Sheep & Goat Research Journal
Volume 20, 2005

[1]Postweaning Performance of Hair and Wool Sheep and Reciprocal-crosses on Pasture and in Feedlot

M. A. Brown[1] and H. S. Mayeux
USDA-ARS, Grazinglands Research Laboratory
El Reno, OK

[1] Mention of a trade name, proprietary product, or specific equipment does not constitute a guarantee or warranty by the USDA and does not imply approval to the exclusion of other products that may be suitable.
The technical assistance of Mr. Scott Schmidt and Dr. David Von Tungeln is gratefully acknowledged.

[2] Corresponding Author: 7207 W. Cheyenne, El Reno, OK 73036, Phone:405-262-5291, Fax: 405-262-0133, email:mbrown@grl.ars.usda.gov)

Summary

Lambs from three diallel-mating plans (Dorset-St. Croix, n=140; Rambouillet-Gulf Coast, n=80; Katahdin-Suffolk, n=78) and a terminal-cross mating plan (Suffolk rams mated to Dorset, St. Croix and reciprocal-cross ewes, n=100) were used to evaluate postweaning grazing performance of traditional meat breeds and tropically adapted breeds of sheep.

Tropically adapted breeds generally had lower postweaning performance than wool breeds in both grazing and feedlot management with the exception that purebred Katahdin and Suffolk were comparable in gain on bermudagrass. Tropically adapted x wool breed lambs were generally intermediate between the parental purebreds except in the Katahdin x Suffolk diallel where there was an indication of heterosis for feedlot ADG and possibly pasture ADG. In general, all lambs performed poorly on forages compared to performance on mixed diets in feedlot. These results indicated a consistent advantage in direct breed effects for wool breeds over tropically adapted breeds in feedlot management systems. The results also suggest that there is little expression of genetic effects in sheep managed on forages, although direct effects for heat adaptation in tropically adapted breeds may compensate for the superior direct breed effects for growth in the wool breeds under summer grazing.

Key words: Postweaning, Tropically-adapted, Wheat Pasture, Grazing, Sheep

This manuscript submitted as part of the Hair Sheep Workshop sponsored by the National Sheep Industry Improvement Center and the NCERA-190 research project, June 21-23, 2005 at Virginia State University.

Introduction

Forages are unique, renewable resources that utilize sunlight, water and soil nutrients to manufacture and store protein, energy and other nutrients. Ruminant animals have been historically used to convert plant nutrients to nutrients available for human consumption. In the southern United States large ruminants, particularly tropically adapted beef cattle, predominate because of the poor adaptation of sheep to heat, humidity and parasites. However, a significant amount of forage resources in the southern United States are not appropriate for cattle because of small land areas available for grazing, as well as the lack of facilities to manage cattle on these small acreages. In areas where cattle predominate, there exist opportunities for additional productivity by incorporation of small ruminants into sustainable grazing systems. In the Southern Great Plains, both warm-season and cool-season forages are available for grazing ruminant animals. The primary cool-season forage for forage-based animal production in the Southern Great Plains is wheat pasture. Wheat forage is of high quality with crude protein concentration varying from 21 percent to 38 percent of the DM, and NDF concentration often less than 50 percent with ADF concentration of less than 30 percent of total DM (Gallavan et al., 1989; Vogel et al., 1989; Phillips and VonTungeln, 1995).

Hair sheep are a recent addition to ruminant animals available in the United States for utilization of forages. They are tolerant of the heat and associated humidity (Bunge et al., 1993a,b; Wildeus, 1997), and parasites (Wildeus, 1997; Vanimisetti et al., 2004) in the Southern United States and have the potential to fill an important niche in meat animal production. In addition, some of the southern landrace breeds, such as the Gulf Coast sheep, have similar traits that would allow them to be productive in the heat, humidity and parasite-laden environments in the southern United States. There is considerable interest in the potential of hair sheep for lamb production in the southern United States. However, there is limited objective information on the growth of these breeds, and there is a need to evaluate the performance of hair and other tropically adapted breeds in grazing-production systems in comparison with conventional wool breeds and their crosses with hair breeds. Consequently, the objectives of this research were: 1) Evaluate the performance of tropically adapted breeds and their crosses with wool breeds as pasture lambs and feedlot lambs; 2) determine the relationship of heterotic expression and maternal- and direct-breed effects to postweaning management.

