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Studies on reproduction and genetic parameters of Black Bengal goat (*Capra hircus bengalensis*) at farmers' field under different agro-climatic zones of West Bengal

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ABSTRACT

The present investigation was conducted on Black Bengal goat maintained in different agro-climatic clusters of West Bengal. Information from 10,348 kids born from 3,138 Black Bengal does during the period April 2010 to March 2019 reared at farmers' fields, was used to study the effect of non-genetic and genetic factors on reproduction traits. Age at first service (AFS) and age at first kidding (AFK) from 1,175 does; service period (SP) and kidding interval (KI) and litter size (LI) were considered for this study. Agro-climatic clusters, year of kidding and season of kidding were included as non-genetic factors whereas; parity of doe was taken as a genetic factor. The mean AFS and AFK were recorded to be 239.86±0.72 and 400.60±2.33 days respectively. The average SP was reported as 88.32±0.93 days, the average KI was 235.48±0.91 days and overall litter size/ kidding were 1.84±0.01 kids. Effect of cluster, season, parity and year of kidding had a significant effect on the reproduction traits. The heritability figures were 0.177±0.125, 0.147±0.118, 0.043±0.106, 0.176±0.091 and 0.182±0.138 for AFS, AFK, KI, SP and LS respectively. Low genetic and phenotypic correlations between KI and LS were observed. The does reared under the Murshidabad and Jhargram clusters showed better reproductive efficiencies than that of other clusters. Low heritability estimates obtained for all reproductive traits in the current study suggested that emphasis should be geared towards improving management practices to combat kid mortality and reduce the kidding intervals.

Keywords: Agro-climatic zones, Black Bengal goat, Genetic parameter, Reproduction

With 34 indigenous registered goat breeds, India is blessed with the world's largest genetic capital for livestock (NBAGR 2018). Domestic demand for goat meat products is growing rapidly for a large human population with economically strong potential customers, and is expected to increase dramatically over the next decades. The state of West Bengal is the breeding ground of the Black Bengal goat, a dwarf breed renowned for its adaptability, fertility, prolificacy, meat delicacy and superior skin quality (Akhtar *et al.* 2006). It is well suited to the hot and humid environment and usually produces twins and triplets. One of the key determinants of goats' productivity is reproductive success. Better production potential could be achieved from goats with high reproductive efficiency and increased litter size (LS) capacity, with a high fertility rate compared to other farm animals (Haque *et al.* 2013) age at sexual maturity, age at first service (AFS), age at first kidding (AFK) and kidding interval (KI) (Maroof *et al.* 2007). The efficiency can be measured by the kidding rate, weaning rate and live weight of kids born or weaned and the length of the reproductive cycle (Okere *et al.* 2011). Reproductive efficiency is often considered to be the most important factor for rising productivity under any given environmental conditions. The extent of reproductive success depends on the relationship between genetic and environmental factors (Greyling 2000). Studies show that many genetic and non-genetic factors also influence the reproductive fitness of various breeds of Indian goats under field conditions (Pathodiya *et al.* 2008, Kumar *et al.* 2011) and organized farms (Singh *et al.* 2002) in Black Bengal and its crosses with Beetal goats. Thus, fixation of performance records for classifiable non-genetic sources of variation is highly recommended to assess precise figures of genetic parameters and breeding values, so that breeding animals with potential genetic merit can be identified and selected for the further genetic improvement program (Thiruvenkadan and Karunanithi 2007). Keeping the above aspects in mind, the study was designed to investigate the influence of non-genetic and genetic factors that affect reproductive performances concerning different agro-climatic clusters of West Bengal, India.

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MATERIALS AND METHODS

The present research work was conducted on 10,348 numbers of kids born from 3,138 Black Bengal does during the period April 2010 to March 2019 maintained at farmers' herd under the project All India Coordinated Research Project on Goat Improvement. Four agro-climatic clusters namely Nadia (Gangetic Alluvial Zone), Sundarban (Coastal Saline Zone), Murshidabad (Old Alluvial Zone) and Jhargram (Undulating Red and Lateritic Zone) of West Bengal were considered for this study with the records for age at first service (AFS) and age at first kidding (AFK) from 1175 does, service period (SP) and kidding interval (KI) from 2,119 does and Litter Size (LI) from 5,665 kiddings. General information (Agro-climatic clusters, the year of kidding, identification number of goats), systematic records of breeding (date of birth of doe, date of service, date of kidding, service period, kidding interval), pedigree information (dam and sire number), date of birth of kids, type of birth, sex of kids, parity of doe (up to first ten parities of doe), the season of birth of doe and kids and survivability of kids during the study period were collected. The records for abortion and stillbirth were excluded from the purview of this study. The generated data were analyzed statistically in IBM SPSS version 21.0 Software. The effect of various non-genetic and genetic factors on reproductive performance was analyzed by one way ANOVA, compared by modified Duncan's Multiple Range Test. Heritability, genetic and phenotypic correlations were estimated by LSMLMW, PC-1 Version, mixed model least squares and maximum likelihood computer program (Harvey 1990). The following statistical model was used for the analysis of traits under study.

$$Y_{ij} = \mu + B_i + e_{ijk}$$

where, Y_{ij}, observation of j^{th} kid born in i^{th} cluster/year/season/sex/parity; μ, the overall mean; B_i , the fixed effect of i^{th} cluster/year/season/sex/parity and e_{ijk}, the residual random error, assumed to be NID (0, σ^2e).

