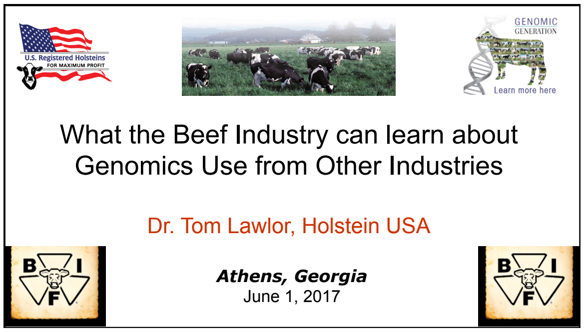


What the Beef Industry can learn about Genomics Use from Other Industries

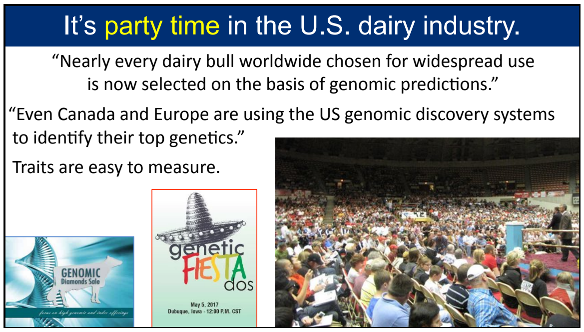
Dr. Tom Lawlor, Holstein USA

Athens, Georgia
June 1, 2017

February 8, 2017

Genetics: What can the beef industry learn from $251,000 dairy heifer sale?

Sold in Australia
Flown to Canada
Bought by Sexing Technology, USA

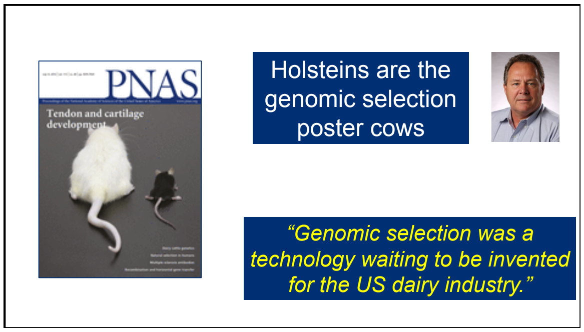


It's party time in the U.S. dairy industry.

"Nearly every dairy bull worldwide chosen for widespread use is now selected on the basis of genomic predictions."

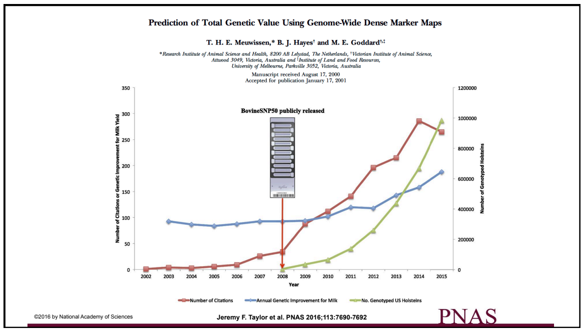
"Even Canada and Europe are using the US genomic discovery systems to identify their top genetics."

Traits are easy to measure.



Holsteins are the genomic selection poster cows

"Genomic selection was a technology waiting to be invented for the US dairy industry."



Prediction of Total Genetic Value Using Genome-Wide Dense Marker Maps

T. H. E. Meuwissen,* B. J. Hayes† and M. E. Goddard†,‡

**Research Institute of Animal Science and Health, 8200 AB Lelystad, The Netherlands, †Victorian Institute of Animal Science, Attwood 3049, Victoria, Australia and ‡Institute of Land and Food Resources, University of Melbourne, Parkville 3052, Victoria, Australia*

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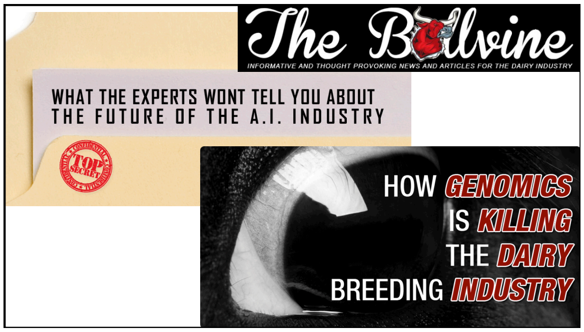
Jeremy F. Taylor et al. PNAS 2016;113:7690-7692

PNAS



WHAT THE EXPERTS WONT TELL YOU ABOUT THE FUTURE OF THE A.I. INDUSTRY

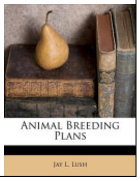
HOW GENOMICS IS KILLING THE DAIRY BREEDING INDUSTRY

We're happy to have genomic information.

But it's a rapidly changing industry .

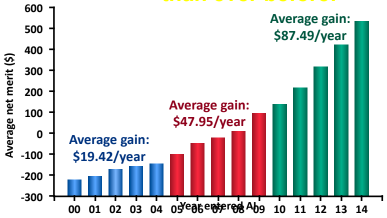
As the industry changes …… it influences how you model and analyze the data.

- Analyst - Data structure
- Everyone else – business opportunities, market share and livelihoods
- Some planning….followed by adjusting, adapting, and competing. With winners and less-than-winners.



Lots to be happy about!

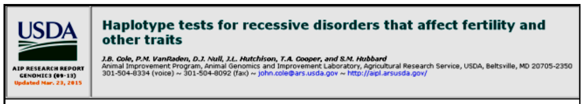
We're making faster genetic gain than ever before!



Genetic merit of marketed

How we're using genomics within the Holstein breed.

- Determine the genetic merit of elite animals at a young age.
- Manage the rate of Inbreeding.
- Keep undesirable genetic defects at a low level.
- Identify Breed composition of crossbreds. ½ HO, ¼ HO, etc.
- Verify or discover Parentage.
- Herd Management, cull low end replacement animals earlier, breed lower genetics to beef bulls.
- Having more animals genotyped allows us to more easily investigate other genetic issues.



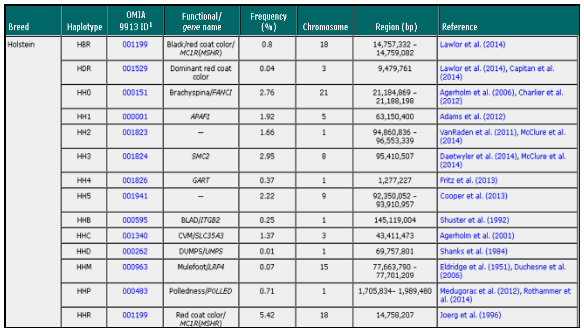
USDA
AIP RESEARCH REPORT
GENOMICS3 (09-13)
Updated Mar. 23, 2015

Haplotype tests for recessive disorders that affect fertility and other traits

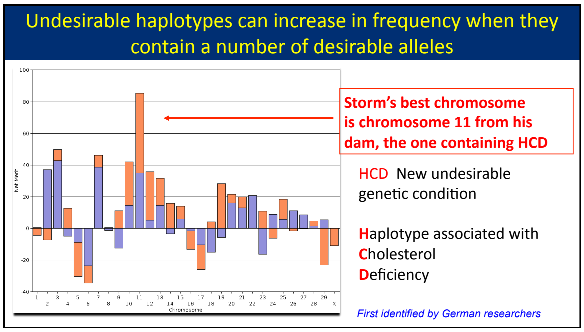
J.B. Cole, P.M. VanRaden, D.J. Null, J.L. Hutchison, T.A. Cooper, and S.M. Hubbard
Animal Improvement Program, Animal Genomics and Improvement Laboratory, Agricultural Research Service, USDA, Beltsville, MD 20705-2350
301-504-8334 (voice) ~ 301-504-8092 (fax) ~ john.cole@ars.usda.gov ~ http://aipl.arsusda.gov/

http://aipl.arsusda.gov/reference/recessive_haplotypes_ARR-G3.html

> One in five animals are expected to be a carrier of a genetic defect causing early embryonic loss.
>
> *VanRaden and Miller, 2006*



