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The incidence and management of footrot in dairy cattle in Monteverde, Costa Rica

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ABSTRACT

This study investigates the frequency of, and factors leading to or preventing, footrot in dairy cattle in the Monteverde area of Costa Rica. Owners of 23 farms were interviewed about their property characteristics, management practices, and incidence of footrot. Then the farms were visually inspected. Ten farms were found to currently have infected cattle and 18 had infected cattle this year. The percent of currently infected cattle had a significant positive correlation with both herd size and hours spent in daily milking rotation. Larger herds showed a greater incidence of infection. The combined presence of rocks and mud in the trails and pastures was significantly associated with an increased occurrence of infection. However, neither rocks nor mud by themselves led to infection. Suggesting that the combined effects of mud (soften hooves and make vulnerable) and rocks (cause abrasions) that allow the infectious bacteria to gain entry. None of the observed management practices attempted were successful in reducing the reoccurrence of infection. However, two management practices (adding supplements to the cattle diet and applying phosphorous to the pastures) were significantly associated with the occurrence of infection, most likely because the farmers added these practices to manage the existing problem, but occurrence of infection was unaffected after the change. This study demonstrates that many of the primary management practices recommended by previous studies to control the occurrence of footrot are not effective in Monteverde, Costa Rica. Further research is necessary to find simple and cost effective alternative management methods for small dairy farms in developing countries.

RESUMEN

Este estudio investiga la frecuencia y los factores que producen o previenen la pudrición de las patas del ganado lechero en el área de Monteverde, Costa Rica. Se entrevistó a los dueños de 23 fincas y se les preguntó acerca de las características de sus propiedades, sus prácticas administrativas y la incidencia de la enfermedad. Las fincas también fueron evaluadas visualmente. Diez de estas fincas tienen ganado infectado y 18 lo habían tenido este año. Se encontró una correlación positiva significativa entre el porcentaje de ganado todavía enfermo y tanto el tamaño del hato como el tiempo que pasaron en la rotación para el ordeño. Los hatos más grandes mostraron una incidencia de infección mayor. La presencia combinada de barro y piedras en los senderos y potreros se asoció significativamente con un aumento en la ocurrencia de la infección. No obstante, ni las rocas ni el barro por sí solos producen la infección. Esto sugiere que son los efectos combinados del barro (Que suaviza las pezuñas y las vuelve vulnerables) y las piedras (Que causa llagas) los que permiten entrar a las bacterias infecciosas. Ninguna de las prácticas de manejo observadas redujo la reinfección. Sin embargo, dos de las prácticas de manejo (Agregar suplementos alimenticios a la dieta del ganado y agregar fósforo a los potreros) presentaron una relación significativa con la ocurrencia de la infección; probablemente porque los granjeros introdujeron estas actividades para controlar el problema ya existente, pero la incidencia de la infección no fue alterada después del cambio. Este estudio demuestra que muchas de las prácticas de manejo recomendadas en estudios previos para controlar la pudrición de la pata no son efectivas en Monteverde. Se necesitan más estudios para encontrar métodos de manejo más simples y baratos para fincas pequeñas en países en vías de desarrollo.

INTRODUCTION

Lameness in dairy cattle represents a major health problem for the dairy industry. In herds where incidence is high, lower milk yields, reduced reproductive performance, higher involuntary culling rates, discarded milk, and the additional management effort required to care for lame cows accounts for the majority of economic loss. One of the most common causes of lameness in cattle is footrot, a disease widespread in most countries worldwide (Meyerholz 1975). Footrot is a contagious, acute infectious disease of cattle, also known as *Interdigital necrobacillosis*. It may be found in individually or can affect up to 80 percent of cattle in problem herds (Meyerholz 1975).

