Preview of genetic evaluations for feed efficiency (and other traits)

Paul VanRaden,[1] Mike VandeHaar,[2] Rob Tempelman,[2] and Kent Weigel[3]

[1]USDA, Agricultural Research Service, Animal Genomics and Improvement Laboratory, Beltsville, MD, USA

[2]Michigan State University, East Lansing, MI, USA

[3]University of Wisconsin, Madison, WI, USA

paul.vanraden@usda.gov

Feed intake data

Research herd	Cows	Records	Researchers
Univ. of Wisconsin & U.S. Dairy Forage Res. Ctr.	1,390	1,678	Weigel, Armentano
Iowa State Univ.	953	1,006	Spurlock
ARS, USDA (Beltsville, MD)	534	834	Connor
Univ. of Florida	491	582	Staples
Michigan State Univ.	273	315	VandeHaar, Tempelman
Purina Anim. Nutr. Ctr. (MO)	151	184	Davidson
Virginia Tech	93	93	Hanigan
Miner Agric. Res. Inst. (NY)	58	58	Dann
All	3,965	4,823	$5 million AFRI grant

Economic values

Statistic	Milk production (3.5% F, 3.0% P)	Dry matter intake	Residual feed intake
Price/pound	$0.17	$0.12	$0.12
Mean income or cost/lactation	$4,250	–$1,992	0
Lifetime value/pound (2.8 lactations)	$0.253	–$0.336	–$0.336
Relative value (% of NM$)	36%	…	–16%

- Since 2000, NM$ has selected for smaller cows using type traits (body weight composite) to reduce expected feed intake (–5% of NM$)
- Economic values for yield and BWC already account for correlated feed intake; RFI measures uncorrelated intake

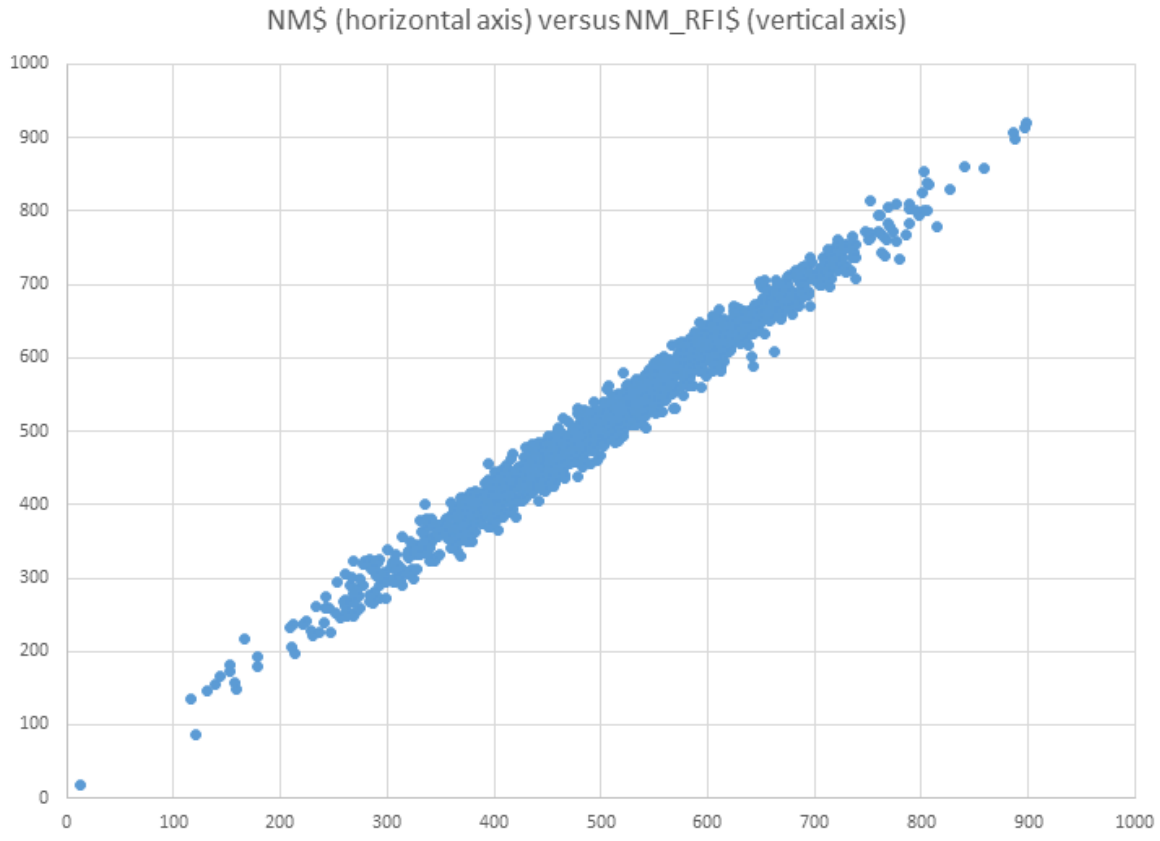
Economic indexes accounting for feed costs