Breed	Haplotype	OMIA 9913 ID[1]	Functional/ *gene* name	Frequency (%)	Chromosome	Region (bp)	Reference
Holstein	HBR	001199	Black/red coat color/ *MC1R*(*MSHR*)	0.8	18	14,757,332 – 14,759,082	Lawlor et al. (2014)
	HDR	001529	Dominant red coat color	0.04	3	9,479,761	Lawlor et al. (2014), Capitan et al. (2014)
	HH0	000151	Brachyspina/*FANCI*	2.76	21	21,184,869 – 21,188,198	Agerholm et al. (2006), Charlier et al. (2012)
	HH1	000001	*APAF1*	1.92	5	63,150,400	Adams et al. (2012)
	HH2	001823	—	1.66	1	94,860,836 – 96,553,339	VanRaden et al. (2011), McClure et al. (2014)
	HH3	001824	*SMC2*	2.95	8	95,410,507	Daetwyler et al. (2014), McClure et al. (2014)
	HH4	001826	*GART*	0.37	1	1,277,227	Fritz et al. (2013)
	HH5	001941	—	2.22	9	92,350,052 – 93,910,957	Cooper et al. (2013)
	HHB	000595	BLAD/*ITGB2*	0.25	1	145,119,004	Shuster et al. (1992)
	HHC	001340	CVM/*SLC35A3*	1.37	3	43,411,473	Agerholm et al. (2001)
	HHD	000262	DUMPS/*UMPS*	0.01	1	69,757,801	Shanks et al. (1984)
	HHM	000963	Mulefoot/*LRP4*	0.07	15	77,663,790 – 77,701,209	Eldridge et al. (1951), Duchesne et al. (2006)
	HHP	000483	Polledness/*POLLED*	0.71	1	1,705,834– 1,989,480	Medugorac et al. (2012), Rothammer et al. (2014)
	HHR	001199	Red coat color/ *MC1R*(*MSHR*)	5.42	18	14,758,207	Joerg et al. (1996)



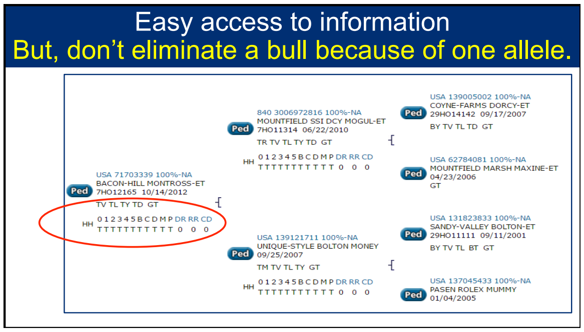
Undesirable haplotypes can increase in frequency when they contain a number of desirable alleles

Storm's best chromosome is chromosome 11 from his dam, the one containing HCD

HCD New undesirable genetic condition

Haplotype associated with **C**holesterol **D**eficiency

First identified by German researchers



Easy access to information
But, don't eliminate a bull because of one allele.

USA 71703339 100%-NA
BACON-HILL MONTROSS-ET
7HO12165 10/14/2012
TV TL TY TD GT
HH 0 1 2 3 4 5 B C D M P DR RR CD
T T T T T T T T T T T 0 0 0

840 3006972816 100%-NA
MOUNTFIELD SSI DCY MOGUL-ET
7HO11314 06/22/2010
TR TV TL TY TD GT
HH 0 1 2 3 4 5 B C D M P DR RR CD
T T T T T T T T T T T 0 0 0

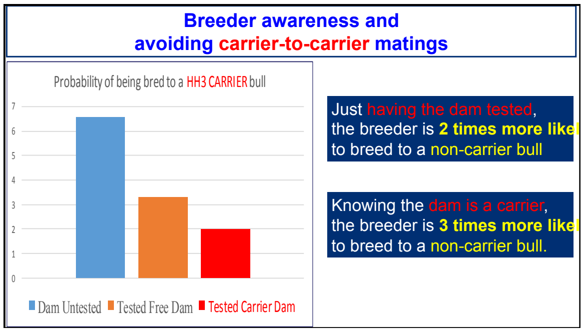
USA 139121711 100%-NA
UNIQUE-STYLE BOLTON MONEY
09/25/2007
TM TV TL TY GT
HH 0 1 2 3 4 5 B C D M P DR RR CD
T T T T T T T T T T T 0 0 0

USA 139005002 100%-NA
COYNE-FARMS DORCY-ET
29HO14142 09/17/2007
BY TV TL TD GT

USA 62784081 100%-NA
MOUNTFIELD MARSH MAXINE-ET
04/23/2006
GT

USA 131823833 100%-NA
SANDY-VALLEY BOLTON-ET
29HO11111 09/11/2001
BY TV TL BT GT

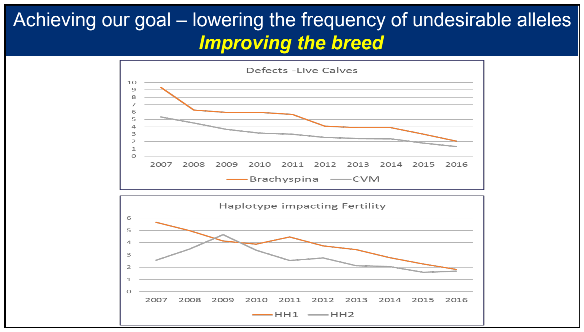
USA 137045433 100%-NA
PASEN ROLEX MUMMY
01/04/2005



Breeder awareness and avoiding carrier-to-carrier matings

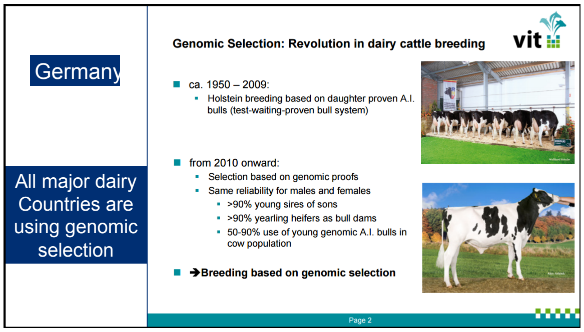
Just having the dam tested, the breeder is **2 times more like** to breed to a non-carrier bull

Knowing the dam is a carrier, the breeder is **3 times more like** to breed to a non-carrier bull.



Achieving our goal – lowering the frequency of undesirable alleles
Improving the breed

Genomic testing allows farmers and countries to jump ahead of their competition !

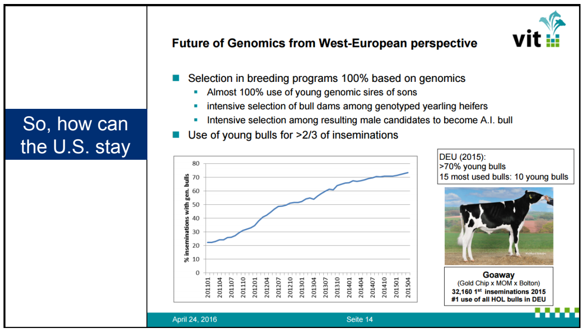


Germany

All major dairy Countries are using genomic selection

Genomic Selection: Revolution in dairy cattle breeding

- ca. 1950 – 2009:
  - Holstein breeding based on daughter proven A.I. bulls (test-waiting-proven bull system)
- from 2010 onward:
  - Selection based on genomic proofs
  - Same reliability for males and females
    - >90% young sires of sons
    - >90% yearling heifers as bull dams
    - 50-90% use of young genomic A.I. bulls in cow population
- ➔**Breeding based on genomic selection**



So, how can the U.S. stay

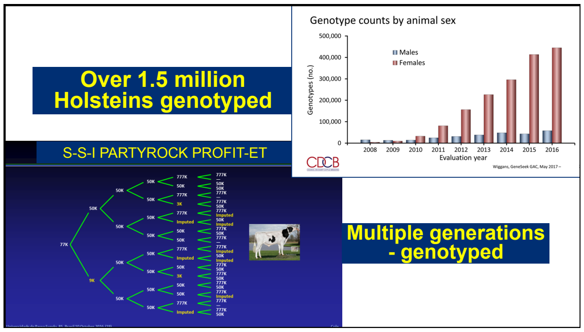
Future of Genomics from West-European perspective

