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COMPARISON OF PRODUCTIVITY OF DIFFERENT BREEDS OF MEAT GOATS UNDER LOW- TO MODERATE-INPUT SYSTEMS IN THE UNITED STATES

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Abstract

Boer and Kiko goats were imported in the 1990s to enhance the productivity of the US base population of Spanish meat goats. Successful breed introductions require adaptation to the destination environment. Well-planned, low-input management is a good route to meat goat enterprise profitability using proper goat genetics. Reproduction drives profit more than growth and carcass traits. Results of breed evaluation studies on doe reproductive and health traits, the Boer goat influence tended to be negative compared with Kiko and Spanish goat influences. Reduced doe herd reproductive output suggests reduced enterprise profitability. Differences in growth or carcass traits among sire breeds have not consistently favored any particular breed. Boer goat genetics improved visual conformation, which increases market value. Improved visual appraisal has not translated into enhancements for objectively measured carcass traits. Proper breed selection and use in meat goat mating systems are important for enhanced doe herd productivity and profitability in low-input, limited-resource operations.
Keywords: Productivity, Breeds, Meat Goat Breeds, Input Systems

Introduction

In the United States, breed choices are limited for commercial meat goat producers to consider when developing a breeding program. Although limited, it is still important for these options to be objectively evaluated to provide producers with research-based guidance on breed strengths and weaknesses for economically important traits. Commercial meat goats are typically managed in low- to moderate-input systems. These are extensive to semi-intensive, forage-based management systems with generally restricted resource inputs. Breeds should be evaluated under conditions that reflect resource-limited production environments. It is not uncommon for seed-stock herds to be managed at higher input levels than the commercial herds that the supplied seed-stock are expected to perform in. The trait with the greatest impact on profitability in a commercial meat goat enterprise is reproductive performance. Unfortunately, reproduction and survivability (both measures of fitness) have been generally neglected when evaluating breeds. Research has historically been lacking for comparing meat goat breeds for health and reproductive traits as compared with more easily measured growth traits (Shrestha and Fahmy, 2007).

Three primary breeds are represented in the US commercial meat goat herd. The Boer goat was developed by a breeder group in semi-arid South Africa (Casey and Van Niekerk, 1988; Campbell, 2003). The Boer goat is arguably the predominant meat goat genotype in the US today. The Kiko goat was developed as a composite type through the crossing of dairy bucks to feral does by a breeder cooperative in humid New Zealand (Batten, 1987). The Spanish goat is a landrace type that evolved primarily in semi-arid Texas from animals brought to the western hemisphere by Spanish explorers in the 1500s (Shelton, 1978; Mason, 1981). New breeds are usually introduced to improve on real or perceived trait deficiencies of the resident production population. Boer and Kiko goats were imported by US interests in the mid-1990s to improve the meat-producing attributes of resident Spanish goats. It is common to see new livestock breeds introduced to improve growth and carcass traits while ignoring the fitness traits that may be greater profit drivers in suckler herds, especially if females are retained as herd replacements. Successful new breed introductions require some level of adaptation to destination environments, particularly in low-input systems (Blackburn and Gollin, 2009).

Objective breed evaluations are important on two fronts. Genetic management decision-making can be reduced to two basic areas: selection and mating. Selection occurs among and within breeds. Selection among breeds require data on the strengths and weaknesses of the breed options available to identify those with desirable trait profiles. In commercial herds, one or more breeds may be selected for use based on available comparative data. Breed selection is half of the genetic management process. Mating decisions are also required to determine if pure breeding or crossbreeding will be implemented. Crossbreeding may be desirable in commercial herds. Thus, it is important to determine the best way to use selected breeds in a crossbreeding scheme. This provides an overview of research conducted at Tennessee State University (TSU) and other locations to evaluate meat goat breeds for fitness, growth, and carcass traits. Emphasis at TSU has been placed on doe fitness.

