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Seroprevalence of Brucellosis in Goats and Sheep in Thailand: Results from the Thai National Brucellosis Surveillance System from 2013 – 2015

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Summary

In Thailand, brucellosis re-emerged in humans in 2003 and is considered a public health risk to goat farmers as the disease is endemic in small ruminants. The Thai Department of Livestock Development (DLD) established a nationwide surveillance system for brucellosis in goats and sheep in 1997. Using data from this surveillance system we describe the seroprevalence of brucellosis from 2013 – 2015 in small ruminants and the spatial distribution of the disease throughout Thailand. Surveillance data collected included the number of animals and herds tested, the province of the animal and herd, and the laboratory results. Seroprevalence was estimated at both the animal and herd level. During the three-year period, 443,561 goats and sheep were tested for brucellosis by the DLD throughout Thailand using the Rose Bengal Plate Test (RBPT) and the enzyme-linked immunosorbent assay (ELISA) test for *Brucella*. Among the three years, 2013 had the highest proportion of herds that tested positive for brucellosis at 13.80% (95% CI, 12.52, 15.16). Overall this study found that brucellosis seroprevalence in small ruminants is decreasing throughout Thailand. However, there is variability in the spread of the disease with provinces in the eastern and western regions of Thailand having higher proportions of animals and herds testing positive. Overall provinces in the south had the lowest proportion of animals and herds testing positive for brucellosis. Periodic review of surveillance data documents the impact of the current brucellosis control program and supports a targeted response in higher prevalence regions when there are limited financial resources for control measures.

Keywords

Brucellosis; Ruminants; Surveillance; Thailand; Goat Farming

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Introduction

Brucellosis, one of the most common zoonotic diseases, poses an occupational risk to livestock farmers in many parts of the world (Dean et al., 2012; Perry et al., 2009; Godfroid et al., 2011). This bacterial disease, also commonly referred to as undulant fever, Malta fever, Crimean fever, and Mediterranean fever, is caused by bacteria of the genus *Brucella* (Corbel, 2006). The most severe and common *Brucella* species in humans is *Brucella melitensis* (*B. melitensis*) whose primary animal hosts are sheep and goats (Godfroid et al., 2011). Brucellosis is considered an occupational risk for those who work with animals (Corbel, 2006). The disease most commonly spreads between animals and to humans through direct contact with fluids from infected animals in birthing products and other bodily fluids such as urine (Corbel, 2006). Symptoms of *B. melitensis* in animals include abortions, stillbirths, infertility and decreased production (Corbel, 2006). Infection in humans can cause a range of symptoms common to febrile illness including joint and muscle pain, sweating, headache, fatigue and weight loss (Spink, 1956). The disease poses a significant risk to pregnant women as it can cause abortion or be transmitted to the infant in utero (Spink, 1956). Additionally, the disease can contribute to chronic illness and disability and is ranked as one of the top ten animal diseases of concern to impoverished rural communities (Addis, 2015; Perry et al., 2009).

There is increasing concern for the risk of brucellosis globally as the disease is re-emerging in certain countries where livestock production is intensifying (Perry et al., 2009). In Thailand two cases of *B. melitensis* in goat farmers were reported in 2003 for the first time since the early 1970s (Laosiritaworn, et al, 2007; Chiewchanyont, et al., 2011). Brucellosis is considered endemic to Thailand and human and animal brucellosis are notifiable diseases (Chiewchanyont, et al., 2011). Understanding seroprevalence in small ruminants is important as goats play a significant role in transmission of the disease to humans. Paitoonpong et al. presented a case analysis of seven laboratory confirmed human cases of brucellosis in Thailand between 1970 and 2005 and determined that the majority of infections were a result of direct contact with goats (Paitoonpong et al. 2006). In 2003, the Thai Bureau of Epidemiology (BOE) with the Thai Department of Livestock and Development (DLD) investigated human brucellosis cases and categorized exposure to brucellosis as an occupational risk for goat farmers (Paitoonpong et al. 2006). In 2009, Thai researchers reviewed 38 human cases of brucellosis reported throughout Thailand from 2003 to 2008 and found that all but two of the cases were associated with goats and one case associated with contact with sheep (Chiewchanyont et al., 2011).