- Selection in breeding programs 100% based on genomics
  - Almost 100% use of young genomic sires of sons
  - intensive selection of bull dams among genotyped yearling heifers
  - Intensive selection among resulting male candidates to become A.I. bull
- Use of young bulls for >2/3 of inseminations

DEU (2015):
>70% young bulls
15 most used bulls: 10 young bulls

Goaway
(Gold Chip x MOM x Bolton)
32,160 1st inseminations 2015
#1 use of all HOL bulls in DEU

April 24, 2016 Seite 14



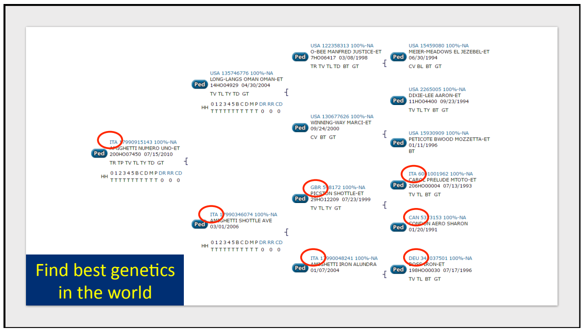
Over 1.5 million Holsteins genotyped

S-S-I PARTYROCK PROFIT-ET

Multiple generations - genotyped

Genotype counts by animal sex

Wiggans, GeneSeek GAC, May 2017 –



Find best genetics in the world

ITA 17990915143 100%-NA
AMIGHETTI NUMERO UNO-ET
200HO07450 07/15/2010
TR TP TV TL TY TD GT
HH 0 1 2 3 4 5 B C D M P DR RR CD
T T T T T T T T T T T 0 0 0

USA 135746776 100%-NA
LONG-LANGS OMAN OMAN-ET
14HO04929 04/30/2004
TV TL TY TD GT
HH 0 1 2 3 4 5 B C D M P DR RR CD
T T T T T T T T T T T 0 0 0

ITA 17990346074 100%-NA
AMIGHETTI SHOTTLE AVE
03/01/2006
HH 0 1 2 3 4 5 B C D M P DR RR CD
T T T T T T T T T T T 0 0 0

USA 122358313 100%-NA
O-BEE MANFRED JUSTICE-ET
7HO06417 03/08/1998
TR TV TL TD BT GT

USA 130677626 100%-NA
WINNING-WAY MARCI-ET
09/24/2000
CV BT GT

GBR 598172 100%-NA
PICSTON SHOTTLE-ET
29HO12209 07/23/1999
TV TL TY GT

ITA 17990048241 100%-NA
AMIGHETTI IRON ALUNDRA
01/07/2004

USA 15459080 100%-NA
MEIER-MEADOWS EL JEZEBEL-ET
06/30/1994
CV BL BT GT

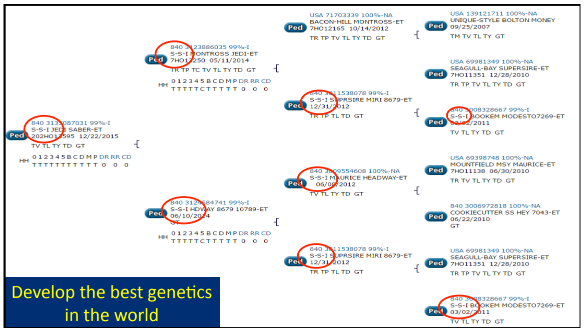
USA 2265005 100%-NA
DIXIE-LEE AARON-ET
11HO04400 09/23/1994
TV TL TY BT GT

USA 15930909 100%-NA
PETICOTE BWOOD MOZZETTA-ET
01/11/1996
BT

ITA 6001001962 100%-NA
CAROL PRELUDE MTOTO-ET
206HO00004 07/13/1993
TV TL BT GT

CAN 5343153 100%-NA
CONDON AERO SHARON
01/20/1991

DEU 34 037501 100%-NA
BOSS IRON-ET
198HO00030 07/17/1996
TV TL BT GT



Develop the best genetics in the world

840 3135087031 99%-I
S-S-I JEDI SABER-ET
202HO12595 12/22/2015
TV TL TY TD GT
HH 0 1 2 3 4 5 B C D M P DR RR CD
T T T T T T T T T T T 0 0 0

840 3123886035 99%-I
S-S-I MONTROSS JEDI-ET
7HO12250 05/11/2014
TR TP TC TV TL TY TD GT
HH 0 1 2 3 4 5 B C D M P DR RR CD
T T T T T C T T T T T 0 0 0

840 3124584741 99%-I
S-S-I HDWAY 8679 10789-ET
06/10/2014
GT
HH 0 1 2 3 4 5 B C D M P DR RR CD
T T T T T C T T T T T 0 0 0

USA 71703339 100%-NA
BACON-HILL MONTROSS-ET
7HO12165 10/14/2012
TR TP TV TL TY TD GT

840 3011538078 99%-I
S-S-I SUPRSIRE MIRI 8679-ET
12/31/2012
TR TP TL TD GT

840 3009554608 100%-NA
S-S-I MAURICE HEADWAY-ET
06/08/2012
TV TL TY TD GT

840 3011538078 99%-I
S-S-I SUPRSIRE MIRI 8679-ET
12/31/2012
TR TP TL TD GT

USA 139121711 100%-NA
UNIQUE-STYLE BOLTON MONEY
09/25/2007
TM TV TL TY GT

USA 69981349 100%-NA
SEAGULL-BAY SUPERSIRE-ET
7HO11351 12/28/2010
TR TP TV TL TY TD GT

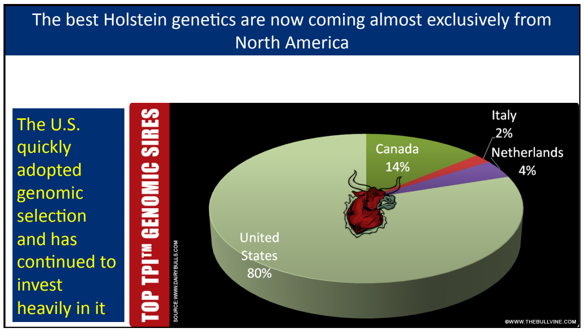
840 3008328667 99%-I
S-S-I BOOKEM MODESTO7269-ET
03/02/2011
TV TL TY TD GT

USA 69398748 100%-NA
MOUNTFIELD MSY MAURICE-ET
7HO11138 06/30/2010
TR TV TL TY TD GT

840 3006972818 100%-NA
COOKIECUTTER SS HEY 7043-ET
06/22/2010
GT

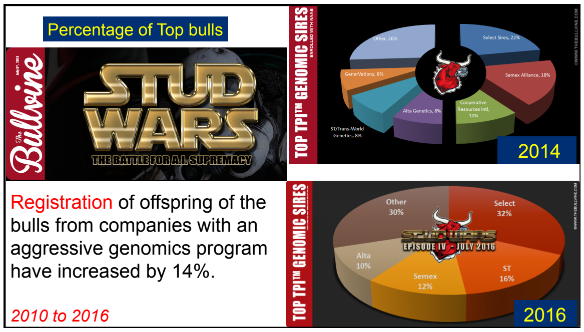
USA 69981349 100%-NA
SEAGULL-BAY SUPERSIRE-ET
7HO11351 12/28/2010
TR TP TV TL TY TD GT

840 3008328667 99%-I
S-S-I BOOKEM MODESTO7269-ET
03/02/2011
TV TL TY TD GT



The best Holstein genetics are now coming almost exclusively from North America

The U.S. quickly adopted genomic selection and has continued to invest heavily in it



Percentage of Top bulls

Registration of offspring of the bulls from companies with an aggressive genomics program have increased by 14%.

2010 to 2016

Select Sires jumps out ahead.

