Combi-Cross – the use of new technologies for improving dairy crossbreeding programs

M. Kargo[1,2], J. Ettema[1,3], M. Fjordside[45], L.H. Sørensen[1] L. Hjortø[2]

[1]University of Aarhus, [2]Knowledge Centre for Agriculture, Denmark,

[3] SimHerd Inc., Denmark, [4]VikingGenetics, [5]VikingDenmark

ABSTRACT:
Combi-cross combines the advantages of pure breeding and crossbreeding within herd through a hierarchical breeding program with use of sexed semen. The highest ranking females in a purebred nucleus are used for pure breeding, while the lower ranking are used for production of Two-cross animals (F1). The Two-cross animals produce Three-cross animals also expressing full heterosis. As sexed semen is intensively used in the first two stages of the program all Three-cross animals can be inseminated with beef semen. With a 30% replacement rate it possible to reduce the purebred nucleus to 33% of the production cows. The Combi-Cross concept is demonstrated in five demonstration herds, where 331 of the more than 1300 cows are Two-cross cows, producing at the same level as the Holstein cows.

Keywords:
dairy cattle
breeding strategies
crossbreeding
sexed semen

Introduction

Crossbreeding is a well-known breeding system to obtain improved efficiency within livestock species and it has been used intensively within pig and poultry production for several decades. Until now, this has not been the case within dairy production, but lately the interest in crossbreeding has increased. One important reason is that the primary focus in the recent years has changed from milk production traits and conformation traits, to inclusion of functional traits, such as fertility, health, calving ease and longevity. This change has mainly happened because a deterioration of the functional traits has been observed in the Holstein breed. This deterioration of the functional traits results from the high selection pressure on the production traits and the antagonistic genetic correlations between functional and production traits (Rauw et al., 1998; Miglior et al., 2005).

Crossbreeding is of special interest for the dairy producers who focus on functional traits, because heterosis tends to be greater for functional traits than for production traits. Furthermore, it is well know that total economic gain also expresses positive heterosis (Sørensen et al., 2008). However the proportion of dairy producers applying systematic crossbreeding programs is still small. One of the reasons for this resistance is the low reproduction rate in cattle, which requires that nearly all female offspring from crossbred females are used as breeding animals as opposed to pig and poultry production where crossbred animals always are production animals. Therefore, many dairy farmers have been reticent about giving up pure breeding.

The introduction of sexed semen (SS) for practical use has changed this limitation and opened up the possibility for producing surplus heifers within herd.

This gave us the idea of combining pure breeding and crossbreeding within herd by use of SS. By doing so the advantages of pure breeding and crossbreeding are obtained within herd and the use of systematic crossbreeding program becomes more interesting for many dairy producers since they maintain the possibility of pure breeding.

The aim of this paper is 1) to describe the idea behind Combi-Cross, 2) to describe the developed tools for handling the combination of pure breeding and cross breeding and 3) to show practical results from five demonstration herds.

Materials and Methods

The idea behind the Combi-Cross concept is illustrated in Figure 1. On level one pure breeding is applied within the nucleus of the herd. Within the nucleus the highest ranking females are inseminated with SS to produce purebred heifers for supplementation of the nucleus. This will increase the genetic level of the purebred nucleus (Sørensen et al., 2011). The lower ranking females within the nucleus are inseminated with SS from a second dairy breed resulting in "Two-cross" animals (F1-animals). The Two-cross females are inseminated with SS from a third dairy breed resulting in "Three-cross" animals (functional F1-animals). Both the Two- and the Three-cross animals express their full heterosis, as genes from the sire and dam in both cases originates from different breeds. As SS is heavily used among both the nucleus females and the Two-cross females, these two groups are able to produce a sufficient amount of replacement heifers for the herd. Three-cross females are therefore all inseminated with beef semen for production of offspring with high quality carcass traits and increased growth potential. Both female and male offspring can be sold for a higher price compared to purebred dairy bull calves.

The project includes five demonstration herds applying the concept. These five herds have together more than 1300 cows in production. Some of the herds had used different kinds of cross breeding programs prior to the start of the project in early 2010. Other herds had only applied

pure breeding prior to the project. The practical management of the breeding programs was carried out in strong collaboration with the AI organization Viking Genetics. The aim of the management of the Combi-Cross programs is to have as many producing cows in the Two and Three-cross group, as heterosis is maximal in these cows.

The maximum proportion of Two and Three-cross cows that can be realized is dependent on the management level within the herd. The most important management key figures in relation to this are conception and estrus detection rate among heifers and cows, replacement rate, the proportion of live born heifers calves reaching a first calving, and the strategy for use of SS. Based on these figures and other herd characteristics, an insemination strategy can be determined using an excel sheet developed for this purpose.

Results and Discussion

Overall we successfully made the Combi-Cross program work within the five herds, as we already have 331 Two-cross animals milking in these herds.
However, different kinds of Combi-Cross programs are applied in the demonstration herds resulting in different distributions of numbers of females within the different breed groups (Table 1). Herd A nearly started from a purebred Holstein herd and therefore there are very few old crossbred cows in that herd. In that herd, Nordic Red (RDC) is used as sire for the Two-cross animals, and Jersey is used as sire for the Three-cross animals. Herd B also nearly started from a pure Holstein herd. In herd B, Jersey is used as sire for the Two-cross animals, while RDC is used as sire for the Three-cross animals. Herd C started out with pure Holstein animals and a few pure RDC animals. For the Two-cross animals RDC was used as sire when the dam was Holstein, while Holstein was used as sire when the dam was RDC. All Three-cross animals had a Jersey sire. Herd D and E had for a number of years before the start of the project used rotational crossbreeding for a part of the herd, but they had both kept a nucleus of both Holstein and RDC. For the Two-cross animals both herds used Holstein and RDC depending of breed of the dam. As sire of the Three-cross animals, herd D used Jersey, while herd E used both Jersey and Montbeliardé.