Heritability estimates were obtained by the paternal half-sib correlation method (Becker 1975). The following statistical model was used:

$$Y_{ij} = m + S_i + e_{ijk}$$

where, Y_{ij} , record of the j^{th} daughter of the i^{th} sire; m, overall mean; S_i, effect of the i^{th} sire; and e_{ijk}, residual random error, assumed to be NID (0, σ^2e).

RESULTS AND DISCUSSION

The average AFS was found to be 239.86±0.72 days, which is in close agreement with the earlier report of a study on Black Bengal goat in three adopted villages of West Bengal (Dhara *et al.* 2008). However, lower estimates of AFS (190±1.89 and 209±32.25 days) were reported in different studies of Bangladesh (Zeshmarani *et al.* 2007, Hossain *et al.* 2004). Comparatively higher figures were also recorded in the cross of Beetal and Black Bengal goats (Singh *et al.* 2002). The AFK was estimated as 400.60±2.33 days, which is almost similar to 401.50±32.08 and 405 days recorded in previous studies (Chowdhury *et al.* 2002, Hossain *et al.* 2004). Lower estimates of 360.5±10 days (Hassan *et al.* 2007) and 368.12±16.96 days (Bhowmik *et al.* 2010) were also reported. In contrast, significantly higher estimates of AFK (503.72±40.70 and 448.26±25.48 days) were also reported by Haque *et al.* (2013) and Hasan *et al.* (2015) respectively. SP has been recorded as 88.32±0.93 days, which is very close to the report of Black Bengal and Jamnapari goats (Miah *et al.* 2016) being 86±7.9 and 83.25±24.32 days respectively under semi-intensive condition. Lower estimates (61.8, 37±2.6 and 61±0.14 days) were also reported (Chowdhury *et al.* 2002, Dhara *et al.* 2008) in some studies. Contrary to that, a significantly higher figure (123.84 days) was reported (Haque *et al.* 2013) in Bangladesh. The average kidding interval (KI) recorded in this study was 235.48±0.91 days. Similar findings of KI as 233.47±15.46, 274.60±14.48 day in two groups of Black Bengal goat were also reported earlier (Akhtar *et al.* 2006). Comparatively lower estimates were figured out as 193.10 days and 179±20 days respectively (Hossain *et al.* 2004, Hassan *et al.* 2007) and as 178.23±50 days (semi-intensive system) and 190.20±20 days (extensive system) respectively in a separate study (Hasan *et al.* 2015). However, comparatively higher estimates were also reported (Singh and Mukherjee 1998) as 271.2±2.4 days and 245.06±30.16, 250.13±41.35, 248.72±38.25 days respectively under three different locations (Chowdhury *et al.* 2002). The overall litter size/ kidding were estimated as 1.84±0.01. Different estimates were reported (Faruque *et al.* 2002) with 1.18±0.04 kids and 1.08±0.11, 1.76±0.12, 1.96±0.12 kids for first, second and third parity respectively (Hossain *et al.* 2004).

Effect of agro-climatic clusters on reproductive traits: Reproductive performance during 2010-11 to 2018-19 (Table 1) revealed a significant ($P<0.05$) effect of agro-climatic clusters over different traits under consideration.

Similar results have been reported on AFS and LS in Black Bengal does (Paul *et al.* 2014) and the effect of the cluster on KI and LS was also recorded in Black Bengal goat reared at Gangatia, Borachala and Pachpai villages of Mymensingh, Bangladesh (Choudhury *et al.* 2013).

Effect of season on reproductive performance: The effect of the season of birth of doe on reproductive performance during 2010-11 to 2018-19 has been presented in Table 2. The same incidence was reported on the effect of season of kidding on KI of Black Bengal does (Ray *et al.* 2016). For this reason, the does kid during the monsoon and winter season, had significantly ($P<0.05$) longer KI than those kidded during the summer season.

Effect of the year of kidding on reproductive performance: The effect of the year of kidding on reproductive performance during 2010-11 to 2018-19 has been presented in Table 3.

The observations were similar as reported (Faruque *et al.* 2010, Malik *et al.* 2010) during earlier studies. The year of kidding had a significant effect on AFK in Assam Local goat and their crosses with Beetal goat (Sarma *et al.* 1981).

