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Contribution to the Study of the Health Status of Dairy Farms in the Doukkala Region – Morocco: Case of Brucellosis

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Abstract

Our study focuses on describing the zootechnical characteristics of dairy cattle farms and conducting serological research on brucellosis in ruminants. To this end, a survey was conducted in 119 dairy farms, collecting 363 serum samples from March to December 2022. The study was carried out in the Doukkala region, within the province of El Jadida and Sidi Bennour, Morocco.

The results indicate that 90.8 % of operators are owners with 37.8 % having no formal education. The cattle population consists of 67.8 % crossbreed and 31.4 % imported breed. A significant proportion of cows are purchased from the souk (57.5 %). The proportion of cows with a history of abortion is higher (p=0.01) in crossbreed cattle than in the imported breed. Notably, only 10.2 % of farmers are aware of bovine brucellosis.

The detection of brucellosis was carried out using the Rose of Bengal test on serum samples collected from the blood. The study revealed a low rate of brucellosis cases (0.8 %) in a sample of 363 cows. This is attributed to the previous enforcement of health and hygiene measures by dairy farms. However, the lack of education and awareness about this disease and the importance of hygiene in dairy production could pose risks to production and consumer safety.

Keywords: Dairy farming; Investigations; Brucellosis; Doukkala; Cattle

1 Introduction

Morocco's dairy sector is a significant contributor to the country's agricultural landscape. While it boasts a staggering 400,000 individuals involved in dairy production, only approximately 40,000 of these farms can be classified as (semi) professional (Ndiongue, 2022). This sector, vital to the Moroccan economy, provides livelihoods for 474,000 people and brings together the efforts of 400,000 producers through 82 dairy manufacturers. The majority of production over 80 % is concentrated in designated "dairy basins" including Ghrab, Loukkos, Tadla, Doukkala, Chaouia, Souss Massa, and Saiss. However, since 2012, the dairy industry has faced stagnation in production, accompanied by numerous challenges related to changing consumption patterns and the management of seasonal production.

Milk and dairy products play a pivotal role in providing essential nutrition, particularly for children, as they are rich sources of macro and micronutrients such as calcium, proteins, vitamins and fats that are vital for the development and maintenance of bodily functions (Leksir et al., 2019). Unfortunately, the safety of milk can be compromised at various points along the supply chain, whether accidentally or deliberately

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(Amenu et al., 2020). This contamination can make milk a potential vector for a wide range of micro-organisms, including pathogenic bacteria such as *Brucella sp.*, which are small, aerobic, non-motile, Gram-negative coccobacilli (Rossetti et al., 2022) causing brucellosis. Brucellosis is the most widespread bacterial zoonosis in the world, with major repercussions on animal production and trade, posing serious public health problems (Lonkar et al., 2023; WHO, 2015). It is also an occupational hazard affecting shepherds, abattoir workers, veterinarians, dairy specialists and laboratory staff (van den Brom et al., 2020).
In light of these concerns, our study was conducted in the Doukkala region, specifically in the provinces of El Jadida and Sidi Bennour, where we surveyed 119 dairy farms. The objectives of our survey were to assess the state of these dairy farms, quantify the quantities of dairy products supplied to the informal market an issue of genuine concern for consumer health and to gain insights into the awareness

2 Materials and methods

2.1 Study zone

Our research focused on the provinces of El Jadida and Sidi Bennour within the Casablanca-Settat region. This region covers a vast Useful Agricultural Area (UAA) of 1,356,933 hectares, of which around 17 % is under irrigation. Notably, it contributes to 20 % of the national agricultural production, with cereal cultivation being a predominant agricultural activity occupying 81 % of the region's landscape. In terms of national importance, this region ranks third in UAA, holding a significant share of 13 % of the country's total UAA. The dairy sector in the area is a key player, with a population of approximately 147,000 dairy cows, predominantly consisting of improved breeds (95 %) and supported by 43,200 dairy producers. In the national context, the dairy sector ranks second in terms of production, following sugar beet and capers, which together contribute 22 % of the region's overall production (Casablanca-Settat region monograph, 2020).

