

# Genetic evaluation for feet and legs

**Bob Weaber, Lane Giess,  
Brady Jensen, Jenny Bormann**



# Who's impacted by feet and leg issues?

- Cow-calf producers
  - Breeding bulls with feet issues
  - Cows or replacement heifers with feet/structure problems that result in culling
- Seedstock producers
  - Returns or sale credits due to poor feet/longevity
- Are feet and leg traits ERTs or Indicator Traits?
  - Depends, but likely an ERT for bull breeders.

# Why select for feet and leg traits?

- Recently seem to see more problems with feet and leg traits
  - With intense selection for other traits, may have neglected some functional traits
- Welfare issues
  - Severe lameness is not just a production problem
  - Good stewardship
- Longevity!!!
  - Expensive replacements
  - Lost productivity
  - Breeding soundness for bulls

# Why select for feet and leg traits?

- Longevity can help offset the cost of replacements
  - Maintaining a mature cow herd which produces a higher percentage of calves balances the cost of replacement heifers (Cundiff, 1992)
  - A cow takes 6 years to repay her capital investment above depreciation value (Brooks, 2015)

# Challenges and Opportunities

- Challenges selecting for soundness
  - Deciding what to score, difficult to score
  - Unknown relationship of conformation and soundness with longevity
- Benefits of scoring and evaluating soundness
  - Begin to understand relationship of soundness traits with longevity
  - Putting numbers to structure provides data for genetic evaluation
  - EPD for traits allows for more effective selection

# Soundness –what to select?

- Shoulder angle
- Front leg knee orientation
- Front foot –toe angle, toe shape, heel depth
- Hip/stifle set
- Hock set
- Rear foot –toe angle, toe shape, heel depth
- Foot size

# Research on feet and legs in the dairy industry

- Moderate genetic relationships with type traits and longevity (Dekkers et al., 1994)
- Longevity tends to be lowly heritable (Vollema and Groen, 1997)
  - 0.09-0.13
  - Indicator traits would be useful to help select for longevity

# Research on feet and legs in the dairy industry

- Heritabilities

–Foot angle	0.09-0.12
–Rear leg side view	0.15-0.22
–Rear leg rear view	0.06 -0.11
–Composite score	0.13-0.41

(Vollema and Groen 1997, Onyiro and Brotherstone 2008, Laursen et al. 2009, and Wright et al. 2012)



# American Holstein Association

- Genetic evaluation for linear type traits
  - 4 involve feet and legs:
    - Rear legs side view heritability = 0.21
    - Rear legs rear view heritability = 0.11
    - Foot angle heritability = 0.15
    - Feet and legs score heritability = 0.17
- Feet and legs composite index (FLC)
- FLC included in Total Performance Index

American Holstein Association, 2019

# Research on feet and legs in the beef industry

- American Simmental (Kirschten et al. 2001)
  - Over 13,000 records by trained evaluators
  - Rear leg side view heritability = 0.20
  - Foot/pastern angle heritability = 0.21
- Italian Chianina (Forabosco et al. 2004)
  - Over 6000 cows
  - Straight hind leg had 59% higher probability of being culled compared to moderate hind leg
  - Sickle hind leg had 3% higher probability of being culled than moderate hind leg

# Research on feet and legs in the beef industry

- Australian Angus (Jeyaruban et al. 2012), approximately 7000 records
- Heritabilities (SE) and genetic correlations (SE) using linear model

	FA	FC	RA	RC	RH	RS
Front foot angle (FA)	0.32 (0.04)	0.79 (0.06)	0.87 (0.04)	0.57 (0.09)	0.22 (0.13)	0.32 (0.11)
Front foot claw (FC)		0.33 (0.04)	0.40 (0.10)	0.69 (0.07)	0.01 (0.13)	0.08 (0.12)
Rear foot angle (RA)			0.29 (0.05)	0.62 (0.09)	0.33 (0.12)	0.68 (0.09)
Rear foot claw (RC)				0.29 (0.05)	0.07 (0.14)	0.34 (0.13)
Rear leg hind view (RH)					0.17 (0.04)	0.47 (0.12)
Rear leg side view (RS)						0.21 (0.04)

# Australian Angus Association

- Australian Angus first large scale genetic evaluation in beef
  - Measure and calculate EBV ( $1/2 \text{ EBV} = \text{EPD}$ ) on 5 traits
    - Front feet claw set



