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The effect of housing systems on hoof diseases/disorders and percentage of culling in Holstein dairy cows

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ABSTRACT

The objectives of this research were to investigate the effect of the housing system (tie-stall and free-stall barns) on the prevalence of hoof diseases/disorders, as well as on the percentage of culling in 6,348 Holstein dairy cows from 5 farms. During the three months of research the hoof care service on all farms collected records of causes of lameness, diagnoses and treatments. Functional and corrective hoof trimming was conducted by a professional farm trimmer. When all the registered diseases/disorders were observed as a percentage (all diseases = 100%), it was noticed that both housing systems were similarly affected by the same diseases/disorders. In this regard, White Line Disease occurred in both systems in prevalence of 0.5% - 1%, Toe Ulcer and Necrosis in 3% - 6%, Rusterholz Ulcer / Sole Ulcer in 20% - 23%, Digital Dermatitis in 18% - 20%, Interdigital Hyperplasia / Tyloma in 10% - 12%, Panaritium / Interdigital Phlegmon in 0.7% - 0.77%, while the prevalence of Mechanical Injury was negligible and in similar amounts - 0.2% - 0.5%. Cows in the free-stall barns were much more burdened with Dermatitis Interdigitalis / Heel Erosion Disease (39.11%) compared to cows in the bound housing system (20.40%). In contrast, diagnosed acute, chronic and haemorrhagic Laminitis was significantly more pronounced in the tie-stall barns (18.61%) than in the free-stall barns (0.88%). In the statistical analysis conducted, statistically significantly more diseases/disorders were registered in the tie-stall system than in the free housing system ($P<0.01$). During the three months of the study, the average percentage of culling in the free system was 5.4%, while in the tie-stall system it was 4.9%. This difference was not statistically significant ($P>0.05$).

Key words: hoof diseases/disorders; Holstein cows; housing system; culling

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Introduction

Impaired hoof health and lameness in dairy cattle still represents one of the most expensive problems in milk production. Many studies have shown that, in addition to reductions in milk yield (HERNANDEZ et al., 2005., HUXLEY, 2013; BACH et al., 2007; LEACH et al., 2012), dry matter intake (DMI) (CHARFEDDINE and PEREZ-CABAL 2017), longevity and reproductive performance, (RANDALL et al., 2016; BRUIJNIS et al., 2010; GARBARINO et al., 2004), the percentage of culling also increases especially before the end of lactation (BOOTH et al., 2004; BICALHO et al., 2007). Furthermore, irregular and incorrect processing of hoofs and incomplete preventive measures could lead to the spread of these issues in a herd.

Cows with impaired hoof health show changes in behaviour. For example, they spend a great deal more time lying down (ITO et al. 2010), they stay in the manger for a shorter amount of time, i.e. they shorten their feeding behaviour time, and often animals lose the will to go to the milking parlour (BORDERAS et al., 2004). This could all result in irrecoverable losses in production.

A positive association was observed between lameness score and rear leg view, indicating the greater probability of cow hock rear leg view in lame cows. Lame cows exhibited a poor body condition score, indicating a negative correlation between body condition score and lameness score (SINGH et al., 2018). Impaired hoof health is associated with a large number of factors, the most significant of which relate to different housing systems, flooring design, bedding material (LOBECK et al., 2011, HASKELL et al., 2006; COOK, 2003; CHAPINAL et al., 2014; VANEGAS et al., 2006; CRAMER et al., 2009) and utilizing pasture (HERNANDEZ-MENDO et al., 2007). Early detection of hoof diseases and prevention of their occurrence, and the application of good practice (regular treatment) certainly lead to improved hoof health (OSORIO, 2016), and together reduce the economic consequences and the animals' suffering, and accelerate their recovery (ADAMS et al. 2017). SINGH et al. (2019) conclude that supplementation of dairy cows with biotin and $ZnSO_4$ might have a synergistic and protective effect on the horn quality, as it not only reduced the severity of lameness and claw lesions, but also prevented their occurrence. The aim of this study was to evaluate the effect of housing systems on hoof diseases/disorders and the percentage of culling in Holstein dairy cows.