Materials and Methods

Dorset and St. Croix ewes (n=59; n=61) were spring-bred in 1999, 2000, and 2001 in a diallel-mating scheme to Dorset and St. Croix rams (n=10; n=8) to produce Dorset (n=30), St. Croix (n=37), Dorset x St. Croix (n=39), and St. Croix x Dorset lambs (n=34) for postweaning trials. Similarly, Rambouillet and Gulf Coast ewes (n=27; n=27) were spring-bred in 1999, 2000, and 2001 in a diallel-mating scheme to Rambouillet and Gulf Coast rams (n=6 ; n=4) to produce Rambouillet (n=17), Gulf Coast (n=22), Rambouillet x Gulf Coast (n=19) and Gulf Coast x Rambouillet (n=22) lambs. With the exception on one year of the experiment, after breeding, ewes from the St. Croix x Dorset and Rambouillet x Gulf Coast were managed similarly, lambed at the same time in the fall, their lambs were weaned at the same time, and lambs from each diallel were assigned and managed in postweaning treatments concurrently. Thus, feedlot pens contained Dorset, St. Croix, Rambouillet, Gulf Coast, Dorset x St. Croix, St. Croix x Dorset, Rambouillet x Gulf Coast, and Gulf Coast x Rambouillet lambs. Similarly, lambs on wheat pasture consisted of all breed groups, with the exception of one year, where lambs from the Gulf Coast x Rambouillet diallel were started later due to drought and lack of wheat pasture for all lambs. Ewe lambs from the Dorset-St. Croix diallel were retained and bred to Suffolk rams (n=4) in the spring of 2003 and 2004 to produce two- and three-breed cross lambs (n=100). Dorset, Rambouillet, and Suffolk rams were purchased from producer flocks, either private treaty or at sheep auction sales. Pedigree records for wool rams used in the study that were purchased prior to 1999 were not available, but for rams purchased after 1998, full-sibs or half-sibs were not used. St. Croix, Gulf Coast, and Katahdin rams were obtained from experimental flocks or purchased private treaty as needed and half-sib or full-sib rams were not used in the experiment.

Ewes were flushed prior to breeding using 0.45 kg/d corn and bred in single-sire pastures in 45-day breeding seasons. Ewes were managed on bermudagrass pastures in the summer and fall and managed in large outside lambing pens prior to lambing in the fall. Ewes and lambs were put into sheltered lambing pens for three days after lambing and moved to mixing pens prior to placement on bermudagrass pastures. All lambs were weighed at birth and ram lambs were castrated at birth; lambs did not receive creep feed during the preweaning period. Lambs were weaned and weighed in December of each year at an average age of 80 d. Neither ewes nor lambs were exposed to wheat pasture or cool-season forages during the preweaning period.

After weaning lambs were moved to feeding pens and started on a weaning ration (Table 1). When wheat pasture became available for grazing, lambs were stratified by breed group and sex and assigned to either a feedlot or wheat pasture treatment. Feedlot lambs were fed a high-fiber grower ration that approximated TDN levels normally observed in wheat pasture and had sufficient dietary protein to meet crude protein requirements of the lambs (Table 1). Wheat pasture lambs were allowed to graze for eight hours during the day and lotted at night with fresh water available. Because of differences in wheat pasture availability, the first postweaning trial was initiated in January, 2000; but the second and third could not be initiated until March 2001, and March 2002, respectively. Full weights were taken the morning of trial initiation each year and at least twice a week for six weeks. Data reported includes postweaning ADG of lambs in feedlot from weaning until removed from the feedlot, and it includes postweaning ADG of lambs placed on wheat pasture until the end of the trial with the intent of maximizing the time on a postweaning management regimen for purposes of evaluation of gain on that regimen. Consequently, any inference of comparison of the two postweaning management systems will necessarily reflect those time differ-

Table 1. Diet composition and protein and energy estimates for mixed rations and forages, % DM.

