Preliminary Investigations into Developmental Origins of Pulmonary Arterial Pressure in Beef Cattle

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Abstract

- The abstract can be found here.

Introduction

Pulmonary Arterial Pressure

- High altitude disease is a condition that affects beef cattle raised at altitude due to reduced atmospheric oxygen levels.
- Reduced oxygen initiates the remodeling of the pulmonary artery, increasing pressure and ultimately results in right-sided heart failure.
- Pulmonary Arterial Pressure (**PAP**) is a tool used by beef cattle producers to identify those individuals more susceptible to developing high-altitude disease.

Genotype by Environment Interactions

- PAP phenotype is dependent on both genetic and non-genetic factors.
- Heritability of PAP ranges from 0.30 to 0.45, depending on the data source.
- The environment (elevation, temperature, etc.) an animal resides in leading up to the measure PAP can also influence an individual's measure.
- Gestational environment has not previously been considered as a contributor to offspring PAP in high altitude cattle

Objective

Evaluate the impact of temperature during gestation, on yearling PAP in offspring from cattle residing at high altitudes.

Materials & Methods

Phenotypic Data

- Yearling PAP data collected from 1993-2021 was obtained from the John E. Rouse Beef Improvement Center outside Saratoga, WY (Elevation ~ 2,165 m)
- Local historical temperature data from 1986-2022 were collected from the National Oceanic and Atmospheric Administration.
- Average historical temperatures for mid-to-late gestation (September to March) were compared to yearly mid-to-late gestational average temperatures and classified as an above or below-average temperature year.

Table 1. Summary Statistics

Item	N	Mean	SD	Minimum	Maximum
PAP (mmHg)	8080	42.23	9.59	21	139
Above Avg.	4353	42.50	9.58	26	139
Below Avg.	3727	41.92	9.59	21	138
Age (d)	8080	338.1	46.4	166	284

Analysis

- A single-trait linear regression model was used.
- Dependent Variable – PAP (mmHg)
- Independent Variables:
  - PAP Age (d), Sex (B / S / H),
  - Temperature Classification (Above Average / Below Average)

Results

- Significant sources of variation in PAP.
  - PAP Age ($P < 0.0005$)
  - Calf Sex ($P < 0.0005$)
  - Temperature Classification ($P < 0.05$)

- For each additional day of age an animal was, when PAP was measured, their PAP score was expected to be 0.009 ± 0.002 mmHg higher.

Least Square Means - Table 2

- Calf Sex
  - Bulls had the highest PAP, followed by steers and then heifers.

- Temperature Classification During Gestation
  - Individuals experiencing colder than average temperatures during gestation had lower PAP scores than those experiencing warmer temperatures.

Conclusions & Implications

- **Calves from dams who experienced colder than average temperatures during the last 2/3 of gestation had lower yearling PAP.**
- **Internalization of maternal blood flow during colder temperatures may protect fetal oxygen and nutrient delivery, promoting normal heart and lung development at high altitudes.**

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Table 2. Temperature and Sex Least Square Means for PAP

Item	Mean	SE	95% Lower CL	95% Upper CL
Temperature				
Above Avg.	42.8	0.151	42.5	43.1
Below Avg.	42.3	0.170	42.0	42.6
Sex				
Bull	45.0	0.206	44.6	45.5
Steer	41.5	0.278	41.0	42.1
Heifer	41.1	0.144	40.8	41.4

