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Central Performance Testing: Purpose, Benefits, Impacts, and Trends

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CENTRAL PERFORMANCE TESTING: PURPOSE, BENEFITS, IMPACTS, AND TRENDS

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Abstract
The premise of the central performance test is that differences in performance of young animals raised in a common environment are largely attributed to genetics; however, this can be confounded by differences in pre-test environments. It is assumed top-ranking individual's genetic advantage is a permanent change transferable to the next generation. The popularity of the central performance tests has waxed and waned over the past decades. A strengths-weaknesses-opportunities-threats analysis indicates factors influencing producer participation can include cost, time, geographical coverage, alignment with industry, association support, and relevancy. A second generation of central performance tests with innovative, targeted approaches is needed to face the challenges of the goat industry. Genomics has the potential to impact all aspects of the livestock industry, including central performance testing. However, the building of a reference population large enough to yield meaningful genomic estimated breeding value (GEBV) takes time. The future of central performance test remains unknown.
Keywords: Central Performance Test, Genetics, Selection, Evaluation, Strengths-Weaknesses-Opportunities-Threats

Introduction
The basic definition of a central performance test (CPT) is thus: animals, generally young, growing males, from different herds or flocks are gathered into one central location and performance is measured and recorded on each individual. The fundamental principle of a CPT is the observed differences in performance are primarily due to genetic differences and those animals with better performances possess a better set of genes or breeding value (BV) for the production trait under question. Those genes are passed onto offspring, which is the foundation for permanent change in the trait, as compared to environmental effects, which are not.

History of CPT for Meat Goats
The Angelo State CPT was the first CPT for meat goats in the U.S. Boer goat breeders started it in 1996 shortly after the advent of the Boer goats to the U.S. The management basis of the Angelo State CPT was confinement, basically within a feedlot environment. Proponents of this CPT system purport to accurately assess a production trait, like growth; nutrition must not be a limiting factor. The Angelo State CPT was able to calculate intake on a pen basis but not on an individual animal basis. The second CPT established was by Fort Valley State University, which was a forage-based CPT. Proponents of this CPT system argue the predominant management system for meat goat producers is a forage-based system and the CPT environment should mimic the production environment as closely as possible. In addition, proponents argue resistance to internal parasites can be assessed on a forage-based CPT. A third CPT was established by Langston University. The unique aspect of the Langston CPT was the use of Calan gate feeders, which allowed measurement of individual feed intake and subsequently measure of residual feed intake. In the mid-2000s, interest in CPT was high and several new CPTs were established by the

University of Maryland (Western Maryland), Kerr Center/Eastern Oklahoma State College (EOSC), Pennsylvania Department of Agriculture (PA Dept. of Ag), and Western Illinois University. The former two CPTs are forage-based CPTs and the latter two are confinement CPTs. Most recently, West Virginia University has established a confinement CPT for meat goats. The Pennsylvania Department of Agriculture, Western Illinois University, and West Virginia University CPTs also utilized the testing facilities for rams. Western Maryland, Kerr Center/Eastern Oklahoma State College, Pennsylvania Department of Agriculture, and West Virginia University CPTs are still active; the others have been terminated or have been suspended for an indefinite time. Western Maryland recently announced "The Western Maryland Pasture-Based Meat Goat Performance Test will not be held in 2017. After 11 years of the test and 13 years of small ruminant grazing, the test site will be rested. … The present test has run its course. High levels of parasite infection, coupled with lack of efficacy of the anthelmintics (dewormers) has resulted in too many goats being unable to adapt to test conditions. A new test will be considered for 2018 (source: http://mdgoattest.blogspot.com/ for Tuesday, October 11, 2016, and http://mdgoattest.blogspot.com/2017/ 08/a-new-era.html)." A timeline for CPTs is presented in Figure 1 and they are categorized by management system and location in Table 1.

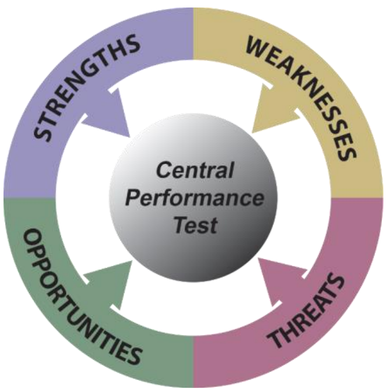

Figure 1. Timeline for CPTs

Table 1. Types of Meat Goat CPTs by Management System and Location

Confinement (Feedlot)	**Forage (Pasture)**
Angelo State University	Kerr Center/Eastern Oklahoma State College
Langston University	Fort Valley State University
PA Department of Agriculture	Western Maryland
West Virginia University	
Western Illinois University	

CPTs for meat goats are like any other enterprise and have internal and external factors affecting them. The internal factors are the strengths and weaknesses of enterprise and the external factors are generally opportunities and threats.