Ingredient	Weaning Ration, %	Growing Ration, %	Wheat Pasture, %	Bermudagrass Pasture, %
Molasses	5	5		
Cottonseed Meal	8	13		
$CaCO_3$	0.5	0.5		
Ca_2CO_3	0.5	0.5		
Chopped Corn	35.5	40.5		
Alfalfa Hay	50.5	40.5		
Crude Protein[a]	15.9	16.9	28.6	7.9
TDN[a]	70.1	72.8	75.0	64.7

[a] Weaning and growing rations based on average NRC values for diet ingredients; wheat pasture and bermudagrass pasture based on laboratory NIRS analyses for pasture samples.

ences, if they are, in fact, influential. However, reanalysis of the data constraining times for both postweaning management systems to be equal and congruent (first six weeks after initiation of grazing wheat pasture in the wheat-pasture lambs) did not result in practically significant changes in ADG for the feedlot lambs, but did bias the wheat-pasture lambs downward because of the 21 d adaptation period common in wheat-pasture stockers (cattle and sheep), where animals do not gain or actually lose weight. The most accurate estimate of performance of lambs on wheat pasture is for the period analyzed and reported (eight-weeks average, rather than six) and is representative of the spring-grazing period from initiation of wheat pasture availability through grazeout in the late spring.

Suffolk and Katahdin ewes (n=28 ; n=18) were fall-bred in 2003 in a diallel-mating scheme to Suffolk (n=2) and Katahdin (n=2) rams to produce Suffolk (n=28), Katahdin (n=15), Suffolk x Katahdin (n=14), and Katahdin x Suffolk (n=21) lambs. Management of ewes and lambs was similar to other studies reported. Lambs were weaned at an average age of 80 d and moved to bermudagrass pastures in early June, 2004. Growth as pasture lambs on bermudagrass was evaluated through mid-August and lambs were moved to feedlot for finishing (90 d).

Linear models used in analyses of postweaning growth included fixed effects of year, sire breed, sire in sire breed (random), dam breed, sex of lamb, parity, postweaning management (pasture vs feedlot) and any appropriate interactions among fixed effects ($P < 0.25$). Direct heterosis was estimated as the contrast between the average of the reciprocal-cross lambs and average of the purebred lambs. Maternal-breed effects were estimated as the contrast between the reciprocal-cross lambs. Direct-breed effects were estimated as twice-the-breed-of-sire main effect contrast. Test of hypotheses were done using t-tests appropriate to the contrast. Sample sizes for lambs in the study are given in Table 2.

Results and Discussion

Least squares means, heterosis, maternal breed, and direct-breed effects for pasture and feedlot postweaning ADG for St. Croix, Dorset, and reciprocal-cross lambs are given in Table 3. Purebred St. Croix gained slower than purebred Dorset on wheat pasture and in feedlot ($P < 0.10$ and $P < 0.01$, respectively; data not shown). There was little evidence of direct heterosis or maternal breed effects but direct-breed effects in favor of Dorset were evident in feedlot lambs ($P < 0.05$). Gains on wheat pasture were 75 percent of gains on feed for St. Croix and numerically less for other breed groups. Results are similar to those of Bunch et al. (2004), who reported lower daily gains in St. Croix than wool breeds.

Least squares means, heterosis, maternal-breed, and direct-breed effects for pasture and feedlot postweaning ADG for Gulf Coast, Rambouillet, and reciprocal-cross lambs are given in Table 4. There was little evidence of breed-group differences on wheat pasture, although Gulf Coast were numerically less than other breed groups. In feedlot, Gulf Coast had lower gains than Gulf Coast x Rambouillet, Rambouillet x Gulf Coast and Suffolk ($P < 0.06$, $P < 0.05$, $P < 0.06$, respectively; data not shown), which were similar in their

Table 2. Sample size for sire breed x dam breed x postweaning management subclasses.