The most frequent cause of footrot in cattle are widespread opportunistic bacteria such as *Fusobacterium necrophorum,* which inhabits ruminant digestive tracts and may survive in soil for up to ten months. It compromises cattle immune reactions and causes supportive necrosis (Griffin 1998). It also acts synergistically with other microorganisms (bacteria, spirochetes, yeasts or fungi), thereby becoming more infective at lower doses (Kirkpatrick and Lalman 1993). *Fusobacterium necrophorum* is excreted in cattle feces. Persistently wet conditions in poorly drained muddy pens with the constant replenishment of *Fusobacterium necrophorum* from cattle feces are likely reasons for the high ubiquity of *Fusobacterium necrophorum* and they favor the occurrence of infection (Hauptmeier 1997).

Fusobacterium necrophorum cannot penetrate intact, healthy skin; rather, the infectious organism must enter through abrasions in the epidermal layer of the foot. Continuous exposure to mud or moist manure can cause softening, irritation, erosion, and excessive drying of the hoof and skin. Over time, this leads to skin breaks which facilitate establishment of infectious agents (Wolf 1998). The infection causes painful inflammation, swelling and necrosis of the subcutaneous tissue of the foot. This is followed by the acute onset of severe lameness in one or more limbs, with hind limbs being affected most frequently (Wolf 1998). In chronic cases, the foot will abscess above the hoof with a discharge that has a characteristic foul odor that can be used to identify the infection (Whittier 1999). The infection is often accompanied by a high fever of 103-104 ºF, a drop in milk production, and a loss of appetite and weight (Wolf 1998).

For every day that treatment is delayed, longer recovery is necessary, often extending to many months and requiring multiple treatments (Whittier 1999). Early treatment is essential to prevent animals from developing chronic problems. In severely advanced cases where treatment is delayed or ineffective, the organism penetrates deeper to adjacent tendon sheaths, joint capsules or bone, causing septic arthritis. Severe illness or death can occur in prolonged cases (Meyerholz 1975).

Previous studies have suggested several methods to reduce the risk of foot problems, including supplementing cattle diets with calcium, phosphorous, carbohydrates, protein, trace minerals, salt, and vitamins (Ishler et al. 1999) and preventative management strategies such as filling mudholes and draining stagnant pools or fencing them off. In addition, lots should be well drained and manure removed frequently. Grading or filling areas heavily traveled by cattle and, hence, creating well-drained pathways may help to prevent footrot. Mounds of soil in the feedlot help to promote drainage and give cattle a dry place to lie (Whittier 1999). Around feed bunks or watering troughs, a concrete standing platform is ideal to reduce injuries and help keep feet dry. Lime or phosphorous fertilizer along the feed bunk can also be used as a drying agent (Meyerholz 1975). Lastly, removing sources that might cause injury or bruising, such as rough or sharp areas in barnyards, pastures, or lanes. (Wolf 1998).

Despite the fact that most farmers in Monteverde, Costa Rica enjoy a relatively high standard of living today, due to a booming tourism industry in the area, there are still some farmers, especially in outlying areas such as Guacimal, who depend on dairy cattle farming; thus, the loss of even one cow can have serious economic consequences for them. Yet the cost of treating a lame or ill cow until recovery, with veterinary assistance, is often greater than the cost of the loss of its milk production. If a lame animal is not too emaciated, the owner will either sell or cull the animal; if that is not an option, then the animal is just left in the pasture to suffer or recover on its own and the family must suffer the economic loss. Few, if any, studies of footrot have been conducted in developing countries where many small farmers require simple and cost effective alternative management methods, which might reduce occurrence or improve recovery after infection.

For many small farmers in the Monteverde area, giving their cattle the recommended regular veterinary care, complete nutritional diets, proper treatments, preventative footbaths, or landscape manipulation necessary might be too strenuous, require too much time, or be too costly to be feasible. This study seeks to investigate whether biotic or abiotic factors, such as wetter areas with inadequate drainage and rougher terrain, are the primary causative agents that enhance vulnerability to footrot infection in the Monteverde, Costa Rica area. Additionally, it seeks to measure how effective different management practices are at improving recovery from or reduce the reoccurrence of infection.