SWOT Analysis

A SWOT (strengths, weaknesses, opportunities, and threats) analysis is a powerful tool in assessing the viability of an enterprise (Piercy and Giles, 1989) and has been used often in evaluating livestock enterprises (Shrestha et al., 2004; Wasike et al., 2011; Martín-Collado et al., 2013). This paper will not conduct a classical SWOT analysis (Ghazinoory et al., 2011), which is based upon survey data, but will utilize personal conversations with breeders and extension specialists and principles of SWOT.

Factor Affecting CPT

Cost

Generally, CPTs operate as a service of the managing entities and operate at cost, excluding CPT personnel. For the confinement CPT, producers have often stated that cost of a CPT is approximately equal to their cost if they would have kept the bucks on their ranch/farm and maintained them for the same timeframe and they add the care and attention given the bucks is probably better than if the bucks were maintained at home. Therefore, cost is definitely a strength for the CPT and one often overlooked when marketing them to breeders.

Time

Time is a precious commodity and can be split into two periods; the time immediately before and after the CPT and the length of the CPT itself. The former is a commitment by breeders to transport their bucks to and from the CPT. This time commitment is directly related to the distance a breeder is from the CPT. Unless completely committed to a CPT, breeders farther from a CPT are disincentivized from participating. This time factor can be confounded with geographical coverage. One solution for this time issue is to provide a pick-up service for breeders distant from the CPT for CPT enrollment, when it is less critical for breeders to be present. At the end of the CPT, when reports and awards are given or a sale of bucks is held, the presence of participating breeders is more important. The Langston CPT utilized this approach.

Generally, CPTs have elected for a long test duration—the standard is 84 days—to ensure accurate and reliable measures are obtained. However, as CPT length increases, expenses in feeding and management inevitably increase. In recent years, optimizing the duration of performance tests for growth rate which is generally measured as average daily gain (ADG), feed intake, and feed efficiency as assessed by average daily gain ADG:feed intake ratio and residual feed intake (RFI) has been studied in Boer goats on the Langston University CPT over a 10-year span (Hu et al., 2012). Therefore, the duration of confinement CPT could be decreased from the standard 84 to 63 days with little loss in accuracy (Hu et al., 2012), which would result in cost savings for an already cost-efficient system. These findings are similar to those in beef cattle (Archer et al., 1997; Archer and Bergh, 2000; Wang et al., 2006), where the duration of performance testing could be shortened by varying extents to lengths of 63–84 days compared with original lengths of 91 days or longer. Also, the duration of performance testing for growing pigs could be shortened from 56 to 35 days (Arthur et al., 2008). The optimal length of a forage-based CPT is unknown but the opportunity exists for data analysis and appropriate recommendations. Time is probably a weakness of the

CPT but an opportunity exists to assist breeders with transport, especially transporting bucks to the CPT. An opportunity also exists for various CPTs to provide a uniform set of standard operating procedures that would reduce variation between CPTs.

Pre-Test Environment

Studies on the pre-test environment are lacking in meat goats but findings from beef cattle and sheep have shown various pre-test factors affect performance while on CPT. In performance-tested ram lambs, ADG is affected by numerous environmental factors including diet, management practice, facility characteristics, initial body weight and age of animals on the test, etc. (Waldron et al., 1990; Snowder and Van Vleck, 2002). In beef cattle, the pre-test environment is often questioned as to its effect upon performance-test results (Dalton and Morris, 1978). Herd of origin, which is confounded with sire and pre-test management, was found to have the greatest effect (Simm et al., 1985; Liu and Makarechian, 1993; Schenkel et al., 2004; Nephawe et al., 2006), while initial age or weight on-test had minimal or no effect (Patterson et al., 1950; Tong, 1982). Consequently, modifying the initial age or weight at the start of the CPT might not have any effect on the final results. Evidence from other beef cattle findings (Archer and Bergh, 2000) suggested that there is no need for different test lengths for different breeds or biological types in spite of differences in feeding patterns and growth rates. The failure to account for pre-test differences is a weakness of the CPT but presents an opportunity for study.

