

GENETIC EVALUATION OF LINEAR TYPE TRAITS AND THEIR ASSOCIATION WITH MILK PRODUCTION TRAITS IN BEETAL GOATS IN PAKISTAN

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ABSTRACT

Data on linear type and milk production traits of Beetal does (n=127) were analyzed to estimate variance components hence genetic parameters and to find the relationship between linear type and milk production traits fitting an individual animal model. Fixed effects were flock and parity in the model while linear and quadratic effects of age of doe were fitted as covariables. Genetic parameters (heritability estimates) of linear type traits and their correlations with milk production traits were computed using ASREML software. Heritability of various body measurement traits varied from 0.04 to 0.98. Genetic correlations between different body measurements and milk production traits ranged from -0.41 to 0.88 for lactation milk yield (LMY) and from -0.69 to 0.64 for lactation length (LL). Phenotypic correlations in corresponding combinations ranged from -0.33 to 0.90 for LMY, and from -0.46 to 0.89 for LL. In conclusion, some of the correlations could provide strong effects in selection and prediction of milk production from linear type traits.

Key words: Beetal goats, linear type traits, milk production, genetic parameters.

INTRODUCTION

Beetal is an important goat breed in Pakistan that is characterized by Black and White, sometimes red mottled and black mottled coat colour. The breed may be horned or polled, and is considered as large-sized breed. Furthermore, Beetal goats are known for a number of features, including heat tolerance, prolificacy and multi-purpose utilization. Beetal goats are found almost everywhere in the province of Punjab (in Pakistan), and are approximately 4% to the total goat population (GOP, 2017) that is more than 72 millions. Beetal goats produce on average from 1.5 to 3 liters of milk daily. Milk production in Beetal breed is considered reasonable yet studies at population level are scanty. Body measurements are related to milk yield either genetically or phenotypically and could be a useful tool for predicting milk production. Relationship between live body weight and body measurement has been reported in some breeds (Moaeen-ud-Din *et al.*, 2006). Body measurements are important tools for phenotypic description. These measurements include heart girth, belly girth, withers height, rump height, head length, neck length, etc. Among performance traits, milk production need special attention if any of the breed is to be developed as dairy or dairy-cum meat goat. Any study regarding genetic parameters of body measurements and their relationship with milk production in these local goats is lacking. The objective of the study was to estimate the genetic parameters for conformation traits and compute genetic

and phenotypic correlations between conformation and milk production traits in Beetal goats.

MATERIALS AND METHODS

Conformation and milk production data on Beetal does (n=127) were recorded on five farms: Livestock Experiment Station (LES), Rakh Kheirewala, (District Layyah), LES, Rakh Ghulaman (District Bhakkar), LES, Alladad (District Khanewal), Livestock Production Research Institute (LPRI), Bahadurnagar (District Okara) and LES, University of Agriculture, Faisalabad (UAF). The animals were allowed to graze from 0800 AM to 1700 PM routinely. No concentrate were offered at any farm. Water was offered twice daily. The animals were kept indoors at night. Similar management practices were performed on all of the farms. Animal ID, sire ID, dam ID were obtained from the birth record registers maintained at these farms. Data comprised of following body measurements and milk production traits: Head length, Head girth (above and below eyes), Ear to ear distance, Mouth width, Ear length and Ear blade width, Neck length and neck girth, Body weight, Body length, Heart girth and Body depth at heart, Belly girth and Body depth at belly, Ribs sprung and belly sprung, Rump length, rump width at back and front, Rump height and withers height, Tail length, tail diameter and circumference at base, mid and end, Forelimb (sole to elbow), Fore arm, shank and thigh circumferences, Hind limb (sole to stifle), Teat length, teat diameter and

teat circumference, Teat placement (distance between tips of two teats), Lactation milk yield and lactation length.

Linear body traits (cm) were measured by tailor tape, vernier calipers, graduated rods and steel tape, while milk production was measured by graduated beakers in milliliters. Length of lactation was measured in days from kidding till drying off of the animals. Body weights (kg) were measured by a weigh bridge.