Materials and methods

The study used the herd records of 6,348 Holstein dairy cows bred on 5 farms located in the Republic of Serbia. The data set for this study was collected during three months in the period from October to December 2019. From the total number of cows, 1,937 were kept in free-stall barns, while 4,411 were housed in tie-stall barns. Free-stall farms were equipped with individual boxes with cubicle divisions, while tie-stall ones were supplied with an ordinary tie rail and chain within the individual boxes. In free-stall farms, there were concrete slats in the walkways and feeding area (except the milking area), equipped with a carousel milking parlour. For improvement of hoof health, a footbath was used supplied with a solution of copper and zinc sulphate. Tie-stalls were built in the 1980s, so it was noticeable that the cows' lying areas were much shorter than optimal. These barns had concrete flooring with a low chain manure scraper. Milking was carried out by pipeline milking units. All the cows were fed total mixed ration diets of forage and grain, in accordance with the stage of lactation. The hoof care service on all 5 farms collected records regarding the causes of lameness, diagnoses and treatments. Functional and corrective hoof trimming was performed by professional farm trimmers, referred to as 'the Dutch method', developed by Dr. E. Toussaint Raven. During the whole period of the research, the following foot and claw disorders were routinely recorded according to ICAR claw health atlas (2020): Functional and Corrective Foot Trimming (FT); Laminitis (Acute, Chronical and Haemorrhagic, (L)); White Line Disease (WLA + WLF); Toe Ulcer and Necrosis (TU+TN); Rusterholz Ulcer/Sole Ulcer (septic and aseptic, (SU)); Digital Dermatitis Papillomatous, (DDP); Dermatitis Interdigitalis - Heel Erosion (HHE); Digital Dermatitis (All M-Stages, (DD)); Fibrom-Interdigital Hyperplasia/Tyloma (IH);

Panaritium /Interdigital Phlegmon/Foot Rot (IP); and Mechanical Injury (MI). Concerning the method of disease/disorder registration, all the diseases/disorders observed in one or all legs were registered for each individual animal during the three months of the research. In this regard, one animal could be registered for one or more diseases/disorders recorded on one or all legs (front and hind limbs). Every treatment or functional processing was registered, regardless whether it was performed on one or all four legs.

For statistical analysis, a two-proportions z-test was applied in order to compare two observed proportions, within the TIBCO Statistica™ software package (ver. 14 StatSoft., 2020). The z-test was used to characterize statistically significant differences between the prevalence of hoof diseases/disorders in different housing systems (free and tie barns). Statistically significant differences at the level 0.05 and 0.01 were marked in the tables by the P-value.

Results

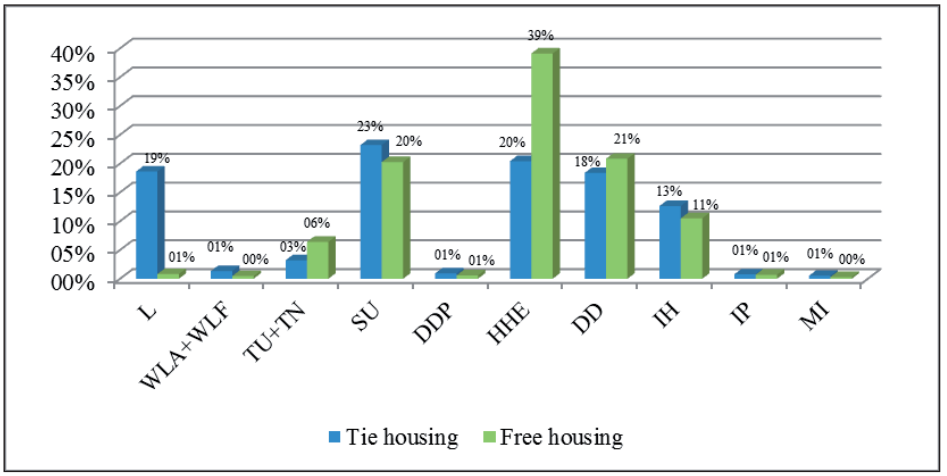
Table 1 shows all changes determined during the research where the prevalence of one or more diseases/disorders on one or more legs relates to an individual animal. During the research, in both housing systems in total 3,223 functional and corrective foot trimming (FT), 1,600 cases of Laminitis (acute, chronical and haemorrhagic, (L)), 121 of White Line Disease (WLA+WLF), 383 of Toe Ulcer and Necrosis (TU+TN), 2,323 of Rusterholz Ulcer / Sole Ulcer (septic and aseptic, (SU)), 90 of Digital Dermatitis Papillomatous, (DDP), 2,405 of Dermatitis Interdigitalis / Heel Erosion (HHE), 1,921 of Digital Dermatitis (All M-Stages, (DD)), 1,255 of Interdigital Hyperplasia / Tyloma (IH), 78 of Panaritium / Interdigital Phlegmon / Foot Rot (IP) and 50 Mechanical Injuries (MI) were recorded. When all the determined diseases/disorders were analysed as prevalence (all diseases/disorders = 100%, Diagram 1), it was noticed that both housing systems were similarly involved with the same diseases/disorders. In this regard, White Line Disease occurred in both systems in a prevalence of 0.5% - 1%, Toe Ulcer and Necrosis in 3% - 6%, Rusterholz Ulcer / Sole Ulcer in 20% - 23%, Digital Dermatitis in 18% - 20%, Interdigital Hyperplasia / Tyloma in 10% - 12%, Panaritium / Interdigital Phlegmon in 0.7% - 0.77% while the prevalence of Mechanical Injury was similar and negligible in 0.2% - 0.5%.

