

(C16:1n7),  $\alpha$ -linolenic (C18:3n3; 1.80 or 1.24 vs. 2.84%), and C18:3n6 (0.83 or 0.65 vs. 2.66%) acids, but a lower ( $P < 0.01$ ) concentration of C18:1n9 in subcutaneous fat; and a higher ( $P < 0.01$ ) concentration of C14:1n5, but a lower concentration of C18:1n9 in kidney fat. The results indicate that fresh lamb from pasture only fed-lambs might have healthier fatty acid profiles compared with that from lambs supplemented with soy hull or corn gluten feed.

**Key Words:** agro-byproduct, fatty acid, lamb

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## SMALL RUMINANT SYMPOSIUM: ENHANCING SMALL RUMINANT PROFITABILITY

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**1726 Profitability of small ruminant production systems.** G. W. Williams\* and D. P. Anderson, *Texas A&M University, College Station.*

The prolonged decline in U.S. sheep numbers is well documented. Well known reasons for the decline include dwindling U.S. demand for lamb, relative prices for competing meats, the rise of man-made fibers competing with wool, discontinuation of the U.S. Wool Incentive payment program, grazing allotment policies for public lands, and restrictions on predator control. Another critically important force behind falling U.S. sheep numbers has been rising costs resulting in unprofitable conditions, forcing producers to reduce the size of their flocks or exit the industry. Using extension sheep production budgets, this study examines and compares sheep production costs across various states representing conventional sheep production based on an average flock size with costs and returns on a per ewe basis. The weighted total variable cost was \$124.44 per ewe in 2015 and ranged from \$148 per ewe in Kentucky to \$118 per ewe in Wyoming. Receipts were the highest in the Eastern region at \$179 per ewe and were the lowest in Texas at \$98 per ewe. Net returns ranged from a-\$41 to \$21 per ewe in Texas and Kentucky, respectively. Costs between regions reflected significant differences in production systems. For example, feed made up just over 50% of total variable costs in Texas and 22% of total variable costs in Wyoming. Hired labor made up 37% of total variable costs in Wyoming or \$44 per ewe. Predator control costs were \$10.50 per ewe in Texas but only \$1-\$2 in the other regions. The results highlight the variable nature of the cost of sheep production and the range of production systems across the country. Policy changes that affect hired labor costs, for example, affect Wyoming and Western region production more than smaller flocks in the East with little, if any, hired labor. New technologies or predator control systems would be likely to see the greatest returns in Texas and the Southwest or in the Mountain West. Changes in public land grazing policies would have the biggest effect in the West. Positive returns in Kentucky indicate opportunities for

industry expansion in the Eastern half of the U.S.

**Key Words:** cost of production, net returns, production systems, sheep

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**1727 Contribution of hair sheep to small ruminant profitability.** J. Morgan\*, *Round Mountain Consulting Service, Fayetteville, AR.*

Hair sheep numbers in the United States have increased dramatically in the past twenty years as documented by breed registry data. Characteristics promoted by hair sheep producers include: moderate or small framed, easy care, parasite resistant, twinning, productivity in extensive systems, aseasonal breeders, and adapted to heat and humidity. These descriptors suggest that hair sheep have the potential to add to the profitability of small ruminant production in the USA. Two hair sheep breeds rank among the top six breeds for numbers of sheep registered in the USA from 2002 to 2015 (Table 1 for 2003–2015). The increase in hair sheep registrations occurred while the vast majority of wool sheep registries experienced declines of 25–75% in their registration numbers from 1990 to 2015. Research results from three research stations will be discussed since they document productivity of hair sheep and hair sheep crosses. These stations include USDA ARS Meat Animal Research Center in Nebraska, USDA ARS Small Farm Research Center in Arkansas, and Texas A&M Agrilife Research Center in San Angelo, Texas. Data from these stations and other university studies find that the weights of weaned and finished hair sheep lambs are well suited to markets and regions of the country that reward the non-traditional or light lamb market. In the Nebraska and Arkansas production systems, hair sheep genetics produced 150–200% lamb crops in forage-based systems compared to annual NASS reports of 110% for the United States. In west Texas, research results indicate that lamb markets differentially impact hair sheep (Dorper) and wool sheep (Rambouillet) producers based on corn prices and weather (Sheep and Goat Research Journal, In Press). During drought years, Dorsers wean significantly more lambs. When corn prices are high, Dorsers bring premium prices for the light lamb, non-traditional markets. When corn prices are low, wool feeder lambs bring premium prices. A significant percentage of the hair sheep operations, using breed association membership, are located in regions of the country where sheep numbers have traditionally been low, especially the Southeastern region. It is suggested that lack of shearers, decreased quality and quantity of wool, resistance to parasites (documented by Virginia Tech, LSU, USDA Booneville, among others) and adapted to heat and humidity help with popularity of these breeds in this region.

