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Field Epidemiology Training Program, Bureau of Epidemiology
Department of Disease Control, Ministry of Public Health, Thailand
Tel: +6625901734-5, Fax: +6625918581, Email: osireditor@osirjournal.net, http://www.osirjournal.net

An Investigation of Human Brucellosis and Goat Farm Network Analysis in Ratchaburi Province, 2013

Thanidtha Te-chaniyom[1,*], Sinanan N[1], Watthanakul M[2], Choomkasean P[1], Chuxnum T[1], Smithsuwan P[1], Pimprapai W[3], Hinjoy S[1]

1 Bureau of Epidemiology, Department of Disease Control, Ministry of Public Health, Thailand
2 Ratchaburi Provincial Livestock Office, Department of Livestock Development, Ministry of Agriculture and Cooperatives, Thailand
3 Faculty of Veterinary Medicine, Kasetsart University, Thailand

* Corresponding author, email address: Polarbear_pig@hotmail.com

Abstract

In April 2013, a person was confirmed to have *Brucella melitensis* in Chombueng District; and Ratchaburi Provincial Health Office notified about this patient to Bureau of Epidemiology. As the patient was a goatkeeper in a farm that had animal movement with other goat farms, active human case finding was conducted. History of goat movement among the related goat farms was explored to identify key persons for disease transmission in the network. Serum samples from 53 goatkeepers in 28 goat farms and two livestock officials who investigated the farm with confirmed case were tested for brucellosis. Only one goatkeeper was identified as a probable case, with attack rate of 1.8%. Goat serum specimens from 12 out of total 34 goat farms were tested positive for *Brucella*. In egocentric network, 44 nodes were included in the network analysis, including 34 goat farms, four slaughterhouses and six merchant's goat shelters. Visualization from network analysis was useful to identify goat farm networks at risk of disease spreading. Key person in the network with the highest degree centrality (26) and betweenness centrality (2455.462) was identified as a merchant's goat shelter with a goat tested positive for brucellosis. Hence, knowledge on brucellosis prevention and control should be disseminated among goatkeepers and merchants in that network. The information should also be used for strengthening communication between goat farmers and local livestock officials.

Keywords: outbreak, investigation, brucellosis, Ratchaburi Province, goat farm network

Introduction

Brucellosis is a disease caused by *Brucella* spp.[1] which is a facultative intracellular Gram-negative cocco-bacillus.[2] *Brucella melitensis* is the most important zoonosis among *Brucella* spp. as it is the most common species found in goats and the most virulent to humans.[1,3] Brucellosis poses severe economic losses in affected goat farms.[4] The cost for controlling brucellosis in a herd of 60 goats in Thailand was estimated at 7,000 USD[5], and loss of work productivity due to prolonged illness can lead to socioeconomic problems as well.[1]

In April 2013, Ratchaburi Provincial Health Office notified Bureau of Epidemiology of a confirmed brucellosis case. The case was a 66-year-old male goat farmer with diabetes mellitus. He was admitted on 4 Apr 2013 due to intermittent fever, weight loss about five kilograms and myalgia since 2012. On 5 Apr 2013, laboratory testing of his specimen reported gram-negative coccobacilli and he was confirmed to have *Brucella melitensis* by hemoculture on 25 Apr 2013. He had a goat farm since 2012 and recently imported new goats into his farm from many sources. In 2012, one goat in his farm aborted and that goat was sent back to the originating farm. He often exposed to secretions and placentas while assisting goats giving birth. Furthermore, goats in his farm showed positive results of *Brucella* infection during April 2013. Hence, in May 2013, Bureau of Epidemiology set up a team to conduct an investigation.

Objectives of the investigation were to verify the diagnosis and the outbreak, describe the network of goat farms, identify key persons for disease transmission in the network, and provide recommendations for prevention and control.

Methods

Ratchaburi Province locates in the central region of Thailand, approximately 100 kilometers south of Bangkok. Nine out of total 10 districts have goat farms. It is also one of the provinces where Department of Livestock Development has set up the laboratory surveillance and the monitoring program for brucellosis in goats. The farms in Chombeung and

Saun Pheung Districts which had live goat movement with the confirmed case's farm (index farm) were included in the study. A cross-sectional study was conducted with sampling by snowball technique from the index farm in Chombeung District.