Australian Angus Assoc. 2019

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- Australian Angus first large scale genetic evaluation in beef
  - Measure and calculate EBV (their version of EPD) on 5 traits
    - Front feet angle and Rear feet angle



Australian Angus Assoc. 2019

# Australian Angus Association

- Australian Angus first large scale genetic evaluation in beef
  - Measure and calculate EBV (their version of EPD) on 5 traits
    - Rear leg side view and rear leg hind view

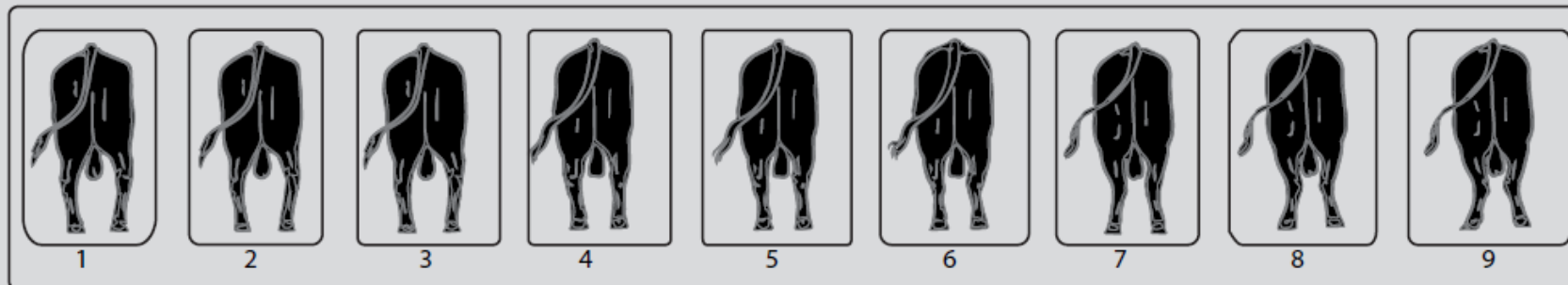


Straight rear leg (ST)

desirable

Sickle hocked rear leg (SI)

Reference: Angle measured at the front of the hock.



Bow legged rear leg (BL)

desirable

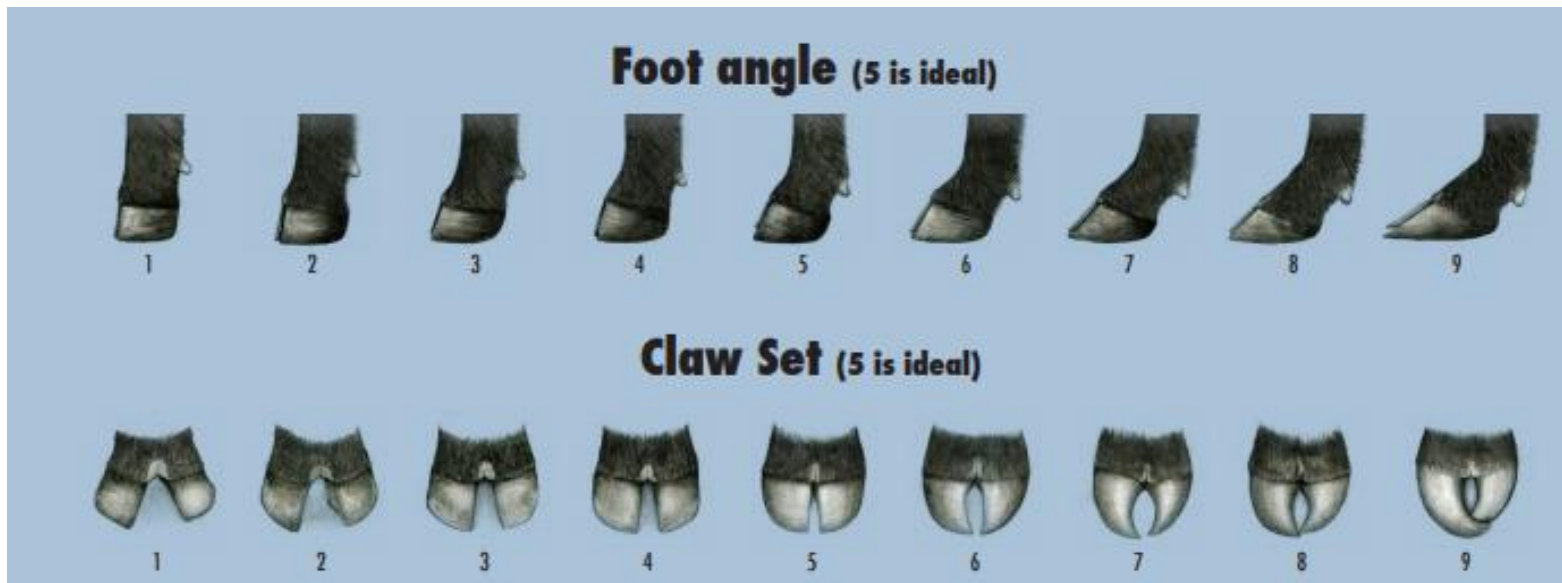
Cow hocked rear leg (CH)