Doe Traits

Profitability in a meat goat enterprise is tied to doe herd reproductive output. An unproductive doe herd will be unprofitable, regardless of the genetic merits for growth or carcass traits among the sires used or kids produced in the herd. Computer simulations conducted by Blackburn (1995) around the time that the first Boer goats arrived in North America predicted that Boer does would be similar to or inferior to Spanish does for reproductive output under moderate to low levels of forage nutrient resources. For fall breeding herds under lower forage conditions, Boer does weaned about 60% of the number of kids weaned (i.e., kids sold) by Spanish does in the simulations. Blackburn (1995) concluded that the Boer doe may require a more intense level of management than typical of meat goat operations. Perhaps the more salient implication of this early work was that the Boer goat did not offer an improvement over the resident Spanish goat for doe herd performance under moderate to poor forage conditions. It is not clear if the simulation outcomes were included as part of the general outreach recommendations provided to the industry in the mid- to late-1990s or beyond.

Straight-Bred Does.

A series of evaluations has been conducted at TSU since 2002 comparing Boer, Kiko, and Spanish does for fitness traits. The studies are highlighted by a pair of six-year datasets (2004-2009: Phase I and 2009-2014: Phase II). Parts of these datasets have been presented in various documents (Browning et al., 2011; Pellerin and Browning, 2012; Nguluma et al., 2013; Wang et al., 2017; Khanal et al., 2019). Across the 12 years, 205 Boer, 207 Kiko, and 193 Spanish straight-bred does were managed on pasture and bred to bucks of various breeds to produce spring-born purebred and crossbred kids. Service sire breeds, doe ages and parity were balanced across the doe breeds. Does represented a diverse sampling of genetic lines within each breed. The TSU research station in Nashville is in the humid, subtropical southeastern region of the US. Does were managed on tall fescue (*Festuca arundinacea*) and bermudagrass (*Cynodon dactylon*) pastures supplemented with orchardgrass hay (*Dactylis glomerata*) for *ad libitum* consumption and limited amounts of various winter concentrate supplements. A distinction between the Phase I and Phase II evaluations was that supplementation extended as long as to 9 months per year in Phase I, whereas doe herd nutrient supplementation was no longer than 4 months per year in Phase II. Stocking rate was approximately 3-4 does per acre. Does were scheduled for deworming once or twice each year, including once at kidding. Kids were not creep-fed and were weaned at 90 days of age. Culling of does from the research herd was based on repeated reproductive failure.

Under uniform management conditions, whole herd reproductive output was lower ($P < 0.05$) for Boer does than for Kiko and Spanish does (Table 1). The breeds were similar among doe populations that kidded or weaned kids. However, for the more economically relevant whole herd evaluation (i.e., population of all does in the herd at fall breeding), Boer doe kid production was about half the values of their Kiko and Spanish herd mates at the spring kidding and summer weaning endpoints (Table 1).

Doe health is an important contributor to reproductive outcomes. The single most inhibiting health challenge to efficient goat performance is arguably internal parasitism (Kaplan et al., 2004). Using breeds identified as having reduced susceptibility to internal parasites would be a large step towards improving goat herd profitability and sustainability. As anthelmintic resistance continues to rise across the industry, the selection and use of goats with inherent hardiness under chronic internal parasite exposure will become increasingly important. The principal indicator trait used to assess internal parasite burdens in goats is fecal egg counts (FEC). Boer does generally had higher ($P < 0.05$) geometric mean FEC than Kiko and Spanish does at kid weaning (Table 1). This trait should receive more attention in the future for genetic improvement.

Table 1. Effect of doe breed on fitness traits for straight-bred does.

	Breed of doe			
Trait	Boer	Kiko	Spanish	SE
Does, n	205	207	193	
Litter size born, kids	1.80	1.76	1.74	0.08
Litter size weaned, kids	1.38	1.46	1.61	0.10
Per doe in fall breeding herd				
Does birthing kids, %	48.8 [b]	83.7 [a]	81.4 [a]	4.3
Does weaning kids, %	30.5 [b]	71.5 [a]	71.0 [a]	5.9
Litter size weaned, kids	0.43 [b]	1.07 [a]	1.12 [a]	0.12
Fecal egg counts, eggs/g [1]	1226 [a]	718 [b]	589 [c]	-
Annual survival rate, % [2]	53.5 [b]	86.5 [a]	84.5 [a]	4.4

[ab]Means with different letters differ significantly ($P < 0.05$).
[1]Collected from does at kid weaning at 90 days.
[2]Surviving does included those that avoided death or culling.