Effect of parity of doe on reproductive performance: The effect of parity of doe on reproductive performance during 2010-11 to 2018-19 has been presented in Table 4. Similar results on the effect of parity on KI were informed (Hossain *et al.* 2004, Islam *et al.* 2009) and a significant effect of

Table 1. Agro-climatic cluster wise variation of reproductive traits

Agro-climatic cluster	AFS (days)	AFK (days)	SP (days)	KI (days)	LS (No.)
Overall	239.86±0.72 (1175)	400.60±2.33 (1175)	88.32±0.93 (2119)	235.48±0.91 (2119)	1.84±0.01 (5665)
Nadia	246.28^{a} ±0.90 (671)	392.50^{b}±0.88 (671)	91.95^{a}±1.27 (1041)	237.99^{a}±0.26 (1041)	1.90^{b}±0.01 (3206)
Sundarban	235.78^{b}±1.69 (269)	445.14^{a}±9.38 (269)	87.34^{a}±1.61 (732)	236.64^{a}±1.61 (732)	1.84^{b}±0.02 (1503)
Murshidabad	227.94^{c}±1.56 (79)	376.50^{bc}±1.58 (79)	67.70^{c}±4.23 (91)	217.19^{c}±4.28 (91)	2.01^{a}±0.04 (362)
Jhargram	225.31^{c}±1.51 (156)	370.84^{c}±1.53 (156)	83.70^{b}±2.98 (255)	228.47^{b}±2.58 (255)	1.44^{c}±0.02 (594)

Values in parenthesis are the number of observations. Column-wise similar superscripts do not differ significantly (P<0.05).

Table 2. Effect of season on reproductive performance

Season	AFS (days)	AFK (days)	SP (days)	KI (days)	LS (No.)
Overall	239.86±0.72 (1175)	400.60±2.33 (1175)	88.32±0.93 (2119)	235.48±0.91 (2119)	1.84±0.01 (5665)
Summer	234.62^{b}±0.86 (396)	400.45±4.77 (396)	90.21±1.49 (825)	237.48±1.49 (825)	1.83^{b}±0.02 (2051)
Monsoon	241.98^{a}±1.40 (386)	402.49±4.14 (386)	85.89±1.65 (683)	232.68±1.59 (683)	1.88^{a}±0.02 (1898)
Winter	243.05^{a}±1.37 (393)	398.90±3.03 (393)	88.49±1.74 (611)	235.92±1.59 (611)	1.82^{b}±0.02 (1716)

Values in parenthesis are the number of observations. Column-wise similar superscripts do not differ significantly (P<0.05).

Table 3. Effect of the year of kidding on reproductive performance

Year	AFS (days)	AFK (days)	SP (days)	KI (days)	LS (No.)
Overall	239.86±0.72 (1175)	400.60±2.33 (1175)	88.32±0.93 (2119)	235.48±0.91 (2119)	1.84±0.01 (5665)
2010–2011	239.82^{bc}±1.15 (195)	417.50±9.29 (195)	84.08±2.84 (161)	232.20±2.84 (161)	1.84^{ab}±0.03 (677)
2011–2012	239.40^{bc}±1.85 (74)	404.79±10.17 (74)	90.44±2.58 (251)	237.78±2.58 (251)	1.88^{a}±0.03 (512)
2012–2013	237.97^{bc}±1.30 (74)	410.20±10.13 (74)	91.31±2.98 (194)	238.12±2.97 (194)	1.83^{ab}±0.03 (487)
2013–2014	235.70^{bc}±1.20 (94)	404.10±7.43 (94)	90.14±3.01 (195)	237.03±3.00 (195)	1.88^{a}±0.03 (482)
2014–2015	241.93^{b}±1.13 (115)	398.15±3.80 (115)	91.14±3.20 (169)	238.00±3.16 (169)	1.81^{ab}±0.03 (486)
2015–2016	233.49^{c}±1.48 (154)	391.14±7.09 (154)	94.74±3.41 (188)	241.57±3.37 (188)	1.77^{b}±0.03 (715)
2016–2017	236.64^{bc}±1.91 (158)	386.92±2.09 (158)	83.08±2.41 (349)	230.46±2.27 (349)	1.82^{ab}±0.02 (813)
2017–2018	238.85^{bc}±2.89 (137)	389.90±3.57 (137)	88.78±2.68 (289)	234.97±2.52 (289)	1.90^{a}±0.03 (718)
2018–2019	251.13^{a}±3.04 (174)	404.75±5.22 (174)	85.96±2.39 (323)	233.84±2.39 (323)	1.85^{ab}±0.02 (775)

Values in parenthesis are the number of observations. Column-wise similar superscripts do not differ significantly (P<0.05).

