Pulmonary hypertension in moderate elevation feedlots: New research and developments

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High Altitude Disease

- Condition affecting cattle at altitudes of >5,000 ft.
- Pulmonary artery begins to constrict and thicken in response to low oxygen being transported.
- Selecting bulls with lower PAP has been successful in producing progeny with lower PAP scores thus more adapted to elevation.

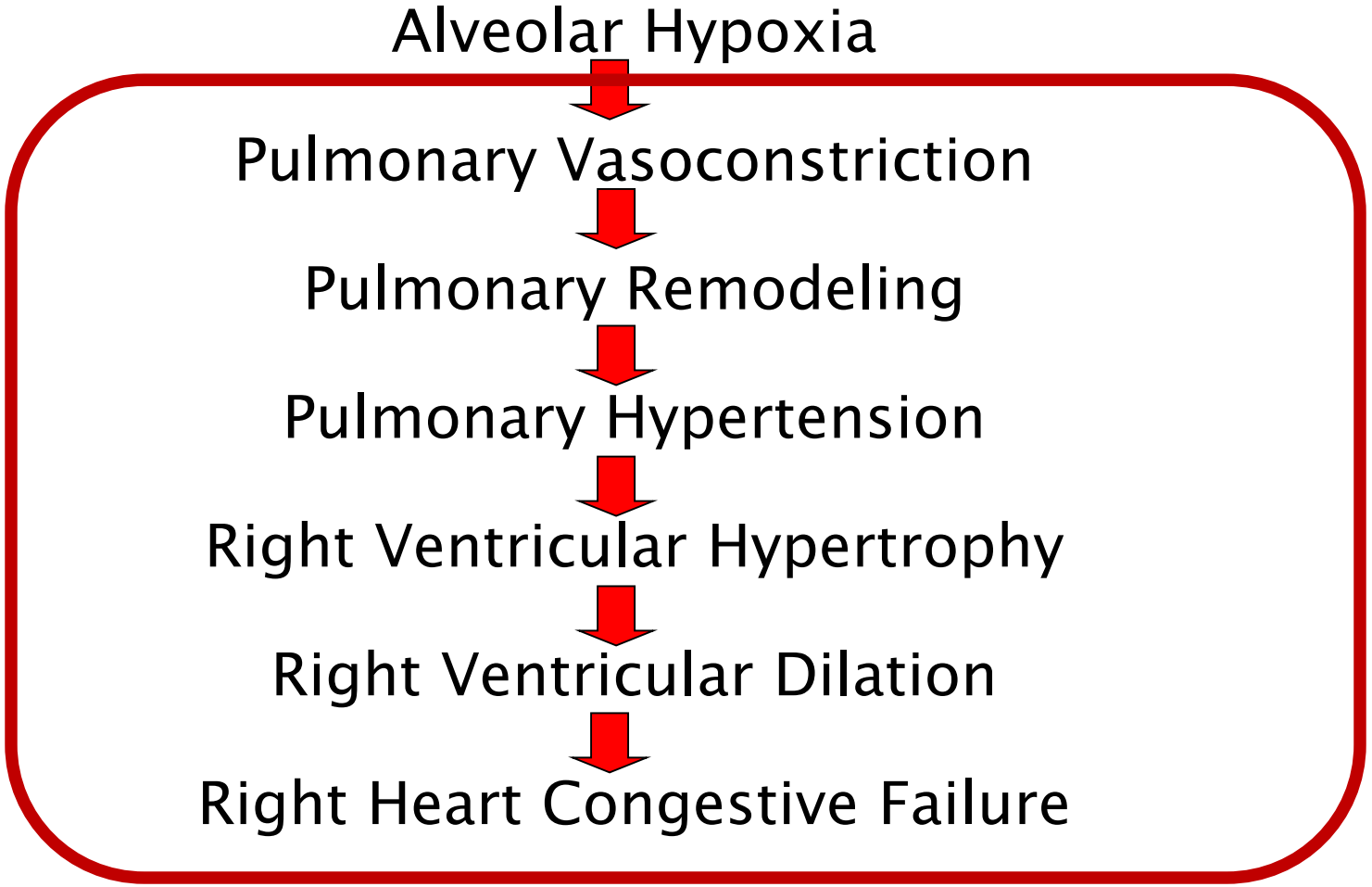
Feedlot Heart Disease

- Condition affecting feedlot cattle at low to moderate altitudes.
- Direct cause is currently unknown, but these individuals experience heart remodeling similar to animals experiencing brisket disease.

PAP is currently used as a decision factor for culling animals in the herd, who display high PAP at early ages.

