2023, Scienceline Publication
World's Veterinary Journal
World Vet J, 13(1): 191-199, March 25, 2023
ISSN 2322-4568
DOI: https://dx.doi.org/10.54203/scil.2023.wvj20

Risk Factors Associated with Brucellosis Seropositivity in Goat Farms of Sing Buri Province, Thailand

Nattanan Thuamsuwan[1,2], Karoon Chanachai[3], Monaya Ekgatat[4], Prakit Srisai[5], Tippawon Prarakamawongsa[3], and Theera Rukkwamsuk[2]

[1]*The Graduate School, Kasetsart University, Pahol Yothin Road, Chatuchak, Bangkok 10900, Thailand*
[2]*Department of Large Animal and Wildlife Clinical Sciences, Faculty of Veterinary Medicine, Kasetsart University, Kamphaeng Saen, Nakhon Pathom 73140, Thailand*
[3]*R-FETPV Coordination Unit, National Institute of Animal Health, Department of Livestock Development, Kasetklang, Ladyao, Chatuchak, Bangkok 10900, Thailand*
[4]*Immunology and Serology Section, National Institute of Animal Health, Department of Livestock Development, Kasetklang, Ladyao, Chatuchak, Bangkok 10900, Thailand*
[5]*Nakhon Phanom Provincial Livestock Office, Department of Livestock Development, Nakhon Phanom 48000, Thailand*

*Corresponding author's Email: theera.r@ku.ac.th

ORIGINAL ARTICLE
pii: S232245682300020-13
Received: 15 December 2022
Accepted: 08 February 2023

ABSTRACT

During 2012 - 2016, goat farms in Sing Buri province were growing rapidly with support from the Thai government. In the following three years (2017-2019), the analysis of brucellosis surveillance data indicated that the seropositivity of brucellosis in goats increased. Therefore, this study attempted to identify possible risk factors associated with brucellosis seropositivity in meat goats raised in Sing Buri province of Thailand. A case-control study was conducted in a random sampling of 72 goat farms in Sing Buri province, Thailand. Questionnaires were used to collect information regarding farm production types, husbandry, goat health management, grazing management, breeding, carcass management, and goat purchasing. Bivariate and logistic regression analyses were used to determine the risk factors of *Brucella* seropositivity. Results revealed that the most frequent health complaint by the farmers was a stillbirth. *Brucella* seropositivity at the farm level was 26.4%. The two most probable risk factors for seropositivity included raising goats in a communal pasture and keeping goats with a history of clinical signs associated with brucellosis. In conclusion, approximately 25% of goat farms in Sing Buri province were infected by the bacteria genus *Brucella*. The farmers were recommended to attentively seek and cull for a brucellosis-suspected goat in their farms using clinical signs or symptoms together with active serosurveillance. Furthermore, communal pasture avoidance would also help prevent the goat from *Brucella* infection.

Keywords: Brucellosis, Meat goat, Risk factor

INTRODUCTION

Brucellosis is a zoonotic infectious disease, known as undulant, Mediterranean, or Malta fever, caused by the bacteria genus *Brucella* (Xavier et al., 2009). The disease in animals is characterized by abortion or reproductive failure (Samadi et al., 2010). The most common *Brucella* species that cause infection in goats is *Brucella melitensis*, which can also infect sheep, cattle, buffalos, swine, dogs, camels, horses, and rodents; or can contaminate their products (Xavier et al., 2009). The economic losses due to brucellosis were 6.8 US$ per cattle, 18.2 US$ per buffalo, 0.7 US$ per sheep, 0.5 US$ per goat, and 0.6 US$ per pig (Singh et al., 2015). Brucellosis in humans most often occurs as a result of drinking raw milk from infected animals (Fuquay, 2011). Humans are accidental hosts, and all age groups can be affected by this disease. Some evidence indicated that brucellosis is an occupational hazard for livestock officers and goat farmers (Te-Chaniyom et al., 2016). Human infections of *Brucella melitensis* were confirmed in Southern Vietnam (Campbell et al., 2017). The disease in humans may persist as relapse, chronic localized infection, or delayed convalescence (Nimri, 2003). Brucellosis continues to be a major public health concern worldwide. The disease is widely distributed throughout the developing world, considered to be a serious public health problem. Livestock prevalence of brucellosis in 2010 was 8.2% in East Africa, 15.5% in West Africa, 14.2% in South Africa, 13.8% in North Africa, 16.0% in South Asia, and 2.9% in South-East Asia (McDermott et al., 2013). From 2000 to 2009, the seroprevalence of brucellosis in Malaysia was 0.91% among goats and 7.09% among goat farms (Bamaiyi et al., 2015).

Seropositivity risk factors have been reported in different studies (Akhter et al., 2014; Tsegay et al., 2015; Rajala et al., 2016). In Northern Thailand, herd size, reproductive problems, brucellosis test program, source of the new goat, and disinfection in the farm played significant roles in *Brucella* seropositivity (Kladkempetch et al., 2017). A study in South China demonstrated that introduction in the past 12 months, improperly disposal of sick or dead goats, and poor hygiene in the lambing pen were the potent risk factors associated with *Brucella* seropositivity on local goat farms (Li et al., 2021).