2.2 Survey conducted

Our study encompassed the evaluation of one hundred and nineteen dairy farms to assess the zootechnical characteristics of these dairy cattle farms, emphasize the significance of the informal market within the region and identify transmission risks associated with brucellosis, a notable zoonotic disease. Additionally, we aimed to pinpoint farm-level risk factors contributing to the spread of this disease for the purpose of containment.

2.3 Survey sheet design

To assess the risk of brucellosis transmission through the consumption of unprocessed milk, we created a structured questionnaire tailored to dairy farms. Simultaneously, we collected blood samples for subsequent laboratory analysis.
Our questionnaire predominantly consisted of closed-ended questions. This approach ensured clarity and consistency in the data collection process while minimizing any potential ambiguity among respondents. This method allowed as well for the gathering of precise and objective information regarding the various aspects we aimed to explore. We also included a small set of open-ended questions to gain additional insights into the breeders' understanding of brucellosis, further enhancing the depth of our data.
The survey of "dairy farms" encompassed 33 municipalities, comprising 15 in the Sidi Bennour province and 18 in the El Jadida province (as indicated in Table 1).

2.4 Blood test

To identify brucellosis in dairy cows within the region, we collected blood samples during our farm visits. We performed a qualitative analysis using the Rose Bengal method (Delpharm Biotech, France).
The blood samples were obtained by puncturing either the jugular vein or the tail vein of the animals. For serum collection, we transferred the blood to dry 5 or 10 mL vacuum tubes. The sample preparation steps varied with regard to centrifugation (IKAG-L, USA), based on envi-

Table 1: Distribution of farms surveyed according to administrative organization

Province	Municipalities		Farms	
	Number	**%**	**Number**	**%**
El Jadida	18	54.5	60	50.4
Sidi Bennour	15	45.5	59	49.6
Total	**33**	*100*	**119**	*100*

ronmental conditions. During the hot period, which spans from March to June, we consistently employed centrifugation, spinning the samples at 9,000 rpm for 5 minutes. In contrast, when the weather allowed, samples were left at room temperature for 24 hours. The resulting serum was then collected in 1.5 mL microtubes and stored at 20 °C until analysis.

The Rose Bengal antigen reaction (30 mL), also known as the buffered antigen reaction, is a rapid agglutination test that employs a suspension of bacterial suspension of *Brucella abortus* (Weybridge strain 99) inactivated by heat and phenol, dispersed in an acid buffer and stained by Rose Bengale. To conduct the test, we mixed equal parts of Rose Bengal antigen with the collected serum. We then observed the emergence of colored agglutinates, which indicate the presence of brucellosis. In dairy cattle the Rose Bengal test and the serum agglutination test are the most commonly used serological tests to diagnose Brucella spp. (Wang et al., 2024).

2.5 Data analysis and processing

Following the completion of the survey, we established a database for the breeders' survey sheets. Microsoft Office Excel 2013® software was employed for this purpose. The information was recorded in a numerical format (e.g., livestock numbers) or in the form of clearly defined responses (e.g., Yes/No/NA) to streamline the data analysis process.

Data processing was conducted utilizing the same software mentioned above, and we made use of the "Pivot Table Report" function to summarize and analyze the data. For comparing proportions based on various criteria, we employed the statistical tools available in the EpiInfo7 software.

3 Results and Discussion

3.1 Persons surveyed and owners

Among the individuals surveyed from the dairy farms, 90.8 % are farm owners, with 37.8 % of them having no formal education. A significant portion of the respondents (49.6 %) reported having 10 to 20 years of experience in animal breeding, as detailed in Table 2.

3.2 Description of the farms surveyed

Herd characteristics in the study area

The livestock in the study area exhibits a notable breed composition, with three distinct categories. The crossbreed stands out as the predominant group, representing 68 % of the total, followed by the imported breed at 31 %. The local breed, on the other hand, comprises just 1 % of the population. A majority of these animals are procured at the local souk (57.5 %), with imports accounting for 21.7 % of the acquisitions. The age range of these animals spans from 2 to 8 years, as detailed in Table 3.

