The Journal of Veterinary Medical Science

FULL PAPER

Epidemiology

Economic loss due to treatment of bovine respiratory disease in Japanese Black calves arriving at a backgrounding operation in Miyazaki

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J. Vet. Med. Sci.
84(10): 1328–1334, 2022
doi: 10.1292/jvms.22-0178

Received: 12 April 2022
Accepted: 22 July 2022
Advanced Epub:
3 August 2022

ABSTRACT. The present study assessed the economic loss due to treatment of bovine respiratory disease (BRD) in Japanese Black calves that were introduced to a backgrounding operation from the age of 3 to 4 months until the age of 10 months. The data collected from a backgrounding operation in Miyazaki, Japan included the records of 2,690 animals entering the farm from 2013 to 2018. The treatment duration was defined as the number of days from the beginning to end of treatment. The cost of treatment was defined as the total cost of treatment during the treatment duration. The average incidence of BRD was 54.6%, and the relative frequency of calves that had BRD once, twice, and three or more times until they left the farm was 64.4%, 26.8%, and 8.8%, respectively (total recorded diagnoses of BRD: 2,494). Among the 2,494 recorded diagnoses, the average and median duration of treatment of BRD was 5.9 days and 3.0 days, respectively. The average and median cost of treatment was 7,767 and 5,600 Japanese yen, respectively. A prolonged duration of treatment and high cost of treatment were associated with BRD relapse, steers, and early stage of production ($P<0.05$). At the studied farm, the total cost of treatment during the 6-year study period was 19,658,988 yen, and the annual cost was approximately 3 million yen. In summary, the present study showed that BRD had a large economic impact in this backgrounding operation.

KEYWORDS: backgrounding operation, bovine respiratory disease, economics, Japanese Black cattle, treatment duration

Bovine respiratory disease (BRD) is the most common and costly disease in beef cattle. It is a multifactorial disease that can be caused by bacteria such as *Mannheimia haemolytica*, *Pasteurella multocida*, and *Histophilus somni* and by viruses such as bovine herpesvirus, bovine respiratory syncytial virus, and bovine viral diarrhea virus [20]. BRD is a leading cause of morbidity and mortality in calves [4, 5]. Based on the national Japanese report of 2017 [24], around 35.5% of calves, including both dairy and beef calves, are diagnosed with and treated for BRD, and 15.8% of all calf deaths are attributed to BRD. These numbers reflect the high incidence and mortality of this complex disease. BRD is also a major disease in Japanese Black cattle (also known as Wagyu cattle), the most common beef cattle breed in Japan. In our previous study [23], we assessed the incidence of BRD in Japanese Black calves raised on a backgrounding operation and found that more than half of these calves had BRD. Backgrounding operations introduce calves aged 3 to 4 months and raise them until the age of 10 months, and these operations have recently increased in number because they improve the growth efficiency of calves and decrease the burden on small farmers in cow–calf operations. Several studies have estimated the economic impact of BRD in mixed-breed in a commercial feedlot [2] and in dairy calves [6], but no study has quantified this impact in Japanese Black calves raised on a backgrounding operation.

The economic impact of BRD can be estimated using both the treatment duration and treatment cost for each diagnosis of BRD. These measurements differ according to the incidence of BRD because approximately 90% of cattle that develop a relapse of BRD receive retreatment with a different antimicrobial mechanistic class [28]. In addition, sex, season, and age at BRD, which are reportedly associated with the incidence of BRD [8, 9, 13, 15, 18, 26], are possibly related to the treatment duration and treatment cost. Therefore, the objective of the present study was to assess the economic loss due to treatment of BRD in Japanese Black calves and to investigate factors associated with the treatment duration and treatment cost at a backgrounding operation.