Table 1. Registered changes on hoofs during the three months of research in both housing systems

Housing system	Month	N	FT	L	WLA+WLF	TU+ TN	SU	DDP	HHE	DD	IH	IP	MI
Tie	Oct.	4440	621	600	43	95	798	44	607	569	435	18	17
	Nov.	4406	551	517	35	77	646	31	516	464	338	17	10
	Dec.	4388	587	469	35	102	534	5	616	533	303	31	18
	Total	4411	1759	1586	113	274	1978	80	1739	1566	1076	66	45
Free	Oct.	1934	596	11	6	47	141	8	239	121	80	10	3
	Nov.	1942	398	2	1	33	98	1	172	118	48	1	1
	Dec.	1935	470	1	1	29	106	1	255	116	51	1	1
	Total	1937	1464	14	8	109	345	10	666	355	179	12	5
Both	Oct.	6374	1217	611	49	142	939	52	846	690	515	28	20
	Nov.	6348	949	519	36	110	744	32	688	582	386	18	11
	Dec.	6323	1057	470	36	131	640	6	871	649	354	32	19
	Total	6348	3223	1600	121	383	2323	90	2405	1921	1255	78	50

Where: FT - Functional and corrective foot trimming; L - Laminitis (acute, chronic and haemorrhagic); WLA + WLF - White Line Disease; TU+TN -Toe Ulcer And Necrosis; SU-Rusterholz Ulcer / Sole Ulcer (septic and aseptic; DDP - Digital Dermatitis Papillomatous; HHE - Dermatitis Interdigitalis - Heel Erosion; DD - Digital Dermatitis (all M-stages); IH - Fibrom-Interdigital Hyperplasia / Tyloma; IP - Panaritium /Interdigital Phlegmon / Foot Rot; MI -Mechanical Injury.

Figure 1 shows two diagnosed diseases/disorders that appeared completely unevenly. Cows in the free stall barns were much more burdened with *Dermatitis interdigitalis* / Heel Erosion Disease (39.11%) compared to cows in the bound housing system (20.40%). In contrast, acute, chronical and haemorrhagic Laminitis was significantly more pronounced in the free housing system (P<0.01), and Toe Ulcer and Necrosis was also more common in the free system but with no statistically significant difference (P>0.05), (Table 2). As previously mentioned, Figure 2 shows that these diseases/disorders in hoofs lead to too early culling of animals from further production, despite the two different systems.



Where: FT - Functional and corrective foot trimming; L - Laminitis (acute, chronic and haemorrhagic); WLA + WLF - White Line Disease; TU+TN -Toe Ulcer and Necrosis; SU - Rusterholz Ulcer / Sole Ulcer (septic and aseptic; DDP - Digital Dermatitis Papillomatous; HHE - Dermatitis Interdigitalis - Heel Erosion; DD - Digital Dermatitis (all M - stages); IH - Fibrom-Interdigital Hyperplasia / Tyloma; IP - Panaritium /Interdigital Phlegmon / Foot Rot; MI - Mechanical Injury.

Fig. 1. Prevalence distribution of diseases/disorders determined in both housing systems (expressed as total = 100%)

Table 2. Results of "Z-test" statistics for hoof diseases/disorders in different housing systems

Diseases/disorders	P - value			
	October	November	December	Total
FT	0.00**	0.00*	0.00**	0.00**
L	0.00**	0.00**	0.00**	0.00**
WLA + WLF	0.057*	0.0003**	0.0003**	0.00**
TU+TN	0.4699^{ns}	0.8918^{ns}	0.0336^{ns}	0.3678^{ns}
SU	0.00**	0.00**	0.00**	0.00**
DDP	0.0185*	0.0007**	0.4586^{ns}	0.0001**
HHE	0.1554^{ns}	0.0007**	0.3605^{ns}	0.0001**
DD	0.00**	0.00**	0.00**	0.00**
IH	0.00**	0.00**	0.00**	0.0**
IP	0.5355^{ns}	0.021*	0.0007**	0.0035**
MI	0.135^{ns}	0.1214^{ns}	0.0164*	0.0016**

