Claw Disease Incidence as a New Trait in the Breeding Goal for the Czech Holstein Population

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Summary

The aim of the present study was to calculate an economic value for claw disease (CLD) incidence, and to estimate its correlated genetic and economic responses to selection, using an index with diverse selection criteria, within the Czech Holstein cattle population. Information sources in the index were either leg type traits or CLD incidence, or both. The estimated economic value for CLD was 100.08 € per case per cow per year. According to the current Czech Holstein sire index, the leg index with the weight traits reduced the CLD incidence indirectly by -0.02 cases per generation (economic response of 2.01 €). The highest reduction in the CLD incidence (-0.04 cases) was obtained using the combined index, which included both CLD incidence and type traits (economic response of 4.1 €). The reliability of the investigated indices ranged between 17% and 56%. Among the traits in the combined index, the highest contribution to the response in CLD incidence was observed for CLD incidence, followed by the type traits, locomotion and legs. The inclusion of claw health as a new breeding objective trait, and the implementation of CLD incidence in the routine breeding value estimations and the sire index would be beneficial for the Czech Holstein population.

Key words

claw disease, economic weight, selection, genetic response, economic response

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Introduction

The primary attention in animal breeding in Europe has partly turned away from increasing production and towards improving functional traits such as reproduction, longevity, and health. In addition to mastitis, claw diseases (CLDs) have a substantial impact on animal welfare and the economics of cattle production. The presence of genetic variation for the resistance of cows to a disease opens up new possibilities for using genetic selection to lower the incidence of that disease (Bicalho and Oikonomou, 2013). Therefore, incorporation of these traits into selection is generally recommended (Philipsson and Lindhé, 2003; Stott et al., 2005). Genetic correlations between claw diseases and feet and leg conformation traits range from low to moderate, and thus, feet and leg conformation traits are potentially useful indicators of claw health (van der Linde et al., 2010).

In many breeding programs, the breeding objective is expressed in economic terms and a selection index is constructed using the breeding objective and/or indicator traits. Inclusion of CLD incidence into a breeding objective requires the estimation of the economic value (EV) for this trait. Krupová et al. (2016) estimated the EV for CLD for dual-purpose cattle in Slovak Republic. However, for the Czech Holstein cattle population, CLD was not included in the suite of traits for which EVs were estimated by Wolfová et al. (2007). According to Holstein Cattle Breeders Association of the Czech Republic (personal communication), the average incidence rate of CLD is one case per cow per lactation. Currently, claw health is not included in the breeding objectives for the Czech cattle populations. However, breeding values (EBVs) for some leg type traits are routinely estimated and considered in the selection index of Holstein sires (SIH), with a relative weight of 12.5% (Plemdat, 2017).

The aim of the present study was to calculate an economic value for CLD incidence, and to estimate its correlated genetic and economic responses to selection, using an index with diverse selection criteria, within the Czech Holstein cattle population.

Material and methods

Calculation of economic value for CLD incidence

Claw disease incidence was defined as the number of CLD cases per cow per year at risk. The marginal EV of CLD incidence (ev_{CLD}) was calculated as the partial derivative of the profit function with respect to the trait:

$$ev_{CLD} = \left.\frac{\partial TP}{\partial TV_{CLD}}\right|_{TV_{CLD}=TV_{CLD_{av}}}$$

where TV_{CLD} is the value of CLD incidence, TV_{CLDav} is the mean CLD incidence within the population, and TP is the present value of the total profit per cow per year, which was calculated as the difference between the total revenues and total costs, all discounted to the date of calving with a discount rate of 2%. The base parameters for calculating the EV of CLD incidence are given in Table 1. The losses from discarded milk per cow per year were calculated from the lactation curves and the fractions of cows treated with antibiotics in partial lactations, as well as the milk price. The principles used for calculating the revenues and costs, the present value of profit, and economic values of traits in cattle production systems have been described by Wolfová et al. (2007) and are provided in the manual of the program package ECOWEIGHT (Wolf et al., 2013). The details for the calculation of EV for CLD have been given by Krupová et al. (2016). The program EWDC from the program package ECOWEIGHT, Part I (Wolf et al., 2013), was used to model the Czech dairy Holstein production system and to calculate the EV for CLD incidence.

