Genetic and non-genetic factors affecting body weight in Tellicherry goats

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Abstract

Data on 566 Tellicherry goats, recorded between 1988 and 2007 were used to study the effect of non-genetic factors on body weight and daily gain from birth to 12 months of age. The least-squares means for body weight at birth and at 12 months of age were 2.17 ± 0.03 and 18.78 ± 0.44 kg, respectively. The pre- and post-weaning average daily weight gains were 72.41 ± 1.68 and 37.46 ± 1.49 g, respectively, and the associated growth efficiencies were 3.11 ± 0.08 and 1.34 ± 0.05, respectively. Significant differences associated with the year of kidding were observed in body weight, weight gain and efficiency in weight gain at different stages of growth. Growth rate of kids born between December and February was relatively slower than those born in other months and this can result from seasonal changes and suggests that it is necessary to plan the kidding season rationally by controlling the oestrus and mating time. The kids born as twin had lower birth weight and slower early growth rate than those born as single but had a higher post-weaning growth rate. The heritabilities of different traits were moderate to high, except for birth weight, which was of low heritability. The phenotypic and genetic correlations among the different body weights were positive and low to high in magnitude.

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Introduction

Growth potential of kids is one of the most important traits in genetic improvement schemes for chevon production. A number of non-genetic factors affects these growth traits and directly obscures recognition of genetic potential. Hence, the performance records of an animal should be corrected for classifiable non-genetic sources of variation, which is essential for obtaining precise estimates of genetic parameters and breeding values so that breeding animals with the potential genetic merit can be identified and selected for further genetic improvement. Tellicherry goats are one among the recognised breeds of goat in India and is widely distributed in Malabar region of Kerala (Acharya, 1982) and also reared in different places of Tamil Nadu. This breed is considered as a unique genotype exhibiting higher multiple birth percentages and higher milk yields. Studies on performance of Tellicherry goats in their native environment have been reported (Mukundan *et al*., 1980; Acharya, 1982) and in Tamil Nadu (Sivakumar & Thiagarajan, 1999; Thiruvenkadan *et al*., 2007). However, these studies were based on fewer numbers of observations and there have not been a systematic study on the influence of non-genetic factors on body weight at specific feeding and management conditions. Hence, this study was conducted to estimate the non-genetic influences on body weight of Tellicherry goats under prevailing natural and ecological conditions in Tamil Nadu, India, and to estimate the genetic parameters for different traits, which is needed for suitable selection and breeding plans.

Material and Methods

The data on the body weight of 566 Tellicherry goats, maintained at Mecheri Sheep Research Station Pottaneri, Tamil Nadu, India were collected over a period of 20 years (1988 - 2007). The body weights at different ages (i.e. at birth and at three, six, nine and 12 months) were recorded. The average daily gains in live weights from birth until weaning (WADG) and from weaning until the age of 12 months (PADG) were estimated. The efficiency of growth was assessed as the gain in body weight per kg of initial weight (Mandal *et al*., 2003). The data were classified according to period, season, parity of dam, type of birth and sex. The years of kidding were divided into five periods. The data were analysed using a mixed-model least-squares analysis of fitting constants (Harvey, 1990). The variance and covariance components of growth traits were estimated by fitting a series of univariate animal models using a derivative free REML algorithm

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(DFREML, Meyer, 2000).

Results and Discussion

The least-squares means (± s.e.) for body weight at different ages are presented in Table 1. The overall least-squares means for kid weights at the different ages were within the range of values observed by Mukundan *et al.* (1980), Acharya (1982), Sivakumar & Thiagarajan (1999) and Thiruvenkadan *et al.* (2007). The kids born in the south-west monsoon season had higher body weights than those born in other seasons and they were significantly higher at three, nine and 12 months of age. Comparison of the least-squares means for kids' weight at different age showed that the difference between male and female kids increased from 0.21 kg at birth to 1.42 kg at 12 months of age. Most of the environmental factors (period, parity, season, type of birth and sex of the kid) had significant to highly significant effects on body weights at different ages. These factors were also proven to be important in other studies on kids of different breeds (Bobhate *et al.*, 2003; Yadav *et al.*, 2003; Sharma & Pathodiya, 2006). The significant differences in body weight among kids born in different periods may be attributed to differences in management, selection of bucks and environmental conditions such as the ambient temperature, humidity, rainfall, etc.