Herd characteristics in the study area

Based on our survey findings, it was observed that 11.1 % of the 119 surveyed farms reported at least one incidence of abortion during the productive life of their cows, as indicated in Table 4. Abortion is more prevalent among crossbreed animals aged between 2 and 8 years, accounting for

Table 2: Individual information on the people surveyed

Designation		Number of answers/ 119	Frequency (%)
Status	Owner	108	**90.8**
	Manager	5	4.2
	Salaried worker	2	1.7
	Member of the family	4	3.4
Educational level	None	45	**37.8**
	Koranic school	16	13.4
	Primary	31	**26.1**
	Secondary	25	21
	Superior	2	1.7
Years of experience	<10 years	7	5.9
	>20 years	53	44.5
	10 to 20 years	59	**49.6**

Table 3: Characteristics of the herd in the Doukkala region

Features		Number of answers	%
Breed	Crossed	**335**	**67.8**
	Imported	155	31.4
	Local	4	0.8
	Total	*494*	*100*
Age class	2 to 8 years	**469**	**94.9**
	>8 years	25	5.1
	Total	*494*	*100*
Origin	Bought from the souk	**284**	**57.5**
	Imported	107	21.7
	Native to breeding	103	20.9
	Total	*494*	*100*

Table 4: Abortive status of the herd

Abortive status	Number of answers	%
No abortion	439	88.9
Abortion	55	**11.1**
Total	***494***	***100***

Table 5: Distribution of dairy animals based on individual characteristics and abortion history

Characteristics	History of abortion		Total
	Positive	**Negative**	
Breed			
Crossed	45(13.4%)	290	335
Imported	9(5.8%)	146	155
Local	1(25%)	3	4
Total	*55(11.1%)*	*439*	*494*
Age class			
>8 years	1(4.0%)	24	25
2 to 8 years	54(11.5%)	415	469
Total	*55(11.1%)*	*439*	*494*
Origin			
Imported	8(7.5%)	99	107
Native breeding	9(8.7%)	94	103
Bought from the souk	38(13.4%)	246	284
Total	*55(11.1%)*	*439*	

11.5 % of such cases, as shown in Table 5. Breeds that have experienced abortion incidents are notably those acquired from the souk. This observation raises concerns about the potential for disease transmission within the souk, suggesting that it may serve as a conducive environment for disease spread. Indeed, Traore et al. (2020) reported that local and crossbred breeds are more susceptible to the disease due to their greater sensitivity (same source mentioned previously). An experimental study on bovine brucellosis conducted by Plommet et al. (1973) showed that there are no bovine breeds more resistant to brucellosis infection than others. Likewise, no study has demonstrated that males are more resistant than females, although it has been suggested.
The animals most affected by *Brucella spp.*, are those aged between 2 and 8 years. However, according to a study conducted by Traore et al. (2020), the highest infection rate was observed in animals aged 10 years or older. According to the same study, animals aged 10 and older are more likely to contract brucellosis.

3.3 Statistical comparison of abortion results depending on individual characteristics of cattle

The percentage of cows with a prior history of abortion is notably higher among crossbreed cattle compared to the imported breed, and this discrepancy is statistically significant (p=0.01). However, a comparison of abortion rates among cows from different origins did not reveal a statistically significant difference, as presented in Table 6.

3.4 Type of farms surveyed

Among the surveyed farms, mixed farms account for the majority, representing 64 % of the total, while cattle farms make up the remaining 36 %, as indicated in Table 7. In fact, in Egypt, large ruminants are generally raised as a single species, or mixed with small ruminants and equines. There are different farming systems: ruminants graze during the day and are kept in pens at night, while other farmers raise their ruminants indoors or in mobile herds (Hegazy et al., 2015).

3.5 Categories of cattle on the farms surveyed

Out of the 119 farms included in the survey, 57.7 % of them raise dairy cows, whereas 42.3 % primarily have cows for milk production, as detailed in Table 8.

