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# Breed evaluation for health, reproductive, and carcass traits in meat goats: observations from the southeastern US

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## Introduction

Commercial meat goat producers have a somewhat limited variety of breeds to consider when developing a breeding program compared to other livestock industries. Nevertheless, it is still important to provide these producers with objective, research-based information on the strengths and weaknesses of different breeds for economically important traits (e.g., reproduction, growth, and carcass merit). Most goats raised for meat production are managed under low- to moderate input systems. Breed evaluations should similarly be conducted under conditions reflective of limited-resource production systems. Reproductive performance is arguably the production trait with the greatest impact on profitability in a commercial meat goat enterprise. However, reproduction and survivability (both measures of fitness) are often overlooked when evaluating a new breed in a unique production environment. Little research attention has been given to variation among meat goat breeds for health and reproduction as compared to growth (Shrestha and Fahmy, 2007).

In the United States, three primary breeds are represented in the commercial herd. The Boer is a meat breed developed in the semi-arid region South Africa (Casey and Van Niekerk, 1988). Boer is the predominant meat goat genotype in the U.S. today. The Kiko is a composite meat goat breed developed in humid New Zealand (Batten, 1987). The Spanish is a non-descript landrace breed-type that evolved in the semi-arid region of south-central Texas from stock brought by Spanish explorers to the western hemisphere in the 1500s (Shelton, 1978; Mason, 1981). Spanish goats were the main meat goat genotype in the US before the arrival of Boer and Kiko goats in the mid-1990s. The widespread use of Boer genetics was based on claims that growth rates and carcass traits would be improved over those of the Spanish goat base population. A pilot project preceding the present study suggested that substantial differences in fitness and performance may exist between Kiko and Boer goats (Browning et al., 2004).

Warm, humid pasture conditions optimal for gastrointestinal parasites and hoof pathogens make efficient meat goat production in the southeastern US difficult. Internal parasites represent the greatest threat to goat health, survival, and productivity (Kaplan et al., 2004). Internal parasites and lameness lead to added inputs in terms of time, labor, and supplies used for prevention and (or) treatment. Research at this station has focused on evaluating performance and health indicators of Boer, Kiko, and Spanish goats under semi-intensive, pasture management conditions of the southeastern United States.

## Methodology

Across five years, 132 Boer (**B**), 92 Kiko (**K**), and 79 Spanish (**S**) straightbred does were managed on pasture and bred to 20 Boer, 18 Kiko, and 12 Spanish bucks. Does were between 2 and 8 years old with age and parity balanced across breeds. Bucks and does represented a diverse sampling of genetic lines within each breed. The study herd was managed on the Tennessee State University research station in Nashville, Tennessee, USA (36E17'N, 86E81'W). Nashville is in the humid, subtropical southeastern region of the United States, sits 183 m above sea level, and has an annual precipitation amount of 1222 mm. The 12-month precipitation amount during the project ranged from a high of 1434 mm in Year 1 to a low of 790 mm in Year 4.

Does were managed on tall fescue (*Festuca arundinacea*) and bermudagrass (*Cynodon dactylon*) pastures supplemented with orchardgrass hay (*Dactylis glomerata*) for *ad libitum* consumption and 341 g/d of a pelleted supplement (16% CP, 69% TDN, as-fed). The supplement was fed during breeding and from kidding to weaning. Stocking rate was approximately 12 does per hectacre. Does were exposed for 30-45 days each fall to Boer, Kiko, and Spanish bucks in single-sire mating groups as part of a complete three-breed diallel mating scheme. Does kidded on pasture in March and May. A total of 323 Boer, 291 Kiko, and 263 Spanish doe matings occurred. Dams and kids were weighed at birth and at weaning (3 months). Does were scheduled for deworming once or twice each year, including once at kidding. Additional treatments were given to does displaying clinical signs of internal parasitism. Fecal samples were collected from does at weaning to determine fecal egg count by McMaster technique as an indication of internal parasite burden. Does were also treated individually for hoof scald and hoof rot upon observation of lameness. Culling of does from the research herd was involuntary.

Kid records included 1406 birth weights and 1064 weaning weights. Kids were not creep-fed, vaccinated, or dewormed as a group before weaning and buck kids were left intact. Carcass data was collected from 275 buck kids produced in three years across the nine kid genotypes from the diallel. Buck kids were managed on pasture and supplemented with 341 g/d of pelleted supplement from weaning to 7 months of age.