Table 1. Basic parameters in the calculation of the economic value for claw disease (CLD)

Parameter (unit)	Value
Average cost of drugs per CLD case treated with antibiotics (€/case)	14.81
Average time spent by veterinarian per antibiotic treatment of CLD (hour/case)	0.50
Average charge for veterinary service (€/hour)	12.96
Cost of drugs per CLD case treated without antibiotics (€/case)	9.26
Average herdsman time dealing with a CLD case[1] (hours)	1.0
Value of herdsman time (€/hour)	7.78
Range of the number of CLD cases per cow-year at risk[2] during different lactations	0.93 to 1.25
Range of the number of CLD cases treated with antibiotics[3]	0.20 to 0.30
Range of daily CLD incidence during partial lactation	0.002 to 0.106
305-d milk yield[4] (kg)	9 546
Milk price[5] (€ per kg)	0.279

[1]For both treatments, with and without antibiotics. [2]CLD incidence. [3]Expressed as a fraction of all CLD cases per cow per year during different lactations. [4]Averaged over all lactations. [5]Milk with 3.80% fat and 3.34% protein.

Calculation of response in CLD incidence to selection on health sub-index

The trait CLD incidence alone was included in the breeding objective for improving cow claw health. Selection criteria in the complete health index were breeding values for CLD incidence and the four traits currently included in the sub-index "legs" of the Holstein sire selection index SIH: rear leg rear view (RLRV), foot angle (FA), locomotion (LOC), and legs (LEGS). In addition to the complete health indices (Indices 3A and 3B), the incomplete indices with either only CLD incidence (Indices 2A and 2B) or only leg traits (Indices 1A and 1B) were also investigated. The coefficients for the traits in selection indices and the appropriate selection response were calculated using the general principles of the selection index theory, which are universally available in the literature.

Altogether, six variants of selection indices were investigated:

1A: Index with the four leg traits, with coefficient *b* used in the leg sub-index of SIH, namely,
I = RLRV + 3 × FA + LOC + 5 × LEGS.

1B: Index with the four leg traits, with coefficient *b* calculated to maximise the response in breeding objective (i.e. to minimise the CLD incidence)
I = RLRV + 3 × FA + 56 × LOC + 41 × LEGS.

Table 2. Genetic correlations among CLD incidence and four leg traits in the SIH[1]

Trait	CLD	RLRV	FA	LOC	LEGS
CLD	1				
RLRV	0.230	1			
FA	0.180	0.277	1		
LOC	0.510	0.392	0.237	1	
LEGS	0.440	0.641	0.673	0.587	1

[1]Czech Holstein sire index; CLD - claw disease, RLRV - rear leg rear view, FA - foot angle, LOC - locomotion, LEGS - legs. Source: own calculation and van der Linde et al. (2010)

2A: Index with CLD incidence only, assuming a 20% reliability of the EBV for this trait.

2B: Index with CLD incidence only, assuming a 50% reliability of the EBV for this trait.

3A: Complete index with the four leg traits and CLD incidence, assuming a 20% reliability of the EBV for CLD incidence
$I = 57 \times CLD + RLRV + FA + 24 \times LOC + 17 \times LEGS$.

3B: Complete index with the four leg traits and CLD incidence, assuming a 50% reliability of the EBV for CLD incidence
$I = 68 \times CLD + RLRV + FA + 17 \times LOC + 13 \times LEGS$

Genetic correlations among the leg traits were calculated using the data provided by the Czech and Moravian Breeders Association. Genetic parameters for the CLD incidence were obtained from van der Linde et al. (2010), or were based on own calculations (see in Table 2). The phenotypic mean and the genetic standard deviation for CLD incidence were set as 1.00 and 0.054 cases per cow per year, respectively. The reliability of the breeding value estimate for type traits was 0.70 for all calculations. A standardised selection intensity of 1.0 was assumed while calculating the selection response in CLD incidence per generation. The economic response was obtained by multiplying the selection response in CLD incidence with the economic value of this trait.

Results and discussion

The EV for the CLD incidence in the Czech Holstein cattle was -100.08 € per case per cow per year. From these total economic losses, about 76% came from reduced revenues due to discarded milk and 7% from the costs for drugs and veterinary service, whenever antibiotics were used. The impact of claw diseases on the other, simultaneously included traits in the complex breeding objectives for Czech Holstein cattle (i.e. milk yield, reproductive traits, and cow longevity) was not considered during the EV calculation for CLD incidence, to avoid double counting.

According to earlier studies (e.g. Kargo et al., 2014), the EV of CLD incidence is mainly affected by the losses in milk yield (reduced production and discarded milk after antibiotic treatment) and the costs for drugs and veterinarian services related to claw diseases (treatments both with and without antibiotics).

