

## Crossbreeding of Dairy Cattle

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## Global milk production has come increasingly from Holsteins

- Superiority of the Holstein breed for production has been documented
- However, domination by a single breed is unusual among mammals for food production
- Beef cattle, pigs, and sheep all use heterosis to improve fertility, health, and longevity
- The global Holstein breed is comprised almost completely of genes from the U.S.



## Change of cows over 35 years in U.S.

- Dramatic gain in milk production +5000 kg
- Much better udders
- Larger body size taller, broader, deeper
- Less body condition more "sharpness"

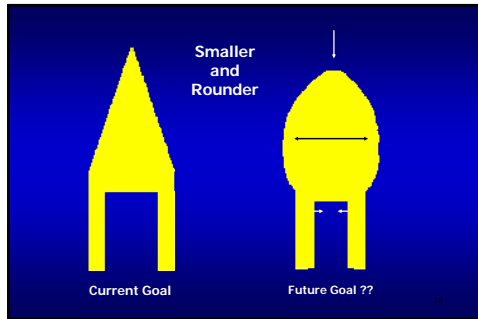


## Genetic relationships with survival of Holsteins in U.S. (on scale of +1 to -1)

Trait	Birth year of cows	
	1980-82 <sup>1</sup>	1995-97 <sup>2</sup>
Milk	+0.43	-0.11
Dairy form ("sharpness")	+0.41	-0.25
Stature	+0.05	-0.13
Strength	-0.13	-0.20
Body Depth	-0.07	-0.29

<sup>1</sup>Wolgel et al. (1998) J. Dairy Sci. 81:2040.  
<sup>2</sup>Suruta et al. (2005) J. Dairy Sci. 88:1156.





Genetic Relationship of Longevity and Cow Fertility

**+0.51**

(on a +1.0 to -1.0 scale)

Traits ignored for Holstein selection (until recently)

- calving difficulty
- stillbirth
- cow fertility
- cow health
- cow longevity

These traits were not ignored by all breeds of dairy cattle

Change of days open since 1960 in USA

Birth year	Holstein	Jersey
1960	0	0
1970	+12	+9
1980	+14	+6
1990	+22	+9
2000	+38	+19

----- (days) -----

Average inbreeding of U.S. Holsteins

Birth year	Inbreeding (%)
1989	2.3
1995	3.7
2001	4.7
2007	5.3

Inbreeding when international Holstein sires are mated to U.S. Holstein cows

Country	Sires	Inbreeding (%)
United States	8941	5.1
Spain	353	5.1
Japan	375	5.0
Canada	2132	4.9
Italy	2056	4.9
France	3775	4.8
United Kingdom	756	4.8
Germany	5437	4.7
Denmark	2083	4.7
Australia	1397	4.6
Sweden	474	4.6
The Netherlands	4324	4.2
New Zealand	1514	3.5

VanRadon, P. M., 2005, Proceedings of 2005 Interbull Meeting

Relationship of U.S. Holsteins

• Elevation (born 1965)	15%
• Chief (born 1962)	14%
• <b>Blackstar</b> (37.5% Elevation and Chief blood)	<b>16%</b>

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Relationship of Canadian Holsteins

• Starbuck (son of Elevation)	20%
• Elevation	19%
• <b>Blackstar</b>	<b>18%</b>

High-impact bulls for the future of the global Holstein breed

Bull	Sire (ppg) x MGS (mgs)	% Elevation + % Chief (%)	Major sons
<b>Blackstar</b>	Chairman (Milk) x Wayne (Hilltop)	37.5	Patron, Duster, Lord Lily
<b>Prelude</b>	Starbuck (Elevation) x Glendell (Chief)	37.5	Mtoto, Outside, Tugolo (all 3 from Blackstar dams)
<b>Manfred</b>	Cubby (Bova) x Tesk (Valiant)	34.4	O-Man, Potter, Ally
<b>Leadman</b>	Tradition (Elevation) x Valiant (Chief)	43.8	Lukas, Formation, Funkis
<b>Rudolph</b>	Aerostar (Starbuck) x Mattador (Admiral)	25.0	Ramos, Champion, Machoman
<b>Jocko Besne</b>	Bosne Buck (Starbuck) x Southwind (Bell)	27.1	Jet Stream, Spoutnik, Jose

## Inbreeding depression and Heterosis

Both are expressed mostly for:

- cow fertility
- stillbirth
- health
- mortality
- longevity

All are "masked" traits

## Overview of California study

- Seven cooperating dairies in central California
- Holstein cows bred to A.I. sires from other breeds
  - Normande
  - Montbeliarde
  - Scandinavian Red (Swedish Red and Norwegian Red)