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MATERIALS AND METHODS

Data collection

Data for this study were collected from a backgrounding operation, called a calf station, in suburban areas of Miyazaki city in Miyazaki prefecture, Japan. Miyazaki prefecture, which is located on the southeastern coast of Kyushu, is a major cow–calf producing region and has the second largest cattle population in the country [16, 22]. Miyazaki city, which is located at 131° 24′ E longitude and 31° 56′ N latitude, has a temperate climate with warm humid summers and cold winters. The studied farm had collected Japanese Black calves at 3 to 4 months of age from cow–calf operations located in Miyazaki prefecture and raised them until the age of 10 months. All calves entering the backgrounding operation received a combination vaccine on arrival to protect them against infectious bovine rhinotracheitis, bovine parainfluenza virus type 3, bovine respiratory syncytial virus, bovine viral diarrhea virus, and bovine adenovirus. Every month, 40 to 50 calves from cow–calf operations were entered into this farm, and approximately 300 calves were always reared. All animals were reared in an intensive system in which they were housed in freestalls for the duration of their stay. The size of freestall was approximately 42 m^2 (4.7 m × 8.9 m), and each freestall was contained 5–7 calves. The calves were separately assigned to the freestalls based on their sex and arrival weight, and they came to the calf station from multiple sources of cow-calf operations. Because cattle grazing is not performed in this region, the calves were fed roughage such as rice straw, Italian ryegrass, oat straw, and a dietary concentrate twice daily. The average productivity for Japanese Black cattle has been previously reported [10, 11, 14, 21, 27].

The records for calves entering the farm from 2013 to 2018 were extracted from an existing database on the farm. Data on animal health were also collected from a veterinary hospital. The dataset contained information for 2,968 Japanese Black calves. Data validation and error checking were performed, and 278 records were excluded from the analysis because the data were incomplete or unavailable. Hence, 2,690 animals comprised the study group.

Because these data were obtained from a regional database and no experiments were performed on live animals, University Animal Care and Use Committee approval was not sought.

Determination of BRD

In this study, BRD was defined as a diagnosis of BRD by veterinarians and subsequent treatment with an antimicrobial. The health status of all the calves on the studied farm was checked by farm staff at the time of feeding in the morning, and any problems were diagnosed by a clinical veterinarian each day. Rectal temperature was measured by farm staff before any diagnosis was made, and any issues were reported to the clinical veterinarians. The typical diagnostic criteria used for BRD were as follows: pyrexia, abnormal chest sounds auscultated with a stethoscope, dyspnea, and purulent nasal discharge. During the study period, the animals on the farm were examined by several veterinarians, all of whom belonged to the same veterinary hospital and used the same criteria to diagnose BRD.

All diagnoses of BRD during the research period at the studied farm were counted in this study. The treatment duration and cost were calculated for each diagnosis of BRD. The treatment duration was defined as the number of days from the beginning to end of treatment. All treatments were performed by the clinical veterinarian. The cost of treatment was defined as the total cost of treatment during the treatment duration. The cost was expressed as Japanese yen, with an assumed exchange rate of 1 US dollar and euro to 110 and 130 yen, respectively, in September 2021. The cost of each treatment is defined in Diagnosis and Therapy in Animal Mutual Aid [17], and the costs of major treatments are shown in Table 1. An example of calculation of the cost of treatment is shown in Table 2. In this example, a calf was treated for 3 days, and the total cost of treatment was 6,805 yen. In this manner, the cost of treatment was calculated for each diagnosis. This cost included both the need for clinical examinations by veterinarians and antibiotic treatments.

The total cost of treatment at the studied farm during the research period was calculated as the sum of the cost of treatment for all diagnoses of BRD during the research period. The annual cost of treatment at the studied farm was calculated as the total cost of treatment at the studied farm during the research period divided by the research period (6 years).

Table 1. Cost for a single dose of each treatment

Treatment	Cost (JP Yen)
Florfenicol 45% IM	1,308
Enrofloxacin 10% SC	1,359
Noeas IM	1,379
Meloxicam SC	1,451
Tilmicosin SC	1,555
Marbofloxacin IV	1,500
Thiamphenicol IM	1,230
Tylosin SC	2,843
Flunixin meglumine IM	1,245

IM, intramuscular injection; SC, subcutaneous injection; IV, intravenous injection.

Table 2. Example of cost of treatment for a calf treated for 3 days

Day	Treatment	Cost (JP Yen)
Day 1	Florfenicol 45% IM	1,308
	Meloxicam SC	1,451
Day 2	Florfenicol 45% IM	1,308
	Noeas IM	1,379
Day 3	Enrofloxacin 10% SC	1,359
Total		6,805

IM, intramuscular injection; SC, subcutaneous injection; IV, intravenous injection.

