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Performance of Boer-Spanish and Spanish goats in Texas I: Body weights, fertility, prolificacy, and number of kids weaned[1]

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ABSTRACT: Production records from 291 Boer-Spanish and Spanish does, collected between 1994 and 2004 in the Edwards Plateau region of West Texas, were examined to compare Boer-Spanish and Spanish does for body weights, fertility, prolificacy, and number of kids weaned. Traits were analyzed using single-trait mixed models. Boer-Spanish does were heavier at birth than Spanish does (2.79 vs. 2.67 kg, $P = 0.05$) but similar weight at weaning (15.2 vs. 15.0 kg, $P = 0.59$). Boer-Spanish does had a heavier body weight at breeding than Spanish does (46.5 vs. 43.5 kg, $P < 0.01$). Boer-Spanish does had similar fertility over 8 annual breeding seasons (0.87 vs. 0.84, $P = .22$). Boer-Spanish does had an advantage over Spanish does for fertility to a 30-d breeding season (0.53 vs. 0.48; $P = .09$). Boer-Spanish does produced more kids than Spanish does (1.70 vs. 1.62, $P = .09$). Boer-Spanish does weaned a similar number of kids (1.30 vs. 1.31, $P = .76$). Age of doe significantly affected ($P < 0.05$) both number of kids born and number of kids weaned, with older does giving birth to, and weaning, more kids. Boer-Spanish does had greater birth weight, body weight at breeding, and number of kids born than Spanish does. Boer-Spanish does had a similar number of kids weaned as Spanish does.

Key Words: Boer-Spanish goat, doe fertility, growth rate, prolificacy, Spanish goat

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INTRODUCTION

Spanish goats have been the primary breed used for meat production in the southwestern United States for many years. Most meat goat producers in this region have practiced a low-input management system while using goats to consume brush and other undesirable plants. The term Spanish goat has been used in this region to refer to a diverse population of goats that are not Angora, Boer, or dairy breeds (Shelton, 1978).

As the value of goats increased and goat producers desired to improve production, Boer goats were imported into the United States in the 1990s as an alternative to, or to cross with, Spanish goats. The improved Boer goat of South Africa is known for its large mature size, muscularity, growth rate, and prolificacy (Erasmus, 2000; Greyling, 2000; Malan, 2000). There is a need for direct comparison of the performance of Spanish goats with Spanish-Boer crosses in the geographical area where much of the U.S. meat goat population is raised. Profitable meat production from goats depends on reproduction, growth rate, and adaptation to the environment.

The objective of this study was to compare Boer-Spanish and Spanish does for body weight, fertility, prolificacy (number of kids born), and number of kids weaned when managed under extensive production conditions in Texas.

MATERIALS AND METHODS

Pedigree and production records from 291 (160 Boer-Spanish, 131 Spanish) does sired by 24 different Boer and Spanish bucks were used in this study. Does were owned and managed by Texas A&M AgriLife Research. Does were born in 1994 and 1995 at the Winters Ranch in McCulloch County, Texas. Kidding records were collected on these does from 1995 to 2004. In 1999, the goats were transferred to the Hill Ranch in Edwards County, Texas. These does were mated to 39 Boer and Boer-cross sires, producing 1,941 kids over the course of their lifetime. All procedures

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involving animals were approved by the Texas A&M University Institutional Agricultural Animal Care and Use Committee under protocols 4–111 and 2000–157.

Foundation Females

A herd of mixed-age Spanish does was used to produce Boer × Spanish and Spanish × Spanish kids in March and April of 1994 and 1995. No pedigree information was available for the original Spanish does. Does were assigned at random to be bred to either Boer or Spanish bucks. Because of the limited number of Boer bucks in the United States, and their associated high cost, artificial insemination, using frozen thawed semen, was used to produce most of the Boer-Spanish kids. The Boer bucks were a representative sample of those available in the United States at that time. Bucks were chosen to be as unrelated as possible. The semen had been imported into the United States from New Zealand. Spanish bucks were naturally mated in single-sire pastures. Spanish sires were obtained from different herds in west-central Texas and came from breeders who had a reputation of selecting for increased growth rate. The goal of the project was to compare two alternatives for improving a meat goat herd, using selected Spanish bucks vs. using a representative sample of Boer bucks. The does born in 1994 and 1995 were retained and managed as a single herd in an annual mating-kidding system. Body weights were recorded on these does at birth, weaning, and start of each breeding season.