Geographical Coverage

Outside the northeastern U.S. (Figure 2), meat goat breeders have limited access to a CPT unless they are extremely dedicated to the concept of performance testing. Breeders in the Northeast can choose between two confinement CPTs or one forage-based CPT. Breeders in the Midwest have a single forage-based CPT. Figure 2 has circles with a radius of 250 miles around each CPT; the circle radii represent a manageable day's round-trip drive from the CPTs. Reports of the 2016 test results indicated breeders from Alabama, Delaware, Georgia, Illinois, Indiana, Kansas, Kentucky, Maryland, North Carolina, Oklahoma, Pennsylvania, South Carolina, Tennessee, Vermont, Virginia, and West Virginia consigned bucks to the Western Maryland CPT and breeders from Alabama, Georgia, Kansas, Mississippi, Missouri, Oklahoma, Texas consigned bucks to the EOSC CPT. Thus, 63% of the states for Western Maryland CPT and 43% for EOSC CPT were outside of the 250-mile radius. Conversely, for the confinement CPTs, almost all their consigned bucks came from within the 250-mile radius. It is not known exactly how the limited geographical availability affects CPT participation but evidence from the forage-based CPTs indicates it is probably minimal. Geographical coverage appears to be a strength for the forage-based CPTs and a weakness for the confinement CPTs. An opportunity exists for a CPT to be established in the Western U.S. Several years ago, a California university discussed the possibility of establishing a CPT but it never materialized.

Alignment with Industry/Relevancy

There has been a debate about whether CPTs give producers what they want, that is, does the buck's performance on tests relate to anything important? A study conducted in the early years of CPT for meat goats concluded CPT results did not accurately predict progeny performance due to pre-test factors biasing sires' CPT performance (Waldron et al., 2002). From that study, the authors encouraged breeders to consider testing several sons from each sire rather than only one or two

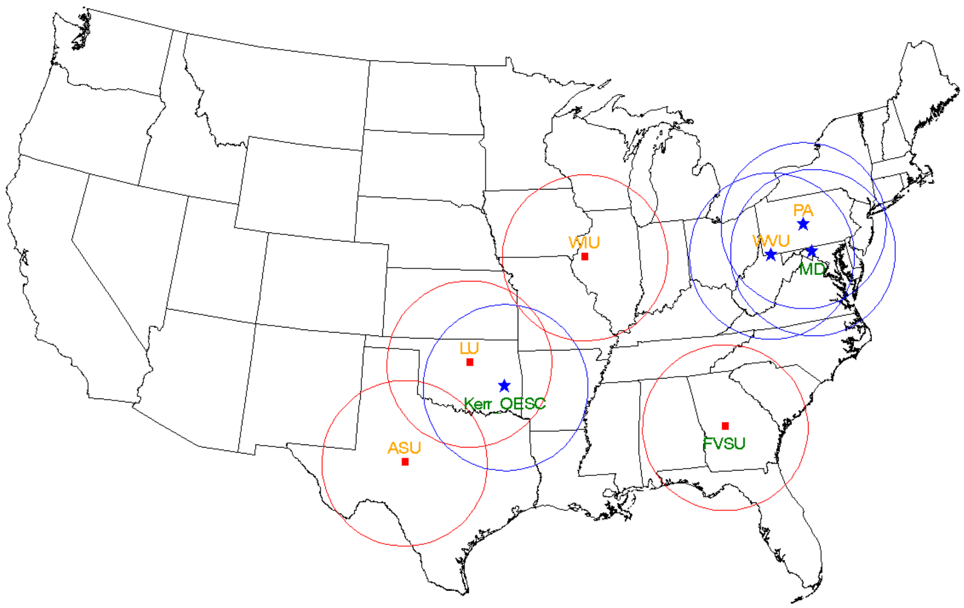

Figure 2. Geographical location of various CPTs. Red squares indicate a CPT that is discontinued and blue stars indicated an ongoing CPT. Orange lettering indicates a confinement CPT and green lettering indicates a forage-based CPT. Circle indicate a 250-mile radius

sons from each sire. This would result in the CPT becoming a variation of a progeny test. The rationale was the pre-test environment would be virtually identical for all buckings born within the same year from the same herd and when performance from half-sibs is added to the sire's performance, a more accurate genetic evaluation of the sires is obtained. Those authors also encouraged breeders to record performance measures such as birth weight, weaning weight, post-weaning ADG, and doe efficiency on their own ranch/farm because at that time, most goats were raised under extensive management systems and little performance data was collected on ranches/farms. Meat goats are still raised under extensive conditions but record-keeping is becoming more prevalent. Both Kentucky State University and Tennessee State University offer producer services for analyzing on-farm performance data. Thus, predicting progeny performance from sires' performance on CPT is a weakness for confinement CPT; however, this may be a weakness for forage-based CPTs, too.