METHODS

This study was carried out from October 22- November 16, 2005. Farms were selected, based on availability, from a list of all local dairy producers that obtained from the Fábrica de Queso in Monteverde, Costa Rica. Twenty-three dairy cattle farms were examined in the surrounding area, including Guacimal, San Luis, Monteverde, Santa Elena, La Cruz and Las Nubes, Costa Rica. First, personal interviews were conducted with individual farmers using the survey questions found in Appendix 1, followed by a visual inspection of the farm. Elevation was measured at each farm using an altimeter. The purpose of this was to evaluate the farmer's description of their property relative to that observed on other farms, and to adjust the data accordingly.

With the data obtained from the interviews and visual inspection two types of data analysis were run: (1) The first analysis tested for correlations between the percent of currently infected cattle (%CI) and the number of cattle in the herd, distance walked by cattle to the milking barn, time spent in daily milking rotation, number of times cattle were milked per day, and elevation. (2) The second was a contingency table and Chi-square analysis to determine whether the presence or absence of a variable was associated with the presence or absence of infection either (a) currently present, or (b) annually, (present at some point in the past twelve months). Variables analyzed included: trail or pasture characteristics, removal of rocks, use of a footbath, use of calcium or phosphorous, and use of diet supplements. Pasture or trail characteristics were categorized as (i) Just dirt, just rock or just mud (ii) Rocks and mud (iii) Just cement or (iv) Cement/other (Table 3, 5).

RESULTS

The percent of infected cattle ranged from 0-29% currently and 0-58% annually. Elevation ranged from 385-1475 m, but elevation was not correlated with the %CI (Table 1). Farm size ranged from 5-80 ha, and similarly had no correlation with the %CI (Table 1). Distances between pastures and the milking barns (only measured for half of the farms) ranged from 30-2000 m. Distance was not significantly correlated with the %CI (Table 1). The number of times each herd was milked per day also had no correlation with %CI (Table 1). However, the number of hours the cattle spent in daily milking rotation, which ranged from one to eight hours for different farms, had a significant positive linear correlation with the %CI (Table 1, Figure 1). The number of cattle in each herd also had a significant positive correlation with the %CI (Table 1, Figure 2). There was also a significant positive correlation between the herd size and the number of hours spent in milking rotation (Table 2). As the number of cattle in each herd increased, and therefore the number of hours spent in milking rotation, so did the %CI cattle in a given herd.

Among the 23 farms, there were various combinations of soil, mud, rocks, and cement in the trails and pastures. Results showed that each characteristic alone, on trails or in pastures, were not significantly associated with the presence or absence of infection (Table 4, 6). However, when pasture characteristics and trail characteristics were combined, together they had a significant association with the annual presence of infection (Table 6). When characteristics of the pasture were combined with characteristics of the trails there was a significant higher occurrence of infection.

Removal of rocks, use of a footbath, and application of calcium on the pastures had no significant effects on the presence or absence of infection (Table 7). Use of food supplements and the application of phosphorous on pastures both were significantly associated higher occurrences of infection (Table 7).

DISCUSSION

The prediction that wetter, muddier conditions combined with rocky terrain would enhance vulnerability to injury, and therefore footrot infection, was supported, as there was a significantly higher occurrence of infection on farms that had both muddy and rocky areas. When either one of the factors occurred separately, there was no relationship with occurrence of infection. Of the three farms with no history of infection, none had both rocks and mud present on their property. These data reinforce previous findings that muddy, wet conditions probably soften the hooves and predispose them to abrasions which occur thereafter when cattle cross rocky terrain. Additionally, dairy breeds, which must travel over greater distances of rough terrain to the milking barn every day, are known to have much higher incidences of infection than beef breeds, which always walk less (Wolf 1998).

