Influence of Mastitis and Repeat Breeding Incidence on Participation in the Animal Insurance Program for Dairy Farmers in Ba Vi, Hanoi, Vietnam

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Abstract

The livestock insurance program for dairy farmers in Vietnam targeting various acute diseases began in 2011 as a pilot project; however, due to vaccination campaigns, outbreaks of such diseases are rare. The objective of this study was to investigate the effects of mastitis and reproductive failure-which chronically affect the farming economy-on the decision to participate in the insurance program. A survey involving a questionnaire and milk sampling from apparently healthy animals was conducted on the 38 participating and 59 non-participating dairy farms in the livestock insurance program in Ba Vi, Hanoi, Vietnam, in August 2014. Microbiological tests were performed to detect sub-clinical mastitis, whereas the questionnaire was administered to collect information regarding farm management and the occurrence of clinical mastitis and reproductive failure over the previous three months. There were no significant differences in the proportion of farms having cows with clinical mastitis (insured: 8/38 farms, 21.1% vs. non-insured: 13/58 farms, NA = 1, 22.8%, p = 1) and repeat breeders (insured: 16/36 farms, NA = 2, 44.4% vs. non-insured: 20/57 farms, NA = 2, 35.1%, p = 0.49) over the previous three months. The proportion of farms having cows with sub-clinical mastitis at the time of the survey was also not significantly different between insured (5/38 farms, 13.2%) and non-insured (7/59 farms, 11.91%) farms (p = 1). Based on the obtained results, neither endemic disease nor farm management is respectably involved in the decision of farms to participate in the animal insurance program targeting acute animal infectious diseases.

Keywords

Animal insurance, decision, bovine mastitis, repeat breeding, Vietnam

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Introduction

Milk production has drastically increased over the last four decades, particularly in Southeast Asia, including Vietnam (Food & Agricultural Organization, 2013). This growth has been attributed to an increase in the domestic demand for dairy products and the government-led importation of highly productive dairy animals for breeding purposes (Garcia *et al*., 2006). A comparison with the average milk yield in 1997 indicated that due to genetic improvements in the lactating ability of Vietnamese dairy cows, one Vietnamese cow produces as much milk as four dairy cows in India, the second-largest milk-producing country in the world. Proper nutritional management is necessary for high milk-producing cows because of their sensitive energy balance (Grant & Albright, 1995). The risk factors for diseases in dairy cows are interconnected (LeBlanc *et al*., 2006), and rapid changes in dairy productivity are assumed to have increased the incidence of various diseases, including sub-clinical forms of mastitis, ketosis, rumen acidosis, and endometritis.

In addition to the increased production and consumption of livestock products in Southeast Asia, rapid economic growth has been accompanied by increased risks of infectious disease epidemics such as foot-and-mouth disease (FMD) (Vu *et al*., 2017) and avian influenza (Poolkhet *et al*., 2018), primarily due to increases in the frequency and quantity of trade and travel. As the majority of livestock producers in Southeast Asia are small scale, the economic impact of such outbreaks is immense.