As a result of the re-emergence, the Thai DLD initiated several programs to control and prevent brucellosis in small ruminants (Ninprom et al., 2016). Activities include farm certification programs, free brucellosis testing, education and awareness campaigns, regulations to strictly control animal movement, policies for testing and slaughtering, and compensation schemes (Sagarasaeranee et al., 2016; Nakavisut et al., 2014). The DLD policy for positive brucellosis tests includes culling the animal and testing the remaining animals in the herd every two months until three consecutive negative test results (Sagarasaeranee et al., 2016). Six months following the last negative test, the farm can be

declared brucellosis free (Sagarasaeranee et al., 2016). In 1997, the DLD established a surveillance system for brucellosis for goats and sheep in Thailand. This system uses serological samples collected during annual brucellosis testing by the DLD at registered farms.

Knowledge of *Brucella* seroprevalence in small ruminants is limited in Thailand with most research concentrated to specific regions of the country. For instance, Ninprom et al., estimated seroprevalence of goats in the five most southern provinces of Thailand using data collected in 2014 from 15,281 goats from 845 herds (Ninprom et al., 2014). Ninprom et al. estimated herd level prevalence at 1.78% and animal level prevalence 0.44% (Ninprom et al., 2014). In 2008, Kaewket estimated seroprevalence of brucellosis at 11.5% in goats in the western region of Thailand (Kaewket, 2008). One study examined seroprevalence throughout Thailand and estimated prevalence at 12.1% (438/3,626) at the herd level and 1.4% (1,297/94,722) at the animal level (Sagarasaeranee et al., 2013). Using data from the national brucellosis surveillance system, this study reviews seroprevalence at both the animal and herd level among small ruminants and describes the spatial distribution of brucellosis throughout Thailand during a three-year period.

Materials and Methods

This study used sample results collected for the Thai National Surveillance System. The surveillance system includes test results from annual DLD brucellosis testing among sheep and goats at all registered farms for small ruminants older than six months. Farms voluntarily register for brucellosis testing with the DLD, a department under the Thai Ministry of Agriculture. All samples included in the surveillance system were analyzed at a DLD regional laboratory. An animal was considered *Brucella* positive if either the Rose Bengal Plate Test (RBPT) or the enzyme-linked immunosorbent assay (ELISA) test was positive. Testing methods for laboratory serodiagnosis of brucellosis used by the DLD include the RBPT and the ELISA test for *Brucella*. A herd was defined as infected if it had at least one positive animal sample. The term ‘herd’ is categorized by the DLD as a group of animals owned by the same farmer(s). To characterize prevalence across the country provinces were divided into six livestock administration regions established by the DLD including; south, central, western, eastern, northern and northeastern regions.

Brucellosis prevalence at the herd and animal level was characterized by province and region. Regions were categorized following the DLD livestock administrative regions. The precision of the prevalence estimates are described with 95% confidence intervals. The spatial distribution of brucellosis seroprevalence was further described at the provincial level for all three years using ArcMap 10.5 and is based on digital national maps of Thailand (ESRI, Redlands, CA, 2011). In these presentations, the prevalence is presented as quartiles based on the prevalence distribution for all three years across the country. A multivariable Poisson model was used to model the count of *Brucella* positive animals and herds, with the number of herds and animals tested as an exposure variable adjusted for year. All analyses were completed using the statistical package Stata 14 (Stata Corporation, College Station TX, 2015). Approval to carry out the analysis was obtained from the Thai DLD.

Results

The DLD tested a total of 443,561 serum samples collected from sheep and goats between 2013 and 2015. Among the farms tested all were registered with the DLD. Three thousand one hundred and seventeen (3,117) animals and 1,010 herds were identified as seropositive during the three year period. Samples were collected from 76 provinces of 77 provinces in Thailand. The number of samples collected accounts for 27.3% of the total small ruminant population and 7.79% of the total small ruminant herd population. In 2013, the proportion of all goat and sheep that tested positive at the individual animal level was 1.39% (95% CI, 1.32, 1.46), 0.20% (95% CI, 0.05, .0.23) in 2014, and 0.82% (95% CI, 0.77, 0.86) in 2015. Nationwide, the proportion of positive herds in 2013 was 1.39% (95% CI, .51, 2.33), 8.29% (95% CI, 7.41, 9.23) in 2014 and 7.47% (95% CI, 6.72, 8.27) in 2015.