Statistical model: Univariate animal model was used for estimating heritability of conformation traits and bivariate model for estimating genetic and phenotypic correlations between body measurements and milk production traits. The model included fixed effects of flock and parity and animal additive genetic effect as random. Age of doe was fitted as a covariable. Following mixed effect model was adopted:

$$Y_{ijkl} = \mu + F_i + P_j + Age_k + a_{ijkl} + e_{ijkl}$$

Where,

Y_{ijkl} = Observation on linear body measurement/milk yield/lactation length

μ = population means

F_i = effect of i th flock ($i=1 \dots 5$)

P_j = effect j th parity ($j=1, 2$ or later)

Age_k = age of doe at the time of kidding

a_{ijkl} = additive genetic effect of animal

e_{ijkl} = random error

ASREML (Gilmour *et al.*, 2007) computer program was used for estimating (co)variance components for these traits. Genetic parameters were obtained by post-processing of (co)variance components. Forward regression was performed for the selection of traits having significant correlations with milk traits.

RESULTS

Regression coefficients for dependence of body measurements on age are given in Table 1. Heritability estimates for conformation traits are presented in Table 2 and genetic and phenotypic correlations between body measurements, LMY and LL are given in Table 3.

Heritability estimates: Heritability estimates for different linear body measurements ranged from 0.004 to 0.99 (Table 2). Heritability estimates for head and neck traits ranged from 0.02 to 0.96. Most of them had h^2 estimates above 0.70, neck length being the highest heritable trait (0.96). For head and neck traits, heritability estimates ranged from 0.30 to 0.99 showing high proportion of genetic variance. Heritability estimates for height and depth traits ranged from 0.004 to 0.90. Heart and belly girths were highly heritable (0.90 and 0.89). The heritability estimates for length of fore limb (sole to elbow), length of hind limb (sole to stifle), fore arm, shank and thigh circumferences were 0.73, 0.17, 0.81, 0.94 and 0.04, respectively. The heritability estimate for

teat length, teat diameter and teat placement were 0.84, 0.45 and 0.13, respectively.

Genetic and phenotypic correlations

Head and neck traits and milk traits: Genetic and phenotypic correlations between head and neck traits and lactation milk yield (LMY) ranged from -0.40 to 0.88 and -0.33 to 0.90, respectively. Corresponding correlations with lactation length (LL) ranged from -0.64 to 0.54 and -0.46 to 0.51, respectively. Genetic correlations of head length, mouth width, horn length, ear length and neck length were 0.39, 0.42, 0.67, -0.40, and 0.56 with LMY and 0.15, -0.002, 0.11, -0.64 and 0.54 with LL, respectively. Corresponding phenotypic correlations were 0.09, -0.28, 0.90, -0.33 and 0.42 with LMY and 0.10, 0.28, -0.01, -0.46 and 0.44 with LL, respectively.

Back and tail traits and milk traits: Genetic and phenotypic correlations between back traits and tail and LMY ranged from -0.41 to 0.48 and -0.23 to 0.44, respectively. Corresponding correlations with LL ranged from -0.29 to 0.47 and -0.27 to 0.44, respectively. Genetic correlations of rump length, tail length and tail circumference at base (TCB) with LMY and LL were 0.47, 0.39 and -0.41 and 0.47, 0.36 and -0.29, respectively. Corresponding phenotypic correlations were 0.44, 0.37 and -0.23 and 0.44, 0.26 and -0.19, respectively.

Body weight, height and depth traits and milk traits: Genetic and phenotypic correlations between body weight, height and depth traits and LMY ranged from 0.37 to 0.82 and 0.16 to 0.44, respectively. Corresponding correlations with LL ranged from -0.69 to 0.52 and 0.13 to 0.89, respectively. Genetic correlations of body length, heart girth, body depth at heart, rib sprung and body weight with LMY and LL were 0.37, 0.43, 0.41, 0.73 and 0.59 and 0.24, 0.33, 0.28, 0.30 and 0.52, respectively. Corresponding phenotypic correlations were 0.17, 0.34, 0.29, 0.44 and 0.34 and 0.13, 0.29, 0.22, 0.30 and 0.89, respectively.

Leg traits and milk traits: Genetic and phenotypic correlations between leg traits and LMY ranged from -0.40 to 0.45 and -0.25 to 0.41, respectively. Corresponding correlations with LL ranged from -0.35 to 0.49 and -0.21 to 0.49, respectively.

Genetic correlations of length of fore limb (sole to elbow), hind limb (sole to stifle) and shank circumference with LMY and LL were -0.40, 0.4 and 0.39 and -0.35, 0.49 and 0.39, respectively. Corresponding phenotypic correlations were -0.25, 0.41 and 0.37 and -0.21, 0.49 and 0.29, respectively.

Teat traits and milk traits: Genetic correlations of teat length, teat diameter and teat placement with LMY and LL were 0.42, 0.03 and 0.05 and 0.29, 0.05 and 0.64,

respectively. Corresponding phenotypic correlations were 0.38, 0.08 and 0.18 and 0.26, 0.10 and 0.22, respectively.

