Iranian Journal of Applied Animal Science

Estimation of Genetic and Phenotypic Parameters of Some Reproductive Traits of Black Bengal Does

Research Article

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Received on: 1 May 2013
Revised on: 28 Jul 2013
Accepted on: 27 Sep 2013
Online Published on: Dec 2013

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Online version is available on: www.ijas.ir

ABSTRACT

The objective of this study was to evaluate genetic and phenotypic parameters for some reproductive traits of Black Bengal does. Genetic parameters were estimated by Residual Maximum Likelihood procedure, fitting an animal model ignoring maternal genetic or permanent environmental effects. The least-squares means of litter size at birth (LSB), litter size at weaning (LSW), litter weight at birth (LWB), litter weight at weaning (LWW) and gestation length were 1.50, 1.29, 1.58 kg, 6.37 kg and 144.71 days, respectively. The effect of parity of doe was significant for LSB, LSW, LWB and LWW. In general, LSB, LSW, LWB and LWW increased with the progress of parity. The effect of season of kidding was significant for LSW, LWB and LWW. Estimates of heritability for LSB, LSW, LWB, LWW and gestation length were 0.08, 0.13, 0.10, 0.00 and 0.18, respectively. The low estimates of heritability obtained for reproductive traits indicated that selection based on the doe's own performance may result in slow genetic improvement.

KEY WORDS Black Bengal does, fixed factors, genetic parameters, heritability, reproductive traits.

INTRODUCTION

With the widespread application of artificial insemination in domestic animals, there has been a growing interest and necessity for more knowledge concerning the reproductive characteristics of farm animals. Reproduction is a complex composite trait influenced by many components including puberty, estrus, ovulation, fertilization, embryo implantation, pregnancy, parturition, lactation, and mothering ability. The genetic effect on each component of reproduction varies (Safari *et al.* 2005). The phenotypic variation of a composite trait is influenced by the level of variability among its component traits and their interactions (Snowder, 2008).

Although component traits of reproduction are under the influence of many genes, a limited number of major genes associated with separate components of reproduction have been reported (Piper and Bindon, 1982; Bradford *et al.* 1986). Reproductive performance in goats is a composite of several processes which are influenced by environmental, developmental, genetic, and managerial factors (Terrill and Foote, 1987). Expressions of the genetic effects on reproduction are affected by numerous environmental factors such as season, climatic conditions, management, health, nutrition, breeding ratio, age and weight of doe, and libido of buck and fertility. Because genetic and environmental factors interact, genetic improvement of reproduction is very complicated.

Genetic improvement of livestock is generally motivated by economics. Economic and biological efficiency of animal production enterprises can generally be improved by increasing reproductive performance (Dickerson, 1970). The goats' reproductive performance is an indicator of their adaptation to the adverse environments (Casey and Van Niekerk, 1988). Reproductive performance is one of the main determinants of productivity of the goat irrespective of their use for meat, milk, skin or hair production. Economic principles applied to livestock production show that reproductive traits are four times more important than production traits (Melton, 1995). Reproductive performance of goats is a major determinant of productivity and economic viability of commercial goat farms. The reproductive process is regulated by genetic and environmental factors and the net effect of all these influences determine the level and efficiency of reproduction. The level of reproductive performance of goats is dependent on genetic and environmental factors, but this performance is particularly sensitive to the latter (Riera, 1982; Song *et al*. 2006). A high rate of reproductive efficiency is often thought to be the most important prerequisite for the production of meat, milk, skins, and breeding stock (Terrill and Foote, 1987; Steinbach, 1988; Wilson, 1989). Reproduction efficiency in female goats is determined by many different processes (Shelton, 1978).

These processes include, for example, the length of the breeding season, cyclic activity, ovulation rate, fertilization rate, the post-partum anoestrous period and the growth and viability of the offspring. Reproductive efficiency as such can be measured and expressed as the kidding rate, weaning rate, kidding interval, live weight of kids born or weaned and the length of the reproductive cycle (Greyling, 1988; Greyling, 2000). The goat is the most prolific of all domestic ruminants under tropical and sub-tropical conditions and certain breeds are able to breed throughout the year, while other breeds like, for example, the Angora have a restricted breeding season (Shelton, 1978; Van der Westhuysen, 1980).

