PEER REVIEWED

Survey of veterinarians and hoof trimmers on methods applied to treat claw lesions in dairy cattle

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Abstract

A survey was administered to members of the American Association of Bovine Practitioners (AABP) and the Hoof Trimmers Association (HTA) to identify various treatment methods for claw horn lesions. A total of 345 people responded to the survey, of which 196 identified themselves as members of AABP, 111 as members of HTA, 9 as having membership in both organizations, and 29 providing no information as to affiliation with either of these organizations. A total of 307 respondents were included in the final analysis. The majority of veterinarians (80%) indicated that their knowledge about foot care was part of their veterinary education, 34% developed or refined their skills and understanding through experience and attendance at various continuing education programs, and 9% cited additional training from attendance at a formalized foot care program. Training cited by hoof trimmers included the following: 65% apprenticeship with another trimmer, 41% professional hoof care training program, and 30% learning primarily through experience. Sixty-eight percent of veterinarians reported removing all loose horn adjacent to the lesion without causing it to bleed, compared to 86% of hoof trimmers ($P < 0.01$). Seventy-six percent of veterinarians reported routine application of a foot block to the sound (healthy) claw when treating sole ulcers compared to 86% of hoof trimmers ($P < 0.05$). Topical medications for ulcers and abscessed claw horn lesions were used by 59% of veterinarians and 53% of hoof trimmers. The medication used most frequently was the powder form of tetracycline or oxytetracycline (48% by veterinarians and 81% by hoof trimmers). The majority of survey participants did not recommend withholding milk following topical treatment with tetracycline or oxytetracycline. Both survey groups agreed that sole ulcers were a painful condition, but the majority of veterinarians did not recommend analgesics for the treatment of sole ulcer lesions.

Key words: dairy cattle, lameness, hoof trimming, claw lesions

Résumé

Une enquête a été menée auprès des membres de l'*American Association of Bovine Practitioners* (AABP) et de l'*Hoof Trimmers Association* (HTA) afin d'identifier les différentes méthodes de traitement des lésions des onglons. Un total de 345 personnes ont répondu au questionnaire : 196 s'identifièrent comme membre de l'AABP, 11 comme membre de l'HTA, 9 comme membre des deux associations alors que 29 n'étaient pas membres de ni l'une ni l'autre des associations. À l'analyse finale, on a retenu un total de 307 répondants. La plupart des vétérinaires (80%) ont indiqué que leur connaissance concernant le soin des onglons faisait partie de leur éducation vétérinaire, 34% développèrent ou raffinèrent leurs compétences et compréhension par eux-mêmes et en participant à des cours de formation continue, et 9% citèrent une formation supplémentaire acquise en participant à des cours spécialisés sur le soin des onglons. La formation des pareurs d'onglons était variée : 65% participèrent à un programme d'apprentis avec d'autres pareurs, 41% suivirent des programmes de formation professionnelle sur le soin des onglons, et 30% apprirent principalement par eux-mêmes. Un total de 68% des vétérinaires déclarèrent pouvoir enlever toute la corne lâche près d'une lésion sans entraîner de perte de sang alors que ce total atteignait 86% chez les pareurs d'onglons ($p < 0.01$). L'utilisation d'un bloc apposé à l'onglon sain lors du traitement d'ulcère de

la sole était rapportée par 76% des vétérinaires par rapport à 86% des pareurs d'onglons ($p < 0.05$). Des médicaments topiques pour le traitement des ulcères et d'abcès de la corne des onglons étaient utilisés par 59% des vétérinaires et par 53% des pareurs d'onglons. Le médicament le plus souvent utilisé était la tétracycline ou l'oxytétracycline sous forme de poudre (48% des vétérinaires et 81% des pareurs d'onglons). La plupart des répondants ne recommandaient pas de retirer le lait suivant l'utilisation d'un traitement topique avec la tétracycline ou l'oxytétracycline. Les deux groupes à l'étude s'entendirent pour dire que les ulcères de la sole étaient douloureux mais la majorité des vétérinaires ne recommandaient pas l'utilisation d'analgésiques pour le traitement des lésions de la sole ulcérée.