A possible relevancy issue for forage-based CPTs is one of parasite resistance. Forage-based CPTs have advertised their advantage over confinement CPTS in being able to measure parasite resistance via fecal egg counts (FEC) and FAMACHA© scores. Grazing animals have been known to avoid foraging in areas that are contaminated by parasites, to select diets that increase their resistance to parasites, and to select diets containing antiparasitic compounds (Hutchings et al., 2008). Studies in sheep have shown sheep will avoid grazing areas heavily contaminated with feces (Hutchings et al., 1998) and will select diets containing tannins for a self-cure (Villalba et al., 2010). Therefore, the assessment of parasite resistance using FEC on a forage-based CPT is confounded with animals' grazing behavior. Eventually, an extremely infected pasture will overwhelm even the most grazing-averse goat and it will succumb to internal parasites. The assessment of resistance to internal parasites, which is confounded with grazing behavior, for forage-based CPT is neither a strength nor a weakness but could be transformed into a strength with the addition of a single or repeated artificial challenge (Gaba et al., 2006).

Association Support

Generally, the various goat associations are very supportive of CPT. The major breed associations for Boers and Kikos recognize achievements made by bucks on a CPT. For example, under the American Boer Goat Association rules for Ennoblement and Sire of Merit Award, bucks can earn points based upon CPT performance (ennoblement) or their sons' performance (Sire of Merit). However, points can be earned based on a buck's show ring performance(s) and that of his progeny. It is not clear what percentage of points earned for ennoblement or Sire of Merit are earned via a CPT. For a buck or his progeny to earn points via CPT, the average ADG for all bucks entered in the CPT must be $\geq$0.30. According to the rules, Sire of Merit appears to be more production-oriented than Ennoblement. Perhaps this is apparent from Figure 3, which indicates many more animals receive ennoblement each year compared to Sire of Merit. Obviously, only males can be Sires of Merit, whereas males and females can be Ennoled—an examination of the ennobled records for the last few years indicates an approximate 50:50 split between males and females.

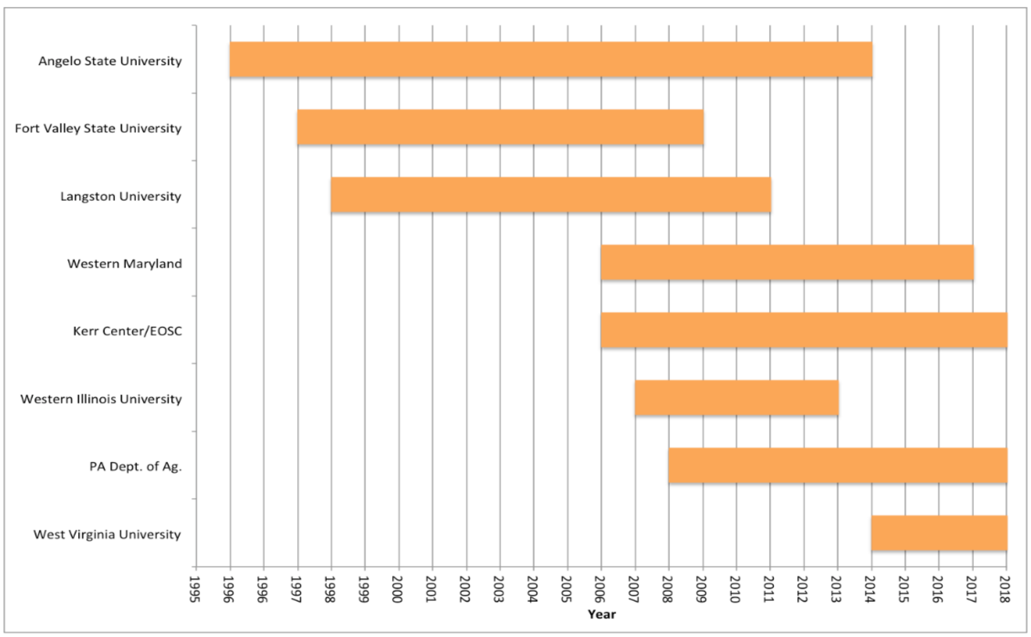

Figure 3. Establishment and duration of various CPTs for meat goats.

