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Factors associated with the occurrence of claw disorders in dairy cows under smallholder production systems in urban and peri-urban areas of Nairobi, Kenya

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ABSTRACT

A cross-sectional study was carried out between December 2005 and June 2006 in smallholder dairy farms within and around Nairobi, Kenya to determine risk factors associated with the occurrence of claw disorders in dairy cows. Farm-and cow-level factors were evaluated in 32 farms and 300 cows respectively. The occurrence of claw disorders was determined. Chronic laminitis was significantly ($P<0.05$) associated with three or higher parities ($\chi^2 = 11.57$, $P = 0.009$), lactation period between 90 to 180 days ($\chi^2 = 9.75$, $P = 0.021$), overstocking (O.R. = 1.7, $\chi^2 = 24.29$, $P = 0.0002$), absence of cubicle bedding (O.R. = 1.6, $\chi^2 = 29.13$, $P = 0.003$), earthen floor (O.R. = 1.5, $\chi^2 = 8.98$, $P = 0.0006$) and a curb dividing walk-alleys and cubicles (O.R. = 1.5, $\chi^2 = 5.06$, $P = 0.0262$). Subclinical laminitis was significantly ($P<0.05$) associated with lactation period between 1-90 days ($\chi^2 = 9.06$, $P = 0.028$), and concentrate feeding (O.R. = 2.08, $\chi^2 = 5.5$, $P = 0.0212$). However, lack of mineral supplementation and leaving manure (slurry) in the walk alleys for a long time seemed to enhance laminitis. Concentrate feeding had positive (contributor) (β-estimate = 2.187, $P<0.05$) association with sole bruising, while mineral supplementation (β-estimate = -4.59, $P<0.05$) and earthen floor (β-estimate = -1.796, $P<0.05$) had negative (protector) association. White line separation was enhanced by concentrate feeding (β-estimate = 3.69, $P = 0.002$), but reduced by mineral supplementation (β-estimate = -4.07, $P<0.05$), and frequent manure (slurry) removal from walk-alleys (β-estimate = -3.58, $P<0.05$). Non-slip and non-defective concrete floors were negatively (protectively) (β-estimate = -1.969, $P<0.05$) associated with heel erosion.

Key words: claw disorders, farm-level factors, dairy cows, smallholder

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Introduction

Small-scale farms contribute 80% of the national commercial dairy herd in Kenya (WANYOIKE and WAHOME, 2004). The smallholder dairy production systems in Kenya have varied designs and management practices. The housing designs vary from farm to farm, and there is neither a standard nutritional regimen nor a management protocol consistent for all the farms. All these vary from farm to farm and even within individual farms.

Lameness in cattle is one of the main causes of poor economic output (KOSSAIBATI and ESSLEMONT, 1997; HERNANDEZ et al., 2005). It has a multifactorial aetiology resulting from interaction of factors related to housing, management, nutrition and animal factors (CLARKSON et al., 1996). Claw horn disorders in cattle are discernible at clinical level by causing lameness or at subclinical level by hoof trimming (CLARKSON et al., 1996; NOCEK, 1997).

Rapidly fermented carbohydrates and finely chopped silage have a capacity to develop subacute ruminal acidosis (SARA) when fed in excessive quantities. SARA is common when concentrate to forage (C:F) ratio in the feed is high. Prolonged reduction in rumen pH triggers laminitic processes that increase prevalence of lameness in cattle (VERMUNT, 2004). Excessive protein feeding has also been associated with laminitis and increased horn-growth (VERMUNT, 2004; SOMERS et al., 2005). Nutritional effects leading to laminitis are commonest from transitional diets of high concentrates fed in the peri-parturient period (DONOVAN et al., 2004).

Trace-minerals fed to cattle improve claw health and reduce the lesion scores (TOMLINSON et al*.,* 2004). Claw horn macro-cracks were observed to diminish in biotin supplemented animals (HIGUCHI and NAGAHATA, 2001). Vitamins A, D and E are reported to help the keratinization process that improves claw-horn integrity and decreases lesion incidence (TOMLINSON et al*.,* 2004).