Reference: Direction of the feet when viewed from the rear.

Australian Angus Assoc. 2019

# American Angus Association

- Research EPD for two traits: Foot angle, Claw set
- Approximately >20,000 phenotypes
- Heritability of both traits = 0.25, genetic correlation = 0.22



American Angus Assoc. 2019

# American Angus Association

- Research EPD for two traits: Foot angle, Claw set
- Working with collegiate judging teams to collect scores
- Guidelines:
  - Score before trimming hooves
  - Score worst hoof
  - Score at yearling time
    - Bulls 320-440 days of age, Heifers 320-460 days of age
  - Mature cows can be scored when mature weights collected
  - Older bulls can be submitted if groups available

American Angus Assoc. 2019



# American Angus Association

- Research EPD for two traits: Foot angle, Claw set
  - Not updated Friday like other traits
  - Only using scores  $\geq 5$  at this time
    - Very few scores lower than 5 in the population
  - Average EPD is 0.5
    - Selecting for lower EPD will improve foot structure
  - Continuing to collect phenotypes to move research EPD into regular genetic evaluation
  - Included in \$M index

American Angus Assoc. 2019

# Feet and leg structure evaluation at K-State

- Estimate genetic parameters for feet and leg structure in Red Angus and Simmental cattle
- Investigate relationships within feet and leg structure traits and between feet and leg structure and production traits



# Traits Measured

- 1,885 Red Angus cattle were subjectively scored on 14 traits including:
  - Body Condition Score
  - Front Feet Hoof Angle
  - Front Feet Heel Depth
  - Front Feet Claw Shape
  - Front Leg Side View
  - Front Leg Front View Knee Orientation
  - Front Leg Front View Hoof Orientation
  - Rear Feet Hoof Angle
  - Rear Feet Heel Depth
  - Rear Feet Claw Shape
  - Rear Leg Side View
  - Rear Leg Rear View
  - Hoof Size
  - Composite Score

# KSU feet and leg scoring system

Front Feet Side View  
(Knee and Shoulder)



**Buck-kneed**

10



STRAIGHT LEG

35



IDEAL

50



TOO MUCH

65



**Calf-kneed**

90

0 10 20 30 40 50 60 70 80 90 100

Knee and Shoulder Relationship



# KSU feet and leg scoring system

Front Feet  
Forward View Orientation



Pigeon-toed  
(feet in)

**20**



Bowlegged

**35**



Correct

**50**



Knocked-kneed

**65**



Splayfooted  
(feet out)

**80**

0 10 20 30 40 50 60 70 80 90 100

Knee Orientation

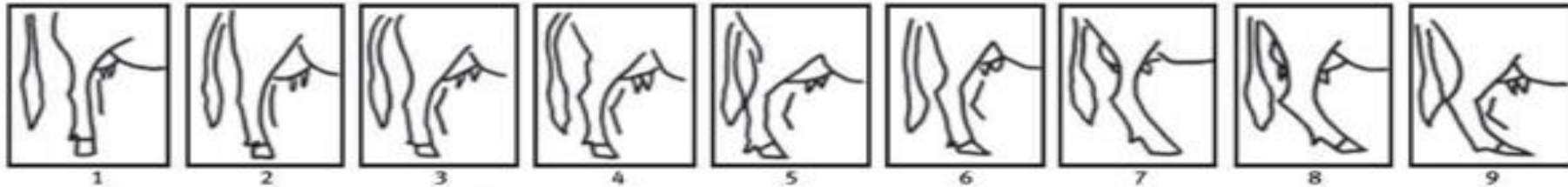


Hoof Orientation



# KSU feet and leg scoring system

Rear Leg Side View  
(Hip and Hock)