Kukor et al., 2021

The process: Now occurring in the feedlot in increasing incidence



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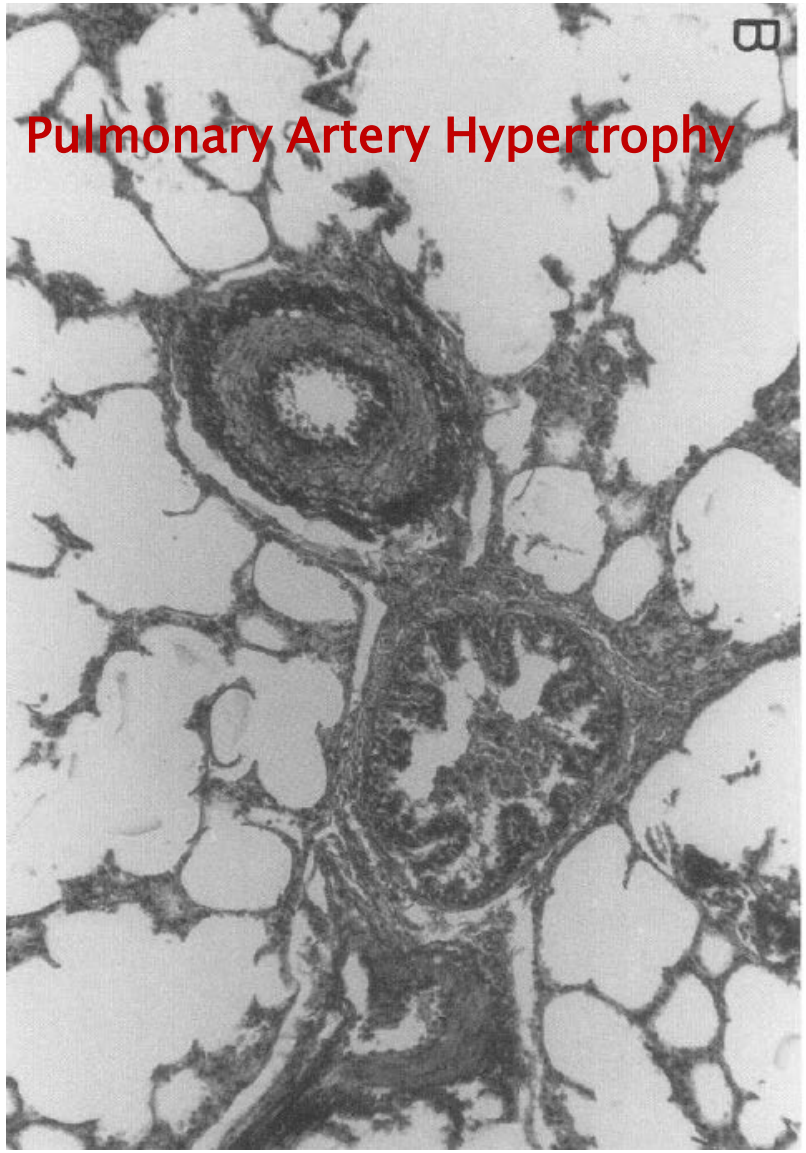