Active Case Finding in Humans

The investigation team reviewed medical records of human brucellosis cases who received treatment during 1 Jan to 24 Apr 2013 in the hospital where the confirmed case admitted. A probable case was defined as a goatkeeper in the network who had fever or intermittent fever, with at least two out of five following symptoms: headache, myalgia, arthralgia, night sweat or orchitis, and positive result for brucellosis using parallel testing by rose bengal test (RBT) and enzyme-linked immunosorbent assay (ELISA). A confirmed case was a probable case who was tested positive for *Brucella* spp by hemoculture.

A questionnaire was used as a tool for face-to-face interview about demographic information, date of onset, clinical signs and risk activities. Serum specimens of goatkeepers from related goat farms that had goat movement with the index farm and livestock officials who investigated in the index farm were collected as well. The specimens were sent to the Department of Medical Sciences for IgM and IgG antibodies testing by RBT and ELISA.

Active Case Finding in Animals

Serum specimens were also collected from goats in the related farms and tested with RBT at Central Veterinary Research and Development Center. Information on herd size and history of brucellosis, sharing goats and movement of goats since 2012, was retrieved as well. A positive farm was defined as a goat farm in the network which had at least one goat tested positive by RBT and reported by Provincial Livestock Office during August 2012 to May 2013. The status of *Brucella* infected goat farms was obtained from database of the routine sero-survey conducted by local livestock offices.

Network Analysis

Network analysis is a tool that can be used to describe linkages between different particular members, including directions, locations and frequencies of activities.[6] Information from network analysis is usually presented in nodes (units of interest) and ties (relationships between each node).[7] This method helps to visualize directions of connections between individuals. Moreover, visual presentations of network analysis can describe important nodes within the network, providing a range calculated from the number or the frequency of linkages and activities.[6]

Quantitative measurements for relationship, including degree centrality and betweenness centrality, can provide relative values of each node.[7] Degree centrality is measured from number of ties related to each node. Non-direction is the total number of paths while direction includes number of in-degree and out-degree paths. Betweenness centrality is a ratio measurement on sum of the shortest path of each pair of nodes.[7] An egocentric network emphasizes interactions or activities related to each particular node.[8]

Partial network analysis was explored from the index farm to other nodes within the study area. Egocentric analysis from the index farm was performed to represent the linkage between nodes and identify the highest centrality node within the network. Network visualization included graphical depictions and network measurement related to degree centrality and betweenness centrality, which were calculated by UCINET 6 program.[9] A node with high value of betweenness centrality means that this node is a high representative of the middle node in this pathway.

Results

Total 34 goat farms were found to have linkage with the index farm in Chombeung and Suan Pheuang Districts.

Active Case finding in Humans

Medical records review in the hospital did not identify new human cases. Total 55 human serum samples were collected, including 53 goatkeepers from 28 goat farms and two livestock officials who investigated the index farm. There were 22 females and 33 males. Median age was 47 years, with age range of 15-67 years old. Out of 53 goatkeepers, 46 were from 25 goat farms in Chombueng District while seven were from three goat farms in Saun Pheung District. Only one goatkeeper was identified as a probable case, with attack rate of 1.8%.

Active Case finding in Animals

Out of total 34 goat farms, 29 farms were located at Chombueng District and five were in Saun Pheung District. Goats from 12 goat farms were tested positive for *Brucella*, including 2 farms identified during August to December 2012 and 10 farms during January to May 2013.

Network Analysis

The egocentric network analysis revealed that total 89 nodes had linkage with the index farm, including 34 goat farms, four slaughterhouses, six merchant's

goat shelters and 45 other locations. Information of 34 goat farms was matched with *Brucella* sero-positive results of goats from Provincial Livestock Office.

Network Visualization

The egocentric network showed relation among goat farms with brucellosis, neighboring farms and merchant's goat shelters during January to May 2013 (Figure 1). After we explored the *Brucella* infection status of goat farms, we found that the merchant's goat shelter A had a goat with brucellosis since August 2012, followed by identification of brucellosis in other farms that received the goats from the merchant's goat shelter A in December 2012, March and April 2013 (Figure 2).