Introduction

Lameness is a worldwide health problem in dairy cattle contributing to reduced milk yield, decreased reproductive performance, premature culling, and increased costs associated with treatment of lame animals.[2,3,6,8,9,29] Welfare concerns relate to pain, transportation, and handling of lame cows.[5,7] Efforts to find a pharmacological intervention for pain associated with lameness have not yielded desired outcomes associated with either US Food and Drug Administration approval or withdrawal times for milk and meat.[4,17,25,27]

Claw horn lesions such as sole ulcers, white line disease, and traumatic lesions of the sole (sole punctures or foreign bodies) are commonly associated with lameness and elevated locomotion scores.[31] The scientific literature contains little information regarding specific treatment protocols for claw horn lesions, while there is more information on treatment of infectious skin disorders of the foot (i.e. interdigital necrobacillosis, digital dermatitis, interdigital dermatitis and heel horn erosion). Digital dermatitis, a widespread condition affecting both the beef and dairy industry, has the most documented treatment protocols in the literature.[1,9,11,24,30]

Reported treatments for sole ulcers and white line disease include therapeutic trimming of the affected claw with or without the application of a hoof block to the unaffected claw, and producer-dependent use of systemic antibiotics and analgesics.[12] The majority of treatments reported in the literature were not evaluated by means of a randomized clinical trial; therefore, treatments are often based on anecdotal information, which may result in empirical treatment regimens with the potential for doing more harm than good to tissues of the sole.

We hypothesize that the most common topical treatments in North America include tetracycline or oxytetracycline soluble powder and copper sulfate. Both compounds are listed as skin irritants on material safety data sheets (MSDS) available through a variety of sources.[a,b] Oxytetracycline's MSDS advises against application to broken skin lesions due to its irritant properties and access to the bloodstream. Cattle treated using intramuscular injections of oxytetracycline can have injection-site reactions leading to tissue damage and potential abscess formation.[19]

Copper-containing compounds, including copper sulfate, are used for topical treatment of skin lesions and other conditions. Copper sulfate is also routinely used in foot baths for treatment and control of digital dermatitis.[10] Topical application of copper sulfate and/or astringents, followed by bandaging, is also recommended to control infection and prevent regrowth of granulation tissue in the treatment of sole ulcers.[13,22]

The purpose of this survey was to document the most common approaches used by veterinarians and hoof trimmers for treatment of claw horn lesions. For the present study, a survey was distributed to both veterinarians and hoof trimmers through the American Association of Bovine Practitioners (AABP) and the Hoof Trimmers Association (HTA). Members of these organizations were invited to participate in an online survey where both groups were asked the same set of questions concerning their experience treating bovine claw horn lesions.

Material and Methods

Data Collection

Information on the treatment practices of veterinarians and hoof trimmers was obtained from an online questionnaire that members of AABP and HTA could access using the web-based program, SurveyMonkey® (www.surveymonkey.com). This program was chosen because it allowed participants to remain anonymous. The survey contained a variety of close-ended questions, in some cases permitting participants to choose more than one response. Some questions allowed respondents to supplement their choices with additional comments, which were reviewed and summarized by the study authors.

The online questionnaire was publicized on AABP's email list serve (AABP-L) and was made available on AABP's website under "QuickLinks" from February 23 to May 6, 2013. Information on participation in the survey was made available to members of the HTA through both the HTA newsletter and an announcement at the HTA biannual meeting in February 2013. The survey closed May 6, 2013.

Content of the Survey

Survey questions related to the training and experience level of respondents, including number of years trimming and/or treating lameness disorders, type of training, number of cows trimmed or treated weekly, and length of time required to trim and treat a foot prob-

lem. Additional questions focused on issues related to topical antibiotic therapies and concerns about potential drug residues in milk or meat from treated animals. Questions assessing the use of systemic antibiotics and analgesics were included. Respondents were also asked about types of bandage materials used on sole ulcers, and bandage removal policies. The project was reviewed by the institutional review board of Iowa State University, and declared exempt from human subject protections regulations as described in 45 CFR 46.101(b).

Statistical Analysis

Statistical analysis was performed using IBM SPSS Statistics, Version 21. A chi-square analysis was performed to evaluate differences between hoof trimmers and veterinarians regarding the following topics: routine use of topical medications, application of a claw block to the contralateral (healthy) claw, and approach to trimming sole ulcers.

Results

A total of 345 surveys were completed, 29 of which were discarded because the respondents failed to identify their organization affiliations. Nine people reported memberships in both the AABP and HTA, and their information was removed from the data set to allow us to focus on comparison between hoof trimmers and veterinarians. A total of 307 surveys were used in the analysis: 64% of respondents were veterinarians affiliated with AABP and 36% were hoof trimmers affiliated with HTA.