Lamb Breed	Katahdin	K x S[a]	S x K[a]	Suffolk
Pasture	15	21	14	28
Feedlot	15	21	14	28
Lamb Breed	**St. Croix**	**S x D[a]**	**D x S[a]**	**Dorset**
Pasture	20	19	23	15
Feedlot	17	15	16	15
Lamb Breed	**Gulf Coast**	**G x R[a]**	**R x G[a]**	**Rambouillet**
Pasture	11	11	8	10
Feedlot	11	11	11	7
Ewe Breed	**St. Croix**	**S x D[a]**	**D x S[a]**	**Dorset**
Pasture	14	13	13	11
Feedlot	16	14	10	9

[a] K x S = Katahdin x Suffolk, S x K = Suffolk x Katahdin, D x S = Dorset x St. Croix, S x D = St. Croix x Dorset, G x R = Gulf Coast x Rambouillet, R x G = Rambouillet x Gulf Coast (sire breed listed first).

Table 3. Least squares means, heterosis, maternal breed, and direct breed effects for pasture and feedlot postweaning ADG for St. Croix, Dorset, and reciprocal-cross lambs, kg/d.

Lamb Breed	St. Croix	S x D[a]	D x S[a]	Dorset	Heterosis[b]	Maternal[b]	Direct[b]	No. Years/ No. Lambs
Pasture, 56d	0.12±0.01	0.13±0.01	0.14±0.01	0.16±0.02	0.00±0.01	-0.00±0.02	0.04±0.03	3/77
Feedlot, 98d	0.16±0.02	0.22±0.02	0.22±0.02	0.28±0.03	-0.00±0.02	0.00±0.02	0.12±0.05*	3/63
P/F[c], %	75	59	64	57				

† P < 0.10, * P < 0.05, ** P < 0.01

[a] D x S = Dorset x St. Croix, S x D = St. Croix x Dorset (sire breed listed first).

[b] Heterosis = direct heterosis [(S x D + D x S)/2 – (St. Croix + Dorset)/2], Maternal = maternal breed effects [S x D – D x S], Direct = direct breed effects [(Dorset + D x S) – (St. Croix + S x D)].

[c] Pasture ADG/Feedlot ADG x 100 for each breed group

Table 4. Least squares means, heterosis, maternal breed, and direct breed effects for pasture and feedlot postweaning ADG for Gulf Coast, Rambouillet, and reciprocal-cross lambs, kg/d.

Lamb Breed	Gulf Coast	G x R[a]	R x G[a]	Rambouillet	Heterosis[b]	Maternal[b]	Direct[b]	No. Years/ No. Lambs
Pasture, 54d	0.11±0.01	0.13±0.01	0.14±0.01	0.14±0.01	0.01±0.01	-0.01±0.02	0.03±0.02	3/40
Feedlot, 119d	0.22±0.01	0.25±0.01	0.27±0.01	0.27±0.02	0.02±0.01	-0.01±0.01	0.06±0.02*	3/38
P/F[c], %	50	52	52	52				

† P < 0.10, * P < 0.05, ** P < 0.01

[a] G x R = Gulf Coast x Rambouillet, R x G = Rambouillet x Gulf Coast (sire breed listed first).

[b] Heterosis = direct heterosis [(G x R + R x G)/2 – (Gulf Coast + Rambouillet)/2], Maternal = maternal breed effects [G x R – R x G], Direct = direct breed effects [(Rambouillet + R x G) – (Gulf Coast + G x R)].

[c] Pasture ADG/Feedlot ADG x 100 for each breed group

ADG. Effects for direct heterosis and maternal-breed effects were not evident on either postweaning treatment, but there were direct-breed effects in favor of Rambouillet in the feedlot lambs (P < 0.05). Gains on wheat pasture as a proportion of gains in feedlot were similar among the breed groups and ranged from 50 percent to 52 percent.