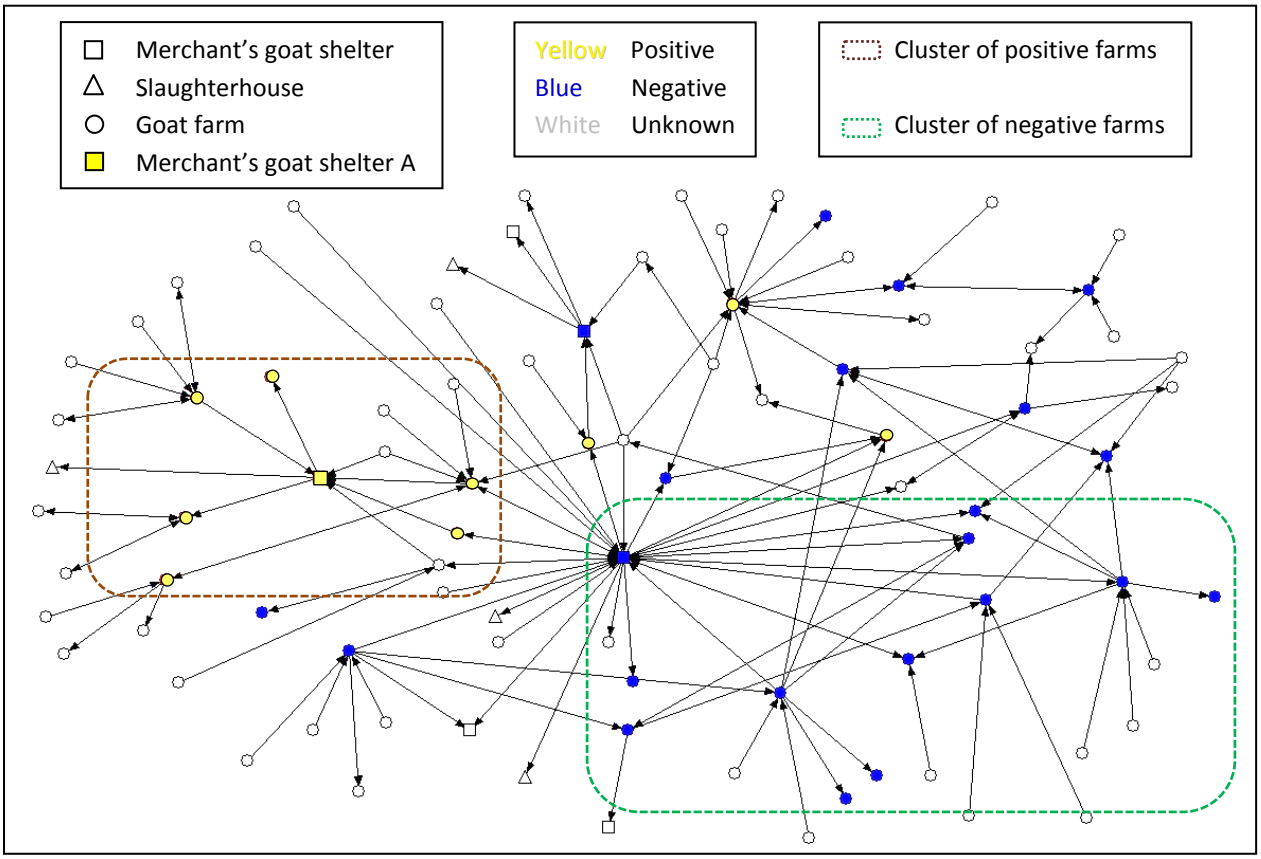


Figure 1. Network analysis of *Brucella* infection in 44 locations related to the first confirmed case's farm, Chombeung and Saun Pheung Districts, Ratchaburi Province, Thailand, 2013