The results showed that the number of cattle in a herd and the time spent in daily milking rotation were positively correlated. This indicates that larger herds require more milking time. Significant positive linear correlations were found for both herd size and the number of hours in daily milking rotation with the percent of cattle currently infected. The most probable reason is that increasing the number of cattle or overstocking will lead to more manure being deposited per square foot and the cows in larger herds must spend more time directly in it (Cook 2004). Since the causative agents are believed to originate from the gastrointestinal tract of the cow, it is expected that manure management would be helpful in reducing the occurrence of disease (Shearer 2000). Nevertheless, this study showed that none of the farms studied in the Monteverde area currently manage manure in the pastures or trails.

Previous studies have also shown that in overstocked conditions, there were individuals in the herds that consistently spent less time laying down every day. Ideally, dairy cattle should have 10 to 14 hours per day for reclining and ruminating (Ishler et al. 1999). Galindo and Broom (2000) confirmed that low-ranking individuals in the herd hierarchy spend less time lying and more time standing still and perching than middle and high-ranking cows. In addition, the highest-ranking cows are always the first to be milked and spend the least time in milking rotation, while the lowest-ranking cows stand the longest, typically in mud or manure, waiting for their turn. An excessive amount of time spent bearing weight, or insufficient time spent lying has been identified as a significant risk factor for interdigital and heel lesions, leading to lameness (Cook 2004). The herd hierarchy is manifested as the herd travels, with high-ranking cows in the front and low-ranking cows, or those that are already lame, walking in the back of the herd. This could potentially exacerbate existing problems since the mud in a given area increases as each cow passes across the area.

In addition, during the rainy season, the harsher climate often forces the cattle herds to seek refuge in stands of trees to escape from the wind and rain. With greater amounts of rain and mud, the cattle are also less likely to lie down on completely saturated pastures. This leads to decreased activity and less time foraging for food. Exercise is important for stimulating blood flow through the feet and keeping the tissues healthy. Too little exercise can cause sluggish blood flow, edema, and swelling (Ishler et al. 1999). This, in combination with a weaker body composition due to less foraging, and increased sole lesions from shorter daily lying times, could lead to greater overall susceptibility to illness during the rainy seasons.

Unfortunately, none of the observed recommended preventative measures currently practiced in the Monteverde area proved to be successful in either reducing the occurrence of infection or improving recovery. The removal of rocks, use of a footbath, and application of calcium on the pastures had no significant effects on reducing the occurrence of infection. On the contrary, two recommended practices (use of food supplements, such as minerals, salt, or paste, and the application of phosphorous on pastures) actually were associated with a higher occurrence of infection. One possible explanation is that the farms using these techniques had were experienced high occurrences of infection in the past and began adding supplements or phosphorous to prevent future occurrences. However, the infection rates did not decline.

This study showed that footrot is a problem, and many of the primary management practices recommended by previous studies for the prevention of foot rot, which were typically for developed countries, have proven ineffective in the Monteverde, Costa Rica area. Further research is necessary to find simple and cost effective alternative management methods for small dairy farms in developing countries.

TABLE 1. *Simple-regression results showing the effects of (7) factors on the percent of currently infected cattle. Number of cattle and daily hours in milking rotation both had significant positive linear correlations with percent currently infected.*

Factor	**Equation**	**F-Value**	**P-Value**	**DF**	**Significant (≤0.05)**
Number of Cattle in Herd	Y = -2.512 + .456 * X; R^2 = 0.334	10.55	0.004	1	Yes
Number of Streams Crossed	Y = 7.343 - .095 * X; R^2 = 8.988E-5	0.002	0.966	1	No
Number of Times Milked/ Day	Y = 6.352 + .548 * X; R^2 = 0.001	0.02	0.900	1	No
Elevation (m)	Y = 7.827 - 4.854E-4 * X; R^2 = 4.133E-4	0.01	0.927	1	No
Distance to Milk Barn (m)	Y = 4.665 + .007 * X; R^2 = 0.175	1.91	0.200	1	No
Number of Hectares	Y = 5.647 + .089 * X; R^2 = 0.039	0.85	0.366	1	No
Daily Hours in Milking Rotation	Y = -1.269 + 2.392 * X; R^2 = 0.221	5.97	0.023	1	Yes