One method of dealing with the risk of disease outbreaks is insurance. In Japan, agricultural insurance for dairy farms is subsidized 50% by the government and covers not only the death of animals but also treatment costs (Japanese Ministry of Agriculture Forestry & Fisheries, 2010). Moreover, under the Act on Domestic Animal Infectious Diseases Control, the Japanese government compensates farmers for 80% of the value of animals culled due to several important infectious diseases, such as FMD, and the remaining 20% of the value is compensated by the insurance program for participating farmers (Kadowaki *et al*., 2016). Crop and livestock insurance was first introduced in Vietnam between 1985 and 1987 (phase 1), without government support. However, except for crude rubber insurance, phase 1 was withdrawn in 1987 due to problems associated with moral hazards and conflicts regarding pay-out value (Kono *et al*., 2017). By order of the Vietnamese prime minister, dairy insurance premiums were implemented in 2011 within the phase 2 pilot program for three years, covering rice plants, livestock (buffaloes, cows, pigs, and chickens), and aquatic products (catfish, tiger prawns, and white-leg shrimp) (Kono *et al*., 2017). Under the pilot program involving commercial insurance companies, the state-subsidized 100% of the insurance premiums for poor farming households and individuals, initially 80% and later 90% for near-poor, 60% for the remaining, and 20% for relevant farming organizations (Duc, 2017). Three causes of death were covered by the dairy insurance: FMD, anthrax, and *Pasteurella* infection, but no treatment costs were covered for endemic and non-infectious production diseases. Vaccination campaigns against FMD, anthrax, and *Pasteurella* infection are being implemented in dairy production areas of Vietnam (personal communication with local veterinary officers), and animal deaths due to these diseases appear to be rare. The Ba Vi district of Hanoi is an important dairy production area in Vietnam and characterized by advanced dairy technology. As of October 2013, 260 farms in Ba Vi were participating in the insurance program (Kono *et al*., 2017). The phase 2 pilot insurance program was successful, with a high proportion (76.8%) of poor households in the target area participating. However, the program also had several weaknesses, including a lack of testing and certification facilities for diseases, resulting in limited compensation or farmers receiving inconsistent damage assessments (Duc, 2017). The government, therefore, considered instituting a public-private partnership (Duc, 2017) covering 90% of insurance premiums for poor and near-poor farming households and 20% for remaining households (Viet Nam News, 2018).

Mastitis has been described as the most expensive disease affecting dairy farms worldwide; however, the chronic nature of this disease can lead farmers to ignore and/or underestimate the financial effects of decreased milk production and increased culling (Hogeveen *et al.*, 2011). Mastitis is caused by a wide variety of pathogenic bacteria. Microorganisms causing mastitis are classified as either contagious or environmental pathogens, depending on the vector of transmission. The major contagious pathogens are *Staphylococcus aureus* and *Streptococcus agalactiae, S. aureus* is reportedly the most problematic udder pathogen in bovine mastitis in many parts of the world (Roberson *et al.*, 1994). In southern Vietnam, mastitis is commonly caused by *S. agalactiae*, a contagious organism associated with sub-clinical mastitis (Keefe, 1997; Östensson *et al.*, 2013). In Ba Vi, a 25% prevalence of sub-clinical mastitis was reported (Suzuki *et al.*, 2006), but much higher prevalences (63.2% at quarter, and 88.6% at cow levels) were reported in southern Vietnam (Lam, 2011).

Repeat breeders are cows that have failed to conceive after three or more services. Repeat breeders are characterized by a normal estrus cycle length, no abnormalities in vaginal discharge, and no palpable abnormalities in the reproductive tract (Bartlett *et al.*, 1986; Gustafsson & Emanuelson, 2002). A repeat breeder cow appears to be normal, and it is, therefore, difficult to diagnose the cause of the failure to conceive. Repeat breeding results in a delay in starting lactation and fewer calves per cow; therefore, total farm milk yield is also reduced, causing substantial economic losses to farmers. A study involving Holstein and Lai Sind crossbred cattle in Ho Chi Minh city found that reproductive performance was satisfactory in heifers but poor for cows due to declining body condition scores during the first months of lactation and at insemination (Nguyen-Kien *et al.*, 2017), suggesting the potential for improvement in feed management.

This study aimed to determine whether the occurrence of chronic and expensive diseases such as mastitis and repeat breeding affected the decision-making process regarding participation in the phase 2 dairy insurance scheme among dairy farmers in a dairy-production area of Vietnam.

Materials and Methods

Study site

This study was conducted in two communes, Yen Bai and Van Hoa, located in Ba Vi, Hanoi (Figure 1). This area, located in northern Vietnam, has a humid tropical climate, characterized by monsoons. Summers (May to July) are very hot, with an average temperature over 27°C, whereas winters (November to January) are cold and relatively dry (Garcia *et al.*, 2006). This survey was carried out in August 2014. The average precipitation in August is the highest of the entire year, at over 300 mm. Precipitation in winter is low, but these communes are at or near a lake, and extensive irrigation and pumping systems have been established (Garcia *et al.*, 2006).