Whether it leads to reproductive failure and subsequent culling or general animal morbidity and mortality, internal parasitism likely plays a role in doe stayability and longevity. There are biological and economic implications of does exiting the herd and the need to replace them. Early exits (i.e., does leaving the herd after one or two years) can be especially burdensome. Boer does had lower ($P < 0.05$) annual survival rates that Kiko and Spanish does (Table 1). In the first six-year study period it was reported that Boer does had lower ($P < 0.05$) stayability rates compared with Kiko and Spanish does (Figure 1) and lower ($P < 0.05$) cumulative kid production values after 2, 3, and 5 years of possible herd presence (Pellerin and Browning, 2012). For does with the opportunity to stay in the herd for 5 breeding years, Boer does weaned a total of 3.2 kids and 125 lbs, whereas Kiko does weaned 6.1 kids and 244 lbs and Spanish does weaned 6.2 kids and 220 lbs. Does that stay in the herd longer are more likely to have greater lifetime productivity and offset the costs associated with the purchase and/or development of replacement does.

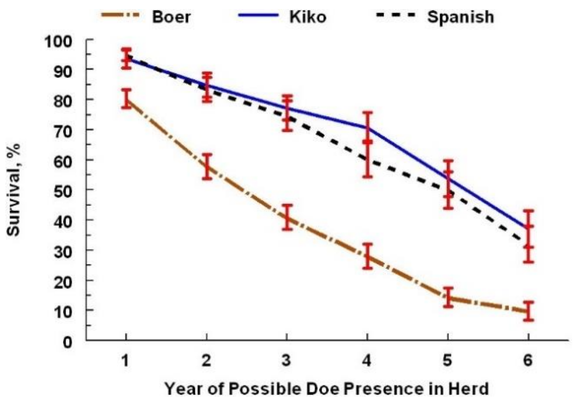

Figure 1. Doe survival (± SE) for doe breeds using the culling protocol of removal after second reproductive failure. Boer does differed ($P < 0.05$) from Kiko and Spanish does for the survival curve over 6 years of production and for doe stayability rate at each year of possible presence in the herd. Does in Year 1 were approximately 2–3 years of age. Does reaching Year 6 would have been approximately 7–8 years of age. (Pellerin and Browning, 2012).

Boer does had generally poor fitness. The separation of Spanish and Boer does in the TSU evaluations under semi-intensive management concurred with the simulations of Blackburn (1995) for moderate to low forage conditions. It has become common for US producers to indicate that Boer-influenced goats lack hardiness. The semi-arid origin of Spanish goats did not cause fitness problems under these experimental conditions. Unimproved goats in South Africa were reportedly more disease resistant than improved Boer goats (Ramsay et al., 1978; Campbell, 2003). It may be surmised that general hardiness was compromised when the Boer breed was developed under artificial selection pressures.

Crossbred Does

Crossbred does are most likely to be found in the commercial meat goat herd. The predominant genotype among commercial meat-type does is probably the Boer crossbred. While the Phase I effort at TSU focused exclusively on straight-bred does, Phase II included 245 Boer F1 (first-cross) does along with 162 Kiko and 150 Boer does (Nguluma et al., 2013; Browning et al., 2014; Khanal et al., 2019). The Boer F1 does were reciprocal-cross Boer x Kiko (n = 133) and Boer x Spanish (n = 112). Boer F1 does performed at levels similar to the base Kiko and Spanish does (Table 2) with the only exception being fertility where the Boer F1 does had lower kidding rates ($P < 0.05$) than the straight-bred Kiko and Spanish does. Across 8 production years in Texas, Rhone et al. (2013) observed Boer x Spanish does had reproductive levels similar to ($P > 0.05$) Spanish does in a study herd of nearly 300 breeding females. In the TSU study, the Boer-cross does were better ($P < 0.05$) than the limited number (n = 20) of Boer straight-bred does for the various traits. Reproductive values for the Boer does were low: 13% does birthing kids, 7% does weaning kids and 0.13 kids weaned per doe in the breeding herd.

Table 2. Effect of doe breed on fitness traits for crossbred does.