Statistical analysis

Data were analyzed using SAS 9.4 (SAS Institute Inc., Cary, NC, USA). A generalized linear model with gamma distribution using the GLIMMIX procedure was used to compare the treatment duration of BRD and cost of treatment of BRD by the factors associated with the incidence of BRD. The dependent variables were the treatment duration of BRD and cost of treatment of BRD. The independent variables were the number of occurrences of BRD (first case, second case, and third and later cases), sex (steer and heifer), season of diagnosis [winter (December–February), spring (March–May), summer (June–August), and autumn (September–November)], and number of days to diagnosis of BRD (0–30, 31–60, and ≥61 days after farm entry). All possible two-way interactions between significant factors were included, but non-significant interactions (P>0.05) were removed from the final models. The identifications of the cow–calf operations and the entry years were each included as a random effect.

RESULTS

The average incidence of BRD was 54.6% (1,469/2,690). Of 1,469 calves diagnosed with BRD, the relative frequency of calves that had BRD with first case, second case, and third and later cases until they left the farm was 64.4% (942 calves), 26.8% (392 calves), and 8.8% (135 calves), respectively (total recorded diagnoses of BRD: 2,494). Figure 1 shows the incidence of BRD after farm entry by the numbers of BRD occurrences among the 2,494 recorded diagnoses. More than 50% of the first occurrences of BRD were found within 30 days of entering the farm, whereas most of the second occurrences were observed from 20 days of entering.

Figure 2 shows the relative frequencies of treatment duration (number of days from beginning of treatment to end) in calves treated for BRD. Of 2,494 recorded diagnoses, the average and median duration of treatment of BRD was 5.9 days and 3.0 days,

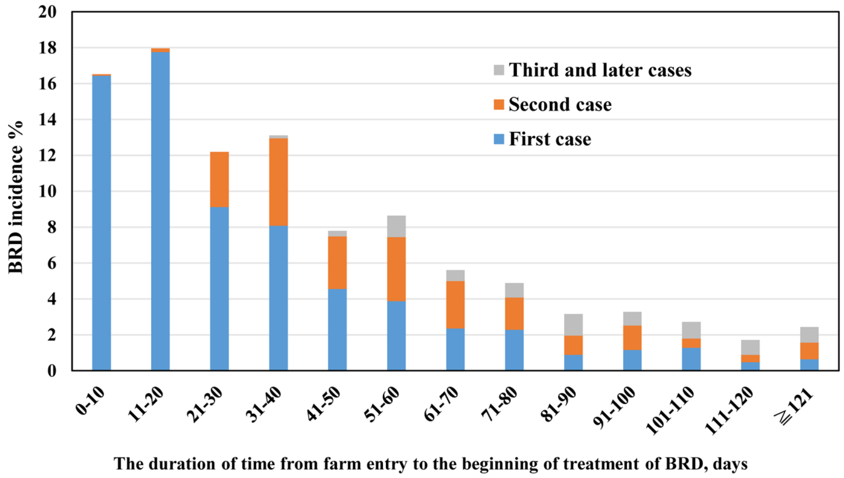

Fig. 1. Relative frequency of occurrences of bovine respiratory disease (BRD) by the duration of time from farm entry to the beginning of treatment of BRD among the 2,494 recorded diagnoses.

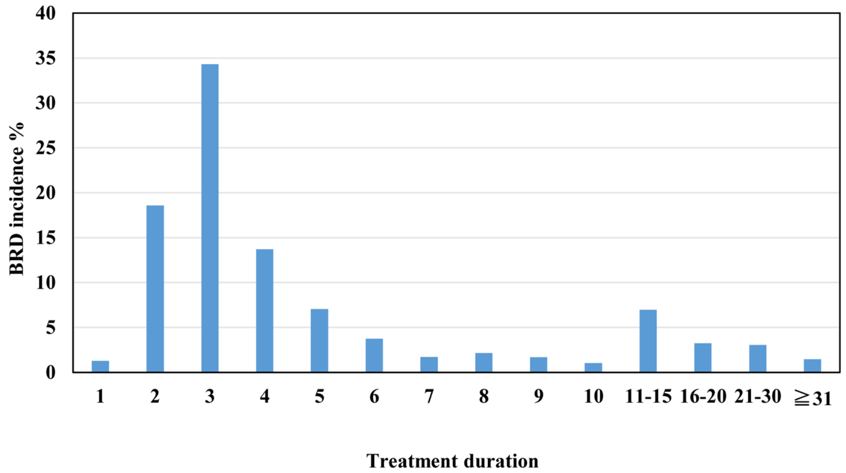

Fig. 2. Relative frequencies of treatment duration (number of days from beginning to end of treatment) for calves treated for bovine respiratory disease (BRD).