Sing Buri province is divided into six districts, where all districts raise goats. During 2012-2016, goat farms in Sing Buri province are growing rapidly with support from the Thai government. The Department of Livestock

To cite this paper: Thuamsuwan N, Chanachai K, Ekgatat M, Srisai P, Prarakamawongsa T, and Rukkwamsuk Th (2023). Risk Factors Associated with Brucellosis Seropositivity in Goat Farms of Sing Buri Province, Thailand. *World Vet. J.*, 13 (1): 191-199. DOI: https://dx.doi.org/10.54203/scil.2023.wvj20

Development (DLD) launched a nationwide brucellosis surveillance campaign on goats. This campaign monitored goat health status both at the provincial and national levels. From laboratory surveillance data of small ruminant brucellosis in 2013, seroprevalence was 12.1% among farms, 1.4% at the animal level for goats, and 1.6% for sheep (Sagarasaeranee et al., 2016). The previous results showed that after 2013 the seroprevalence seemed to be increasing year by year, which would increase the risk of poor goat production. *Brucella* could also contaminate the goat products and the environment; therefore, the risk of human infection increase (Te-Chaniyom et al., 2016; Maksimović et al., 2022). However, no previous study on identifying risk factors of seropositivity of brucellosis in goats was performed in Sing Buri province.

Therefore, this study was designed to investigate possible risk factors associated with brucellosis seropositivity in goat farms raised in Sing Buri province. The expected results could be used to recommend prevention and control measures for brucellosis in goat farms.

MATERIALS AND METHODS

Ethical approval

Institutional Animal Care and Use Committee, Kasetsart University (ACKU65-VET-048) approved all procedures in this study. However, the study did not involve animals as an experimental setup. The seropositive (case) and seronegative (control) farms were from the routine measures for the brucellosis surveillance system of the DLD, Thailand. The permission in a verbal form to conduct the study and to use the data was agreed upon by the relevant authorities involved in this study.

Study area

Sing Buri province has six districts (Inburi, Bang Rachan, Mueang, Khai Bang Rachan, Phrom Buri, and Tha Chang). The study area covered six districts of Sing Buri province (Figure 1). The global positioning system (GPS) coordinate of Sing Buri province is 14°53'20.99" N 100°24'25.19" E. The hot season lasts 2 months, from March 6 to May 5, with an average daily high temperature above 36°C. The hottest month of the year in Sing Buri is April, with a temperature range of 27-37°C. The cool season lasts 4.6 months, from August 29 to January 15, with an average daily temperature below 33°C. The coldest month of the year in Sing Buri is December, ranging from 21°C to 32°C. The rainy period of the year lasts for 8.9 months, from March 1 to November 28, with rainfall of at least 13 mm. The month with the most rain in Sing Buri is September, with an average rainfall of 210 mm (Weather Spark, 2022).

Study design

A case-control study between December 2016 and February 2017 was conducted. The case and the control goat farms were from the DLD brucellosis surveillance program. The DLD operated a brucellosis surveillance campaign in meat and dairy goats throughout Thailand. In brief, goats older than 6 months in all farms were tested for *Brucella* infection using a modified Rose Bengal Test (mRBT; Ferreira et al., 2003) at the provincial laboratory. If serum samples were positive, those serum samples would then be sent to the central laboratory at the National Institute for Animal Health of the DLD for further confirmation using the complement fixation test (CF test) and enzyme-linked immunosorbent assay (ELISA). When the confirmatory test results were positive, the goats must be culled. Other goats in the same herd of the positive goat had to be re-tested at least three times for the two-month interval. When the confirmatory tests were negative for three consecutive samplings, the test would be performed again after 6 months. When the last tests were negative, the outbreak was declared over. In Thailand, *Brucella* vaccines were not used to prevent brucellosis in small ruminants.

The laboratory records of brucellosis were critically reviewed for brucellosis testing results in each goat farm. The case was defined as the farm in which at least one goat was diagnosed as positive to the confirmation tests, while the control was defined as the farm without any goats that tested positive to the mRBT three consecutive times for the two-month interval.

Sample size calculation

The study unit was the farm. The sample size was calculated by Stat Calc of Epi Info program (Centers for Disease Control and Prevention, USA). Out of 156 farms under the brucellosis surveillance program, the sample size required for this study was 72 farms (case = 19; control = 53) to achieve 95% confidence level, 80% power, and an odds ratio of 4.8. All goat farms in the province were listed, then each goat farm was selected by simple random sampling.

Data collection

Face-to-face interview with goat farmers using questionnaires was conducted. The questions concerned with herd management, husbandry, and health care were asked, and relevant information was given by the farmers in charge of

To cite this paper: Thuamsuwan N, Chanachai K, Ekgatat M, Srisai P, Prarakamawongsa T, and Rukkwamsuk Th (2023). Risk Factors Associated with Brucellosis Seropositivity in Goat Farms of Sing Buri Province, Thailand. *World Vet. J.*, 13 (1): 191-199. DOI: https://dx.doi.org/10.54203/scil.2023.wvj20

caring for the farm animals. Variables of interest for the herd level were included in the questionnaires. The interview process was performed by a veterinarian.

Data analysis

Descriptive and inferential statistics were applied to identify potential risk factors associated with seropositivity of brucellosis using Stat Calc of Epi Info program (Epi Info™ 7, USA). Bivariate analysis was performed to determine the impact of each variable on seropositivity. If any variables got $p \leq 0.1$ in the bivariate analysis (Chi-square test), those variables were recruited into the multiple logistic regression analysis. The odds ratios were used to interpret the risk factors associated with seropositivity in this study.