3.6 Breeding area

Based on the information provided by the surveyed individuals, cattle farming appears to be more prevalent in the irrigated zone, comprising 43.7 % of the cases. The Bour zone follows closely with 42 %, as presented in Table 9. For Iglesias et al. (2011), cited by González-Quintero et al. (2020), the diversification of livestock farming, agriculture and forestry on cattle farms could generate productive and environmental benefits.

3.7 Types of breeding on the farms surveyed

According to the responses from the surveyed individuals, the study area exhibits three distinct types of livestock farming, with the most prominent being intensive farming, constituting 68.9 % of the total, as shown in Table 10. However, the breeding method in Algeria was semi-extensive and varied depending on the herds, the means of the breeder and the available area (Haou et al., 2021).

3.8 Production and marketing of milk

Dairy production destinations

As reported by the survey respondents, milk is transported to either collection centers or other locations for various purposes before processing. As illustrated in Table 11, the quantity of milk delivered to alternative destinations is relatively substantial at 9.76 %, with approximately 30.3 % of breeders indicating that they deliver their production to these other locations. Indeed, the results indicate that 87.7 % of the milk is processed while the remaining portion is either self-consumed or delivered to the informal market. The informal market, considered an operation in violation of the law, deals with fresh milk and resells it to the "Mahlabats" processors which serve as the primary transformation sites where milk flows are channeled through hawking. This percentage is lower than the 25 % reported in 2005 by the Tadla Regional Agricultural Development Office (ORMVAT). Indeed, the region has witnessed the establishment of two significant processing units striving to absorb the quantities produced by the CCLs while providing appropriate technical guidance.
Despite the advantages that the hawking system offers in terms of economic security and food security for the population, informal activities have the potential to yield adverse effects on the health of consumers who are vulnerable due to relative undernutrition or malnutrition. Sanitary standards are often not rigorously adhered to in this sector particularly during hawking.

Table 6: Statistical comparison of abortion results depending on individual characteristics of cattle

Characteristic	History of abortion		Total	Chi2	dl	p-value
	Positive	**Negative**				
Breed						
Crossed	45 (13.4%)	290	335			
Imported	9 (5.8%)	146	155	6.2	1	**0.01**
Total	***54 (11.1%)***	***436***	***490***			(**)
Origin						
Imported	8 (7.5%)	99	107			
Native breeding	9 (8.7%)	94	103	3.5	2	**0.17**
Bought from the souk	38 (13.4%)	246	284			(NS)
Total	***55 (11.1%)***	***439***	***494***			

(**) Highly significant statistical difference (NS) Not significant

Table 7: Types of farms surveyed

Farmed species	Number of answers	Percentage %
Cattle operations	43	36.1
Mixed farms (cattle, sheep, goats)	76	63.9
Total	***119***	***100***

Table 8: Categories of cattle on the farms surveyed

Farmed species	Number of farms	Workforce	%	The average
Cows	119	2548	100	21.41
Milk cow	119	1470	57.70	12.35
milking cow	119	1078	42.30	9.06

Table 9: Distribution of cattle farms according to breeding area

Area	Number of cattle farms	%
Irrigated	52	43.7
Favorable Bour	50	42.0
Bour	17	14.3
Total	***119***	***100***

Table 10: Types of livestock farming on the farms surveyed

Breeding type	Number of cattle farms	%
Extensive	32	26.9
Intensive	82	68.9
Mixed	5	4.2
Total	***119***	***100***

Table 11: Destinations of milk production

Milk production (Average quantity in liters per day)	Number of farms	Qty. Average	%	95% CI	Min	Max
Quantity of milk produced	119	153.7	100	79.5-227.8	7	4000
Self-consumed	2	3.9	2.53	2.8-4.9	0	50
Delivered to the collection center	89	134.8	87.70	60.5-209.2	0	4000
Delivered to other destinations (hawkers, dairies, etc.)	36	15	9.76	8.3-21.7	0	246

