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ORIGINAL ARTICLE

BEHAVIOURAL DETERMINANTS OF LIVESTOCK FARMERS AND SEROPREVALENCE OF BRUCELLOSIS IN SMALL RUMINANTS IN THE SUB-PREFECTURE OF DOUNET (MAMOU), REPUBLIC OF GUINEA

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Ethical considerations: When reporting experiments on animals Observation of the ARRIVE guidelines 2.0: Updated guidelines for reporting animal research, published on July 14, 2020 (DOI: 10.1371/journal.pbio.3000410), is applied. The authors ensure that all procedures were performed in compliance with the guidelines for animal care of their institutions or with national/international guidelines.

ABSTRACT

This study assessed the brucellosis seroprevalence of small ruminants and hazardous practices of contamination in the sub-prefecture of Dounet in Guinea. A survey was carried out among 60 people, mainly livestock farmers, and 192 small ruminants were clinically examined. Ninety serum samples were subjected to the Rose Bengal Test (RBT) and Indirect Enzyme-Linked Immunosorbent Assay (I-ELISA). Abortion and sterility were the most commonly observed symptoms, with 73.33% and 18.18%, respectively, for goats, and 81.82% and 26.67% for sheep. Farmers' knowledge about brucellosis in small ruminants was significantly lower (18.33% [9.9%–30.85%]). Regarding sanitary measures to prevent disease occurrence, 31.67% [20.60%–45.09%] of the farmers did not apply any specific measures, compared to 55% who applied sanitary measures and 8% who applied quarantine. The results of RBT showed that the overall seroprevalence of brucellosis was 27.77% (25/90) compared to 11.11% (10/90) using I-ELISA ($p = 0.008$). Female goats were significantly more affected, with a prevalence of 85% (17/20) compared with 20% (3/15) in males ($p < 0.001$). Bacterial infection did not vary significantly between study sites or age groups. The results of this study confirm that brucellosis is widespread among small ruminants and underline the urgent need for increased surveillance of the disease in all regions of the country.

Key word: Brucellosis; goats, Guinea; I-ELISA; RBT; sheep

INTRODUCTION

Small ruminant farming is a highly profitable activity that contributes significantly to Guinea's food self-sufficiency and economy. Factors affecting the productivity of the country's livestock include reproductive problems, poor nutrition, and various bacterial, viral, and parasitic diseases. One of the diseases responsible for the high number of abortions, stillbirths, prolonged calving intervals, infertility, and reduced milk production on most farms is brucellosis. It is a widespread zoonotic disease that is a public health problem in most parts of the world, including Guinea [1]. It affects both animal and human populations but is classified by the World Health Organization (WHO) as one of the seven most neglected diseases, with 500,000 new cases worldwide each year [2, 3]. This zoonosis is caused by Gram-negative bacteria of the genus *Brucella*. *Brucella abortus* affects cattle, *Brucella melitensis* is found in small ruminants, and *Brucella suis* in pigs [4]. Transmission between animals is generally achieved through direct and indirect contact. Fluids such as infected birth fluids, placental mucosa, skin cuts, and aborted fetuses can all be sources of infection [5]. Human infection is caused by direct contact with sick animals and consumption of raw milk and other unpasteurized dairy products contaminated with *Brucella* [6]. *Brucella* species can cause fever, arthritis, and neurological symptoms in humans [7, 2]. The risk of transmission from animals to humans appears to be increased by certain factors such as recent climate change and its impact on farming practices, dietary habits, and human activities [8, 9].

In sub-Saharan Africa, brucellosis remains endemic, with seroprevalence in humans and cattle ranging from 0 to 40%, depending on geographical location [10, 11, 12]. A survey carried out in different regions of Guinea showed a prevalence of brucellosis in sheep/goats of 12.5%, compared with 30% in humans [1].

Overall, data on the true prevalence of brucellosis in Africa are patchy. In Guinea, the first epidemiological survey to assess the presence of this disease in cattle was carried out in 19 herds in different regions. The baseline data showed that seroprevalence varied according to the geographical location of the country, with an average of 6.9% [0–27%] [13]. A few years later, Diallo [9] showed that the coastal region of Guinea appeared to be the most affected. Since then, several studies have confirmed the influence of geographical location on the overall seroprevalence of bovine brucellosis, ranging from 8.7% [5.3–12%] in 2010 to 11.8% in 2020 [14, 15]. In western Guinea, brucellosis seroprevalence in cattle was estimated at 11%. In sheep and goats, it was 0.4% and zero, respectively [16]. A recent study on priority zoonoses showed a high risk of brucellosis in Kankan but less in Conakry and N'Zérékoré [17]. Although there is some data on this pathology, it remains poorly documented.