	Breed of doe				
Trait	Kiko	Boer x Kiko	Spanish	Boer x Spanish	SE
Doe, n	162	133	150	112	
Litter size born, kids	1.62	1.65	1.50	1.54	0.08
Litter size weaned, kids	1.45	1.45	1.38	1.32	0.08
Per doe in fall breeding herd					
Does birthing kids, %	74.0 [a]	61.5 [b]	72.3 [a]	57.4 [b]	8.1
Does weaning kids, %	54.9	46.4	59.9	45.8	6.6
Litter size weaned, kids	0.79	0.68	0.79	0.61	0.1
Fecal egg counts, eggs/g [1]	740	775	758	561	-
Annual survival rate, % [2]	83.0	75.8	79.4	77.9	3.7

[ab]Means with different letters differ significantly ($P < 0.05$).
[1]Collected from does at kid weaning at 90 days.
[2]Surviving does included those that avoided death or culling.

The doe evaluation outcomes suggested that crossbred Boer does would not improve reproductive rates compared with Kiko or Spanish straight-bred does. This could have been anticipated given the relatively poor performance of the Boer genetic influence contributing to the crosses. However, it was somewhat surprising the Boer-cross does were close to the Spanish and Kiko does for the fitness indicator traits. The non-additive genetic results of crossbreeding (heterosis) were probably the reason for the Boer-cross does approaching the levels of Kiko and Spanish for doe fitness. If the use of a new breed is to improve on the resident population, then the crossing with Boer did not enhance doe fitness. Conversely, crossbreeding with Kiko or Spanish can be beneficial in herds of predominantly Boer to improve doe herd fitness.

The Kiko and Spanish does had fairly similar reproductive values across the purebred studies (Browning et al., 2011, Wang et al., 2017). However, the Kiko influence had better reproductive values than the Spanish influence when purebred and crossbred does were merged for one evaluation (Browning et al., 2014). An advantage the Spanish demonstrated over their Kiko herd mates is lower postpartum FEC (Table 1; Browning et al., 2011, 2014). As a heritage breed-type, the Spanish goat remains a valuable genetic resource for meat goat production with regard to female fitness.

Preweaning Kid Traits

Kid performance from birth and weaning can be affected by breed selection and mating systems. Offspring growth traits usually receive the majority of attention when breeds are compared. Often the sire breeds are evaluated because they are more easily interchangeable within an established production system. Sires are also the point of selection focus because of their singular influence on genetic contributions to a broad set of offspring when compared with the potential contributions of individual breeding females. To a lesser extent, maternal breeds have been tested for offspring performance. Phase I of the TSU effort included evaluating sire and dam breed contributions to individual kid performance (Browning and Leite-Browning, 2011). This dataset included 1,547 kids born and 1,173 kids weaned. The study ran a complete three-breed diallel mating plan with all possible matings among Boer, Kiko, and Spanish breeding stock and 9 kid genotypes produced.

Kid Weights

Sire breed and dam breed interacted (*P* < 0.05) for birth weight (Figure 2). Straight-bred Boer kids were heavier (*P* < 0.05) than straight-bred Kiko and Spanish kids. Sire breed did not affect birth weight within Boer dams, but Boer-sired kids were heavier (*P* < 0.05) than Kiko- and Spanish-sired kids when born to Kiko or Spanish does. Sire breed and dam breed also interacted (*P* < 0.05) for weaning weights (Figure 3). Kiko kids were heavier (*P* < 0.05) than Boer and Spanish among straight-bred comparisons. For Boer-sired kids, Kiko does weaned heavier (*P* < 0.05) kids than Boer or Spanish dams. For Kiko-sired kids, Kiko dams weaned heavier (*P* < 0.05) kids than Spanish dams. Per main effects, sire breed did not affect 90-day weaning weights, whereas Kiko dams weaned heavier (*P* < 0.01) kids than Boer and Spanish dams (35.0 vs. 31.2 and 31.7 ± 4.4 lbs).

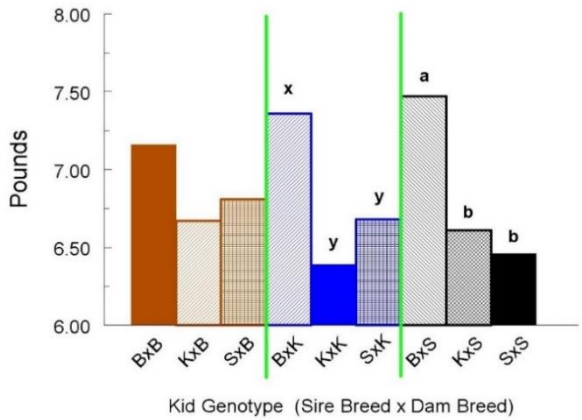

Figure 2. Kid birth weight (LSM ± 0.28 lbs) from Boer (B), Kiko (K), and Spanish (S) parental stock. [ab]Within S dams, B-sired kids were heavier (*P* < 0.05) than K- or S-sired kids. [xy]Within K dams, B-sired kids were heavier (*P* < 0.05) than K- or S-sired kids. Straight-bred BB kids were heavier (*P* < 0.05) than straight-bred KK and SS kids.

