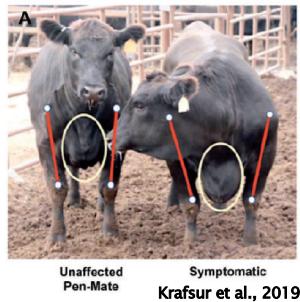


**PAP, HMD, FHD:**  
**Alphabet soup of what we know, and don't know, about genetics of pulmonary hypertension (PH)**



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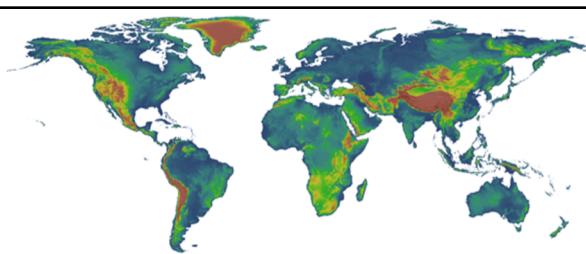
**USDA-ARS-NAGP:**  
 Harvey Blackburn  
 Beth Krehbiel  
 Ted Manahan  
 Carrie Wilson

**Faculty:**  
 Mark Erins  
 Scott Speidel  
 Stephen Coleman  
 Milt Thomas  
  
**Grad Students:**  
 Miranda Culbertson  
 Xi Zeng  
 Rachel Pauling  
 Natalie Crawford  
 Kaysie Jennings  
 Miguel Sanchez

**Health (DVM/MD/PhD):**  
Tim Holt  
 Frank Garry  
 Dick Bowen  
 Kurt Stenmark  
 Dale Brown  
Greta Krafsur (pathology & DVM-PhD)

**Important Others:**  
 Becca Cockrum  
 Angela Canovas and JF Medrano  
 Joe Neary (DVM-PhD)  
 Kuehn, Keele, and McDanel (USDA-ARS-MARC)

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**High Elevation (yellow to brown)**

<http://www.cgiar-csi.org>

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### Causes of hypoxia in mammals

- Altitude
- Exercise (endurance sports)
- Lung disease
- Heart disease
- Anemia (RBC)
- Blood flow restriction
- Tissue-metabolism (glycolytic)
- Obesity
- Etc.

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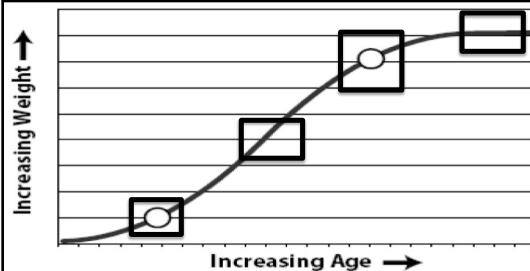


<https://www.cabattle.com/research/>

Pulmonary Hypertension (PH) in beef cattle: Complicated threat to health and productivity in multiple beef industry segments

M.G. Thomas et. al; Colorado State University et. al

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# Anecdotal Pics and Myth-Busters?

