

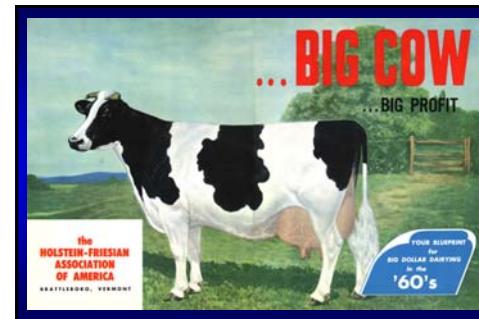
Global milk production has come increasingly from Holsteins

- 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"

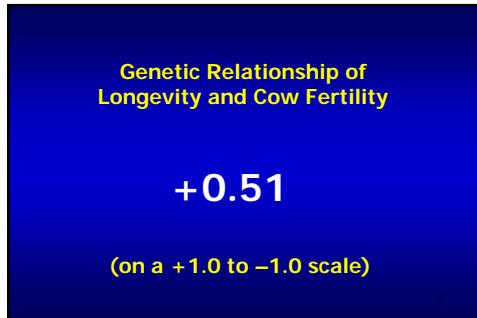
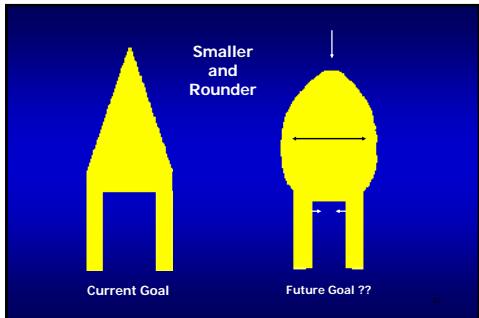


**Genetic relationships with survival of Holsteins in U.S.
(on scale of +1 to -1)**

Trait	Birth year of cows	
	1980-82 ¹	1995-97 ²
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

¹Weigel et al. (1998) J. Dairy Sci. 81:2040.
²Tsuruta et al. (2005) J. Dairy Sci. 88:1156.





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
.....(days).....		
1960	0	0
1970	+12	+9
1980	+14	+6
1990	+22	+9
2000	+38	+19

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

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

Relationship of U.S. Holsteins	
• Elevation (born 1965)	15%
• Chief (born 1962)	14%
• Blackstar (37.5% Elevation and Chief blood)	16%

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Relationship of Canadian Holsteins	
• Starbuck (son of Elevation)	20%
• Elevation	19%
• Blackstar	18%

Bull	Sire (pgs) x MGS (mgs)	% Elevation	+ % Chief	Major sons	
				(%)	
Blackstar	Chairman (Milu) x Wayne (Hilltop)	37.5		Patron, Duster, Lord Lily	
Prelude	Starbuck (Elevation) x Glender (Chief)	37.5		Moto, Outside, Tugolo (all s from blackstar dams)	
Manfred	Cubby (Bova) x Teek (Valiant)	34.4		O-Man, Potter, Ally	
Leadman	Tradition (Elevation) x Valiant (Chief)	43.8		Lukas, Formation, Funks	
Rudolph	Aerostar (Starbuck) x Mattader (Admiral)	25.0		Ramos, Champion, Machoman	
Jocko Besne	Besne Buck (Starbuck) x Southwind (Bell)	27.1		Jet Stream, Sputnik, 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 1st 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 1st calving

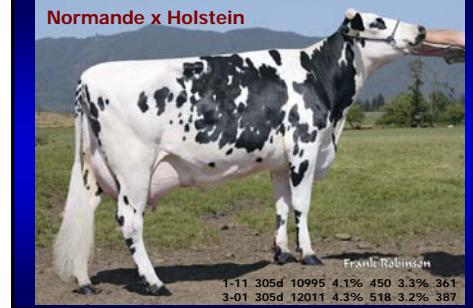
	Calves	Calving difficulty	Stillbirth
Holstein	676	17.7	14.0
Normande-Holstein	262	11.6 *	9.9
Montbeliarde-Holstein	370	7.2 *	6.2 *
Scandinavian Red-Holstein	264	3.7 *	5.1 *

