50 years of the Wyoming ram test: How sheep have changed

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ABSTRACT: Production characteristics of white-faced rams have been systematically evaluated over a 140-d test in Wyoming since 1961. Individual test records (n = 4,240) from rams on test were analyzed to determine change over the past 52 yr. Although rams on test are not older, weight on and off test has increased (P < 0.001) since 1961. Weight off test increased 22.7 kg and contributed to an increase (P < 0.001) in clean fleece weight. Rate of gain (P < 0.001) almost doubled over this 50-yr period. Growth efficiency improved from 0.23 ± 0.01 kg/d from 1961 to 1966 to 0.39 ± 0.01 kg/d from 2008 to 2013. Cubic, rather than linear, effects better explain the change in growth characteristics, suggesting a plateau or tapering of these traits. Wool characteristics remain an important component of the test index, and despite increases in body size and gain, wool diameter was unchanged (P > 0.15). Average daily gain correlated (r² > 0.67; P < 0.001) with lamb and feeder lamb price, with the strongest correlation at a 2-yr (r² > 0.76) time lag. U.S. sheep inventory was negatively correlated (r² > −0.72; P < 0.001) with sheep price and ADG, with the greatest correlation at no time lag. Wool price 0, 2, or 5 yr prior did not correlate (r² < 0.1; P ≥ 0.5) with spinning count. Influences on white-faced ram selection appear to have largely impacted growth traits while avoiding negative impacts on wool quality.

Key words: historical trend, production, sheep


INTRODUCTION

Sheep numbers in the United States have declined since 1945 (Jones, 2004). There is a trend for an increase in numbers of small (<100 sheep) operations, representing 94% of all sheep producers and 35% of the sheep inventory (National Agriculture Statistics Service [NASS], 2013). Large sheep operations are primarily located in the western plains states, including Wyoming, Colorado, California, and Idaho, where ≥80% of the sheep inventory in these states is managed in flocks of >1,000 animals (NASS, 2013). Of the total sheep inventory, 44% is in large operations (NASS, 2013). The shift in inventory away from large flocks may be caused by the aging of sheep producers. In Wyoming >50% of all sheep producers are older than 55 yr, and only 3% of producers with large flocks are <35 yr (Gardiner et al., 2012).

Wyoming is ranked third in the United States in numbers of breeding ewes, behind Texas and California (NASS, 2013). Most sheep in Wyoming are produced on large range operations (Gardiner et al., 2012). Sheep were initially raised for their wool with meat as a by-product. In the 1950s and 1960s formal outerwear monopolized wool consumption (Richardson, 2001). Consumer acceptance of man-made fibers, an increase in casual dressing styles, and decreased use of wool for military uniforms reduced the market demand for wool (Richardson, 2001; Jones, 2004). Regardless of the change in the wool market over time, many range sheep continue to be a wool or dual-purpose breed. Because of their purported hardiness and flocking instinct (American Sheep Industry [ASI], 2013), the Rambouillet breed remains a foundation breed for many Western range flock operations.

Production characteristics of predominantly Rambouillet rams have been systematically evaluated in the Wyoming white-faced ram test since 1961. These rams are representative of traits desired by producers of the time. The magnitude of change and production characteristics that remained constant
within the Rambouillet breed were investigated utilizing 52 yr of ram test results.

MATERIALS AND METHODS

Performance records ($n = 4,240$) from the Wyoming ram test from 1961 to 2013 were analyzed to determine how ram size, rate of gain, and fleece characteristics have changed over the past 52 yr (no test was conducted in 1989). This data set is particularly suited for this analysis since the 140-d late fall/winter production test has remained relatively constant, with predominantly Rambouillet rams from top producers in the region. These rams presumably are representative of the best of the breed from the Rocky Mountain region in each respective year. Although the test diet has changed over the years, rams have consistently received an ad libitum total mixed grover ration with a 60:40 ratio of forage to concentrate providing approximately 15% CP designed to meet or exceed NRC requirements. Although technology and methods for data collection have changed over the years, ram weights have recently been taken as a fasted weight. However, records for the early tests are not complete, and weights reported here may reflect differences in methods in addition to absolute change in body size over time.

Wool characteristics are determined by fleece grown while on test. Rams are sheared at test initiation and completion with staple length as well as fleece weight adjusted to 365 d. Fiber diameter was initially assessed as spinning count with fibers measured in μm starting in the early 1980s. Although fiber diameter is currently assessed by LaserScan (Block Engineering, Marlborough, MA), early tests utilized microprojection with manual measurement. Accuracy and precision have likely improved over the 50-yr test period. To determine how fiber diameter has changed over the 50-yr period, fiber diameter in μm (recorded since 1981) was converted to spinning count (Kott, 1993).

Scoring systems for face wool cover and body wrinkles have been consistent with Terrill and Hazel (1946). The face and body are scored separately on a 1 to 5 scale, with 1 being the desired open face with wool not covered beyond the poll and the body free of wrinkles. A face score of 5 is an animal with wool almost or completely covering the face and subject to wool blindness, and a 5 wrinkle score implies the body is completely covered with heavy or large skin folds (Terrill and Hazel, 1946).