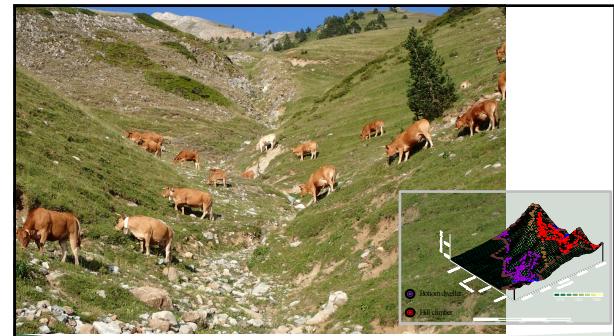
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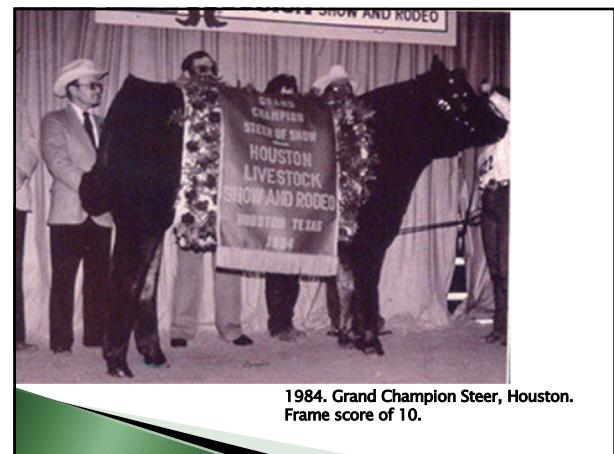
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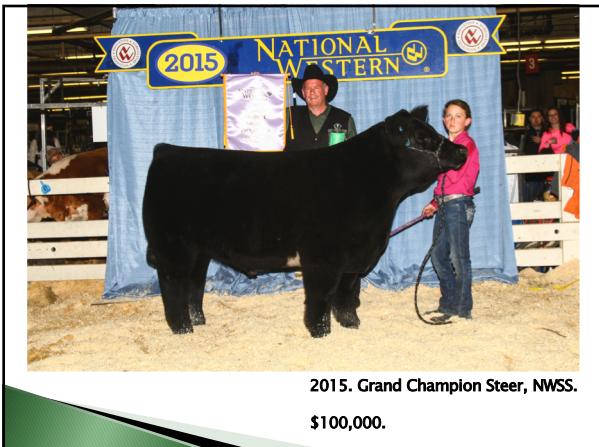
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1945. "TO Model," Grand Champion Steer, Denver, 1945., weight = 965 lbs; frame score 2.0



1984. Grand Champion Steer, Houston.  
Frame score of 10.



**GENETIC IMPROVEMENT IN TURKEYS**  
RBC 1966      Modern 2003

Havenstein and Qureshi, 2004

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**Heart-lung Alphabet and Semantics**

- PH
- RV
- PAP
- HMD (brisket disease)
- FHD (late feedlot death)
- BRD (BRSV)
- G-EPD

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Pulmonary Arterial Pressure (PAP)

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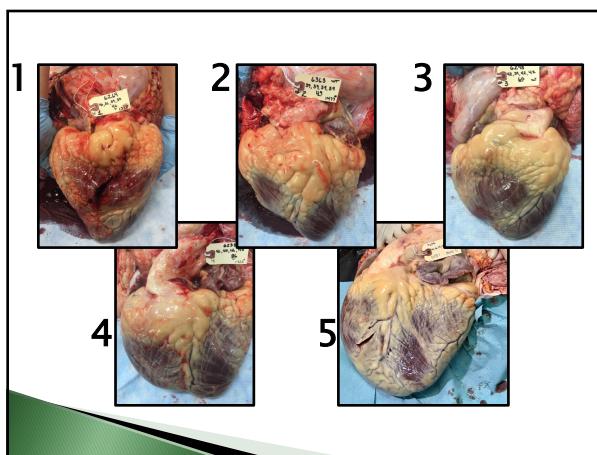
**Distribution of yearling PAP Scores; n = 5659 (bulls, heifers, steers, Zeng, 2016).**

Low risk;  $\leq 41$  mmHg; 50.8%  
Moderate risk  $\geq 42$  to  $\leq 49$  mmHg; 38.1%  
High risk  $> 50$  mmHg; 11.1%  
*(Holt and Callan, 2007)*

