

Estimates of genetic parameters for birth weight of Jakhrana goat

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ABSTRACT

Estimates of co(variance) components and genetic parameters were obtained for birth weight in Jakhrana goat maintained at the Central Institute for Research on Goats, Makhdoom, Mathura, India, over a period of 5 years (2005 to 2009). Records of 498 kids from 140 does sired by 29 bucks were used in the study. Analyses were carried out by REML fitting an animal model and ignoring or including maternal genetic or permanent environmental effects. Four different animal models were fitted for birth weight. Direct heritability estimates were inflated substantially for the trait when maternal effects were ignored. Direct heritability estimates for birth weight ranged from 0.40 to 0.61 depended on models used. Maternal heritability for this trait was 0.10, whereas, the estimates of the fraction of variance due to maternal permanent environmental effects was 0.11. Results suggest that the maternal effects (i.e. both maternal additive and/or permanent environmental maternal effect) were also important for birth weight. These results indicate that there is ample scope of genetic progress through selection for this trait.

Key words: Animal model, Birth weight, Genetic parameters, Jakhrana goat, Maternal effects

Studies on traits measured at an early age in farm animals have shown that both direct and maternal influences are important for animal growth (Mandal *et al.* 2006a,b, Kushwaha *et al.* 2009, Zhang *et al.* 2009). Exclusion of genetic or environmental factors may lead to overestimates of the remaining (co)variance components fitted in the model. Näsholm and Danell (1994) observed that when maternal genetic effects are on importance, but not accounted for, heritability estimates are biased upward and the realized efficiency of selection is reduced. Hence, to maximize the genetic gain in any selection program, information on both direct and maternal effects should be taken into account, especially if there is an antagonism between them (Meyer 1992).

Many of the published heritability estimates for growth traits in Indian goat breeds were derived from sire models that did not take account of additive maternal effects. Therefore, the present study was conducted to estimate variance and covariance components due to additive direct and maternal genetic effects and maternal permanent environmental effects for birth weight in Jakhrana goat.

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MATERIALS AND METHODS

Study area and description of the breed: This study was conducted at the CIRG, Makhdoom, Mathura, with a semi-arid climate. The annual rainfall in the area averaged 750 mm, while the average annual temperature varied from 6°C (winter) to 44.5°C (summer). The Jakhrana breed of goats is one of the most important dairy breeds in India and is generally well adapted to the semi-arid climatic conditions of Rajasthan. The natural habitat of Jakhrana breed is around Jakhrana village near Behror Tehsil in Alwar district of Rajasthan. However, the breed is also found in neighbouring areas (Basai, Jatganwara, Khor, Nimrana etc.) of this district (Rai *et al.* 2001). In brief, these animals were maintained under semi-intensive system of feeding management where they are allowed to graze for 7–8 h on natural pasture with supplementation of some amount of concentrate depending upon the status and age category of the animals. Controlled mating was practiced in the flock. Each kid was weighed at birth, identified by a metal ear tag and suckled its mother until weaning at 90 days of age. The animals were vaccinated against peste des petits for ruminants (PPR), enterotoxaemia and foot-and-mouth diseases (FMD).

Data: Birth records of 498 kids from 140 does sired by 29 bucks were used for this analysis. Characteristics of the data structure and phenotypic mean and standard deviation for this trait are summarized in Table 1.

Statistical analyses: (Co)variance components were

Table 1. Characteristics of data structure for birth weight of Jakhrana goat

Item	Birth wt.
No. of records	498
No. of animals ^a	614
No. of sires with progeny records	29
No. of dams with progeny records	140
Average weight (kg)	2.80
Standard deviation (kg)	0.60
CV (%)	21.43

^aAnimals in pedigrees.