Flock Management

Kid production records from the Spanish and Boer-Spanish does were collected from the first mating, at ~1.5 yr of age, until the eighth mating at ~8.5 yr of age. The start of the breeding season varied from summer to early fall from 1995 to 2004. At the start of the breeding season, does were weighed and randomly assigned to single-sire breeding pastures containing 25 to 40 does and a single buck. The number of does by age at the start of the breeding season is given in Table 1. Before kidding, does were taken from pasture and placed in small pens to facilitate collection of kidding records. The goats were returned to pasture 3 to 14 d after kidding, depending on weather, pen space, and strength of kids. Kids were vaccinated for sore mouth (contagious ecthyma) at ~30 d of age. Does were given an anthelmintic as needed. Kids were vaccinated for overeating disease (enterotoxemia) at weaning. The goats in the study were maintained on native pasture and run as one flock throughout the year, except during breeding seasons. Kids were typically weaned in groups, once or twice a year, from May through July. Dams were evaluated for culling when kids were weaned. Goats were culled for health problems if the problem was serious enough to affect production.

Table 1. BW and number of does mated by age and breed

	Spanish		Boer-Spanish	
Age, yr	*n*	BW, kg[1]	*n*	BW, kg[1]
1.5	117	32 ± 5	152	34 ± 6
2.5	113	35 ± 5	145	38 ± 5
3.5	101	38 ± 5	134	42 ± 5
4.5	78	41 ± 6	116	45 ± 7
5.5	63	42 ± 6	96	47 ± 7
6.5	48	49 ± 6	72	53 ± 9
7.5	39	53 ± 7	62	57 ± 7
8.5	29	52 ± 5	49	58 ± 8

[1]mean ± SD

Data and Statistical Analyses

All traits were analyzed using PROC MIXED of SAS (SAS Inst. Inc., Cary, NC). The model used for birth weight included fixed effects of breed of sire, birth month and year, type of birth, and random effects of sire nested within breed, and dam. Weaning weights of the does were first adjusted to 120 d. Age-adjusted weaning weight was analyzed with a model with fixed effects of breed of sire, birth month and year, type of birth, and random effects of sire nested within breed, and dam. Preliminary models for birth weight and weaning weight included breed of sire by type of birth interaction. The interaction was not a significant source of variation and was not included in the final model. Does had annual records for body weight at breeding and all reproductive traits. Therefore, a doe could have as many as 8 annual records if she was still present at her eighth mating year. The mean number of records per doe was 5.2. The model for body weight of the doe at breeding included fixed effects of breed of sire, production year, age of doe, breeding date nested within production year, and random effects of sire nested within breed of sire, and doe nested within sire and breed of sire. The interaction between age of doe and breed of sire was found to be not significant in preliminary models for body weight at breeding.

Two measures of fertility were used to evaluate does. The first fertility variable was created by assigning a value of 1 to does that kidded anytime in the production year and a value of 0 to does that did not kid in the production year. For the second fertility measure, only does that kidded as a result of conceiving during the first 30 d (**Fert30**) of the breeding season were given a value of 1. Does that kidded later, or did not kid, were given a value of 0. The fertility models included fixed effects of breed of sire, production year, age of doe, breeding date nested within production year, and random effects for service

Table 2. Least squares means and standard errors for BW and reproduction traits of Boer-Spanish and Spanish does

	Records	Spanish	Boer-Spanish	*P*
Birth weight, kg	291	2.67 ± 0.05	2.79 ± 0.05	0.05
Weaning weight, kg	291	15.0 ± 0.35	15.2 ± 0.34	0.59
Weight at breeding, kg	1,414	43.5 ± 0.61	46.5 ± 0.51	<0.01
Fertility	1,414	0.84 ± 0.02	0.87 ± 0.02	0.22
Fert30[1]	1,414	0.48 ± 0.04	0.53 ± 0.04	0.09
Kids born per doe kidding	1,188	1.62 ± 0.05	1.70 ± 0.05	0.07
Kids weaned per doe kidding	1,188	1.31 ± 0.06	1.30 ± 0.05	0.76

[1]Fert30 = probability of kidding to a 30-d breeding season.