The majority of veterinarians (80%) indicated that most of what they learned about foot care was part of their veterinary education; 34% developed or refined their skills and understanding through experience and attendance at various continuing education programs; and 9% cited additional training from attending a formalized foot care program. Training cited by hoof trimmers included the following: 65% served an apprenticeship with another trimmer, 41% attended a professional hoof care training program, and 30% indicated learning primarily through experience.

Table 1 documents the type of equipment used by both veterinarians and hoof trimmers. When asked about restraint devices used for foot work, AABP members reported using whatever was available on the farm. Most AABP members (61%) reported having no chute available, whereas HTA members were more likely to use a trimming chute. AABP members (52%) used hoof knives as their primary trimming tool, while 91% of HTA members reported using an angle grinder, with most (96%) utilizing a chipper wheel.

The majority of members in both organizations took a corium-sparing approach to the therapeutic trimming of a sole ulcer, described as removing all the loose horn adjacent to the ulcer with the goal of not making the corium bleed (Table 2). This method is used by a higher percentage of HTA members (86%) compared to AABP members (68%; $P < 0.01$).

Information about hoof block application and use of topical medications for treatment of sole ulcers is summarized in Table 2. The majority of participants routinely place a claw block on the contralateral claw after treating a sole ulcer (AABP 76% vs HTA 86%; $P < 0.05$), which indicates that hoof trimmers are more likely to use a block to relieve weight bearing on damaged claws than veterinarians. Over half of the respondents

Table 1. Details regarding equipment used by veterinarians and hoof trimmers.

	Overall response (%)		Response (%) by group	
			AABP	HTA
Type of restraint used for foot trims*	301 (98)	No chute, manual restraint	117 (61)	0 (0)
		Manual standing chute	84 (44)	7 (6)
		Hydraulic standing chute	19 (10)	49 (45)
		Tilt table	65 (34)	53 (49)
Primary tool used to trim feet	295 (96)	Angle grinder	30 (16)	99 (91)
		Hoof nippers	59 (32)	5 (5)
		Knives	98 (52)	4 (4)
Type of wheel preferred by angle grinder users†	123 (95)	Chipper wheel	18 (64)	91 (96)
		Abrasive wheel	10 (36)	4 (4)

*Column percentages do not sum to 100; respondents could select multiple restraints.
†Only respondents answering positively to using angle grinders could respond to this question.

Table 2. Percentage of participants reporting on sole ulcer/abscess treatment details.

	Overall response (%)		Response (%) by group		
			AABP	HTA	*P*-value
Approach to trimming sole ulcers	270 (88)	Remove loose horn without drawing blood	119 (68)	83 (86)	< 0.01
		Remove loose horn until drawing blood	55 (32)	13 (14)	
Do you routinely apply a hoof block to the sound claw?	294 (96)	Yes	142 (76)	93 (86)	< 0.05
		No	44 (24)	15 (14)	
Do you routinely apply topical medications to sole ulcers and sole abscesses?	294 (96)	Yes	110 (59)	57 (53)	
		Tet/oxytet powder*†‡	53 (48)	46 (81)	< 0.009
		Tet/oxytet solution*†‡	28 (25)	4 (7)	< 0.003
		Copper sulfate*†	25 (23)	8 (14)	< 0.181
		QuickHit*†§	0 (0)	10 (18)	
		Ichthammol*†	16 (15)	12 (21)	< 0.064
		Other*†‡ ‖	36 (33)	13 (23)	< 0.182
		No	76 (41)	51 (47)	

*Only respondents answering positively to using topical medications could respond to this question.
†Column percentages do not sum to 100; respondents could select multiple topical medications.
‡Hoof trimmers and veterinarians differed significantly.
§Chi-square analysis inappropriate; 1 cell with expected count < 5.
‖ Other choices listed include a variety of over-the-counter products such as iodine-containing products, sugar and scarlet oil, to name a few. Even though the percentage of participants choosing "other" was significant, the percentage of these products reported individually was less than 5%, so individual details of the products comprising the "other" category were left out of the table.

in both organizations reported that they routinely apply topical medication to sole ulcers (AABP 59% vs HTA 53%), with tetracycline or oxytetracycline products being the favored topical medications by members of both organizations. The response "other" was evaluated by the authors, and although a wide variety of over-the-counter products were reported, no single product or group of products were used sufficiently to warrant detailed documentation herein. Compared with veterinarians, hoof trimmers were more likely to report using tetracycline or oxytetracycline soluble powder ($P < 0.009$) and less likely to use tetracycline or oxytetracycline injectable solution applied topically to the lesion ($P < 0.003$). Because tetracycline and oxytetracycline products are used topically for treatment of claw horn lesions, the survey inquired about recommendations for meat or milk withholds. Overall, 84% of respondents (81% AABP and 86% HTA) reported that they did not recommend withholding milk following topical treatment with tetracycline or oxytetracycline products. There was no significant difference in recommendations between hoof trimmers and veterinarians ($P < 0.25$).