The seroprevalence for the entire country and all three years at the animal level was 0.72% (95% CI, 0.68, 0.73) and 9.31% (95% CI, 8.77, 9.88) at the herd level. Provinces in the southern region of the country had the lowest proportion of animals testing positive for brucellosis compared to other parts of Thailand with an overall herd level seroprevalence of 2.93% (95% CI 2.4, 3.5) and .31% (95% CI .27, .34) animal level seroprevalence. Our estimates indicate that overall seroprevalence among provinces ranged from 0.31% (95% CI, .27%, .34%) to 1.12 (95% CI, 0.89%, 1.39%) at the animal level and 2.92% (95% CI, 2.44%, 3.5%) to 18.42% (95% CI, 1.32%, 2.47%) at the herd level. The seroprevalence of brucellosis at the animal and herd level is summarized by year and by region in Tables 1 and 2.

Regional differences in brucellosis prevalence were investigated while controlling for year. Both model's pseudo r^2 suggests the fit was appropriate with values between 0.2 – 0.4 (McFadden, 1974). The year 2013 was used as the reference year and the southern region was chosen as the referent region. For the animal level seroprevalence, the eastern, central and northeastern regions were higher compared to the southern region (Table 3). Compared to the south, the seroprevalence at the herd level was higher in all regions except for the northern region (Table 4). The eastern region had the largest prevalence ratios for both animal, PR=1.87 (95% CI=1.23, 2.82) and herds, PR = 2.34 (95% CI=1.59, 3.44).

The spatial distributions of brucellosis by province is shown in Figure 1 for animal level and Figure 2 for herd level. Provinces in the eastern region of Thailand had on average the highest proportion of herds testing positive during the three year period. The second highest animal and herd level seroprevalence were detected in the western region. The western region had a herd level seroprevalence of 17.81% and an overall herd level seroprevalence of 13.80% in 2013 (see Table 2). Among provinces that had greater than ten herds, Kanchanaburi Province, in the central region of Thailand, had the highest proportion of herds that tested positive for brucellosis at 59.78% (95% CI, 49.04, 69.87) in 2013. The province with the highest proportion of animals testing positive at the individual animal level was Phichit, in the northern region, with 30.64% (95% CI, 24.8, 36.96) in 2013. The provincial patterns largely reflect regional differences, but there is notable heterogeneity by province within the regions. For greater details on the referenced provinces and the livestock administrative regions see Figure 3.

Discussion

Using data from the Thai National Brucellosis Surveillance System, this study estimated the regional and annual prevalence of brucellosis in small ruminants at the animal and herd level from 2013 to 2015. This analysis suggests that overall the proportion of positive brucellosis cases is decreasing throughout the country at both the animal and herd level. However, the high proportion of herd level seropositivity in some regions suggest that continued prevention and control efforts are essential for brucellosis control. One potential contributing factor to the re-emergence of brucellosis has been the substantial increase in goat farming throughout Thailand (Nakavisut et al., 2014). Since the early 2000's the number of registered goat farms has more than doubled and continues to increase (Kanitpun et al., 2014). The increase in goat farming is partly due to government support for small-scale goat farming through agricultural policies that promote goat rearing (Srinoy et al., 1999; Nakavisut et al., 2014). Policies to encourage goat farming were primarily created to increase Muslim food production with goat farming originating in only a few select provinces in the south (Satchaphun et al., 2014; Nakavisut et al., 2014). Goat farming has since expanded beyond the southern region and now occurs throughout Thailand with most farmers raising goats for their meat with goat milk becoming increasingly popular (Anotaisinthawee et al., 2012). Similar to other parts of the world, goat farming is promoted in Thailand as a profitable means to supplement household income for low-income farmers.