In Dounet, a location in the Mamou region, more than 80% of the population is involved in agro-pastoral activities. Unfortunately, the livestock sector is currently experiencing enormous difficulties. The climatic conditions (low temperatures and waterways used as drinking troughs for migratory animals) are conducive to the occurrence of infectious diseases, such as brucellosis, in small ruminants. However, the clinical and epidemiological diagnosis of brucellosis is variable and not very specific. Brucellosis is associated with a variety of symptoms: abortion, retained placenta, mastitis, sterility, orchitis, and epididymitis. However, confirmation by a laboratory diagnostic test is absolute proof of infection and has a specificity of 100% [18]. Nevertheless, as no serological test is 100% accurate, the simultaneous use of at least two different serological techniques is strongly recommended to assess the brucellosis status of herds, with combinations of tests varying according to the epidemiological situation [19].

This study was carried out to provide updated epidemiological data on brucellosis in small ruminants (goats and sheep) in Dounet, located in the Mamou region of Guinea. This information on the seroprevalence and factors associated with this zoonosis will be useful in assessing the risks to human health and animal production and in defining appropriate prevention and control strategies.

MATERIALS AND METHODS

Study sites

This study was carried out from October to December 2023 in the sub-prefecture of Dounet, Mamou prefecture (Fig. 1). It covers an area of 570 km^2 and has a population of 32,656, giving a density of 57 inhabitants per km^2. It has a tropical climate with two alternating seasons: a dry season (November to May) and a rainy season (June to October). The area is characterized by a steep rainfall gradient,