Table 1 Least-squares means (± s.e.) of body weight (kg) of Tellicherry goats at different age groups

Effect	Birth	3 months	6 months	9 months	12 months
Overall	2.17 ± 0.03 (566)	8.71 ± 0.15 (485)	12.05 ± 0.19 (411)	15.09 ± 0.26 (358)	18.78 ± 0.44 (304)
Period	**	**	**	**	**
P$_1$ (1988-1991)	2.18[b] ± 0.09 (28)	10.03[b] ± 0.51 (21)	13.40[b] ± 0.64 (18)	16.07[b] ± 0.86 (16)	18.53[b] ± 1.40 (15)
P$_2$ (1992-1995)	2.15[a] ± 0.06 (62)	7.66[a] ± 0.30 (56)	11.25[a] ± 0.36 (54)	13.43[a] ± 0.46 (52)	17.72[ab] ± 0.73 (51)
P$_3$ (1996-1999)	2.23[b] ± 0.04 (137)	10.59[b] ± 0.22 (121)	14.56[c] ± 0.26 (117)	18.1 1[b] ± 0.35 (113)	22.61[c] ± 0.57 (104)
P$_4$ (2000-2003)	2.24[b] ± 0.03 (208)	7.67[a] ± 0.17 (179)	10.53[a] ± 0.23 (146)	13.79[a] ± 0.31 (122)	17.29[a] ± 0.54 (98)
P$_5$ (2004-2007)	2.07[a] ± 0.04 (131)	7.59[a] ± 0.22 (108)	10.52[a] ± 0.31 (76)	14.05[a] ± 0.46 (55)	17.74[ab] ± 0.88 (36)
Season		**		**	**
Winter (Dec. to Feb.)	2.25 ± 0.04 (179)	7.99[a] ± 0.21 (166)	11.59 ± 0.26 (151)	14.39[a] ± 0.36 (128)	17.57[a] ± 0.62 (104)
Summer (Mar. to May)	2.12 ± 0.05 (112)	9.01[b] ± 0.26 (95)	12.43 ± 0.35 (72)	15.18[bc] ± 0.47 (61)	18.46[a] ± 0.79 (53)
South-west monsoon (June to Aug.)	2.16 ± 0.05 (98)	9.66[b] ± 0.27 (80)	12.40 ± 0.34 (71)	16.11[b] ± 0.44 (69)	20.97[b] ± 0.71 (67)
North-east monsoon (Sep. to Nov.)	2.18 ± 0.04 (177)	8.17[a] ± 0.21 (144)	11.79 ± 0.26 (117)	14.68[ac] ± 0.36 (100)	18.11[a] ± 0.62 (80)
Type of birth	**	**	**	**	**
Single	2.34[b] ± 0.03 (324)	9.16[b] ± 0.18 (281)	12.97[b] ± 0.23 (241)	16.13[b] ± 0.31 (212)	19.68[b] ± 0.54 (179)
Multiple born	2.01[a] ± 0.03 (242)	8.25[a] ± 0.19 (204)	11.14[a] ± 0.24 (170)	14.05[a] ± 0.32 (146)	17.88[a] ± 0.52 (125)
Sex of the kid	**	**	**	**	**
Male	2.28[b] ± 0.03 (289)	9.27[b] ± 0.18 (251)	12.57[b] ± 0.24 (210)	15.75[b] ± 0.32 (178)	19.49[b] ± 0.54 (139)
Female	2.07[a] ± 0.03 (277)	8.15[a] ± 0.19 (234)	11.53[a] ± 0.24 (201)	14.43[a] ± 0.32 (180)	18.07[a] ± 0.53 (165)
Parity		**	**	*	
First	2.06 ± 0.04 (175)	8.05[a] ± 0.20 (151)	11.59[a] ± 0.25 (130)	14.96[b] ± 0.34 (113)	18.14 ± 0.58 (94)
Second	2.18 ± 0.04 (131)	8.57[a] ± 0.23 (118)	11.72[a] ± 0.28 (101)	15.02[b] ± 0.38 (90)	18.19 ± 0.65 (72)
Third	2.20 ± 0.05 (106)	9.35[b] ± 0.26 (83)	12.98[b] ± 0.32 (74)	15.81[b] ± 0.43 (65)	19.40 ± 0.70 (60)
Fourth	2.18 ± 0.05 (77)	9.11[b] ± 0.30 (63)	12.37[b] ± 0.39 (51)	15.88[b] ± 0.52 (44)	19.66 ± 0.87 (39)
Fifth	2.23 ± 0.07 (40)	8.02[a] ± 0.39 (37)	11.53[a] ± 0.50 (30)	13.28[a] ± 0.69 (24)	17.61 ± 1.25 (18)
Sixth and above	2.20 ± 0.08 (37)	9.15[b] ± 0.41 (33)	12.11[b] ± 0.54 (25)	15.61[b] ± 0.72 (22)	19.67 ± 1.16 (21)