Table 3. Least squares means and standard errors for BW at breeding, and fertility of Boer-Spanish and Spanish does

Age at mating, yr	BW, kg	Fertility	Fert30[1]
1.5	24.2 ± 2.6	0.74 ± 0.08	0.01 ± 0.10
2.5	30.6 ± 1.9	0.87 ± 0.07	0.23 ± 0.09
3.5	37.0 ± 1.3	0.78 ± 0.06	0.37 ± 0.08
4.5	44.7 ± 0.8	0.95 ± 0.05	0.56 ± 0.07
5.5	50.1 ± 0.7	0.89 ± 0.05	0.61 ± 0.07
6.5	55.5 ± 1.2	0.90 ± 0.06	0.65 ± 0.08
7.5	58.0 ± 1.9	0.83 ± 0.08	0.81 ± 0.10
8.5	60.1 ± 2.7	0.87 ± 0.10	0.80 ± 0.13

[1]Fert30 = probability of kidding to a 30-d breeding season.

sire (of kids), sire of the doe nested within breed, and doe nested within sire and breed of sire. The interaction between age of doe and breed of sire was found to be not significant in preliminary models for both fertility traits.

Only records of those does that kidded were analyzed for number of kids born and number of kids weaned. Records with 0 born were excluded, but records with 0 kids weaned were included. For analysis of number of kids born and weaned, a variable for accounting for differences in kidding dates was created by forming contemporary groups. A new contemporary group was created when there was a 10-d interval between births. The number of kids born and number of kids weaned models included fixed effects of breed of sire, production year, age of doe, kidding contemporary group, and random effects of sire nested within breed, doe nested within sire and breed of sire, and service sire. Random effects of service sire, sire, and doe effects in the above models were assumed to have mean 0 and a common variance. Random residual effects were assumed to have mean 0 and a common variance. Variances for random effects were estimated using the restricted maximum likelihood estimation (REML) option in SAS PROC MIXED.

RESULTS AND DISCUSSION

Birth Weight, Weaning Weight, and Body Weight at Breeding

The results for birth and weaning weights of does are presented in Table 2. For birth weight, all effects in the model were significant ($P < 0.05$) sources of variation. Boer-Spanish does were heavier at birth than Spanish does (2.79 kg vs. 2.67 kg, $P = 0.05$). Does born as singles were heavier than twins (3.05 vs. 2.74 kg, $P < 0.01$) and twins were heavier than triplets (2.74 vs. 2.40 kg, $P < 0.01$). For weaning weight, type of birth was a significant source of variation, whereas all other fixed effects, including breed, were not ($P \geq 0.59$). Does born as singles were 2.5 kg heavier ($P < .01$) than twins and twins were 1.7 kg heavier ($P < .01$) than triplets at weaning.

The higher birth weights of the Boer-sired does for birth weight is not surprising and is consistent with reports of 4.2-kg birth weights of Boer goats (Van Niekerk and Casey, 1988), and the lighter birth weights of Spanish does (2.7 kg), as reported by Bogui (1986). Luo et al. (2000) reported Boer-Spanish kids had superior growth from 3 to 8 wk of age, compared with Spanish kids when being fed milk replacer and a pelleted starter diet. They reported growth rates of 60 g/d for Spanish kids and 77 g/d for Boer-Spanish kids. The preweaning growth rate of kids in the current study was ~100/g/d. Therefore, the environments of the 2 studies appear to have produced a difference in mean growth rate and therefore the results may not be directly comparable. Because goats are usually reared in extensive management situations, adaptation to the environment is important.

All effects in the body weight at breeding analysis, including breed and age of doe, were significant sources of variation ($P < 0.001$). Results from using repeated records of body weight at breeding (Tables 2 and 3) showed that Boer-Spanish does had an average body weight of 46.5 ± 0.51 kg and were heavier ($P < 0.05$) at breeding than Spanish does, which averaged 43.5 ± 0.61 kg. At first mating at 1.5 yr of age, does had an average body weight of 24.2 kg, which steadily increased by ~6 to 7 kg/yr until age 6.5 yr. The estimates for body weight at breeding continued to rise but at a slower rate after 6.5 yr. Typical body weights of mature Boer goats usually range from 60 to 75 kg for females (Gall, 1981; Erasmus, 2000; Greyling, 2000). Gall (1981) reported North Mexican Criollo females averaged from 35 to 50 kg, similar to results of the present study.

Fertility Traits

The results for both measures of fertility are shown in Tables 2 and 3. Production year and age of doe were significant sources of variation ($P < 0.05$) for fertility, whereas breed and breeding date were not significant sources of variation ($P \geq 0.21$). Effects of age of doe, production year, and breeding date were all significant

sources of variation ($P < 0.05$) for percentage kidding to the first 30 d of mating, whereas breed approached significance ($P = 0.09$). The differences between the breed estimates were small. Fertility was lowest for young does (Table 3) and the age effect was more pronounced in Fert30 than fertility.