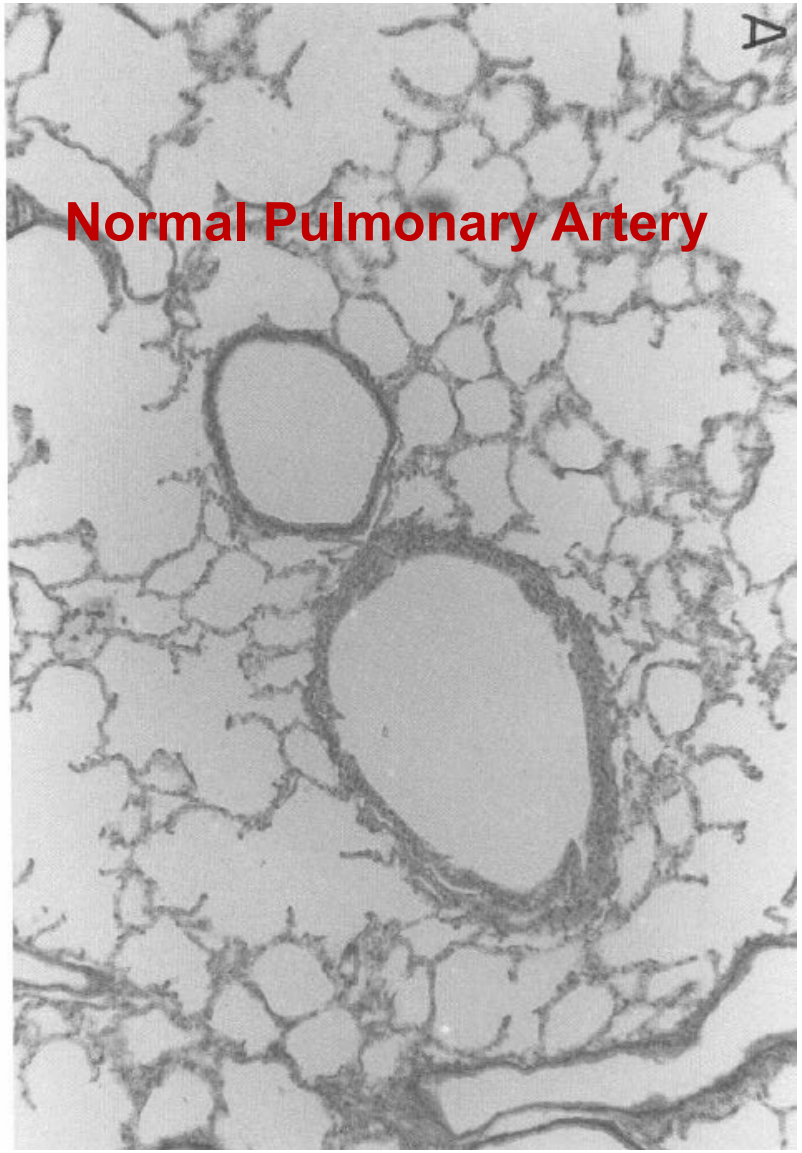

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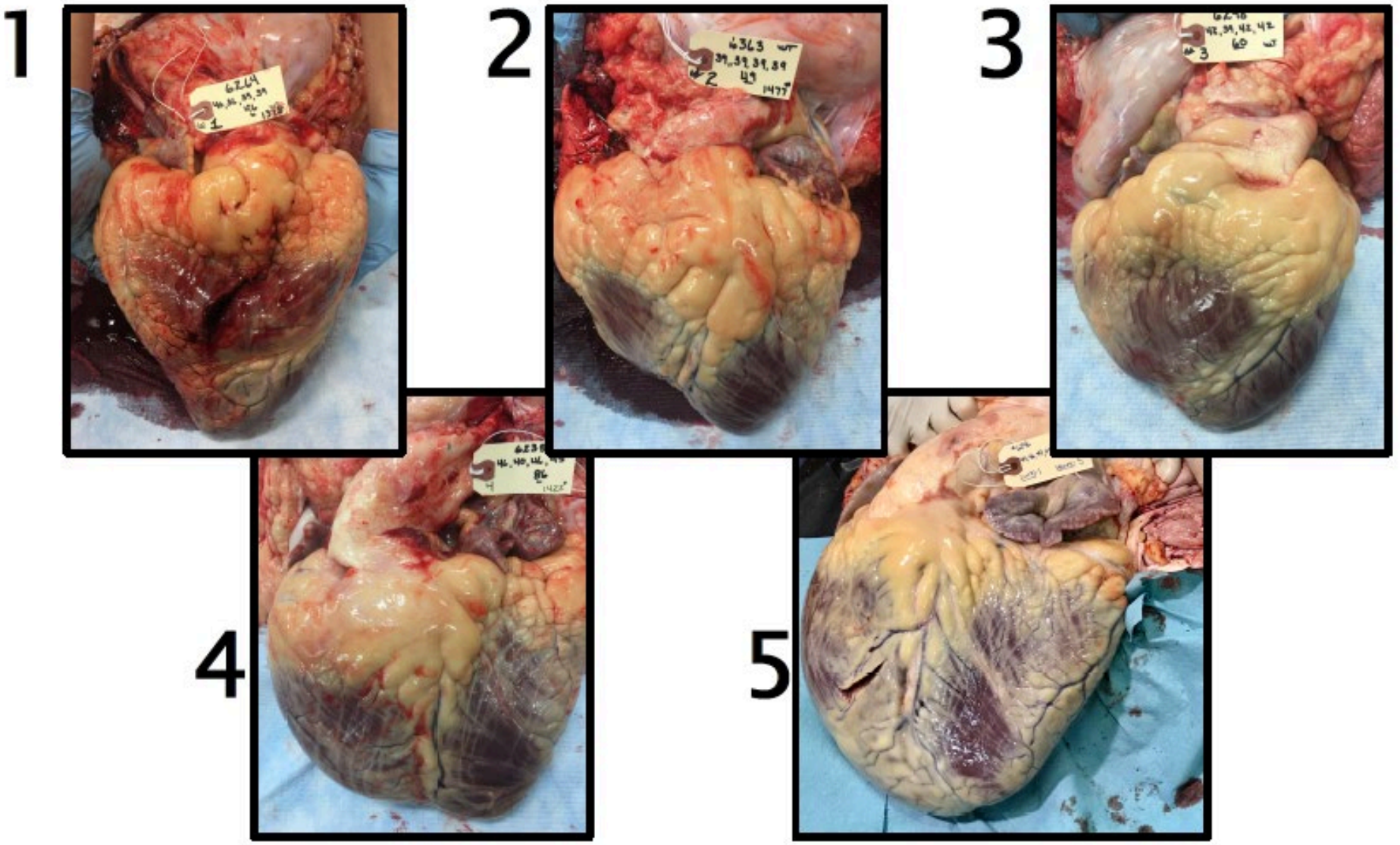
Heart Scoring System



Holt et al., as presented in Heffernan et al., 2020

3 Distinct Populations to date:

- High altitude adapted population commercial Angus (Elevation ~ 7,200 feet)
  - Heffernan et al., 2020

- Moderate elevation commercial Angus (Elevation ~ 4,700 feet)
  - Thomas et al., 2018
  - Metabolism and inflammation predict cardiopulmonary outcomes in fattening beef cattle.
    - USDA-NIFA: 2018-67015-28241

- Moderate to low elevation commercial Angus influenced (Elevation ~ 3,484 feet)
  - Speidel et al., 2021
  - Development of metrics to identify cattle predisposed to feedlot heart failure.
    - ICASA-0000000018

Development of metrics to identify cattle predisposed to feedlot heart failure.

- Foundation for Food and Agricultural Research's (FFAR)
- International Consortium for Antimicrobial Stewardship in Agriculture (ICASA)
- Collaborators:
  - Colorado State University
  - RTI LLC. Brookings, SD
  - ABS Global
  - Cactus Research, Hy-Plains Feedyard LLC.
  - Veterinary Research and Consulting Services, LLC

- Objectives:
  1. Quantify the relationship between pulmonary arterial pressure measured in fattened cattle and heart scores collected at slaughter.
  2. Examining potential factors indicated in feedlot heart disease including the role of genetics in disease incidence.
  3. Determine the effect of heart remodeling during the feeding period on feedlot and carcass performance.
  4. Development of selection tools in the form of EPD for Feedlot Heart Disease Resistance.

Summary Statistics:

Total of 1,422 head

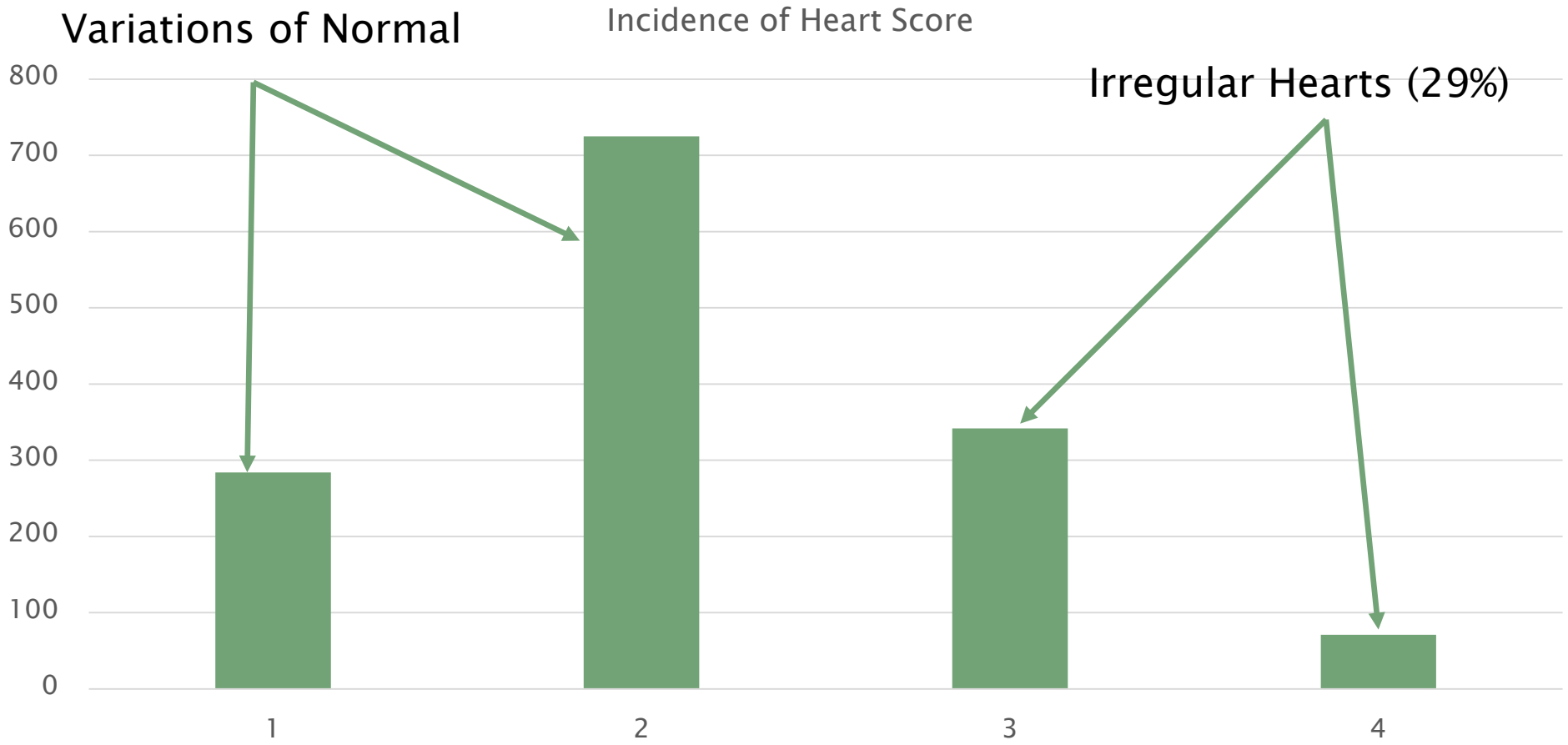
760 steers
661 heifers

Location: Texas Panhandle
~ 1,100m of elevation

Trait	n	Mean	Standard Dev	Min	Max
Heart Score	1,422	2.13	0.78	1.00	4.00
PAP (9 months) mmHg	178	39.84	2.83	34.00	48.00
Systolic (9 months) mmHg	178	68.8	8.32	55.00	95.00
Diastolic (9 months) mmHg	178	11.62	6.40	-12.00	26.00
PAP (14 months) mmHg	352	49.36	12.84	32.00	151.00
Systolic (14 months) mmHg	352	80.95	15.93	35.00	193.00
Diastolic (14 months) mmHg	352	20.85	13.90	-30.00	113.00
Backfat (mm)	1,401	17.78	5.33	4.64	41.66
Marbling Score	1,401	502.2	97.23	281.00	952.0
Ribeye Area(mm^2)	1,401	9,116.11	922.58	5,374.18	12,619.33
Hot Carcass Weight (kg)	1,414	404.77	50.31	214.09	561.82
Average Daily Gain (kg)	557	2.05	0.51	-1.37	3.43
Average Dry Matter Intake (kg)	323	10.25	1.38	4.70	15.22
Feed Conversion Rate (kg)	206	2.40	1.10	-7.36	6.27
Weaning Weight (kg)	868	208.23	42.09	87.27	349.09

Kukor, 2022

Heart Score Proportions



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Average Phenotype by Heart Score

Trait	Heart Score			
	1	2	3	4
PAP9 (mmHg)	39.61 ± 2.48	39.82 ± 2.78	40.36 ± 3.47	39.80 ± 3.77
Systolic9 (mmHg)	69.25 ± 7.44	68.38 ± 9.06	69.24 ± 8.71	66.00 ± 6.89
Diastolic9 (mmHg)	11.78 ± 6.61	11.63 ± 6.41	10.79 ± 6.01	14.80 ± 6.57
PAP14 (mmHg)	45.00 ± 5.71	47.77 ± 8.95	51.79 ± 11.82	66.83 ± 30.27
Systolic14 (mmHg)	76.63 ± 11.47	79.93 ± 13.2	83.27 ± 14.43	94.79 ± 33.90
Diastolic (14m) mmHg	17.20 ± 9.72	19.21 ± 10.08	22.22 ± 12.65	39.83 ± 29.72
Backfat(mm)	17.78 ± 5.84	17.78 ± 5.8	17.78 ± 4.82	17.27 ± 5.33
Marbling Score	520.06 ± 107.09	502.51 ± 96.49	484.87 ± 102.43	478.17 ± 92.73
Ribeye Area (mm^2)	9290.30 ± 941.93	9206.43 ± 903.22	9174.18 ± 941.93	8896.76 ± 987.09
Hot Carcass Weight (kg)	390.71 ± 51.49	407.23 ± 47.37	410.19 ± 51.51	393.74± 57.28
Average Daily Gain (kg)	1.91 ± 0.4	2.09 ± 0.48	2.12 ± 0.49	1.95 ± 0.87
Dry Matter Intake (kg)	10.07 ± 1.28	10.32 ± 1.29	10.31 ± 1.53	10.31 ± 1.88
Yield Grade	2.95 ± 0.9	3.00 ± 0.83	3.06 ± 0.81	3.02 ± 0.96