Survey responses regarding the use of analgesics in cattle with claw lesions were assessed only for AABP members, as hoof trimmers cannot legally make treatment recommendations for use of prescription medications. The majority of AABP respondents (76%) did not recommend the use of analgesics for treatment of sole ulcer lesions.

Discussion

Veterinarians and hoof trimmers were unanimous in their belief that the proper way to trim a sole ulcer is to remove all loose and necrotic horn adjacent to the lesion; however, they differed slightly in their concern about peripheral damage to adjacent corium tissues resulting in hemorrhage. The practice of removing damaged horn while leaving the corium intact was originally documented by the late Toussaint Raven as the final step of corrective trimming the bovine claw,[23] and others have adopted these corium-sparing techniques.[14,15,18,21,26,32,33] One of the caveats to avoiding damage to the corium is the growth of granulation tissue. The presence of granulated corium accompanying a sole ulcer has been associated with delayed healing of a claw horn lesion by a ratio of 1:2.4.[32] As a result, exuberant granulation tissue on the corium should be surgically removed.[20,32]

Application of a claw block to the contralateral claw as part of a claw horn lesion treatment protocol was common practice among veterinarians and trimmers.

This survey found more trimmers (86%) reporting the use of claw blocks than veterinarians (76%); however, the questionnaire was not designed to determine why more trimmers place blocks than veterinarians. Specific treatment details of claw horn lesions in the literature is limited, but several reports support the use of a claw block on the contralateral claw.[12,14,16,18,21-23,26] The purpose of a claw block is to reduce weight bearing on the diseased claw. In contrast, several authors report not using a claw block if they can adequately reduce weight bearing on the injured claw by transferring weight to the contralateral claw and lowering the weight-bearing surface over the injured area. This reduces pressure on the affected claw when the cow places the foot on a solid surface.[12,14,15,18,23,33] It is unclear why hoof trimmers are more likely to place a claw block on the non-affected claw than veterinarians. It could be due to increased revenue generated for the trimmer when using a claw block, but one could argue the same is true for veterinarians. It is also possible that more trimmers use claw blocks than veterinarians because claw blocks can more easily be applied when the cow is well restrained, and 61% of veterinarians work on foot problems without the benefit of a trimming chute.

Approximately half of veterinarian and trimmer respondents reported routine use of topical medications when treating claw lesions. Of respondents who replied "yes" to using topical medications, the most common medication used by veterinarians and trimmers was tetracycline or oxytetracycline powder, followed by copper sulfate for veterinarians and ichthammol ointment for trimmers. Other surveys have evaluated treatment philosophies among producers, veterinarians and claw trimmers;[12,16] however, neither of these studies inquired about specific use of topical therapies to treat claw horn lesions. A study published in 1997 evaluated the outcome in cows treated for claw horn lesions with either a claw block or only a bandage containing 20 g of copper sulfate.[22] The authors reported that using a claw block alone increased the rate of recovery within the first 7 days of block placement compared to applying a bandage alone. However, differences in healing were only significant for the first 7 days following treatment, and by day 14 post-treatment there was no significant difference in recovery between cows treated with a claw block or a bandage containing copper sulfate. Sala and associates compared the use of wooden or plastic claw blocks to topical medicated wraps containing copper and zinc chelates in a gel.[26] These authors concluded the application of a claw block appeared to improve the healing rate when compared to cows not receiving a claw block, and the significance of the wrap containing the gel product could not be determined.

The majority of veterinarians responding to the survey indicated they do not suggest using analgesics as part of sole ulcer treatment, which is similar to the responses from British veterinarians treating claw disease in cattle.[16] AABP members responded that their primary reasons for not recommending the use of analgesics in cows with claw lesions included concerns about drug efficacy (41%), and that there are no approved products for pain management in cattle (26%). The only non-steroidal anti-inflammatory drug currently approved for use in cattle in the United States is flunixin meglumine, and its labeled use is for pyrexia resulting from bovine respiratory disease and mastitis, as well as control of inflammation associated with endotoxemia.[28]

Conclusion

Veterinarians gain most of their hoof care knowledge from their veterinary education, whereas hoof trimmers acquire much of their understanding and skills through an apprenticeship or attendance at a foot-care training program. Members from both groups reported learning from experience. Hoof trimmers and veterinarians differ significantly when it comes to treatment of claw horn lesions in cattle. Hoof trimmers are more likely to practice corium-sparing therapeutic trimming techniques as well as place a block on the healthy, contralateral claw compared to veterinarians. In general, trimmers are better equipped to restrain feet and utilize power tools when trimming feet. Many veterinarians still use manual restraint for examination and treatment of lame cows.