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

Number of cows

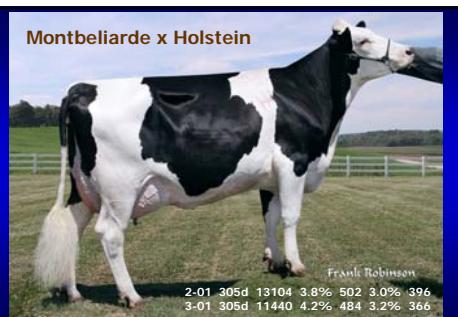
Breed	Cows	Sires
Holstein	380	69
Normande-Holstein	245	24
Montbeliarde-Holstein	494	23
Scandinavian Red-Holstein	328	13

Normande x Holstein



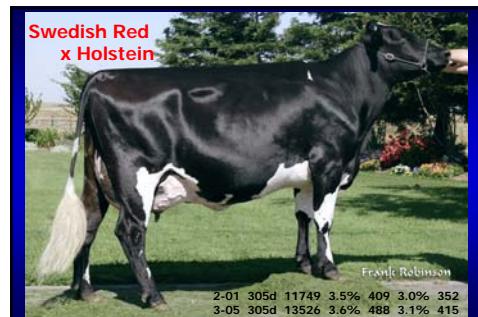
1-11 305d 10995 4.1% 450 3.3% 361
3-01 305d 12011 4.3% 518 3.2% 387

Montbeliarde x Holstein



2-01 305d 13104 3.8% 502 3.0% 396
3-01 305d 11440 4.2% 484 3.2% 366

Swedish Red x Holstein



2-01 305d 11749 3.5% 409 3.0% 352
3-05 305d 13526 3.6% 488 3.1% 415

1st 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 1st lactation (305 days)

2 nd lactation actual production in 305 days				
Trait	Pure Holstein	Normande- Holstein	Montbeliarde- 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 2nd lactation (305 days)

3 rd lactation actual production in 305 days				
Trait	Pure Holstein	Normande- Holstein	Montbeliarde- 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 3rd time, and some records are projected to 305 days

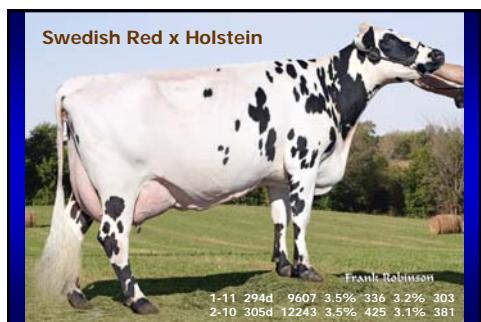
4 th lactation actual production in 305 days				
Trait	Pure Holstein	Normande- Holstein	Montbeliarde- Holstein	Scand. Red- Holstein
Cows	89	85	109	56
Milk (kg)	12372	10602 *	11456 *	11517 *
Fat (kg)	443	392 *	426	429
Protein (kg)	379	341 *	364 *	363 *
Fat (kg) + Protein (kg)	822	733 *	790 *	792 *
% of Holstein		-11%	-4%	-4%

Some cows have calved a 4th 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*
Montbeliarde-Holstein	494	93*
Scandinavian Red-Holstein	328	90*

Percentage of cows starting a 2 nd lactation within fixed periods				
Breed	Cows	14 mo	17 mo	20 mo
Holstein	380	44	63	71
Normande-Holstein	245	61 *	79 *	85 *
Montbeliarde-Holstein	494	63 *	78 *	84 *
Scandinavian Red-Holstein	328	59 *	72 *	79 *

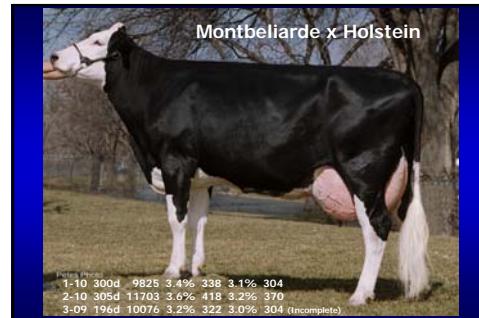
Averages for days open			
	Number		
	Cows	Sires	Days open
Holstein	360	69	147
Normande-Holstein	235	24	122 *
Montbeliarde-Holstein	478	23	124 *
Scandinavian Red-Holstein	315	13	131 *



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
1 st lactation	n = 72	n = 76	
Fat + Protein (kg)	514	497	-17
SCS	3.0	3.2	+0.2
Days open	150	127	23
2 nd lactation	n = 53	n = 63	
Fat + Protein (kg)	608	573	-35 *
SCS	2.7	3.1	+0.4
Days open	162	130	32 *
3 rd lactation	n = 31	n = 48	
Fat + Protein (kg)	641	598	-43 *
SCS	3.2	4.0	+0.8 *



