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Estimation of genetic parameters for productive life, reproduction, and milk-production traits in US dairy goats

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ABSTRACT

Heritabilities and correlations for milk yield (MY), fat yield (FY), protein yield (PY), combined fat and protein yield (FPY), fat percentage (F%), protein percentage (P%), age at first kidding (AFK), interval between the first and second kidding (KI), and real and functional productive life at 72 mo (FPL72) of 33,725 US dairy goats, were estimated using animal models. Productive life was defined as the total days in production until 72 mo of age (PL72) for goats having the opportunity to express the trait. Functional productive life was obtained by correcting PL72 for MY, FY, PY, and final type score (FS). Six selection indexes were used, including or excluding PL72, with 6 groups of different economic weights, to estimate the responses to selection considering MY, FY, PY, and PL72 as selection criteria. The main criteria that determined the culling of a goat from the herd were low FS, MY, and FY per lactation. Heritability estimates were 0.22, 0.17, 0.37, 0.37, 0.38, 0.39, 0.54, 0.64, 0.09, and 0.16 for PL72, FPL72, MY, FY, PY, FPY, F%, P%, KI, and AFK, respectively. Most genetic correlations between the evaluated traits and PL72 or FPL72 were positive, except for F% (−0.04 and −0.06, respectively), P% (−0.002 and −0.03, respectively), and AFK (−0.03 and −0.01, respectively). The highest genetic correlations were between FPL72 and MY (0.39) and between PL72 and MY (0.33). Most phenotypic correlations between the traits evaluated and FPL72 and PL72 were positive (>0.23 and >0.26, respectively), except for F% (−0.004 and −0.02, respectively), P% (−0.05 and −0.02), KI (−0.01 and −0.07), and AFK (−0.08 and −0.08). The direct selection for PL72 increased it by 102.28 d per generation. The use of MY, FY, PY, KI, or AFK as selection criteria increased PL72 by 39.21, 27.33, 35.90, −8.28, or 2.77 d per generation, respectively. The inclusion of PL72 as selection criterion increased the expected response per generation from 0.15 to 17.35% in all selection indices studied.

Key words: productive life, heritability, genetic correlation, selection index

INTRODUCTION

Genetic evaluations for milk, fat, and protein yields in US goats have been calculated since 1983 in bucks and since 1984 in does. Genetic evaluations for these traits of US dairy goats have been calculated annually by the USDA Animal Improvement Programs Laboratory (Beltsville, MD) from records that are available through DHI programs and the American Dairy Goat Association (Spindale, NC; Wiggans and Hubbard, 2001).

For developing efficient selection programs, it is necessary to estimate genetic parameters (Weppert and Hayes, 2004). Some of the traits considered as potential selection criteria in dairy goats are milk, fat, and protein yields, type traits (Montaldo and Manfredi, 2002), reproductive traits (Torres-Vázquez et al., 2009; Montaldo et al., 2010), and longevity (Pérez-Razo et al., 2004). Longevity, despite being a little-studied trait not used so far in the genetic evaluation of goats, is of great economic importance, as it combines many traits associated with the permanence of an animal in the herd (Tsuruta et al., 2005). The increase in longevity allows a reduction in the number of replacement animals (Sewalem et al., 2007). It also allows a reduction in health care costs, especially those caused by mastitis (Rogers et al., 1998; Jensen et al., 1999), and an increase in the total milk production of the herd by increasing the proportion of mature animals with a greater production per lactation (Vollema et al., 2000).

Several definitions of longevity or productive life (**PL**) exist. Real PL is described in various ways, such

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as number of days from first calving to death or culling (VanRaden et al., 2006; Sewalem et al., 2007), total days in production (VanRaden and Klaaskate, 1993), stayability at different ages (Jakobsen et al., 2010) or at a specific number of calvings (Martinez et al., 2004), total months in production until a certain age (VanRaden et al., 2006), and number of lactations recorded (Pérez-Cabal et al., 2006). Functional PL (**FPL**) is defined as the ability to avoid involuntary culling caused by health or reproductive problems, and is obtained by including some covariates potentially used as voluntary culling criteria (e.g., milk, fat, and protein first-lactation production, and type traits) in the statistical models used to analyze PL (Dekkers, 1993; Mark, 2004).