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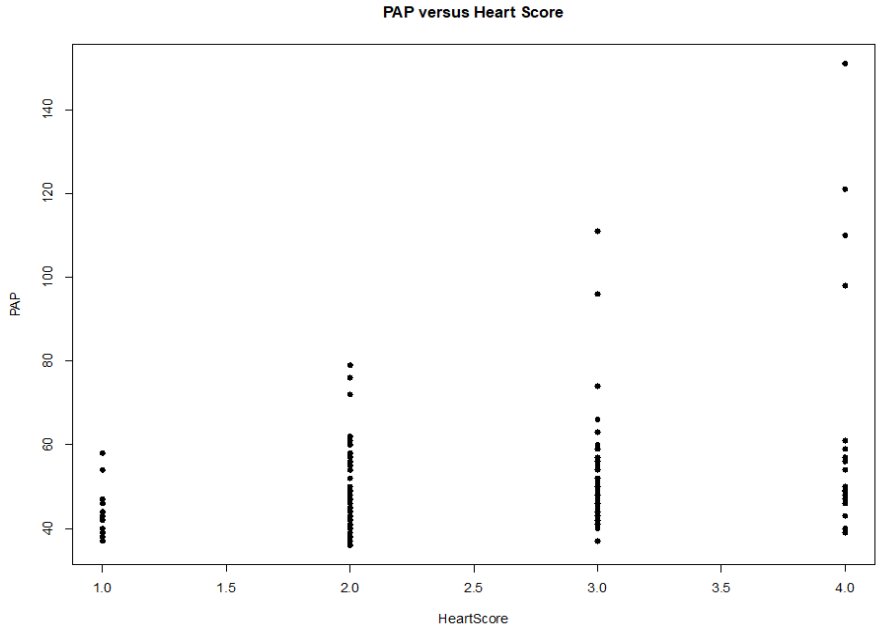
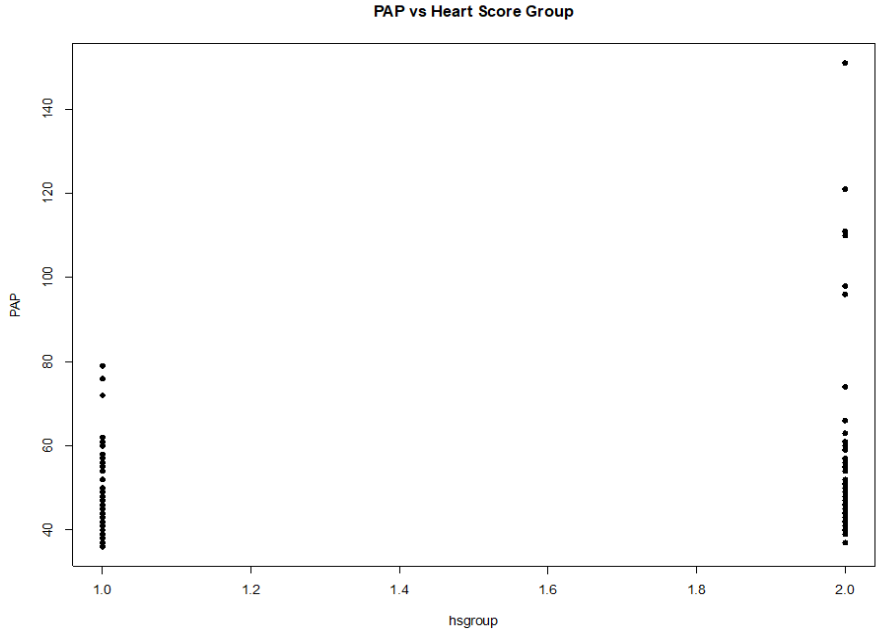
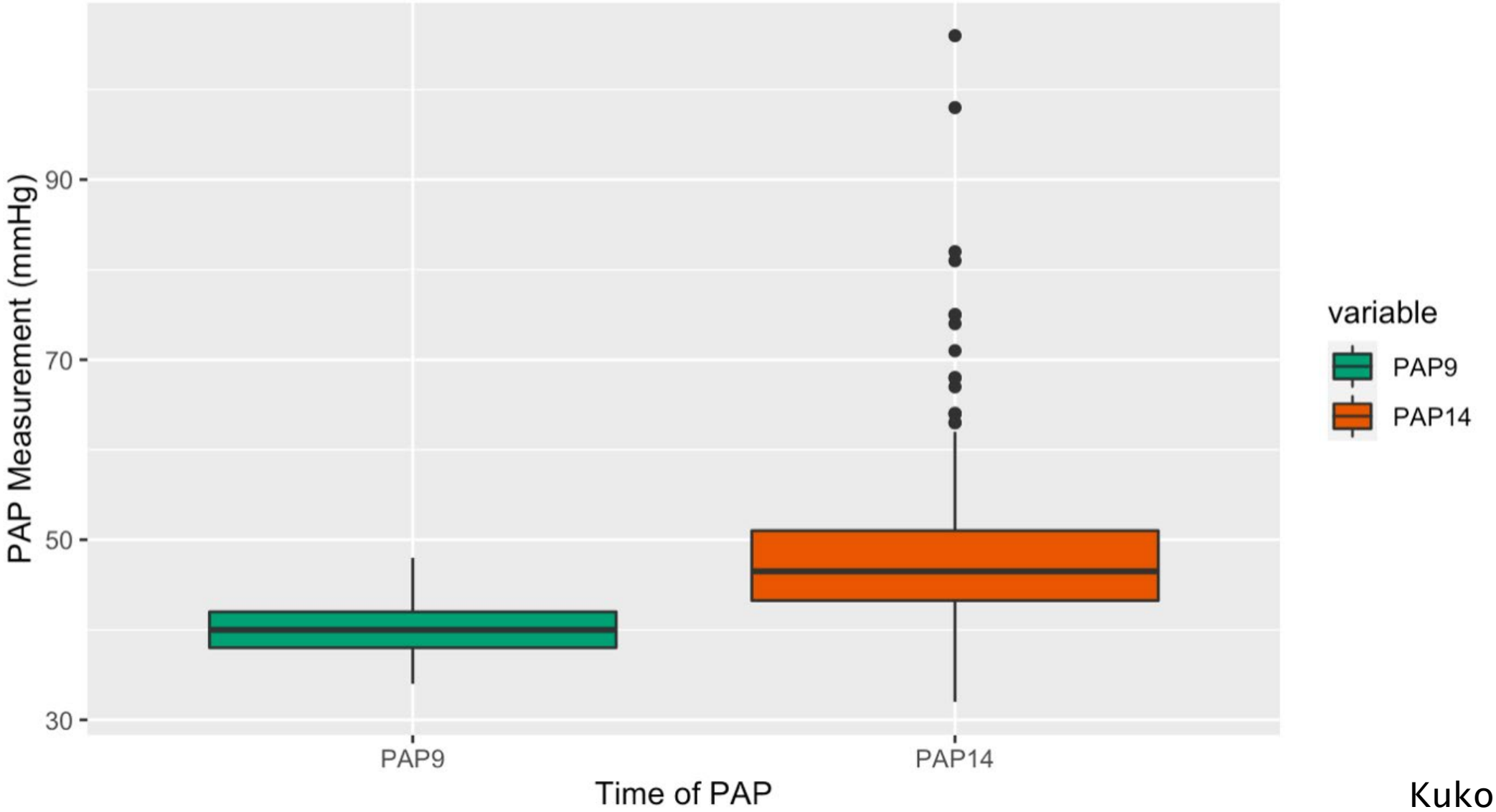
PAP versus Heart Score – Low Elevation Cattle