Mixed model analysis of variance procedures of SAS (SAS Institute, Cary, NC, USA) were used for data testing. Fixed effects in the models included breed of doe, service sire breed, parturition month and production year. The interaction of sire breed and dam breed was added to models for analysis of kid and carcass data. Weaning weights were adjusted to a 90-day basis. Kid sex and litter size were also included in the kid weight models. Animals within breed of doe and breed of sire were specified as random terms in the mixed effects models. Fecal egg counts (FEC) were log-transformed for statistical testing. Binary responses such as successfully weaning kids and doe attrition from herd were also analyzed using MIXED models. Probability levels less than 0.05 for the F-statistic indicated significant main effect or interactive term effects. The Tukey-Kramer means separation test was used to compare least squares means for all traits (alpha = 0.01).

## Results

***Doe traits*** - Dam weights at kidding were heavier ($P < 0.01$) for Boer and Kiko dams (45.6 and 46.6 ± .7 kg) than for Spanish dams (42.1 ± .8 kg). The proportion of doe matings resulting in at least one live kid at birth was lower ($P < 0.01$) for Boer (77%) than for Kiko and Spanish does (95% and 93 ± 2%). Litter size and litter weight at birth did not differ among Boer (1.83 ± 0.04 kids, 5.78 ± 0.12 kg), Kiko (1.84 ± 0.04 kids, 5.63 ± 0.12 kg), and Spanish dams (1.95 ± 0.04 kids; 6.01 ± 0.13 kg). Maternal breed did not affect litter traits at birth. However, Boer does exhibited lowered levels of fertility as indicated by parturition rates.

Dam body weights at weaning were heavier ($P < 0.01$) for Boer and Kiko dams (43.1 and 42.4 ± .7 kg) than for Spanish dams (39.1 ± .8 kg). Kiko dams lost more ($P < 0.01$) weight (4.8 ± .3 kg) than Boer and Spanish dams (3.1 and 3.0 ± .3 kg) from kidding to weaning. The proportion of exposed does resulting in at least one live kid weaned was lower ($P < 0.01$) for Boer does (61%)

than for Kiko and Spanish does (85 ± 3% each). At weaning, indicators of reproductive output and production efficiency demonstrated consistently lower ($P < 0.01$) performance for Boer does than for Kiko and Spanish does **(Table 1)**.

**Table 1.** Effect of doe breed on litter traits at weaning.

| Trait | Breed of doe | | | |
|---|---|---|---|---|
| | Boer | Kiko | Spanish | s.e. |
| Per doe weaning kids | | | | |
| Litter size, kids/dam | 1.49 [b] | 1.60 [b] | 1.77 [a] | 0.04 |
| Litter weight, kg | 23.9 [b] | 28.2 [a] | 27.5 [a] | 0.7 |
| Litter weight / doe wt, % | 55.1 [b] | 66.2 [a] | 70.1 [a] | 1.7 |
| Per doe exposed to bucks | | | | |
| Litter size, kids/doe | 0.93 [b] | 1.38 [a] | 1.51 [a] | 0.06 |
| Litter weight, kg | 14.8 [b] | 24.1 [a] | 23.3 [a] | 1.0 |

[ab]Means with different letters differ significantly ($P < 0.01$).

A significantly larger proportion of Boer does experienced lameness, internal parasitism, and left the herd annually compared to Kiko and Spanish does **(Table 2)**. Geometric mean fecal egg counts for Boer, Kiko, and Spanish does were 732, 595, and 416 eggs/g, respectively and differed ($P < 0.01$) between Boer and Spanish; Spanish and Kiko tended to differ ($P = 0.06$).

Boer does exhibited poor reproductive performance and generally poor fitness. In computer simulations of Blackburn (1995), reproductive traits under excellent forage conditions were similar for Boer and Spanish does or tended to favor Boer, whereas reproductive output under poor forage conditions were higher for Spanish does. The separation of Spanish and Boer does in the current project under semi-intensive pasture management concur with Blackburn (1995) for moderate to low forage conditions. It has become common for producers in the southeastern US to indicate that Boer-influenced goats lack hardiness. Body weight in Kiko does and the semi-arid origin of Spanish does did not appear to cause fitness problems under these experimental conditions. Unimproved goats in South Africa were found to be more disease resistant than Boer goats (Ramsay et al., 1978). It is plausible to surmise a loss of general hardiness when the Boer breed was developed under artificial selection pressures.