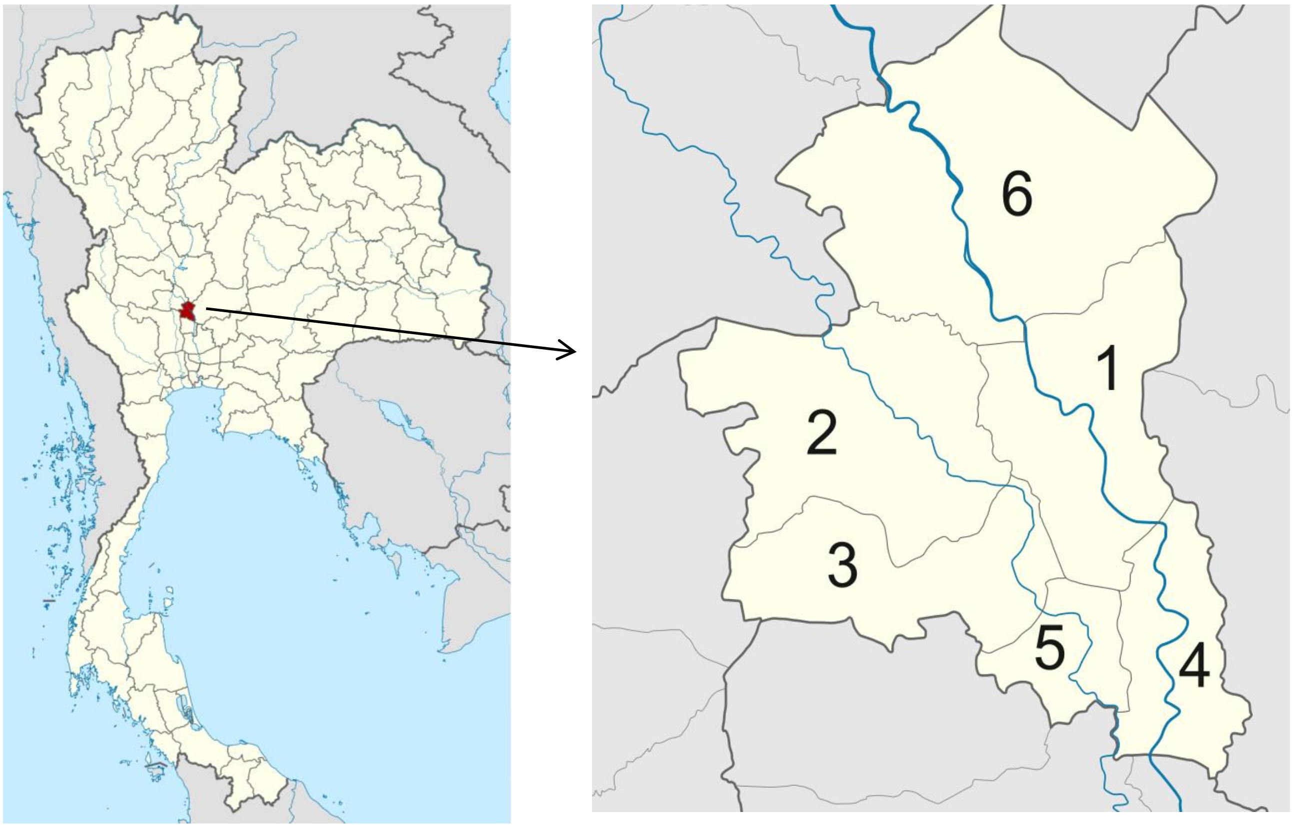

Figure 1. The map of the study area in Sing Buri province (Left), Thailand. The study site for identification of risk factors associated with seropositivity to goat brucellosis in six districts of Sing Buri province (Right); 1: Muang Sing Buri, 2: Bang Rachan, 3: Khai Bang Rachan, 4: Prom Buri, 5: Tha Chang, 6: Inburi. Source: Wikipedia

RESULTS

Table 1 demonstrates the overall brucellosis seropositivity in 72 goat farms according to the brucellosis surveillance program at the beginning of the study (December 2016). Out of 72 goat farms, Bang Ra Chan district had the highest prevalence (29.17%). Only one goat farm in Prom Buri and one in Tha Chang district were active in their business and were recruited into the study. The farm in Prom Buri was positive, and the farm in Tha Chang district was negative for brucellosis.

Table 2 presents the characteristics of goat farms and management in Sing Buri province. In total, 5,221 goats were raised in all 72 studied farms. All farms raised crossbred meat goats. There were two types of goat farms: fattening and breeding. The average herd size in infected farms was 73 goats/farm (range = 12-600), and in non-infected farms was 48 (range = 8-206). The average number of breeder males (buck) was 1.36 (range = 0-10), and the average number of breeder females (doe) was 35.9 (range = 2-300). The average number of goats categorized by age group in all farms was 18.75 goats/herd (range = 0-200), 16.65 goats/herd (range = 0-99), and 36.68 goats/herd (range = 3-302) for less than 6 months old, 6-12 months-old, and greater than 12 months old, respectively. The floor type of the barn was predominantly a combination of the slatted floor where the goats stayed during the night and the ground floor during the day. The main roughages included *leucaena*, straw, and para-grasses (*Brachiaria mutica*, Forsk). Most farms fed their goats with commercially available concentrates and offered the goats some mineral supplements. Most farms used the communal pasture, and only a few farms had their own pastures. Almost all farms consumed the water supply from tap water. For breeding purposes, 20% of the farms shared their bucks with others, while only one farm used artificial insemination.