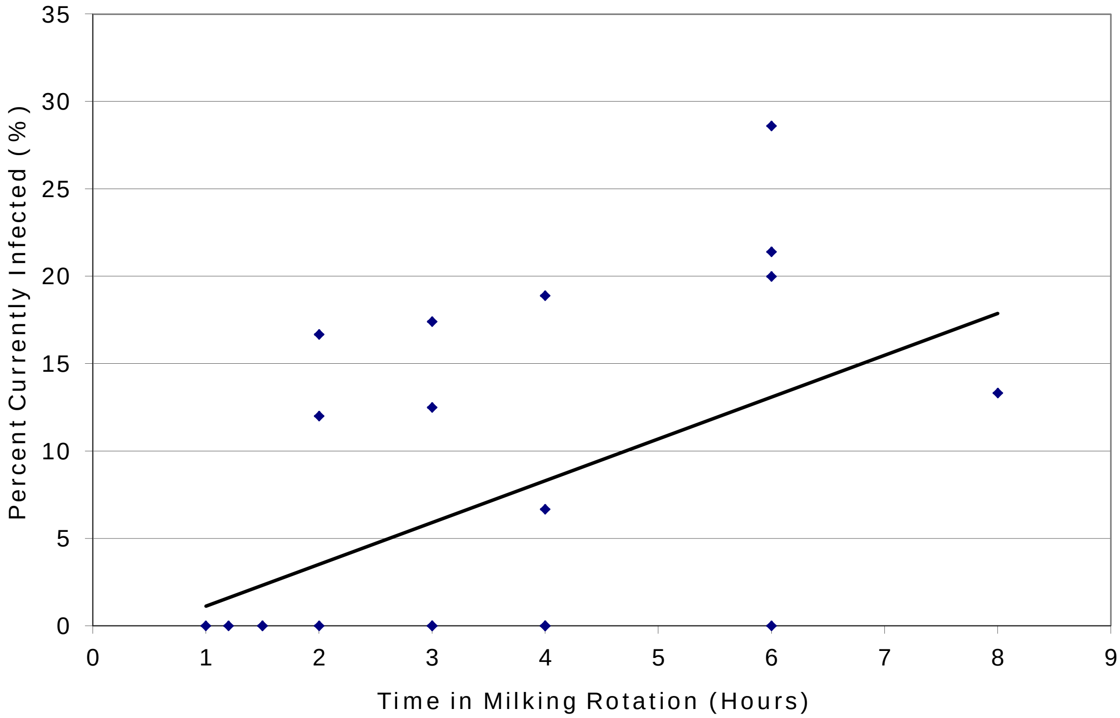

FIGURE 1. Relationship between the number of hours spent in daily milking rotation and the percent of currently infected cattle.