Dairy cows lie down for long periods in comfortable stalls, but spend long periods standing in walk-alleys when stalls are uncomfortable. This means the claws remain in a wet slurry environment and are loaded for long periods. Cows exposed to such conditions were reported eventually to have more sole haemorrhages and other claw lesions (LEONARD et al., 1994). Standing long in a wet environment increases claw moisture content and softens the horn of the sole. Such claws are easily penetrated by foreign materials and abraded by concrete floors, resulting in more claw lameness (VERMUNT, 2004).

A positive correlation was reported between long periods of standing on concrete floors and incidence of claw lesions in cattle (SOMERS et al., 2003). The abrasiveness of concrete floors, hygiene and moisture content of the floor are important factors in development of claw disorders (VOKEY et al., 2001). Adequate room in the cow house

allows for enough exercise, which is good for blood circulation in the claws (SOGSTAD et al., 2005).

Earthen floors and straw yards do not cause claw-horn wear. Cows raised on such ground surfaces often have overgrown claws that inevitably become overloaded at specific zones, thus being highly predisposed to claw-horn lesions (RHEBUN and PEARSON, 1982; SOMERS et al., 2003). Features of stall design such as lack of ground surface cushion (particularly cubicle bedding), low divider rail, limited lunge space, and high rear curbs are incriminated as causes of increased claw-horn lesions by contributing stress to the claws during the act of rising and movement of cows (LEONARD et al., 1994; PHILIPOT et al., 1994; FAULL et al., 1996).

Incidence of lameness in dairy cows is highest in the first 120 days and lowest in the last three months of lactation due to the stress of heavy milk yield (ROWLANDS et al., 1985) and high energy feed intake in early lactation (VERMUNT, 2004). The incidence of lameness was reported to increase at a rate of 8% units per lactation (ESPEJO et al., 2006). More sole lesions were found in primiparous than multiparous cows (BERGSTEN, 1994; BERGSTEN and HERLIN, 1996). However, whether in primiparous or multiparous cows, physiological processes at peri-parturient period favour development of claw lesions (BERGSTEN and FRANK, 1996; TARLTON et al., 2002).

A qualitative (observational) description of association between risk factors and claw lesions in cattle has been documented (SOMERS et al., 2003; COOK et al., 2004; SOGSTAD et al., 2005). However, there is lack of quantitative (statistical) description of such associations in the smallholder dairy production systems. The Kenyan smallholder production system is unique because it consists of smallholder subunits that are not uniform but vary in housing designs, nutritional regime and management protocol from farm to farm. The main objective of this study was therefore to find out what type of cow-and farm-level factors as well as dairy cow claw disorders exist in such varied smallholder production systems, and then try to statistically quantify the association between them.

Materials and methods

Study area. The study was carried out within and around Nairobi, Kenya. Nairobi is the capital city of Kenya with an area of 696 square kilometers and over 2.1 million people. It is a fertile agricultural region lying between 01° 18´S and 36° 45´E. It is 1798 metres above sea level and has an annual rainfall estimated at 765 mm maximum and 36 mm minimum in two distinct seasons (March to June, and October to December). The region has a high concentration of zero-grazed smallholder dairy farms owing to its ready market for milk and other dairy products.

Sample size. A purposive selection was made of 29 zero-grazed smallholder dairy farms each with 5-20 adult cows and 3 larger dairy farms each with more than 60 adult cows. The median number of cows in most of the farms was 10. The reasons for the purposive selection were logistical based on the difficulties of getting enough farms due to the unwillingness of most farmers to participate. Selection was facilitated by local veterinarians and animal health technicians with whom the farmers were more acquainted. From these 32 dairy farms, a total of 300 cows were recruited for the study using simple systematic sampling. Friesians accounted for 76% (228), Ayrshires 20% (60) and the remaining 4% (12) were a mixture of Guernsey and Jersey. The majority (83%) of them were zero-grazed and 17% were pasture-grazed.