To cite this paper: Thuamsuwan N, Chanachai K, Ekgatat M, Srisai P, Prarakamawongsa T, and Rukkwamsuk Th (2023). Risk Factors Associated with Brucellosis Seropositivity in Goat Farms of Sing Buri Province, Thailand. *World Vet. J.*, 13 (1): 191-199. DOI: https://dx.doi.org/10.54203/scil.2023.wvj20

When the farmers found their dead goats, 83% of the farmers buried the carcass on their farms. About half of the farmers sold their goats to other farms, and the most frequent selling method was straight to the buyers on the farm site.

Table 1. Distribution of brucellosis seropositivity of goat farms according to the brucellosis surveillance program in Sing Buri province, Thailand, in December 2016

District	Number of farms	Number of seropositive farms	Percentage
Bang Rachan	24	7	29.17
Inburi	29	6	20.69
Khai Bang Rachan	5	2	40.00
Mueang	12	3	25.00
Phrom Buri	1	1	100.00
Tha Chang	1	0	0.00
Total	72	19	26.39

Table 2. Characteristics of goat farms and management in Sing Buri province, Thailand, between December 2016 and February 2017

Farm characteristics	Seropositive farms (n = 19)	Seronegative farms (n = 53)	Total (n = 72)
Farm production			
Fattening	19	46	65
Breeding	13	42	55
Average herd size (goat per farm)	73	48	60
Stall			
Cement floor	1	5	6
Ground floor	13	37	50
Slat floor	17	45	62
Feeding			
Leuceana	14	42	56
Straw	0	3	3
Grass	16	44	60
Concentrates	5	23	28
Mineral supplementation	15	47	62
Own pasture	1	7	8
Sharing pasture with other farms	1	3	4
Communal pasture	18	31	49
Water supply			
Tap water	18	49	67
Underground water	0	5	5
Surface water	2	5	7
River water	0	2	2
Breeding			
Artificial insemination	1	0	1
Sharing buck with other farms	1	14	15
Sharing doe with other farms	0	0	0
Dead goat management			
Bury	18	42	60
Consumed by farmers	0	1	1
Burn	0	1	1
Selling production to			
Local traders	1	2	3
Other farms	11	31	42
Co-operatives	0	0	0
Selling methods			
On-farm site	18	42	60
By mobile phone	0	10	10
At the live market	1	3	4

To cite this paper: Thuamsuwan N, Chanachai K, Ekgatat M, Srisai P, Prarakamawongsa T, and Rukkwamsuk Th (2023). Risk Factors Associated with Brucellosis Seropositivity in Goat Farms of Sing Buri Province, Thailand. *World Vet. J.*, 13 (1): 191-199. DOI: https://dx.doi.org/10.54203/scil.2023.wvj20

The previous health problems concerning brucellosis are reported in Table 3. In this study, the most serious problems among goat farms included stillbirth, weak kids, abortion, mastitis, and lameness. In seropositive farms, the most complaint of health problems was stillbirth and abortion, while mastitis and stillbirth were the most frequent concerns in seronegative farms.

Twenty possible risk factors associated with brucellosis seropositivity were analyzed using bivariate analysis (Table 4). Farms that had flooding during 2012-2016 tended to have 3.1 times at risk of brucellosis seropositivity, compared with farms that did not have flooding. Farms that shared their bucks with others for mating tended to have 0.1 times at risk of seropositivity when compared with farms that did not share. Farms that had raising experience for more or equal to 60 months compared with farms that had less than 60 months tended to have 0.4 times at risk of seropositivity. Farms with previous health problems related to brucellosis were 5.1 times at risk of seropositivity, compared with farms without previous health problems. In addition, farms that used communal pasture were 12.8 times at risk of seropositivity when compared with farms that did not use it. Two factors were significant risk factors for brucellosis, were raising goats in communal pastures and goats with clinical signs of suspected brucellosis. In addition, goats that were not confined only in the barn tended to be 6.5 times at risk of seropositivity compared to goats confined in the barn.

For logistic regression analysis, the six important risk factors were recruited in the analysis, which was raising goat in the communal pasture, sharing bucks with other farms, quarantining newly introduced goats before entering the herd, receiving goats with previous health problems related to brucellosis, raising experience; and flooding occurrence. The results indicated that raising goats in communal pastures and the farm receiving goats with previous health problems related to brucellosis were most likely to be the significant risk factors for brucellosis seropositivity (Table 5).