Table 12: Importance of demand for milk in the month of Ramadan

Specific period	Number of answers	%
Ramadan	44	42.3
Others	60	57.7
Total	***104***	***100***

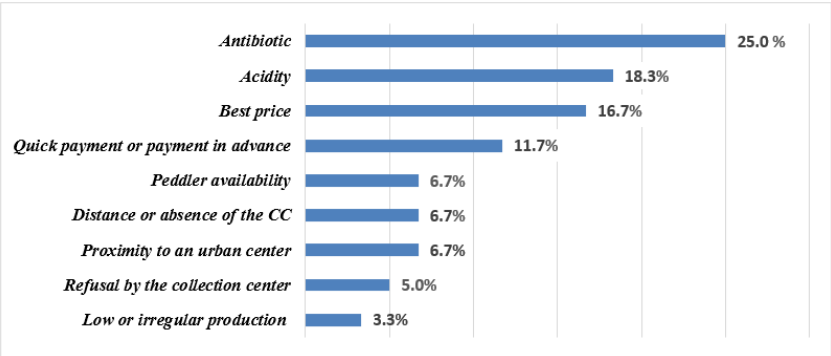

Figure 1: Determination of caffeine in drink sample 'X'

Table 13: Variation in milk price depending on destination and time

Destinations	Sale price (in Dhs)	Number of answers	Average	95% CI	Min-Max
Collection center	*Minimum price of milk delivered during periods of high demand*	93	**3.2**	3.05-3.28	2.5-4.3
	Maximum price of milk delivered during periods of high demand	94	3.4	3.3-3.5	2-4.5
	Minimum price of milk delivered during periods of low demand	91	2.9	2.8-3.08	2-4.3
	Maximum price of milk delivered during periods of low demand	90	3.1	3-3.3	2.3-4.3
Other destinations	*Minimum price of milk delivered during periods of high demand*	37	**2.6**	2.2-2.9	1-4.25
	Maximum price of milk delivered during periods of high demand	38	3	2.7-3.3	1.5-4.5
	Minimum price of milk delivered during periods of low demand	30	2.3	2-2.6	1-4.25
	Maximum price of milk delivered during periods of low demand	30	2.6	2.4-2.9	1.5-4.25

Table 14: Causes of abortions in ruminants

Causes of abortions in ruminants	Number of answers	%
Toxic plants	59	62.8
Pathogens and Toxic Plants	23	24.5
Pathogens	12	12.8
Total	***94***	***100***

Table 15: Other causes of abortions in ruminants

Causes	Number of answers	%
Traumatic	37	45.68
Infectious or parasitic	24	29.63
Infectious or parasitic, Traumatic	18	22.22
Medicinal drugs	1	1.23
Food, Traumatic	1	1.23
Total	***81***	***100***

Factors influencing the delivery of milk to destinations other than collection centers

As depicted in Figure 1, based on responses from the surveyed individuals, the primary reasons for delivering milk to locations other than collection centers include the use of antibiotics (25 %), acidity (18.3 %), and seeking a better price (16.7 %). In fact, the low quality of milk produced, herd health problems, low genetic potential of cows, inadequate and insufficient feed, reduced reproduction rates, all contribute to increasing production costs and imposing barriers to marketing for dairies (Michetti et al., 2020).

Milk price variation factors

The price of milk varies depending on several factors:

- Specific period (Ramadan)
- Period of high or low demand
- Destination of milk

According to Michetti et al. (2020), the price of milk varies according to the season: during the rainy season, pastures are naturally more abundant, enabling higher production volumes. In the dry season, on the other hand, milk volumes fall sharply due to the lack of fodder in the pastures. The range of price variation for milk delivered to the collection center exhibits minimal fluctuations, regardless of whether it's a period of low or high demand. Conversely, the range of price variation for milk delivered to other destinations experiences significant fluctuations in both low and high-demand periods. This disparity arises from the pre-established pricing agreements between the factory and the cooperative which lead to only slight price fluctuations in the former case. In contrast, the price of milk delivered to other destinations varies considerably, as different sellers may offer varying prices, as outlined in Table 13. In Russia, the rise in milk prices is helped by insufficient milk production. On the other hand, the supply of high-quality raw milk poses a serious problem in Russia, given the lack and poor quality of food resources and hygiene (Nosov et al., 2020), and also the contamination of raw milk

with antibiotics (Artyukhova et al., 2020).