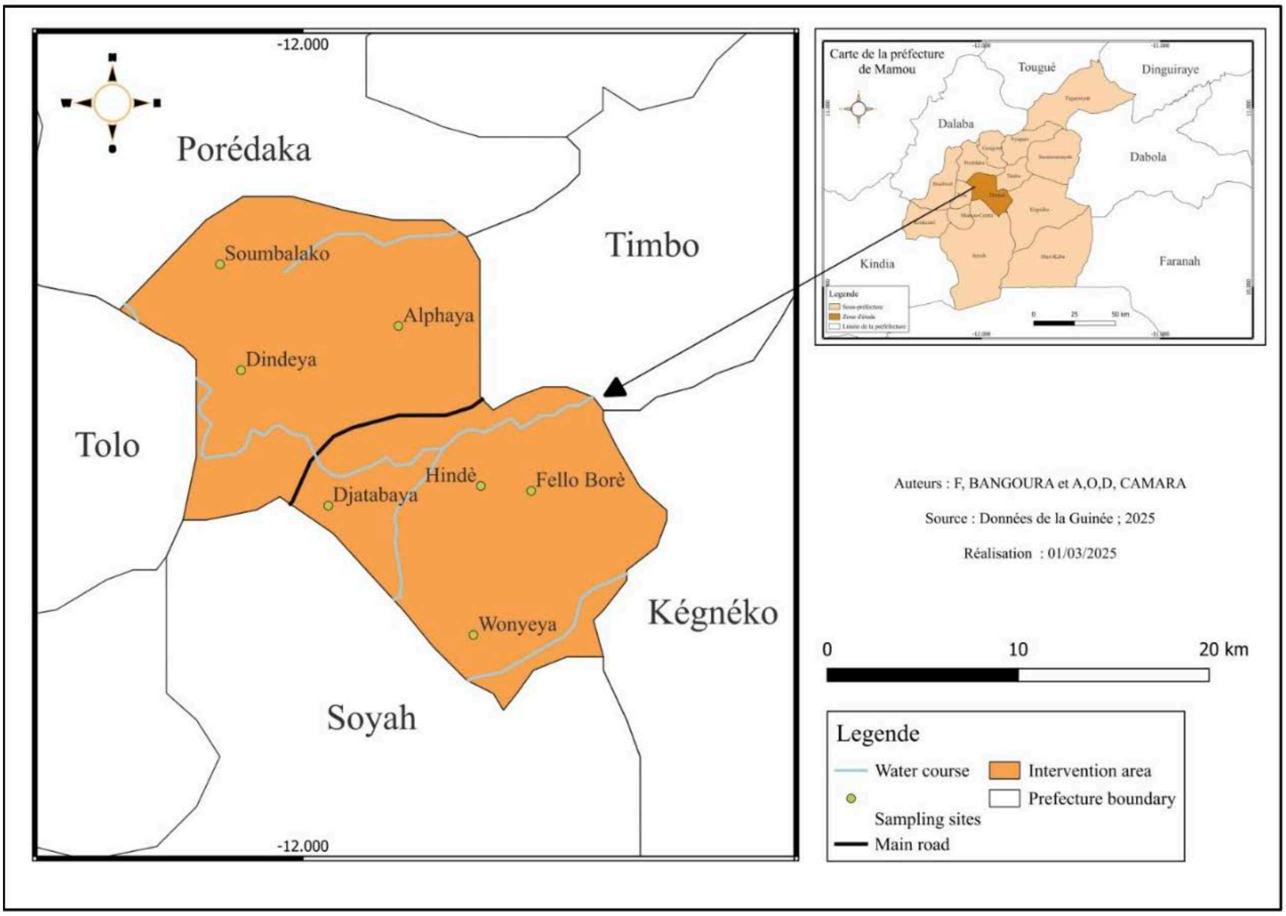

Fig. 1. Study area

ranging from 2,400 to 650 mm per year. The average annual rainfall can be as high as 2,400 mm. Average temperatures range from 15°C to 36°C and average relative humidity from 23% to 45% [20]. The dominant winds are the Harmattan, which blows from east to west during the dry season, and the Monsoon, which blows from south-west to north-west. Wind speeds vary between 9.3 km/h and 11.7 km/h. These climatic conditions (temperature, humidity, wind, rainfall) favor the development and multiplication of bacteria (*Brucella*) and, above all, their persistence in the external environment. The relief of the area is rugged, with plateaus that form the beginning of the Fouta Djallon. The average altitude varies from 400 m in the south to 800 m in the north of the prefecture.

The vegetation consists mainly of open forests, wooded savannahs, and galleries. The most common species are *Erythropheum guineensis*, *Khaya senegalensis,* and *Cassia siberiana*. The area is irrigated by the Konkouré river, which has its source in the Mamou region at an altitude of almost 1,000 meters.

Agriculture, trade, and livestock are the main income-generating activities. Livestock rearing is essentially family-based, and most animals are on the move throughout the year, except during the growing season. However, the mixture of different species, the lack of identification of pregnant females, the extensive nature of livestock farming, and poor feeding are all factors in the occurrence and spread of brucellosis. Similarly, the use of manure from brucellosis-infected animals in horticulture and the consumption of vegetables grown on soil treated with this manure are risk factors for brucellosis contamination in humans. Finally, the presence of a market for animal products and a livestock market is a factor in the spread of this zoonosis [20].

Type and period of survey

The present survey, carried out from October to December 2023, was cross-sectional and descriptive, based on a quantitative and qualitative questionnaire. The surveys were carried out specifically among farmers/shepherds. In addition to the quantitative surveys, a focus group was organized with livestock management staff, followed by an analysis of health records for diseases affecting small ruminants.

The survey process

The survey was conducted in the field in several stages. The first stage was to contact the local chiefs to explain the importance of the study and to invite them to participate and to involve their peers. Once we had the agreement of the chiefs, a member of the community was appointed to accompany us to the pastoralists, where the importance and scope of our study were explained as well. After their consent, the survey has been carried out. Farmers were selected using the snowball method (non-probabilistic). Sixty (60) farmers were interviewed by qualified interviewers. This survey allowed to collect information on the animal characteristics of each breeding, their management, and their movements. The questionnaire covered the type of farming practiced, the farmers' knowledge of brucellosis and other small ruminant diseases, their attitudes and practices regarding brucellosis, preventive measures, and the socio-economic impact of brucellosis on the farms.

In addition to the individual information gathered through the questionnaire, a focus group was held with ten (10) executives of the Mamou Prefectural Department of Agriculture and Livestock and from the Dounet Livestock Section to get a better understanding of the existence, evolution, and impact of small ruminant brucellosis in the sub-prefecture. An analysis of the archives was also carried out to obtain information on the various diseases prevalent in the area, in particular abortive diseases such as small ruminant brucellosis.

This approach also made it possible to identify the links between breeding: communal drinking troughs for stray animals, the existence of livestock markets, nocturnal gatherings, the exchange of animals, and the management of abortions, with a view to identifying the epidemiological risks that could favor the circulation of pathogens and the creation of outbreaks.

Sampling and blood collection

Herd sampling was snowball sampling (non-probabilistic). Herds were thus selected in a non-random manner on the basis of recommendations and with the consent of the farmers. A total of 101 goats and 91 sheep were included in this study. All of these animals underwent a clinical examination to identify those with the main symptoms of brucellosis (abortions, infertility, orchitis, and reproductive problems).