**Key Words:** breed registry, hair, sheep

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**1728 Contribution of newer goat breeds to small ruminant profitability.** R. Browning, Jr.<sup>1</sup> and M. L. Leite-Browning<sup>2</sup>, <sup>1</sup>Tennessee State University, Nashville, <sup>2</sup>Alabama A&M University, Huntsville.

Profitability in commercial meat goat enterprises is affected by animal productivity, market value, and input costs. Productivity indicators include doe reproductive output, kid growth rate, carcass merit, and hardiness. Breed choice(s) can affect these profit factors and set the path to profit or loss. Meat goat breed options are scant compared to other ruminant livestock sectors in the US. The South African Boer goat was a highly visible new breed introduced in the 1990s to enhance meat production of the US herd base of primarily Spanish-type goats. This model has been repeated worldwide. New Zealand Kiko goats were also imported by US interests in the 1990s. New breeds are usually introduced with a focus on improving growth and end-products (e.g., meat, milk, fiber) while overlooking fitness traits (health and reproduction) that may be greater profit drivers, especially if doelings are retained for future breeding. Successful new breed introductions require some level of adaptation to destination environments, particularly in low-input systems. Loss of native or naturalized local genotypes possessing desirable fitness levels while pursuing improved growth or end-product traits is a global concern. This was true after large-scale crossbreeding of naturalized Spanish goats with imported Boer commenced. Research indicated that Boer germplasm generated an insignificant to negative impact on doe fitness compared to the Spanish maternal base. Reductions in doe reproductive output, wellness, and stayability point to lowered expected enterprise profitability. Health and stayability problems increase input costs. Economic analysis demonstrated lower annual net return for Boer does (-\$52.25) compared to Spanish does (\$7.18) in a low-input setting. Some relative increases in weight were evident using Boer at various research stations, but improvements in carcass merit were not so obvious. One carcass trait noticeably improved by the Boer influence was conformation score. Improved conformation score can increase market value. Across performance traits, other data suggests that Kiko goats may be a favored import over Boer for increasing commercial herd profitability. The newest breed garnering attention among US producers is the South African Savanna. Like Boer and Kiko in the 1990s, current industry use of Savanna is preceding objective characterization. The newer breeds have increased industry popularity, but not necessarily profitability. Proper selection and use of new and established breeds in meat goat mating systems is important for profitability in a low-input commercial setting. Managing around poor meat goat breed choices is probably not profitable or sustainable.

**Key Words:** breed, meat goat, profitability

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**1729 Contribution of forage production systems to small ruminant profitability.** R. Ehrhardt\*, Michigan State University, East Lansing.