U.S. Registered Holsteins FOR MAXIMUM PROFIT
Holstein Association USA, Inc.

Top 200 TPI® Genomic Young Bulls APRIL 2017

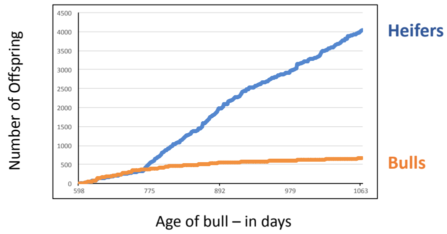
Semen status is GENOMIC with no daughters in their proofs for Production or Type.

Rank	Name		% RHA	NAAB	PRODUCTION PRO	FAT	MILK	FE	%R	HEALTH SCS	PL	%R	FI	%R	CONFORMATION PTAT	%R	UDC	FLC	BSC	TPI®
1	BLUMENFELD JEDI REASON-ET	TR TP	99-I	507HO12941	80	86	2221	215	76	2.70	8.6	71	2.9	69	1.66	74	1.33	1.66	0.35	2888G
2	LEANINGHOUSE BIG BUBBA-ET	TR TP	99-I	507HO12940	79	76	2023	205	76	2.95	7.4	71	4.0	68	2.08	75	1.86	1.63	0.40	2884G
3	S-S-I MONTROSS JEDI-ET	TR TP	99-I	7HO13250	89	82	2726	212	79	2.95	7.2	74	2.5	72	2.04	79	1.43	1.72	0.79	2867G
4	SANDY-VALLEY COPYCAT-TW-ET	TR TP	99-I	507HO12974	63	83	1476	171	76	2.73	6.5	71	3.9	68	2.52	75	2.11	2.22	2.09	2861G
5	BLUMENFELD JEDI RESOLVE-ET	TR TP	99-I	507HO12942	70	83	1802	189	76	2.74	8.4	71	3.9	69	1.69	74	1.52	1.77	1.22	2858G
6	LADYS-MANOR MJED LANTERN-ET		99-I	7HO13746	62	88	1617	184	76	2.74	7.6	71	3.8	68	2.41	75	1.81	1.77	1.08	2854G
7	S-S-I MODESTY PIZAZZ-ET	TR TP	99-I	507HO13628	70	78	1894	200	76	2.90	8.0	71	2.8	68	2.35	74	1.97	2.19	-0.35	2846G
8	SANDY-VALLEY CADET-ET	TR TP	99-I	507HO12983	75	85	1779	204	76	2.77	5.6	71	3.0	69	1.98	75	1.84	1.80	1.12	2841G
9	WELCOME THONMAKER 3170-ET	TR TP	100-NA	7HO12998	54	100	1808	203	77	2.90	8.7	71	2.5	69	2.70	76	2.37	1.92	-1.15	2834G
10	SANDY-VALLEY CODEC-ET		99-I	507HO12973	72	88	1849	194	76	2.69	6.2	71	3.1	69	1.82	75	1.80	1.09	1.51	2824G
11	S-S-I JEDI GOMES-ET	TR TP	99-I	7HO13572	65	69	1806	172	76	2.85	8.0	71	4.2	69	2.18	75	1.69	1.96	0.43	2823G
12	S-S-I MODESTY MAGICTOUCH-ET	TR TP	99-I	507HO13607	58	71	1192	174	75	2.80	8.2	71	3.3	68	2.58	74	2.24	2.48	0.41	2820G
13	S-S-I MODESTY MARQUEE-ET	TR TP	99-I	507HO13608	62	65	1609	185	76	2.87	10.4	70	4.4	68	1.71	75	1.81	1.34	-1.14	2819G
	SANDY-VALLEY AIRJET-ET	TR TP	99-I	7HO12985	69	91	2327	191	76	2.88	6.8	70	2.8	68	2.17	75	2.07	1.50	0.59	2819G
15	BUTZ-HILL DELTA-WORTH-ET	TC TV	99-I	551HO03415	59	108	1867	221	78	2.71	8.5	73	2.5	70	2.04	76	1.68	0.30	-1.08	2818G
16	S-S-I JETT JAMOCHA-ET		99-I	7HO13605	73	83	2295	185	76	2.72	6.3	71	2.3	68	2.43	75	1.63	2.01	1.11	2814G
17	BACON-HILL PETY MODESTY-ET	TR TP	100-NA	7HO12600	64	97	1909	221	79	3.03	7.7	73	1.9	71	2.20	78	2.21	1.67	-1.34	2802G
18	S-S-I BG MODESTY VORTEX-ET		100-NA	250HO13663	61	87	1455	205	75	2.93	8.0	70	2.2	68	2.47	74	2.52	1.80	-0.61	2799G
19	WELCOME-TEL BRENNAN 3158-ET	TR TP	99-I	507HO12999	56	86	1555	180	75	2.75	7.2	71	2.0	68	2.73	75	2.88	1.49	0.30	2797G
20	S-S-I LA JEDI KNIGHT-ET	TR TP	99-I	507HO13576	73	57	1834	161	76	2.80	6.7	70	3.4	68	2.16	73	1.83	1.64	1.48	2791G

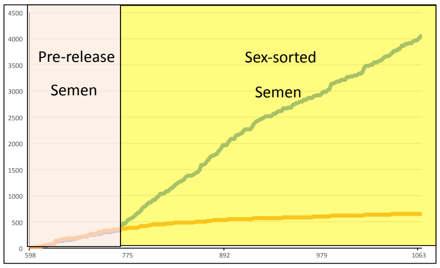
Companies are controlling access to their top genetics
Pre-release semen & Sexed Semen

- Early access to the top young bulls is being limited to a "select group"
- Their own females or cooperator herds with a marketing agreement.
  - Right of first refusal
  - 40% of young bulls coming from this source.
- Female-sex-sorted semen
  - When semen is released to the mass market

Spread of genetics has changed in the genomics era
Offspring of a top bull



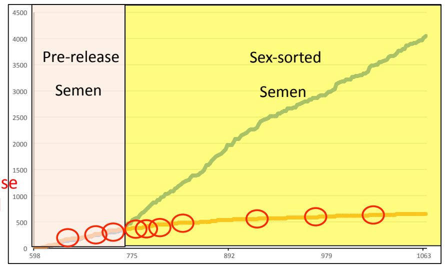
Control of Genetics
Harder for individual breeders to produce elite genetics



It's HARD to Control the access to the TOP Genetics

Top 10 Sons

7 are AFTER Pre-release period



Very competitive environment
Catch up with "Free Agents"

U.S. Registered Holsteins FOR MAXIMUM PROFIT
Holstein Association USA, Inc.

