Phenotypes for novel functional traits of dairy cattle

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Introduction



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What are function altraits?conference

30th – 31st of May, 2013 • The ICAR Functional Traits Working Group currently is working on:

General health traits

Female fertility

Feet and legs problems

• Udder health

Workability

Why are functional traits important?

- Growing emphasis on functional traits
 - Economically important because they impact other traits
- Challenges with functional traits
 - Inconsistent trait definitions
 - Many have low heritabilities
 - Unclear incentives for collection

Functional traits are being used



Functional traits have low heritabilities

$\mathsf{P} = \mathsf{G} + \mathsf{E}$

The percentage of total variation attributable to genetics is small. •CA\$: 0.07 •DPR: 0.04 •PL: 0.08 •SCS: 0.12 The percentage of total variation attributable to environmental factors is large: Feeding/nutrition Housing Reproductive management

What traits are commonly recorded?

Group	Ν	Traits included
Calving	4	Direct & maternal calving ease, direct & maternal stillbirth
Conformation	19	Stature, chest width, body depth, angularity, rump angle, rump width, rear leg set, rear leg rear view, foot angle, fore udder, rear udder height, udder support, udder depth, teat placement, teat length, rear teat placement, overall conformation score, overall udder score, overall feet & leg score
Fertility	5	Heifer conception rate, days to first service, cow conception rate, services per conception, and days open
Longevity	1	Direct longevity
Production	3	Milk, fat, and protein yields
Udder health	2	Milk somatic cell count, clinical mastitis
Workability	2	Milking speed, temperament

Holstein traits evaluated by the International Bull Evaluation Service (https://wiki.interbull.org/public/CoP_chapter6?action=print&rev=16).

Some traits are underutilized

- Some traits are commonly recorded, but not often genetically evaluated
 - e.g., gestation length, milking speed, temperament
- Breeding objectives differ across countries
 - Not all traits equally valuable to all people
- New phenotypes can supersede old ones

Lots of genotypes are available in the US

Chip	Traditional evaluation?	Animal sex	Holstein	Jersey	Brown Swiss	Ayrshir e
≥ 50K	Yes	Bulls Cows	25,276 22,094	4,262 1,203	5,862 136	678 27
	Νο	Bulls Cows	51,122 38,182	4,428 1,462	806 201	427 196
<50K	Yes	Bulls Cows	24 48,552	13 17,246	28 757	14 4
	Νο	Bulls Cows	35,639 294,875	3,935 34,018	243 1,149	43 677
Imputed	Yes No	Cows Cows	2,983 1,394	265 50	96 99	15 16
All			520,141	66,882	9,377	2,097
						598,497

Other countries are doing genomics, too!

Country Australia Denmark/Finland/Sweden France Germany Italy **Netherlands** Poland Switzerland (Red Holstein) Animals (no.) 5,314 23,961 24,313 25,624 21,041 23,047 3,174 4,194

Phenotypes may come from genotypes

Name	Chrome	Location (Mbp)	Carrier Freq	Earliest Known Ancestor
HH1	5	62-68	4.5	Pawnee Farm Arlinda Chief
HH2	1	93-98	4.6	Willowholme Mark Anthony
HH3	8	92-97	4.7	Glendell Arlinda Chief, Gray View Skyliner
HH4	1	1.2-1.3	0.37	Besne Buck
HH5	9	92-94	2.22	Thornlea Texal Supreme
JH1	15	11-16	23.4	Observer Chocolate Soldier
BH1	7	42-47	14.0	West Lawn Stretch Improver
BH2	19	10-12	7.78	Rancho Rustic My Design
AH1	17	65.9-66.2	26.1	Selwood Betty's Commander

For a complete list, see: http://aipl.arsusda.gov/reference/recessive_haplotypes_ARR-G3.html.

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Why do we need new phenotypes?