Sampling and questionnaire survey

Sample size was calculated for a comparison of two proportions, with the confidence level set at 95% and the power set at 80% (Equation 1), in order to primarily compare the prevalence of sub-clinical mastitis at the animal level between insured and non-insured farms (Dohoo *et al.*, 2014). In equation 1, Z_α is a multiplier for type I errors, alpha = 0.05, 1.96; Z_β is a multiplier for type II errors = 0.2; p is the expected prevalence, 0.25 (Suzuki et al., 2006); q is the expected prevalence complement, 0.75; p1 is the expected prevalence at insured farms, 0.35; and p2 is the expected prevalence at non-insured farms, 0.15, assuming a 20% difference in the prevalence of sub-clinical mastitis. The sample size was adjusted for a clustering effect assuming an intra-class correlation coefficient of 0.1 (Dohoo *et al.*, 2014).

$$\frac{(Z_\alpha\sqrt{2pq}-Z_\beta\sqrt{p_1q_1+p_2q_2})^2}{(p_1-p_2)^2} \text{ (Equation 1)}$$

The sample size was calculated at 73; however, 95 farms were involved in the study. The sample size was proportionally allocated between Yen Bai and Van Hoa communes to reflect the total number of insured dairy farmers
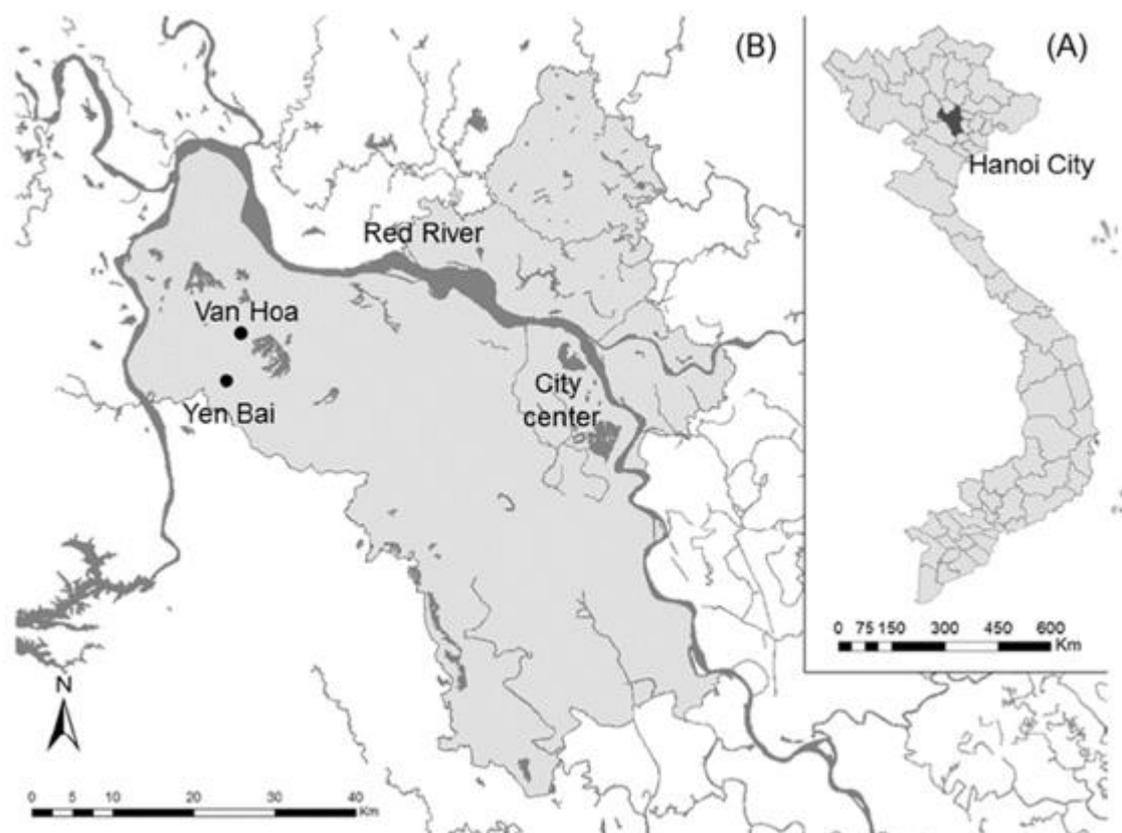
Figure 1. Study areas: (A) a map of Vietnam indicating the location of Hanoi,
and (B) the locations of Van Hoa and Yen Bai communes in Hanoi

in each commune reported to the commune offices. These numbers were accessed based on availability from the field.

