Genetic and phenotypic parameter estimates for feed intake and pulmonary arterial pressure\textsuperscript{1,2}

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INTRODUCTION

Within the cattle industry, feedstuffs can be considered one of the more costly variable inputs representing approximately 70% of production costs. With the increasing world population and a corresponding decrease in available resources, the focus on economically relevant traits such as feed intake have been shown to aid in the financial conservation of the beef industry (Carstens and Tedeschi, 2006).

Pulmonary arterial pressure (PAP) is used for risk identification of pulmonary hypertension in cattle. Animals who reside at high elevation (>1,584 m) are in an environment that is conducive to the development of psychological conditions, collectively known as high altitude or brisket disease, that are detrimental to their survival. Collection of PAP records has historically been used to select animals that are adapted to high-altitude environments. Previous research has indicated that PAP measurements are moderately heritable which suggest that genetic selection for high-altitude-adapted animals is possible (Shirley et al., 2008).

With the topic of feed efficiency becoming a highlight of interest in the cattle industry, and an increase in commercially available technologies for individual animal monitoring, the opportunity for development in this area through research is becoming more viable (Shike, 2013). This project focuses on genetic relationship between PAP and efficiency traits such as average dry matter intake (ADI) and average daily gain (ADG). As expected progeny differences for PAP are becoming commercially available through the American Angus Association and with other breeds developing similar genetic evaluations, it is important to understand potential antagonisms between PAP and other production traits receiving selection pressure in individual breeding objectives, particularly at high elevations. Because of these developments, the objective of this study was to estimate phenotypic and genetic parameters for PAP and feed intake traits in a population of commercial Angus steers.

MATERIALS AND METHODS

Animal Information and Data Collection

The Institutional Animal Care and Use Committee at Colorado State University (approval number 17-7179A) approved all animal procedures.

Pulmonary arterial pressure and feed intake data were collected on Angus steers \((n = 544)\) for...
a total of 5 yr ranging from 2013 through 2018. Cattle were born at an elevation of approximately 2,115 m located at Colorado State University’s Beef Improvement Center research facility located in Encampment, WY. Steers used for this study were calved in the spring months ranging from February to May spanning the years 2013 to 2017. Male calves not chosen to enter CSUBIC’s annual gain test and sale were castrated and directed toward the feedlot program. Post-weaning steers were then brought to a lower elevation (1,557 m) facility to evaluate feed intake and feed utilization at Colorado State University’s Feed Intake Unit (FIU) located at the university’s Agriculture Research Development and Education Center (ARDEC) in Fort Collins, CO. Upon arrival of the testing center, calves were weighed and sorted into three or four pens depending on incoming animal number.

Age of steers entering the feedlot ranged from 223 to 543 d depending on the year the test was conducted. Feed utilization traits were collected daily on a per animal basis with the use of a GrowSafe intake monitoring system. Cattle were allotted a warm up period prior to the start of the performance test to allow for adaptation of the facilities and diet with this typically being 21 d in length. Duration of the performance tests varied by year with an average test length of 67 ± 9.20 d. For further information regarding test information, see Table 1. Body weights were collected for each animal in 14-d increments starting from 0 d until the conclusion of the test. Steers were fed an ad libitum diet consistently throughout all 5 yr of testing. Ration composition is summarized in Table 2. The efficiency traits evaluated in this study consisted of ADG and ADMI.

### Statistical Analysis

Heritabilities of each trait and genetic correlations between traits were estimated using the statistical software package ASReml 3.0 (Gilmour et al., 2009). Estimates were collected using two bivariate analyses with the first analysis including PAP as the first trait and second trait being ADMI. Second analysis included PAP as the first trait and ADG as the second. This model included fixed effects of PAP contemporary group which consisted of PAP date and PAP age as a linear covariate. Effects relating to feed intake included in the model were length of test, start age as a linear covariate, and contemporary group consisting of weaning date and feed intake pen. Contemporary groups for intakes were formed based on the management practices of the CSUBIC. In both models, animal was the sole random effect. Average daily dry matter intake was calculated as the mean observation of all days that data were collected for the duration of the test.