Similar to the results of our study, Enting et al. (1997) estimated an EV of 104 €/case for CLD incidence (clinical lameness) for the dairy cattle in Netherlands. For Holstein and Red dairy cattle populations in Nordic countries (Kargo et al., 2014), a higher EV than in our study was estimated for CLD incidence (ranging from 155 to 188 € per case). The reason for this difference could be the higher veterinary costs (75 to 90 € per case) and longer veterinarian time (1.43 to 1.87 hours) spent per case in Nordic countries compared with the Czech Republic (compare these values in Table 1). On the other hand, financial losses associated with discarded milk, due to the antibiotic treatment of cows, have not been mentioned in the Nordic study, and thus, it can be assumed that they were not considered in the EV calculation for CLD incidence. For an extensively farmed Slovak dairy cattle population with low milk yield (4473 kg per cow per lactation), a low EV of CLD incidence was obtained (-26.73 € per case per cow per year; Krupová et al., 2016), because of the lower prevalence of this disease in cows with regular access to pasture (0.26 cases per cow per year) and lower costs of drugs (10.05 € per case treated with antibiotics). The Czech Holstein is an intensively farmed cattle breed with high selection pressure on the milk yield. Clinical mastitis is the only health trait included into the current breeding objectives of this breed and the somatic cell score is the only selection criterion included in the Holstein sire index.

Selection responses in the CLD incidence (per standardised selection differential and per generation) on the selection criteria specified in each of the six selection indices are summarised in Table 3. For all these indices, the selection response was negative, ranging from -0.020 to -0.041 CLD cases per cow per year. The appropriate economic response (i.e. saving costs and increasing profit) varied from 2.01 € to 4.06 € per cow per year. Among the evaluated indices, the lowest annual selection response was found for the actual leg index (index 1A). Nevertheless, selection on this index would cause a correlated response in the CLD incidence as well, and thus, it could improve the claw health. Direct selection, based only on the EBV for CLD incidence (indices 2A and 2B), would reduce the CLD incidence with a slightly higher intensity, e.g. the response in the CLD incidence increased from -0.026 to -0.038 cases per cow per year, when comparing indices 1B and 2B. Using the complete selection index with CLD incidence and type traits, the annual selection response doubled (to -0.041 CLD cases) in comparison with the actual leg index. A similar response (-0.041 cases per generation) was estimated for the German Holstein population (Koenig et al., 2005), when foot angle was the only index information source. A higher response was reported when the claw disease, sole ulcer, was added to the index (-0.124 cases per cow per year and per generation).

The annual selection response for several CLDs in Dutch Holstein population (van der Linde et al., 2010) varied from

Table 3. Selection response (SR)[1] in the claw disease (CLD) incidence to sire selection on different indices

Index[2]	Reliability of EBV[3] for CLD (%)	Natural SR (CLD cases per cow/yr)	Economic value of SR (€ per cow/yr)	Index reliability (%)
1A		-0.020	2.01	17
1B		-0.026	2.57	23
2A	20	-0.024	2.42	20
2B	50	-0.038	3.82	50
3A	20	-0.032	3.21	35
3B	50	-0.041	4.06	56

[1]SR expressed per standardised selection differential. [2]Indices include: 1 = leg traits only, 2 = CLD incidence only, 3 = both leg traits and CLD incidence. For a greater description of the indices, please see Material and methods. [3]Reliability of breeding values (EBV) for the type traits was set to 0.70 in all index variants.

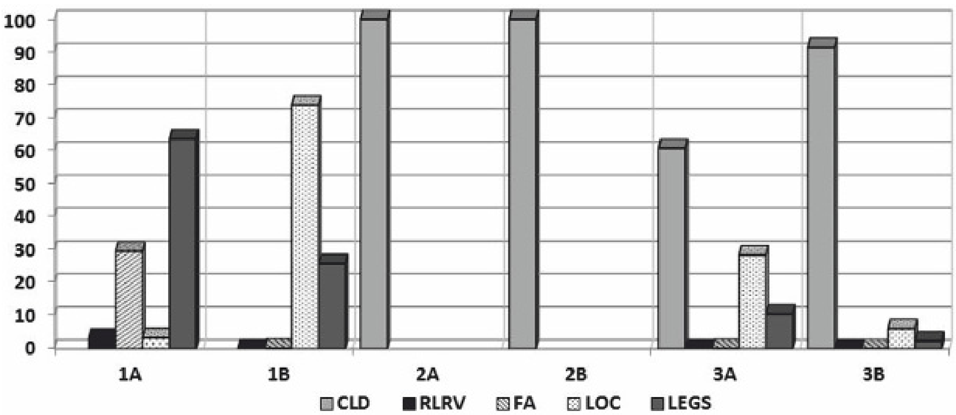

Figure 1.
Contribution of index traits[1] (%) to the selection response in CLD incidence ([1] CLD - claw disease, RLRV - rear leg rear view, FA - foot angle, LOC - locomotion, LEGS - legs. Selection indices include: 1 = leg traits only, 2 = CLD incidence only, 3 = both leg traits and CLD incidence. For a greater description of indices, please see Material and methods.)