Where: FT - Functional and corrective foot trimming; L- Laminitis (acute, chronic and haemorrhagic); WLA + WLF - White Line Disease; TU+TN -Toe Ulcer and Necrosis; SU-Rusterholz Ulcer / Sole Ulcer (septic and aseptic; DDP -Digital Dermatitis Papillomatous; HHE -Dermatitis Interdigitalis -Heel Erosion; DD -Digital Dermatitis (all M-stages); IH -Fibrom-Interdigital Hyperplasia / Tyloma; IP -Panaritium /Interdigital Phlegmon / Foot Rot; MI-Mechanical Injury; P<0.01**, P<0.05*, P>0.05 n.s.

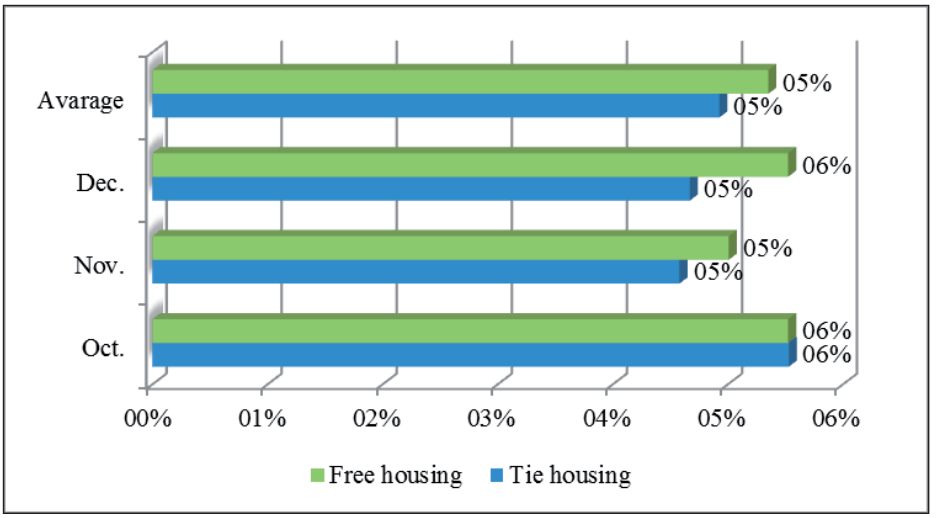


Fig. 2. Number of animals culled from further production on the basis of diagnosed hoof diseases/disorders in the tie-stall and free housing

Discussion

Dermatitis interdigitalis and *dermatitis digitalis* are highly contagious diseases of cattle hoofs, which do not suppress it adequately (HADŽIĆ et al., 2013). As mentioned, the tie-stalls in this research were built in the 1980s, so they were found more in the tie-stall barns (18.61%) than in the free stall barns (0.88%). According to BIELFELDT et al. (2005), lameness was more frequently observed in cows housed in tie-stalls than in cows housed in free stall systems, but similar results could be found for sole disorders and cow comfort in tie-stalls, and this was directly affected by the stalls' dimensions, for which recommendations exist. On the basis of the statistical analysis and Z-test conducted, during the research period statistically significantly more diseases/disorders were registered in the tie-stall system than in the free stalls. It was noticeable that the cows' lying areas were much shorter than optimal, which could be a similar finding to that in the study by NASH et al. (2016), where they found that narrow stalls and short chains were risk factors for leg lesions.

In the Republic of Serbia, the problem in intensive cattle production is caused by old stalls for keeping cattle in a tied system of housing because most of them were built decades ago, when the stalls were adequate for the size and shape of animals housed in the stalls. Improved market development and genetic selection have improved production characteristics, and as a side effect animals have become significantly larger. Accordingly, that has led to the fundamental problem of short stalls, which remained neglect by cattle owners, due to the expense of repairs. Construction of stalls where animals are housed should be adjusted to their physiognomy, that is they should be large enough for the specific cattle breed, its zootechnics and bedding types, and on a slope for adequate drainage. When the stalls are too short, because of the insufficient capacity for the animal to take up a normal position, the animal is forced to stand on the edge of the stall and this often leads to posture disorders in the rear legs. Likewise, while the animal is standing it may slip and incur mechanical injury, especially during removal of manure (SOMERS et al., 2005).