The cows that were included in the study were those that had calved at least once. The proportion of those with 3rd and 4th parities was 60% and those in the 1st and 2nd parities were 40%. Both lame and non-lame cows of any dairy breed were included. In each farm, cows that had the study criteria were tagged with serial numbers 1, 2, 3, to n, where n was the serial number of the last cow being selected in the farm. To avoid biased numbering, assigning of serial numbers was randomly done by an independent farm worker. The first author did systematic selection of individual cows from the serialized groups by picking every second one from the serial numbers. For example in the serial n_1, n_2, n_3, n_4, n_5, n_6, n_7, n_8, n_9, n_{10}, if the first cow selected was n_1, the next serially would be n_3, n_5, n_7 and n_9. But if the first cow selected was n_2, the next serially would be n_4, n_6, n_8 and n_{10}. The serial number of the first cow selected was alternated from farm to farm. In the first farm cow number 1 was selected first, in the second farm cow number 2 was selected first, in the third farm cow number 1 and in the fourth farm cow number 2. This pattern was repeated until all the farms were covered. Therefore, the cows selected in any farm were those with either odd or even serial numbers.

Data collection. Data on cow-level factors were collected by the first author (as interviewer) administering questionnaires either to farmers, farm managers or stockmen (as respondent interviewees) before examination of each cow. The data which included breed, parity, milk yield per day, and lactation stage were pre-coded and recorded in the questionnaires. The questionnaires were structured simple "Yes" and "No" and "I do not know" responses to minimize variations and information bias from the respondents.

Data on farm-level factors were collected during visitation to each of the 32 farms. Some data (housing and stall design, presence and number of cubicles, type of cubicle bedding and floor, presence or absence of a curb, and lunging space, and adequacy of feeding space) were collected through observation. Other data such as curb height were collected through measurements, while the rest (frequency of concentrate feeding, mineral supplementation, type of fodder, and frequency of manure removal from the walk-alleys were collected by the first author interviewing the farmer, farm managers or stockmen.

All the data were entered into the questionnaires using codes adopted at the pre-coding stage during an initial pilot study in 5 sample farms.

Data on claw disorders were collected by examining only the hind claws of each cow. Each cow was restrained in a standing posture in the farm crush. Lifting of one hind limb at a time was done using a rope tied to an overhead pole or cross-bar. The claws were thoroughly washed with soap and water and examined for any lesions particularly on the weight-bearing surface. About 1-2 mm thickness of the horn of the sole was trimmed-off using a sharp quittor knife to expose any underlying lesions. Trimming did not reach level of the corium and therefore no pain was caused to the cows. In cases with painful claw conditions, foot anaesthesia using 2% lignocaine hydrochloride was applied to allow painless manipulation. The lesions found on each cow were recorded.

Data management and analysis. The data were imported into SAS© 2002-2003 (SAS Institute Inc., Cary, NC, USA). Descriptive statistics were computed for cow-level and farm-level factors. The prevalence rate of each claw disorder was calculated independent of other claw disorders.

The prevalence of each claw disorder was calculated as the number of cows (CL) affected by the specific claw disorder divided by the total number of cows (300) examined multiplied by 100.

$$\text{Prevalence (\%)} = \frac{CL}{300} \times 100$$

Chi-square (χ^2) statistics were used to determine unconditional associations between all risk factors and the claw lesions. An association was considered significant at the level of $P<0.05$. Multiple logistic regressions were done through a step-down regression in which the risk factors that made the least variation to the occurrence of the claw lesions were eliminated one at a time through consideration of their odds ratios. Only the factors that were found to influence the occurrence of claw lesions significantly were retained in the model. The effects of confounding the risk factors were dealt with in the analysis but they were minimal because of the similarities of the management in the smallholder farms.

Results

The results of this study revealed that dairy cows from the varied smallholder farms in Kenya have a high (88%) prevalence of claw lesions and 69% of these are subclinical. The highest prevalence was in laminitis (70%) with subclinical laminitis being higher (49%) than chronic laminitis (21%). No cases of acute laminitis were encountered. Other disorders with high prevalence were sole bruising (45%), regular claw overgrowth (30%), heel erosion (27%), white line separation (18%) and double (underrun) soles (17%).