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| Animals                            | Altitude (m) | mPAP (mmHg)     | Range (mmHg) | Reference, etc.                            |
|------------------------------------|--------------|-----------------|--------------|--|
| Angus fattening steers; n = 100    | 1,400        | 54.1 ± 2.7      | 42-143       | Krafsur et al., 2017<br>Neary et al., 2015 |
| Yearling Angus bulls; n = 1397     | 2,200        | 45.8 ± 0.3      | 29-139       | Zeng et al., 2016                          |
| Yearling bulls at 4C; n = 2,426    | 2,200        | 45.1 ± 0.8      | 29-145       | Crawford et al., 2017                      |
| Mature Angus cows; n = 44          | 2,200        | 42.8 ± 0.8      | 31-55        | Bailey et al., 2016                        |
| Yearling Angus heifers; n = 3489   | 2,200        | 41.4 ± 0.2      | 22-135       | Zeng et al., 2016                          |
| Yearling Angus stockers; n = 773   | 2,200        | 41.1 ± 0.2      | 27-138       | Zeng et al., 2016                          |
| <b>Angus-crossed cows, n = 49</b>  | <b>0</b>     | <b>34 ± 0.5</b> | <b>28-41</b> | Holt, personal comm.                       |
| Mature American Bison; n = 6       | 2,280        | 29.8 ± 0.8      | 28-34        | Holt, personal comm.                       |
| Mature Himalayan Cow; n = 6        | 3,720        | 26.5 ± 1.4      | 24-30        | Anand et al., 1986                         |
| Mature Himalayan Yak; n = 6        | 3,720        | 20.2 ± 1.4      | 18-21        | Anand et al., 1986                         |
| Healthy Human, (meta-analysis)     | ≤ 400        | 25              | 15-35        | Bosson et al., 2013                        |
| Human hypertension (meta-analysis) | ≤ 400        | >35             | 15-70        | Morae et al., 2000                         |

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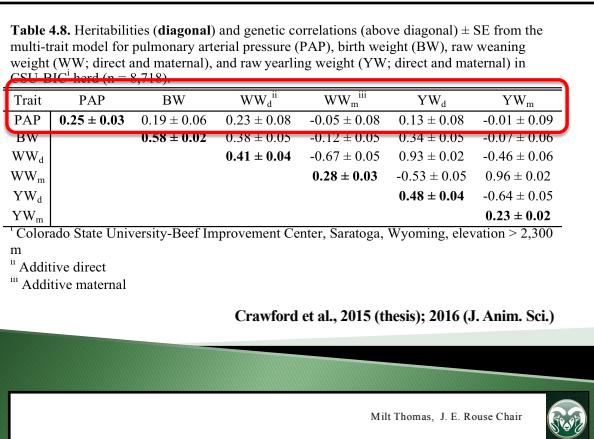
## Heritability of mPAP

| Study                 | Heritability   | Breed                         |
|-----------------------|--|-------------------------------|
| Enns, et al. 1992     | .46  | Angus (Seedstock, registered) |
| Shirley et al. 2008   | .34  | Angus (Seedstock, registered) |
| Crawford et al. 2016  | .25  | Angus (Seedstock, research)   |
| Zeng, 2013            | .56 (weaning)<br>.31 (yearling)<br>.67 (genetic correlation) | Angus (Seedstock, research)   |
| Pauling et al. 2018   | .25  | Angus (AAA)                   |
| Cubertson et al. 2018 | 0.29   | 7 breed composites            |