- Model:
  - PAP = HeartScore + Lot
- LSMeans – HeartScore – r = 0.34
  - HS1: 41.6
  - HS2: 47.4
  - HS3: 50.7
  - HS4: 63.3
- LSMeans – HeartScore Group (Normal vs Heart Remodeling) – r = 0.28
  - HS1: 46.5
  - HS2: 54.5





Early (9 mo) and Late Feeding (14 mo) PAP – Low Elevation



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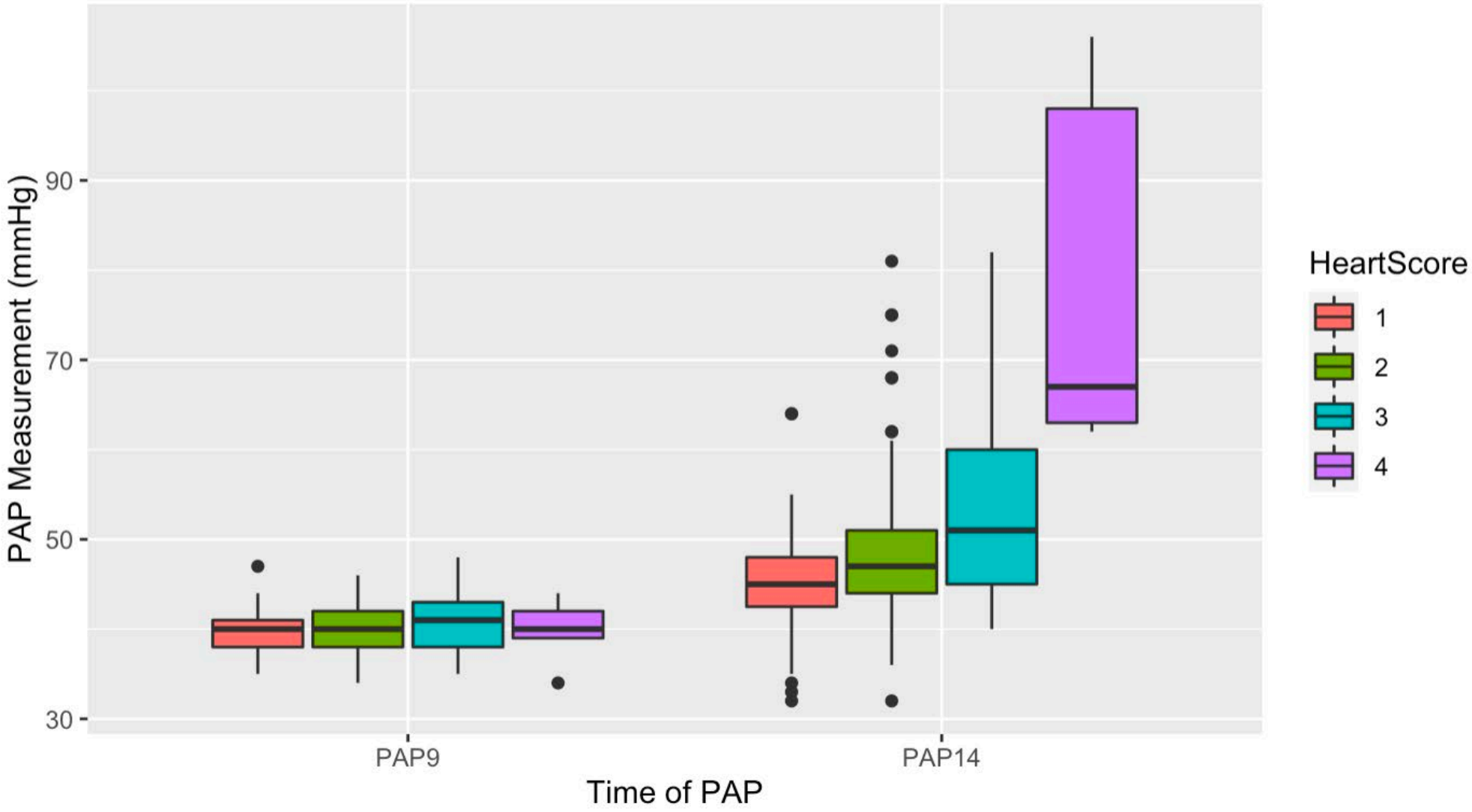
Early (9 mo) and Late Feeding (14 mo) PAP vs Heart Score – Low Elevation