Conversely, cases of digital infections had low prevalence (4.7%) mainly being digital dermatitis and interdigital necrobacillosis.

The farm survey showed that the concentrate feeds used were referred to as 'Dairy Meal' (Manufactured by Unga Farmcare limited, Kenya). Information provided from the manufacturer indicated that the average constituents of the concentrate feeds were protein (15.5% to 16%), oils (6% to 8%), fibre (9% to 10%) and moisture (12%). The concentrates were in fine ground-grains physical form. It was also found that in the farms that practiced regular concentrate feeding, each cow was fed with 6 to 8 kilograms per day. The forages that were used were either Napier, Rhodes, or mixed wild grasses. These were fed in wilted or dried form and very occasionally in succulent form. The Napier grass was fed to the cows in chopped small pieces but the Rhodes and wild grasses in whole lengths without chopping. No single farm used any standardized concentrate to forage ratios.

The standard mineral supplements used in these farms averagely consisted of sodium chloride (18% to 20%), calcium (16% to 18%), phosphorus (11% to 12%), magnesium (2.5% to 3%), iron (0.5%), copper (0.16%), Manganese (0.4%), zinc (0. 5%), sulphur (0.4%), cobalt (0.02%), iodine (0.02%) and selenium (0.0015%).

The observed claw disorders that were tested for association with cow-level and farm-level risk factors were subclinical and chronic laminitis, white line separation, heel erosion, sole bruising, double soles, sole ulcers, sole foreign bodies, and claw deformities such as claw overgrowth, concave claws, flattened claws, widened claws, corkscrew claws and splayed claws.

The results of this study indicated that 3rd or higher parities ($\chi^2 = 11.57$, $P = 0.009$) and lactation stage between 90 to 180 days ($\chi^2 = 9.75$, $P = 0.021$) were significantly associated with chronic laminitis. But lactation stage between 1 to 90 days was significantly ($\chi^2 = 9.06$, $P = 0.028$) associated with subclinical laminitis.

From the descriptive statistics, the farm-level factors that were shown to have unconditional association with subclinical laminitis were failure to remove manure (more than one day) from the walk-alleys ($r = 0.215$, $\chi^2 = 13.85$, $P<0.001$), regular (2-4 times per day) concentrate feeding ($r = 0.135$, $\chi^2 = 5.45$, $P = 0.0196$) and lack of or inadequate mineral supplementation ($r = 0.172$, $\chi^2 = 8.9$, $P = 0.0307$) (Table 1).

However stepwise logistic regression analysis (screening interactions of floor types, presence or absence of cubicles, type of cubicle bedding, manure removal, concentrate feeding, type of fodder and mineral supplementation) revealed that the most significant farm-level contributor to the occurrence of subclinical laminitis was regular concentrate feeding (O.R. = 2.08, $\chi^2 = 5.5$, 95% C.I: 1.1 to 3.9, $P = 0.0212$).

Table 1. Association of subclinical laminitis with farm-level factors in a study carried out in 300 dairy cows from 32 farms to evaluate digital characteristics of laminitis and related claw lesions in Nairobi and its environs (December 2005-June 2006)

Farm variables	χ^2	r-value	P-value
Lack of manure removal	13.85	0.2149	< 0.001
High concentrate feeding	5.45	0.1348	0.0196
Lack of mineral supplementation	8.9	0.1722	0.0307
Floor types	5.52	0.1356	0.02381
Overstocking (fewer cubicles than cows)	6.2	0.1438	0.1844
Type of cubicle bedding	7.2	0.1549	0.5155
Presence of a curb	0.13	0.021	0.9361
Fodder type	3.26	0.104	0.5151

Table 2. Association of chronic laminitis with farm-level factors in a study carried out in 300 dairy cows from 32 farms to evaluate digital characteristics of laminitis and related claw lesions in Nairobi and its environs (December 2005-June 2006)