estimated by restricted maximum likelihood (REML) using a derivative-free algorithm fitting an animal model (DFREML, Meyer 2000). Data were first analyzed by least-squares analysis of variance (Harvey 1990) to identify the fixed effects to be included in the model. The statistical model included the fixed effect of birth year, season of birth, parity of dam, and sex and birth status (single vs. twin) of kids. All these effects were significant ($P < 0.05$) for birth weight and all were included in the models subsequently used to estimate genetic parameters. Convergence of the REML solutions was assumed when the variance of function values ($-2\log L$) in the Simplex was less than 10^{-8} . To ensure that a global maximum was reached, analyses were restarted for several other rounds of iterations using results from the previous round as starting values. When estimates did not change, convergence was confirmed. Standard errors were calculated for the estimated parameters as a part of the DFREML programme (Meyer 2000).

Univariate animal models were fitted to estimate (co)variance components for each trait. The following four models were used:

$$y = Xb + Z_a a + e \quad (1)$$

$$y = Xb + Z_a a + Z_c c + e \quad (2)$$

$$y = Xb + Z_a a + Z_m m + e \text{ with Cov}(a, m) = 0 \quad (3)$$

$$y = Xb + Z_a a + Z_m m + Z_c c + e \text{ with Cov}(a, m) = 0 \quad (4)$$

where, y is the vector of observations for each trait; b , a , m , c and e are vectors of fixed effects (birth year, season of birth, parity of dam, sex and birth status of kid), direct additive genetic effects, maternal additive genetic effects, permanent environmental effects of the dam and residual effects, respectively; X , Z_a , Z_m , Z_c are the corresponding incidence matrices relating these effects to y . The analysis used the standard assumptions and definitions, i.e.

$$V(a) = A\sigma_a^2, V(m) = A\sigma_m^2, V(c) = I\sigma_c^2 \text{ and } V(e) = I\sigma_e^2$$

Where, I is an identity matrix, and σ_a^2 , σ_m^2 , σ_c^2 , and σ_e^2 are additive direct, additive maternal, maternal permanent environmental, and residual variances, respectively. Estimates of heritability (h^2), maternal heritability (m^2), and permanent maternal environmental (c^2) effects were calculated as ratios of estimates of σ_a^2 , σ_m^2 , and σ_c^2 , respectively, to the phenotypic variance (σ_p^2). Likelihood

ratio tests (LRT) were used to test whether random effects contributed significantly to the likelihood given the data. The total genetic contribution was calculated (Willham 1972) as $h_t^2 = h^2 + 0.5 m^2 + 1.5 m r_{am} h$, to estimate the expected response to phenotypic selection.

RESULTS AND DISCUSSION

Characteristics of data: Phenotypic mean, standard deviation, and coefficient of variation for birth weight are shown in Table 1. In these data, 53% of the kids were male and 47% female. Single, twin and triplet-born kids represented 31.5, 64.1 and 4.4% of the data, respectively. Coefficient of variation for birth weight was 21.43%, which was well comparable with the estimates reported by Roy *et al.* (2008).

Fixed effects: The present study revealed that different environmental factors (*viz.*, birth year, season of birth, parity of dam, sex and birth status of kids) were important for birth weight of kids. The birth year had significant ($P < 0.01$) effect on birth weight of kids. The kids of younger does were significantly ($P < 0.01$) lower birth weight than the kids born in later parities. The kids born in the month of March-April had significantly ($P < 0.01$) higher birth weight than those born in the month of October-November. The male kids had significantly ($P < 0.01$) higher birth weight than females. The single-born kids also showed higher birth weight than multiple-born kids. The effects of various fixed factors like year of birth, season of birth, sex and birth status of kids on birth weight were reported in other goat breeds (Rai *et al.* 2004, Swami *et al.* 2006).