Table 3. Comparisons of duration of treatment of bovine respiratory disease (BRD) by various factors

Variable	Number of treatment records	Duration of treatment of BRD			
		P value	Median (IQR)	Estimate	SEM
Number of BRD incidence		<0.01			
First case	1,718		3 (3–6)	−0.210	0.036
Second case	584		3 (3–5)	−0.047	0.066
Third and later cases	192		3 (3–4)	Ref.	
Sex		0.02			
Steer	1,514		3 (3–6)	Ref.	
Heifer	980		3 (3–5)	−0.071	0.031
Season[1]		0.25			
Spring	451		3 (3–5)	−0.043	0.046
Summer	413		4 (3–6)	0.060	0.047
Autumn	914		3 (3–5)	−0.011	0.038
Winter	716		3 (3–6)	Ref.	
Number of days to diagnosis of BRD		<0.01			
≤30 days	1,164		4 (3–7)	0.593	0.045
31–60 days	738		3 (3–6)	0.355	0.045
≥61 days	592		3 (2–4)	Ref.	

IQR, interquartile range. [1]Months of diagnosis were categorized by season: winter (December–February), spring (March–May), summer (June–August), and autumn (September–November).

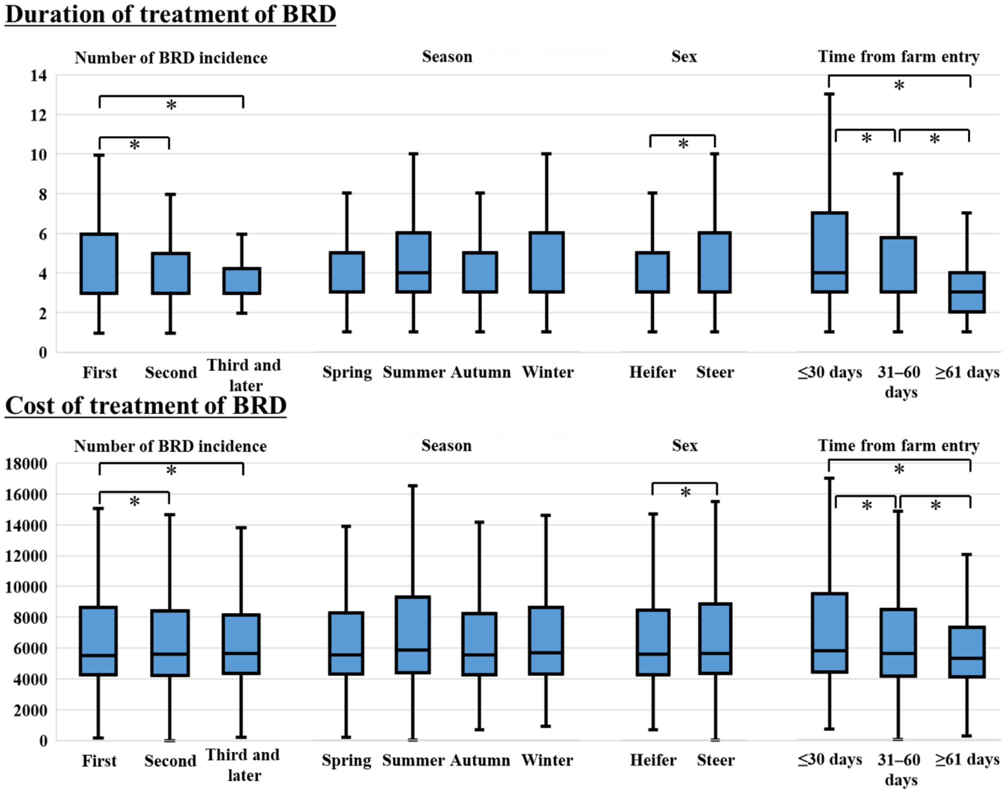

Fig. 3. Comparisons of duration and cost of treatment of bovine respiratory disease (BRD) by various factors. Months of treatment were categorized by season: winter (December–February), spring (March–May), summer (June–August), and autumn (September–November). Time from farm entry indicates the duration of time from farm entry to the beginning of treatment of BRD. * Indicates $P<0.05$.

respectively (interquartile range, 3–6 days). Approximately 80% of treatments were completed within 7 days. Table 3 and Fig. 3 show comparisons of the duration of treatment of BRD by various factors. The duration of treatment of BRD was associated with the number of occurrences of BRD ($P<0.01$), sex ($P=0.02$), and number of days to diagnosis of BRD ($P<0.01$), but not with season at treatment ($P=0.25$). Calves with their first case of BRD had a shorter duration of treatment than those with their second or later cases.