Table 1. Linear (b1) and quadratic (b2) regression coefficients for age of does at the time of recording.

Trait (in cm units)	Significance	Regression		
		a	b1	b2
Head length	NS	20.22	0.037	-0.000
Head girth above eyes	NS	44.25	0.069	-0.001
Head girth below eyes	NS	33.32	0.009	-0.000
Eye to distance	NS	9.89	0.095	-0.001
Horn to horn distance	NS	13.29	0.016	-0.000
Mouth width	NS	3.71	-0.003	0.000
Horn length	*	10.12	0.071	0.071
Ear length	NS	23.97	-0.012	0.000
Ear blade width	**	10.92	-0.048	0.000
Neck length	NS	27.43	-0.031	0.000
Neck girth	NS	33.72	-0.025	0.000
Body length	NS	68.40	-0.036	0.000
Heart girth	NS	79.54	-0.068	0.001
Belly girth	NS	85.55	-0.039	0.000
Body depth at heart	NS	29.53	0.004	-0.000
Body depth at belly	NS	31.34	0.003	-0.000
Rib sprung	NS	25.39	-0.028	0.000
Belly sprung	NS	22.46	-0.033	0.000
Rump width at front	NS	14.25	-0.001	0.000
Rump width at back	NS	12.80	0.011	-0.000
Rump length	NS	15.56	-0.028	0.000
Body weight (Kg)	NS	35.37	0.026	-0.000
Tail length	*	15.86	0.059	-0.001
Tail diameter at base	NS	3.15	-0.004	0.000
Tail diameter at mid	*	2.46	-0.012	0.000
Tail diameter at end	NS	1.39	-0.002	0.000
Tail circumference at base	NS	9.89	-0.012	0.000
Tail circumference at mid	*	7.69	-0.035	0.000
Tail circumference at end	NS	4.35	-0.007	0.000
Forearm-sole to elbow	NS	21.74	0.054	-0.001
Fore arm circumference	NS	8.91	0.018	-0.000
Hind Limb Sole to Stifle	NS	44.74	-0.081	0.000
Shank circumference	NS	9.56	0.009	-0.000
Thigh circumference	NS	24.42	-0.034	0.000
Rump height	NS	76.65	-0.053	0.000
Wither height	NS	79.98	-0.006	-0.000
Teat length	NS	8.12	0.016	-0.000
Teat circumference	**	13.08	-0.117	0.001
Teat diameter	**	4.37	-0.045	0.000
Teat placement	NS	7.62	-0.001	0.000

!Body weight in kg; NS = Non significant (P>0.05); *P<0.05; **P<0.01

Table 2. Heritability estimates and standard errors of linear body measurement traits.

Trait(in cm units)	h ² ±s.e	Trait(in cm units)	h ² ±s.e
Head length	0.0599± 0.0985	Rump length	0.9362±0.0071
Head girth above eyes	0.8076± 0.0213	Body weight(kg)	0.4080±0.0626
Head girth below eyes	0.7040± 0.0325	Tail length	0.8501±0.0165
Eye to distance	0.8654± 0.0145	Tail diameter at base	0.6941±0.0334
Horn to horn distance	0.0187± 0.0000	Tail diameter at mid	0.9882± 0.0000
Mouth width	0.7961± 0.0001	Tail diameter at end	0.9258± 0.0000
Horn length	0.0698± 0.0000	Tail circumference at base	0.7571± 0.0269

Ear length	0.7384± 0.0307	Tail circumference at mid	0.9890± 0.0000
Ear blade width	0.9060± 0.0102	Tail circumference at end	0.8901± 0.0124
Neck length	0.9588± 0.0046	Forearm-sole to elbow	0.7310± 0.0301
Neck girth	0.9016± 0.0110	Fore arm circumference	0.8128± 0.0207
Body length	0.3326± 0.0671	Hind Limb-Sole to Stifle	0.1667± 0.0000
Heart girth	0.8986± 0.0111	Shank circumference	0.9352± 0.0071
Belly girth	0.8938± 0.0115	Thigh circumference	0.0437± 0.0000
Body depth at heart	0.7406± 0.0264	Rump height	0.1667± 0.0000
Body depth at belly	0.5226± 0.0519	Wither height	0.8200± 0.0201
Rib sprung	0.5898±0.0453	Teat length	0.8430± 0.0175
Belly sprung	0.0037±0.0000	Teat circumference	0.7694± 0.0242
Rump width at front	0.5492±0.0494	Teat diameter	0.4451± 0.4377
Rump width at back	0.3030±0.0753	Teat placement	0.1292± 0.3616

¹Body weight is in kg

Table 3. Genetic and phenotypic correlations between body measurements and milk yield and lactation length of goats.