Direct selection for longevity in the species used for milk production is not feasible, mainly because to obtain the information, the animal should be able to reach an advanced age or die, which would mean waiting too long and not being able to keep a herd with an age structure suitable for production or for selecting replacements. Trying to address this situation, several studies on cattle have been carried out to obtain early measures related to longevity, such as type traits (Martinez et al., 2004), functional traits, and milk-production traits (Tsuruta et al., 2005). Some of the countries that have used early measures as indirect predictors of longevity in cows are the United States (Short and Lawlor, 1992; Cruickshank et al., 2002), Canada (Sewalem et al., 2004, 2007), Japan (Hagiya et al., 2005), and Spain (Pérez et al., 1999).

Information about genetic parameters for longevity in goats and its relationship with milk production, reproductive, or conformation traits are scarce and limited to stayability estimates at a certain age or number of kiddings as a measure of PL (Pérez-Razo et al., 2004; Vicencio, 2009; Valencia-Posadas et al., 2010). Stayability merely indicates the presence or absence of the goat at a fixed age; therefore, it does not provide detailed quantitative information of the time during which a goat was productive. Thus, the aim of this study was to estimate the heritabilities and the genetic and phenotypic correlations between real PL and FPL at 72 mo, and milk-production and reproductive traits, using a quantitative definition of PL.

MATERIALS AND METHODS

Data

This study used data from the American Dairy Goat Association, processed by the USDA Animal Improvement Programs Laboratory, which contained information about milk (**MY**), fat (**FY**), and protein (**PY**) yields of Alpine, La Mancha, Nubian, Saanen, and Toggenburg breeds. Yields were corrected to 305 d and mature equivalents. The records also included fat percentage (**F%**); protein percentage (**P%**); information of the sire, herd, birth, and kidding dates; and DIM production (15 to 305 d).

To estimate the parameters more precisely, we only used records from goats with consecutive information for $\geq$1 lactation, with a maximum of 10 lactations, and which remained in the same herd in all lactations. Records with information errors about date of birth and date of kidding were eliminated; herds with $<$5 observations or $<$2 breeds were also eliminated. The records containing information on FY but not on PY, or vice versa, were considered as missing observations. The final data file contained information on MY, FY, and PY of the first lactation for 33,725 goats born from 9,716 sires and 24,474 dams. Data of individuals without breed or identification information were eliminated from the original pedigree data set. The pedigree was subsequently ordered generationally and recoded using the software Pedigree Viewer 6.3 (Kinghorn and Kinghorn, 2009); the final file contained the complete information of 209,530 individuals from the breeds analyzed.

We calculated the age of the animals as the difference between the last date of kidding and the date of birth plus the last days in production recorded; we also calculated the age at first kidding (**AFK**), the interval between the first and second kidding (**KI**), and the PL at 48, 60, and 72 mo (**PL48**, **PL60**, and **PL72**, respectively), using the same criteria used for the genetic evaluation of longevity in dairy cows in the United States (VanRaden and Klaaskate, 1993); PL was obtained using information from the first to the tenth lactation. Records with KI $<$168 or $>$885 d (236 animals), and AFK $<$271 or $>$1,140 d (479 animals) were considered missing.

Productive life was defined as the total number of days in production recorded (VanRaden and Klaaskate, 1993) until the goat was 48, 60, and 72 mo of age. If the goat did not stay in the herd or did not have the opportunity to complete each period, data was considered as censored and was not included in the analysis. To obtain PL, we first determined if the animal had the opportunity to stay in the herd at 3 different ages (48, 60, and 72 mo), depending on the period of recording of the herd to which it belonged. This was calculated as last registration of the herd $-$ date of birth $\geq$48, 60, or 72 mo.

If the goat did not have the opportunity to stay in the herd at 48, 60, or 72 mo, the PL was defined as a missing value and was not included in the file for analysis. If the goat had the opportunity to stay in the herd, its PL was the sum of the DIM production