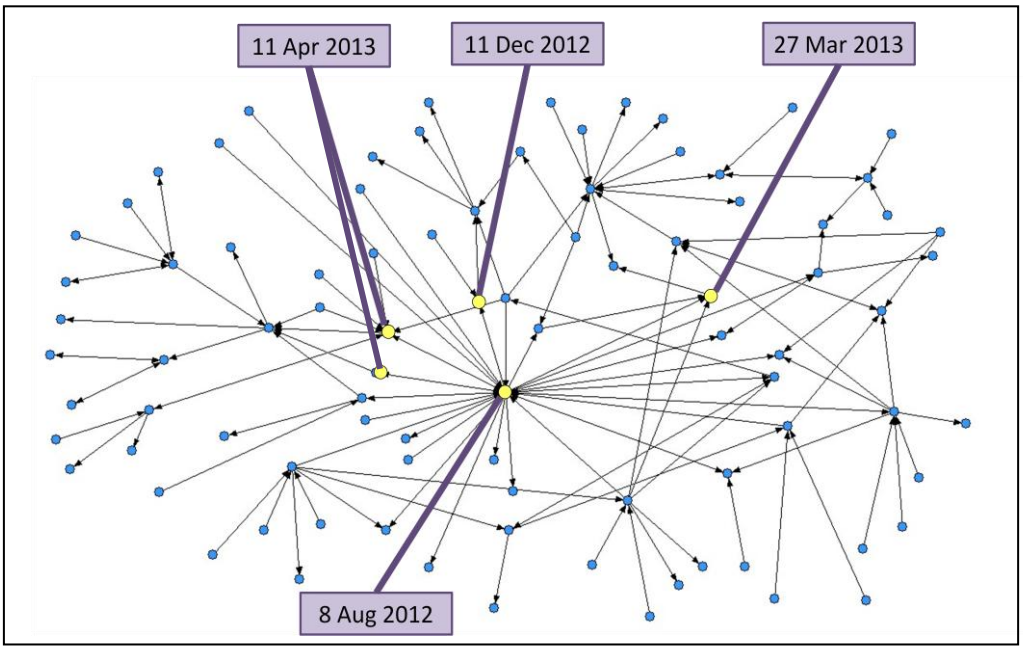
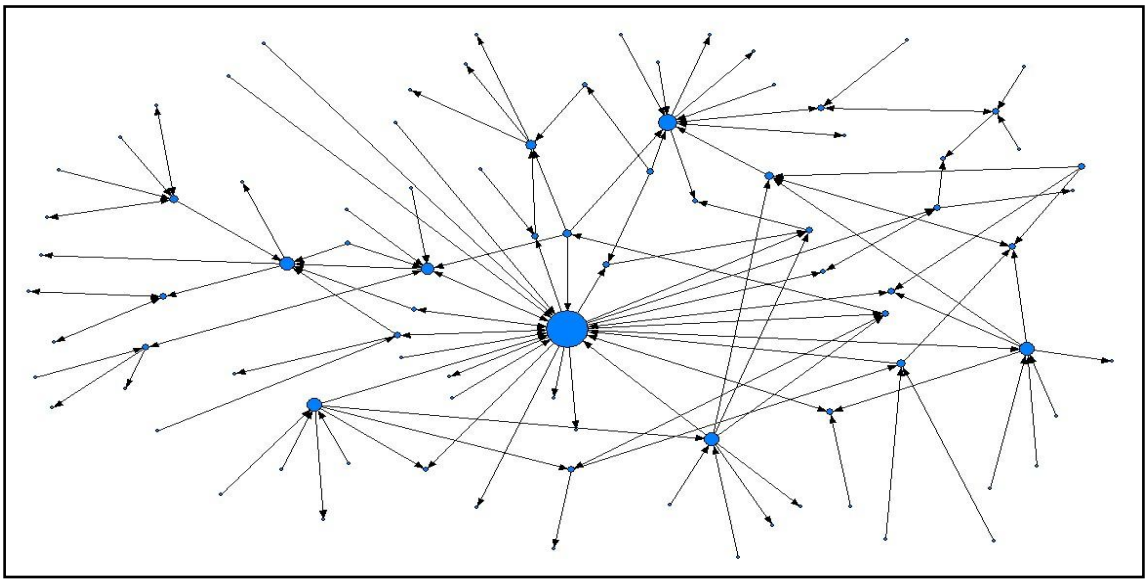


Figure 2. Network analysis of farms with goat positive for brucellosis (yellow circles), stating date of diagnosis, Chombeung and Saun Pheung Districts, Ratchaburi Province, Thailand, 2013

Arrow that pointed towards the node means goat movement into the farm, in-degree, while arrow pointed out of the node states goat movement out of the farm, out-degree. In egocentric network analysis, the highest degree centrality was 26 both in and out degree while the smallest was one tie (Figure 3). Our results revealed a node with highest value for both degree centrality (26) (Figure 3) and betweenness centrality (2455.462) (Figure 4), which was merchant's goat shelter A where goats were raised temporarily for trade. After a goat in the merchant's goat shelter A had brucellosis, the disease later spread to other farms that received the goats from the merchant's goat shelter A, which led to extensive spread of *Brucella* infection in the network.