## Calving difficulty and stillbirth for breed of sire with 1<sup>st</sup> calf dams

	Calves	Calving difficulty ----- (%) -----	Stillbirth
Holstein	371	16.4	15.1
Montbeliarde	158	11.6	12.7
Scandinavian Red	855	5.5 *	7.7 *

All dams of calves were first-calf Holsteins

## Calving difficulty and stillbirth for breed of dam at 1<sup>st</sup> calving

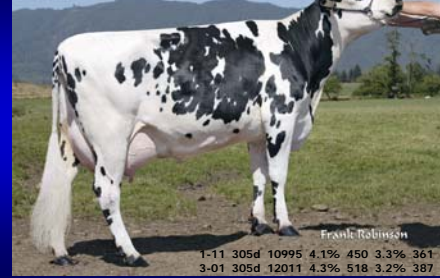
	Calves	Calving difficulty ----- (%) -----	Stillbirth
Holstein	676	17.7	14.0
Normande-Holstein	262	11.6 *	9.9
Montbeliarde-Holstein	370	7.2 *	6.2 *
Scandinavian Red-Holstein	264	3.7 *	5.1 *

Breeds of sire were Brown Swiss, Montbeliarde, and Scandinavian Red

## Number of cows

Breed	Cows	Sires
Holstein	380	69
Normande-Holstein	245	24
Montbeliarde-Holstein	494	23
Scandinavian Red-Holstein	328	13

## Normande x Holstein



## Montbeliarde x Holstein



## Swedish Red x Holstein



## 1<sup>st</sup> lactation actual production in 305 days

Trait	Pure Holstein	Normande-Holstein	Montbeliarde-Holstein	Scand. Red-Holstein
Cows	380	245	494	328
Milk (kg)	9891	8595 *	9202 *	9309 *
Fat (kg)	352	323 *	337 *	343
Protein (kg)	307	278 *	292 *	298 *
Fat (kg) + Protein (kg)	659	601 *	629 *	641 *
% of Holstein		-9%	-5%	-3%

All cows have completed 1<sup>st</sup> lactation (305 days)

### 2<sup>nd</sup> lactation actual production in 305 days

Trait	Pure Holstein	Normande-Holstein	Montbelliarde-Holstein	Scand. Red-Holstein
Cows	310	217	432	274
Milk (kg)	11965	9990 *	10683 *	10782 *
Fat (kg)	427	375 *	400 *	404 *
Protein (kg)	373	326 *	342 *	347 *
Fat (kg) + Protein (kg)	800	701 *	742 *	751 *
% of Holstein		-12%	-7%	-6%

All cows have completed a 2<sup>nd</sup> lactation (305 days)

### 3<sup>rd</sup> lactation actual production in 305 days

Trait	Pure Holstein	Normande-Holstein	Montbelliarde-Holstein	Scand. Red-Holstein
Cows	213	156	307	192
Milk (kg)	12311	10625 *	11359 *	11400 *
Fat (kg)	447	398 *	423 *	425 *
Protein (kg)	379	342 *	360 *	363 *
Fat (kg) + Protein (kg)	826	740 *	783 *	788 *
% of Holstein		-10%	-5%	-5%

More cows will calf a 3<sup>rd</sup> time, and some records are projected to 305 days

### 4<sup>th</sup> lactation actual production in 305 days

Trait	Pure Holstein	Normande-Holstein	Montbelliarde-Holstein	Scand. Red-Holstein
Cows	89	85	109	56
Milk (kg)	12372	10602 *	11456 *	11517 *
Fat (kg)	443	392 *	426 *	429 *
Protein (kg)	379	341 *	364 *	363 *
Fat (kg) + Protein (kg)	822	733 *	790 *	792 *
% of Holstein		-11%	-4%	-4%

Some cows have calved a 4<sup>th</sup> time, and most records are projected to 305 days

### Survival during first lactation

Breed	Cows	Survival to 305 days (%)
Holstein	380	83
Normande-Holstein	245	90*
Montbelliarde-Holstein	494	93*
Scandinavian Red-Holstein	328	90*

### Percentage of cows starting a 2<sup>nd</sup> lactation within fixed periods

Breed	Cows	14 mo 17 mo 20 mo		
		..... (%) .....		
Holstein	380	44	63	71
Normande-Holstein	245	61 *	79 *	85 *
Montbelliarde-Holstein	494	63 *	78 *	84 *
Scandinavian Red-Holstein	328	59 *	72 *	79 *