Table 3. Previous health problem (clinical signs/symptoms) in relation to brucellosis among goat farms in Sing Buri province**,** Thailand between December 2016 and February 2017

Signs/symptoms	Seropositive (n = 19)		Seronegative (n = 53)		Total (n = 72)	
	No.	(%)	No.	(%)	No.	(%)
Stillbirth	6	31.6	6	11.3	12	16.7
Weak kid	2	10.5	9	17	11	15.3
Abortion	5	26.3	5	9.4	10	13.9
Mastitis	3	15.8	7	13.2	10	13.9
Lameness	2	10.5	4	7.6	6	8.3
Infertility	2	10.5	3	5.7	5	6.9
Arthritis	1	5.3	2	3.8	3	4.2
Metritis	1	5.3	2	3.8	3	4.2
Retained placenta	1	5.3	1	1.9	2	2.8
Orchitis	0	0	1	1.9	1	1.4

No: Number

Table 4. Bivariate analysis on possible risk factors for brucellosis seropositivity in goat farms, Sing Buri province, Thailand, between December 2016 and February 2017

Factors		Brucellosis test		Crude OR	95 %CI		p-value
		Seropositive	Seronegative		Lower	Upper	
Flooding occurrence	Yes	8	10	3.1	1.0	9.8	0.06
	No	11	43				
Raising experience	Low, <60 months	7	33	0.4	0.1	1.0	0.06
	High, ≥ 60	12	20				
Previous case of brucellosis on a farm during 2012-2015	Yes	4	0	NA*	2.0	NA	0.003
	No	15	53				
Raising goats and sheep on a farm	Yes	1	1	2 .9	0.2	48.6	0.46
	No	18	52				
Previous health problems related to brucellosis	Yes	9	8	5.1	1.6	16.4	0.009
	No	10	45				
Herd size	High, ≥ 73 goat	10	18	2.2	0.7	6.3	0.15
	Low, < 73 goat	9	35				
Purchase into the farm	Yes	11	38	0.5	0.2	1.6	0.27
	No	8	15				
Purchase out of the farm	Yes	19	41	NA	1.1	NA	0.02
	No	0	12				
Quarantine new goats before introducing	Yes	0	7	0	0	1.9	0.10
	No	19	46				
Testing brucellosis before introducing	Yes	9	20	1.5	0.5	4.3	0.46
	No	10	33				
Sharing bucks with other	Yes	1	15	0.1	0.02	1.1	0.05

To cite this paper: Thuamsuwan N, Chanachai K, Ekgatat M, Srisai P, Prarakamawongsa T, and Rukkwamsuk Th (2023). Risk Factors Associated with Brucellosis Seropositivity in Goat Farms of Sing Buri Province, Thailand. *World Vet. J.*, 13 (1): 191-199. DOI: https://dx.doi.org/10.54203/scil.2023.wvj20

farms	No	18	38				
Using communal pasture	Yes	18	31	12.8	1.6	102.9	0.004
	No	1	22				
Confine only in the barn	No	18	39	6.5	0.8	53.0	0.10
	Yes	1	14				
Water canal	Yes	2	5	1.1	0.2	6.4	0.89
	No	17	48				
Contact with other goats outside the farm	Yes	4	8	1.5	0.3	6.6	0.55
	No	15	45				
Contact with other animals outside the farm	Yes	12	41	0.5	0.2	1.6	0.24
	No	7	12				
Cement floor	Yes	1	5	0.5	0.1	4.9	1.00
	No	18	48				
Ground floor	Yes	13	37	0.9	0.3	2.9	0.91
	No	6	16				
Disinfectant	Yes	15	39	1.3	0.4	4.7	0.76
	No	4	14				
Vehicle control	Yes	17	38	3.4	0.7	16.3	0.21
	No	2	15				

*NA: Not available for calculation; OR: Odds ratio

Table 5. Multiple logistic regression analysis on possible risk factors for brucellosis seropositivity in goat farms, Sing Buri province, Thailand, between December 2016 and February 2017

Factors	Crude OR	Adjusted OR	95%CI	
			Lower	Upper
Using communal pasture	12.8	14.8	1.5	140.6
Sharing bucks with other farms	0.1	0.1	0	1
Quarantine new goats before introducing them to the farm	0	0	0	$>1x10^{12}$
Previous health problems in relation to brucellosis	5.1	6.3	1 .3	30.6
Raising experience	0.4	2.9	0.7	12.2
Flooding occurrence	3.1	3	0.6	14.6

OR: Odds ratio, CI: Confidence interval

DISCUSSION

Sing Buri Province is located in the central part of Thailand, which is one of the most populated areas for goat farming. The farms are predominantly small-holder farms, where their raising practices might not be appropriate. However, the Provincial Livestock Office of the DLD assisted these farmers in disease treatment, prevention, and control. For brucellosis, the primary goal of the DLD was to eradicate this disease from goat farms. Therefore, a test-and-slaughter policy was implemented (Sagarasaeranee et al., 2016). The study was not designed to determine the seroprevalence; however, 26.39% of the studied farms were seropositive to *Brucella* infection. This seropositivity rate was higher than the seroprevalence of 16.67% reported by Kladkempetch et al. (2017) in Chiang Mai, the northern province of Thailand, and even higher than in Nakhon Si Thammarat, the southern province of Thailand (Te-Chaniyom et al., 2016). In a recent study in Ethiopia, the herd level seroprevalence of goat brucellosis was 46.61% (Teshome et al., 2022), which was rather high, compared to the present study. The underlying reason for the high prevalence was that no actual control plans for brucellosis were strictly implemented in some study areas. The *Brucella* infection could be expected to be relatively high if the farm had no effective control measures.