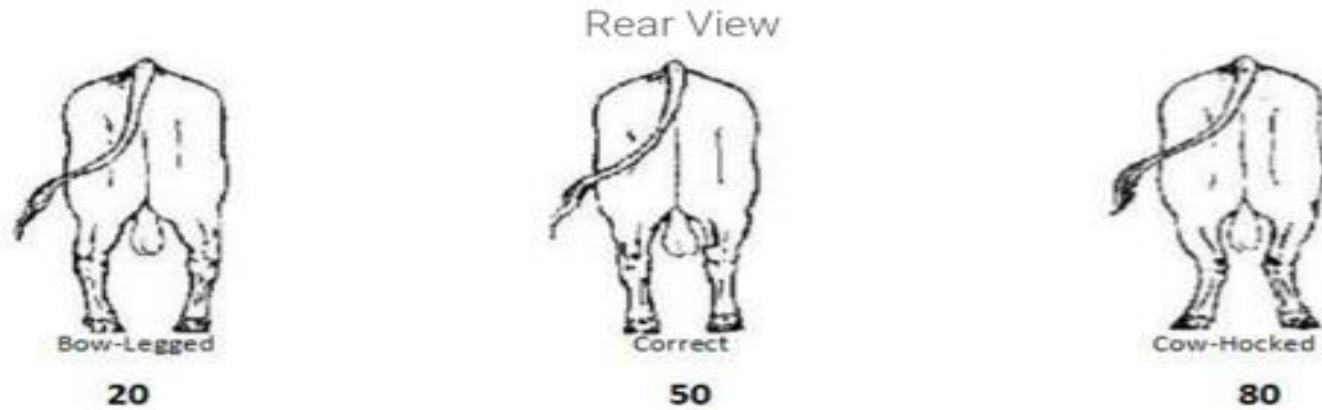
1 – straight (post legged); 5 – good; 9 – sickle-hocked

0      10      20      30      40      50      60      70      80      90      100

Side View of the Hip and Hock



# KSU feet and leg scoring system



0 10 20 30 40 50 60 70 80 90 100

Rear View of Back Feet



# Material and Methods

- Every animal must be scored by at least two trained evaluators
- Scores for each animal were averaged to reduce scorer bias
- All animals included in the evaluation must have a registration number with Red Angus Association of America