**1st lactation actual
305-day production**

Trait	Pure Holstein	Montbeliarde-Holstein	Montbeliarde-(Jersey x Holstein)
Cows	61	48	35
Milk (kg)	7658	7294 *	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 1st time, and some records are projected to 305 days

**2nd 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 2nd 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)
1st lactation			
Number of cows	56	47	32
Body Condition Score	2.77	3.23 *	3.21 *
2nd lactation			
Number of cows	18	24	7
Body Condition Score	2.65	3.31 *	3.23 *

Dry matter intake during 1st 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



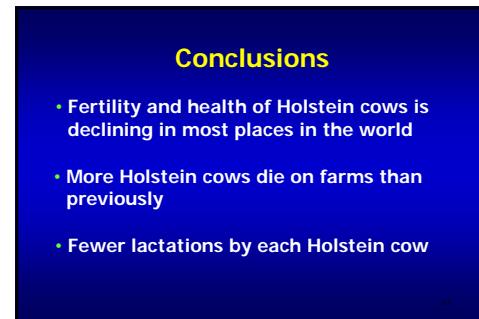
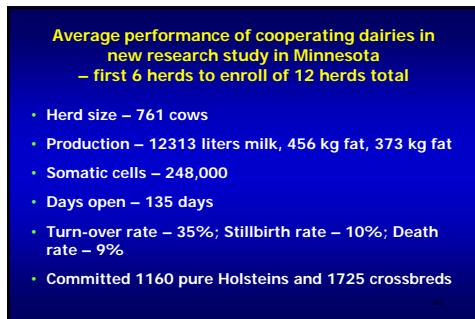
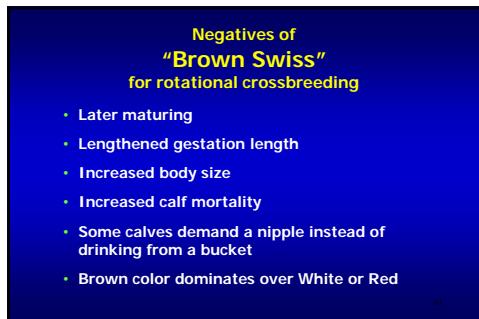
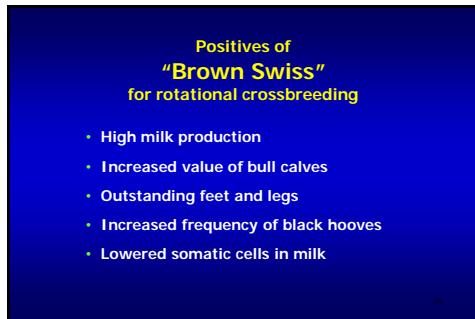
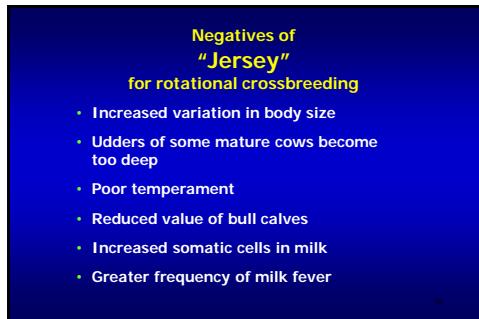
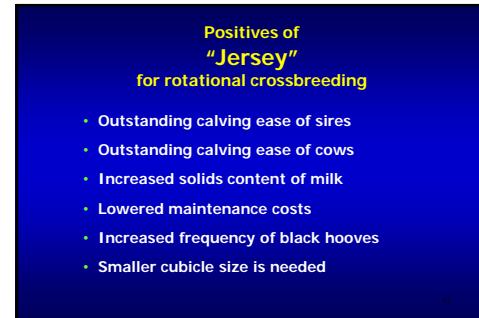
3-breed rotational crossbreeding



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)





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

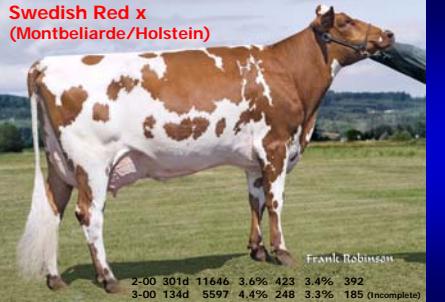
Conclusions (continued)

- 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)



2-00 301d 11646 3.6% 423 3.4% 392
3-00 134d 5597 4.4% 248 3.3% 185 (Incomplete)