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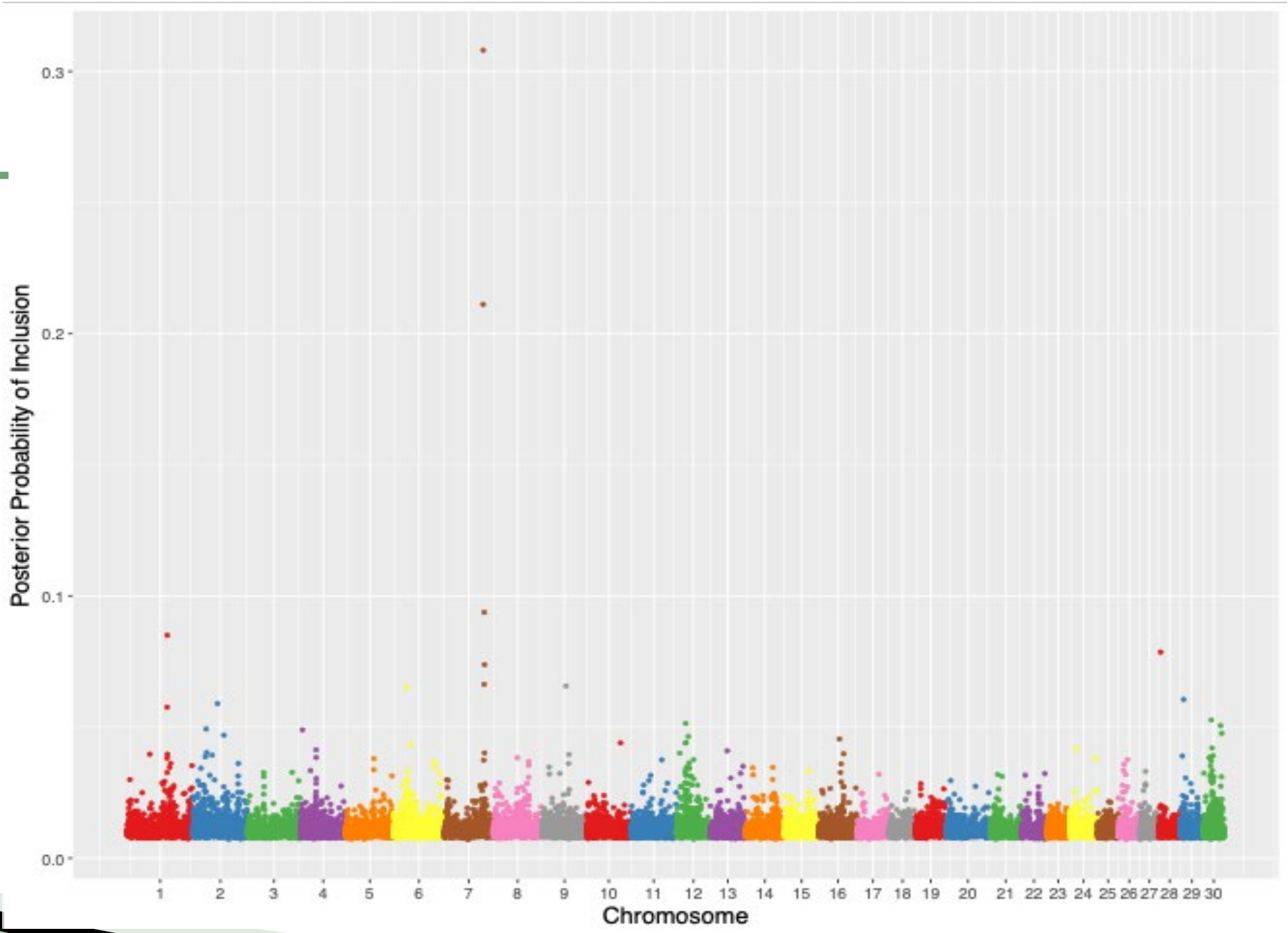
PAP
Highly Polygenic

Many Genes Influence

No single gene with an overriding effect.



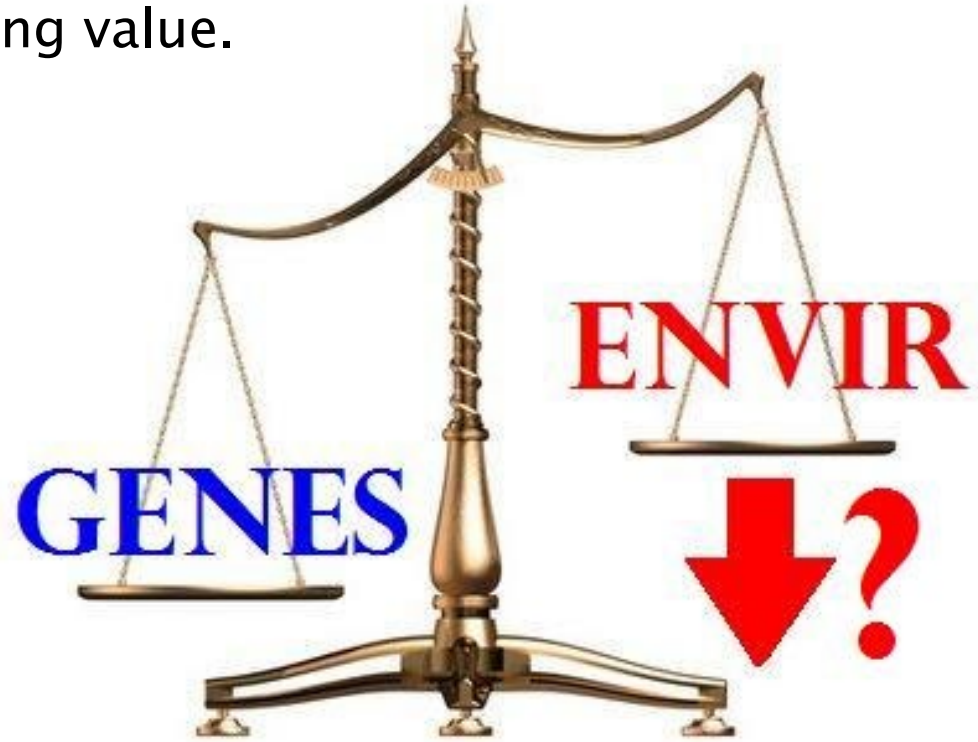
What is heritability?

- A measure of the strength of the relationship between *performance* (phenotypic values) and *breeding values* (genetic value) for a trait in a population.

- When heritability of a particular trait is low, an animal's own performance is not likely to be a good indicator of its breeding value.