Flock reproductive rate also affects selection intensity and consequently the rate of genetic improvement in all traits under selection (Abegaz *et al*. 2002). Furthermore, improvement of the reproduction rate supports the increase of the selection intensity and genetic progress of production traits (Bagnicka *et al*. 2007). Reproduction is a major contributing factor to efficiency of meat production and makes an important contribution by a) influencing the number of surplus animals which may be utilized for meat and b) contributing to current and future production through culling (Shelton, 1978).

Moaeen-Ud-Din *et al*. (2008) stated that reproductive efficiency of goats can be established based on number of live born kids, mass of kids at birth and weaning, kidding interval and duration of reproduction cycle, whereas Song *et al*. (2006) stated that reproductive efficiency of goats is determined by age of goats at first kidding, kidding interval, litter size and mass of kids at birth and weaning.

Reproductive efficiency is one of the important preconditions for increasing production potential in any given environment.

In order to evaluate the productive ability of goats, prolificacy and birth weight are considered the most important and economic criteria. The number of young born alive per kidding is an important factor in increasing productivity as it contributes more to the total weight weaned per dam than the growth rate of the kid (Bradford, 1985).

Reproductive development is affected by genetic and environmental factors and the interaction between these factors (Land, 1978).

Genetic improvements of growth rate and of reproductive traits are both important to increase meat production (Dickerson, 1978). Improvement of reproductive traits can have more economic impact than improving growth rate (Wang and Dickerson, 1991). Reproductive traits have lower heritability than growth rate. Low heritability of reproductive traits is probably due to the greater proportional influence of environmental effects as well as little genetic variability for fertility, litter size, lamb survival and lambing frequency and other reproductive traits (Turner and Young, 1969).

Though heritability of reproduction traits for dairy cattle is generally low (Pryce *et al*. 1998; Veerkamp *et al*. 2001) or moderate for some breeds of sheep (Okut *et al*. 1999), the reproduction traits are oftentimes elements of the breeding objective, as for example in Scandinavia for dairy cattle (Berglund and Philipsson, 2001).

In sheep breeding, genetic improvement of reproductive traits is at least as important for increasing lamb-meat production as the improvement of the growth rate (Dickerson, 1978).

Incorporating the reproduction complex into the breeding objective requires knowledge of the variance / covariance components of the traits involved.

To date only limited published reports (Odubote, 1992) have estimated genetic properties for metric traits in goat populations reared in tropical and subtropical environments. On the other hand, in Bangladesh, no estimates of genetic parameters for reproduction characteristics of Black Bengal goats are available.

Therefore, the purpose of this study was (1) to examine the effects of different factors on reproductive traits of Black Bengal goat; and (2) to estimate variance components and heritability for some reproductive traits of Black Bengal goat.

MATERIALS AND METHODS

Location

The study was conducted from April 2007 to March 2011 in the Nucleus Breeding Flock (NBF) at the Artificial Insemination Centre under the Department of Animal Breeding and Genetics, Bangladesh Agricultural University, Mymensingh.

Animals and management

A total of 63 Black Bengal does were used in this study. The animals were reared semi intensively. They were housed indoors grouped in stalls in a galvanized iron sheet shed with a wooden slatted floor raised above the ground level.

The house was provided with necessary arrangements for feeding and watering with provision of sufficient access to fresh air and freedom of movement. The does were stall fed twice daily on a diet consisting of Napier, German and/or Maize fodder as per requirement. The feed was supplemented with commercial concentrate (Surma Feed, BRAC Feed Mill, Sreepur, Gazipur) in pellet form in the morning and again in the afternoon at the rate of 250 g/doe/day (crude protein content: 23%; crude fat: 6.5%; crude ash: 10%; crude fiber: 4%; NFE: 45.45%; moisture: 11% and energy content: 3100 kcal ME/kg DM). Grazing was also allowed for animals four hours at morning all over the year except during inclement weather. Animals in an advanced stage of pregnancy were kept in maternity pens under close observation for kidding and proper care of kids during and after birth. Clean and safe water was made available at all times.