All animals with at least one of these symptoms had blood samples taken. When the number of symptomatic animals was less than ninety (90), asymptomatic animals from the seven (07) target localities in the sub-prefecture of Dounet were selected and added to reach this sample size. These samples were subjected to serological tests.

After each animal was restrained, a total volume of 5 ml of blood was collected by venipuncture into an EDTA tube and stored tilted in carboglass before being transported to the laboratory. Then, the tubes were centrifuged at 5,000 rpm for 10 to 15 minutes. After centrifugation, the clear serum from each sample was transferred to sterile, labelled tubes and immediately stored at -20°C for serological testing.

Serological tests

Two serological tests were used to detect brucellosis in animal serum samples in this study: the Rose Bengal Test (RBT) and the Indirect Enzyme-Linked Immunosorbent Assay (I-ELISA).

Rose Bengal Test (RBT)

The RBT was used to test for anti-*Brucella* antibodies according to the manufacturer's instructions (ID vet, Rose Bengal antigen for RSA test, ID vet 310, rue Louis Pasteur, Grabels, France). Thereby, 30 µl of *Brucella* antigen was mixed with an equal volume of serum on a single-ended plate and spread on complete circles of approximately 2 cm diameter according to the manufacturer's instructions. The plates were manually rotated for four minutes according to the standard procedure described by the International Office of Epizootics (OIE) [21]. Any agglutination is considered positive, while the absence of agglutination is considered negative. The Rose Bengal Test has a sensitivity of 96.10% and a specificity of 99.30% [22].

Indirect Enzyme-Linked Immunosorbent Assay (I-ELISA)

The indirect enzyme-linked immunosorbent assay (I-ELISA) was used to detect antibodies to *Brucella* species. The I-ELISA kit (ID vet France, kit reference BRUS-MS-5P) was used to test sera for multi-species smooth lipopolysaccharide (S-LPS) antibodies of *Brucella*, including *Brucella melitensis*, *Brucella abortus,* and *Brucella suis*, according to the standard protocol of the International Office of Epizootics (OIE) [21]. For this purpose, all serum samples, including controls and reagents, were brought to room temperature (18–25°C). Diluted (1:20) test sera and controls were incubated with Brucella lipopolysaccharide (LPS)-coated plates for 45 minutes at room temperature. After washing, 100 µl of multi-species horseradish peroxidase (HRP) conjugate was added to each microplate well and stored at room temperature for 30 minutes. After washing in order to remove excess conjugate, a tetramethylbenzidine (TMB) substrate solution was added and stored in the dark for 15 minutes. The color developed depended on the amount of specific antibody present in the test sample. The plates were then read using an ELISA microplate reader (Lab system, USA) at a wavelength of 450 nm. The percentage value (S/P%) was calculated using the formula recommended by the kit manufacturer (ID Vet, France) for the BRUS-MS ver 1014GB batch kit protocol.

Statistical analysis

Survey data were collected using the KoboCollect mobile application, then transferred to KoboToolbox for processing. Microsoft Excel spreadsheet software was used for data storage, and R statistical software, version 4.1.2 (R CoreTeam, 2021), was used for analysis. Seroprevalence in sheep and goats was calculated by dividing the number of RBT and I-ELISA positive animals by the total number of animal sera tested. The Chi2 test for comparison of proportions was used to compare the proportions of farmers and the seroprevalence of brucellosis in goats and sheep. A p-value less than or equal to 0.05 was considered statistically significant.

RESULTS

Farmers' knowledge of brucellosis and identification of hazardous contamination practices

Extensive livestock production is the main type of farming practised in Dounet. In fact, 86.67% (n = 58) of the 60 farmers surveyed practised it (Table 1). Overall, a small proportion (18.33% [9.9%–30.85%], 8/60) of farmers were aware of the existence of brucellosis in small ruminants. The proportion of farmers who were aware of peste of small ruminants (60% [46.54%–72.17%]; n = 36) was significantly higher than those who reported being aware of brucellosis (18.33% [9.9%–30.85%]), Q fever (3.33% [0.57%–12.54%]), ovine abortive salmonellosis (6.67% [2.15%–17.00%]), and fasciolosis (11.67% [5.21%–23.17%]) (Table 1).