3.9 Main diseases transmitted by milk

Diseases can be transmitted to humans through the consumption of food contaminated with pathogenic bacteria, which may potentially be present in raw milk and various other dairy products. Milk is, indeed, a vital source of nutrients crucial for the proper functioning of our bodies. However, at times, it can serve as a carrier for various pathogens responsible for foodborne illnesses (TIA) or severe zoonotic diseases, such as brucellosis.
Using a well-structured questionnaire. Pathogens of interest were *Brucella spp., Escherichia coli, Listeria monocytogenes, Salmonella spp., Staphylococcus aureus*, and *Cryptosporidium*. Only 20.9% of dairy producers reported knowing Brucella spp. As a milk-borne pathogen. The most known pathogen was *E. coli* (54.7%), followed by *Listeria spp.* (41.0%), *Staphylococcus spp.* (38.8%) and *Salmonella spp.* (35.3%). (Diniso & Jaja, 2024).

3.10 State of knowledge of brucellosis within dairy farms

Out of the 119 surveyed farms, only 12.6 % of breeders demonstrated awareness of brucellosis in ruminants while a significant majority, meaning that 87.4 %, were not familiar with this disease. This can be attributed to the fact that the majority of those surveyed have a lower level of education and the emphasis on disease control by the factories is insufficient. According to Lindahl et al. (2015a), farmers with lower levels of education are less likely to possess knowledge about brucellosis compared to those with higher levels of education. Similarly, some other studies have also reported that farmers who consult veterinarians on animal health issues are more knowledgeable about brucellosis (Lindahl et al., 2015a). The principal factor contributing to the persistence of bovine brucellosis is the absence of essential conditions for the strict implementation of health measures (Traore et al., 2020).
Therefore, the lack of knowledge about brucellosis has implications for the physicochemical and microbiological quality of milk and its derivatives at milk collection centers. This could pose a danger to consumer health. Our figure is higher than that found by Rajkumar et al. (2016) in Sri Lanka where only 2.6 % of farmers were aware that brucellosis was a zoonosis and higher than that reported by Kothalawala et al. (2018) in Senegal where no farmers were aware of brucellosis. However, our figure is lower than that mentioned in a study in Ecuador (Pérez Ruano & Aguayo, 2017) where 48.0 % and 30.0 % of farmers, respectively, were aware of brucellosis.

3.11 Causes of abortion and signs of brucellosis in ruminants

The causes of abortion, as reported by the interviewed breeders, are distributed as follows: 62.8 % attribute abortions to the ingestion of toxic plants, 12.8 % confirm that abortion may be due to a pathogen and 24.5 % claim that abortion results from a combination of both a pathogen and toxic plants. This last scenario indicates that a pathogen is a factor, contributing to the lack of knowledge concerning the effects of pathogens, as detailed in Table 14. Some breeders also put forth additional causes for abortions including traumatic factors (45.68 %) and infectious and parasitic causes (29.63 %), as presented in Table 15. The causes of abortion may be infectious or non-infectious. Non-infectious causes include ingestion of toxic plants, mycotoxins, physical, genetic/chromosomal, nutritional (trace element deficiency), chemical, medicinal, hormonal and other agents (Yadav et al., 2021).
Direct contact with infected animals and consumption of food of animal origin are the main routes of transmission of brucellosis (Samadi et al., 2024). Long efforts have been made to control and eliminate brucellosis from animal populations in developing countries, particularly in low- and middle-income countries (LMICs), but the disease is still endemic in these regions (Samadi et al., 2024).
Among the symptoms of brucellosis reported by