The direct breed effect (i.e., the effect of breeds contributing to the kid genotype) at weaning did not contribute (*P* > 0.05) to the variation in kid weaning weights (Boer = 0.77 lbs, Kiko = 1.01 lbs, Spanish = -1.78 lbs; Browning and Leite-Browning, 2011). The maternal breed effect (i.e., the effect of breeds contributing to the dams raising the kids) played an important role (*P* < 0.05) in kid weaning weights. Boer dams contributed a loss (*P* < 0.05) of 2.73 lbs per kid at weaning, Kiko dams added (*P* < 0.05) 2.86 lbs per kid weaned, and Spanish dams did not affect (*P* > 0.05) kid weaning weight (-0.13 lbs). The crossbreeding advantage of hybrid vigor was only significant for the Boer-Kiko matings (1.76 lbs of added weight above the combined breed average, *P* < 0.05). The Boer-Spanish and Kiko-Spanish crosses generated 0.73 lbs and 0.37 lbs, respectively in added weight relative to the combined breed averages; these hybrid vigor levels not being significant (Browning and Leite-Browning, 2011).

Boer sires generated heavier kids at birth. However, dam breed had a greater effect on weaning weights than sire breed with Kiko dams yielding heavier weaning weights than the other dam breeds. Goodenwardene et al. (1998) also reported that the weight advantage of Boer-sired kids at birth was not maintained through weaning. Boer sires increased weaning weights compared with other sire breeds in some reports (Haas, 1978; Merlos-Brito et al., 2008), but not in others (Goonewardene et al., 1998; Rhone, 2005; Oliveira, 2006; Menezes et al., 2007). Steinbach (1988) and Martinez-Rojero et al. (2014) reported that Boer sires increased weaning weights when compared with local sires when mated local does but Boer sires and imported dairy breed sires were similar for crossbred kid weaning weights. Enhancing kid weaning weights by crossbreeding with Boer sires in limited-input meat goat production systems in the US is possible, but not automatic. It may depend on the quality of the sires and alternative sire breeds under consideration as well as other genetic and environmental factors. There was a clear advantage for Kiko does compared with the other doe breeds for kid weaning weights. This is a trait where the Kiko introduction showed improvement over the resident Spanish doe base.

Figure 3 illustrates how proper use of breeds is as influential as proper selection of breeds in a crossbreeding program. Viewing the two kid genotypes resulting from the crossing of Boer and Kiko, kids produced from matings of Boer sires to Kiko dams had a significant advantage (P < 0.05) of 4 lbs over kids produced from matings of Kiko sires to Boer dams. The proper use of selected breeds is important to enhancing doe-kid performance in a planned crossbreeding scheme.

Kid Survival

Sire breed did not affect preweaning kid survival. Kid survival from birth to weaning was affected (P < 0.05) by dam breed (Browning and Leite-Browning, 2011). Boer dams raised a lower (P < 0.05) percentage of their kids to weaning (68.7 ± 6.2%) than Kiko (84.1 ± 4.1%) and Spanish dams (87.2 ± 3.6%). In their native southern Africa, Boer does also had reduced preweaning kid survival rates compared with Nguni does (87 vs. 66%; Lehloenya et al., 2005), unimproved Veld does (86 vs. 24% in Year 1 and 90 vs. 70% in Year 2; Casey and Van Niekerk, 1988) and Tswana does (91 vs. 75%; Senyatso and Masilo, 1996). Observations of reduced kid survival for Boer dams mirror the narrative of Boer does having reduced fitness compared to other maternal breed options. In a low-to-moderate-input management system, the expectation is that does in the breeding program will deliver and raise kids unassisted to weaning. There is little room in such commercial systems for orphans (bottle babies) or excessive feeding or management to overcome deficiencies in maternal merit if profit is an objective.