Table 4. Comparisons of cost of treatment of bovine respiratory disease (BRD) by various factors

Variable	Number of treatment records	Cost of treatment of BRD			
		P value	Median (IQR)	Estimate	SEM
Number of BRD incidence		<0.01			
First case	1,718		5,560 (4,300–8,670)	−0.122	0.054
Second case	584		5,630 (4,260–8,480)	−0.002	0.055
Third and later cases	192		5,710 (4,400–8,250)	Ref.	
Sex		0.01			
Steer	1,514		5,620 (4,310–8,870)	Ref.	
Heifer	980		5,560 (4,240–8,430)	−0.068	0.026
Season[1]		0.13			
Spring	451		5,540 (4,310–8,280)	−0.052	0.038
Summer	413		5,910 (4,380–9,300)	0.077	0.039
Autumn	914		5,560 (4,280–8,260)	0.015	0.032
Winter	716		5,710 (4,290–8,650)	Ref.	
Number of days to diagnosis of BRD		<0.01			
≤30 days	1,164		5,790 (4,380–9,500)	0.295	0.038
31–60 days	738		5,600 (4,160–8,480)	0.151	0.037
≥61 days	592		5,300 (4,080–7,310)	Ref.	

IQR, interquartile range. [1]Months of diagnosis were categorized by season: winter (December–February), spring (March–May), summer (June–August), and autumn (September–November).

Steers had a longer duration of treatment than heifers. In addition, the duration of treatment of BRD decreased as the number of days to diagnosis of BRD increased. No significant interactions between these factors were found ($P \geq 0.05$).

Of 2,494 recorded diagnoses, the average and median cost of treatment was 7,767 and 5,600 yen, respectively (interquartile range, 4,300–8,620 yen). Table 4 and Fig. 3 show comparisons of the cost of treatment of BRD by various factors. The cost of treatment of BRD was associated with the number of BRD occurrences ($P<0.01$), sex ($P=0.01$), and number of days to diagnosis of BRD ($P<0.01$), but not with season at treatment ($P=0.13$). Calves with their first case of BRD had a lower cost of treatment than those with their second or later cases. Steers had a higher cost of treatment than heifers. In addition, the cost of treatment of BRD decreased as the number of days to diagnosis of BRD increased. No significant interactions between these factors were found ($P \geq 0.05$).

At the studied farm, the total cost of treatment of BRD during the 6-year study period was 19,658,988 yen, and the annual cost was approximately 3 million yen.

DISCUSSION

The present study quantified the cost of treatment of BRD by assessing both the treatment duration and treatment cost for each diagnosis of BRD in calves that showed clinical symptoms of BRD. Our results showed that the annual cost of treatment of BRD in the studied backgrounding farm, which reared 300 calves, was approximately 3 million yen, indicating that a single calf with BRD incurred an annual cost of 10,000 yen. In addition, at the prefecture level in Miyazaki, 34,057 calves out of 69,100 born in 2017 were treated for BRD [24], and the annual total cost of treatment of BRD in Miyazaki prefecture was 264.5 million yen, which estimated by the 34,057 calves multiplied by the average cost of treatment of BRD, 7,767 yen. These findings reveal that BRD has one of the highest economic impacts in modern beef cattle production. This study did not include losses caused by decreased daily gain [23] and mortality [4] due to BRD; thus, the actual economic impact is higher than our estimation. It is important to prevent BRD by strengthened biosecurity measures [25], which will financially benefit producers [6].

In this study, more than half of the calves raised on a backgrounding operation had BRD, and most BRD treatments were completed within 7 days, suggesting that most cases of BRD are mild. However, the 10% of calves with a prolonged duration of treatment would be considered to have more severe cases of BRD. These calves received antimicrobials for a longer period of time, which is a major problem worldwide from the viewpoint of antimicrobial resistance. To prevent severe cases of BRD, producers are advised to closely monitor high-risk calves to promptly identify any clinical signs of BRD and thus initiate effective treatment. Arrival information at backgrounding operations of Japanese Black calves can be used to detect high-risk calves [23].