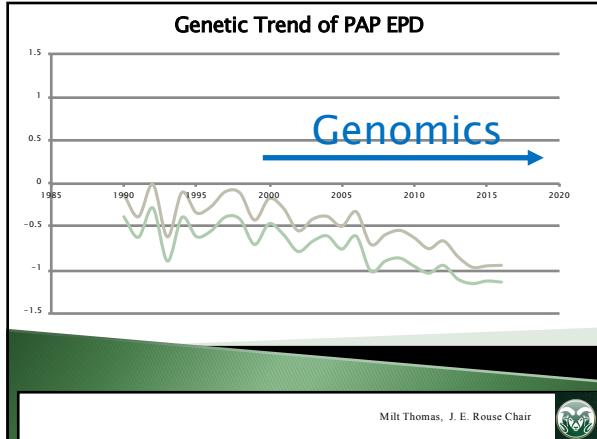
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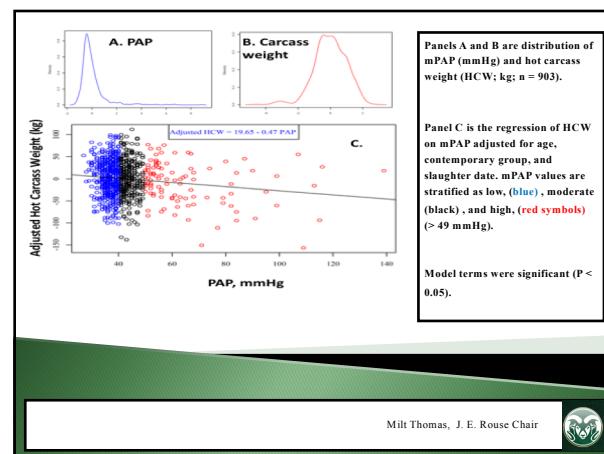
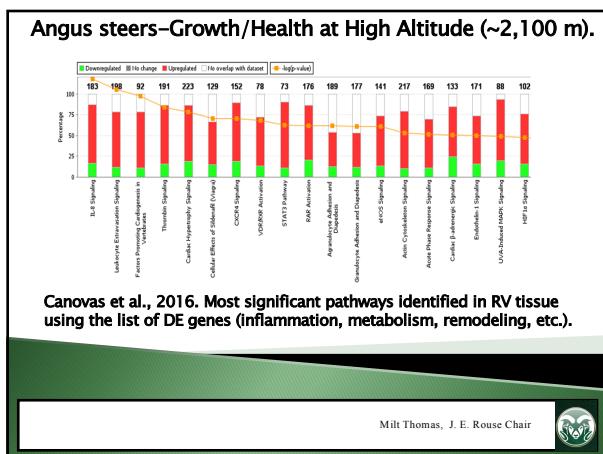
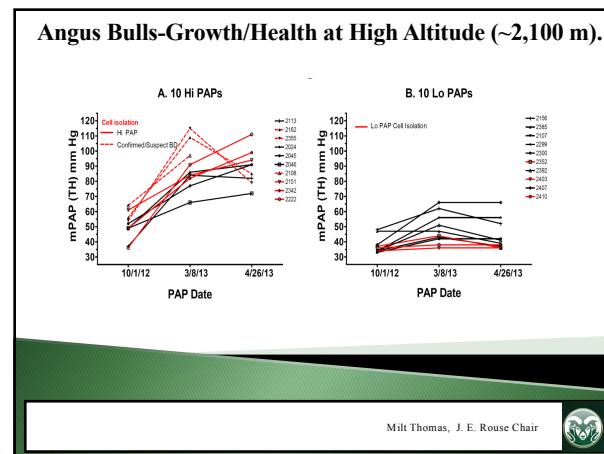
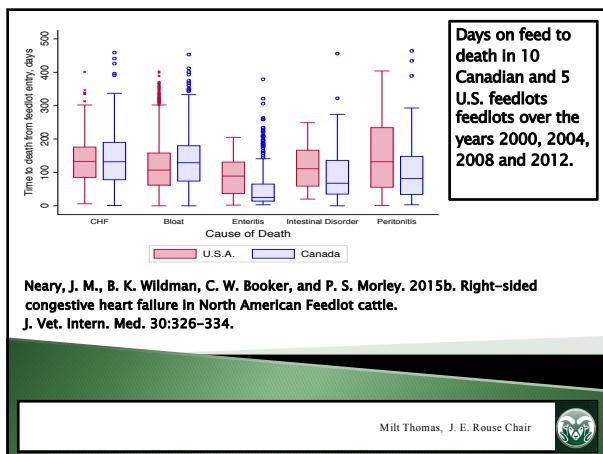
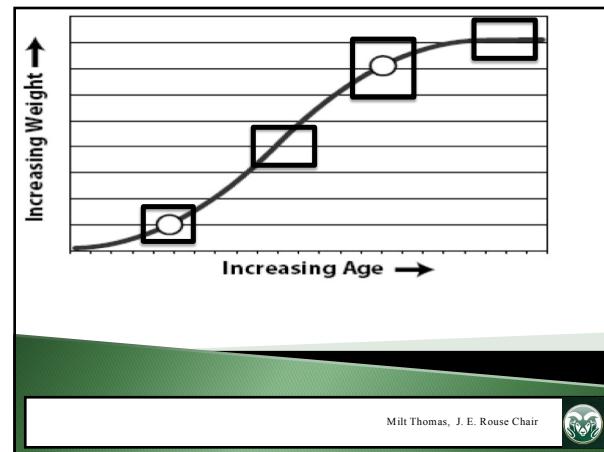
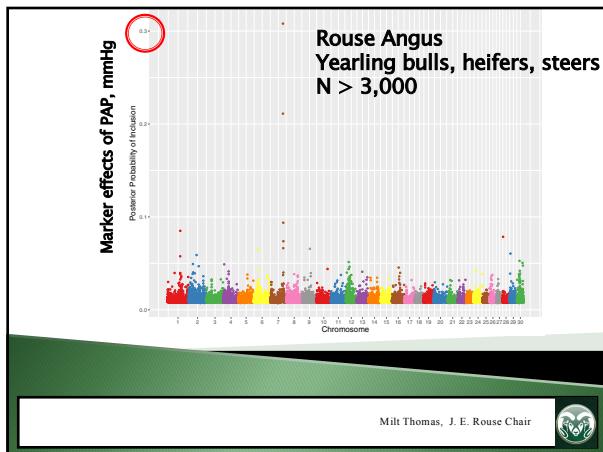