In this study stillbirth, weak kids, abortion, mastitis, and lameness were the most noticeable signs or symptoms associated with *Brucella* infection. Rerkyusuke et al. (2022) studied the clinical evidence and risk factors for reproductive disorders in meat goats in Northeastern Thailand and indicated that abortion with arthritis, orchitis, repeat breeder, sterile, and week kids have occurred in goat herds seropositive to either Q fever or chlamydiosis, or brucellosis. *Brucella* infection in goats is important in female reproductive disorders, especially abortion. In the study of Samadi et al. (2010) in Jordan, the prevalence rate of *Brucella* infection among aborted sheep and goats was 27.1%. It is also evident that *Brucella* was detected in a higher frequency in the samples such as blood, milk, supra mammary lymph nodes, udder tissue, aborted fetal organ, and placenta collected from the aborted animals than those samples collected from asymptomatic animals (Maksimović et al., 2022).

Sing Buri Province is one of the central-plains provinces in Thailand that has been affected by flooding during the monsoon season from July to October every year. During the flooding period, goat farmers had to rescue their goats to communal places where goats from several farms could most likely be contacted with each other. The flood situation might lead to the situation of poor management and overcrowding. It has been reported that a lack of separation of young, pregnant, or sick animals could increase the likelihood of *Brucella* seropositivity (Natesan et al., 2021). This might be one of the possible reasons why raising goats in a flooding area tended to increase the risk of *Brucella*

To cite this paper: Thuamsuwan N, Chanachai K, Ekgatat M, Srisai P, Prarakamawongsa T, and Rukkwamsuk Th (2023). Risk Factors Associated with Brucellosis Seropositivity in Goat Farms of Sing Buri Province, Thailand. *World Vet. J.*, 13 (1): 191-199. DOI: https://dx.doi.org/10.54203/scil.2023.wvj20

seropositivity in this study. When a buck was used in an infected farm, it could transmit the infection to other farms. In this study, sharing bucks with other farms for mating showed an increased risk of seropositivity. In Thailand, it has been common for goat farmers to share their bucks for breeding purposes. The infected bucks could potentially be a source of disease transmission among goat farms (Te-Chaniyom et al., 2016; Rerkyusuke et al., 2022). This study demonstrated that farms with a longer period of goat farming, more than 5 years, were less likely to be seropositive to brucellosis. Farmers who have owned their farms for a longer time might have more concerns about brucellosis and might take action on prevention and control according to the guidance of the DLD officers. While relatively new farmers might have fewer concerns and might pay less attention to the brucellosis surveillance provided by the DLD. It could be noted that education and awareness of goat farmers play a key role in the effectiveness of brucellosis prevention and control (Natesan et al., 2021). Since the DLD has implemented the test and culling policy for goat brucellosis for several years, the seropositive farms were expectedly to decline yearly. The decline of *Brucella* infection depending largely on the testing and culling measures has been reported by Rerkyusuke et al. (2022). It could also be implied that farms that did not participate in the annual brucellosis testing and culling would most likely be seropositive (Rerkyusuke et al., 2022).

In this study, goat farms with previous health problems related to brucellosis, particularly reproductive problems, had more likely to be *Brucella* seropositive. This finding agreed with other studies (Samadi et al., 2010; Boukary et al., 2013; Kladkempetch et al., 2017). Boukary et el. (2013) found that the prevalence rate of *Brucella* seropositivity increased with the occurrence of abortion on the farm. In their study, farms with females that aborted among the animals had 4.2 times at risk for *Brucella* seropositive compared with the farms that did not have an abortion. Samadi et al. (2010) indicated that the number of *Brucella melitensis* cases is rather high among aborted animals. Likewise, Kladkempetch et al. (2017) found that reproductive problems significantly depended on *Brucella* seropositivity in goat farms. Teshome et al. (2022) also reported that a history of reproductive problems was a potential risk factor for the prevalence of brucellosis in goats in the Borana zone of Ethiopia. Farms with a previous history of reproductive problems closely related to brucellosis should be seriously monitored for the reservoir animals within the farm. Regular testing and culling measures could be helpful to completely eradicate the disease from the farm.

In addition, the present finding showed that farms that used communal pasture had an increased risk of seropositivity. The pasture-sharing practice could increase the potential for exposure to *Brucella* spp. in a contaminated environment or to the secretion of infected goats that share the same pasture (Reviriego et al., 2000). Samadi et al. (2010) provided evidence that grazing at a common pasture was a significant risk factor positively associated with brucellosis seropositivity. In Thailand, most goat farmers were small-scale holders. To reduce the feed costs, it was common for the farmers to share the communal pastures with others, for both small and large ruminants. Without any precautions, the pasture could be contaminated with *Brucella* spp., which could then be transmitted to other animals during grazing. In addition, the goats from different farms could have direct contact with each other, which was prone to receive the bacteria from the infected ones. From the logistic regression analysis results in this study, raising goats in communal pastures and the farm receiving goats with previous health problems related to brucellosis were most likely to be the significant risk factors for brucellosis seropositivity. Some other interesting risk factors for *Brucella* seropositivity were identified at the herd level. In India, brucellosis prevalence increased due to the frequent purchase of goats with an unknown background of brucellosis on the farm (Natesan et al., 2021). In Thailand, Te-chaniyom et al. (2016) found that goat farms that have dogs and/or rats on the farm were 5.12 times at risk of *Brucella* seropositive. Dogs and cats might spread the bacteria within the farm, and probably between farms if the dogs and cats were roaming freely.