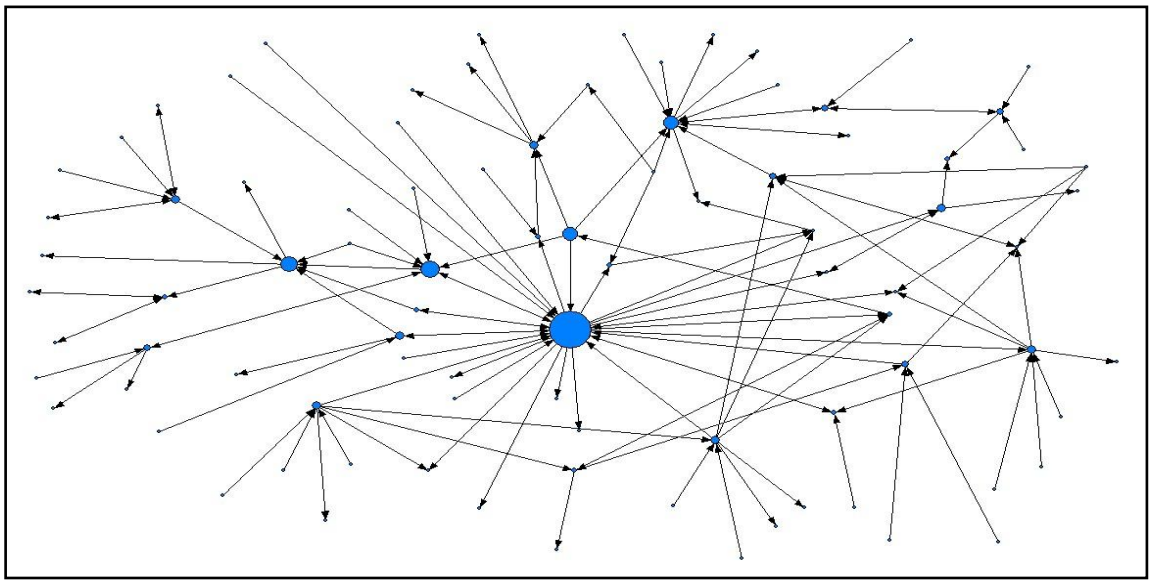
Discussion

From our investigation, the index case was not included as a new case, as his onset was before 1 Jan 2013. Therefore, one probable case of human brucellosis was identified in Chombeung District, Ratchaburi Province during 2013. The attack rate of probable human case from was only 1.8% which was different from other studies e.g. the one conducted in Petchabun Province with attack rate of 10.3% (4/39).[4] This was probably due to intensive brucellosis control and management activities that have been conducting in the province since 2003 after a human brucellosis outbreak occurred.[5]



Remark: Size represents degree value.

Figure 3. Network analysis showing degree centrality of 44 locations related to the index farm, Chombeung and Saun Pheung Districts, Ratchaburi Province, Thailand, 2013



Remark: Size represents degree value.

Figure 4. Network analysis showing betweenness centrality of 44 locations related to the index farm, Chombeung and Saun Pheung Districts, Ratchaburi Province, Thailand, 2013

Some inappropriate methods of farm management were identified in the study. The most inappropriate one was selling infected goats to other farms. This goat-share practice could cause the spread of brucellosis between farms in the network.[1,10] Some farms imported new goats with unknown infection status from other provinces, and thus increase the risk of disease transmission among goats and further spreading to goatkeepers[11].

Goatkeepers and people who exposed to infected goats can then be infected with brucellosis as well. Hence, health knowledge on brucellosis should be distributed among goatkeepers and merchants in the network, and collaboration between goat keepers and livestock officials should be strengthened.

In this study, we demonstrated the use of network analysis to visualize the linkage among the nodes with goat movement. The nodes with high betweenness centrality and degree centrality are the key persons that should be under attention as these nodes can spread the disease to other connected nodes in the network. Thus, in case of limited resources are available, disease control and prevention should be mainly focused on the key persons.[12]

Limitations

This investigation might be subjected to selection bias as some farms that were not referred by the goatkeepers could not include in the study. There might also be information bias due to long incubation period of brucellosis[2,13].

In addition, this study covered only a partial network with egocentric data started at the index farm in Chombeung District and expanded to other nodes in Saun Pheung District. However, we did not include other nodes outside of these two districts.

Although this study revealed the direction of goat movement, frequency between each node was not explored. Moreover, as this study was focused on the herd level, the source of the disease could not be precisely concluded as some farms had introduced goats from many sources.

Conclusion

A probable human brucellosis case was found in the goat farm network of Chombeung and Saun Pheung Districts. Egocentric network started from the index farm and linked with other farms through live goat movement. A key person in the network was identified as a merchant's goat shelter A. Visualization from network analysis was important to identify network and key persons for disease control and prevention. Our recommendations included knowledge distribution among goatkeepers and merchants who were key persons for disease transmission in that network, and strengthening communication between goat farmers and local livestock officials.

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