The present study showed that the duration and cost of treatment of BRD increased as the number of BRD occurrences increased. This finding indicates that BRD recurrences are more difficult to treat than the first case. In this study, 35% of calves with BRD developed repeated recurrences. Early identification of such calves can reduce antibiotic use. Lack of prompt treatment increases the likelihood of treatment failure, death, or retreatment [1], which can increase the cost due to BRD. Additionally, calves with severe BRD can be isolated to protect the general population. Population medicine by vaccination is another option for control. Furthermore, metaphylaxis can be implemented to prevent the spread of infectious diseases among animals that are in close contact with one another and are therefore at considerable risk of contracting BRD or may already be infected with or incubating it.

The decrease in the duration and cost of treatment of BRD with the increase in the duration of time from farm entry to diagnosis of

BRD in the present study can be explained by the increased disease resistance with the growth of calves. The highest BRD infection frequency was observed within 1 month of farm entry because the calves had developed transport stress and experienced changes to their diet, both of which are thought to be risk factors for BRD [3]. In particular, young calves have fewer opportunities to be exposed to major respiratory pathogens during this period and are therefore expected to be more immunologically naïve than older calves [8]. In addition, the large variation in the immune status and vaccine history among calves affects their risk of BRD [7] when coming from different cow–calf operations. These findings indicate that producers should pay careful attention to calves during the first month after farm entry and promptly identify calves with clinical signs of BRD.

The season at treatment was not associated with either the cost of treatment or the treatment duration of BRD. Our previous study revealed a higher risk of BRD in autumn because of the large variations in diurnal temperatures [23]. A high incidence of BRD was also observed in autumn in the present study, but the cost of treatment and treatment duration in autumn were similar to those in other seasons. These findings indicate that calves that arrive on the farm in autumn are most susceptible to BRD but that their clinical symptoms do not differ from those in calves arriving in other seasons.

The cost of treatment and treatment duration were higher for steers than for heifers. Steers also reportedly have a higher risk of BRD [23]. One possible reason is castration, which is a very stressful event for calves and decreases their immune status [12]. The trauma associated with castration likely contributes directly to the pathogenesis of BRD [19], and extra care is needed to alleviate the burden of castration on calves' overall health condition. In the present study, we were not able to assess the relationship between the timing of castration and BRD risk because detailed data of castration was not available. Further investigation is needed to determine this point. Additionally, pain control or mitigation could be beneficial to both the calf and the producers, and more research into this topic is needed.

The present study had several limitations. First, information regarding the health condition of the calves raised at the cow–calf operations was not available; however, we included the identification of the cow–calf operation in the statistical analysis as a random effect, and this effect was adequately taken into account. Second, although the type of housing unit for the calves may have affected the cost of treatment and treatment duration, such information on housing was unavailable. Third, several veterinarians examined the calves in the studied farm, and the accuracy and consistency of their diagnoses of BRD was unknown. However, all veterinarians belonged to the same veterinary hospital and used the same criteria to diagnose BRD. The final limitation is that the present study was based on data from only a single farm. However, this farm was the largest backgrounding operation in the Miyazaki region, and clinical veterinarians examined the calves daily; therefore, there was likely little bias due to missed diagnoses. Furthermore, it is important to note that very few epidemiological studies have been published on this topic in beef calves, making the present study relevant and novel.

In conclusion, the present study quantified the cost of treatment of BRD and showed that BRD had a large economic impact at a backgrounding operation. Various factors were associated with both the cost of treatment and treatment duration of BRD in Japanese Black calves. Our findings could contribute to design and implement an effective prevention or control of BRD and finally to decrease burden of labor and clinical veterinarian.

POTENTIAL CONFLICTS OF INTEREST. The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

ACKNOWLEDGMENTS. The authors gratefully acknowledge the farm cooperatives' producers for providing their data for use in the present study. The authors also thank the veterinarians and staff at the Miyazaki Agricultural Mutual Aid Association for their assistance. This research was supported by the Science and Technology Research Partnership for Sustainable Development (SATREPS), Japan Science and Technology Agency (JST)/ Japan International Cooperation Agency (JICA) (Project: The Acceleration of Livestock Revolution in Thailand aiming to be the Kitchen of the World through the Development of Novel Technologies for Stable Livestock Production and Food Safety).

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