High Ranking Genomic Young Bulls APRIL 2017

Bulls with no daughters in their genomic proofs for Production or Type. No requirement for semen status.
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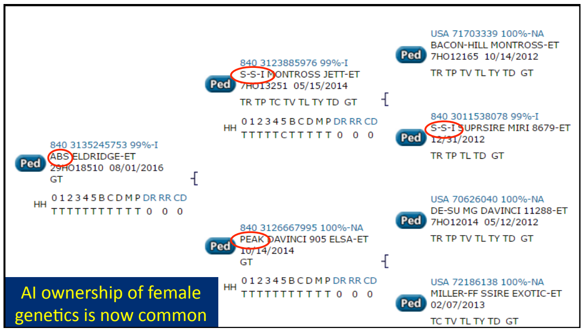
Registration Number	Name	Requester	NAAB code	Birth Date	GFI	Pro	Fat	Feed Eff.	Yield % Rel.	SCS	PL	Fert. Index	PTAT	UDC	FLC	BSC	Type % Rel.	DCE	DSB	GTPI
HO840003137878481	BOMAZ SKYWALKER-ET	GeneSeek	029HO18611	20161122	8.3	79	99	248	73	2.92	8.2	4.2	1.58	1.38	1.43	-0.29	72	2.2	3.6	2952
HOCAN000012609015	PROGENESIS FABULOUS	Semex	200HO10900	20160825	8.3	72	85	185	75	2.66	7.5	1.5	3.32	2.84	2.94	0.88	74	3.6	5.1	2952
HO840003138498788	PEAK DIVINE JEDI 80308-ET	Alta		20170204	8.1	65	75	173	75	2.88	9.3	4.4	2.76	2.64	2.08	1.11	73	3.3	4.4	2947
HOUSA000074345956	HURTGENLEA RICHARD CHARL-ET	HO		20161228	8	70	118	249	74	2.84	9.5	3.8	1.66	1.36	0.65	-1.23	71	3.1	4.2	2944
HO840003138277108	CAL-ROY-AL YODA-ET	HO	029HO18545	20160909	8.4	83	114	254	74	2.79	7.4	1.0	2.27	1.80	1.47	0.06	72	4.1	4.3	2928
HO840003138310311	REDROCK-VIEW KLUTCH-ET	HO	551HO03501	20160801	8.7	62	75	175	76	2.66	9.6	3.9	2.72	2.47	1.51	0.57	74	3.4	4.6	2924
HO840003138498761	PEAK LADYBUG JEDI 80281-ET	Alta		20170105	8.5	83	89	231	75	2.86	7.9	2.5	2.13	2.12	1.54	0.01	73	3.9	5.3	2923
HOCAN000012529327	PROGENESIS TOPNOTCH	Semex	200HO10864	20160622	8.6	73	85	202	75	2.75	9.5	2.9	2.37	2.08	1.69	0.52	73	4.1	5.7	2921
HO840003134407079	PEAK ALTAMONTOYA-ET	Alta	011HO11981	20160806	8.3	82	110	241	75	2.79	7.2	1.7	2.21	1.83	1.42	0.82	74	5.4	4.9	2916
HO840003135087428	S-S-I MODESTY PINNACLE-ET	Select	507HO13598	20160217	8.1	74	89	214	76	2.92	8.9	2.1	2.57	2.18	2.42	-0.64	74	3.3	3.9	2915
HO840003005586762	SSI-HORSENS BLU 11	Select	507HO13673	20160315	8.6	67	101	230	76	2.77	7.8	2.8	2.45	2.43	1.31	-0.87	75	4.8	5.0	2907
HO840003127565651	CLEAR-ECHO JEDI 745-ET	Select	007HO13907	20160625	8.4	67	90	198	75	2.76	8.4	4.1	2.06	1.69	1.19	0.61	74	3.0	4.1	2897
HO840003132351832	ST GEN 77998-ET	GenVis		20161205	8.1	73	103	220	75	3.01	6.7	1.4	3.33	2.87	1.72	0.06	72	5.1	4.9	2896
HO840003141227727	LARCREST B COMPLETE-ET	Select		20161224	8.4	64	74	174	75	2.78	8	4.0	2.61	2.56	1.63	1.22	72	3.3	3.3	2896
HO840003136807571	S-S-I BANDARES BIGGIE-ET	Select	007HO13857	20160904	8.3	58	80	164	76	2.61	9.8	2.9	2.62	2.68	2.01	1.73	74	5.6	3.5	2895
HO840003132351625		GenVis		20161026	8.9	73	78	184	75	2.69	8.7	2.2	2.33	2.34	1.93	0.84	73	3.4	4.7	2894
HOCAN000012529391	PROGENESIS MAVERICK	Semex	200HO10866	20160720	8.7	64	67	169	76	2.68	8.9	5.1	2.28	2.03	1.51	0.18	74	4.2	5.1	2893
HO840003134652431	BLUMENFELD JEDI REASON-ET	Select	507HO12941	20160309	8.1	80	86	215	77	2.70	8.6	2.9	1.66	1.33	1.66	0.35	74	4.6	4.6	2888
HO840003140616139	SANDY-VALLEY BDS ATHOS-ET	Select		20161220	8.3	55	78	153	75	2.79	9.2	4.1	2.38	2.83	2.05	1.22	74	3.8	3.9	2888
HO840003140985990	LEANINGHOUSE FLGSP 23507-ET	HO		20161112	8.7	72	104	210	74	2.75	7.5	1.6	2.55	1.75	2.04	0.78	73	3.9	4.3	2888



840 3135245753 99%-I
ABS ELDRIDGE-ET
29HO18510 08/01/2016
GT

HH 0 1 2 3 4 5 B C D M P DR RR CD
T T T T T T T T T T T 0 0 0

840 3123885976 99%-I
S-S-I MONTROSS JETT-ET
7HO13251 05/15/2014
TR TP TC TV TL TY TD GT

HH 0 1 2 3 4 5 B C D M P DR RR CD
T T T T T C T T T T T 0 0 0

840 3126667995 100%-NA
PEAK DAVINCI 905 ELSA-ET
10/14/2014
GT

HH 0 1 2 3 4 5 B C D M P DR RR CD
T T T T T T T T T T T 0 0 0

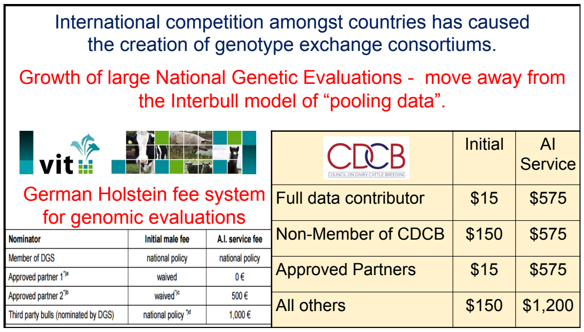
USA 71703339 100%-NA
BACON-HILL MONTROSS-ET
7HO12165 10/14/2012
TR TP TV TL TY TD GT

840 3011538078 99%-I
S-S-I SUPRSIRE MIRI 8679-ET
12/31/2012
TR TP TL TD GT

USA 70626040 100%-NA
DE-SU MG DAVINCI 11288-ET
7HO12014 05/12/2012
TR TP TV TL TY TD GT

USA 72186138 100%-NA
MILLER-FF SSIRE EXOTIC-ET
02/07/2013
TC TV TL TY TD GT

AI ownership of female genetics is now common



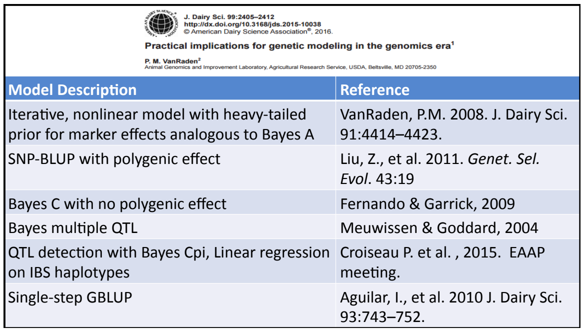
International competition amongst countries has caused the creation of genotype exchange consortiums.

Growth of large National Genetic Evaluations - move away from the Interbull model of "pooling data".

German Holstein fee system for genomic evaluations

Nominator	Initial male fee	A.I. service fee
Member of DGS	national policy	national policy
Approved partner 1*)a	waived	0 €
Approved partner 2*)b	waived*)c	500 €
Third party bulls (nominated by DGS)	national policy *)d	1,000 €

CDCB	Initial	AI Service
Full data contributor	$15	$575
Non-Member of CDCB	$150	$575
Approved Partners	$15	$575
All others	$150	$1,200



J. Dairy Sci. 99:2405–2412
http://dx.doi.org/10.3168/jds.2015-10038
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Practical implications for genetic modeling in the genomics era[1]