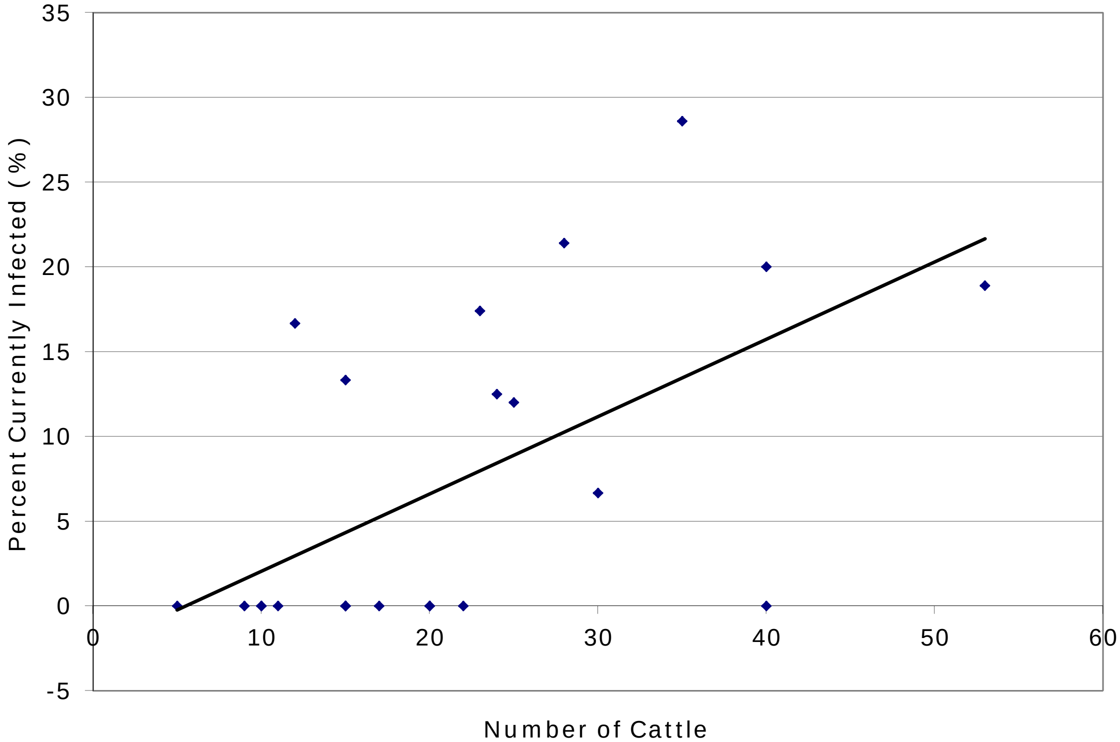

FIGURE 2. Relationship between number of cattle in the herd and the percent of currently infected cattle.

TABLE 2. *Simple-regression analysis showing the effect of the number of cattle on the number of hours cattle spend daily in milking rotation.*

Factor	**Equation**	**F-Value**	**P-Value**	**DF**	**Significant (≤0.05)**
Number of Cattle	$Y = 2.07 + .07 * X; R^2 = 0.204$	5.37	0.031	1	Yes

TABLE 3. *Classification of current trail and pasture characteristics with infections currently present or absent.*

	Pasture		Trail		Pasture & Trail	
	Present	**Absent**	**Present**	**Absent**	**Present**	**Absent**
Soil OR Mud OR Rock	8	9	3	7	1	6
Mud AND Rocks	2	3	3	4	5	5
Just Cement	0	0	1	0	0	0
Cement/Other	0	0	2	2	3	2

TABLE 4. *Chi-squared test results of the effects of current trail or pasture characteristics on presence or absence of infection.*

Area	Chi-square	P-Value	DF	Significant
Trails	0.08	0.781	1	No
Pasture	0.30	0.585	1	No
Both	2.30	0.129	1	No

TABLE 5. *Classification of annual trail and pasture characteristics with infections annually present or absent.*

	Pasture		Trail		Pasture & Trail	
	Present	**Absent**	**Present**	**Absent**	**Present**	**Absent**
Soil OR Mud OR Rock	14	3	6	4	3	4
Mud AND Rocks	4	1	7	0	10	0
Just Cement	0	0	1	0	0	0
Cement/Other	0	0	3	1	4	1

TABLE 6. *Chi-squared test results of effects of annual trail or pasture characteristics on presence or absence of infection. 'Both' had a significant effect on presence of infection.*

Area	Chi-square	P-Value	DF	Significant
Trails	0.01	0.905	1	No
Pasture	3.66	0.056	1	No
Both	7.68	0.022	2	Yes

TABLE 7: *Chi-squared test results of (5) effects on the presence or absence of infection during the past twelve months. Use of phosphorous and feed supplements both had significant effects on the presence of infection.*

Effects	**Chi-square**	**P-Value**	**DF**	**Significant (≤0.05)**
Removal of Stones (when present)	0.84	0.360	1	No
Use of Footbath	0.61	0.435	1	No
Apply Phosphorous to Pastures	4.12	0.043	1	Yes
Apply Calcium to Pastures	1.78	0.183	1	No
Feed Supplements	6.32	0.012	1	Yes

Cuestionario
Instrucciónes: Conteste las preguntas y marque todas las respuestas que se refieren.

