95% CI	No of farmers (%)	95% CI	P value
Viral Diseases					
PPR	124 (55)	46,36 ± 63,87	102 (45,33)	35,67 ± 54,99	
FVR	43 (19)	7,36 ± 30,86	64 (28,44)	17,39 ± 39,50	0,009
Clavelée	36 (16)	4,02 ± 27,98	36 (16)	4,02 ± 27,98	
Ecthyma	22 (10)	-2,63 ± 22,19	23 (10,22)	-2,16 ± 22,60	
Bacterial Diseases					
Ovin Brucellosis	45 (20)	8,31 ± 31,69	57 (25,33)	14,04 ± 36,62	
Tuberculosis	39 (17)	5,45 ± 29,21	38 (16,89)	4,98 ± 28,80	0,042
Agalactia	115 (51)	41,97 ± 60,25	96 (42,67)	32,77 ± 52,56	
Pasteurellosis	26 (12)	-0,73 ± 23,84	34 (15,11)	3,07 ± 27,15	
Parasitic Diseases					
Verminose	115 (51)	41,97 ± 60,25	97 (43,11)	33,26 ± 52,97	
Gale	35 (16)	3,55 ± 27,56	44 (19,56)	7,84 ± 31,28	
Coccidiose	27 (12)	-0,26 ± 24,26	38 (16,89)	4,98 ± 28,80	0,045
Trypanosomose	27 (12)	-0,26 ± 24,27	25 (11,11)	-1,21 ± 23,43	
Echinococcose	21 (9)	-3,11 ± 21,78	21 (9,33)	-3,11 ± 21,78	

Table VIII. Control of various diseases observed by farmers within their farms. p 0.05 = Not significant difference; PPR: Peste des Petits Ruminants; RVF: Rift Valley Fever.

Discussion

To aid livestock sector development, assessing the health of small ruminant farms in Benin is essential for establishing a surveillance plan. This involves evaluating the health situation in the southern zone, identifying prevalent diseases, and conducting the first assessment of herd health and *Chlamydia abortus* prevalence in small ruminants to create an initial inventory.

Seroprevalence and risk factors for C. abortus.

The overall seroprevalence of *C. abortus* in unvaccinated goats and sheep was 7.79% (30 out of 385) in Pole 2, while this prevalence was 6.49% (25 out of 385) in Pole 1. The variation in prevalence by commune ranged from 2.67% to 12.22% (see Table II) for Pole 2 and from 3.13% to 8.89% for Pole 1 (see table III), and seropositive small ruminants were identified in all sampled non-vaccinated herds. This finding suggests that the bacterium is widespread in both Poles posing a potential risk to humans and animals in direct contact or in the surrounding areas. Nonetheless, it is noteworthy that the seropositivity rate was most elevated among animals with a history of abortion in both departments. In Africa, data on sheep and goat prevalence of enzootic abortion remain scarce; however, there are reports of significantly lower prevalence levels, including 7.10% recorded in the Republic of Mali 3. In Europe, the prevalence remains higher, exceeding the 5.8% observed in herds with recent cases of abortion in Sardinia 7, as well as 3.97% in Belgium 8 and 7.70% in the Slovak Republic 9.

The risk factors associated with seropositivity are shown in table IV and table V. Statistically significant associations were identified for herd size, animal species, age of animals, season, and post-abortion measures in both Poles. With regard to herd size, statistical disparities were found between small and medium-sized herds compared with all herds, respectively. For example, the odds ratio (OR) for the presence of antibodies in animals from medium-sized herds was almost thrice as high (OR= 3.157; CI = 6.90 - 20.02; p = 0.038) in Pole 2 (see table V) while it was one and a time for Pole 1 (OR= 1.669; CI = 3.32 – 14.33; p = 0.038) (see table IV) as in goats and sheep from small or large herds.