Regarding hygiene measures on the farm, 50% [37.73%–62.26%] of farmers did not use any hygiene measures, whereas 15% [7.50%–27.07%] cleaned it regularly, 11.67% [5.21%–23.17%] disinfected the premises, and 23.33% [13.77%–36.33%] isolated sick animals. Overall, 55% ([41.69%–67.66%]; n = 33) of the farmers took sanitary measures to prevent the outbreak of zoonotic diseases, whereas only 13.33% ([6.33%–25.14%], n = 8) quarantined animals. On the other hand, 31.67% [20.60%–45.09%] of farmers did not apply any specific measures (Table 1).

Overall, 50% [37.73%–62.26%] of the farmers surveyed did not take any measures to deal with abortion cases, and 30% [19.20%–43.37%] discarded the fetus and placenta in the wild (Table 1). On the other hand, a few minor measures, such as burial (13.33% [6.33%–25.14%]) and incineration (6.67% [2.15%–17.00%]) of the fetus and placenta, were used in the management of abortion cases.

The socio-economic impact of brucellosis on farms varied. According to the farmers interviewed, abortions due to brucellosis and neonatal deaths resulted in economic losses of 43.33% [30.81%–56.70%] and 38.33% [26.35%–51.80%], respectively. Other economic losses were due to the reduced market value of diseased animals (13.33% [6.33%–25.14%], n = 8) and treatment costs (5% [1.30%–14.82%], n = 3).

Statement on brucellosis by the executives of the Mamou Prefectural Livestock Directorate

The focus group with managers from the Prefectural Livestock Directorate of Mamou and the sub-prefecture of Dounet showed that they were aware of the existence of brucellosis in small ruminants. According to them, brucellosis is a recurrent disease that generally occurs at the end of the rainy season. It is most commonly characterized by abortions in the last months of pregnancy, with females more susceptible than males. In some cases, the pregnancy can be completed, but the resulting young (lambs and kids) are very weak or die within a few hours of birth. If there is a series of abortions in several female ruminants, brucellosis may be suspected. However, serological tests are required to confirm or exclude this possibility.

A nosological analysis of infectious diseases in health records showed that brucellosis in small ruminants reduces

Table 1. People's knowledge, attitudes, and practices regarding brucellosis

Terms and conditions		Number of respondents	Proportions (%)	95% CI
Farmers' knowledge of brucellosis in small ruminants	Know	11	18.33	[9.9–30.85]
	Do not know	49	81.67	[69.14–90.06]
Types of livestock farming	Extensive	52	86.67	[74.85–93.66]
	Semi-extensive	8	13.33	[6.33–25.14]
Knowledge of the main pathologies	Ruminant plague	36	60.00	[46.54–72.17]
	Brucellosis	11	18.33	[9.9–30.85]
	Q fever	2	3.33	[0.57–12.54]
	Ovine abortive salmonellosis	4	6.67	[2.15–17.00]
	Fasciolosis	7	11.67	[5.21–23.17]
Health measures in place for the prevention of disease outbreaks	Health measures	33	55.00	[41.69–67.66]
	Quarantine	8	13.33	[6.33–25.14]
	No specific measures	19	31.67	[20.60–45.09]
Premises hygiene measures	Regular cleaning	9	15.00	[7.50–27.07]
	Disinfection	7	11.67	[5.21–23.17]
	Separation of sick animals	14	23.33	[13.77–36.33]
	No specific measures	30	50.00	[37.73–62.26]
Abortion case management measures	By burial	8	13.33	[6.33–25.14]
	By incineration	4	6.67	[2.15–17.00]
	Disposal in the natural environment	18	30.00	[19.20–43.37]
	No measures	30	50.00	[37.73–62.26]
Socio-economic impact of the disease on farms	Abortion	26	43.33	[30.81–56.70]
	Treatment costs	3	5.00	[1.30–14.82]
	Neonatal losses	23	38.33	[26.35–51.80]
	Loss of market value of animals	8	13.33	[6.33–25.14]

%: percentage; CI: Confidence Interval

the number of small ruminants because of the abortions or losses of lambs and kids that it causes. In addition to brucellosis in small ruminants, other abortifacient diseases such as chlamydiosis and toxoplasmosis are also widespread in the sub-prefecture of Dounet.

Pathological effects of the disease on the animals

Table 2 revealed that of the 101 goats and 91 sheep examined, 13.54% (n = 26) showed various symptoms (abortion and sterility) of brucellosis. Abortion was the most frequently observed symptom (73.33% in goats and 81.82% in sheep) compared to sterility (26.67% in goats and 18.18% in sheep), with a significant difference (p-value < 0.05) (Table 2).