Throughout this study the nutrition of animals remained uniform. Animals were clinically examined regarding the health of their external genitalia. Immediate veterinary assistance was given as and when necessary. The health care package includes dipping, deworming and routine vaccination against *Peste des Petits Ruminants* (PPR). All the females were inseminated with frozen semen of the Black Bengal bucks maintained at NBF. Inbreeding was avoided in the flock.

Selection among dams was limited and the little amount of culling was done, mostly on disease grounds. All the breeding animal and progeny were identified with neckband tags in order to maintain their individual identity and pedigree.

The identities of newborns and their parents, date of insemination, date of kidding, sex of kid, litter size and parity of does were recorded. For each individual under study a record sheet with full details of each parameter along with pedigree information were maintained. New-born kids were allowed to suckle their does and were left with them up to 3 month of age. Kids were weaned at 3-month of age.

Following weaning, kids were offered 50-100 g/head/day of the same commercial concentrate. All the female kids were kept in shed with their dams, but males over 3 month of age were housed separately in individual pens of one square meter in the buck shed to avoid uncontrolled breeding. The female kids were monitored from 90 days of age until all females showed at least the first oestrous cycle (period between the first oestrous behavior and the subsequent oestrus). The oestrous behavior was checked every day at 6:00 and 17:00 h with the aid of an androgenized female goat. Oestrus was noted if the female stood willing for the androgenized female to mount her. No castration was performed on the male kids. Body weight (kg) was recorded in the morning before the animals were fed.

Traits analysed

The following parameters were investigated: litter size at birth (LSB), litter size at weaning (LSW), litter weight at birth (LWB, kg) and gestation length (GL, days).

Statistical analyses

The significance of fixed effects (nongenetic factors) was tested by least-squares analyses of variance using the general linear model (GLM) procedure of the Statistical Analysis System (SAS, 1996) according to the following linear model:

$$Y_{ijk} = \mu + S_i + M_j + E_{ijk}$$

Where:
Y_{ijk}: the dependent variable.
μ: the overall mean.
S_i: the fixed effect of i^{th} parity.
M_j: the fixed effect of j^{th} season of kidding.
E_{ijk}: the residual error.

The year was divided into three seasons; winter (from November to February), summer (from March to June) and rainy (from July to October). The significant means were separated using the Duncan's multiple range test. Genetic parameters were estimated with Residual Maximum Likelihood (REML) procedure fitting an animal model using VCE 4.2.5 software (Groeneveld, 1998). The models used to estimate genetic parameters included random effects and all fixed effects that were found significant in least-squares analysis. The model fitted was as follows:

$$y = Xb + Za + e$$

where:
y: vector of observations.
b: vector of fixed effects.
a; vector of random animal effects (direct genetic).

X: incidence matrix for fixed effects.
Z: incidence matrix for random effects.
e: vector of random residual effects.

It was assumed that all effects in the models are independent and normally distributed.

RESULTS AND DISCUSSION

Descriptive statistics for female reproductive traits of Black Bengal goats are provided in Table 1. The mean LSB, LSW, LWB (kg) and GL (days) were 1.50, 1.29, 1.58 and 144.71, respectively. Highest coefficient of variation (52.84%) was observed for LSW and the lowest (3.61%) for GL. Average LSB for Black Bengal goat has been reported to be of 2.31 (Moulick *et al.* 1966), 1.4, 2.15 (Amin *et al.* 2001), and 1.6 (Hossain *et al.* 2004) which confirms the reputation of Black Bengal goats for high fecundity. Recognized, highly productive breeds like Alpine or Saanen have mean prolificacy of about 1.6-1.8 (Devendra, 1984; Amoah *et al.* 1996; Santucci, 1995). Prolificacy found in the Black Bengal goats is as in highly productive breeds. Litter size at birth of Black Bengal goats in the present study was higher than that of Verma *et al.* (1991) who observed that the average litter size of Black Bengal goat was 1.10.