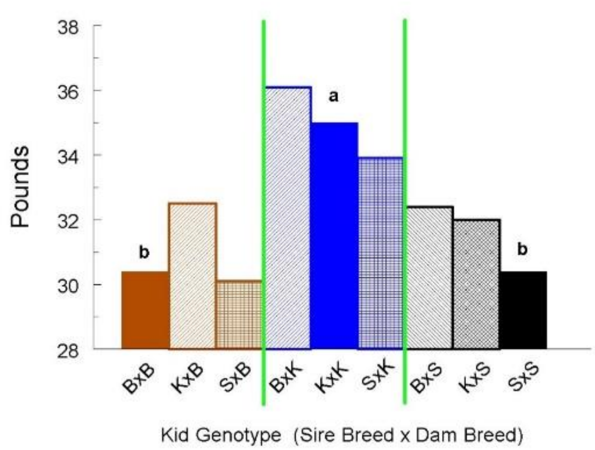

Figure 3. Kid weaning weight (90-day adjusted; LSM ± 1.3 lbs) from Boer (B), Kiko (K), and Spanish (S) parental stock. [ab]Straight-bred KK kids were heavier (P < 0.05) than BB or SS straight-bred kids. Weights were also heavier (P < 0.05) for kids of K dams than of B and S dams within B-sired (BK vs. BB, BS) and S-sired (SK vs. SB, SS) groups.

Postweaning Kid Traits

Kid performance after weaning is important for developing market kids and replacement doelings. Most male kids are destined for harvest, so weight gain until harvest is important as well as carcass yield. In the US, there are no official systems of quality or yield grading for marketed meat goat carcasses. Yield estimates are loosely based on unofficial live animal and carcass conformation scoring systems (McMillin and Pinkerton, 2008; Chisley and Phelps, 2010). Offspring growth traits usually receive the majority of attention when breeds are compared for performance. In terminal sire breeding programs, doelings would also be grown out for harvest. Among the various production traits, carcass merit is probably the least important driver of meat goat enterprise profitability.

Doelings in seed-stock and commercial herds are expected to develop to the point that they successfully enter the breeding herd. Few weaned buckings should be expected to merit further development as herd sire prospects with most coming from seed-stock herds, not commercial herds. Market kid and replacement stock development both depend on post-weaning growth and survival to the pertinent end-points.

Carcass Traits

Phase I of the TSU breed evaluation effort included 3 years of harvested buck kids (n = 275) representing the 9 kid genotypes (Browning et al., 2012). Sire breed affected ($P < 0.05$) live grade and dressing percent, whereas dam breed affected ($P < 0.05$) live grade, live weight, carcass weight and dressing percent (Table 3). Live grade is used to help assign market value to kids. Mean grades suggested that the market kids from Boer sires or dams would be higher valued with higher-yielding carcasses compared to Kiko sires and Spanish dams, respectively. However, Boer-influenced progeny produced lighter carcasses, lower dressing percentages, and no differences in measured lean:bone ratios when compared with the Kiko and Spanish influences (Table 3; Browning et al., 2012). Sire breed was also a non-factor ($P > 0.05$) for the ribeye area. Consistent with the preweaning data, dam breed had a greater influence on carcass yield traits than sire breed.

Table 3. Effect of sire and dam breeds on meat goat carcass traits.[1]

	Breed			
Trait	Boer	Kiko	Spanish	SE
Per sire breed				
Live conformation grade[2]	2.81 [a]	2.60 [b]	2.69 [a]	0.11
Live body weight, lbs	55.2	57.2	55.0	3.3
Cold carcass weight, lbs	23.4	24.8	24.3	2.0
Cold dress-out, %	40.1 [b]	41.4 [a]	41.7 [a]	1.0
Per dam breed				
Live conformation grade[2]	2.76 [a]	2.68 [a]	2.66 [b]	0.11
Live body weight, lbs	53.9 [b]	58.5 [a]	54.8 [b]	3.3
Cold carcass weight, lbs	23.1 [b]	25.7 [a]	23.7 [ab]	2.0
Cold dress-out, %	40.2 [b]	41.9 [a]	41.1 [ab]	1.0

[ab]Means with different letters differ significantly ($P < 0.05$).
[1]Adapted from Browning et al., 2012
[2]Muscle conformation improves subjectively as grades increase from 2.0 to 2.9.