Veterinarians have broader responsibilities in health care and likely see more complicated foot problems that may require surgery. Although veterinarians in general feel that claw horn lesions are painful, the majority do not commonly recommend extra-label use of currently available analgesics. The most common topical medication used for treatment of claw horn lesions is tetracycline or oxytetracycline, with hoof trimmers more commonly using soluble powder or granular tetracycline products than injectable forms. Significantly more veterinarians used tetracycline or oxytetracycline solutions topically to treat claw horn lesions compared to hoof trimmers.

Endnotes

[a]Old Bridge Chemicals I. *Copper Sulfate*. MSDS Copper Sulfate. Available online at: http://www.cen.iitb.ac.in/cen/usage-policies/msds/CopSulOBFeeGra-m.pdf. 2013. Accessed October 14, 2013.

[b]Santa Cruz Biotechnology I. *Oxytetracycline Hydrochloride*. MSDS. Santa Cruz Biotechnology, Inc., 2145 Delaware Avenue, Santa Cruz, CA 95060. Available online at: http://datasheets.scbt.com/sc-205785.pdf. 2013. Accessed October 14, 2013.

Acknowledgements

The authors gratefully acknowledge funding for this study from a grant by the Hoof Trimmers Association and the American Association of Bovine Practitioners Foundation.

The authors declare no conflict of interest.