- PTA definitions for columns on next slide
  - MFP$gross — Gross income from lifetime milk, fat, protein
  - MFP$net — Net income (correlated feed cost removed)
  - BWC$ — Body weight composite (lifetime value)
  - RFI$ — Residual feed intake (lifetime value)
  - FeedSaved$ — BWC$ + RFI$
  - NM$ — Lifetime net merit $ (current official)
  - NM$_RFI — NM$ + RFI$

PTAs for top NM$ calves in research herds

MFP$gross	MFP$net	BWC$	FeedSave$	RFI$	NM$	NM_RFI$
931	510	16	39	23	898	921
949	524	1	18	17	897	914
1027	574	–4	7	11	888	899
909	488	5	25	20	886	906
909	476	19	20	1	858	859
884	470	8	29	21	840	861
846	466	3	6	3	827	830
955	557	–8	–44	–36	815	779
891	474	15	45	30	807	837

NM$ before and after including feed intake data



Correlation = 0.990

Reliabilities of economic indexes

- REL definitions for research calves (same as previous slide)
  - MFP$ Official REL average of 79%
  - BWC$ Official REL average of 77%
  - RFI$ REL average of 12%
  - FeedSaved$ $(REL_{BWC} \times 67^2 + REL_{RFI} \times 209^2)/(67^2 + 209^2)$
  - NM$ REL average 76% for current official
  - NM$_noRFI $REL_{NM\$}$ including $REL_{RFI} = 0\%$ (no info)
  - NM$_RFI $(REL_{NM\$} \times 193^2 + REL_{RFI} \times 70^2)/(193^2 + 70^2)$

RELs for top NM$ calves in research herds

MFP$net	BWC$	FeedSave$	RFI$	NM$	NM_noRFI$	NM_RFI$
77	76	16	10	74	65	67
76	76	17	11	73	65	66
78	78	17	10	75	66	67
76	74	17	11	73	65	66
79	78	20	14	76	67	69
77	74	18	13	74	65	67
76	77	18	12	74	65	67
76	73	17	11	73	65	66
76	76	16	10	73	65	66

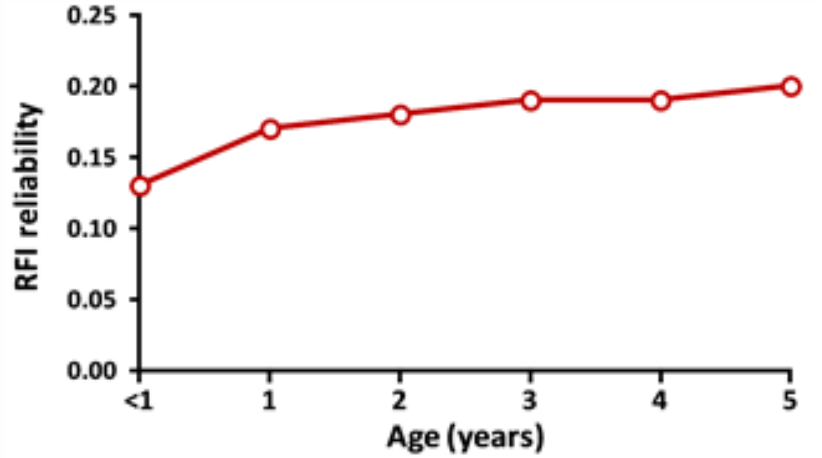
Daughters and RELs of top proven bulls (April 2019)

Bull	Dtrs_Milk	Dtrs_PL	Dtrs_RFI	REL_RFI	REL_NM	REL_NM_RFI
Rowdy	243	0	0	13	90	81
Raiden	65	0	0	13	87	78
Josuper	9,362	5,073	0	15	97	88
Rubicon	4,108	1,980	0	17	97	88
Frazzled	21	0	0	12	84	76
Dante	840	187	0	15	94	85
Delta	6,054	1,817	0	17	97	88
Coleman	77	0	0	13	86	77
Passat	158	0	0	13	89	80
Duke	614	30	0	13	92	83