CONCLUSION

Brucella spp. infected about 25% of goat farms in Sing Buri province; hence brucellosis was still a problem in goat production in Sing Buri province. The transmission of the disease could be reduced when the farmers carefully seek a suspected brucellosis goat using clinical signs/symptoms together with active serosurveillance. If any goats developed signs/symptoms of a case definition, most likely related to reproductive problems, or got seropositive by the test, they should be immediately culled by proper methods. Avoiding communal pastures or, if not possible, carefully managing the pasture with others should be considered to alleviate the risk of exposure to *Brucella* reservoir goats or contaminated pastures. Further studies on goat farmers' knowledge, attitude, and practice on communal pasture-sharing practices are also necessary to reduce goat brucellosis transmission in risky locations.

DECLARATIONS

Authors' contributions

Karoon Chanachai, Monaya Ekgatat, Tippawon Prarakamawonga, and Theera Rukkwamsuk conceived, designed, and supervised the project. Nattanan Thaumsuwan executed the experiment and analyze the data. Nattanan

To cite this paper: Thuamsuwan N, Chanachai K, Ekgatat M, Srisai P, Prarakamawongsa T, and Rukkwamsuk Th (2023). Risk Factors Associated with Brucellosis Seropositivity in Goat Farms of Sing Buri Province, Thailand. *World Vet. J.*, 13 (1): 191-199. DOI: https://dx.doi.org/10.54203/scil.2023.wvj20

Thuamsuwan, Prakit Srisai, and Theera Rukkwamsuk interpreted the data and drafted the manuscript for intellectual content. Theera Rukkwamsuk and Nattanan Thuamsuwan critically revised the manuscript and all authors approved the final version. In addition, all authors had full access to all data in the study and took responsibility for the integrity of the data and accuracy of the data analysis. All authors checked and approved the results and the final version of the manuscript before publication.

Competing interests

The authors certified that there is no conflict of interest.

Acknowledgments

The authors wish to acknowledge the Field Epidemiology Training Program for Veterinarians (FETPV), Bureau of Disease Control and Veterinary Services, Department of Livestock Development, Thailand, for financial support of this study. This research is also supported in part by the Graduate Program Scholarship from the Graduate School, Kasetsart University. The staff of the Sing Buri Provincial Livestock Office and District Livestock Office in Sing Buri Province for their technical help during a farm visit and data collection. The National Institute of Animal Health (NIAH) is acknowledged for the laboratory test. The goat farmers are also thanked for their cooperation.

Ethical consideration

The authors declared that this studied data had not been submitted previously for publication. The manuscript was original without plagiarism. The authors had scientifically conducted the research. Data were analyzed and taken care of for their fabrication and/or falsification. All authors agreed to publish the results.

Funding

The study was funded by the Graduate Program Scholarship, Graduate School of Kasetsart University, Thailand.

Availability of data and materials

The authors declare that they will prepare all the necessary data for the study upon reasonable request.

REFERENCES

Akhter L, Islam MA, Das S, Khatun MM, and Islam MA (2014). Seroprevalence of brucellosis and its associated risk factors in sheep and goat in the farms and slaughterhouses in Mymensingh, Bangladesh. Microbes and Health, 3: 25-28. DOI: https://www.doi.org/10.3329/mh.v3i1.19778

Bamaiyi PH, Hassan L, Khairani-Bejo S, Zainal Abidin M, Ramlan M, Adzhar A, Abdullah N, Hamidah NHM, Norsuhanna MM, and Hashim SN (2015). The prevalence and distribution of *Brucella melitensis* in goats in Malaysia from 2000 to 2009. Preventive Veterinary Medicine, 119(3-4): 232-236. DOI: https://www.doi.org/10.1016/j.prevetmed.2015.02.001

Boukary AR, Saegerman C, Abatih E, Fretin D, Alambédji-Bada R, De Deken R, Harouna HA, Yenikoye A, and Thys E (2013). Seroprevalence and potential risk factors for *Brucella* spp. infection in traditional cattle, sheep, and goats reared in urban, periurban, and rural areas of Niger. PLOS One, 8(12): e83175. DOI: https://www.doi.org/10.1371/journal.pone.0083175

Campbell JI, Lan NPH, Phuong PM, Chau LB, Trung Pham Duc, Guzmán-Verri C, Ruiz-Villalobos N, Minh TPT, Muñoz Álvaro PM, Moreno E et al. (2017). Human *Brucella melitensis* infections in southern Vietnam. Clinical Microbiology and Infection, 23: 788-790. DOI: https://www.doi.org/10.1016/j.cmi.2017.06.028

Ferreira AC, Cardoso R, Travassos Dias I, Mariano I, Belo A, Rolão Preto I, Manteigas A, Pina Fonseca A, and Corrêa De Sá MI (2003). Evaluation of a modified Rose Bengal test and an indirect enzyme-linked immunosorbent assay for the diagnosis of *Brucella melitensis* infection in sheep. Veterinary Research, 34(3): 297-305. DOI: https://www.doi.org/10.1051/vetres:2003005

Fuquay JW (2011). Pathogen in milk / *Brucella* spp. Encyclopedia of dairy sciences, 2nd Edition. pp. 31-39. DOI: https://www.doi.org/10.1016/B978-0-12-374407-4.00389-7

Kladkempetch D, Somtua N, Maktrirat R, Punyapornwithaya V, and Sathanawongs A (2017). Seroprevalence and factors affecting brucellosis in goats in Chiang Mai Province. Veterinary Integrative Sciences, 15(2): 99-107. Available at: https://he02.tci-thaijo.org/index.php/vis/article/view/145932