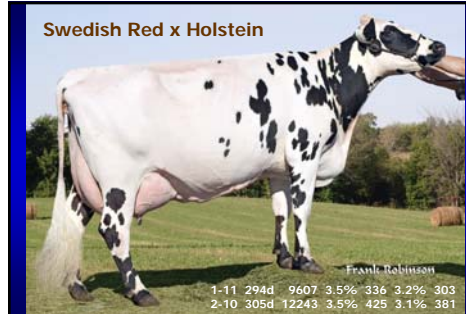
### Averages for days open

	Number		
	Cows	Sires	Days open
Holstein	360	69	147
Normande-Holstein	235	24	122 *
Montbelliarde-Holstein	478	23	124 *
Scandinavian Red-Holstein	315	13	131 *

Swedish Red x Holstein



Swedish Red x Holstein



Montbelliarde x Holstein

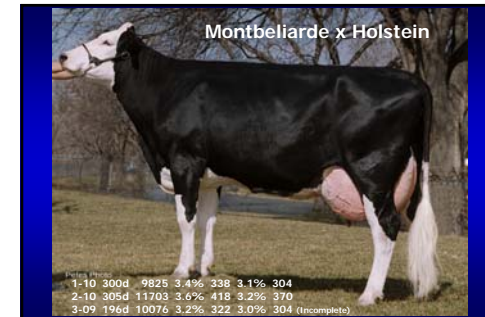


## University of Minnesota Crossbreeding research

- Two research dairies
  - campus herd in St. Paul
  - low-input dairy in western Minnesota
- Crossbreeding system with three breeds
  - Holstein > Jersey > Montbeliarde
  - Holstein > Montbeliarde > Jersey

## Jersey x Holstein crossbreds compared to pure Holsteins at the University of Minnesota

Trait	Pure Holstein	Jersey x Holstein	Difference
<b>1<sup>st</sup> lactation</b>			
	n = 73	n = 76	
Fat + Protein (kg)	514	497	-17
SCS	3.0	3.2	+0.2
Days open	150	127	23
<b>2<sup>nd</sup> lactation</b>			
	n = 53	n = 63	
Fat + Protein (kg)	608	573	-35 *
SCS	2.7	3.1	+0.4
Days open	162	130	32 *
<b>3<sup>rd</sup> lactation</b>			
	n = 31	n = 48	
Fat + Protein (kg)	641	598	-43 *
SCS	3.2	4.0	+0.8 *



## 1<sup>st</sup> lactation actual 305-day production

Trait	Pure Holstein	Montbeliarde-Holstein	Montbeliarde-(Jersey x Holstein)
Cows	61	48	35
Milk (kg)	7658	7296 *	7331
Fat (kg)	264	256	264
Protein (kg)	238	230	235
Fat (kg) + Protein (kg)	502	486	500
% of Holstein		-3%	-0%
Somatic Cell Score	2.66	2.59	2.89

More cows will calve a 1<sup>st</sup> time, and some records are projected to 305 days

## 2<sup>nd</sup> lactation actual 305-day production

Trait	Pure Holstein	Montbeliarde-Holstein	Montbeliarde-(Jersey x Holstein)
Cows	26	30	12
Milk (kg)	9325	9074	8847
Fat (kg)	326	329	332
Protein (kg)	292	288	285
Fat (kg) + Protein (kg)	618	617	617
% of Holstein		-0%	-0%
Somatic Cell Score	2.51	1.37 *	1.69

More cows will calve a 2<sup>nd</sup> time, and most records are projected to 305 days

## Days open during first lactation

Trait	Pure Holstein	Montbeliarde-Holstein	Montbeliarde-(Jersey x Holstein)
Cows	46	44	30
Days open	161	128 *	114 *
Difference from Holstein		-33 d	-47 d

## Body condition score

Trait	Pure Holstein	Montbeliarde-Holstein	Montbeliarde-(Jersey x Holstein)
<b>1<sup>st</sup> lactation</b>			
Number of cows	56	47	32
Body Condition Score	2.77	3.23 *	3.21 *
<b>2<sup>nd</sup> lactation</b>			
Number of cows	18	24	7
Body Condition Score	2.65	3.31 *	3.23 *

## Dry matter intake during 1<sup>st</sup> lactation

Trait	Pure Holstein	Montbeliarde-Holstein	Montbeliarde-(Jersey/Holstein)
Cows	24	26	11
Daily dry matter intake (kg)	20.60	19.60 †	20.08
Total dry matter intake (kg)	3024	2880 †	2962

Data for only the first 150 days of first lactation  
† p < .10 for statistical significance