Farm variables	χ^2	r-value	P-value
Overstocking (fewer cubicles than cows)	38.87	0.36	< 0.0001
Absence of cubicle bedding (bare concrete)	29.13	0.312	0.0003
Manure removal (infrequent)	23.33	0.279	< 0.0001
Earthen floor type	12.33	0.203	0.0151
High concentrate feeding	14.25	0.218	0.0002
Lack of mineral supplementation	30.85	0.321	< 0.0001
Presence of a curb	7.43	0.157	0.0244

Descriptive statistics indicated the farm-level factors that had unconditional association with chronic laminitis. These were overstocking (fewer cubicles than the number of cows) ($r = 0.36$, $\chi^2 = 38.87$, $P<0.0001$), presence or absence of cubicle bedding ($r = 0.312$, $\chi^2 = 29.13$, $P = 0.0003$), earthen floor ($r = 0.203$, $\chi^2 = 12.33$, $P = 0.0151$), presence of a high curb between walk-alley and the cubicles ($r = 0.157$, $\chi^2 = 7.43$, $P = 0.0244$), leaving manure (more than one day) in the walk-alleys ($r = 0.279$, $\chi^2 = 23.33$, $P<0.0001$), regular (2-4 times per day) feeding with concentrates ($r = 0.218$, $\chi^2 = 14.25$,

P = 0.0002), and regular (once per day) mineral supplementation (r = 0.321, χ^2 = 30.85, P<0.0001) (Table 2).

Furthermore, stepwise logistic regression analysis (testing interactions of all these unconditionally associated factors) pointed out the farm-level factors that most significantly contributed to the occurrence of chronic laminitis. These factors were: overstocking (O.R. = 1.7, χ^2 = 24.29, 95% C.I : 1.3 to 2.2, P = 0.0002), earthen floor (O.R. = 1.5, χ^2 = 8.98, 95% C.I:1.2 to 2.0, P = 0.0006), and presence of a curb between walk-alleys and the cubicles (O.R. = 1.5, χ^2 = 5.06, 95% C.I : 1.1 to 2.2, P = 0.0262).

In this study, regular (2-4 times per day) concentrate feeding seemed to significantly (β-estimate = 2.187, s.e. = 0.814, P = 0.007) enhance occurrence of sole bruising. However, earthen floor (bare soil) (β-estimate = -1.796, s.e. = 0.835, P<0.001) and regular (at least once per day) mineral supplementation (β-estimate = -4.59, s.e. = 1.50, P = 0.002) seemed to significantly protect against occurrence of sole bruising.

The study also indicated that removal of manure more than once per day significantly (β-estimate = -3.58, s.e. = 1.01, P<0.001) protected the claws against occurrence of white line separation, while regular (at least once per day) mineral supplementation was found to significantly (β-estimate = -4.07, s.e. = 2.05, P = 0.048) reduce the frequency of its occurrence. However, regular concentrate feeding seemed to significantly (β-estimate = 3.69, s.e. = 1.24, P = 0.003) enhance its occurrence.

Furthermore, good concrete floors (non-slip with no ground defects) seemed significantly (β-estimate = -1.969, s.e. = 0.597, P<0.001) protective against occurrence of heel erosion. There were no statistically significant associations found between the rest of the farm-level factors and the claw disorders.

Among the cows with chronic laminitis 89% were zero-grazed and only 11% were pasture-grazed. However, this difference was found to be statistically significant (χ^2 = 11.0, P<0.001)

Discussion

The strength of this paper is elaborated by the important variations in housing designs, nutritional regimes and management protocol in these smallholder dairy units. Although regular concentrate feeding in these farms for each cow meant 2 to 4 times per day, nevertheless the feeding frequencies and amounts in each farm were inconsistent and this was similar for mineral supplementation.