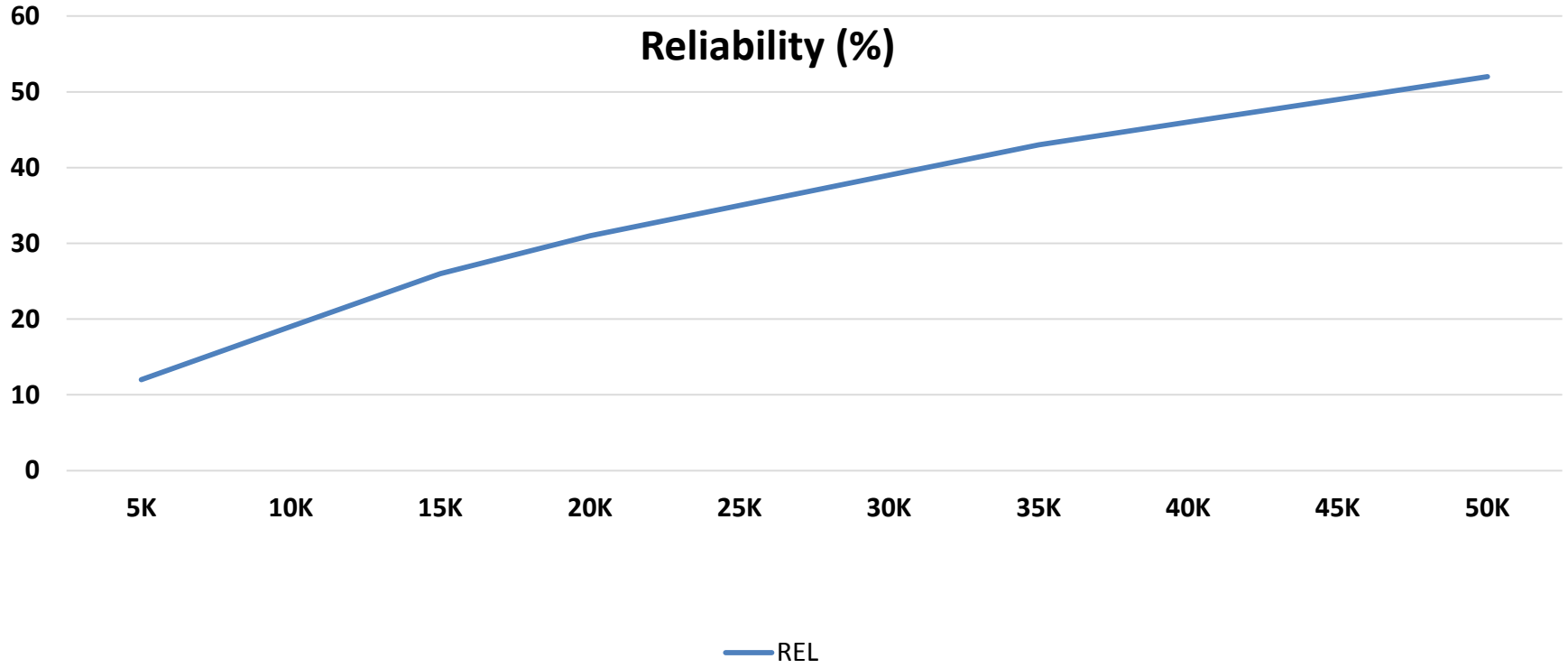
Declining REL by distance from reference cows

- Young bull reliabilities estimated by exact inversion of single-step genomic equations
- Bulls further from reference cows had lower theoretical REL for RFI
- **Conclusion:** Measure feed intake on cows more closely related to elite animals in next generation
- Research of Bingjie Li (AGIL postdoc) and Elif Gunal (CDCB intern)

- REL by age of bull



Expected RFI REL with more reference cows



RFI reliability by animal group

Animal group from national data	RFI Reliability (%)	
	Pedigree	Genomic
3,965 **cows** with RFI phenotypes	30	34
Top 10 **sires** with most RFI daughters	78	85
Top 100 Net Merit **progeny tested** sires	8	16
Top 100 Net Merit **young bulls**	3	12
1.5 million **genotyped** Holsteins	5	13
60 million **non-genotyped** Holsteins	3	3

Multi- vs. Single-Step REL of RFI

Mean REL	Pedigree	Genomic
Multi-step	24%	31%
Single-step (exact inversion)	26%	31%

Results based on 5,981 animals with 60k genotypes;
Multi-step analysis was from national RFI evaluation;
Single-step analysis was from research cows plus ancestors.
(Slight differences in multi- and single-step data modeling).
Research by postdoc Bingjie Li now published in J. Dairy Sci.