P. M. VanRaden[2]
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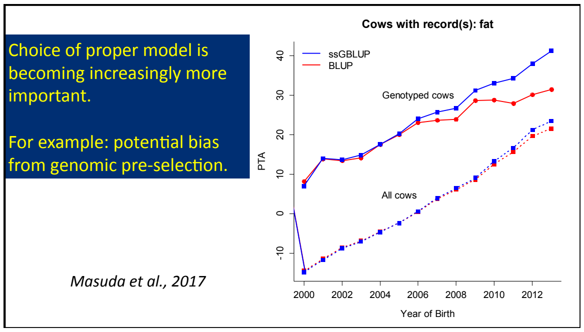
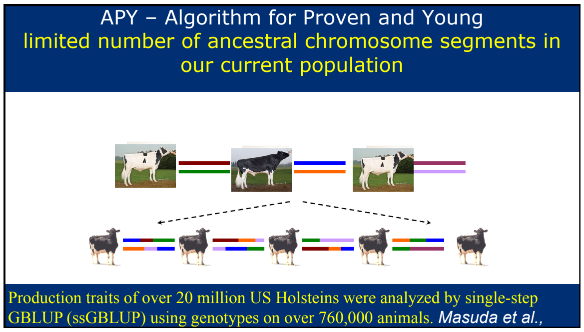
Model Description	Reference
Iterative, nonlinear model with heavy-tailed prior for marker effects analogous to Bayes A	VanRaden, P.M. 2008. J. Dairy Sci. 91:4414–4423.
SNP-BLUP with polygenic effect	Liu, Z., et al. 2011. *Genet. Sel. Evol.* 43:19
Bayes C with no polygenic effect	Fernando & Garrick, 2009
Bayes multiple QTL	Meuwissen & Goddard, 2004
QTL detection with Bayes Cpi, Linear regression on IBS haplotypes	Croiseau P. et al. , 2015. EAAP meeting.
Single-step GBLUP	Aguilar, I., et al. 2010 J. Dairy Sci. 93:743–752.



Choice of proper model is becoming increasingly more important.

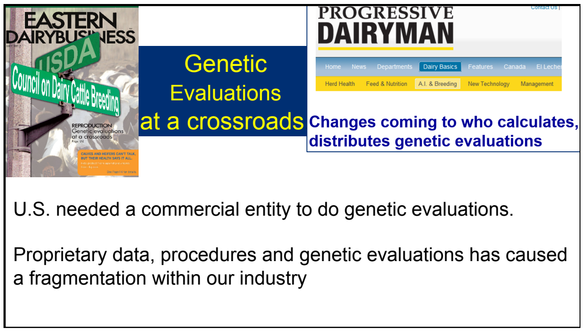
For example: potential bias from genomic pre-selection.

Masuda et al., 2017



APY – Algorithm for Proven and Young limited number of ancestral chromosome segments in our current population

Production traits of over 20 million US Holsteins were analyzed by single-step GBLUP (ssGBLUP) using genotypes on over 760,000 animals. *Masuda et al.,*



Genetic Evaluations at a crossroads

Changes coming to who calculates, distributes genetic evaluations

U.S. needed a commercial entity to do genetic evaluations.

Proprietary data, procedures and genetic evaluations has caused a fragmentation within our industry

In addition to multiple sources of National Genomic Evaluations, we're seeing multiple sources of Domestic information for the same trait

Zoetis - Wellness Traits
ABS Global - TransitionRight
GENEX – Exclusive Health Traits
CDCB - *soon to be released* Health Traits

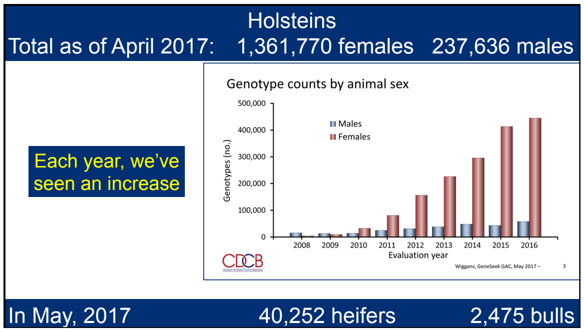
SEMEX – Immunity Plus

Health Monitor

Competition amongst the breeds

Genomic testing - *size matters*

Holstein	1.5 million
Jersey	0.2 million
Brown Swiss	0.03 million
Ayrshire	0.007 million
Guernsey	0.003 million



Holsteins

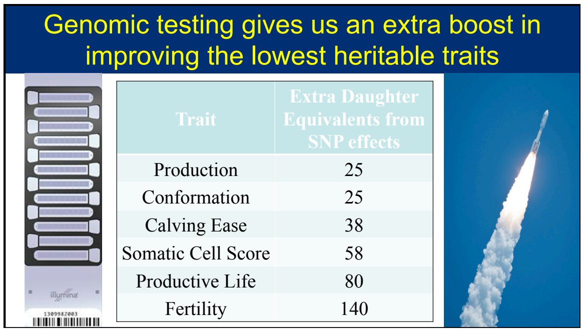
Total as of April 2017: 1,361,770 females 237,636 males

Each year, we've seen an increase

Genotype counts by animal sex

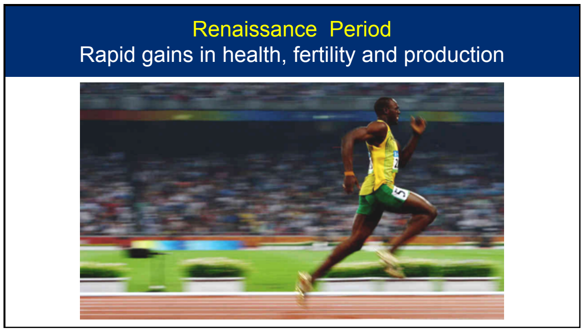
Wiggans, GeneSeek GAC, May 2017 – 3

In May, 2017 40,252 heifers 2,475 bulls



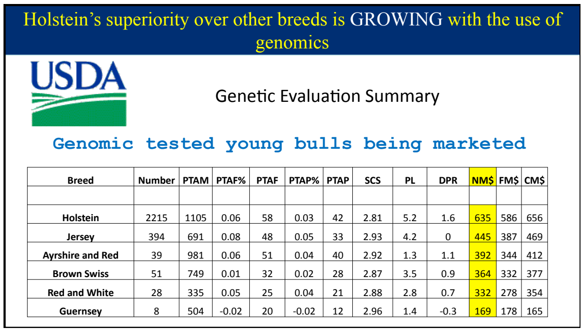
Genomic testing gives us an extra boost in improving the lowest heritable traits

Trait	Extra Daughter Equivalents from SNP effects
Production	25
Conformation	25
Calving Ease	38
Somatic Cell Score	58
Productive Life	80
Fertility	140



Renaissance Period

Rapid gains in health, fertility and production



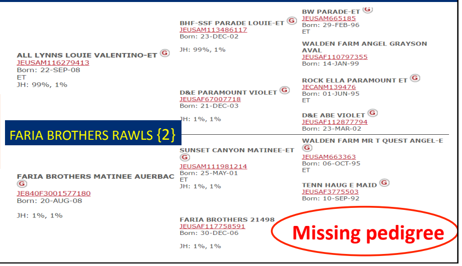
Holstein's superiority over other breeds is GROWING with the use of genomics

Genetic Evaluation Summary

Genomic tested young bulls being marketed

Breed	Number	PTAM	PTAF%	PTAF	PTAP%	PTAP	SCS	PL	DPR	NM$	FM$	CM$
Holstein	2215	1105	0.06	58	0.03	42	2.81	5.2	1.6	635	586	656
Jersey	394	691	0.08	48	0.05	33	2.93	4.2	0	445	387	469
Ayrshire and Red	39	981	0.06	51	0.04	40	2.92	1.3	1.1	392	344	412
Brown Swiss	51	749	0.01	32	0.02	28	2.87	3.5	0.9	364	332	377
Red and White	28	335	0.05	25	0.04	21	2.88	2.8	0.7	332	278	354
Guernsey	8	504	-0.02	20	-0.02	12	2.96	1.4	-0.3	169	178	165

Just like Ancestry.com, breed purity is checked. Jersey breed has brought in Holstein genetics