Li Y, Tan D, Xue S, Shen C, Ning H, Cai C, and Liu Z (2021). Prevalence, distribution and risk factors for brucellosis infection in goat farms in Ningxiang, China. BMC Veterinary Research, 17: 39. DOI: https://www.doi.org/10.1186/s12917-021-02743-x

Maksimović Z, Jamaković A, Semren O, and Rifatbegović M (2022). Molecular detection of *Brucella* spp. in clinical samples of seropositive ruminants in Bosnia and Herzegovina. Comparative Immunology, Microbiology, and Infectious Diseases, 86: 101821. DOI: https://www.doi.org/10.1016/j.cimid.2022.101821

Map of Sign Buri Provine. Available at: https://en.wikipedia.org/wiki/Sing_Buri_province

McDermott J, Grace D, and Zinsstag J (2013). Economics of brucellosis impact and control in low-income countries. Revue Scientifique et Technique, 32: 249-261. DOI: https://www.doi.org/10.20506/rst.32.1.2197

Natesan K, Kalleshamurthy T, Nookala M, Yadav C, Mohandoss N, Skariah S, Sahay S, Shome BR, Kumar ORV, Rahman H et al. (2021). Seroprevalence and risk factors for brucellosis in small ruminant flocks in Karnataka in the Southern Province of India. Veterinary World, 14: 2855-2862. DOI: https://www.doi.org/10.14202/vetworld.2021.2855-2862

Nimri LF (2003). Diagnosis of recent and relapsed cases of human brucellosis by PCR assay. BMC Infectious Diseases, 3: 5. DOI: https://www.doi.org/10.1186/1471-2334-3-5

Rajala EL, Grahn C, Ljung I, Sattorov N, Boqvist S, and Magnusson U (2016). Prevalence and risk factors for *Brucella* seropositivity among sheep and goats in a peri-urban region of Tajikistan. Tropical Animal Health and Production, 48: 553-558. DOI: https://www.doi.org/10.1007/s11250-015-0992-3

Rerkyusuke S, Lerk-u-suke S, and Sirimalaisuwan A (2022). Clinical evidence and risk factors for reproductive disorders caused by bacterial infections in meat goats in Northern Thailand. Veterinary Medicine International, 2022: 1877317. DOI: https://www.doi.org/10.1155/2022/1877317

Reviriego FJ, Moreno MA, and Domínguez L (2000). Risk factors for brucellosis seroprevalence of sheep and goat flocks in Spain. Preventive Veterinary Medicine, 44(3-4): 167-173. DOI: https://www.doi.org/10.1016/s0167-5877(00)00108-2

Sagarasaeranee O, Kaewkalong S, Sujit K, and Chanachai K (2016). Seroprevalence of brucellosis in small ruminants in Thailand, 2013. Outbreak, Surveillance and Investigation Reports, 9(4): 7-10. Available at: http://www.osirjournal.net/index.php/osir/article/view/88

Samadi A, Ababneh MMK, Giadinis ND, and Lafi SQ (2010). Ovine and caprine brucellosis (*Brucella melitensis*) in aborted animals in Jordanian sheep and goat flocks. Veterinary Medicine International, 2010: 458695. DOI: https://www.doi.org/10.4061/2010/458695

Singh BB, NK Dhand, and JPS Gill (2015). Economic losses occurring due to brucellosis in Indian livestock populations. Preventive Veterinary Medicine, 119(3-4): 211-215. DOI: https://www.doi.org/10.1016/j.prevetmed.2015.03.013

Te-Chaniyom T, Geater AF, Kongkaew W, Chethanond U, and Chongsuvivatwong V (2016). Goat farm management and *Brucella* serological test among goat keepers and livestock officers, 2011-2012, Nakhon Si Thammarat Province, southern Thailand. One Health, 2: 126-136. DOI: https://www.doi.org/10.1016/j.onehlt.2016.08.001

Teshome D, Sori T, Banti T, Kinfe G, Wireland B, and Alemayehu G (2022). Prevalence and risk factors of *Brucella* spp. in goats in Borana pastoral area, Southern Oromia, Ethiopia. Small Ruminant Research, 206: 106594. DOI: https://www.doi.org/10.1016/j.smallrumres.2021.106594

Tsegay A, Tuli G, Kassa T, and Kebede N (2015). Seroprevalence and risk factors of brucellosis in small ruminants slaughtered at Debre Ziet and Modjo export abattoirs, Ethiopia. The Journal of Infection in Developing Countries, 9: 373-380. DOI: https://www.doi.org/10.3855/jidc.4993

Weather spark (2022). Climate and average weather year round in Sing Buri, Thailand. Available at: https://weatherspark.com/y/113477/Average-Weather-in-Sing-Buri-Thailand-Year-Round

Xavier MN, Costa ÉA, Paixão TA, and Santos RL (2009). The genus *Brucella* and clinical manifestations of brucellosis. Ciência Rural, 39(7): 2252-2260. DOI: https://www.doi.org/10.1590/S0103-84782009005000167

To cite this paper: Thuamsuwan N, Chanachai K, Ekgatat M, Srisai P, Prarakamawongsa T, and Rukkwamsuk Th (2023). Risk Factors Associated with Brucellosis Seropositivity in Goat Farms of Sing Buri Province, Thailand. *World Vet. J.*, 13 (1): 191-199. DOI: https://dx.doi.org/10.54203/scil.2023.wvj20