1. Cuántas vacas lecheras en el hato?
2. Cuántas hectáreas tiene?
3. Qué tipo de vacas tiene?
   a) Jersey
   b) Cebú
   c) Holstein
4. Alimenta aditivo o suplemento de comida?
5. Tiene un galirón?
   Qué tipo de suelo tiene en el galirón?
   a) la arena
   b) la paja
   c) la piedra
   d) la grava
   e) el cemento
   f) la tierra
   g) el barro
6. Cuánto tiempo las vacas pasan en el galirón?
7. Tiene un otro gradero?
   Qué tipo de suelo tiene en el gradero?
   a) la arena
   b) la paja
   c) la piedra
   d) la grava
   e) el cemento
   f) la tierra
   g) el barro
8. Para que usa el gradero?
9. Cuánto tiempo las vacas pasan en el gradero?
10. Qué tipo de tierra es en el potrero?
    a) la arena
    b) la paja
    c) la piedra
    d) la grava
    e) la tierra
    f) el barro
11. Comó el dranaje en la propiedad?
12. Hay quebradas en la propiedad? Sí / No
    Las vacas crucelas? Sí / No
13. Hay lagunas en la propiedad? Sí / No
    Las vacas crucelas? Sí / No
14. Hay mucho barro en la propiedad? Sí / No
    Las vacas crucelas? Sí / No
15. Hay agua estancado en la propiedad? Sí / No
    Las vacas crucelas? Sí / No
16. Tiene un cerco entre el galirón y el potrero? Sí / No
17. Llevan las vacas para ordeñar?
18. Qué tipo de tierra es en el sendero entre el galirón y el potrero?
    a) la arena
    b) la paja
    c) la piedra
    d) la grava
    e) el cemento
    f) la tierra
    g) el barro

19. Mantiene los senderos de las vacas?
20. Dónde las vacas beben agua?
    Qué tipo de tierra es alrededor la área?
    a) la arena
    b) la paja
    c) la piedra
    d) la grava
    e) el cemento
    f) la tierra
    g) el barro
21. Quita estiércol de la propiedad? Sí / No
    i. Con qué frecuencia?
22. Use calcio o fósforo en la tierra?
23. Cuántas vacas tuvieron infecciónes de las patas este año?
24. Cuántas vacas murieron o se vendieron porque tuvieron infecciónes en este año?
25. Cuántas vacas tienen infecciónes de las patas ahora?
26. Cuándo durante este año se encuentre lo mas infecciónes?
27. Cuál es la primera indicación que una vaca tiene la infección?
28. Qué cambia en el comportamiento cuando una vaca está enferma?
    a) Está coja
    b) Detiene de comer
    c) Menos producción de leche
    d) No camina lejos
    e) Deja mucho
29. Primera cosa hace despues de encontrar una vaca con la infección?
    a) Llama el veterinario
    b) Limpia la pata con infección
    c) Da una inyección
        i. Cuántas veces?
    d) Añade otras cosas en la comida o agua
        i. Qúe?
    e) Pone formalina/formaldehido/sulfato de cobre en la tierra
        i. Dónde pone?
    f) Mantiene en el granero
        i. Por cuánto tiempo?
30. Cuánto exitoso tiene con el tratamiento?
31. Cuánto tiempo se necesita para recuperarse?
32. Qué manipula en la dirección de la finca para que las infecciónes esten reducidas?
    Ha tenido éxito?

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