Average for fertility (0.87) for Boer-Spanish does was >0.79 reported for Boer does in South Africa (Erasmus et al., 1985). Browning et al. (2011) reported fertility of 0.80 for Boer and 0.94 for Spanish. The highest fertility estimate found was 0.98 in Boer does managed on a high plane of nutrition (Campbell, 1984). Nutrition and other environmental factors affect fertility. Therefore, breed comparisons must be carefully designed so that the results can be applied to the desired production system. Erasmus et al. (1985) reported a maximum fertility at 3.5 yr of age at mating in Boer goats. The highest fertility in the current study was at 4.5 yr mating age. Boer-Spanish does having a higher percentage kidding in the first 30 d (53%) may indicate that Boer females have a slight advantage to coming in heat faster as reported by Casey and Van Niekerk (1988), and may also be due to heterosis. However, according to Lawson et al. (1984), where kids were weaned off does early, Spanish does have been reported to have up to 74% of does conceiving within the first 60 days postpartum.

Number of Kids Born and Weaned

The results for number of kids born and number of kids weaned are presented in Tables 2 and 4. Production year and kidding contemporary group were significant sources of variation for number of kids born per doe kidding ($P < 0.05$), whereas breed approached significance ($P = 0.07$). In the number of kids weaned analysis, all effects accounted for significant variation, except breed ($P = 0.76$).

Number of kids born and weaned increased with age (Table 4). This increase differs from the results of Erasmus et al. (1985) with records from Boer does, where the maximum number of kids born was at 3.5 yr and lower at later ages. Bogui (1986) reported the highest occurrence of multiple births in Spanish does was at age 4. Spanish does had a litter size of 1.7 kids born per doe kidding in an annual kidding management system (Bogui, 1986).

Even though Boer-Spanish does had a tendency for higher number born, there was not a significant difference for number of kids weaned. The number weaned (1.30) for Boer-Spanish does is substantially lower than values of 1.82 reported by Erasmus et al. (1985) and 1.48 reported by Campbell (1984) for purebred Boer does. Previous literature from Bogui (1986) showed number weaned at 1.38 for Spanish does, which is similar to results seen in this study (1.31). These results indicate that the survival rate of kids from Boer-Spanish doe was apparently lower than that of kids from Spanish does. Based on past literature, low survival rates are usually due to kids with extremely low birth weights and kids that are born as triplets or quadruplets (Gall, 1981; Erasmus et al., 1985; Holst, 1990). The cause of having lower number weaned could be due to Boer-Spanish does not performing as well on a lower plane of nutrition, with resulting inability of the doe to adequately provide for the kid, as seen in Casey and Van Niekerk (1988), where Boer does reportedly had 30% kid mortality rates. In addition, the similar performance in number weaned between the two dam breed types may also be due to a balancing in combined heterosis levels of kids and dams. With sires of the kids of the does being purebred Boer or a high percentage Boer, kids from Spanish does would have 100% direct hybrid vigor but no maternal heterosis. Kids from the Boer-Spanish does would have 50% direct hybrid vigor but 100% maternal hybrid vigor. Therefore, one might expect the performance in kid survival to be related to both hybrid vigor in the kid and their dams. However, due to the fact that kids of the Boer-Spanish females had a maternal heterosis advantage over that of the from the Spanish does, one might also expect to see higher survival rates in kids from the Boer-Spanish does, as reported by Sebhatu et al. (1993), where favorable maternal heterosis was seen in kid mortality rates of kids 90 d of age.

Boer-Spanish does had greater birth weight, body weight at breeding, and number of kids born than Spanish does. Boer-Spanish does had a similar number of kids weaned as the Spanish does. Differences in fertility were small, with the Boer-Spanish having an advantage when fertility was defined as kidding to a 30-d breeding season. Further research is needed to fully understand what environmental conditions are needed to fully capitalize on the genetic potential of the Boer goat and investigate potential genotype by environment interactions.

Table 4. Least squares means and standard errors for number of kids born and number of kids weaned of Boer-Spanish and Spanish does by age of doe

Age at mating, yr	Kids born	Kids weaned
1.5	0.86 ± 0.16	0.46 ± 0.18
2.5	1.11 ± 0.13	0.70 ± 0.15
3.5	1.32 ± 0.11	0.85 ± 0.12
4.5	1.55 ± 0.09	1.06 ± 0.11
5.5	1.93 ± 0.09	1.43 ± 0.11
6.5	2.07 ± 0.11	1.63 ± 0.13
7.5	2.19 ± 0.15	1.98 ± 0.17
8.5	2.25 ± 0.20	2.34 ± 0.22

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