Milk samples were collected from lactating dairy cows exhibiting no obvious clinical symptoms of mastitis and no visible changes in milk composition. Samples were taken from 60% of the delivered cows at all of the studied farms. The first few streams were discarded. Samples from each of the four quarters were collected into the same bottle and defined as a single milk sample for this study.

At each visit, an interview with the questionnaire was administered to obtain information regarding dairy management and hygiene awareness as well as cattle health outcomes. Occurrences of mastitis and repeat breeding within the previous three months were queried for each individual cow. The degree of each farm's sanitation was graded on a scale of 1-4 (1: cleanest to 4: dirtiest) for three parts of each cow: legs, udder, and flank and upper leg

(Reinemann, 2007). The average score of the three parts for all cattle was recorded as the farm's hygiene score. Farmers were also asked to rate their level of awareness regarding diseases common in cows, including mastitis and repeat breeding, using a Likert scale, with 0 indicating no problem and 5 indicating a significant problem.

Informed consent was obtained from all the farmers participating in this study at the time the interview was performed. This study did not involve invasive treatments in animals or collection of personal information through interviews. All interviewing and sampling procedures adopted in this study were approved by the ethics committee of Rakuno Gakuen University, Japan (approval number: 16-8).

Laboratory examinations

Causal organisms of sub-clinical mastitis were isolated from the collected milk samples. Microbial species isolated included coagulase-

positive staphylococci (CPS) other than *S. aureus, S. agalactiae, Escherichia coli*, and *Klebsiella* spp. Cows were categorized as having sub-clinical mastitis if they presented no apparent symptoms but their milk samples were positive for bacterial growth. Milk samples were streaked on sheep blood agar plates, which support the growth of various types of bacteria. The plates were incubated at 37°C overnight. Three major bacterial colonies on each agar plate were selected and sub-cultured on blood agar plates. Biochemical tests were used for species identification, including the hemolysis, CAMP, catalase, and tube coagulase tests. Bacterial isolates that produced no hemolysis were subjected to biochemical testing for confirmation as *E. coli* or *Klebsiella* spp. *Staphylococcus hyicus* produces no hemolysis on blood agar, but *S. aureus, S. intermedius*, and *S. agalactiae* exhibit β-hemolysis. Therefore, these bacteria were classified based on the catalase test, which is primarily used to distinguish gram-positive bacteria. The results obtained with the catalase and coagulase tests were confirmed by PCR for *S. aureus* species-specific genes using the forward primer 5'-GCG ATT GAT GGT GAT ACG GTT-3' and the reverse primer 5'-AGC CAA GCC TTG ACG AAC TAA AGC-3' (Sasaki *et al.*, 2010).

Statistical analysis

Data were digitized in a Microsoft Access® Database and analyzed using R statistical software (R×64, version 3.0.3) for Windows®. The association between insurance subscription and the aforementioned disease occurrence/ management practices was analyzed at the farm level. A farm was denoted as positive for mastitis/repeat breeding if at least one animal with the problem was reported or diagnosed by microbiological testing. These occurrences (0 = negative and 1 = positive) were used as response variables, and the other data collected in the questionnaire were used as explanatory variables. Each variable was analyzed using the Wilcoxon rank-sum, chi-square, or Fisher's exact test, depending on the data structure.

Results

Farm characteristics

All of the farms in the study were small scale (1 to 22 cows per farm), and 88.7% (86/97) of the farms had less than 10 cows. Table 1 shows the number of farms, milk samples, and mean herd sizes of the insured and non-insured farms. All cattle were housed on concrete surfaces. Cattle were fed raw grass and purchased concentrate at both insured and non-insured farms. There were no significant differences between insured and non-insured farms in any of the characteristics examined (Figure 2).

Cumulative incidence of clinical mastitis and prevalence of sub-clinical mastitis

In the questionnaire survey, factors related to mastitis were investigated using data from 95 farms, as two farms did not provide information regarding the incidence of mastitis in the interviews. The three-month cumulative incidence of clinical mastitis, calculated from the questionnaire survey results, was 22.1% (21/95) at the farm level. In addition, at the individual level, the incidence was 8.4% (29/344, health information regarding clinical mastitis was not obtained for 85 cows).