Regression analysis was utilized to determine linear, quadratic, and cubic change over time and the influence of other predictors, with ram record being the experimental unit. Historical market lamb prices (NASS), available since 1974, were used to determine relatively recent correlations (SAS version 8.1, SAS Inst. Inc., Cary, NC) of production characteristics with potential market forces. Production characteristics (ADG, spinning count) and sheep inventory were correlated to market price reported for that year and to market prices from 2 and 5 yr prior.

RESULTS AND DISCUSSION

The initial year of the Wyoming white-faced ram test (1961) marked the beginning of the second steep decline of sheep numbers in Wyoming and the United States (NASS, 2013). The number of rams on test were low in the early years, averaging approximately 35 rams/yr. The peak in the number of rams on test occurred during the early 1980s (mean = 121 rams/yr) when the severe decline in sheep numbers was tempered with moderate increases in inventory (NASS, 2013). Numbers of rams on test have remained relatively stable in recent years, with approximately 75 rams on test. Year-to-year fluctuation in ram numbers likely reflects the cost of the test in relation to alternative management options.

It is no surprise that sheep have increased in size over the past 50 yr. Although the age of ram varied by year ($P < 0.001$), a linear increase was not observed since adjusted $r^2$ for year accounted for less than 1% (Fig. 1) of the variation. Even though the age of the ram remained relatively stable ($354 ± 0.5$ d), final ram weight increased ($P < 0.001$) from 88.3 ± 1.5 kg in 1961 to 106.5 ± 1.2 kg 50 yr later (Fig. 2). Not unexpectedly, the initial weight of rams on test contributed to the ram’s final weight and accounted for the majority of the explained variation (0.60 adjusted $r^2$) in the model. However, how final weight changed across the years was interesting. Although there was a significant ($P < 0.001$) linear effect (0.34 adjusted $r^2$), indicating a simple increase in weight over time, a cubic effect of year was a better fit and accounted for more of the
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explained variation (0.47 adjusted $r^2$). The cubic effect of the final weight suggests that ram weights have plateaued and may now be on a downward trend (Fig. 2).

The increase in ram weight across the past 50+ yr is largely a reflection of increased growth efficiency; ADG in combination with weight at test onset accounted for 98% of the explained variation of final weight. The linear increase ($P < 0.001$) in weight at the test initiation reflects an overall increase in ram body size over the 50+yr period (Fig. 2). The linear effect of year for initial weight was weaker than that for final weight but accounted for 10.3% of the explained variation. The cubic effect of year for weight on and off test increased linearly ($P < 0.001$) by year, but the cubic effect of year accounted for more variation for weight on and off test (0.15 and 0.47 adjusted $r^2$, respectively).

Clean fleece weight was most influenced by body size, with weight off test explaining 0.20 (adjusted $r^2$) of the variability. Both final test weight and clean fleece weight increased approximately 25% over the 50+yr period. Weight off test in combination with staple length explained approximately 1/3 of the variability for fleece weight. Staple length increased ($P < 0.001$) moderately (0.16 adjusted $r^2$) over the time period, with only a modest improvement in line fit with a cubic effect (0.21 adjusted $r^2$). The effect of year on clean fleece weight was nominal, explaining only approximately 1% of the variation. Wool characteristics are moderately (0.24 to 0.36 $h^2$; Wuliji et al., 2011) to highly (0.37 to 0.56 $h^2$; Safari et al., 2005) heritable, and wool traits would be expected to change with market demands. Over the time period reflected in this paper, there was a robust drive for meat production (Jones, 2004). Despite the increased meat market, decreased demand for wool, and the end of wool price support (USDA Economic Research Service, 1999), spinning count (a measure of wool fiber diameter) remained stable (linear effect, $P = 0.12$; Fig. 4), with an average spinning count of 62 (22.05 ± 5.89 µm), reflecting a medium to fine wool (Kott, 1993).

Rams on test are ranked on the basis of a performance index (Alexander et al., 2008) that is influenced by ADG and fleece characteristics. The index is calculated as 60 (ADG in pounds) + 4.0 (365-d adjusted staple length in inches, up to 5.5 inches) + 4.0 (365-d adjusted clean wool in pounds) + wool fiber diameter and variability points. Diameter points are calculated as
(22.0 – actual fiber diameter in μm) × 3, with a maximum of ±9 points. Fiber variability points are calculated as (22.0 – actual coefficient of variation) × 1.25, with a maximum of ±5 points. The test index was designed to account for economically important traits and to simplify selection of superior animals. Rams with exceptional gain performance could have a high index with average fleece characteristics. However, poor fleece growth with a coarse and variable fiber diameter would decrease a ram’s index and, presumably, breeding value. Furthermore, for a ram to be certified in the American Rambouillet Association minimal wool standards are required (American Rambouillet Sheep Breeders Association, Milo, IA). Assuming producers purchase replacement sires on the basis of their test performance and overall rank or index, wool characteristics would be preserved even with increased selection for growth performance.