Table 16: Signs of brucellosis in ruminants

Signs of Ruminant Brucellosis	Number of answers	%
Abortion	11	73.3%
Abortion, orchitis	3	20
Abortion,decrease in milk production	1	6.7
Total	***15***	***100***

Table 17: Transmission of brucellosis between ruminants

Transmission of Brucellosis between Ruminants	Number of answers	%
No transmission	43	81.1
Transmission	10	18.9
Total	***53***	***100.0***

Table 18: Causes of transmission of brucellosis between ruminants

Causes of transmission of Brucellosis between Ruminants	Number of answers	%
Coupling	5	**50.0**
Mating, Cohabitation	4	**40.0**
Cohabitation	1	**10.0**
Total	*10*	*100*

Table 19: Transmission of brucellosis from ruminants to humans

Designation	Number of answers	%
No transmission	44	88.0
Transmission	6	**12.0**
Total	***50***	***100***

the surveyed individuals are abortion (73.3 %), as well as orchitis and reduced milk production, as outlined in Table 16. Common clinical signs of brucellosis in natural hosts are Loss of reproduction due to abortion, birth of weakened offspring and infertility (Sonawane et al., 2011), cited by Edao et al. (2020).

3.12 Transmission of *Brucellosis*

Within the surveyed farms, a significant percentage of breeders, specifically 81.1 %, hold the belief that there is no transmission of brucellosis among ruminants, as shown in Table 17.
The breeders interviewed presented various understandings regarding the causes of brucellosis transmission. 50 % of respondents mentioned that transmission might occur during mating while 10 % confirmed that cohabitation could be a mode of transmission. A significant proportion, amounting to 40 %, expressed the view that transmission could result from both mating and cohabitation, as depicted in Table 18. However, according to Traore et al. (2020), the primary factor that promotes the persistence of bovine brucellosis is the lack of essential conditions for the strict implementation of health measures. According to Tukana and Gummow (2017) the most important reason for the spread of brucellosis is the fact that healthy animals sharing common water sources with *Brucella*-positive animal. Moreover, according to Hegazy et al. (2015) mobile herds of small ruminants without shelter could favor the spread of B. melitensis, because they pass through several Egyptian governorates in search of pasture and come into contact with other ruminants. Only 12 % of breeders believe that brucellosis can be transmitted from ruminants to humans, as indicated in Table 19. This result is low compared to a study in Pakistan, where 3.0 % of farmers were aware of brucellosis transmission from animals to humans (Arif et al., 2017).
Among the 119 surveyed farms, only six breeders possess knowledge about the causes of brucellosis transmission from animals to humans. Out of these six, five breeders, constituting 83.3 %, attribute transmission to contact with the infected animal, while one breeder, representing 16.7 %, affirms that brucellosis is the result of both contact with the infected animal and contact with the runt, as detailed in Table 20. According to Béjaoui A (2022) *Brucella* can be transmitted from animals to humans via a number of routes: it can be present in unpasteurized milk, dairy products and undercooked meat from infected animals, through direct exposure to sick animals, and researchers working with *Brucella* in the laboratory can become exposed to this bacterium through cuts or other skin wounds. *Brucella* transmission can also occur through direct contact with aborted material, blood transfusion and tissue transplantation. Similarly, Stanly (2013) states that risk factors for human seropositivity to "*Brucella spp.*" may be due to direct contact with animals, abortion or parturition material, and consumption of contaminated milk and milk products from diseased animals. Edao et al. (2020), add that the lack of awareness of zoonoses facilitates its transmission between livestock and humans.