Figure 1. Pulmonary Arterial Pressure (mmHg) Histogram

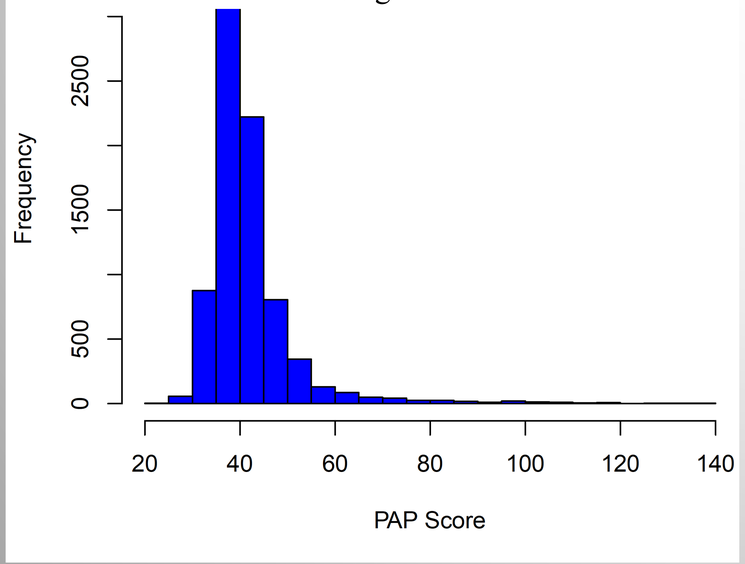
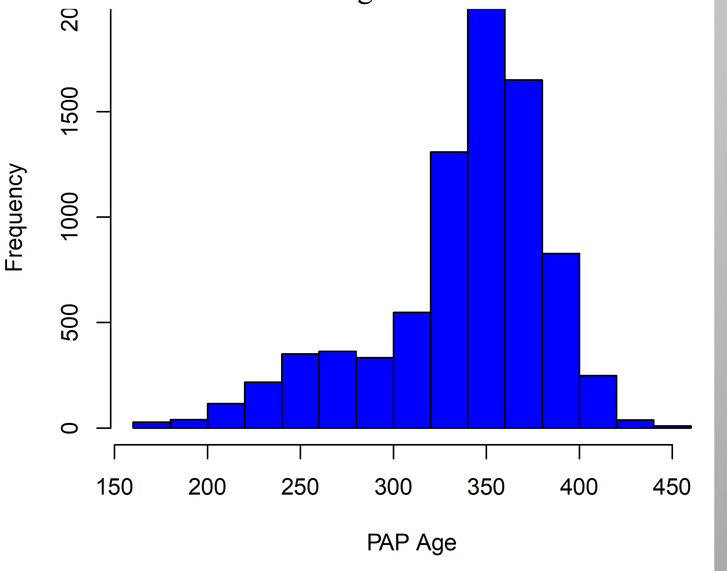


Figure 2. Pulmonary Arterial Pressure Age (d) Histogram



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Abstract

High pulmonary arterial pressure (PAP) is a predisposing factor in the development of high mountain disease in cattle. Since PAP testing is often utilized to prevent disease, a better understanding of the genotype X environmental interactions that drive PAP may lead to the development of additional management and selection strategies. Hypoxia during gestation promotes adaptive fetal programming, a hallmark of which is altered cardiovascular development and disease. However, to our knowledge, no studies have investigated the link between maternal gestational environment and offspring cardiovascular performance as indicated by PAP score. Thus, the objective of this preliminary study was to evaluate the impact of temperature during gestation on yearling PAP in offspring from cattle residing at high altitudes. Yearling PAP data from Colorado State University's Beef Improvement Center located near Saratoga, Wyoming (2,165 m elevation) was used in the analysis. Data were collected on individual Angus animals born from 1993 to 2021. There were 8,080 individuals with PAP phenotypes averaging 42.23 $\pm$ 9.59 mmHg. PAP testing was performed in individuals at an average age of 338.1 $\pm$ 46.4 d. Local historical temperature data from September to March, representing the time frame of middle to late gestation, were collected from the (National Oceanic and Atmospheric Administration (NOAA) database) and averaged. This historical average was compared to the yearly mid- to late gestational average temperatures to classify whether an individual animal went through gestation in an above or below-average temperature year. To determine the influence of temperature during gestation on PAP, a single trait linear regression model was used to regress PAP on age at PAP, sex, and temperature classification. The effects of age ($P < 0.005$), sex ($P < 0.0005$), and temperature classification ($P < 0.05$) all accounted for a significant amount of variation in PAP. The least-square means for temperature classification were 42.8 $\pm$ 0.15 and 42.3 $\pm$ 0.17 for above and below-average temperatures, respectively, which suggests that cows experiencing colder temperatures during gestation produce calves with lower yearling PAPs versus those from cows experiencing warmer temperatures. The internalization of maternal blood during cold temperatures may protect fetal oxygen and nutrient delivery, promoting normal heart development in a high-altitude environment.

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