¹ Trait(in cm unit)	Lactation Milk Yield		Lactation Length	
	O ² _G	O ² _P	O ² _G	O ² _P
Head length	0.39±0.48	0.09±0.09	0.15±0.39	0.10±0.09
Head girth above eyes	0.53±0.09	0.38±0.07	0.34±0.09	0.27±0.08
Head girth below eyes	0.32±0.11	0.18±0.08	0.11±0.11	0.07±0.09
Ear to ear distance	0.37±0.09	0.25±0.08	0.22±0.09	0.18±0.08
Mouth width	0.42±0.00	-0.28±0.00	-0.00±0.00	0.28±0.00
Ear length	-0.40±0.09	-0.33±0.07	-0.64±0.07	-0.46±0.07
Ear blade width	0.39±0.08	0.34±0.07	0.43±0.08	0.32±0.07
Neck length	0.56±0.08	0.42±0.07	0.54±0.07	0.44±0.07
Neck girth	0.59±0.07	0.48±0.07	0.54±0.07	0.51±0.06
Body length	0.37±0.16	0.17±0.08	0.24±0.15	0.13±0.08
Heart girth	0.43±0.09	0.34±0.08	0.33±0.08	0.29±0.08
Belly girth	0.41±0.09	0.32±0.08	0.25±0.09	0.22±0.08
Body depth at heart	0.42±0.09	0.29±0.07	0.28±0.09	0.22±0.07
Body depth at belly	0.82±0.09	0.43±0.07	0.28±0.11	0.29±0.08
Rib sprung	0.73±0.09	0.44±0.07	0.30±0.11	0.30±0.08
Belly sprung	-0.16±0.08	-0.69±0.54	0.06±0.09	-
Rump width at front	0.02±0.00	0.05±0.00	-0.00±0.00	-0.01±0.00
Rump width at back	0.03±0.01	0.08±0.01	0.07±0.01	0.03±0.00
Rump length	0.47±0.08	0.44±0.07	0.47±0.07	0.44±0.07
Body weight(kg)	0.59±0.12	0.34±0.07	0.52±0.07	0.89±0.10
Tail length	0.39±0.08	0.37±0.07	0.36±0.09	0.26±0.08
Tail diameter at base	0.48±0.11	0.28±0.08	0.33±0.11	0.22±0.09
Tail diameter at mid	0.00±0.00	0.04±0.07	0.00±0.00	0.06±0.07
Tail diameter at end	0.00±0.00	0.20±0.08	0.00±0.00	0.14±0.09
Tail circumference at base	-0.41±0.11	-0.23±0.08	-0.29±0.10	-0.19±0.09
Tail circumference at mid	0.00±0.00	0.03±0.07	0.00±0.00	0.11±0.07
Tail circumference at end	-0.23±0.09	-0.21±0.08	-0.30±0.08	-0.27±0.07
Forelimb-sole to elbow	-0.40±0.10	-0.25±0.08	-0.35±0.10	-0.21±0.09
Fore arm circumference	0.45±0.09	0.34±0.08	0.41±0.09	0.33±0.08
Hind limb sole to stifle	0.41±0.00	0.41±0.00	0.49±0.00	0.49±0.00
Shank circumference	0.39±0.08	0.37±0.07	0.39±0.08	0.29±0.07
Thigh circumference	-0.04±0.00	0.03±0.00	-0.07±0.00	-0.04±0.00
Rump height	0.32±0.00	0.33±0.00	0.35±0.00	0.35±0.00
Wither height	0.49±0.08	0.41±0.07	0.33±0.09	0.28±0.07
Teat length	0.42±0.08	0.38±0.07	0.29±0.09	0.26±0.07
Teat circumference	0.35±0.02	0.21±0.01	0.23±0.02	0.16±0.01
Teat diameter	0.03±0.02	0.08±0.08	0.05±0.02	0.10±0.08
Teat placement	0.05±0.59	0.18±0.08	0.64±0.88	0.22±0.07

¹Body weight is in Kg; LMY= Lactation milk yield; LL=Lactation length

DISCUSSION

Body measurements are key indicators of milk production in goats. Knowledge of their genetic control helps making in decisions about selection based on body measurements. We can predict the milk producing ability of does just by taking a few body measurements because they have positive and high correlations with milk production traits.