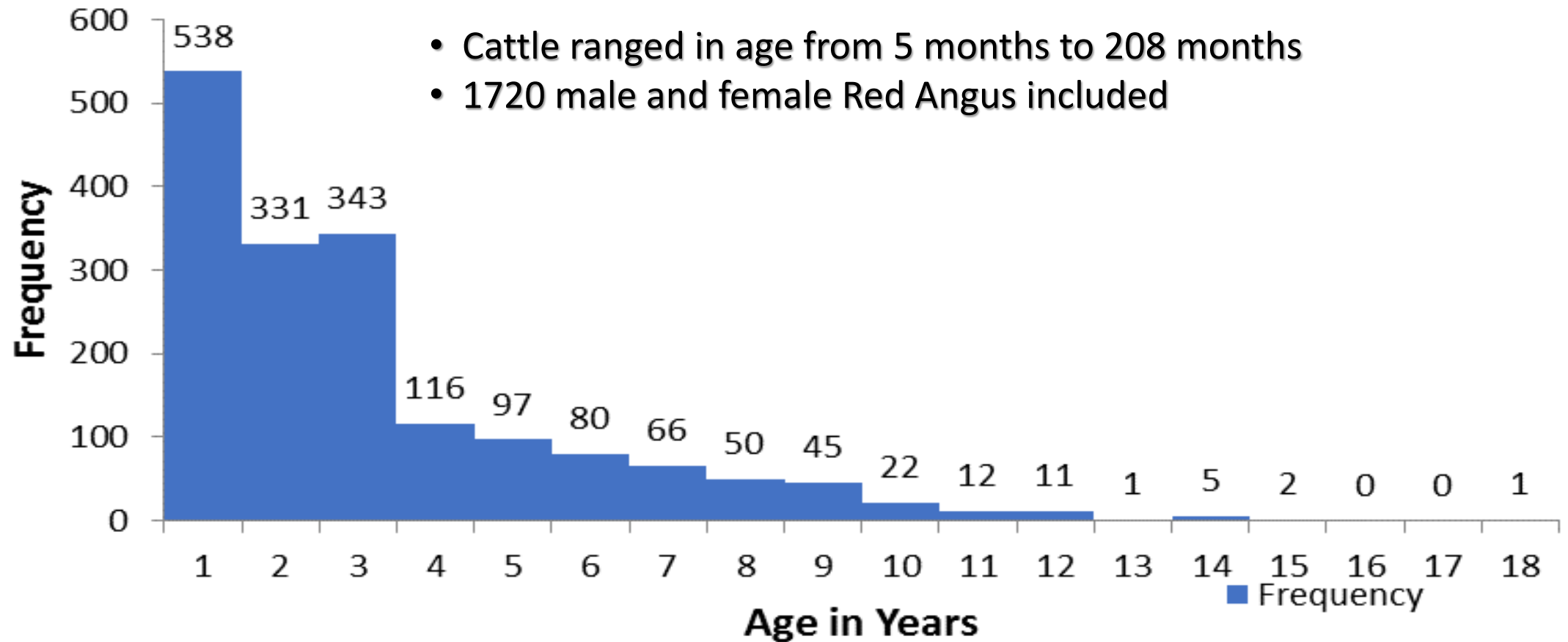


# Materials and Methods

- 1,720 animals included in the evaluation after edits
- 3 generation pedigree file was acquired from the Red Angus Association of America
  - 13,306 animals
  - 3157 sires, 1282 sires of sires, and 2467 sire of dams
  - 8724 dams, 5913 dam of dams, and 2249 dam of sires

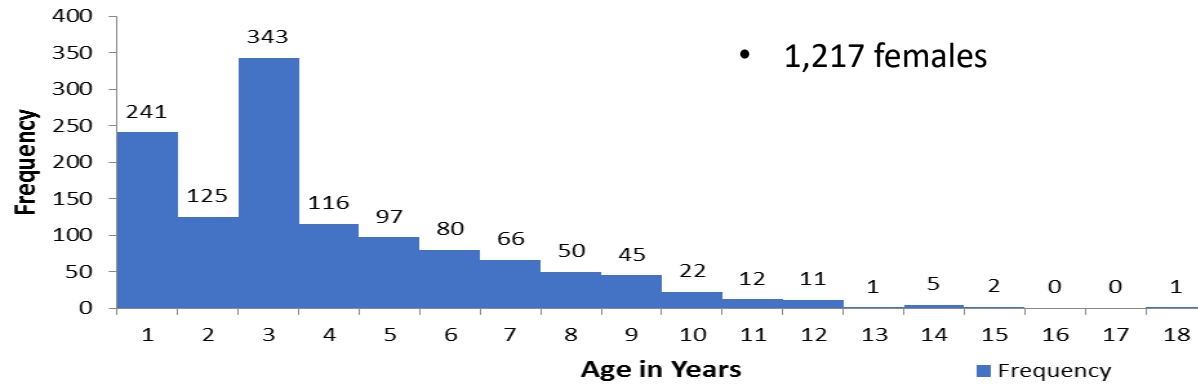


## Age Distribution

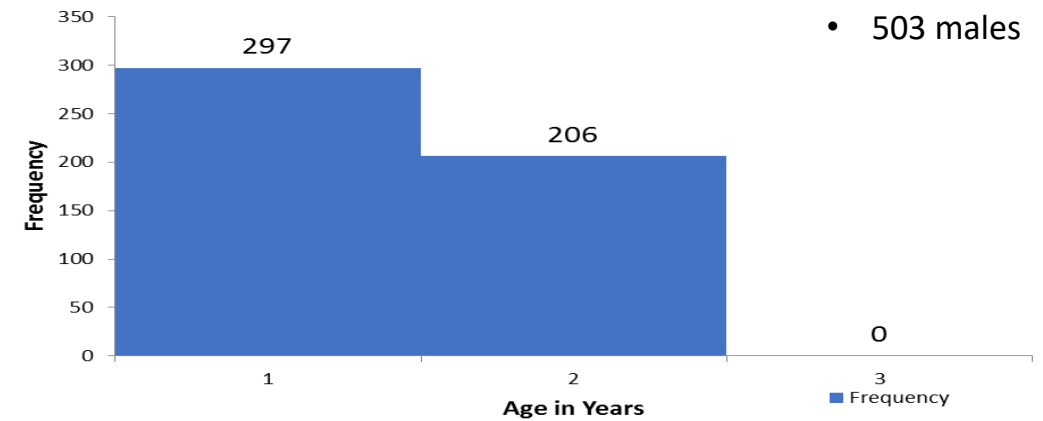




### Age Distribution of Females



### Age Distribution of Males



# Heritability of feet and leg traits

Series of bivariate linear animal models (91!)