The following is the general matrix form for the equation used for the analysis:

\[
\begin{bmatrix}
    y_1 \\
    y_2
\end{bmatrix}
= X_1 \begin{bmatrix} 0 \\ 0 \end{bmatrix} \beta_1 + Z_1 \begin{bmatrix} 0 \\ 0 \end{bmatrix} u_1 + \begin{bmatrix} e_1 \\ e_2 \end{bmatrix},
\]

where \( y_i \) was a vector of observations for the traits corresponding to PAP and each of the efficiency traits, \( X_i \) and \( Z_i \) were known incidence matrices relating observations in \( y \) to levels of fixed effects in \( \beta \), and random solutions in \( u \), respectively, and \( e \) was a vector of random residuals. Variances and means for the random effects that were included in the model are as follows:

\[
\text{Var} \begin{bmatrix} u_1 \\ u_2 \end{bmatrix} = \begin{bmatrix} \sigma_u^2 & \sigma_{u1} \\ \sigma_{u1} & \sigma_u^2 \end{bmatrix} \otimes A \quad \text{and} \quad \text{Var} \begin{bmatrix} e_1 \\ e_2 \end{bmatrix} = \begin{bmatrix} \sigma_e^2 & \sigma_{e1} \\ \sigma_{e1} & \sigma_e^2 \end{bmatrix} \otimes I \quad \text{and} \quad E \begin{bmatrix} u \\ e \end{bmatrix} = \begin{bmatrix} 0 \\ 0 \end{bmatrix}
\]

where \( A \) was Weight’s numerator relationship matrix, and \( I \) was an identity matrix of whose order was equal to the number of animals with each respective phenotype.

### Table 1. Performance test lengths and age for steers involved in the study

| Test | Length | Steers | Age |
|------|--------|--------|-----|
| 1    | 70     | 92     | 490 |
| 2    | 77     | 110    | 455 |
| 3    | 69     | 109    | 375 |
| 4    | 74     | 96     | 376 |
| 5    | 73     | 126    | 277 |

1Performance test.
2Mean age of animals per group at the beginning of each test.
3Number of observations for each test.
4Test measured in days.

### Table 2. Feed ration utilized for steers in the study

| Ingredient          | Ration, % |
|---------------------|-----------|
| Corn silage         | 10        |
| Alfalfa hay         | 6.90      |
| Cracked corn        | 74.46     |
| Dry distillers grain| 3.79      |
| Limestone           | 0.75      |
| Mineral supplement  | 4.10      |
RESULTS AND DISCUSSION

The number of observations, mean, SD, as well as minimum and maximum values for both PAP and each feed efficiency trait measured are presented in Table 3. Summary statistics for all traits analyzed were within the range of previous published results (Boldt et al., 2018).

Heritability estimates (diagonal) as well as genetic correlations (above off diagonal) with corresponding SE are shown in Table 4. Average daily gain was found to be more heritable (0.35 ± 0.10) than average daily dry matter intake (0.16 ± 0.09). This estimate of ADG was within the range of previous findings (0.16 to 0.43) (Fan et al., 1995). Correspondingly, the heritability estimate for ADMI was lower than the range of previous findings (0.32 to 0.40; Rolfe et al., 2011; Sobrinho et al., 2015). The differences between previously reported estimates for DMI heritability and our findings can be explained through data inconsistencies revolving around startup of the Growsafe system and the management plan inconsistencies during the first few years of the study.

Genetic correlations between PAP and ADG were found to be lowly correlated (0.04 ± 0.19). Average dry matter intake recorded a moderately positive correlation with PAP (0.40 ± 0.25). Surprisingly, the positive moderate correlation between PAP and ADMI was larger than expected. Our hypothesis was that animals that have increased ADMI could have an increased level of vascular adipose tissue causing hypertensive tendencies. The results of this study conclude that there is opportunity selecting high-altitude-adapted individuals with lower PAP values without negatively influencing feed intake. Ideally to achieve maximum profit, we would like to see a trait that would decrease the likelihood of obtaining a high PAP measurement while increasing feed utilization. With the positive correlation between PAP and ADMI, we can assume that the traits will follow the same directional trend. This correlation will suggest that cattle with lower PAP have a tendency to have lower reported intake values. This result is congruent with Maddock et al. (2010) who found that animals with a lower PAP exhibited lower intake corresponding to a lower feed efficiency value compared to animals with a high PAP.

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Table 3. Summary statistics for Black Angus steers

| Trait | N   | Mean  | SD   | Min | Max |
|-------|-----|-------|------|-----|-----|
| PAP   | 6,868 | 42.295 | 9.627 | 21  | 139 |
| ADG2  | 533  | 1.652  | 0.290 | 0.305 | 2.446 |
| ADMI2 | 533  | 11.554  | 2.337 | 4.344 | 19.200 |

1PAP = pulmonary arterial pressure; ADG = average daily gain; ADMI = average dry matter intake.

2Reported in kilograms.

Table 4. Heritability estimates (diagonal) ± SE and genetic correlations (above diagonal) ± SE from the two trait models

| Trait | PAP         | ADG         | ADMI       |
|-------|-------------|-------------|------------|
| PAP   | 0.279 ± 0.028 | 0.047 ± 0.186 | 0.401 ± 0.256 |
| ADG   | 0.345 ± 0.103 | –           | –          |
| ADMI  | 0.163 ± 0.092 | –           | –          |

1PAP = pulmonary arterial pressure; ADG = average daily gain; ADMI = average dry matter intake.