Conversely, animals from small herds had an OR of 0.342 (CI = 1.67 - 7.56) in Pole 2 and an OR of 0.69 (CI = 2.25 – 8.33), a protective characteristic for both Poles (see table IV and table V). Herd size was related to the animal management methods used on farms; most herds were subject to intensive or semi-extensive management practices, favouring close contact between animals, which could facilitate transmission of the bacteria and spread of the disease 10. In this context, seroprevalence was found to be significantly higher in intensively managed herds for both poles (OR = 1.421; CI = 4.38 - 12.12; p = 0.032 in Pole 1; OR = 1.479; CI = 3.71 – 11.26 in Pole 2) compared with those under semi-extensive or extensive management 11. In addition, inappropriate management practices have also been associated with a high incidence of zoonotic abortions within herds 12. However, it is pertinent to mention that the abortion history of the surveyed animals and the potential exchange of breeding males with neighbouring farms did not exert a significant influence on the prevalence of *C. abortus* infection, as indicated in Table IV and Table V, albeit it remains a concern regarding the security of these establishments.

Significant seasonal variations have been observed. Specifically, a statistically significant significance was noted during the season of heavy rainfall in both poles (OR = 1.130; CI = 3.54 - 11.31; p = 0.021 for Pole 2 and OR = 1.556; CI = 3.36 – 13.17; p = 0.002 for Pole 1) (table IV and table V), even though a higher incidence of infections was observed during the small rainy season (8.25% for Pole 2 and 6.67% for Pole 1) (see table IV and table V). In fact, the risk of infection in animals was nearly 1.1 times higher (OR = 1.119; CI = 3.50 - 15.05 for Pole 2 and OR = 1.067; CI = 1.90 -11.44 for Pole 1) (see table IV and table V) during this period than during other seasons. The rainy season promotes an increase in food availability and, consequently, creates favourable environmental conditions for the proliferation of *C. abortus* 13. Positive cases observed during the dry season can be explained by factors such as food scarcity, long distances between grazing and shelter areas, exposure to high temperatures, and a shortage of clean water, common conditions during this period that can induce stress and lead to abortions 14. The season was also associated with measures of prevention taken after abortions. A high prevalence (10.15% in Pole 2 and 8.18% in Pole 1) was observed in farms where no preventive measures were in place, with an infection risk almost two and half times higher (OR = 2.237; CI = 5.52 - 13.77 in Pole 2 and OR = 2.240; CI = 4.56 – 11.80 in Pole 1) compared to farms where preventive measures were partially in effect (OR = 0.582; CI = 2.50 - 9.21 in Pole 2 and OR = 0.514; CI = 1.17 – 7.32 in Pole 1) (see table IV and table V). Herd disinfection and cleaning of contaminated equipment reduce the risk of disease spread in the livestock 15 and eliminate potential pathogens dispersed in the environment by seemingly healthy animals 16.

Regarding species-specificity, a significantly higher prevalence (8.50%) was observed in sheep compared to goats in both poles, with sheep being 1.2 times more likely to be infected than goats (OR = 1.229; CI = 4.63 - 12.37; p = 0.010) for Pole 2 and 1.7 times for Pole 1 (OR = 1.668; CI = 4.03 – 11.21) (see table IV and table V). This phenomenon can be attributed to the greater susceptibility of sheep to *C. abortus* compared to goats 17 18. Furthermore, small ruminants aged 2 to 3 years exhibited a notably higher prevalence (8.92%) than individuals in other age groups (<2 years and >3 years), with these animals being 1.3 times more likely to be infected than their counterparts in different age groups (OR = 1.297; CI = 3.49 - 11.80) in Pole 2 and 1.5 times (OR = 1.541; CI = 3.72 – 11.85) in Pole 1 (see table IV and table V). This trend can be explained by the gradual acquisition of natural immunity in animals as they grow, providing protection against infectious diseases such as *C. abortus* 19.

Characteristics of various contagious diseases in animals’ herds

Animal husbandry was mainly characterised by rambling, as all the farmers in the two areas studied practised it for at least part of the year. This practice was due to the lack of fenced pastures that they could own. Permanent grazing is also the main livestock management method in the department of Mvila, in southern Cameroon 20, and in Walungu, in Congo 21. During the rainy season and agricultural work, the animals were tied to the stake, which could be fixed or mobile. In these study areas, herders had food crops close to the concessions where the animals were kept; tying them to the stake prevented them from devastating the fields. This practice was also observed by 22 in a farming context in Togo, where small ruminants are either tied to posts (the most common practice in the northern part of the country), or locked up and fed during the growing season. The practice of herding animals to pasture was also widespread among livestock farmers, mainly among the Peuls involved in a mixed farming system (sheep and goats). According to the farmers, sheep are docile and always move in groups, which also leads dwarf goats, in particular, to adopt a tolerant behaviour that favours group grazing. This practice of driving small ruminants to pasture was also reported by 23 in a farming context in northern Benin.