In the laboratory analyses, the prevalence of sub-clinical mastitis was 11.1% (17/153) at the individual level, and the prevalence at the farm level was 12.4% (12/97). Two samples had mixed infections involving *S. agalactiae* and *S. aureus*, and of the 19 isolates, these bacteria accounted for 57.9% (11 isolates) and 21.1% (4 isolates), respectively. There were three CPS isolates other than *S. aureus*, and these contagious mastitis-causing bacteria (*S. agalactiae* and CPS) accounted for 94.7% (18/19). One *Klebsiella* isolate causing environmental mastitis was detected; however, *E. coli* was not detected. Sub-clinical mastitis was found at 12 farms; thereby, both clinical mastitis and sub-clinical mastitis were identified in cattle at one farm.

Clinical and/or sub-clinical mastitic cattle were present on 33.0% (95% CI: 24.0-43.4, 32/97) of the farms, based on the questionnaire survey and

laboratory examination results. The proportion of farms with mastitic cattle was not significantly different between insured (34.2%, 13/38) and non-insured farms (32.2%, 19/59, p = 1). There was also no significant difference in terms of the incidence rates of clinical and/or sub-clinical mastitis between insured (29.3%, 17/58) and non-insured farms (22.1%, 21/95, $x2 = 0.6527$, p = 0.42).

Table 1. Farm size and number of milk samples

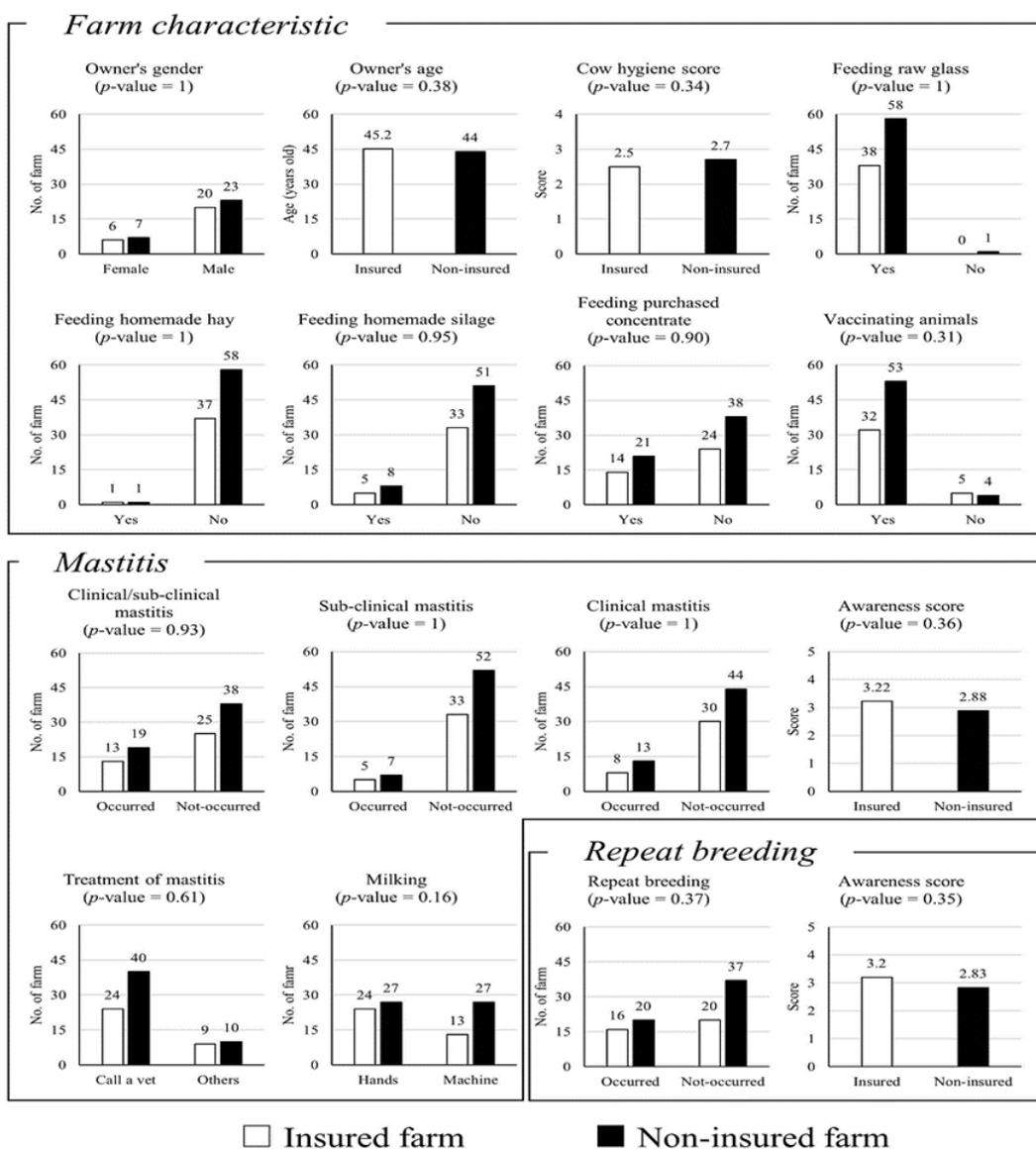| Insurance	Farms in Yen Bai	Farms in Van Hoa	Mean herd size (range)	Adult cows	Milk samples (sampling fraction)
I	16	22	5.4 (2-22)	153	58 (37.9%)
Non-insured	33	26	5.9 (1-13)	239	95 (39.7%)
Total	49	48	5.7 (1-22)	392	153 (39.0%)