At the moment, 331 Two-cross cows and 34 Three-cross cows are producing within the demonstration herds. This will however increase as there are 187 Two-cross and 252 Three-cross heifers in the herds. Figures for all traits from these herds will be analyzed, so far only production figures have been analyzed. The production results do not deviate that much depending on breed group as seen in Table 2. The crossbred animals do have a yield comparable with Holstein, which is in accordance with unpublished Danish within herd comparisons. Given that many more traits are expected to express heterosis, Combi-Cross seems promising. Still it is important to realize that in order to obtain reliable estimates for heterosis effects, more data is needed than can be obtained from these five herds alone. The estimation of the heterosis effects will be based on production figures from all Danish herds applying systematic crossbreeding programs (Norberg et al., 2014).

The insemination strategy is important in all herds using Combi-Cross. The important aspect is to use the breed of the nucleus enough within the nucleus to ensure having replacement heifers enough for both the nucleus and the whole herd in the future. This can be calculated using the developed excel sheet. The possibilities in using Combi-Cross are illustrated for a herd which is in the initial phase of a Combi-Cross program. The distribution on breed groups are 56% purebred and 44% Two-cross cows at the starting point, and a heifer distribution being 37% purebred, 48% Two-cross and 15% Three-cross. In this example, normal Danish production levels for yield, fertility and calf survival are assumed except that replacement rate is only 30%. The insemination strategy consists of using SS on all nucleus and Two-cross females with two times use of SS followed by conventional semen for heifers and SS only once for cows followed by conventional semen. By doing so, the herd has enough replacement heifers, once the insemination strategy has reached equilibrium. The distribution of production cows on breed groups are 32% purebred cows, 24% Two-cross cows and 43% Three-cross cows. In a situation where replacement rate is increased to 40% more females in the nucleus must be inseminated with the nucleus breed, and three times SS must be used for heifers and two times SS for cows to have replacement heifers enough. In that situation the future distribution of production cows on breed groups are 45% purebred cows, 23% Two-cross cows and 32% Three-cross cows. This illustrate that herd management is very important for the insemination strategy in Combi-Cross programs and thereby important for the breed group distribution of production cows. A 10% increment of the replacement rate reduces the proportion of crossbred cows expressing their full heterosis from 67% to 55%.

Conclusion

This study illustrates the idea behind the combination of pure breeding and cross breeding within herd in Combi-Cross breeding programs. Efficient tools for handling the insemination strategies were demonstrated, and practical management of Combi-Cross in five demonstration herds is shown. Preliminary production results from the demonstration herds show that the crossbred animals produces the same amount of energy corrected milk as purebred Holstein cows.

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Table 1 Number of female animals within herd groups in the 5 demonstration herds.

Herd	Age group	Breed group			
		HF	RDC	Two cross	Three cross
A	heifers	56	-	52	55
	1st parity	29	-	38	2
	2+ parity	56	-	7	0
B	heifers	56	-	12	50
	1st parity	18	-	38	5
	2+ parity	43		27	-
C	heifers	72	20	110	92
	1st parity	34	4	84	0
	2+ parity	160	18	40	0
D*	Heifers*	22	44	45	28
	1st parity*	6	19	7	9
	2+ parity	23	30	28	6
E*	heifers	17	102	68	27
	1st parity	10	29	23	8
	2+ parity	22	80	49	4

D* In addition 98 heifers, 21.parity cows and 61 2+ parity in a rotational crossbreeding system.
E* In addition 52 heifers, 22 1.parity and 25 2+ parity in a rotational crossbreeding system.

Table 2 daily yield (Energi corrected milk) within breed groups.

Herd	Age group	Breed group		
		HF	RDC	Two and Three crosses
A	Par 1	33.2	-	35.5
	Par 2+	38.8	-	40.3
B	Par 1	30.4	-	31.4
	Par 2+	39.6	-	35.7
C	Par 1	25.8	25.4	29.0
	Par 2+	35.5	35.7	34.2
D	Par 1	27.0	26.9	28.9
	Par 2+	34.1	33.5	33.3
E	Par 1	34.4	32.7	33.7
	Par 2+	38.8	39.1	41.8

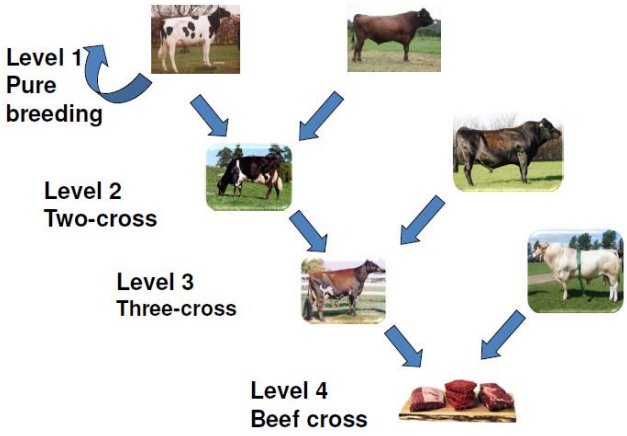

Figure 1 An illustration of the idea behind Combi-Cross.

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