Table 4. Effect of parity of doe on reproductive performance

Parity	SP (days)	KI (days)	LS (No.)
Overall	88.32±0.93 (2119)	235.48±0.91 (2119)	1.84±0.01 (5665)
First	–	–	1.38^{c}±0.02 (1184)
Second	92.30^{ab}±2.11 (405)	239.84±2.12 (405)	1.75^{d}±0.02 (1138)
Third	95.49^{a}±2.36 (392)	241.34±2.14 (392)	1.94^{c}±0.02 (1013)
Fourth	87.59^{ab}±2.07 (396)	234.80±2.05 (396)	2.02^{bc}±0.02 (798)
Fifth	83.40^{ab}±2.30 (340)	230.62±2.31 (340)	2.06^{bc}±0.03 (593)
Sixth	85.50^{ab}±2.65 (230)	232.62±2.64 (230)	2.12^{b}±0.04 (406)
Seventh	81.72^{b}±3.25 (168)	229.21±3.24 (168)	2.15^{b}±0.05 (251)
Eighth	84.44^{ab}±4.24 (105)	232.40±4.18 (105)	2.09^{b}±0.06 (152)
Ninth	86.48^{ab}±5.42 (58)	236.31±5.62 (58)	2.15^{b}±0.08 (85)
Tenth	81.28^{b}±9.51 (25)	229.68±9.55 (25)	2.33^{a}±0.11 (45)

Note: Values in parenthesis are the number of observations. Column-wise similar superscripts do not differ significantly (P<0.05).

1985) in Ganjam goat. Almost the same heritability of LS at birth (0.15±0.18) in Black Bengal goat in Bangladesh was reported in an earlier study (Faruque *et al.* 2010).

Genetic and phenotypic correlations of KI with SP as 0.993 and 0.997±0.001 respectively have been reported in Sirohi goat (Gautam *et al.* 2010). The genetic and phenotypic correlations of KI with LS as 0.14±0.6 and 0.11±0.1 respectively were also reported in Tunisian local goats (Atoui *et al.* 2018). Low estimates of heritability obtained in the present study for all reproductive traits indicated that attention should be directed towards the improvement of management practices. Both genetic and phenotypic correlations between KI and LS observed here were low and positive.

The disparities in the reproductive potential of the different agro-climatic clusters can indeed be due to the variation in the genetic make-up of the animals, the variation in the agro-climatic environments of the clusters (temperature, precipitation and humidity, etc.), the accessibility of pastureland and the management techniques followed by the farmers in the various clusters. The agro-climatic conditions of the Murshidabad and Jhargram clusters were proved to be beneficial for the reproductive performance of Black Bengal does. The low and positive genetic and phenotypic association can be an indication that in the subsequent pregnancy, animals with greater kidding interval from the previous kidding are expected to bear more foetuses. The research indicates that, as shown by low heritability and modest associations, there are a wide variety of changes in the kidding interval and service period. To reduce mortality rates, enhanced management efforts and supervision are most desired, which can increase litter size at birth and weaning, and minimize intervals between two successive kidding. More elaborate research work may be carried out encompassing a larger number of goats covering all agro-climatic zones of West Bengal which was beyond the purview of this study. The reproductive performance can be studied in farm conditions along with farmers' fields for a better comparison of results to make a more justified conclusion.

Table 5. Heritability (diagonals), Genetic (below diagonals) and Phenotypic correlation (above diagonal) for reproductive traits

Trait	AFS	AFK	KI	SP	LS
AFS	0.177±0.125	0.323±0.123	–	–	–
AFK	0.286±0.123	0.147±0.118	–	–	–
KI	–	–	0.043±0.106	0.135±0.135	0.064±0.145
SP	–	–	0.138±0.135	0.176±0.091	0.132±0.164
LS	–	–	0.108±0.145	0.032±0.164	0.182±0.138

parity on LS was also reported (Haque *et al.* 2013), whereas, reported a significant effect of parity on postpartum heat period was also revealed in an earlier study (Miah *et al.* 2016).

Genetic parameters of reproductive traits: The heritability and the correlations (genetic and phenotypic) of reproductive traits have been estimated and presented in Table 5.

Similar report on heritability of AFS as 0.153±0.016 in Osmanabadi goat was reported at Maharashtra under scarcity zone (Patil *et al.* 2008). The heritability of AFK and KI was 0.501±0.178, 0.235±0.124 in Sirohi goat in Rajasthan (Shashank 2015) whereas the same as 0.26±0.19, 0.36±0.12 respectively in the indigenous goat of northern Odisha were also recorded (Ray *et al.* 2016). Similar estimates of heritability for SP (0.174±0.027) were reported (Gautam *et al.* 2010) in Sirohi goat. Contrary to that, higher estimates (0.386±0.328) were also reported (Mohanty *et al.*

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