Improving forage utilization is a key consideration in increasing production efficiency and decreasing the cost of production in a small ruminant farming systems. In much of North America, winter dormancy and to a lesser extent, slow growth in mid-summer, creates barriers in both forage availability and quality in perennial-based grazing/forage production systems for small ruminants. To better understand how to optimize forage systems for sheep production in the upper Midwest USA, a series of grazing studies were conducted with sheep over a 3 yr period to examine forage utilization, animal performance, and cost of production on annual, short-term perennial, and perennial pastures. These pastures were evaluated as part of a 3 yr pasture rotation system and compared to a perennial only system. This rotation was established in year 1 by converting perennial pastures to annual crops between after attaining approximately 60% of historical seasonal biomass production (mid-June conversion). Annual crops evaluated included warm season grasses, brassicas, and their mixtures. In year 2 a short-term perennial pasture consisting of red clover, ryegrass, and chicory was established in early spring into the annual forage residue from year 1. In late summer of year 3, a perennial pasture was reestablished. The perennial pasture used as a base of comparison consisted of a mixture of alfalfa, endophyte free tall fescue and orchard grass. Animal performance on these pastures and within these systems was measured by the growth performance of lambs post-weaning expressed on a lamb (g/day) and land basis (kg/hectare). Individual lamb gains on brassica (310 g/d) and short-term perennial (278 g/d) pastures approached that of the same genotype fed a concentrate diet fed in confinement (330 g/d). On a land basis, seasonal gains on short-term perennial pasture excelled (1430–1640 kg/ha) over other pastures. The cost of lamb gain was calculated for each pasture ranking lowest to highest were short term perennial < perennial < brassica monocultures < brassica/warm season mixes < warm season monocultures. In summary, complimentary pasture rotation systems offer value to small ruminant production by reducing the cost of gain, allowing opportunities for finishing on pasture, improving parasite management, improving soil health, and overall system productivity and profitability.

**Key Words:** sheep, goats, forages, grazing

## SWINE SPECIES

**1730 Probiotic treatment using *Bacillus subtilis* PB6 improves the growth performance, intestinal morphology, enzyme activities and barrier function in low birth weight piglets.** L. Hu, L. Che\*\*, X. Peng, Q. Xu, Z. Fang, S. Xu, Y. Lin, and D. Wu, *Institute of Animal Nutrition, Sichuan Agricultural University, Chengdu, China.*

This study aimed to investigate the effects of *Bacillus subtilis* PB6 supplementation in milk formula on growth performance, intestinal development, and immune function in low birth weight (LBW) piglets. Piglets with a birth weight near the mean litter birth weight (SD 0.5) were identified as normal birth weight (NBW), whereas those with at least 1.5 SD lower birth weight were defined as LBW. Fourteen pairs of NBW and LBW piglets (7 d old) were randomly assigned to receive the formula milk or formula milk with *Bacillus subtilis* PB6 for a period of 21 d. At Day 28, blood samples, intestinal tissues, and digesta were collected at necropsy and analyzed for morphology, digestive enzyme activities, immune cells, gene, and protein expressions as well as microbial population. Data were analyzed by SPSS software using the MIXED procedure. Regardless of the diet, LBW decreased the average daily dry matter intake ( $-31\%$ ,  $P < 0.001$ ) and the average daily growth ( $-28\%$ ,  $P < 0.001$ ). Moreover, LBW decreased plasma concentration of immunoglobulin A ( $-17\%$ ,  $P < 0.001$ ), interleukin- $1\beta$  ( $-12\%$ ,  $P = 0.006$ ), the count ( $-33\%$ ,  $P = 0.021$ ) and percentage ( $-13\%$ ,  $P = 0.025$ ) of blood lymphocytes compared to NBW piglets. LBW decreased the villous height ( $-8\%$ ,  $P = 0.039$ ) and enzyme activity of maltase ( $-24\%$ ,  $P = 0.011$ ), as well as the mRNA abundances of *Toll-like receptor 9* ( $-34\%$ ,  $P = 0.020$ ) and *Toll-interacting protein* ( $-21\%$ ,  $P = 0.001$ ) in ileum. Regardless of body weight, the supplementation of *Bacillus subtilis* PB6 markedly decreased the feed:gain ratio ( $-10\%$ ,  $P = 0.034$ ), which could be related to the better intestinal morphology, increased enzyme activities of maltase ( $+19\%$ ,  $P = 0.082$ ) and sucrase ( $+23\%$ ,  $P = 0.095$ ) in jejunum. Moreover, the protein abundances of *Zonula occludens-1* and *Claudin-1* ( $+33\sim 54\%$ ,  $P < 0.05$ ) in ileum, as well as the copy number of *Bacillus* ( $P = 0.01$ ) in colonic digesta were increased in piglets supplemented with *Bacillus subtilis* PB6 relative to piglets with control diet. Our results indicated that LBW impaired the growth and intestinal development as well as immunity of piglets, however, dietary supplementation of *Bacillus subtilis* PB6 improved the growth performance with better intestinal development and barrier function in both NBW and LBW piglets.