Least squares means, heterosis, maternal breed, and direct breed effects for pasture and feedlot postweaning ADG for Katahdin, Suffolk and reciprocal-cross lambs are given in Table 5. Breed group means for lambs grazing bermudagrass were similar, and there was little evidence of heterosis, maternal-breed effects, or direct-breed effects in lambs grazing bermudagrass. However, there was a nonsignificant trend for heterosis in the pasture lambs on bermudagrass with a 17 percent advantage of crossbred lambs over purebred lambs. This was partly a function of the low gains in the purebred Suffolk lambs on bermudagrass, which may have been suppressed by high temperatures during the summer. In the feedlot lambs, purebred Katahdin lambs had lower ADG than the other breed groups (P < 0.05,

Table 5. Least squares means, heterosis, maternal breed, and direct breed effects for pasture and feedlot postweaning ADG for Katahdin, Suffolk, and reciprocal-cross lambs, kg/d.

Lamb Breed	Katahdin	K x S[a]	S x K[a]	Suffolk	Heterosis[b]	Maternal[b]	Direct[b]	No. Years/ No. Lambs
Pasture, 70d	0.12±0.01	0.15±0.02	0.13±0.02	0.12±0.02	0.02±0.01	0.01±0.03	-0.02±0.03	1/74
Feedlot, 97d	0.15±0.01	0.21±0.02	0.22±0.02	0.22±0.02	0.03±0.02†	-0.01±0.03	0.08±0.03*	1/75
P/F[c], %	80	71	59	55				

† P < 0.10, * P < 0.05, ** P < 0.01

[a] K x S = Katahdin x Suffolk, S x K = Suffolk x Katahdin (sire breed listed first).

[b] Heterosis = direct heterosis [(K x S + S x K)/2 – (Katahdin + Suffolk)/2], Maternal = maternal breed effects [K x S – S x K], Direct = direct breed effects [(Suffolk + S x K) – (Katahdin + K x S)].

[c] Pasture ADG/Feedlot ADG x 100 for each breed group

Table 6. Least squares means, maternal heterosis, and grandmaternal breed effects for pasture and feedlot postweaning ADG for Suffolk-sired lambs from St. Croix, Dorset, and reciprocal-cross ewes, kg/d.

Ewe Breed	St. Croix	S x D[a]	D x S[a]	Dorset	Maternal Heterosis	Grand-Maternal[b]	No. Years/ No. Lambs
Pasture, 77d	0.16±0.02	0.14±0.02	0.18±0.02	0.17±0.02	-0.00±0.02	-0.04±0.02†	1/51
Feedlot, 77d	0.24±0.02	0.22±0.02	0.22±0.02	0.20±0.03	-0.00±0.02	-0.01±0.03	1/49
P/F[c], %	67	64	82	85			

† P < 0.11, * P < 0.05, ** P < 0.01
[a] D x S = Dorset x St. Croix, S x D = St. Croix x Dorset (grandsire breed listed first).
[b] Maternal heterosis [(S x D + D x S)/2 – (St. Croix + Dorset)/2]; Grandmaternal = grandmaternal breed effects [(S x D) – (D x S)
[c] Pasture ADG/Feedlot ADG x 100 for each breed group

data not shown), there was some evidence of heterosis (P< 0.10) and there was evidence of a direct-breed effect in favor of Suffolk (P < 0.05). There was no evidence of maternal-breed effects in the feedlot treatment group. Pasture performance of Katahdin and Katahdin x Suffolk lambs was 80 percent and 71 percent of contemporaries in feedlot, whereas performance of Suffok x Katahdin and Suffolk lambs on bermudagrass was 59 percent and 55 percent of contemporaries on feed, respectively. Bunch et al. (2004) reported feedlot gains lowest in purebred St. Croix, intermediate in St. Croix x wool crosses but not significantly different from St. Croix, and highest in purebred wool lambs.