Although the Boer influence (sire or dam) enhanced subjective estimates of carcass yield, objective measurements indicated that the Boer effect was negative or non-existent for the carcass yield traits recorded compared with Kiko and Spanish. Boer sires have been well studied for their potential to improve carcass yield traits as reviewed by Browning et al. (2012). The majority of studies reviewed in the scientific literature indicated that Boer sires did not improve carcass weight or dressing percent over alternative sire breeds. For carcass weight comparisons of Boer-sired F1 kids compared to straight-bred kids of base doe breeds, Merlos-Brito et al. (2008) reported Boer sires increased carcass weights, whereas five other studies found no crossbreeding advantage (Goonewardene et al., 1998; Dhanda et al., 2003; Menezes et al., 2009; Rodrigues et al., 2009; Martins et al., 2014). For carcass weight comparisons of Boer-sired F1 kids compared to F1 kids of other sire breeds, four studies found no sire breed effects (Dhanda et al., 1999, 2003; Rodrigues et al., 2009; Merlos-Brito et al., 2008), whereas a fifth (Goonewardene et al., 1998) indicated Alpine sires produced heavier carcasses than Boer sires. For dressing percentage, Boer sires did not differ from other sire breeds in five studies (Goonewardene et al., 1998; Dhanda et al., 2003; Merlos-Brito et al., 2008; Menezes et al., 2009; Rodrigues et al., 2009), while a sixth report indicated that Saanen-sired F1 kid generated higher dressing percentages than Boer-sired F1 kids (Dhanda et al., 1999). The findings of three smaller-scaled US carcass studies were also reviewed. In Texas, Oman et al. (1999) indicated that under feedlot conditions, using Boer sires to cross with Spanish does increased live and carcass weights, but the crossing with Boer did not change the ribeye area or percent lean yield; the weight advantages were not evident under range conditions. Cameron et al. (2001) in Oklahoma found no difference between Boer x Spanish and straight-bred Spanish kid carcasses for live or carcass weight, dressing percent, ribeye area, or percent lean tissue. In Alabama, Solaiman et al. (2012) reported that purebred Boer kids were heavier than Kiko kids for live weight, the two breeds were similar for carcass weight, dressing percent, and ribeye area, and Kiko kids yielded a higher lean tissue percentage than Boer kids. The scientific evidence generally suggested that Boer genetics should not be expected to improve carcass yield traits with a high degree of certainty.

Doeling Development

Replacement doeling development is a management task that can impact the future performance of a herd. Replacement doelings carry the improved genetics that a manager has selected and bred for. Replacement doelings are expected to enhance future herd performance or generate revenue if sold to enhance the future performance of other herds. Raising replacement doelings is not a cost-free endeavor. Doeling development has probably received the least amount of attention as an area of meat goat research.

A study was conducted to evaluate different aspects of doeling selection and development (Khanal and Browning, 2019). Doelings weaned across Phase I and II evaluations were used to assess, in part, how kid breed affected doeling development from weaning through their first year in the breeding herd. Records were used for Boer (n = 60), Kiko (n = 102), Spanish (n = 96), and Boer-cross (n = 138) doelings. In the TSU herd, first mating occurs in the second fall breeding season when replacement does are approximately 18-20 months of age. A sample of traits is provided in Table 4. The consistent observation was that straight-bred Boer doelings were less fit compared with Kiko, Spanish, and Boer-cross does across the developmental traits tested. Deficiencies noted for Boer does within the management system of the research herd were evident as early as the yearling age measurement date. Fitness of Boer-cross doelings was similar to the Kiko and Spanish straight-bred doelings, mirroring observations in the main doe herd (Table 2).

Table 4. Effect of doe breed on replacement doeling fitness traits post-weaning.[1,2]

	Breed of doe				
Trait	Boer	Boer-F1	Kiko	Spanish	SE
Doelings weaned, n	60	138	102	96	
Survival to yearling age, %	66 [b]	88 [a]	91 [a]	91 [a]	5
Survival to 1st breeding, %	52 [b]	87 [a]	90 [a]	90 [a]	5
1st year kidding rate, %	37 [b]	77 [a]	83 [a]	89 [a]	10
1st year weaning rate, %	20 [b]	57 [a]	71 [a]	74 [a]	10

[ab]Means with different letters differ significantly ($P < 0.05$).
[1]Adapted from Khanal and Browning, 2019.
[2]Doelings were weaned at 3 months of age and first bred at 18 months of age.