**Table 2.** Effect of doe breed on annual fitness indicators.

| Trait | Breed of doe | | | |
|---|---|---|---|---|
| | Boer | Kiko | Spanish | s.e. |
| Lameness, % does | 60.8 [b] | 28.5 [a] | 37.5 [a] | 3.6 |
| Internal parasitism, % does | 49.6 [b] | 23.2 [a] | 20.5 [a] | 3.2 |
| Reproductive failure [c], % does | 39.3 [b] | 15.4 [a] | 15.5 [a] | 3.0 |
| Attrition rate, % does | 23.7 [b] | 8.4 [a] | 10.3 [a] | 2.3 |

[ab]Means with different letters differ significantly ($P < 0.01$).
[c]Failure to wean a kid.

***Kid traits -*** Weights at birth and weaning were affected by sex of kid and litter size. Birth and weaning weights were heavier ($P < 0.01$) for male kids compared with female kids and kid weights decreased ($P < 0.01$) with increasing litter size from singles to triplets. The interaction of sire breed by dam breed was significant ($P < 0.01$) for kid birth weight **(Figure 1)**. Among straightbred kids, Boer kids were heavier ($P < 0.01$) than Kiko and Spanish kids, the latter two did not differ. Within Boer dams, sire breed did not affect birth weight. When born to Kiko or Spanish dams, Boer-sired kids were heavier ($P < 0.01$) than kids of the other two sire breeds.

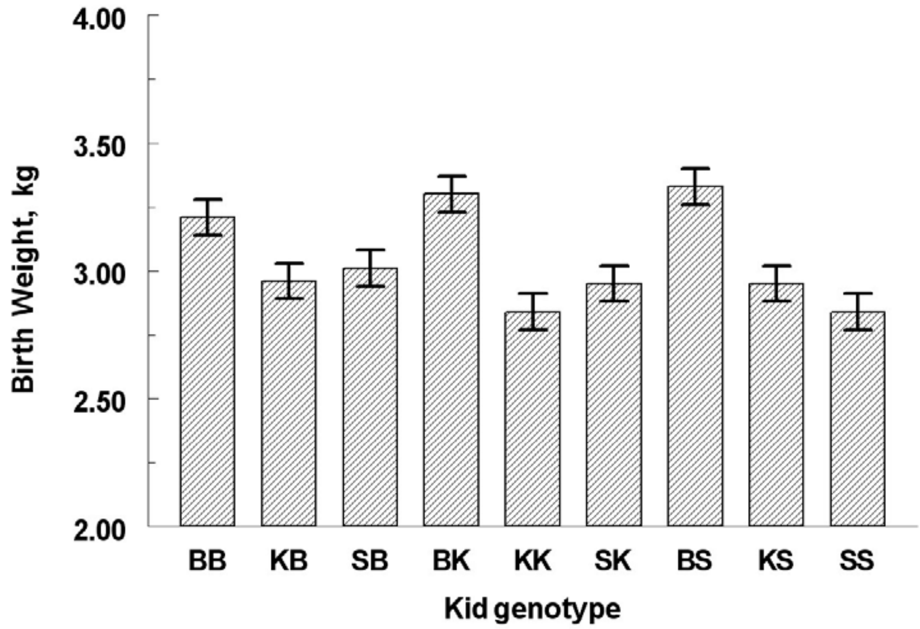


**Figure 1.** Birth weight (LSM ± s.e.) for meat goat kids out of Boer (B), Kiko (K), and Spanish (S) parental stock over five years. First letter of kid genotype represents sire breed. Second letter represents dam breed.

The sire breed by dam breed interaction was significant ($P = 0.01$) for weaning weights **(Figure 2)**. Kiko straightbred kids were heavier ($P < 0.01$) than Boer and Spanish straightbred kids, the latter two did not differ. Within Boer sires, kids were heavier ($P < 0.01$) from Kiko dams than from Boer or Spanish dams, the latter two did not differ. Within Kiko-sired kids, Kiko dams produced heavier weaning weights ($P < 0.01$) than Spanish dams. As main effects, sire breeds did not differ significantly for 90-day weaning weights, whereas kids from Kiko dams were heavier ($P < 0.01$) than from Boer and Spanish dams at weaning (15.9 vs. 14.2 and 14.4 ± 0.2 kg).