Least squares means, maternal heterosis, and grandmaternal-breed effects for wheat pasture and feedlot postweaning ADG for Suffolk-sired lambs from St. Croix, Dorset, and reciprocal-cross ewes are given in Table 6. There was some evidence of a grandmaternal effect in the wheat-pasture lambs with lambs from Dorset x St. Croix ewes gaining better than lambs from St. Croix x Dorset ewes (P < 0.11). There was no evidence of maternal heterosis in either postweaning treatment group nor was there evidence of grandmaternal effects for feedlot lambs. Wheat-pasture gains of lambs from Dorset and Dorset x St. Croix ewes was 85 percent and 82 percent of contemporaries on feed while performance of lambs from St. Croix and St. Croix x Dorset ewes was 67 percent and 64 percent of contemporaries in feedlot.

Rastogi et al. (1975) reported individual heterosis in postweaning ADG for crosses among Columbia, Suffolk, and Targhee but it was only around 2 percent above the purebred mean. Bourfia and Touchberry (1993) reported that individual heterosis for carcass weight per day of age was not important in crosses among Moroccan breeds of sheep. Bidner et al. (1978) reported little evidence of sire breed x dam breed interactions in postweaning ADG for crosses of breed groups involving Suffolk, Rambouillet, and Gulf Coast Native breeds. Mavrogenis (1996) reported positive but small estimates of direct heterosis for postweaning ADG in crosses of Chios and Awassi breeds. Consequently, it is reasonable to conclude that direct breed effects may have more influence on postweaning lamb performance than individual heterosis, with the possible exception of superior summer performance from crosses among Suffolk and Katahdin breeds.

Tropically adapted breeds generally had lower postweaning performance than wool breeds in both grazing and feedlot management. Tropically adapted x wool breed lambs were generally intermediate between the parental purebreds. Exceptions occurred in the summer grazing trial with the Katahdin x Suffolk diallel, where purebred Katahdins and Suffolks were comparable in gain on bermudagrass, and there was an indication of heterosis for feedlot ADG and possibly pasture ADG. These exceptions may relate to expression of heat tolerance in the Katahdin and Katahdin crossbred lambs. Further, even with the low performance of St. Croix on wheat pasture in the winter and spring, the purebred St. Croix gained 75 percent of their contemporaries on grain diets, whereas the gains of purebred Dorsets on wheat pasture were only 57 percent of contemporaries on feed. This trend was not noted in the Gulf Coast in the winter, although Gulf Coast crosses performed comparable to Rambouillet purebreds on wheat pasture. Thus, hair sheep and crosses not only may provide advantages in summer grazing, but also may be best suited for forage gains, where costs of gain are lower. If the growth potential of hair sheep were to be improved genetically and other attributes retained, even greater advantage might be possible. Certainly, there is a need to evaluate the

Table 7. Wheat pasture and feedlot performance of Hereford-sired calves from Brahman, Angus, and reciprocal-cross cows, kg/d

Breed of dam	Wheat Pasture	Feedlot	WP/FL[b], %
Brahman	0.78	1.30	60
B x A[a]	0.73	1.37	53
A x B[a]	0.66	1.37	48
Angus	0.66	1.44	46

[a] B x A = Brahman x Angus, A x B = Angus x Brahman (sire breed listed first)
[b] Wheat Pasture/Feedlot x 100

Gulf Coast under summer grazing conditions, where their heat tolerance might be manifest.

In more general terms, sheep seemed to perform poorly on forages compared to performance on mixed diets in feedlot. Results from this location of a three-year trial comparing wheat-pasture gain to feedlot with different breed groups of cattle (Phillips, et al., 2001) are given in Table 7. Cattle gains on wheat pasture averaged 52 percent of gains in the feedlot compared to an average of 64 percent for sheep in the experiments reported in this paper. While the forage gains as a percentage of gains in feedlot would probably be lower for sheep with higher energy density rations, it is reasonable to conclude that the relative performance of sheep on forages is at least as good as cattle. Moreover, the average weight on trial of the cattle on wheat pasture was 312 kg with an average ADG of 0.71 kg. By comparison, the average weight of sheep on wheat pasture in these trials was 37.4 kg. Therefore, 312 kg of lambs grazing forages (8.33 lambs) yielded an average ADG of 1.17 kg. The comparison is not definitive because of differences in the years in which the experiments were conducted. It does raise the question of relative efficiencies of forage utilization of different ruminant genera and species.