3.13 Serological research for *brucellosis*

We chose the Rose Bengal test as a screening test given its low cost, easy to perform and its high sensitivity, particularly in endemic areas (Muma et al., 2007). During the serological investigation for brucellosis, we identified a low rate of positive samples (0.8 %) among a sample of 363 sera collected from dairy farms, as illustrated in table 21. This low rate of positive cases can be attributed to the implementation of sanitary hygiene measures. According to Tukana and Gummow (2017) the most important reason for the spread of brucellosis is healthy animals sharing common water sources with *Brucella*-positive animal. Whereas, a study by Enström et al. (2017) testing blood samples from 225 cattle in Kenya, reported 12.4 % of animals sampled as seropositive. The seroprevalence was found to be higher in females compared to males (Zeng et al., 2017). Also, Tasiame et al. (2016) found a seroprevalence of 22.9 % in cattle, when analyzing blood samples from 315 cattle for brucellosis in Ghana using the Rose Bengal test. According to Lindahl et al. (2015b) Brucellosis seroprevalence is

Table 20: Circumstances of transmission of Brucellosis between humans and ruminants

Circumstances declared	Number of Answers	%
Contact with the infected animal	5	**83.3**
Contact with the infected animal, Contact with the abortionist	1	16.7
Total	***6***	***100***

Table 21: Result of brucellosis serological test in 119 dairy farms

Rose Bengal	Number of answers	%
FP	3	**0.8**
NOT	360	99.2
Total	363	100

FP: strong presence; NOT: Absent

Table 22: Risk factors linked to brucellosis at the level of dairy farms according to the surveys

Categories	***Dairy farms (%)***
Lben	**100**
Raw milk	**90.7**
Butter	**81.4**
Raib	27.9
Jben	9.3
Cheese	0

highly dependent on the farming system in high-risk areas. Another recent meta-analysis of animal diseases in northeast India showed a 17 % prevalence of bovine brucellosis (Barman et al., 2020). The incidence of brucellosis in a recent report was higher in men who consumed relatively more goat's milk (Holt et al., 2021), cited by Khurana et al. (2021).
It's important to note that these findings provide valuable insights into the awareness, practices and risks associated with brucellosis within the context of dairy farming, highlighting the need for educational and preventive measures within the sector.

3.14 Common risk factors

The products most commonly consumed by breeder families, as shown in Table 21, include Lben (100 %), followed by raw milk (90.7 %) and butter (81.4 %). It's worth noting that the popularity of these products correlates with an increased risk. Consequently, these items pose a potential danger to consumers as they are considered carriers of brucellosis with Lben being of particular concern due to its lack of heat treatment. Nonetheless, Holt et al. (2021) suggest that people's exposure to *Brucella sp.* through milk and dairy products from large ruminants is limited as it is common practice to boil milk before consumption. The World Health Organi-

zation (WHO, 2020) also considers *brucellosis* a professional risk for people working in the livestock sector. Exposure occurs as they come into contact with blood, placentas, fetuses and uterine secretions, thereby facing an increased risk of contracting the disease.

4 Conclusions

The aim of this study was to contribute to the understanding of the zootechnical characteristics of dairy farms, the significance of the informal milk distribution network and the level of awareness about brucellosis among dairy farmers. To achieve this, a comprehensive survey in the Doukkala region and serological blood tests using the Rose Bengal method were completed. The several key findings and conclusions are:

- Lack of Awareness: One noteworthy observation is the pervasive lack of awareness about brucellosis among all the dairy farmers interviewed with regards to both its presence in ruminants and the potential risks it poses to humans.

- Limited Understanding of Transmission: Our study revealed that many breeders are not aware of the possibility of brucellosis transmission from animals to humans. This knowledge gap highlights the need for educational initiatives in the region.

- Identification of Risk Factors: The majority of the surveyed dairy farms exhibited key risk factors that can facilitate the spread of brucella infection among ruminants. This suggests that, even in the absence of evident infection, the study area should be considered a high-risk region for potential brucellosis outbreaks.

- Low Rate of Positive Cases: The serological tests conducted on dairy farms showed a relatively low rate of positive cases. This can be attributed to the effective implementation of health and hygiene measures within the region which have likely contributed to the reduced prevalence of brucellosis.

In conclusion, our study sheds light on the significant knowledge gaps and potential risks associated with brucellosis in the Doukkala region. Efforts are required to increase awareness among dairy farmers, promote disease control measures and continue the implementation of health and hygiene protocols to further reduce the prevalence of brucellosis in the region.

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