* Significant (P <0.05) ** Highly significant (P <0.01). Means bearing same superscript don't differ significantly (P >0.05). Figures in parentheses are number of observations.

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Analysis of variance showed that the pre-weaning average daily weight gain was highly significantly affected by period, season, type of birth, sex and parity. However, post-weaning growth efficiency was influenced by period (P <0.01) and season (P <0.05) alone and other factors had no effect (P >0.05) on this trait (Table 2). The highest pre- and post-weaning average daily weight gains were observed in period three (1996 - 1999). The difference in rate of weight gain per day of single-born kids compared to multiple born kids was 8.97 g up to weaning but 1.20 g by 12 months of age, the latter being not significant (P >0.05). The overall pre-weaning ADG in this study was lower than the estimates reported by Thiruvenkadan *et al.* (2007). The efficiency of pre-weaning growth decreased with the parity/age of dam up to the second parity. The efficiency of growth measured in terms of the gain in body weight per kg of initial weight decreased with advancing age. The 1.77 kg (56.9%) reduction in growth efficiency during post-weaning development as against the pre-weaning stage indicated that the maximum growth rate had occurred during the pre-weaning stage.

Table 2 Least-squares means (± s.e.) of average daily weight gain and growth efficiency during pre- and post-weaning stages

Effect	Pre-weaning ADG (WADG) (g)	Post-weaning ADG (PADG) (g)	Pre-weaning growth efficiency	Post-weaning growth efficiency
Overall	72.41 ± 1.68 (485)	37.46 ± 1.49 (302)	3.11 ± 0.08 (485)	1.34 ± 0.05 (302)
Period	**	**	**	**
P₁ (1988-1991)	86.86[b] ± 5.56 (21)	34.81[a] ± 4.73 (15)	3.65[b] ± 0.27 (21)	1.16[a] ± 0.17 (15)
P₂ (1992-1995)	61.41[a] ± 3.30 (56)	36.05[a] ± 2.48 (51)	2.78[a] ± 0.16 (56)	1.42[b] ± 0.09 (51)
P₃ (1996-1999)	92.79[c] ± 2.40 (121)	43.01[c] ± 1.94 (102)	3.86[b] ± 0.11 (121)	1.18[a] ± 0.07 (102)
P₄ (2000-2003)	59.93[a] ± 1.92 (179)	34.30[a] ± 1.83 (98)	2.45[a] ± 0.09 (179)	1.26[a] ± 0.06 (98)
P₅ (2004-2007)	61.05[a] ± 2.45 (108)	39.13[b] ± 2.97 (36)	2.81[a] ± 0.12 (108)	1.69[c] ± 0.10 (36)
Season	**	*	**	
Winter (Dec. to Feb.)	63.81[a] ± 2.32 (166)	35.58[a] ± 2.09 (104)	2.62[a] ± 0.11 (166)	1.38 ± 0.07 (104)
Summer (Mar. to May)	76.44[b] ± 2.89 (95)	36.29[a] ± 2.69 (53)	3.44[b] ± 0.14 (95)	1.31 ± 0.09 (53)
South-west monsoon (June to Aug.)	83.17[c] ± 2.97 (80)	43.00[a] ± 2.44 (65)	3.59[b] ± 0.14 (80)	1.42 ± 0.08 (65)
North-east monsoon (Sep. to Nov.)	66.20[a] ± 2.30 (144)	34.97[a] ± 2.11 (80)	2.79[a] ± 0.11 (144)	1.26 ± 0.07 (80)
Type of birth	**			
Single	76.89[b] ± 2.03 (281)	38.06 ± 1.83 (177)	3.07 ± 0.10 (281)	1.28 ± 0.06 (177)
Multiple born	67.92[a] ± 2.06 (204)	36.86 ± 1.81 (125)	3.15 ± 0.10 (204)	1.40 ± 0.06 (125)
Sex of the kid	**			
Male	76.25[b] ±1.97 (251)	39.05 ± 1.82 (137)	3.11 ± 0.09 (251)	1.34 ± 0.06 (137)
Female	68.56[a] ± 2.05 (234)	35.87 ± 1.77 (165)	3.11 ± 0.10 (234)	1.34 ± 0.06 (165)
Parity	**			
First	66.37 ± 2.25 (151)	37.18 ± 1.98 (93)	3.03 ± 0.11 (151)	1.39 ± 0.07 (93)
Second	70.87 ± 2.48 (118)	36.92 ± 2.23 (71)	3.01 ± 0.12 (118)	1.40 ± 0.08 (71)
Third	78.95 ± 2.86 (83)	37.37 ± 2.37 (60)	3.28 ± 0.14 (83)	1.25 ± 0.08 (60)
Fourth	76.35 ± 3.30 (63)	40.73 ± 294 (39)	3.14 ± 0.16 (63)	1.46 ± 0.10 (39)
Fifth	64.55 ± 4.21 (37)	35.10 ± 4.23 (18)	2.75 ± 0.20 (37)	1.31 ± 0.15 (18)
Sixth and above	77.36 ± 4.45 (33)	37.48 ± 3.92 (21)	3.46 ± 0.22 (33)	1.24 ± 0.14 (21)