Boer sires generally generated heavier birth weight kids. However, dam breed had a greater effect on weaning weights with Kiko dams producing heavier kids within sire breed groups. Goodenwardene et al (1998) also reported that the weight advantage of Boer-sired kids at birth was not maintained through weaning. The utility of Boer goats for enhancing kid growth rates in limited-input meat goat production systems is questionable given the inability of Boer straightbred kids or Boer-sired kids to maintain a weight advantages from birth to weaning. There are a variety of possible reasons as to why Kiko dams improved weaning weights across different sire breeds compared to the Spanish and Boer dams.

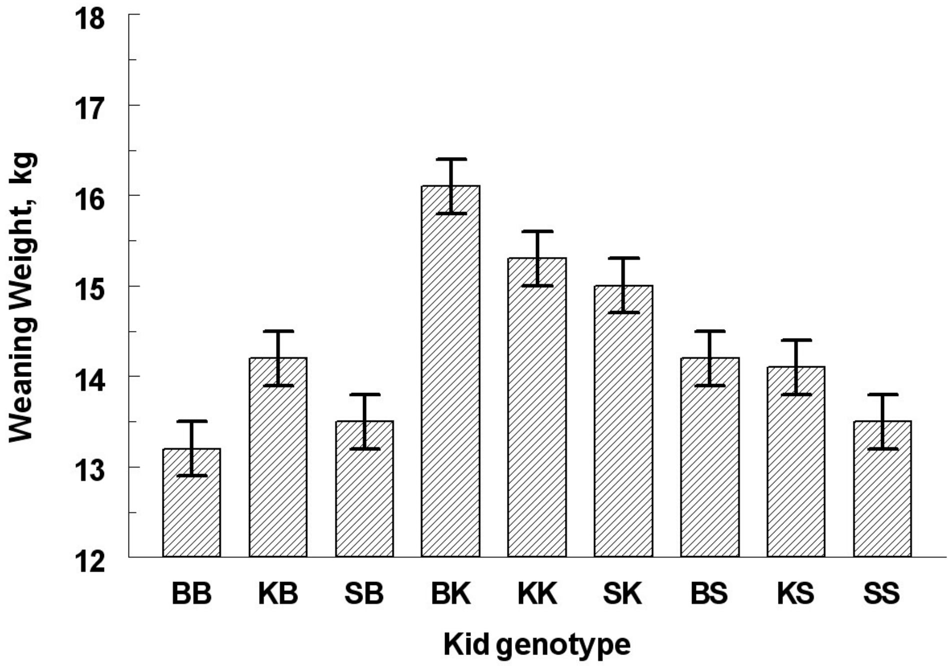


**Figure 2.** Weaning weight (90-day adjusted; LSM ± s.e.) for meat goat kids out of Boer (B), Kiko (K), and Spanish (S) parental stock over five years. First letter of kid genotype represents sire breed. Second letter represents dam breed.

***Carcass traits*** **-** Sire breed interacted ($P < 0.01$) with dam breed to affect live animal visual muscle conformation score **(Figure 3)** and cold carcass weight **(Figure 4)**, along with cold carcass dressing percent **(Figure 5)**. Visual muscle conformation scores were assigned 12-h before slaughter by trained USDA personnel. Increasing USDA visual scores from 1 to 3 correspond to an estimated decrease in meat to bone ratio (McMillin and Pinkerton, 2006). Visual scoring suggested that muscling was greater for Boer compared to Kiko and Spanish straightbred kids and greater for SB and BK crossbred kids compared to SK and KS (Figure 3). However, the SK and KS crosses produced the highest dressing percentages among the crossbreds and the Kiko produced higher dress-outs than the Boer straightbreds (Figure 5). For carcass weights, KK kids were heavier than BB and SS straightbreds, whereas SK was heavier than SB among crossbred kids. Lean to bone proportions did not vary ($P = 0.6$) across the kid genotype, ranging from 68.5 to 70%. As main effects, sire breed and dam breed affected ($P < 0.01$) carcass traits with the one exception of sire breed effect on cold carcass weight **(Table 3)**. Visual conformation scores suggested that the progeny of Boer sires or dams would produce higher yielding carcasses; however, Boer-influenced progeny produced lighter carcasses, lower dressing percentages, and no differences in measured lean:bone ratios with lean proportions at a consistent 69% when compared to the Kiko and Spanish influences.