Heritability estimates for head and neck traits had a wide range (0.02 to 0.96). The horn to horn distance was least heritable while neck length was the most heritable character in Beetal goats. Ear and neck traits were also highly heritable. Body weight, height and depth traits also had high heritability estimates (0.33 to 0.90) except for belly sprung which was lowly heritable (0.04). Heritability estimates for body weight as found in present study matched with (Otuma and Osakwe, 2008) who found heritability estimate of 0.42 for 18 month weight in Sahelian goats. Present finding was lower than reported by Mavrogenis and Papachristoforou (2000) who reported very high heritability of these traits in goat and sheep. Heritability estimates for leg traits ranged from 0.04 to 0.94, except for thigh circumference which was least heritable (0.04). Back and tail traits had heritability value from 0.17 to 0.94 while teat related traits had 0.13 to 0.84. The results of the present study matched with those of Luo *et al.* (1997) for most traits. Estimates for withers height, rump width (back) and teat diameter (base) showed similarity but teat placement did not match. The present findings were also in line with Janssens and Vandepitte (2004). Estimates of present study were quite higher than reported by Mandal *et al.* (2008) for body length, withers height and heart girth. Heritability estimates of present study for teat traits were higher than reported by Manfredi *et al.* (2001) who also reported high estimates. Some of the body measurement were having high heritability might be due the reasons that the flocks were almost remained close for a longer period of time without introduction of foreign genetic material and also only few bucks served all of the does. Hence intense inbreeding might also be a cause of high heritability estimates. Another reason was that ASREML usually generated high estimates as compared to other software. The genetic and phenotypic correlations between head and milk traits in the present study were generally positive and moderate to high with a few exceptions. Ear length had negative genetic and phenotypic correlations with LMY and LL (-0.40 and -0.33; -0.64 and -0.46, respectively). Length of lactation had low to moderate (positive) correlations with these traits whereas mouth width, horn length and ear length were exceptional cases with negative correlations. Body weight, height and depth traits and LMY had positive genetic and phenotypic correlations (0.37 to 0.82 and 0.16 to 0.44). The corresponding correlations between

height, depth and LL were also positive and ranged from 0.24 to 0.33 and 0.13 to 0.33 showing moderate relationship. The genetic and phenotypic correlations between body weight and milk traits were very far from those reported by Mavrogenis and Papachristoforou (2000) who reported very low correlations in Chios sheep and Damascus goat. The correlations between body weight and milk traits were also much higher than reported by Constantinou (1989). Back and tail traits possessed positive genetic and phenotypic correlations with LMY and LL with few exceptions. The corresponding correlations (positive) ranged from zero to 0.59 and 0.04 to 0.37 for LMY and zero to 0.52 and 0.06 to 0.89 for LL, respectively. Tail circumference had negative genetic and phenotypic correlations with LMY and LL (-0.41 and -0.23; -0.29 and -0.19, respectively). Genetic and phenotypic correlations found in present study were higher than those reported by Khan *et al.* (2005).

The genetic and phenotypic correlation between leg and milk production traits were usually positive except for length of forelimb (sole to stifle) and thigh circumference having negative correlations with milk traits. As far as teat traits were concerned, they had positive genetic and phenotypic associations with milk traits of the grade ranging from 0.03 to 0.49 and from 0.03 to 0.41 with LMY and 0.05 to 0.64 and from 0.10 to 0.35 with LL, where teat length showed high correlations with LMY and LL. The highly heritable conformation traits showed that they are greatly influenced by genetics, hence selection can be useful for improvement. The highland positive correlations (either genetic or phenotypic) among some of the body measurements and milk production traits are important and can be used for early prediction of milk production. Hence they are valuable tools for making selection/culling and other management decisions and can help in improved productivity of animals.

In conclusion, heritability estimates of body measurements of Beetal goats as obtained in the present study were generally low to very high for different traits. Head and horn length, teat placement and belly sprung were very lowly heritable. Rump height also had low heritability. While body weight and length had moderate heritability estimates, all other conformation traits were highly heritable (>0.50). The relationship between linear body measurement and milk production traits of Beetal showed that most of the correlations were positive and high. The relationship between body measurements and milk production traits can be used to predict milk yield. From the relationship between milk yield and body measurements it may be inferred that the goats with better body weight and size produced generally more milk. Teat length and circumference also had positive association with milk yield. The study should be

extended to larger herds and other goat breeds for revealing genetic and phenotypic variability.

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