Goat farming is commonly encouraged in low- and middle-income countries due to goats' low maintenance costs and grazing habits in poor arable lands (Devendra et al., 2013). However, research indicates that expansion of animal husbandry programs can have unintentional consequences on the spread of zoonotic diseases and that in different parts of the world where livestock production has increased so has the spread of brucellosis (Jones et al., 2013; Racloz & Roth, 2013). This is evident in post-Soviet era countries where the growth in livestock and density during the 1970s and 1980s have been attributed to a re-emergence of brucellosis throughout former USSR countries. For instance, changes in the livestock system including an increase in livestock handlers per animal and increasing livestock density in Kazakhstan after the collapse of the USSR have been attributed to brucellosis epidemics (Beauvais et al., 2015). A 2015 analysis of livestock surveillance data in Azerbaijan spanning the transition from Soviet dissolution to independence found that in areas where agriculture production had increased so did the number of reported human cases of brucellosis (Kracalik et al., 2015). Policies to intensify livestock production have been attributed as one of the key factors in the re-emergence of brucellosis throughout sub-Saharan Africa (Ducrotoy et al., 2014). For example, in Nigeria researchers found that policies to promote meat production in the 1970s had a direct impact on the increase in brucellosis in livestock and humans (Ducrotoy et al., 2014; Rikin, 1988).

Findings from this analysis are consistent with previous research conducted by the DLD indicating that brucellosis in small ruminants is declining in Thailand (Sagarasaeranee et al., 2016). These are areas of concern as provinces in this region such as Kanchanaburi Province, have previously experienced human brucellosis outbreaks (Sagarasaeranee et al., 2016; Danprachankul et al., 2009). Estimates from the western region are similar to

Kaewket's findings from 2008 with 11.5% at the herd level compared to our herd level seroprevalence of 13.84% (Kaewket et al., 2008). On average, farms in the southern provinces had the lowest seroprevalence at both the herd and animal level. It is worth noting that our results are comparable to previous research estimating seroprevalence in southern provinces. Our estimates are similar to Ninprom et al. who estimated seroprevalence at 0.44% at the animal level and 1.78% at the herd level in the south. However, this analysis contradicts previous research that identified the southern region of Thailand as an area of high concern for brucellosis due to shared borders and high goat meat consumption (Bamaiyi et al, 2015; Ninprom et al., 2014).

The data demonstrate that the surveillance program has been increasingly effective in reaching farms as the number of farms tested increased throughout the country; more than doubling from 1,754 in 2013 to 4,572 in 2015. Provinces in the central and western regions of Thailand had the highest number of goats and sheep tested throughout the country with Nakhon Pathom, Ratchaburi and Kanchanaburi having the highest numbers of animals and herds tested from 2013 – 2015. Population level farm and animal data also indicate that goat and sheep farming is increasing throughout the country. The sheep and goat population increased 22.85% from 476,513 animals in 2013 to 585,387 in 2015. The number of herds increased by 2.64% during this time period indicating that the number of farms is not increasing at a high rate but rather individual farms might be increasing the number of goats and sheep on the farm.

The population level data indicate that the southern and western regions of Thailand have the highest number of goats and sheep among all the regions. As goat farming continues to increase, potential human health consequences should be taken into consideration when adapting policies to promote animal husbandry. Policies to expand and promote animal production should consider public health threats and ensure appropriate disease prevention and control initiatives are implemented. Policy-makers, veterinarians, farmers, physicians and other stakeholders should be aware of the re-emergence of brucellosis and the occupational risk for small ruminant farmers and their families.

The results of this study should be considered with limitations in mind. There was a potential for bias in using data collected for the surveillance system. Farms participating in the surveillance system actively seek out registration with the DLD and voluntarily agree to be tested for brucellosis and may not be entirely representative of farms at the national level. An additional limitation of this data is the lack of information on farm level characteristics including the exact location of the farm within the province and information linking animals to herds. The available data did not permit following herds across years, thus potential cross year correlation could not be accounted for in the analysis.