Changes in production economics

- Rising feed costs drive demand for increased efficiency
- Technology enables collection of new phenotypes
 - Milking speed in AMS
 - Pedometry for changes in behavior
- Better understanding of biology

Sources of novel phenotypes

Barn: flooring type, bedding materials, density, weather data

Cour: body temperature, activity, rumination time, intake

Herdsmen/consultants: health events, foot/claw health, veterinary treatments

Parlor: yield, composition, milking speed, conductivity, progesterone, temperature Silo/bunker: ration composition, nutrient profiles

Pasture: soil type/composition, nutrient composition

http://commons.wikimedia.org/wiki/File:Amish_dairy_farm_3.jpg International Committee for Animal Recording, Berlin, Germany, May 22, 2014 (13)

Novel phenotypes studied recently

- Claw health (Van der Linde et al., 2010)
- Dairy cattle health (Parker Gaddis et al., 2013)
- Embryonic development (Cochran et al., 2013)
- Immune response (Thompson-Crispi et al., 2013)
- Methane production (de Haas et al., 2011)
- Milk fatty acid composition (Soyeurt et al., 2011)
- Persistency of lactation (Cole et al., 2009)
- Rectal temperature (Dikmen et al., 2013)
- Residual feed intake (Connor et al., 2013)

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What do current phenotypes look like?

Low-dimensionality

- Usually few observations per lactation
- Close correspondence of phenotypes with values measured
- Easy transmission and storage

Get cow lactation records

Output from "Get cow lactation records"

Cow	HOCAN00008036612 key=35757290																							
Lac	Fresh	DIM	Herd	CtrlNo	Proc_Date	Mod_Date	LT	Mk	LI	TC	TC2	OS&	PC	Opn	DCR	Milk	DCR	Fat	DCR	Prot	DCR	SCS	Bth	NTD
1	1997/11/05	324	23361868	34	1999/04/22	2009/08/21	. 0	00	0	0		0	0	84	97	33142	97	1170	97	917	94	1.62	0	11
2	1998/11/16	332	23361868	34	1999/11/04	2009/08/21	. 0	40	0	0		0	0	79	103	33174	99	991	100	896	96	2.83	0	11
3	1999/11/26	328	23361868	34	2000/10/02	2009/08/21	. 0	40	0	0		0	0	151	97	34269	97	1192	97	895	95	3.23	0	10
4	2001/02/13	87	23361868	34	2001/06/01	2009/08/21	. 0	c0	0	7		0	0	-1	69	27738	70	996	69	736	73	3.02	0	3

What do new phenotypes look like?

High dimensionality

- Ex.: MIR produces 1,060 points/obs.
- Disconnect between phenotype and measurement
- More resources needed for transmission, storage, and analysis

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Who pays for new phenotypes?

- Costs
 - Labor and materials for recording
 - Data transmission, storage, and processing
- Benefits
 - Farmers provide data and consume services
 - Centers consume data and provide services



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Cost of measurement vs. value



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New phenotypes should add information

henotypic correlatior with existing traits NO NO **Novel phenotypes** include some new information

Novel phenotypes contain little new information

Novel phenotypes include much new information

Novel phenotypes contain some new information

low

high **Genetic correlation with** existing traits

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What can farmers do with novel traits?

Put them into a selection index

- Correlated traits are helpful
- Apply selection for a long time
 - There are no shortcuts
- Collect phenotypes on many daughters
 - Repeated records of limited value
 - Genomics can increase accuracy

What can DRPCs do with novel traits?

- Short-term Benchmarking tools for herd management
- Medium-term Custom indices for herd management
 - Additional types of data will be helpful
- Long-term Genetic evaluations
 - Lots of data needed, which will take time

What do US dairy farmers want?

National workshop in Tempe, AZ in



Advancing Dairy Cattle Genetics: Genomics and Beyond types February 17-19, 2014

cing Dairy Cattle Genetics: Genomics and Beyond was the focus of a three-day wor future of dairy cattle genetics. It marked the first time in over a decade that the entire da community gathered to discuss the long-term future. Commercial dairy producers and greatest interest

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International challenges

- National datasets are siloed
- Recording standards differ between countries
 - ICAR standards help here
- Farmers are concerned about the security of their data
- Many populations are small
 - Low accuracies
 - Small markets

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- New technology is enabling the collection of novel phenotypes
- New phenotypes support increased focus on economically important aspects of dairy production
- Infrastructure for moving new phenotypes from the farm to the data center is needed

Acknowledgments

- ICAR Functional Traits Working Group
- Paul VanRaden, AGIL
- AFRI grant 1245-31000-101-05, "Improving Fertility of Dairy Cattle Using Translational Genomics"

Questions?

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