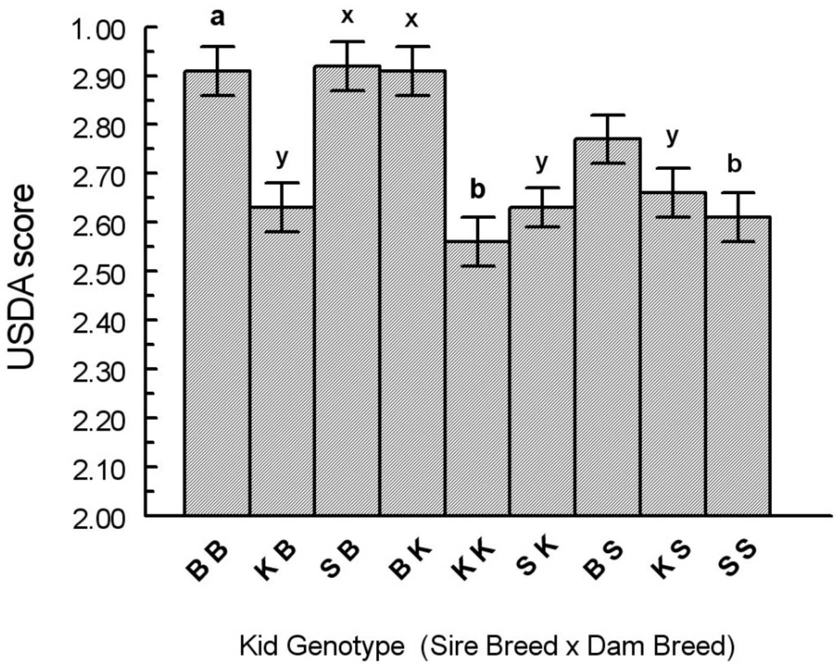


**Figure 3.** Live animal muscle conformation score (LSM ± s.e.) for meat goat kids out of Boer (B), Kiko (K), and Spanish (S) parental stock over three years. First letter of kid genotype represents sire breed. Second letter represents dam breed. Muscle conformation improves as score decreases from 3.0 to 1.9 subjectively. [ab]Straightbred means differ ($P < 0.01$). [xy]Crossbred means differ ($P < 0.01$).

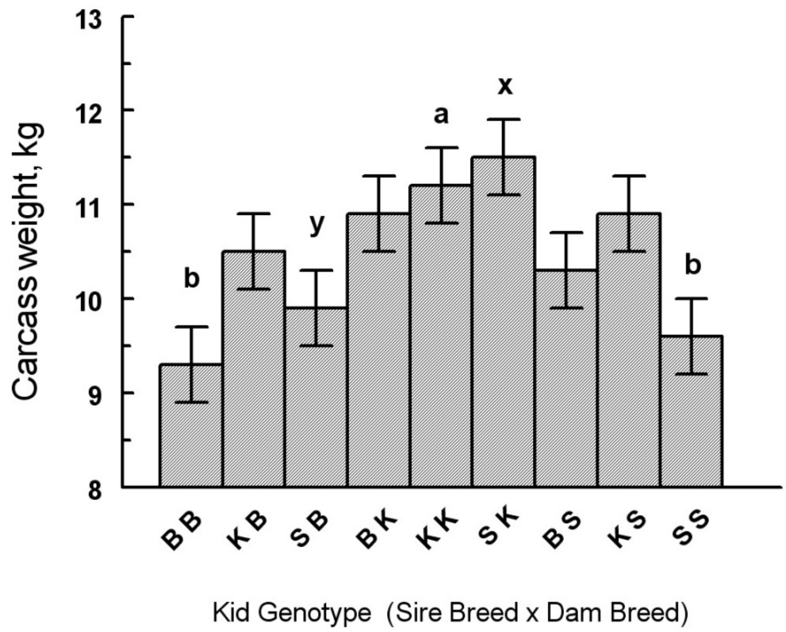


**Figure 4.** Cold carcass weight (LSM ± s.e.) for meat goat kids out of Boer (B), Kiko (K), and Spanish (S) parental stock over three years. First letter of kid genotype represents sire breed. Second letter represents dam breed. [ab]Straightbred means differ ($P < 0.01$). [xy]Crossbred means differ ($P < 0.01$).