The main pathologies of small ruminants observed during the study were grouped into three distinct categories of major diseases. In the group of viral and parasitic diseases, PPR, digestive worm infestations and scabies were frequently identified as the main parasitic diseases faced by small ruminant farms in the southern zone. The presence of these worm infestations has also been observed in traditional herds in Benin, according to studies by 24. Agalactia was a recurring problem that farmers often had to contend with, and its presence is thought to be due to the probable presence of Enzootic Sheep Abortion Disease, although there may be other factors involved. As 25 pointed out in 2022, these diseases are thought to be encouraged by animals roaming around and the absence of a prophylaxis plan on farms. According to farmers, most of the diseases appeared during the rainy season because of the humidity, which favours the survival and development of pathogens, as reported by 25.

The main clinical signs of infection with *C. abortus* were observed and reported by farmers in the two regions studied. They reported cases of premature births, serial abortions and weight loss in newborns at birth. These observations were mentioned in previous studies on the incidence of abortive Chlamydiosis in small ruminants by 13. Although these three signs are not specific to the disease, they are nevertheless major indicators of the presence of this zoonosis on small ruminant farms. In addition, farmers frequently reported cases of weight loss at the end of gestation, metritis, reddish-brown discharge and, above all, retained placenta, which were the main problems they had to contend with on a regular basis, particularly during the rainy season. These observations are consistent with the findings of 6 26, who also discussed the emergence and spread of abortive chlamydiosis and the biosecurity measures that need to be taken to protect farms. It is essential to raise awareness of the presence of this disease in Benin among livestock farmers and animal health professionals, given that it has been neglected until now.

Conclusion

This study established the presence of the aetiological agent of enzootic ovine abortion disease in small ruminants in Ouémé department, the antibodies being of suspicious origin (animals not vaccinated against the disease studied). Seroprevalence rates varied according to study sites (Chlamydia rate higher in Akpro-Missérété and Sèmè-Kpodji in Pole 2; higher in Sakété and Kétou in Pole 1), season, age, management system, flocks' size, and post-abortion measures small ruminant species (sheep more infected with Chlamydia). Digestive verminosis, peste des petits ruminants, mange, brucellosis, agalactia, and Rift Valley fever were the diseases most frequently encountered on farms, according to the people surveyed. These diseases were favoured by the way small ruminants were kept, which was essentially roaming, and the absence of a health and medical prophylaxis plan. Cases of premature births, weight loss of newborns at birth, weight loss of pregnant animals at the end of gestation, waves of abortions, retained placenta, and reddish-brown vulval discharge were among the main clinical signs identified as being associated with enzootic ovine abortion disease or abortifacient chlamydia.

Small ruminant farming was of economic, religious, socio-cultural, and nutritional importance, and deserved to be given greater consideration by the authorities in the livestock sector development program. Studies based on laboratory diagnosis should be carried out to confirm the nature of the suspected pathologies, the presence or otherwise of abortive chlamydia, and to assess their respective importance in this part of southern Benin.

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Ethics approval and consent to participate correction

Ethical clearance for this study was obtained from the University of Abomey-Calavi, the Communicable Disease Research Unit of the Department of Animal Production and Health under reference: EC approval 2022/1927/UAC/BENIN. Before conducting the research, the officials of the Territorial Agricultural Development Agency were informed and their agreement was obtained. Similarly, the farmers were informed of the objectives of the study and the consent of the household representative was obtained. The consent of the herders was verbal as the majority of them are not literate. In addition, they have their own traditional leaders, who manage such agreements in collaboration with the local administration. Their verbal agreement was recorded and approved by the committee.

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