Results of the serological test

The overall seroprevalence of brucellosis detected in small ruminants was 27.77% (25/90) using the RBT test

Table 2. Clinical examination of animals

Localities	Workforce surveyed		Number of animals with symptoms		Symptoms: Number of goats		Symptoms: Number of sheep	
	Goats	Sheep	Goats	Sheep	Abortion	Sterility	Abortion	Sterility
Alphaya	14	18	2	2	2	0	2	0
Soumbalako	13	10	2	1	2	0	0	1
Dindeya	10	10	1	0	1	0	0	0
Hinde	12	12	3	1	2	1	1	0
Djatabaya	15	20	2	2	1	1	2	0
Fello Borè	17	11	3	2	1	2	2	0
Wouyeya	20	10	2	3	2	0	2	1
TOTAL	101	91	15	11	11	4	9	2
%	-	-	14.85	12.09	73.33	26.67	81.82	18.18
P-value	-	-	0.728		0.0284		0.0105	

%: percentage

Table 3. Serology by test used (RBT and I-ELISA) in both species

Species	Serological tests	Number of samples tested	Number of positives	Seroprevalence (%)	P-value
Goats	RBT	45	14	31.11	
	Indirect ELISA	45	6	13.33	0.076
Sheep	RBT	45	11	24.44	
	Indirect ELISA	45	4	8.89	0.0896
Total	RBT	90	25	27.77	
	Indirect ELISA	90	10	11.11	0.008

%: percentage

Table 4. Seroprevalence of brucellosis in small ruminants by study site

Species	Localities	Numbers surveyed	Number of samples analysed	Number of positives	Seroprevalence (%)	95% CI
Goats	Alphaya	14	5	3	60.00	[17.04–92.74]
	Soumbalako	13	5	2	40.00	[7.25–82.95]
	Dindeya	10	6	2	33.33	[5.99–75.89]
	Hindè	12	5	1	20.00	[1.05–70.12]
	Djatabaya	15	6	1	16.67	[0.87–63.51]
	Fello Borè	17	10	9	90.00	[54.11–99.47]
	Wouyeya	20	8	2	25.00	[4.45–64.42]
	Total	**101**	**45**	**20**	**44.44**	**[29.95–59.87]**
Sheep	Alphaya	18	10	6	60.00	[27.36–86.30]
	Soumbalako	10	6	1	16.67	[0.87–63.51]
	Dindeya	10	5	0	0.00	[0.00–53.70]
	Hindè	12	7	2	28.57	[5.11–69.74]
	Djatabaya	20	5	1	20.00	[1.05–70.12]
	Fello Borè	11	7	5	71.43	[30.25–94.88]
	Wouyeya	10	5	0	0.00	[0.00–53.70]
	Total	**91**	**45**	**15**	**33.33**	**[20.43–49.05]**

%: percentage; CI: Confidence Interval

compared with 11.11% (10/90) using the indirect ELISA ($p = 0.008$). These two serological tests showed a higher prevalence of brucellosis in goats, but without a significant difference ($p > 0.05$). In fact, out of a total of 45 serum samples tested by RBT and I-ELISA in goats, a brucellosis seroprevalence of 31.11% (n = 14 positive) and 13.33% (n = 6 positive), respectively, was observed ($p = 0.0759$). The same trend was observed in sheep, with seroprevalences estimated at 24.44% and 8.89% for the RBT and I-ELISA, respectively ($p = 0.0896$) (Table 3). However, 100% of small ruminants (n = 26) showing symptoms of reproductive disorders tested positive for brucellosis bacteria.

The seroprevalence of brucellosis in small ruminants by site (Table 4) showed no significant difference in seroprevalence between sites ($p > 0.05$). In goats, the highest seroprevalence was observed in Fello Borè (90% [54.11–99.47]) and the lowest in Djatabaya (16.67% [0.87–63.51]), with an overall prevalence of 44.44% [29.95–59.87] for the whole study area (Table 4).

For sheep, it ranged from 71.43% [30.25–94.88] in Fello Borè to 16.67% [0.87–63.51] in Soumbalako, with an overall prevalence of 33.33% [20.43–49.05] for the whole study area (Table 4).

Figure 2 shows the seroprevalence of sheep and goats based on sex. Analysis of the figure revealed that female goats are more affected by brucellosis, with a prevalence of 85% (17/20) compared to 20% (3/15) for males ($p < 0.001$). In sheep, the seroprevalence was higher in females (39.39%: 13/33) than in males (16.67%: 2/12), but the difference was not significant ($p > 0.05$).