References

1. Arkins S, Hannan J, Sherington J. Effects of formalin footbathing on foot disease and claw quality in dairy cows. *Vet Rec* 1986; 118:580-583.
2. Booth CJ, Warnick LD, Grohn YT, Maizon DO, Guard CL, Janssen D. Effect of lameness on culling in dairy cows. *J Dairy Sci* 2004; 87:4115-4122.
3. Cha E, Hertl JA, Bar D, Grohn YT. The cost of different types of lameness in dairy cows calculated by dynamic programming. *Prev Vet Med* 2010; 97:1-8.
4. Chapinal N, de Passille AM, Rushen J, Wagner S. Automated methods for detecting lameness and measuring analgesia in dairy cattle. *J Dairy Sci* 2010; 93:2007-2013.
5. Flower FC, Weary DM. Effect of hoof pathologies on subjective assessments of dairy cow gait. *J Dairy Sci* 2006; 89:139-146.
6. Garbarino EJ, Hernandez JA, Shearer JK, Risco CA, Thatcher WW. Effect of lameness on ovarian activity in postpartum Holstein cows. *J Dairy Sci* 2004; 87:4123-4131.
7. Grandin T. Auditing animal welfare at slaughter plants. *Meat Sci* 2010; 86:56-65.
8. Green LE, Hedges VJ, Schukken YH, Blowey RW, Packington AJ. The impact of clinical lameness on the milk yield of dairy cows. *J Dairy Sci* 2002; 85:2250-2256.
9. Hernandez J, Shearer JK, Webb DW. Effect of lameness on the calving-to-conception interval in dairy cows. *J Am Vet Med Assoc* 2001; 218:1611-1614.
10. Hoffman A. Footbaths for the treatment or control of hairy heel warts (digital dermatitis) in dairy herds: summary of seven studies. Washington State University Veterinary Medicine Extension: Washington State University. 2012.
11. Holzhauer M, Bartels CJ, van Barneveld M, Vulders C, Lam T. Curative effect of topical treatment of digital dermatitis with a gel containing activated copper and zinc chelate. *Vet Rec* 2011; 169:555.
12. Horseman SV, Whay HR, Huxley JN, Bell NJ, Mason CS. A survey of the on-farm treatment of sole ulcer and white line disease in dairy cattle. *Vet J* 2013; 197:461-467.
13. Ishler V, Wolfgang D, Griswold D. Prevention and control of foot problems in dairy cows. Penn State Cooperative Extension Service: Pennsylvania State University, 1999.
14. Laven RA, Lawrence KE, Weston JF, Dowson KR, Stafford KJ. Assessment of the duration of the pain response associated with lameness in dairy cows, and the influence of treatment. *New Zealand Vet J* 2008; 56:210-217.
15. Leach KA, Tisdall DA, Bell NJ, Main DCJ, Green LE. The effects of early treatment for hindlimb lameness in dairy cows on four commercial UK farms. *Vet J* 2012; 193:626-632.
16. Lowe KAO, Murray RD, Cripps PJ, Ward WR. Working practices of cattle foot trimmers used for foot care in dairy cattle compared with those of veterinary surgeons for treatment of lameness in large animal practice. *J Vet Med* Series A 2004; 51:429-434.
17. Malreddy PR, Coetzee JF, KuKanich B, Gehring R. Pharmacokinetics and milk secretion of gabapentin and meloxicam co-administered orally in Holstein-Friesian cows. *J Vet Pharmacol Ther* 2013; 36:14-20.
18. Montgomery JA, Forgan K, Hayhurst C, Rees E, Duncan JS, Gossellein J, Harding C, Murray RD. Short term effect of treating claw horn lesions in dairy cattle on their locomotion, activity and milk yield. *Vet Sci Dev* 2012; 2:e7.
19. Nouws JFM, Smulders A, Rappalini M. A comparative study on irritation and residue aspects of five oxytetracycline formulations administered intramuscularly to calves, pigs and sheep. *Vet Quart* 1990; 12:129-138.
20. Oana L, Miclaus V, Pestean C, Ober C, Mates N, Ognean L, Negrea O. Clinical, therapeutically and histopathological aspects in bovine sole ulcer. *Lucrari Stiintifice - Medicina Veterinara, Universitatea de Stiinte Agricole si Medicina Veterinara "Ion Ionescu de la Brad" Iasi* 2009; 52:698-701.
21. Paton R. Treating bovine sole ulcers - an alternative to amputation of granulation tissue. *UK Vet: Livestock* 2010; 15:29-31.
22. Pyman MFS. Comparison of bandaging and elevation of the claw for the treatment of foot lameness in dairy cows. *Aust Vet J* 1997; 75:132-135.
23. Raven ET. *Cattle footcare and claw trimming.* Ipswich (United Kingdom): Farming Press, Limited, 1989; 19-33.
24. Relun A, Lehebel A, Bareille N, Guatteo R. Effectiveness of different regimens of a collective topical treatment using a solution of copper and zinc chelates in the cure of digital dermatitis in dairy farms under field conditions. *J Dairy Sci* 2012; 95:3722-3735.
25. Rushen J, Pombourcq E, de Passille AM. Validation of two measures of lameness in dairy cows. *Appl Anim Behav Sci* 2007; 106:173-177.
26. Sala A, Igna C, Schuszler L. Comparative aspects of pododermatitis circumscripta (sole ulcer) treatment in dairy cow. *Bulletin of University of Agricultural Sciences and Veterinary Medicine Cluj-Napoca. Vet Med* 2008; 65:207-211.
27. Schulz KL, Anderson DE, Coetzee JF, White BJ, Miesner MD. Effect of flunixin meglumine on the amelioration of lameness in dairy steers with amphotericin B-induced transient synovitis-arthritis. *Am J Vet Res* 2011; 72:1431-1438.
28. Smith GW, Davis JL, Tell LA, Webb AI, Riviere JE. Extralabel use of nonsteroidal anti-inflammatory drugs in cattle. *J Am Vet Med Assoc* 2008; 232:697-701.
29. Sogstad AM, Osteras O, Fjeldaas T, Nafstad O. Bovine claw and limb disorders related to culling and carcass characteristics. *Livestock Sci* 2007; 106:87-95.
30. Speijers MHM, Baird LG, Finney GA, McBride J, Kilpatrick DJ, Logue DN, O'Connell NE. Effectiveness of different footbath solutions in the treatment of digital dermatitis in dairy cows. *J Dairy Sci* 2010; 93:5782-5791.
31. Tadich N, Flor E, Green L. Associations between hoof lesions and locomotion score in 1098 unsound dairy cows. *Vet J* 2010; 184:60-65.
32. van Amstel SR, Shearer JK, Palin FL. Case report–clinical response to treatment of pododermatitis circumscripta (ulceration of the sole) in dairy cows. *Bov Pract* 2003; 37:143-150.
33. Whay HR, Waterman AE, Webster AJF, O'Brien JK. The influence of lesion type on the duration of hyperalgesia associated with hindlimb lameness in dairy cattle. *Vet J* 1998; 156:23-29.