Conclusion

General implications from the series of trials conducted at TSU along with related studies at other research locations are that (1) the Boer goat is not the singular breed to improve meat goat production in the US and (2) the Spanish goat should not be discounted as representing a goat population lacking in commercial production value. Each of the three breeds reviewed here can contribute positively to a commercial system if properly used. There are other breeds that may also contribute to commercial meat goat production systems. Two breeds in particular are the Myotonic and Savanna. To date, these two breeds have received little to no research attention under a comprehensive breed evaluation protocol. They were added to the TSU evaluation effort with early Savanna results starting to emerge (Hayes et al., 2016; Goolsby et al., 2017; Wang et al., 2017; Stevens, 2018). Dairy breeds should not be overlooked. Several of the studies reviewed indicated that Alpine, Nubian, and Saanen sires performed equal to or better than Boer sires for slaughter kid production. The Kiko goat is the product of these dairy sire breeds. Selection and use of meat goat breeds may be driven in part by production objectives, marketing interests, and available resources.

Relative breed performance may vary somewhat by environment and management system. However, breed differences should not be ignored or discounted. There is an often echoed concept stated in one form or another that there is more variation within breeds than between breeds. This may be true but there is ample variation between breed averages for some economically important traits, especially fitness traits, that poor breed selection and(or) use can prove costly, especially in resource-limited meat goat production systems. A comprehensive economic analysis of the Phase I dataset was conducted that incorporated most variable and fixed production costs and various income streams based on herd performance data and relevant market price data. Annual returns over variable and total costs resulted in net losses for Boer does, but net profits for Kiko and Spanish does. Additional economic assessments of the dataset revealed that applying market 'premiums' for Boer-influenced kids did little to alter the 'per doe' economic return estimates. Widespread use of breeds without knowing breed strengths and weaknesses can prove financially detrimental. Newer meat goat breeds may increase industry popularity, but not necessarily profitability.

Semi-intensive pasture and extensive range management environments are dynamic and often less than ideal. They require a maternal goat type that can perform under diverse, suboptimal conditions with limited inputs. The part-time nature of most goat managers also dictates that the doe herd not require constant hands-on management and intervention. In the current project, the Boer breed generally performed poorly across the range of performance traits measured when compared to the Kiko and foundation Spanish breeds. The latter two exhibited generally good hardiness and appeared better suited as maternal breeds for commercial meat goat production on humid, subtropical pasture. Reducing stock rates is a common means of controlling internal parasitism. This can be taken to a counterproductive extreme if managing an unfit doe population. Consider an assessment of herd productivity using an acre of land as the production unit instead of the individual doe as the production unit. It is likely that does better able to handle an internal parasite challenge could be managed at a higher stocking rate than does more apt to become debilitated by internal parasites. Thus, 'per acre' herd productivity would benefit from genetically improved doe fitness in addition to 'per doe' herd productivity.

The Boer is better suited as a terminal sire breed with the avoidance of Boer influence on the maternal side. A terminal sire plan was the reason for the initial transfer of Boer goats from South Africa to New Zealand and was recommended by Blackburn (1995) in response to simulation results. Terminal sire use either did not become part of general outreach and information transfer or it was ignored by industry participants. Little benefit was shown in crossbreeding with Boer sires for replacement doeling production compared with maintaining straight-bred Kiko or Spanish base doe populations (or perhaps a crossing of the latter two). In a commercial doe herd, Boer sires may be a preferred choice if the objective is to produce market kids for harvest, taking advantage of possibly enhance kid growth and improved visual conformation. Kiko or Spanish sires may be more appropriate if replacement doeling production is the primary objective; the buck kids will still be suitable for the harvest market as carcass research demonstrated. There is ample opportunity to change trait values for any of the breeds through good performance recording and proper within-breed animal selection. Crossbreeding may be a faster way to alter performance levels with proper breed selection. In any case, start with good breed selection decisions because trying to manage around poor breed choices, especially on the maternal side, is likely unprofitable and unsustainable.

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