The results of this study indicated that most of the claw lesions encountered were laminitic in nature (NOCEK, 1997; BELGE and BAKIR, 2005) and this could highly suggest the presence of predisposing risk factors in the smallholder farms that were studied. Lactation period between 1 to 90 days is the time that subclinical laminitis is most prevalent. This could be attributed to the continuing effects of the transitional period

of feeding with high energy concentrates that cause subacute ruminal acidosis and vasoactive agents, subsequently triggering laminitic processes (DONOVAN et al., 2004; VERMUNT, 2004). The laminitic processes are further aggravated by the stress of heavy milk production during the first 90 to 120 days post-calving (ROWLANDS et al., 1985). Gradual progression of subclinical laminitis lesions culminates into chronic laminitis (NOCEK, 1997), which could explain the reason for association between the later stages of lactation and chronic laminitis.

The association between 3rd or higher parities with chronic laminitis agrees with previous findings by SOGSTAD et al. (2005) that most lameness is generally associated with third or higher parities.

The habit of leaving manure in the walk-alleys for more than one day enhanced development of both subclinical and chronic laminitis. This could be attributed to persistent wetness that causes excessive softening of the claw-horn making it easily susceptible to horn-lesions. With softer solear horn, pressure insult from the ground is easily transmitted to the underlying solear corium which then becomes traumatized, resulting in laminitis. These findings agree with previous reports (BORDERAS et al., 2004; VERMUNT, 2004).

The association of high concentrates feeding with subclinical and chronic laminitis as well as with sole bruising and white line separation is attributed to SARA and production of vasoactive substances. This initially triggers development of subclinical laminitis as has been reported previously (COOK et al., 2004; VERMUNT, 2004). Subclinical laminitis then predisposes the cow to other claw lesions (NOCEK, 1997).

Failure or inadequate supplementation of the cows with mineral mixtures was associated with enhanced development of subclinical and chronic laminitis as well as white line separation. This finding conforms to the reports stating that trace-minerals reduce claw lesion scores (TOMLINSON et al., 2004) and biotin supplementation reduces macro-cracks in the claws (HIGUCHI and NAGAHATA, 2001).

The positive association between overstocking and chronic laminitis may be attributed to the long hours of standing because of fewer cubicles. Standing for long periods causes prolonged pressure injury to the solear corium, thus being an exacerbating factor to the development of claw lesions as reported previously (LEONARD et al., 1994).

Further to this, the presence of a high curb between the walk-alley and the cubicles was found to be one of the main factors enhancing occurrence of chronic laminitis. This factor may possibly cause additional stress to the claws as the cow enters or disembarks from the cubicle, as has been suggested by others (LEONARD et al., 1994; PHILIPOT et al., 1994). Eventually it contributes to compromise of the entire phenomenon of "cow-comfort" and some cows prefer standing on the free alleys to occupying the cubicles. Standing for long periods in the free walk-alleys causes further stress to the corium.

The results of this study also found that housing cows on earthen (bare soil) floors was an important risk factor for development of chronic laminitis. This is possibly due to the fact that such floors have soft (yielding) surfaces which tend to promote overgrowth of the claws for lack of constant hoof-wear (RHEBUN and PEARSON, 1982). Claw overgrowth and change in its angle result in redistribution of weight-bearing that subsequently overloads specific zones of the claw particularly during locomotion (VAN der TOL et al., 2003). Consequently, these effects predispose the affected claws to development of laminitis and other claw lesions (SAGUES, 2002; NEVEUX et al., 2006). However, earthen floors were found to be protective against occurrence of sole bruising. This could be attributed to the floor being soft, yielding and non-abrasive which closely relates to a previous report by SOMERS et al. (2003) stating that cows raised on yielding straw-yard surfaces were found to have very low prevalence of claw disorders.

Chronic laminitis is the only claw disorder that showed a significant difference between cows in zero-grazed and in pasture-grazed farms with higher prevalence in zero-grazed cows. The hard concrete surface that was more common in the zero-grazed farms, probably combined with regular concentrate feeding, could have contributed to the difference in the prevalence rates of chronic laminitis between zero-grazed and pasture-grazed farms (BERGSTEN, 1994; VOKEY et al., 2001; SOMERS et al., 2003).