Conclusion

Results from this research suggested that lambs grazing pasture did not attain their genetic potential for postweaning growth and genetic effects such as direct breed effects were not expressed under pasture grazing, particularly in cool-season forages. However, these results also suggested that hair sheep expressed a greater percentage of their genetic potential for postweaning growth on pasture than did wool sheep. Under feedlot conditions, where genetic potential for postweaning growth can be more easily expressed, direct genetic effects favored wool breeds but there was some evidence that the heat tolerance in hair sheep may offset some of the direct, genetic-breed effects of the wool breeds under summer-grazing conditions. It is clearly evident from these results that further work is warranted in evaluation of efficiency of forage utilization by tropically adapted sheep breeds.

Literature Cited

Bidner, T.D., P. E. Humes, R.Boulware, and P. E. Schilling. 1978. Characterization of ram and ewe breeds. II. Growth and carcass traits. J. Anim. Sci. 47:114-123.

Bourfia, M. and R. W. Touchberry. 1993. Diallel cross of three Moroccan breeds of sheep: I. Lamb growth and carcass traits. J. Anim. Sci. 71:870-881.

Bunch, T. D., R. C. Evans, S. Wang, C. P. Brennand, D. R. Whittier, and B. J. Taylor. 2004. Feed efficiency, growth rates, carcass evaluation, cholesterol level and sensory evaluations of various hair and wool sheep and their crosses. Small Ruminant Research 52:239-245.

Bunge, R., D. L. Thomas, and T. G. Nash. 1993a. Performance of hair breeds and prolific wool breeds of sheep in southern Illinois: Lamb production of F1 ewe lambs. J. Anim. Sci. 71:2012-2017.

Bunge, R., D. L. Thomas, T. G. Nash, and R. L. Fernando. 1993b. Performance of hair breeds and prolific wool breeds of sheep in Southern Illinois: Effect of breed of service sire on lamb production of Suffolk and Targhee ewes. J. Anim. Sci. 71:321-325.

Fogarty, N. M., G. E. Dickerson and L. D. Young. 1984. Lamb production and its components in pure breeds and composite lines. II. Breed effects and heterosis. J. Anim. Sci. 58:301-311.

Gallavan, R. H., Jr., W. A. Phillips and D. L. VonTungeln. 1989. Forage intake and performance of yearling lambs fed harvested wheat forage. Nutrition Reports International 39:643-648.

Mavrogenis, A. P. 1996. Environmental and genetic factors influencing milk and growth traits of Awassi sheep in Cyprus. Heterosis and maternal effects. Small Ruminant Research 20:59-65.

Phillips, W. A. and D. L. VonTungeln. 1995. Dry matter intake of freshly harvested wheat forage and supplemental dry matter. Sheep and Goat J. 11:150-155.

Phillips, W. A., M. A. Brown, A. H. Brown, Jr., and S. W. Coleman. 2001. Genotype x environment interactions for postweaning performance in calves grazing winter wheat pasture or dormant native prairie. J. Anim. Sci. 79:1370-1377.

Rastogi, R., W. J. Boylan, W. E. Rempel, and H. F. Windels. 1975. Lamb performance and combining ability of Columbia, Suffolk and Targhee breeds of sheep. J. Anim. Sci. 41:10-15.

Vanimisetti, H. B., S. P. Greiner, A. M. Zajac, and D. R. Notter. 2004. Performance of hair sheep composite breeds: resistance of lambs to Haemonchus contortus. J. Anim. Sci. 82: 595-604.

Vogel, G. J., W. A. Phillips, G. W. Horn, M. J. Ford and R. W. McNew. 1989. Effects of supplemental silage on forage intake and utilization by steers grazing wheat pasture or bermudagrass. J. Anim. Sci. 67:232-240.

Wildeus, S. 1997. Hair sheep genetic resources and their contribution to diversified small ruminant production in the United States. J. Anim. Sci. 75:630-640.