Genetic effects for birth weight: Estimates of (co)variance components and genetic parameters for birth weight and likelihood values for each of the four different models are summarized in Table 2. Estimates of direct additive

Table 2. Estimates of (co)variance components (kg^2) and genetic parameters for birth weight of Jakhrana goat

Item ^b	Model 1	Model 2	Model 3	Model 4
σ_a^2	0.181	0.114	0.116	0.114
σ_m^2	—	—	0.029	0.000
σ_c^2	—	0.031	—	0.031
σ_e^2	0.116	0.142	0.144	0.143
σ_p^2	0.297	0.288	0.289	0.288
h^2	0.61	0.40	0.40 (0.04)	0.40
m^2	—	—	0.10 (0.02)	0.001
c^2	—	0.11	—	0.11
h_t^2	0.61	0.40	0.45	0.40
log L	62.38	63.99	63.1	63.99

^b σ_a^2 , additive direct genetic variance; σ_m^2 , additive maternal genetic variance; σ_c^2 , maternal permanent environmental variance; σ_e^2 , environmental variance; σ_p^2 , phenotypic variance; h^2 , heritability; m^2 , maternal heritability; $c^2 = \sigma_c^2 / \sigma_p^2$; h_t^2 , total heritability; and log L, log likelihood values. Values in parentheses are standard errors of estimates from this model.

heritability for birth weight (Table 2) depended on the model used, ranging from 0.40 to 0.61. Ignoring maternal effects (model 1) produced higher estimates of σ^2_a and h^2 than those obtained from other models. Fitting a permanent environmental maternal effect (model 2) markedly decreased both σ^2_a and h^2 compared to model 1, indicating a significant maternal effect accounting for 11% of the total variance in this trait. Model 3, which included only direct and maternal additive effects, yielded an estimate of m^2 that also explained 10% of phenotypic variance, with a corresponding decrease in the estimate of direct heritability to 34%. Model 4 attempted to partition the total maternal effect into additive maternal and permanent environmental components. Model 4 did not yield a significant improvement in likelihood compared to models 2 and 3 but was superior to model 1. Both models 2 and 3, showed significant improvement of log-likelihood values indicating a strong evidence for existence of maternal effect on birth weight in this data. The direct heritability estimates of 0.40–0.61 for the birth weight under different models in this study were in agreement with the findings of Supakorn and Pralomkarn (2009) who observed the estimate of 0.44 for birth weight of goats. Similar high direct heritability estimates (0.42) for birth weight was also observed in sheep (Al-Shorepy 2001). However, lower estimates than the present study were reported by Al-Shorepy *et al.* (2002) in Emirati goats (0.18), Boujanane and Hazzab (2008) in Draa goats (0.16) and Shaat and Maki-Tanila (2009) in Egyptian Zaraibi goats (0.03–0.12). Using the different animal models, Roy *et al.* (2008) also obtained the lower heritability (0.12–0.37) estimates for birth weight in Jamunapari goats managed at the same location as the goats used for this study.

The maternal heritability estimates for birth weight (0.10) in this study was well comparable to the estimates of Al-Shorepy *et al.* (2002) in Emirati goat (0.18) and Supakorn and Pralomkarn (2009) in meat goat (0.15). Similar estimates for maternal heritability of birth weight were also observed in sheep (Neser *et al.* 2001, Ekiz *et al.* 2004). Mandal *et al.* (2006 a,b) and Roy *et al.* (2008) reported the maternal heritability of 0.17 and 0.18 for birth weight in Muzaffarnagari sheep and Jamunapari goats, respectively.

Permanent environmental effect due to dam can be attributed to the uterine environment provided by the dam and the effects of multiple births. Estimate of permanent environmental maternal effect (c^2) for birth weight (0.11) in the present study was in agreement with the findings of Roy *et al.* (2008) who observed the estimate of 0.16 in Jamunapari goats.

The total heritability defined as the value to calculate the expected response to phenotypic selection, for birth weight was moderate to high in magnitude, ranged from 0.40 to 0.61 and was similar to direct heritability estimates. The total heritability for birth weight observed in this study was higher than the estimates of Roy *et al.* (2008) in Jamunapari goats

(0.18–0.37). The moderate to high total heritability estimate for this trait indicates the existence of scope of selection progress for birth weight in this breed.

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