Review of surveillance data is an important measure to understand the impact of brucellosis control efforts and to identify areas where targeted response is needed. Overall this study identified that brucellosis seroprevalence in small ruminants may be decreasing throughout Thailand. However, there is variability in the distribution of the disease with some regions experiencing significantly higher rates of disease than others. The persistence of brucellosis along with the increasing goat population indicates a continued potential threat for human

health consequences. This, along with the burden of brucellosis on animal production should be considered when adapting animal husbandry policy. Policy-makers should ensure that initiatives by the DLD are fully funded and supported to ensure that farmers have access to education and training opportunities on the prevention and control of brucellosis. Along with these programs additional information is needed to understand brucellosis in Thailand including the patterns of animal movement between countries and provinces and increase the proportion of all goat operations tested.

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Figure 1.

Figure 2.

Figure 3.

Table 1

Seroprevalence of brucellosis in sheep and goats at the animal level, by region in Thailand, 2013 – 2015

	Region	Animals tested	Positive animals	Animal seroprevalence
2013	Northern	2482	3	0.12%
	Northeastern	6093	95	1.56%
	Central	18734	380	2.03%
	Eastern	1400	22	1.57%
	Western	45050	716	1.59%
	Southern	29621	220	0.74%
	Total	103,380	1,436	1.39%
2014	Northern	3920	2	0.05%
	Northeastern	4488	3	0.07%
	Central	34653	96	0.28%
	Eastern	2733	21	0.77%
	Western	98972	202	0.20%
	Southern	30806	21	0.07%
	Total	175,572	345	0.20%
2015	Northern	4401	23	0.52%
	Northeastern	7613	79	1.04%
	Central	36877	331	0.90%
	Eastern	2890	36	1.25%
	Western	71993	793	1.10%
	Southern	40835	74	0.18%
	Total	164,609	1,336	0.82%

Seroprevalence of brucellosis in sheep and goats at the herd level, by region in Thailand, 2013 – 2015

Table 2

	Region	Herds tested	Positive herds	Herd seroprevalence	95% CI
2013	Northern	36	2	5.56%	(0.7, 18.7)
	Northeastern	190	35	18.42%	(13.2, 24.7)
	Central	488	79	16.19%	(13, 19.8)
	Eastern	33	10	30.30%	(15.6, 48.7)
	Western	949	169	17.81%	(15.4, 20.4)
	Southern	999	77	7.71%	(6.1, 9.5)
	Total	2,695	372	13.80%	(12.52, 15.16)
2014	Northern	60	1	1.67%	(0, 8.9)
	Northeastern	91	2	2.20%	(0.3, 7.7)
	Central	742	82	11.05%	(8.9, 13.5)
	Eastern	76	13	17.11%	(9.4, 27.5)
	Western	1502	181	12.00%	(10.4, 13.8)
	Southern	1150	21	2.00%	(1.1, 2.8)
	Region	3,621	300	8.29%	(7.4, 9.2)
2015	Northern	81	5	6.17%	(2, 13.8)
	Northeastern	211	23	10.90%	(7, 15.9)
	Central	699	74	10.59%	(8.4, 13.1)
	Eastern	81	12	14.81%	(7.9, 24.4)
	Western	1299	169	13.00%	(11.2, 15)
	Southern	2156	28	1.30%	(0.9, 1.9)
	Total	4,527	338	7.47%	(6.7, 8.3)

Table 3

Prevalence ratios of animal seropositivity in sheep and goats by region in Thailand, 2013 – 2015

Region	<i>Prevalence ratio</i>	<i>95% CI</i>
2013	1	–
2014	.13	(.09, .20)
2015	.58	(.41, .82)
Southern	1	–
Northern	0.41	(0.17, .94)
Northeastern	1.30	(0.96, 1.76)
Central	1.46	(0.94, 2.28)
Eastern	1.87	(1.23, 2.82)
Western	1.39	(0.86, 2.24)

Table 4

Prevalence ratios of herd seropositivity in sheep and goats by region in Thailand, 2013 – 2015

Variable	<i>Prevalence ratio</i>	95% CI
2013	1	–
2014	0.50	(.31, .79)
2015	0.47	(.28, .78)
Southern	1	–
Northern	0.56	(0.29, 1.05)
Northeastern	1.31	(0.83, 2.04)
Central	1.44	(0.99, 2.09)
Eastern	2.34	(1.59, 3.44)
Western	1.72	(1.11, 2.67)