The result was lower than those of Moulick *et al.* (1966), Mia (1992), Ghosh *et al.* (1994), Amin *et al.* (2001) and Hoque *et al.* (2002), and close to Hossain *et al.* (2004). Variations in these results might be due to the effect of agroclimatic and managemental conditions. The overall mean for LSW obtained in this study was 1.29 kids. This result was very close with the figure reported by Song *et al.* (2006) of 1.31 kids for Korean native goats and lower than the figure reported by Hamed *et al.* (2009) of 1.60 kids for Zaraibi goats in Egypt. The observed LWB of Black Bengal goats was lower than that of Hoque *et al.* (2002) for Black Bengal goat in Bangladesh. The GL in the present study was almost similar with those observed by Kanaujia and Pander (1988), Gangwar and Yadav (1987), Verma *et al.* (1991) and Mia (1992) but slightly lower than those of Ali *et al.* (1973), Ray *et al.* (1994), Ghosh *et al.* (1994), Hoque *et al.* (2002) and Hossain *et al.* (2004). The influence of nutrition on foetal development during certain months of pregnancy does tend to shorten or lengthen the gestation period, but the variation due to this factor was only 1.5 days (Riera, 1982).

Shelton (1960), Peaker (1978) and Amoah and Bryant (1983) reported that gestation period was shortened approximately by one day for does carrying twins compared to singles.

Fixed effects

Least-squares means and standard errors for LSB, LSW, LWB (kg) and GL (days) of Black Bengal does are shown in Table 2.

Parity of dam

As regards to parity, maximum and minimum litter size and weight were found in kids of 3rd and 1st parity, respectively (Table 2). Litter size at birth, LSW and LWB (kg) increased significantly ($P<0.01$) as parity progressed. Husain *et al.* (1996) noticed that among the four parities, kid's birth weight was lower in 1st parity does compared to 2nd, 3rd and 4th parity. This may be due to improved efficiency of reproduction as the doe matures (Levasseur and Thibault, 1980). The increase in litter size was reported to continue to the fourth parity (Maria and Ascaso, 1999) or to the seventh (Rajab *et al.* 1992) and six (Fogarty *et al.* 2000) years of age and declined thereafter. The increase in litter size with advance in age and parity is the result of increased ovulation rate, uterine capacity and other maternal traits affecting the reproductive efficiency (Fahmy, 1990). It must be stressed that litter size is not directly influenced by management only but also by both genetic and environmental factors (Wilson *et al.* 1989). Parity of doe significantly influenced LSB, LSW and LWB (kg), first kidding being the smallest which was in agreement with the findings of Mohamed (1990), Cabello *et al.* (1992), Mourad (1996), Odubote (1996), Garcia *et al.* (1996), Crepaldi *et al.* (1999), Kale and Tomer (1999), Marai *et al.* (2002), Hoque *et al.* (2002), Song (2003) and Hamed *et al.* (2009). The increase in productivity with parity indicates improvement of reproductive traits as does reach maturity. The effect of parity on GL was found to be non-significant in the present study. Almost similar findings for GL were reported by Das and Tomer (1987), Gangwar and Yadav (1987), Amoah and Gelaye (1990), Deshpande and Mehta (1992) and Hossain *et al.* (2004) in Indian goats, respectively.

Season of kidding

No significant effect existed for the season of kidding even though the highest LSB were registered for goats kidding in winter.

Table 1 Basic statistics for female reproductive traits of Black Bengal goats

Trait	No. of records	Minimum	Maximum	LSM	SD	CV (%)
Litter size at birth	114	1.00	3.00	1.50	0.55	34.64
Litter size at weaning	89	1.00	2.00	1.29	0.45	52.84
Litter weight (kg) at birth	114	0.70	3.28	1.58	0.68	39.59
Gestation length (days)	92	137.00	151.00	144.71	2.94	3.61

LSM: least squares means; SD: standard deviation and CV: coffiecient of variation.

The trend of the effect of season on LSB is not clear. These results were similar to those published by other workers (Galina *et al*. 1995; Odubote, 1996; Silva *et al.* 1998; Crepaldi *et al*. 1999; Song, 2003).