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Research Article

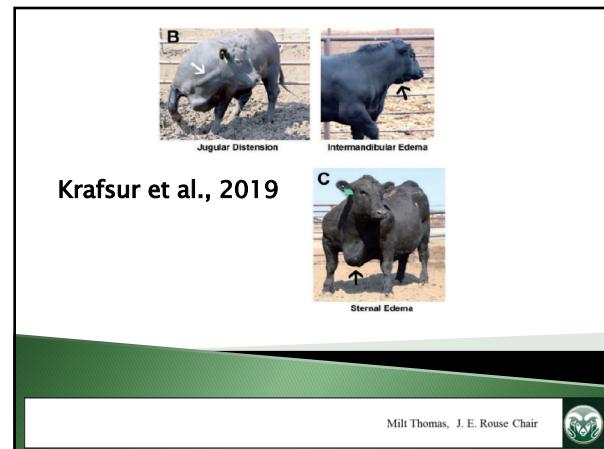
Pulmonary Circulation

**Cardiopulmonary remodeling in fattened beef cattle: a naturally occurring large animal model of obesity-associated pulmonary hypertension with left heart disease**

Greta M. Krafus<sup>1,2,3</sup>, Joseph M. Neary<sup>4</sup>, Franklyn Garry<sup>5</sup>, Timothy Holt<sup>5</sup>, Daniel H. Gould<sup>2</sup>, Gary L. Mason<sup>2</sup>, Milton G. Thomas<sup>3</sup>, R. Mark Enns<sup>3</sup>, Rubin M. Tuder<sup>6</sup>, Michael P. Heaton<sup>7</sup>, R. Dale Brown<sup>1,\*</sup> and Kurt R. Stenmark<sup>1,\*</sup>

Pulmonary Circulation 2019; 9(1) 1–13  
DOI: 10.1177/2045894018796804

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Feedyard Case Control

Feedyard CHF

A B C D

Venoconstriction Adventitial Hypoplasia

Score Score

Feedyard CHF

Krafus et al., 2019

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New Funds:

*Metabolism and inflammation predict cardiopulmonary outcomes in fattening beef cattle. USDA-NIFA (2018-67015-28241).*

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1. Angus-cross steers.  
2. Herd with History of FHD.  
3. Moderate elevation (Eastern Colorado)  
4. Cooperator of ECRC.  
5. No prior BRD in challenge group

Low PAP Vhc BRSV High PAP Vhc BRSV

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