<u>Trait</u>	<u>Avg <math>h^2</math> (std error)</u>	<u>Trait</u>	<u>Avg <math>h^2</math> (std error)</u>
BCS	0.11 (0.04)	Front Leg Side View	0.16 (0.05)
Front Feet Hoof Angle	0.20 (0.06)	Front Leg Knee Orientation	0.17 (0.05)
Front Feet Heel Depth	0.17 (0.05)	Front Leg Hoof Orientation	0.17 (0.05)
Front Feet Claw Shape	0.09 (0.04)	Rear Leg Side View	0.30 (0.06)
Rear Feet Hoof Angle	0.19 (0.06)	Rear Leg Rear View	0.14 (0.05)
Rear Feet Heel Depth	0.25 (0.06)	Composite Score	0.12 (0.05)
Rear Feet Claw Shape	0.17 (0.05)		
Hoof Size	0.36 (0.06)		

# Genetic correlations of interest (among feet)

<u>Traits</u>	<u>genetic correlation</u>
Front feet hoof angle and front feet heel depth	0.89 (0.06)
Front feet hoof angle and rear feet hoof angle	0.88 (0.08)
Front feet hoof angle and rear feet heel depth	0.85 (0.09)
Front feet heel depth and rear feet hoof angle	0.85 (0.10)
Front feet heel depth and rear feet heel depth	0.94 (0.06)
Rear feet hoof angle and rear feet heel depth	0.86 (0.06)
Front feet claw shape and rear feet claw shape	0.75 (0.17)

- Front and rear feet angle and depth very similar, can be combined
- Front and rear claw shape highly correlation, perhaps combined as well
- Feet angle/depth uncorrelated with claw shape

# Genetic correlations of interest (front feet with legs)

<u>Traits</u>	<u>genetic correlation</u>
Front feet hoof angle and front leg side view	0.46 (0.19)
Front feet heel depth and front leg side view	0.45 (0.19)
Front feet hoof angle and rear leg side view	0.63 (0.15)
Front feet heel depth and rear leg side view	0.51 (0.17)
Front feet hoof angle and rear leg rear view	0.36 (0.23)
Front feet heel depth and rear leg rear view	0.51 (0.22)

- Front leg and rear leg modest correlation with front feet angle and depth
- Could leg traits be indicators for hoof attributes?

# Genetic correlations of interest (rear feet with legs)

<u>Traits</u>	<u>genetic correlation</u>
Rear feet hoof angle and rear leg side view	0.72 (0.15)
Rear feet heel depth and rear leg side view	0.56 (0.15)
Rear feet hoof angle and rear leg rear view	0.51 (0.21)
Rear feet heel depth and rear leg rear view	0.63 (0.19)
Rear claw shape with front leg knee orientation	0.41 (0.21)
Rear claw shape with front leg hoof orientation	0.38 (0.21)
Rear claw shape with rear leg side view	-0.36 (0.18)

- Rear leg and front leg modest correlation with rear feet angle, depth and claw shape
- Could leg traits be indicators for hoof attributes?

# Comparison of Scoring Systems

	1-100 scale $h^2$ (SE)	1-10 scale $h^2$ (SE)
Front feet hoof angle	0.20 (0.06)	0.18 (0.06)
Front feet heel depth	0.17 (0.05)	0.12 (0.04)
Front feet claw shape	0.09 (0.04)	0.08 (0.04)
Rear feet hoof angle	0.19 (0.06)	0.17 (0.05)
Rear feet heel depth	0.25 (0.06)	0.24 (0.06)
Rear feet claw shape	0.17 (0.05)	0.15 (0.05)
Front leg side view	0.16 (0.05)	0.15 (0.05)
Front leg knee orientation	0.17 (0.05)	0.11 (0.05)
Front leg hoof orientation	0.17 (0.05)	0.15 (0.05)
Rear leg side view	0.30 (0.06)	0.29 (0.06)
Rear leg rear view	0.14 (0.05)	0.11 (0.04)
Hoof size	0.36 (0.06)	0.29 (0.06)
Composite score	0.12 (0.05)	0.09 (0.04)



# Take-aways

- Feet and leg traits have low to moderate heritability
- If selection pressure is placed on these traits, genetic change can be realized
- A 1-9 scoring system is appropriate
- Strong correlations between feet and leg traits indicate some traits are controlled by similar genes
- Probably don't need 13 different structure traits