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SimHerd Crossbred for estimating the economic effects of systematic dairy crossbreeding

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Summary

The SimHerd Crossbred simulation software was developed for assessing the economic consequences related to introduction of different systematic crossbreeding program at herd level given herd specific assumptions. Given average Danish Holstein management assumptions, the results show that both two breed, and three breed rotational cross breeding systems, as well as Combi-Cross using Danish Red and Jersey are economically competitive with regard to net return per kg ECM. The competitiveness is due to increased levels for the functional traits as the yield level for all systems are equal or lower than the Holstein breed level.

Keywords: Herd management, heterosis, rotational crossbreeding, Combi-Cross

Introduction

Crossbred dairy cows are often more robust and more profitable compared to the purebred cows (Heins *et al.*, 2012, Sørensen *et al.*, 2008). The interest of crossbreeding in dairy cattle has, however, until recently been limited in developed countries within the northern hemisphere. This is due to different reasons. A simple reason may be that the dairy producers like one specific breed, and care much about breed standards and conformation traits. This will be jeopardized in crossbred animals as the crossed breed differs in conformation. Another reason is the opinion that crossbreeding is only beneficial under poor management conditions. However, this is counteracted by results from Bryant *et al.* (2007), Kargo *et al.* (2012), and Clasen *et al.* (2018). A third reason is due to a lack of advisory and management tools for operating this type of breeding system at herd level. This problem can be addressed by development of such tools, and accordingly we have developed SimHerd Crossbred. The aim of this paper is to present SimHerd Crossbred.

Simherd Crossbred

SimHerd Crossbred is a supplement to the SimHerd simulation software. SimHerd is a mechanistic, dynamic and stochastic dairy herd model that simulates the production and state changes of dairy cows and young stock in a herd (Østergaard *et al.*, 2005). The herd state is defined by the herd structure and various input and output factors. The development of the herd is determined indirectly by the state change of each individual animal that is defined by age, parity, lactation stage, actual milk yield, body weight, culling status, reproductive status (estrus and pregnancy), somatic cell count, disease status, and a permanent environmental component of milk yield potential. The simulation of the current herd and animal state is dynamically done in week-by-week time steps. Within each time step, realistic probability distributions triggers relevant events, such as diseases, cow death, culling, calf survival, heat detection, conception etc. It is not an optimization software, but a software being able to estimate the consequences of different management initiatives with herd specific assumptions.

The SimHerd version used as base for SimHerd Crossbred has many features. However, it does not distinguish between different breeds or include any genetic terms. This means that every trait for every cow trait is randomly sampled with means for the trait as given in the herd specific assumption and with phenotypic standard error.

To be able to estimate the effects of crossbreeding, every cow is recognized by the proportion of each breed in the SimHerd Crossbred version. In supplement to the general SimHerd version, it is therefore able to keep track of breed proportions in each animal. The "base" breed is modelled as Holstein, and a resemblance of "additive genetic level" of each other breed is, depending on trait, specified in real figures, relative ratios or odds ratios compared to Holstein. A thorough literature study has been conducted to decide the breed levels for production within all lactations, feed conversion efficiency, somatic cell score, mastitis, seven other disease traits, two hoof disease traits, six reproduction traits, young stock mortality and cow mortality. If the simulated herd is simulated as a purebred Holstein herd, then the traits for each cow is sampled by the herd means as described above. If the cow has breed proportions other than Holstein, the traits are sampled in the same manner and then multiplied with the proportion of Holstein and the trait levels and proportions of the other breeds. On top of the "additive genetic level", a heterosis component is added based on the dominance model. A thorough literature study has been conducted to decide the heterosis levels for the same traits as for breed level. Thus, the trait of the individual cow is defined based on its breed proportions, and the heterosis effect based on the breed proportion of the parents.

In addition, and apart from usual SimHerd assumptions at herd level, a system of crossbreeding system have to selected. Beyond pure breeding, the options are both two-breed and three-breed rotational crossbreeding as well as the Combi-Cross system (Kargo *et al.*, 2014). If pure breeding is used, SimHerd Crossbred can be used to simulate the change of breed in the herd. Furthermore, the use of sexed semen and beef semen can be specified, and the distribution of the semen use in heifers, first parity cows, second parity cows, and third parity and older cows must be specified. If the Combi-Cross system is chosen, the proportion of pure breeding in the nucleus can be specified as well as the order of breeds used in each step.