Multi- vs. Single-Step evaluation of RFI

Correlations	Pedigree	Genomic
EBV (multi- vs. single-step)	0.997	0.939
REL (multi- vs. single-step)	0.989	0.916

Results based on 5,981 animals with 60k genotypes;
Multi-step analysis was from national RFI evaluation;
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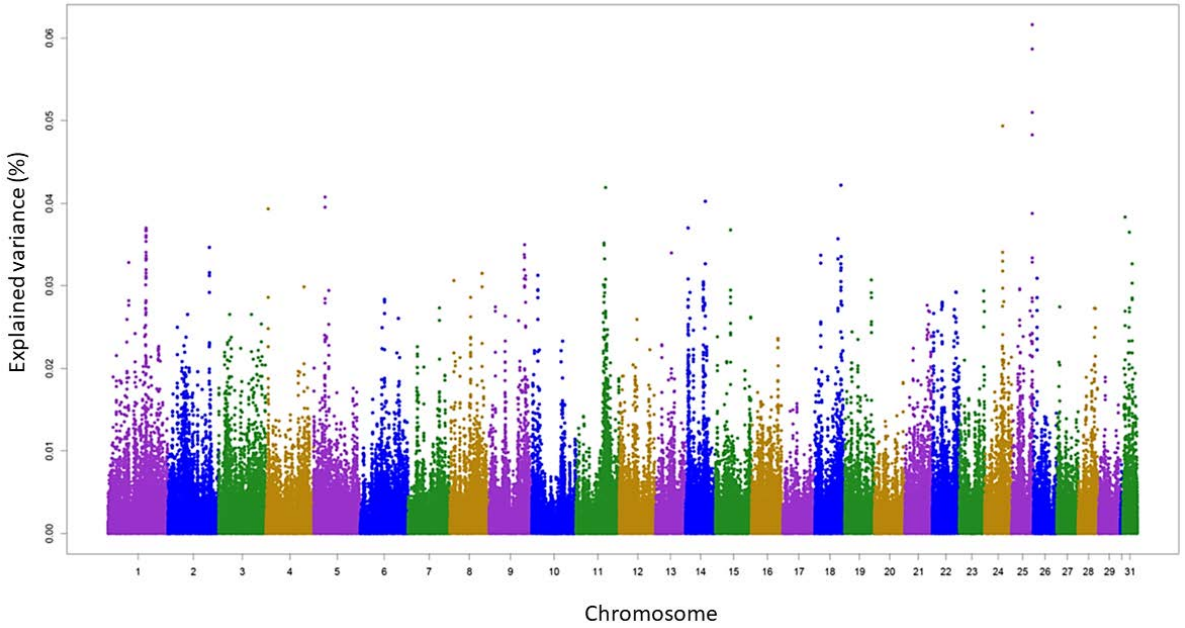
Largest effects for RFI from high-density genotypes

SNP variance explained by 5-SNP windows



Top 350 RFI SNPs provided to labs to design better future chips

Selection for feed efficiency (why now?)

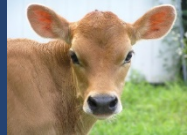
- Before genomics
  - Measurement for 1 cow = $500
  - Young bulls per year = 1,500
  - Daughters per bull = 100
  - Annual cost = $75 million

$50,000 per AI bull

- After genomics
  - Measurement for 1 cow = $500
  - Cost per genomic test = $40
  - No. of reference cows = 25,000
  - Young bulls per year = 5,000
  - One-time cost = $13.5 million
  - Annual update cost = $200,000

$310 per AI bull

Heifer livability (HLIV) data



- Extracted data from CDCB database (birth years 2001–16)
  - 4,428,896 dairy heifer data records
  - Herds with death loss of 2–25%
  - Heifers <2 days old not included (used in stillbirth)
  - Heifers up to 18 months old used
  - Total number of deaths = 142,6202 (3.2%)
- Livability scored as 100 (alive) or 0 (dead)
- Heritability estimate of 0.4% by sire model REML

HLIV evaluation

- Genomic PTAs (GPTAs) for proven bulls
  - Holstein: –1.5% to +1.5% (SD of 0.5%)
  - Jersey: –0.8% to +0.8% (SD of 0.2%)

- RELs for young animals
  - Holstein: 49% REL for GPTA
    19% REL for traditional PA
  - Jersey: 31% REL for GPTA
    13% REL for traditional PA

Correlation of HLIV with other traits (Holstein)