Table 2 Least-squares means with standard errors of litter size at birth (LSB), litter size at weaning (LSW), litter weight at birth (LWB, kg) and gestation length (GL, days) of Black Bengal does according to parity of dam and season of kidding

Factors	LSB	LSW	LWB	GL
Parity of dam	**	*	**	NS
First	$1.37^{b}\pm$ 0.07	$1.04^{b}\pm$ 0.09	$1.25^{c}\pm$ 0.09	144.26± 1.01
Second	$1.52^{ab}\pm$ 0.10	$1.12^{a}\pm$ 0.12	$1.69^{b}\pm$ 0.13	145.07± 1.17
Third	$1.84^{a}\pm$ 0.14	$1.21^{a}\pm$ 0.17	$2.05^{a}\pm$ 0.17	143.25± 1.61
Season of kidding	NS	*	*	NS
Winter	1.54± 0.10	$1.27^{a}\pm$ 0.19	$1.77^{a}\pm$ 0.12	144.55± 1.12
Summer	1.47± 0.08	$1.09^{ab}\pm$ 0.16	$1.64^{ab}\pm$ 0.09	144.80± 1.12
Rainy	1.52± 0.14	$0.81^{b}\pm$ 0.23	$1.41^{b}\pm$ 0.18	143.23± 1.90

The means within the same column with at least one common letter, do not have significant difference (P>0.05).
* (P<0.05) and ** (P<0.01).
NS: non significant.

On the other hand, significantly highest LSW was observed in winter and the smallest litter came during the rainy season. This result is in agreement with those reported by Boujenane *et al*. (1998), Gbangboche *et al*. (2006) and Hamed *et al*. (2009). Litter weight (kg) at birth was also significantly affected by season of kidding. However, there is no literature reference to compare the result.

The present study also indicated that season of kidding had no influence on the GL in Black Bengal goats which was supported by Mishra *et al*. (1979) and Sinha and Sahni (1982).

Variance components and heritability estimation

Estimates of additive genetic variance (σ^2a), residual variance (σ^2e), phenotypic variance (σ^2p) and heritability (h^2) of LSB, LSW, LWB (kg) and GL (days) of Black Bengal kids are in Table 3.

Table 3 Estimates of additive genetic variance (σ^2a), residual variance (σ^2e), phenotypic variance (σ^2p) and heritability (h^2) of litter size at birth (LSB), litter size at weaning (LSW), litter weight at birth (LWB, kg) and gestation length (GL, days) of Black Bengal kids

Trait	σ^2a	σ^2e	σ^2p	h^2
LSB	0.021	0.228	0.249	0.08±0.09
LSW	0.026	0.169	0.195	0.13±0.14
LWB	0.036	0.340	0.376	0.10±0.10
GL	1.347	6.235	7.582	0.18±0.13

It appears from Table 3 that heritability estimates of those traits are rather low, and reflect the generally small genetic variance for the reproductive traits. Low heritability of reproductive traits is probably due to the greater proportional influence of environmental effects as well as little genetic variability for fertility, litter size, lamb survival and lambing frequency and other reproductive traits (Turner and Young, 1969).

Heritability estimate for LSB obtained in this study is in agreement with the findings of Adu *et al.* (1979) for Red Soko goat in Nigeria, Devendra (1984) for Alpine goat in France and Black Bengal goat in India, for Black Bengal goat in India, Hamed *et al.* (2009) for Zaraibi goats in Egypt, Amble *et al.* (1964) for Black Bengal and Beetal goat and Marquez *et al*. (2003) for Nubian, French Alpine, Toggenburgh, and Spanish goats mated to Boer sires.

Land *et al.* (1983) reviewed literature on heritability estimates of litter size in sheep and found an average of 0.10. Bradford (1985) pointed out that heritability of litter size is quite low and, summarizing over 30 estimates for different breeds and methods of estimation, reported a range from 0.15 to 0.35 and a mean of 0.10. In an extended literature review, Fogarty (1995) reported average heritability of 0.07 from estimates based on REML. Using the same method, Al-Shorepy and Notter (1994) and Okut *et al.* (1999) reported values of 0.05-0.10 and 0.01-0.17, respectively for heritability of LSB. Analla *et al.* (1997) found heritability estimates of 0.08 for Spanish Segurena sheep. Similar estimates of heritability from animal models were also reported (Maria, 1995; Altarriba *et al.* 1998; Davis *et al.* 1998; Kominakis *et al*. 1998; Bromley *et al*. 2001; Hanford *et al*. 2002; Matika *et al*. 2003; Hanford *et al*. 2005). Sakul *et al.* (1999) reported a lower estimate of realized heritability (0.01) and a similar mixed-model estimate of heritability (0.09) for lambs born for grade Targhee ewes managed in a range environment. Nagy *et al*. (1999) reported heritability for LSB of Hungarian Merino ewes from 0.02 to 0.07 depending on the age of ewe.