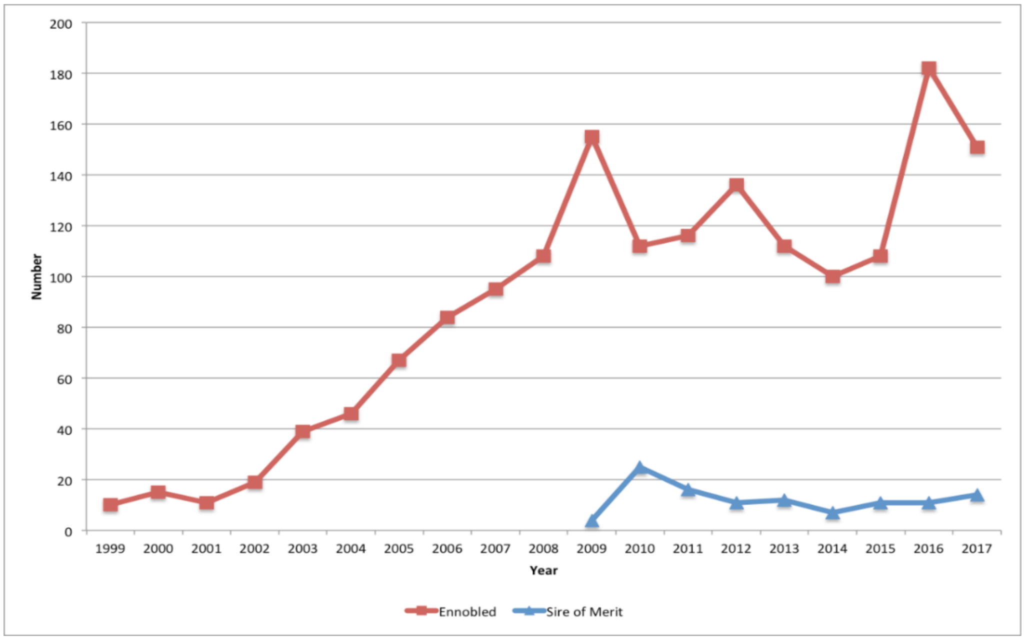

Figure 4. Number of Ennobled animals and Sire of Merit bucks for the American Boer Goat Association by year.

The Kiko associations appear to be supportive of CPT, as indicated by the popularity of the Western Maryland and EOSC CPTs, which include Kiko bucks almost exclusively. The dedication of the Kiko breeders distant from those CPTs to transport their bucks long distances is evidence of the support of those breeders. In addition, the American Kiko Goat Association (AKGA) has a Performance Test Program (PTP) that awards bucks solely upon CPT performance. However, the PTP has been suspended indefinitely to encourage AKGA breeders to utilize the on-farm performance data analysis offered by Kentucky State University and Tennessee State University. In brief, eligible bucks must be registered with the AKGA and their pedigree must be confirmed by DNA testing. Then PTP awards a Performance Buck ID based on the buck's CPT performances in ADG, fecal egg count (FEC), rib or loin eye area (REA LEA). An example of a Buck ID would be 13K101GGG01 BLUE HORNS O' FIRE FO555. The 13K101GGG01 BLUE HORNS O' FIRE is the registration number and name of the buck, respectively. The designation of FO555 indicates the buck earned a score of 5 (i.e. finished in the 50 - 59% percentile) for ADG, earned a score of 5 for FEC, and a score of 5 for REA or LEA, on a forage only (FO) CPT. Other designation for CPT are FS for forage supplemented and FL for feedlot/confined (http://www.kikogoats.com/index. php/akga-information/akga-performance-program/). A buck with the designation of FS999 would have performed in the top 10% for ADG, FEC, and REA on a forage supplemented CPT. A buck with a FL1N1 would have finished in the bottom 20% for ADG and REA on a confinement CPT. The "N" designation indicates that FEC was not evaluated. In addition, AKGA has a Performance Program Breed Points System, which awards breed points based on CPT performance of progeny/siblings. This program is also on hiatus. Unlike the PTP, which is a single record, the Breed Points program changes with additional data from relatives. Association support of CPT is a strength; however, not all associations are equally supportive.