Diagnosed diseases/disorders in hoofs lead to too early and forced culling of animals from further production (Diagram 2). During the three months of the study, the average percentage of culling in the free system was 5.4%, while in the tie-stall system it was 4.9%. This difference was not statistically significant ($P=0.1920$; $P>0.05$). BOOTH et al. (2004) and SOGSTAD et al. (2007) confirmed that lameness is associated with earlier culling of cows. There is a very large diversity of limb diseases, mostly concerning the hoofs and the gap

in the hoof. This may be caused by differences in housing type, which cause different hoof exposure to environmental factors (SWALVE et al., 2005).

Only diseases/disorders that appeared on the hoofs were included in this research, so the percentage of culling was lower than it would be if the complete front or hind limbs were investigated, as in the research by MONSTVILIENE et al. (2004). Up to 85% of disorders are caused by hoof lesions, and the remaining 15% of disorders are caused by traumatic injuries to limbs (MONSTVILIENE et al., 2004). The results of the study by OLECHNOWICZ et al. (2010) indicate that in both housing systems (tie-stall and free stall barns) all lesions were more prevalent in the hind rather than the front hoofs. In accordance with BOOTH et al. (2004), the results frequently demonstrate that the effect of diseases/disorders on culling seem to depend on the time the disease/disorder was diagnosed and the time of culling.

Conclusion

The smallest omission during the process of industrial production could be reflected in financial loss and a reduction in the competitiveness of subjects with the same economic orientation. This relates to contemporary industrial cattle breeding. Maximum production results from valuable cattle breeds may only be achieved by strictly adhering to the recommendations for zootechnical and zoohygienic conditions. The least deviation from the prescribed technological measures and procedures threatens to reduce the level of production of meat and milk caused by the serious disruption of the health status of animals in the herd. This research found statistically significantly more diseases/disorders in the tie-stall system than in the free housing system ($P<0.01$). furthermore, the results of this research support the general view that cows with hoof diseases/disorders have a higher probability of being culled from the herd. The importance of other tools that affect hoof status, such as footbaths, selection, floor and bedding material in the stall, could be the subject of further studies related to the actual conditions in practice.

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SAŽETAK

Cilj je istraživanja bio utvrditi utjecaj držanja (vezani ili slobodni sustav) na pojavnost bolesti i promjena na papcima, kao i na postotak izlučenja u krava holštajnske pasmine. Uključeno je 6348 krava s pet farmi, za koje su tijekom tri mjeseca prikupljeni podaci o obradi i njezi papaka, uzrocima šepavosti, dijagnozama te redovitim liječenjima. Funkcionalno i korektivno obrezivanje papaka provele su osobe educirane za to. Promotre li se svi registrirani poremećaji i bolesti postotno (sve bolesti = 100 %), zapaža se da su oba sustava držanja bila u sličnoj mjeri opterećena istim bolestima. U skladu s tim, bolest bijele linije opažena je u oba sustava, s pojavnošću od 0,5 do 1%, čir i nekroza papka od 3 do 6 %, Rusterholzov čir / *Ulcus soleae* od 20 do 23 %, digitalni dermatitis od 18 do 20 %, interdigitalna hiperplazija / tilom od 10 do 12 %, panaricij / interdigitalna flegmona od 0,7 do 0,77 %, dok je postotak mehaničkih ozljeda bio vrlo sličan i zanemariv (0,2 – 0,5 %). Krave u slobodnom sustavu držanja bile su mnogo više opterećene bolešću interdigitalni dermatitis / erozija pete (39,11 %) u odnosu na krave u vezanom sustavu držanja (20,40 %). Suprotno tomu, pojavnost akutnog, kroničnog i hemoragijskog laminitisa bila je znakovito veća u vezanom sustavu držanja (18,61 %) nego u slobodnom (0,88 %). Na osnovi provedenih statističkih proporcija i Z-testa tijekom istraživanog razdoblja, registrirano je statistički znakovito više bolesti i poremećaja u vezanom sustavu držanja nego u slobodnom ($P<0,01$). Tijekom tri mjeseca istraživanja, prosječan je postotak izlučenja u slobodnom sustavu bio 5,4 %, dok je u vezanom iznosio 4,9 %, međutim ova razlika nije bila statistički znakovita ($P>0,05$).

Ključne riječi: bolesti i poremećaji papaka; holštajnska pasmina krava; sustav držanja; izlučenje