PAP h^2 ~ 0.30 to 0.50

$$h^2 = \frac{Var(G)}{Var(P)}$$



Sire differences related to Heart Score

	N (number of progeny in score)	Sire Average	Minimum Average	Maximum Average
Heart Score (ungrouped)	1= 67 2=351 3=173 4=43 5= 0	2.2 ($P < 0.005$)	1	3.4
Heart Score (grouped)	Group (1)1&2= 418 Group (2) 3,4,5= 216	1.2 ($P < 0.001$)	1	1.9
Heart Fat Score	1=141 2=190 3=66	1.4 ($P < 0.002$)	1	2.2

Kukor et al., 2021

Heart Score Heritability

- Model: $\boldsymbol{y = Xb + Zu + e}$

$$\text{var}\begin{bmatrix}\boldsymbol{u}\\ \boldsymbol{e}\end{bmatrix} = \begin{bmatrix}\boldsymbol{A\sigma_u^2} & 0\\ 0 & \boldsymbol{I\sigma_e^2}\end{bmatrix}$$

- Heart Scores:
  - N = 1,422
  - Mean = 2.13
  - Minimum = 1
  - Maximum = 4

- Fixed Effects:
  - Harvest Date
  - Sex
  - Harvest Age

$h^2 = 0.34 \pm 0.11$

34% of the differences observed in HS are due to differences in genetics.

Trait	h^2
Birth Weight	0.48
Weaning Weight	0.23
Docility	0.40
Milk Production	0.30
Marbling Score	0.37

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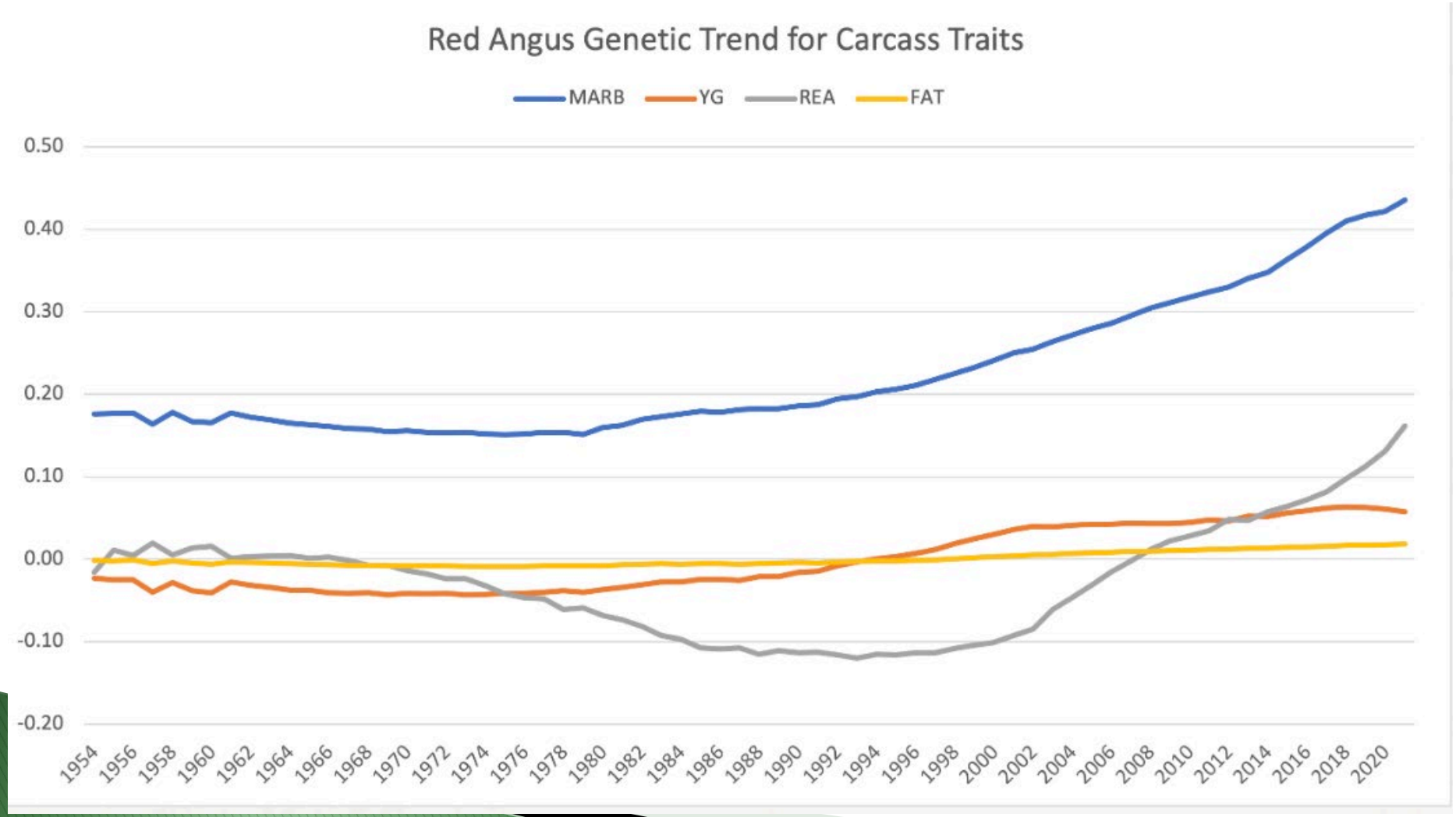
Genetic Trends of traits with similar Heritability – Red Angus

Weaning Wt: 0.23
Ribeye Area: 0.30
Marbling: 0.37



Summary – Trends

- Relatively high incidence of hearts where remodeling has started to occur
  - 21% in the Heffernan Study – This is from a herd selected for HAD resistance
  - 29% overall
- We are not seeing animals with a heart score of 5 in the plants.
  - We do see them in necropsies in the feedlot.
- PAP is showing a relationship with Heart Score
  - Higher PAP indicating higher heart scores
- Trends of increases in heart score indicate decreases in efficiency
- Indications of increases in heart score with decreases in carcass characteristics.
- Regarding Heart Score, differences amongst sires exist.

Summary – Genetics

- Heart Score, differences amongst sires exist, heart score is heritable ($h^2 \sim 0.34$).
  - Approximately 34% of the differences observed are due to Genetic Influence.

- Still to do:
  - Two additional years of data collection
  - Also collecting Heart Score on beef x dairy animals

  - Evaluate the phenotypic and genetic correlations between PAP, HS, Carcass, Intake
  - Genomics
    - – Adding genomics