Genomics

Genomic selection (GS) is a quickly evolving field and one that may soon revolutionize selection of individuals for breeding purposes (Goddard and Hayes, 2007; Goddard, 2009). According to Meuwissen et al. (2016), GS involves the estimation of the genetic merit of an individual based upon its DNA—actually its single nucleotide polymorphisms (SNP). The SNPs of an individual must be compared to a reference population, that is, a group of animals that have been genotyped and have production records for the trait under selection. The size of the reference population depends upon the heritability of the trait and the desired accuracy (Goddard, 2009). The size of the reference population is illustrated in Figure 4. Using ADG in Boer as an example, the heritability of ADG is 0.17 (Schoeman et al., 1997). From Figure 5, a reference population of ~4,000 is required for an accuracy of 0.60, which is slightly greater than the estimated breeding value (EBV) accuracy of the buck's single record on CPT. If a 9-month weight is used, then a reference population of ~3,000 is required for the same accuracy. This is because the heritability of a 9-month weight is 0.40 (Schoeman et al., 1997). Evidently, a higher desired accuracy will result in a larger required reference population as can be seen by ~15,000 and ~8,000 for an accuracy of 0.80 for ADG and a 9-month weight, respectively. Obviously, this reference population does not exist in meat goats as it does for dairy cattle (Wiggans et al., 2012), swine (Knol et al., 2016), and poultry (Wolc et al., 2016), and is being constructed for beef cattle (Silva et al., 2016) and for dairy goats (Carillier et al., 2013). Eventually a reference population will be constructed for simply measured traits and then for more complex traits, such as residual feed intake or carcass traits. Genomic selection is a threat to CPT and it could overtake it, especially as on-farm performance data analyses as offered by Kentucky State University and Tennessee State University grow.

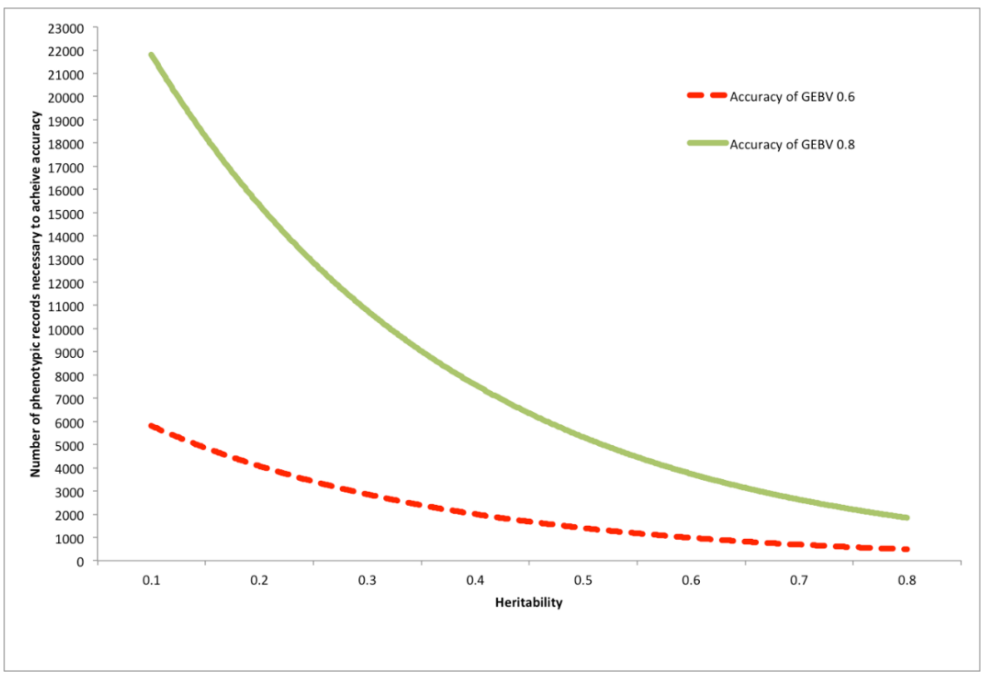

Figure 5. Number of animals in the reference population (phenotyped and genotyped) for GEBV accuracy [(Goddard, 2009) as cited by (Hayes et al., 2009)].

Conclusion

Central performance testing allows selection for genetic improvement that is permanent and cumulative. However, CPTs have strengths, weaknesses, opportunities, and threats that must be addressed if they are to remain a functional and useful tool for meat goat breeders.

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