* Significant (P <0.05) ** Highly significant (P <0.01). Means bearing same superscript don't differ significantly (P >0.05). Figures in parentheses are number of observations.

The genetic and phenotypic correlations and heritability estimates along with their standard errors are presented in Table 3. The heritability of body weight tended to increase with increasing age from birth to six months and then decreased. Weight at birth was of low heritability (0.062 ± 0.069) and the heritabilities of the body weights at three, six, nine and 12 months of age were medium to highly heritable. The heritability

estimates for Tellicherry kids observed are in accordance with earlier reports (Acharya & Malik, 1971; Bhadula & Bhat, 1980; Mandal *et al*., 2003). The low heritability estimate observed for birth weight may be explained by the poor nutritional level of the does ,creating a large environmental variation. The increasing heritability of body weights at the later stages of developmental process indicates that environmental factors had more influence on birth weight than on the weights achieved later in the developmental stages (Mandal *et al*., 2003). The heritability estimates for gain in weight during the pre- and post-weaning stages of development were 0.285 ± 0.118 and 0.385 ± 0.165, respectively, and the estimates for efficiency of growth at pre- and post-weaning ages were 0.224 ± 0.100 and 0.246 ± 0.201, respectively. The phenotypic correlations of birth weight with the body weights at subsequent ages ranged from low to intermediate and were positive (0.159 - 0.336). The six-month body weight had a significant, positive and high genetic correlation with the nine and 12 months body weight. This indicated that selection for increased body weight at this age would result in genetic improvement in the subsequent ages.

Table 3 Estimates of heritability (diagonal), genetic correlation (above diagonal) and phenotypic correlation (below diagonal) of different economic traits of Tellicherry goats

Age	Birth	3 months	6 months	9 months	12 months
Birth	0.062 ± 0.069 (566)	0.685 ± 0.526	0.378 ± 0.417	0.291 ± 0.455	0.075 ± 0.362
3 months	0.314 ± 0.168	0.344 ± 0.163 (485)	0.816 ± 0.113	0.611 ± 0.164	0.882 ± 0.238
6 months	0.336 ± 0.169	0.781 ± 0.286	0.369 ± 0.158 (411)	0.640 ± 0.056	0.887 ± 0.141
9 months	0.256 ± 0.114	0.703 ± 0.301	0.913 ± 0.458	0.298 ± 0.114 (358)	0.939 ± 0.085
12 months	0.159 ± 0.110	0.545 ± 0.212	0.802 ± 0.356	0.886 ± 0.414	0.227 ± 0.110 (304)

Figures in parentheses are number of observations.

Conclusions

Period and season of birth, type of birth and sex of the kids were the major factors affecting growth rate of Tellicherry goats. The effect of birth month suggests that planning kidding season would improve production efficiency. The heritability estimates indicated that selection for weight and weight gain should be done on the basis of the post-weaning traits preferably on six months body weight. A positive response could be expected in other traits owing to the generally high and positive correlations. The selection for weight at a later stage would be expected to lead to increased yearling weights, which is desirable in meat animals, although it may be associated with increased maintenance costs.

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