FARIA BROTHERS RAWLS {2}

ALL LYNNS LOUIE VALENTINO-ET Ⓖ
JEUSAM116279413
Born: 22-SEP-08
ET
JH: 99%, 1%

FARIA BROTHERS MATINEE AUERBAC Ⓖ
JE840F3001577180
Born: 20-AUG-08
JH: 1%, 1%

BHF-SSF PARADE LOUIE-ET Ⓖ
JEUSAM113486117
Born: 23-DEC-02
JH: 99%, 1%

D&E PARAMOUNT VIOLET Ⓖ
JEUSAF67007718
Born: 21-DEC-03
JH: 1%, 1%

SUNSET CANYON MATINEE-ET Ⓖ
JEUSAM111981214
Born: 25-MAY-01
ET
JH: 1%, 1%

FARIA BROTHERS 21498
JEUSAF117758591
Born: 30-DEC-06
JH: 1%, 1%

BW PARADE-ET Ⓖ
JEUSAM665185
Born: 29-FEB-96
ET

WALDEN FARM ANGEL GRAYSON AVAL
JEUSAF110797355
Born: 14-JAN-99

ROCK ELLA PARAMOUNT ET Ⓖ
JECANM139476
Born: 01-JUN-95
ET

D&E ABE VIOLET Ⓖ
JEUSAF112877794
Born: 23-MAR-02

WALDEN FARM MR T QUEST ANGEL-E Ⓖ
JEUSAM663363
Born: 06-OCT-95
ET

TENN HAUG E MAID Ⓖ
JEUSAF3775503
Born: 10-SEP-92

This Top 100 Jersey bull is **20% Holstein**

Missing pedigree

Top Net Merit $
Jersey Sires
With semen available in the U.S.
USDA Evaluations, December, 2016

Bulls with Holstein genetics

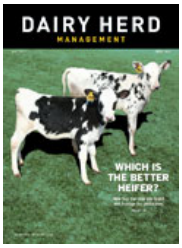
{X} = **Generation Count** where **X** is the number of generations back to an unknown ancestor

BBR Breed Based Representation
93.75% or higher is rounded up to 100

February 4, 2017 **Jersey-Cross Prefix**

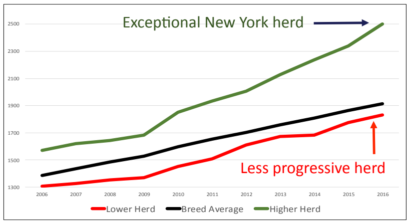
NAAB	Name	BBR or JX	NM$	REL NM$
029JE03866	SCHULTZ VOLCANO HARRIS {4}	100	779	91
001JE00957	FARIA BROTHERS BRAD STEVENS {5}	100	766	68
551JE01650	SUNSET CANYON GOT MAID {5}-ET	100	763	70
200JE00913	FARIA BROTHERS MESSI {5}-ET	100	737	69
001JE00935	CO-OP AD WORLD CUP {5}-ET	100	716	68
014JE00704	FARIA BROTHERS CALVIN HARRIS {4}	100	698	69
001JE00966	FARIA BROTHERS FUTURE {3}-ET	93	692	66
001JE00922	FARIA BROTHERS RONALDO {3}-ET	92	689	69
029JE04033	AHLEM FRISCO {5}	100	682	71
551JE01643	SEXING VALIDATE 60883 {5}-ET	100	680	70
001JE00962	FARIA BROTHERS DEGROM {3}-ET	100	677	66
014JE00652	FARIA BROTHERS MARLO {2}-ET	JX	674	70
007JE01503	FARIA BROTHERS RONALDINHO {3}	100	670	70
001JE00921	FARIA BROTHERS EUSEBIO {4}-ET	93	670	68
029JE03989	FOREST GLEN HARRIS HALT {5}	100	665	70
001JE00964	FARIA BROTHERS JODECI {3}	100	661	66
007XD01535	FARIA BROTHERS SYNDERGAARD	JX	658	53
001JE00963	HEARTLAND HARRIS MAGLIO {5}	100	654	69
007JE01533	FOREST GLEN HARRIS RHUMBA {5}	JX	652	70
011JE01179	CDF VICEROY-ET	100	651	86
001JE00892	FARIA BROTHERS VANDRELL {2}-ET	JX	648	66
029JE04008	AHLEM HARRIS BALTAZAR {5}-ET	100	646	71

Herd Improvement



Genetic education, combination of technologies and economic analysis are more important than ever.

Greater differences between herds HIGH herd make $1012 more lifetime profit per cow



Genomic testing,
In vitro fertilization,
Embryo transfer,
Sexed semen

Using older bulls and little genomic testing

What's your genomics program?

Genomics Program

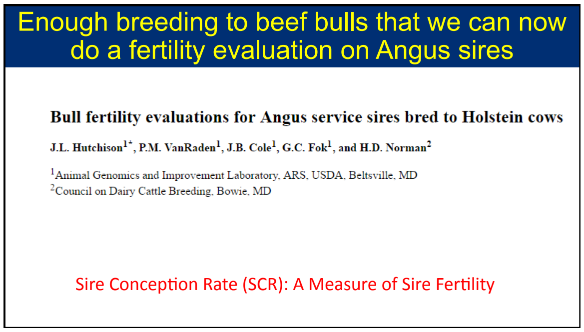
Basic theme:

- Top animals are IVF
- Next tier are bred with sexed semen or conventional semen (if bulls are wanted)
- Bottom 50% to 85% carry embryos

Variations:

- Many have On-farm IVF facility
- Several are selling embryos to other farms
- Low end animals bred to beef bulls

Large herds have an advantage – lots of recipients



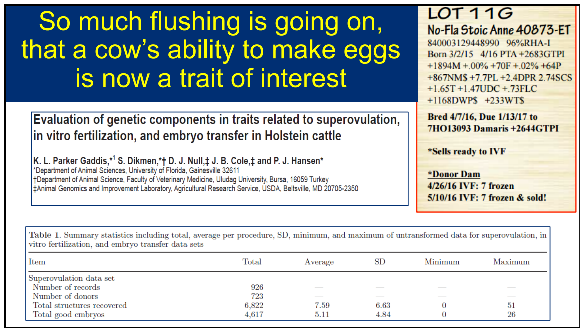
Enough breeding to beef bulls that we can now do a fertility evaluation on Angus sires

Bull fertility evaluations for Angus service sires bred to Holstein cows

J.L. Hutchison[1*], P.M. VanRaden[1], J.B. Cole[1], G.C. Fok[1], and H.D. Norman[2]

[1]Animal Genomics and Improvement Laboratory, ARS, USDA, Beltsville, MD
[2]Council on Dairy Cattle Breeding, Bowie, MD

Sire Conception Rate (SCR): A Measure of Sire Fertility



So much flushing is going on, that a cow's ability to make eggs is now a trait of interest

Evaluation of genetic components in traits related to superovulation, in vitro fertilization, and embryo transfer in Holstein cattle

K. L. Parker Gaddis,*[1] S. Dikmen,*† D. J. Null,‡ J. B. Cole,‡ and P. J. Hansen*
*Department of Animal Sciences, University of Florida, Gainesville 32611
†Department of Animal Science, Faculty of Veterinary Medicine, Uludag University, Bursa, 16059 Turkey
‡Animal Genomics and Improvement Laboratory, Agricultural Research Service, USDA, Beltsville, MD 20705-2350

LOT 11G
No-Fla Stoic Anne 40873-ET
840003129448990 96%RHA-I
Born 3/2/15 4/16 PTA +2683GTPI
+1894M +.00% +70F +.02% +64P
+867NM$ +7.7PL +2.4DPR 2.74SCS
+1.65T +1.47UDC +.73FLC
+1168DWP$ +233WT$

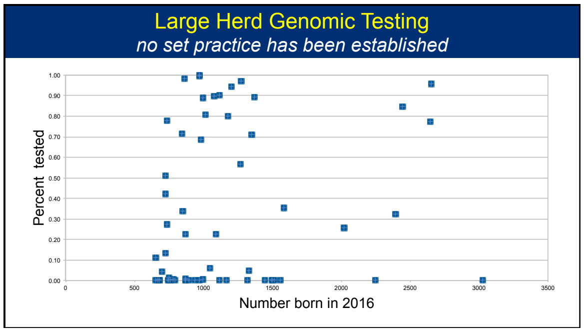
Bred 4/7/16, Due 1/13/17 to
7HO13093 Damaris +2644GTPI

***Sells ready to IVF**

<u>*Donor Dam</u>
4/26/16 IVF: 7 frozen
5/10/16 IVF: 7 frozen & sold!