Absence of cubicle bedding and presence of bare concrete in the cubicles was found to be associated with occurrence of chronic laminitis. Some of the cubicles were narrow in such a way that cows remained in a standing posture even within the cubicles. This act of standing in the cubicles further prolongs the cumulative period of stress exerted on the claws while on concrete. The consequence of this stress is the increased incidence of claw lesions, particularly laminitis (BERGSTEN and HERLIN, 1996; SOMERS et al., 2003).

Good concrete (non-slip, without defects or loose stone pebbles) was protective against heel erosion probably due to the absence of traumatic edges. The non-slip nature of the floor would also prevent abrasive trauma on both the heel and sole.

Conclusion

The smallholder dairy farms within and around Nairobi have uniquely wide variations in their production systems with respect to housing designs, nutritional regime and management protocol. From the statistical associations in this study, it can be concluded that the cow-level factors that strongly contribute to the development of claw lesions are 3rd or higher parities and being in the lactation period between 1 to 90 days. The farm-level factors that strongly enhance claw lesion development are frequent high concentrate feeding, lack of regular mineral supplementation, both concrete and earthen floors, overstocking, the presence of a curb between walk-alley and cubicles, and leaving manure in the walk-alley for a long time. These associations are supported strongly by statistics

that indicate the direction and strength of the relationship. Due to the wide variations in the smallholder production units in the study area, there is a need to carry out a controlled experimental study to further elucidate these risk factors.

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SAŽETAK

Provedeno je istraživanje čimbenika rizika nastanka hromosti vezanih uz pojavu bolesti papaka u mliječnih krava malih proizvođača u Najrobiju i okolici u razdoblju od prosinca 2005. do lipnja 2006. Vrednovani su čimbenici na razini farme i pojedine životinje i to na 32 farme i 300 krava. Kronični laminitis bio je u značajnoj ($P<0,05$) korelaciji s trima ili više steonostima ($\chi^2 = 11,57$, $P = 0,009$), laktacijskim periodom između 90 do 180 dana ($\chi^2 = 9,75$, $P = 0,021$), preopterećenošću nastambe stokom (O.R. = 1,7, $\chi^2 = 24,29$, $P = 0,0002$), nedovoljnim brojem ležišta (O.R. = 1,6, $\chi^2 = 29,13$, $P = 0,003$), zemljanim podom (O.R. = 1,5, $\chi^2 = 8,98$, $P = 0,0006$) i ogradom koja razdvaja prostor za kretanje od prostora za ležanje (O.R. = 1,5, $\chi^2 = 5,06$, $P = 0,0262$). Supklinički laminitis bio je značajno ($P<0,05$) vezan s laktacijskim razdobljem između 1 do 90 dana ($\chi^2 = 9,06$, $P = 0,028$) i hranidbom koncentratom (O.R. = 2,08, $\chi^2 = 5,5$, $P = 0,0212$). Međutim, nedostatno dodavanje minerala i dugotrajno ostavljanje gnoja u prolazima povećavaju opasnost od pojave laminitisa. Hranjenje koncentratom bilo je u pozitivnoj sprezi (β-procjena = 2,187, $P<0,05$) s natiskom tabana, dok su dodatak minerala (β-procjena = -4,59, $P<0,05$) i zemljani pod (β-procjena = -1,796, $P<0,05$) bili u negativnoj sprezi odnosno zabilježeno je njihovo zaštitno djelovanje. Razdvajanje u bijeloj liniji bilo je povećano dodavanjem koncentrata (β-procjena = 3,69, $P = 0,002$), a smanjeno dodatkom minerala (β-procjena = -4,07, $P<0,05$), i redovitijim izđubrivanjem prostora za kretanja goveda (β-procjena = -3,58, $P<0,05$). Protuklizni i neoštećeni betonski podovi bili su u negativnoj sprezi (β-procjena = -1,969, $P<0,05$) s erozijom pete papka odnosno imali su zaštitni učinak.

Ključne riječi: bolesti papka, okolišni čimbenici, mliječne krave, mali proizvođači