0.0 to -0.005 cases of illness, when using an index with only the leg conformation traits, and was up to -0.007 cases, when the CLDs were included as information sources in the index. However, these responses refer to a period of one year, whereas our values refer to one generation. The index with only leg conformation traits yielded a reliability value of 24%, whereas the index with both CLD and leg traits had a reliability of 59% in the above-mentioned study. Similar results were obtained in our study (Table 3). The reliability values for the optimised leg index (1B) and complete index (3B) were 23% and 56%, respectively. The lowest index reliability (17%) was obtained when the actual weighing of leg traits in the SIH was incorporated in our health index (index 1A), showing that this weighing should be re-evaluated to improve the response in terms of CLD incidence.

The contributions of the traits in the specific indices to the response in CLD incidence are shown in Figure 1. The lowest contribution to the response (less than 0.2%) was observed for the conformation traits RLRV and FA, when calculating the selection criterion coefficients that maximise the response to the selection objective. The most important selection criterion among the leg conformation traits was LOC, which had a 74% contribution to the response, when CLD incidence was not included in the index; a 29% contribution was obtained when CLD incidence was included with a low EBV reliability of 20%. The CLD incidence in the complete health index (3B) contributed to 91% of the response, when the reliability of EBV for CLD incidence was 50%.

Conclusion

The current selection for leg traits reduces the CLD incidence indirectly. The joint inclusion of health and type traits in the claw health index is expected to have a favourable impact on the selection response in CLD incidence and on the index reliability. Apart from the CLD incidence, two type traits, locomotion and legs, were found to be the most important sources of information in the health index. The inclusion of claw health as a new breeding objective trait and the implementation of CLD incidence in the routine breeding value estimations and in the sire index would be beneficial for the Czech Holstein population. However, first, the genetic parameters of CLD, including genetic correlations to type traits, need to be estimated.

References

Bicalho R.C. and Oikonomou G. (2013). Control and prevention of lameness associated with claw lesions in dairy cows, Livest Sci 156: 96-105.

Enting H., Kooij D., Dijkhuizen A.A., Huirne R.B.M. and Nordhuizen-Stassen E. N. (1997). Economic losses due to clinical lameness in dairy cattle. Livest. Prod. Sci. 49: 259–267.

Kargo M., Hjortø L., Toivonen M., Eriksson J.A., Aamand G.P. and Pedersen J. (2014). Economic basis for the nordic total merit Index. J Dairy Sci 97: 7879-7888.

Koenig S., Sharifi A.R., Wentrot H., Landmann D., Eise M. and Simianer H. (2005). Genetic parameters of claw and foot disorders estimated with logistic models. J Dairy Sci 88: 3316-3325.

Krupová Z., Krupa E., Michaličková M., Wolfová M. and Kasarda R. (2016). Economic values for health and feed efficiency traits of dual-purpose cattle in marginal areas. J Dairy Sci 99: 644-656.

van der Linde C., de Jong G., Koenen E.P.C. and Eding H. (2010). Claw health index for Dutch dairy cattle based on claw trimming and conformation data. J Dairy Sci 93: 4883-4891.

Philipsson J. and Lindhé B. (2003). Experiences of including reproduction and health traits in Scandinavian dairy cattle breeding programmes. Livest Prod Sci 83: 99-112.

Plemdat. (2017). Calculation of total merit index for bulls and cows of Holstein breed (Výpočet selekčního indexu pro býky a plemenice holštýnského plemene). Plemdat, s.r.o., 4 p. http://www.plemdat.cz/cz/pages/SIH.pdf.

Stott A.W., Coffey M.P. and Brotherstone S. (2005). Including lameness and mastitis in a profit index for dairy cattle. Anim Sci 80: 41-52.

Wolf J., Wolfová M. and Krupa E. (2013). User's Manual for the program Package ECOWEIGHT (C Programs for Calculating Economic Weights in Livestock), Version 6.0.4. Part 1: Programs EWBC (Version 3.0.4) and EWDC (Version 2.2.3). Prague-Uhříněves: Research Institute of Animal Production. 222 p.

Wolfová M., Wolf J., Kvapilík J. and Kica J. (2007). Selection for Profit in Cattle: I. Economic Weights for Purebred Dairy Cattle in the Czech Republic. J Dairy Sci 90: 2442-2455.

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