Figure 2. Statistical analysis results

The average scores regarding farmers' awareness of mastitis were not significantly different between insured (3.22, 95% CI: 3.0-4.5) and non-insured farms (2.88, 95% CI: 2.75-4.00, p = 0.36). For the treatment of mastitis, 77% (64/83) of farmers called a veterinarian, whereas 23% (19/83) of farmers called other staff or treated the disease themselves. There was no significant difference between insured and non-insured farms in terms of factors relating to mastitis.

Incidence and farmers' awareness of repeat breeding

Ninety-three farmers answered the questions relating to reproductive difficulties, and the results indicated that repeat breeding occurred at 38.7% (36/93) of the studied farms. The proportion of farms with these reproduction-related problems did not differ between insured (44.4%, 16/36) and non-insured farms (35.1%, 20/57, $x2 = 0.47$, df = 1, p = 0.49). In addition, the average score of awareness of repeat breeding was not significantly different between insured (3.2, 95% CI: 2.5-4.5) and non-insured farms (2.8, 95% CI: 2.50-3.75, p = 0.35). Artificial insemination was used at all the farms.

Discussion

The main purpose of this study was to test the hypothesis that Vietnamese dairy farmers were motivated to participate in an animal insurance program due to experience with chronic production diseases, even though the program targeted acute infectious diseases. For that reason, two economically important diseases, mastitis and repeat breeding, were examined.

There were no significant differences in terms of farm size, feed management, vaccination, or disease occurrence between insured and non-insured farms in this study. In laboratory analyses, contagious pathogens associated with mastitis were identified much more frequently than environmental pathogens, indicating that the milking method is more important than environmental factors in efforts to control the spread of mastitis in this region. In this study, the p-values of most factors were

greater than 0.30, but the p-value associated with the milking method was relatively lower (p = 0.16), and farms with milking machines tended not to participate in the insurance program. Milking by machine is a sign of intensive dairy farming, and economically developed farmers may evaluate the significance of the program carefully. Another study carried out during the same period but with different farmers (Kono *et al.*, 2017) showed that a farmer's decision to purchase animal insurance was affected by the absence of a trustworthy person nearby and a low rate of time discounting. Such sociological factors seemed to be more significant determinants of insurance participation by dairy farmers than disease burden.

Conclusions

This study found that the incidence of two important production diseases, mastitis and repeat breeding, was not the primary determining factor for the decision to participate in the animal insurance program in Ba Vi, Vietnam. The risk factors for mastitis and repeat breeding in Vietnam will be published elsewhere.

Acknowledgements

Conflicts of Interest

The authors declare no conflicts of interest.

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