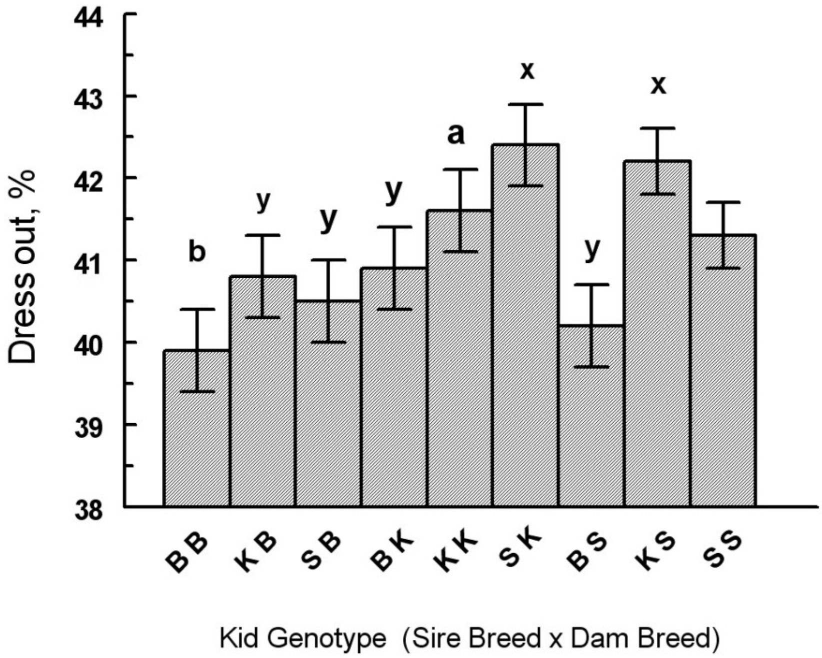


**Figure 5.** Cold carcass dressing percent (LSM ± s.e.) for meat goat kids out of Boer (B), Kiko (K), and Spanish (S) parental stock over three years. First letter of kid genotype represents sire breed. Second letter represents dam breed. [ab]Straightbred means differ ($P$ < 0.01). [xy]Crossbred means differ ($P$ < 0.01).

**Table 3.** Effect of sire and dam breeds on meat goat carcass traits.

| Trait | Breed | | | s.e. |
|---|---|---|---|---|
| | Boer | Kiko | Spanish | |
| Per Sire Breed | | | | |
| Conformation score[c] | 2.81 [a] | 2.61 [b] | 2.73 [a] | 0.03 |
| Cold carcass weight, kg | 10.2 | 10.8 | 10.6 | 0.3 |
| Chilled Dress-out, % | 40.3 [b] | 41.8 [a] | 41.8 [a] | 0.4 |
| Per Dam Breed | | | | |
| Conformation score[c] | 2.81 [a] | 2.68 [b] | 2.61 [b] | 0.03 |
| Cold carcass weight, kg | 9.6 [b] | 11.1 [a] | 10.2 [b] | 0.3 |
| Cold Dress-out, % | 40.4 [b] | 41.9 [a] | 41.5 [a] | 0.4 |

[ab]Means with different letters differ significantly ($P$ < 0.01).
[c]Muscle conformation improves as score decreases from 3.0 to 1.9 subjectively.

Carcass data revealed that although the Boer influence (sire or dam) looked subjectively to have enhanced carcass yield, objective measurements indicated that the Boer effect was actually negative or non-existent for the carcass traits recorded under the conditions of this study when compared to the Kiko and Spanish breeds. Other studies have shown that the infusion of Boer genetics does not consistently result in improved carcass yield (Goonewardene et al., 1998; Oman et al., 1999; Dhanda et al., 2003; Wildeus et al., 2003) when compared to Kiko and Spanish-type genetics.

## Conclusion

Proper breed selection for commercial meat goat production is dependent on the objective assessment of breed options under commercial (generally low-input) production conditions. Fitness (survival and reproduction), growth, and carcass merit are all important sets of traits to evaluate with fitness-related traits most important for the profitability and sustainability of a commercial enterprise. Semi-intensive pasture and extensive range management environments are dynamic and often less than ideal. Widespread use of new breed germplasm without sufficient research to characterize breed strengths and weaknesses under restricted-input management programs can prove financially detrimental in the long-term. In the current project, the introduced Boer breed generally performed poorly across the range of performance traits measured when compared to the foundation Spanish breed and introduced Kiko breed. The latter two exhibited general hardiness and appeared better suited for commercial meat goat production on humid, subtropical pasture.

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