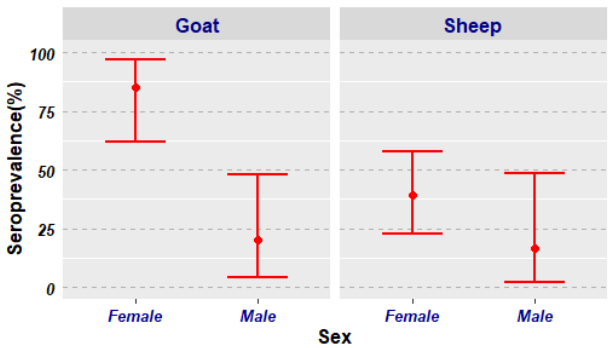

Fig. 2. Brucellosis seroprevalence in small ruminants by sex

Figure 3 examined the influence of age on the susceptibility of small ruminants to brucellosis. Analysis of this figure showed that infection with this bacterial disease in small ruminants did not vary according to age group. However, the most infected age group was between 4 and 6 years, but there was no significant difference with the other age groups ($p > 0.05$). In goats of this age group, the prevalence was 50% [27.99–72.00] compared to 43.75% [20.75–69.44] in sheep. The least affected age group was 6 months to 1 year, with a prevalence of 14.29% [0.75–57.99] in sheep and 40% [7.20–82.95] in goats.

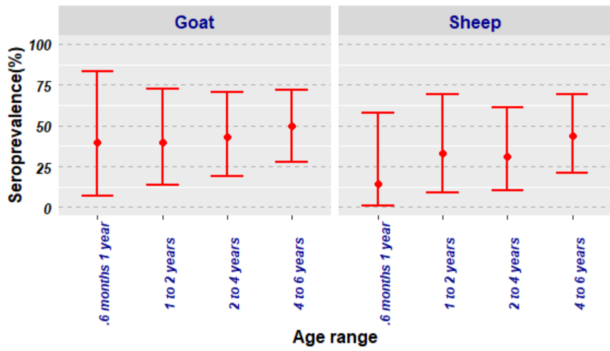

Fig. 3. Seroprevalence of brucellosis in small ruminants by age category

DISCUSSION

This study provided data on the seroprevalence of brucellosis in small ruminants in the sub-prefecture of Dounet, where livestock production is extensive.

Results showed that the seroprevalence of brucellosis in small ruminants in the study area was relatively high. It was 27.77% (25 positives) using the RBT test compared with 11.11% (11 positives) using the I-ELISA. This result is in contrast to that observed by Troupin et al. [16], who recorded a prevalence of *Brucella* bacteria of zero (0 out of 408) in goats and 0.4% (2 out of 486) in sheep between 2017 and 2019 in Guinea. According to this study, the prevalence of brucellosis was zero in the prefectures of Dabola, Dalaba, Faranah, Kouroussa, and Mandiana. However, high seroprevalence rates were only observed in cattle (51 positive; 11%) [16]. This increase in brucellosis infectivity in small ruminants may be due to the more active circulation of *Brucella melitensis* in Guinea [12]. Historically, *Brucella melitensis* has been associated with brucellosis epidemics in small ruminants, mainly in North, East, and Central Africa, while in West Africa almost 90% of isolates were *Brucella abortus* [23, 24]. This potential spread of *Brucella melitensis* would be due to the purchase of ruminants from other countries or regions, which would increase the likelihood of infected ruminants being introduced into herds [25]. This hypothesis is plausible, as the results of the survey showed that farmers had little information about brucellosis in small ruminants, and their overall knowledge of the disease was low (18.33%). As a preventive measure, new animals should be quarantined and tested for *Brucella* infection before introduction into herds. However, it would be interesting to isolate and identify the *Brucella* species circulating among ruminants in Guinea. It would also be important to re-evaluate the seroprevalence in ruminants in the same areas in the coming years to determine whether this pattern of spread continues, with a view to recommending appropriate control measures. Brucellosis is generally transmitted by direct or indirect contact with diseased ruminants or their secretions [26]. Given the extensive nature of livestock farming in Dounet, this rapid spread of brucellosis in small ruminants could be due to contact with or ingestion of feed/drinking water contaminated with bacteria from calving products and uterine secretions [27]. This risk factor for *Brucella* infection is higher in dry areas [28]. Due to the scarcity of grazing land in arid areas, small ruminants are grazed over large areas, suggesting uncontrolled goat-cattle-bovine interaction with a potential risk of transmission. The relatively high prevalence rates observed among small ruminants in Dounet may also be due to the lack of hygiene and sanitation measures and the absence of screening for the disease. Our survey results showed that the majority of farmers do not use hygiene measures, and only 23% of them isolate sick animals. A significant proportion of farmers (31.67%) did not apply any specific measures. Most of the farmers surveyed (80%) had no significant measures to deal with cases of abortion in ruminants, and some even threw the fetus and placenta into the wild.