## Important points

- Crossbreeding is a mating system that **complements** genetic improvement of breeds
- Selection of **best A.I. bulls** within breed results in genetic improvement
- **Heterosis** from crossbreeding is a "**bonus**" on top of genetic improvement within breeds
  - 4 to 10% for production
  - At least 10% for fertility, health, and survival

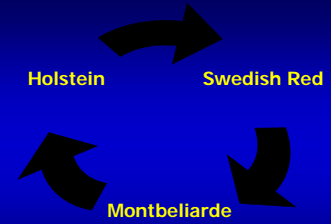


## Recommendations for crossbreeding

- Crossbreeding systems must use **three** breeds to **optimize heterosis**
- Two breeds limits the amount of heterosis
- Four breeds limits the influence of specific breeds
- Therefore, select **three** breeds for specific needs of herd

## Heterosis by generation

Generation	2 breeds	3 breeds	4 breeds
	(%)		
1	100	100	100
2	50	100	100
3	75	75	100
4	63	88	88
5	69	88	94
6	66	84	94
7	67	86	94
8	67	86	93



3-breed rotational crossbreeding

Montbeliarde x (Jersey/Holstein)



2-01 293d 8475 3.6% 302 3.1% 265  
3-00 305d 10503 3.9% 414 3.2% 337

Montbeliarde x (Jersey/Holstein)



2-01 305d 9529 3.5% 328 3.1% 293  
3-02 99d 3600 3.6% 131 3.6% 129 (incomplete)

Swedish Red x (Jersey/Holstein)



2-00 274d 9634 3.3% 316 3.0% 284  
2-11 305d 14556 3.1% 993 3.0% 440

Swedish Red x (Jersey/Holstein)



2-01 294d 9857 3.6% 356 3.4% 337  
3-01 298d 12011 3.9% 463 3.4% 406 (incomplete)

## Dairy cattle breeds with strong selection programs

- "Red" (includes Swedish Red, Finnish Ayrshire, Danish Red, Aussie Red, Angler, Norwegian Red)
- Holstein (includes Red Holstein and Friesian)
- Montbeliarde
- Normande (for low-input production systems)
- Jersey
- Brown Swiss
- Fleckvieh (dual-purpose breed)



Swedish Red  
(146,000 cows)



Danish Red  
(42,000 cows)



Finnish Ayrshire  
(171,000 cows)



- Positives of "Jersey" for rotational crossbreeding**
- Outstanding calving ease of sires
  - Outstanding calving ease of cows
  - Increased solids content of milk
  - Lowered maintenance costs
  - Increased frequency of black hooves
  - Smaller cubicle size is needed

- Negatives of "Jersey" for rotational crossbreeding**
- Increased variation in body size
  - Udders of some mature cows become too deep
  - Poor temperament
  - Reduced value of bull calves
  - Increased somatic cells in milk
  - Greater frequency of milk fever

- Positives of "Brown Swiss" for rotational crossbreeding**
- High milk production
  - Increased value of bull calves
  - Outstanding feet and legs
  - Increased frequency of black hooves
  - Lowered somatic cells in milk



- Negatives of "Brown Swiss" for rotational crossbreeding**
- Later maturing
  - Lengthened gestation length
  - Increased body size
  - Increased calf mortality
  - Some calves demand a nipple instead of drinking from a bucket
  - Brown color dominates over White or Red

- Average performance of cooperating dairies in new research study in Minnesota – first 6 herds to enroll of 12 herds total**
- Herd size – 761 cows
  - Production – 12313 liters milk, 456 kg fat, 373 kg fat
  - Somatic cells – 248,000
  - Days open – 135 days
  - Turn-over rate – 35%; Stillbirth rate – 10%; Death rate – 9%
  - Committed 1160 pure Holsteins and 1725 crossbreds

- Conclusions**
- Fertility and health of Holstein cows is declining in most places in the world
  - More Holstein cows die on farms than previously
  - Fewer lactations by each Holstein cow

### Conclusions (continued)

- Selection for "sharpness" in addition to milk production has reduced fertility and survival
- Cows that are more moderate in size have greater survival
- "Smaller and rounder" cows are more functional than "taller and sharper" cows

### Conclusions (continued)

- Inbreeding is increasing in the global Holstein breed to the point of being alarming
- Production of some crossbreds is very similar to production of pure Holsteins
- Crossbreds have advantages over pure Holsteins for calving ease, stillbirth, cow fertility, and survival

### Conclusions (continued)

- Use of only 2 breeds for crossbreeding provides and inadequate heterosis over time
- Use of 3 breeds for crossbreeding provides adequate heterosis over time
- Rotational mating of 3 distinct breeds over generations is the optimum method for crossbreeding in dairy cattle

Swedish Red x  
(Montbeliarde/Holstein)