- Correlations for HLIV GPTA of recent proven bulls
  - 0.47 with PL and 0.20 with cow livability
  - 0.36 with calving trait dollars (calving ease, stillbirth)
  - 0.32 with early first calving (EFC)
  - 0.30 to 0.32 with yield traits
- Correlation of HLIV GPTA with NM$ is very high (0.55)
- Genetic trend for HLIV already favorable in recent years because of selection for correlated traits and NM$

Economic values for EFC and HLIV

- EFC has value of $2.50 per day (SD of 2.5 days)
  - Relative emphasis on EFC could be about 3% of NM$
  - Emphasis on HCR would decline from 2.1% to about 1.5%
  - Evaluation and derivation in Hutchison et al. (2017 JDS)

- HLIV has value of <$5.00 per 1% (SD of 0.5%)
  - Relative emphasis on HLIV could be <1% of NM$
  - Contributions to NM$ will be very small (less than ±$5)
  - Evaluation being developed by postdoc Mahesh Neupane

Economic value of PL

- Faster genetic gain makes young cows more valuable than old
- NM$ has not accounted for genetic trend of replacements
- PL may have only half the economic value currently assumed
- Based on University of Florida research by Michael Schmitt and Albert De Vries
  - Ranking sires using genetic selection indices based on financial investment methods versus lifetime net merit. J. Dairy Sci. 102:9060–9075. 2019. https://doi.org/10.3168/jds.2018-16081

Economic value of BWC in NM$

- BW pounds = 40 * BWC from Manzanilla-Pech et al., 2016
- BWC$ = BW * [cull price * (1 – cow death loss) – heifer growth cost – cow maintenance cost * 2.8 lactations – cow growth cost]
- Maintenance = $3.28 / pound BW / lactation from NRC values
- Now about twice as high as previously used in NM$ because:
  - $ value was constant using lower feed costs from 1990s
  - Modern cows require more energy for maintenance (NRC)
- The BWC$ contribution to FeedSaved$ and NM$ should double

August 2020 NM$ revision options

- RFI could get 16% of total emphasis but Var(PTA) and REL are low
- BWC should double negative emphasis from –5% to –10% because maintenance cost used since 2000 was too low
- EFC could get 3% of emphasis with reduced emphasis on HCR
- HLIV could get 1% of emphasis depending on calf value
- PL should get less value because faster progress makes younger cows more profitable than older (Schmitt et al., 2019, JDS)

Extra progress from each proposed revision

Index revisions	Old emphasis	New emphasis	Progress (% of NM$ gain)	Value/year (million $)
Add feed intake data (RFI)	…	16%	0.85	4.25
Add early first calving (EFC)	…	3%	0.04	0.20
Add heifer livability (HLIV)	…	<1%	0.01	0.05
Revise maintenance cost (BWC)	–5%	–10%	0.62	3.10
Revise opportunity cost (PL)	12%	7%	0.42	2.10
Total for all revisions	…	…	1.94	9.70

Extra progress from adding more traits to NM$

Year	Traits (no.)	Traits included	Correlation with previous index	Extra progress
1977	3	Milk, fat, protein	…	…
1994	5	PL, SCS	0.84	19%
2000	18	Linear type	0.94	6%
2003	21	DPR, calving ease	0.98	2%
2006	23	Stillbirth	0.975	3%
2014	25	HCR, CCR	0.965	4%
2017	26	LIV	0.989	1%
2018	32	Health traits	0.994	0.6%
2020	35	RFI, EFC, HLIV, revisions	0.981	1.9%

Reporting feed saved, feed efficiency, or RFI

- Feed saved is already reported in AUS and proposed for USA
  - FeedSaved$ combines RFI$ and BWC$ (value of BWC) but not yield traits
- Feed efficiency is already reported by Holstein USA:
  - FE$ combines MFP$net and BWC$ to get milk income – expected feed cost
  - Current definition receives 8% of emphasis in TPI
  - New FE$ could be FE$ + RFI$, then deserves more emphasis
- Multiple choice: FeedSaved$, RFI$, FE$? Or report pounds or kg of DMI?

Conclusions

- RFI could get ~16% of relative emphasis in net merit, but low REL of ~12% for young animals will limit progress
- HLIV could have genomic evaluations in 2020
- NM$ should
  - Include RFI, EFC, and HLIV
  - Put more emphasis on smaller BWC
  - Reduce emphasis on PL and HCR
- REL of NM$ is lower when feed intake or other traits with low REL (such as fertility) are included in selection goal, but progress is faster

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