Selection of Rambouillet rams for decreased wrinkles and wool cover on the face is reflected by a linear decrease (P < 0.001) in face wool cover and body wrinkle score over the 50+-yr period. However, the fit of the line was poor, with <5% (adjusted $r^2$) of the variability accounted for, and fit did not improve with a quadratic or cubic function of year. Although there are criteria for scoring sheep for face cover and body wrinkles (Terrill and Hazel, 1946), scorers are subjective, and how a ram scores on any given year is likely relative to the rams present at any given test, such that rams presenting with the most body wrinkles or face cover would be given a higher score even though overall wrinkling and face cover has steadily declined.

Scrotal circumference data have been included in test results since 1982 but has never been a component of the test index. Scrotal circumference is moderately (0.21 to 0.24 h²; Safari et al., 2005) to highly (0.46 to 0.49 h²; Bourdon and Brinks, 1986) heritable and is a trait of economic interest since scrotal circumference is a reflection of sperm production and breeding capacity (reviewed in Ridler et al., 2012). If rams were selected for this trait, scrotal circumference would be expected to increase linearly in the 30 yr it has been included in the test data. However, a linear increase in scrotal circumference was not noted, with less than 5% (adjusted $r^2$) of the explained variation in scrotal circumference for year. Quadratic and cubic effects of year on scrotal circumference were also nominal, with <11% (adjusted $r^2$) of the explained variation. However, weight off test explained approximately 25% of the variation in scrotal circumference. It is not unexpected that as rams increase in size, testes size increases proportionally. Clearly, scrotal circumference has been considered to be acceptable over the 30 yr it was included in the test data. The American Sheep Industry handbook (ASI, 2003) indicates rams with <30 cm scrotal circumference have reduced reproductive capacity and are unacceptable breeders. With yearly averages ranging from 33.1 to 38.2 (±0.3) cm, rams on test would be considered to have acceptable scrotal circumference, and scrotal circumference was not likely considered to be an important selection criterion.

Sheep inventory is not as elastic as change to the sheep market. A producer’s response to market forces requires a minimum of 2 yr (Jones, 2004). Adjustment of sheep production occurs when a producer responds to market force by either culling or retaining ewe lambs. When ewe lambs are retained, the increase in marketable lambs occurs after those retained ewes attain puberty at 6 to 8 mo (note that they are often not bred in their first year), a 5-mo gestation period, and time for their offspring to reach a marketable weight. This time frame does not account for any obligatory changes to marketing or production infrastructure. Average daily gain strongly correlated ($r^2 > 0.67$) with feeder and lamb price and had the strongest correlation ($r^2 = 0.76$ and 0.79, respectively) with a 2-yr lag time (Table 1). It should be cautioned that correlations indicate only the strength of the linear relationship between 2 variables (Kaps and Lamberson, 2012).
2004) and do not imply any causative or dependent effect. However, it should be accepted that market price would influence selection pressure across time, and selection pressure for increased ADG would be responsive to market price. Sheep inventory negatively correlated ($r^2 > -0.72; P < 0.001$) with ADG and sheep price ($r^2 > -0.82$). This result likely reflects the coincident selection pressure for the meat market, and increased ADG, at a time when sheep inventory was retracting because of other forces. The overall decline in sheep inventory masked cyclic changes due to market forces (Bastian and Whipple, 1998). Although this study is only reflective of the Rambouillet breed, other sheep breeds have likely increased in size (Field and Whipple, 1998), and it should be acknowledged that the increase in body size would increase marketable pounds even though overall numbers of animals were declining. Over the 50+yr time period, inventory decreased approximately 80%, whereas body size increased approximately 25% in this breed. The increase in overall body size and coincident increase in pounds of lamb marketed would somewhat offset the decline in inventory.

Wool price (average market price of all wool grades), surprisingly, did not correlate ($P \geq 0.5$) to spinning count (a measure of wool quality) at any of the time lags investigated (Table 1). Wool characteristics are moderately (0.24 to 0.36 $h^2$; Wuliji et al., 2011) to highly (0.37 to 0.56 $h^2$; Safari et al., 2005) heritable, so it is somewhat surprising that as the wool market declined (Richardson 2001; Jones, 2004), wool diameter did not increase as market forces favored lamb production over wool production. However, in a declining wool market, finer wool would always garner a higher price. Thus, in this dual-purpose breed, it may not be surprising that producers continued to value and select for fine wool even though the overall market price was declining.

**Implications**

Rambouillet rams have increased in size over the last 50 yr, with an increase in ADG. The cubic effect of year on final test weight as well as ADG suggests sheep size and gain efficiency have peaked and may be tapering off. Although clean fleece weight increased proportionally to ram size, fiber diameter has remained largely unchanged and was not correlated with wool price. This suggests selection pressure for white-faced sheep has largely impacted growth traits while avoiding any negative impact on wool quality.

**LITERATURE CITED**