Heritability estimate of LSW in this study (Table 3) is higher than those reported by (Abdel Raheem, 1998; 0.05) for Zaraibi goats in Egypt or breed like West African Dwarf goats (Odubote, 1996; 0.03).

Neopane (2000) applied two different analyses to estimate the heritability of LSW for Hill goats in Nepal and found that the heritability of LSW in first analysis (Harvey) was 0.05 while in second analysis (REML) was lower (0.03). Van Haandel and Visscher (1995) reported heritabilities for LSB and LSW were 0.16 and 0.08, respectively. Neopane (2000) reported the heritability estimate for LWB and GL for Hill goats in Nepal to be 0.21 and 0.03, respectively. The heritability estimate for LSW is also higher than the estimate of 0.04 reported by Burfening *et al.* (1993) for Rambouillet ewes, the weighted mean of reported estimates of 0.05 reported by Fogarty (1995) and the estimate of 0.06

reported by Hanford *et al*. (2005) for Rambouillet ewes. The estimate is also higher than the estimate of 0.02 reported by Bradford *et al*. (1999) for the same grade Targhee ewes used in Sakul *et al*. (1999).

Heritability estimates of most reproductive traits are negligible to low. Van Wyk *et al*. (2003) estimated h^2 to be 0.06, 0.03 and 0.11 for LSB, LSW and LWB, respectively. Estimates of h^2 for mutton and wool type dual-purpose breeds (Columbia, Rambouillet, Targhee, Polypay) were from 0.07 to 0.16 for LSB and from 0.06 to 0.11 for LSW (Matos *et al*. 1997; Rao and Notter, 2000; Bromley *et al*. 2000; Hanford *et al*. 2002).

Heritability estimate for GL in this study is low. It is quite difficult to compare this result to the literature, because there were no estimates reported on the heritability for GL in goats except a few. Neopane, (2000) applied two different analysis to estimate the heritability of GL for Hill goats in Nepal and found the heritability of GL in first analysis (Harvey) as 0.21 while in second analysis (REML) was lower (0.03). Garcia *et al*. (1976) reported heritability of GL for Anglo Nubian and Alpine goat in Venezuela to be 0.11.

Falconer (1989) stated that heritability is a property of the trait of the population and the environmental circumstances to which the animals are subjected. Thus, any change in the components of variance will likely change the estimate of heritability. This could explain the differences in the estimates relevant to different studies.

Heritability estimates were quite small for almost all traits. Heritability estimates may also be influenced by other factors not considered in the model used. The heritability estimates found in this study are in the expected range.

Estimates of heritability of a trait can vary considerably from study to study depending upon breed, population sampled, environmental and management conditions, and errors (both random and systematic) in the estimation procedures. The data set from which these estimates were obtained was relatively small (Table 1), and sampling errors are a consideration.

CONCLUSION

Estimates of heritability for reproductive traits in this study were quite low, indicating that possibility of selection based on doe's own performance to improve these reproductive traits would take a long time. In the next stage, the traits which could be used as selection criteria to indirectly improve doe reproductive traits should be investigated. The low estimates of heritability for reproductive traits indicated the presence of large environmental variances. Hence improvement in these traits through selection may be limited. In order to optimise the reproductive potential of the Black Bengal goat, it is essential to adopt appropriate reproductive management program addressing most important individual traits which are directly involved for increasing lifetime productivity.

ACKNOWLEDGEMENT

This study was a part of my Ph D. work and was supported by the United States Department of Agriculture. I am very thankful to the United States Department of Agriculture for their financial support, Department of Animal Breeding and Genetics, Bangladesh Agricultural University, Mymensingh for logistic support and the authority of Sylhet Agricultural University, Sulhet for granting me study leave to complete the study.

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