However, the seroprevalence observed in this study appears to corroborate the work of Akakpo et al. [1] in February 2009, where significant rates of 12.5% were observed in small ruminants in Guinea.

Our work showed that the seroprevalence of brucellosis was higher in goats (31.11% and 13.33%) than in sheep (24.44% and 8.89%) using the RBT and indirect ELISA tests, respectively. This result confirms the work of Djangwani et al. [29], who reported that the seroprevalence of brucellosis in small ruminants ranged from 0 to 20% in goats compared with 0 to 13.8% in sheep.

A similar prevalence (31%) was found in goats in another study conducted in the mountainous region of Libya between 2006 and 2008 [30]. This higher prevalence in goats is thought to be related to the higher sensitivity observed in goats compared to sheep [31]. In addition, the results showed that the RBT test was highly sensitive for detecting brucellosis in serum samples with high prevalence. As a result, the RBT test appeared to be the most suitable screening test to identify diseased individuals or to ensure the absence of infection in herds [22, 11].

Outbreaks of *Brucella* infection are influenced by a number of related factors, including age, sex, breed, size, housing system, and agro-ecology [12, 32, 33]. In this study, female goats were significantly more affected by brucellosis than males. This result confirms the high seroprevalence (100%) observed in animals showing signs of abortion and infertility. This finding had already been made in cattle, where females were more likely to be infected with *Brucella* than males [34, 35]. This could be explained by the fact that ruminant females generally lick their fetuses and newborns, which increases the level of infection with the bacteria [36]. Furthermore, although age is considered a factor influencing *Brucella* infection in cattle, seroprevalence did not vary significantly between age groups in small ruminants in this study. However, the most infected age group was between 4 and 6 years of age. Brucellosis infection was similar in the seven sites studied. The reasons for this similarity may be due to the similar environmental and geographical characteristics of the sites. Similarly, the small sample size may not have favored the detection of differences in seroprevalence between sites. However, according to one of the previous studies, the difference in the prevalence of *Brucella* could be linked to the different environments: the bacterium survives better in humid conditions but does not multiply very well in an environment that is too hot [16].

For this study, animals were selected on the basis of well-defined clinical signs and according to pre-established objectives: younger animals were of little concern, not all farmers were surveyed, not all farms were included, and serological analysis was carried out using two methods (RBT and indirect ELISA). This approach is a limitation of the study. Future studies will include all animals in the herd and evaluate the diagnostic capacity and discriminatory power of PCR, sequencing, fixing the complement (FC), I-ELISA, and RBT in detecting brucellosis.

CONCLUSION

This study revealed brucellosis spread in small ruminants with variable prevalence in the sub-prefecture of Dounet in Guinea. These animals may pose a potential risk of spreading brucellosis to humans and other animals due to their close association with the human population and the zoonotic nature of the disease. As part of a One Health approach, we recommend screening of human populations at risk (veterinarians, farmers, slaughterers) and public awareness programmes to reduce the risk of zoonotic disease in the human population.

Availability of Data and Materials

The datasets that were analyzed in this study are available from the lead author.

Ethics for Approval and Consent to Participate

Prior approval was obtained from the Mamou's Prefectural Department of Livestock before the study was carried out. After contacting breeders with the agreement of the local chiefs, the objectives and framework of the study were clearly explained. In this way, we were able to obtain or not the herders' consent to participate without any negative consequences for their activities. Only after obtaining their verbal consent were the questionnaires used and samples collected. Privacy of the participating farmers was respected, as other farmers prefer to hide what is happening in their herds to avoid being judged by their peers. To ensure privacy, the questionnaires did not include the names of the farmers but rather the names of the villages where they were run and numbered.

Competing Interests

The authors declare that they have no competing interests.

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Generative AI Statement

The authors declare that no generative AI was used in the creation of this manuscript.

Authors' Contributions

The original study was conducted by AODC, ASS, LK, NK and AOSD who also supplied the data. The idea for the study was conceptualized and generated by AODC, ASS, LK, and AOSD. Data were collected by AODC, ASS, LWS, HMD, CDK, KC, MMD and MYB. AODC, ASS. LK and AOSD drafted the manuscript. Statistical data analysis by ASS and LK. GGP, SE and MCA provided intellectual criticism on the content of the manuscript. All authors have read and approved the final submitted manuscript.

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