**Key Words:** immunity, low birth weight, probiotic

**1731 Dietary nucleotides supplementation improves the intestinal development and immune function of low birth weight piglets.** L. Hu, L. Che\*\*, X. Peng, Q. Xu, Z. Fang, S. Xu, Y. Lin, and D. Wu, *Institute of Animal Nutrition, Sichuan Agricultural University, Chengdu, China.*

This study aimed to determine whether dietary nucleotides supplementation could improve growth performance, intestinal development, and immune function of low birth weight (LBW) piglets. Piglets with a birth weight near the mean litter birth weight (SD 0.5) were identified as normal birth weight (NBW), whereas those with at least 1.5 SD lower birth weight were defined as LBW. Fourteen pairs of NBW and LBW piglets (7 d old) were randomly assigned to receive a liquid milk-based control diet (CON diet) or diet supplemented with nucleotides (NT diet) for a period of 21 d. NT diet was formulated by adding 0.74% nucleotides in CON diet, the pattern of nucleotides (5'-AMP, CMP, GMP, IMP, UMP) was similar as that in sow milk. Data were analyzed by SPSS software using the MIXED procedure. Compared with NBW piglets, LBW piglets had significantly lower average daily dry matter intake ( $P = 0.001$ ) and average daily gain ( $P < 0.001$ ). Moreover, LBW decreased the villous height ( $P = 0.008$ ) and villi: crypt ratio ( $P = 0.014$ ) in duodenum, as well as maltase ( $P = 0.033$ ) activity in jejunum. In addition, LBW decreased the serum concentrations of immunoglobulin A ( $P < 0.001$ ), interleukin- $1\beta$  ( $P = 0.017$ ) and interleukin-10 ( $P = 0.008$ ), as well as the percentage of peripheral lymphocytes ( $P = 0.015$ ). Meanwhile, the downregulation of innate immunity-related genes such as *Toll-interacting protein* (TOLLIP) ( $P = 0.012$ ) and *Toll-like receptor* (TLR) 2 ( $P = 0.073$ ) was observed in the ileum of LBW relative to NBW piglets. Regardless of birth weight, however, feeding NT diet decreased ( $P = 0.001$ ) the feed:gain ratio, increased villous height in duodenum ( $P = 0.036$ ), activities of lactase ( $P = 0.019$ ) and maltase ( $P = 0.055$ ) in jejunum, also increased count of peripheral leukocytes ( $P = 0.039$ ), serum concentrations of immunoglobulin A ( $P = 0.001$ ), and interleukin- $1\beta$  ( $P = 0.019$ ) as well as gene expressions of *TLR-9*, *TLR-4*, and *TOLLIP* (all  $P < 0.05$ ) in ileum. In addition, the protein expressions of *Claudin-1* and *Zonula occludens-1* ( $P < 0.05$ ) in ileum were markedly increased by feeding NT diet relative to CON diet. Our results indicated that LBW impaired the growth performance, intestinal and immune function, but dietary supplementation of nucleotides improved the growth performance, digestive capability, and immunity.

**Key Words:** immunity, low birth weight, nucleotides