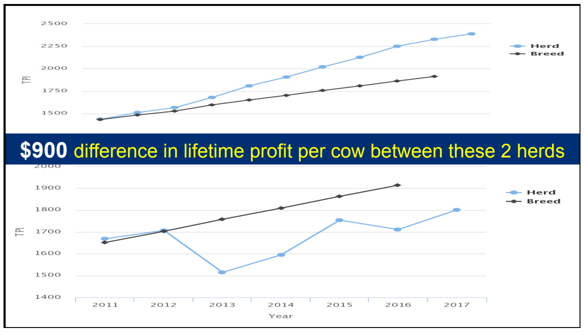
Table 1. Summary statistics including total, average per procedure, SD, minimum, and maximum of untransformed data for superovulation, in vitro fertilization, and embryo transfer data sets

Item	Total	Average	SD	Minimum	Maximum
Superovulation data set					
Number of records	926	—	—	—	—
Number of donors	723	—	—	—	—
Total structures recovered	6,822	7.59	6.63	0	51
Total good embryos	4,617	5.11	4.84	0	26

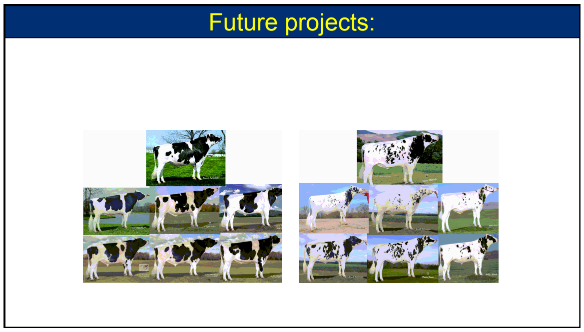


Large Herd Genomic Testing

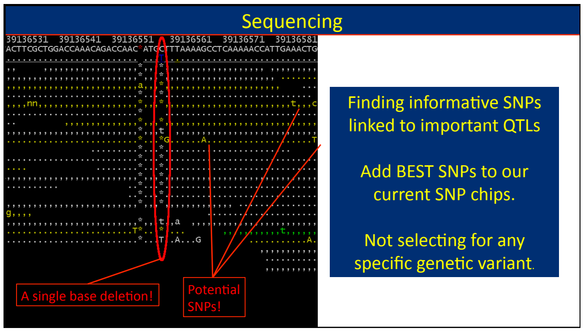
no set practice has been established



$900 difference in lifetime profit per cow between these 2 herds



Future projects:



Sequencing

A single base deletion!

Potential SNPs!

Finding informative SNPs linked to important QTLs

Add BEST SNPs to our current SNP chips.

Not selecting for any specific genetic variant.

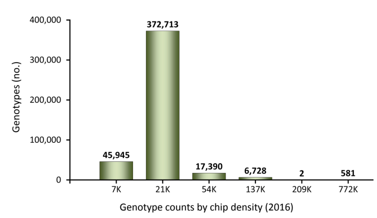
Gains in reliability from adding imputed sequence variants

Trait	60K + selected (reliability %)		
	60K only	60K + 17K	Improvement
PL	35.6	38.2	2.6
SCS	35.1	37.0	1.9
DPR	29.0	33.0	4.0
CCR	28.9	31.8	2.9
HCR	20.5	21.5	1.0

Average trait reliability improvement: **2.7%**

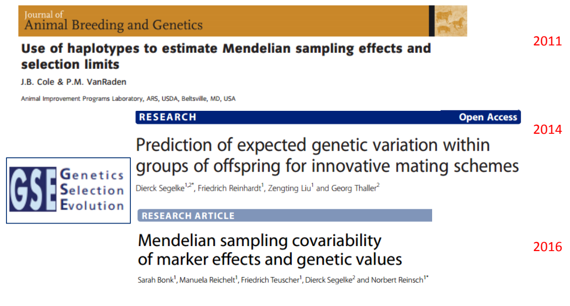
Slide adapted from a presentation by Mel Tooker at ADSA, Salt Lake City, UT. 2016

Key to success is *good* Imputation
Low cost, still informative



Genotype counts by chip density (2016)

00 = Imputed dam
(50K) 01 = 50K
(50K_V2) 02 = 50K (version 2)
(3K) 03 = 3K
(HD) 04 = Illumina 777K
05 = Affymetrix 648K
(LD) 06 = BovineLD 7K
(GGP) 07 = GeneSeek Genomic Profiler 8K
(GHD) 08 = GeneSeek Genomic Profiler HD
(GP2) 09 = GeneSeek Genomic Profiler (version 2)
(ZLD) 10 = Zoetis Low Density
(ZMD) 11 = Zoetis Medium Density
(ELD) 12 = EuroGenomics Low Density
(LD2) 13 = BovineLD 7K (version 2)
(GP3) 14 = GeneSeek Genomic Profiler (version 3)
(ZL2) 15 = Zoetis LD (Version 2)
(ZM2) 16 = Zoetis Medium Density (Version 2)
(GH2) 17 = GGP Bovine 150K
(G7K) 18 = GGP Bovine 7K, Replaced G4K, GGP Bovine
(GP4) 19 = GeneSeek Genomic Profiler (version 4)
(ZL4) 20 = Zoetis Low Density Version 4
(AMD) 21 = Affymetrix Axion OviCap Medium Density
(GF1) 22 = GeneSeek Genomic Profiler F250 (version 1)
(BG1) 23 = Affymetrix Bio-Gensys BGBoviSN
(GMD) 24 = GeneSeek Medium Density
(G9K) 25 = GGP Bovine 9K
(ZL5) 26 = Zoetis Low Density Version 5
(503) 27 = 50K (version 3)



Journal of
Animal Breeding and Genetics

Use of haplotypes to estimate Mendelian sampling effects and selection limits

J.B. Cole & P.M. VanRaden

Animal Improvement Programs Laboratory, ARS, USDA, Beltsville, MD, USA

2011

RESEARCH Open Access

Prediction of expected genetic variation within groups of offspring for innovative mating schemes

Dierck Segelke[1,2*], Friedrich Reinhardt[1], Zengting Liu[1] and Georg Thaller[2]

2014

Genetics Selection Evolution

RESEARCH ARTICLE

Mendelian sampling covariability of marker effects and genetic values

Sarah Bonk[1], Manuela Reichelt[1], Friedrich Teuscher[1], Dierck Segelke[2] and Norbert Reinsch[1*]

2016

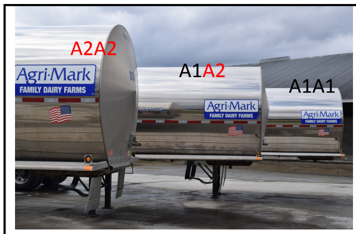
Why do these two bulls have different progeny distribution?

If we can predict "expected progeny distribution" ahead of time we use it in a mating program

	PTA Fat		
	< 0 lbs	0 to 60	> 60 lbs
Denim	3 %	92 %	5 %
Baxter	**9 %**	82 %	**9 %**

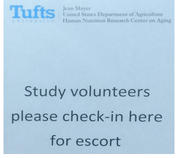
Higher percentage of extreme daughters for AltaBaxter

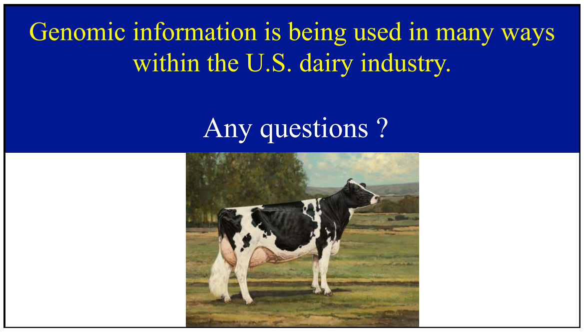
Large farms can provide a tanker truck full of milk with a specified genotype



Personalized Nutrition

Our farmers say…. tell us what you want and we'll produce it.





Genomic information is being used in many ways within the U.S. dairy industry.

Any questions ?