Simulation of crossbreeding scenarios

To demonstrate the use of SimHerd Crossbred as a management tool for crossbreeding, different scenarios have been simulated. The base herd is a conventional Danish Holstein herd with 200 cows and typical management. Five scenarios were simulated: change of breed to purebred Jersey, change of breed to purebred Danish Red, crossbreeding using a two-breed rotational (zig-zag) system with Danish Red, crossbreeding using a three-breed rotational system with Danish Red and Jersey, and a Combi-Cross scenario using Danish Red as the second breed and Jersey as the third breed.

Sexed semen was used for all heifers in the Combi-Cross scenario and for 30% of the heifers all other scenarios. Sexed semen was used for cows only in the Combi-Cross scenario (50%). In the Combi-Cross, beef semen was used for all three-breed cows, 50% of the animals in the purebred nucleus was used for pure breeding. In all scenarios, beef semen was used for cows to ensure a surplus of approximately six pregnant heifers per year.

Results and discussion

In Table 1, the effect of changing from Holstein to Jersey or Danish Red is illustrated. The net return per cow year will decrease 403 DKK if the herd switches to Jersey, despite less costs of disease treatments and fewer young stock. This is obviously due to a substantially lower production level in the Jersey breed. However, it should be emphasized that the net return per kg ECM produced increases with 0.08 DKK in Jersey. If the herd is to change breed from Holstein to Danish Red, an increased net return per cow year of 368 DKK (+0.07 DKK per kg ECM) is expected. This is due to a better health level in Danish Red compared to Holstein, and only a small decrease in production level compared to the Jersey scenario.

Table 1. The long term effect of changing breed within herd from Holstein to Jersey or from Holstein to Danish Red. The figures are shown relative to Holstein.

	Holstein	Jersey	Danish Red
Kg ECM per cow year	10,022	- 1,168	- 370
Calving interval, days	401	- 14	- 8
Replacement rate, %	41.1	- 4.7	- 3.7
# Disease treatments	1.61	-0.29	-0.34
Net return per cow year, DKK	9,503	- 403	+ 368
Net return per. kg ECM, DKK	0.95	+ 0.08	+ 0.07

In Table 2, the effects of using crossbreeding with a two-breed rotational system (zig-zag) with Danish Red, a three-breed rotational system (rotational) with Danish Red and Jersey, and a Combi-Cross system with Danish Red and Jersey are shown.

In every crossbreeding scenario, the net return increases both per cow and per kg milk produced. This is despite a decrease in milk yield per cow in the rotational and Combi-Cross scenarios.

Table 2. The long term effect of using two-breed rotational (Zig-Zag) crossbreeding system with Danish Red, three-breed rotational (rotational) crossbreeding system with Danish Red and Jersey, and Combi-Cross system with Danish Red and Jersey. The figures are relative to purebred Holstein.

	Holstein	Zig-Zag	Rotational	Combi-Cross
Kg ECM per cow year	10,022	+ 24	- 265	- 147
Calving interval, days	401	- 10	- 13	- 6
Replacement rate, %	41.1	- 3.6	- 5.7	- 3.6
# Disease treatments	1.61	- 0.24	- 0.32	- 0.22
Net return per cow year, DKK	9,503	+ 929	+ 712	+ 974
Net return per. kg ECM, DKK	0.95	+ 0.09	+ 0.10	+ 0.11

Conclusion

Based on literature estimates for breed differences and heterosis for the traits of importance for dairy production we have estimated the effect of a breed change from Holstein to Danish Red or Jersey and we have estimated the effects of different crossbreeding systems. The results show that both Danish Red and Jersey are competitive with regard to net return per kg ECM, and all the different crossbreeding programs are competitive. Both in case of breed change and use of systematic crossbreeding programs the economic increase is due to increased levels of functional traits as the milk production level is at the same level or lower.

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