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Evaluation of the reproductive characteristics of Sirohi goats from Udaipur India

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Abstract
The data on reproductive performance of Sirohi goats maintained at AICRP on Sirohi goat at LRS, Udaipur, India, and recorded between 2004-16, were analysed to study the reproductve traits and their genetic control. The overall least squares means of AFC, AFK, KI, SP, GP and DP were 513.20±20.94, 657.20±20.48, 292.03±4.14, 142.17±4.18, 149.95±0.07 and 144.00±4.09 days, respectively while least-squares means for WFC and WFK were 27.84±0.42 and 30.57±0.40 kg, respectively. Sire and Cluster had significant effect on all reproductive traits. Period and season of birth had highly significant effect on AFK. Summer born kids had lowest kidding interval, service period and dry period as compared other season. The heritability estimates of all reproductive traits were moderate (0.13-0.38), except for gestation period, which had low heritability (0.002±0.027). The phenotypic and genetic correlations among the different reproductive traits were positive and high, except for phenotypic correlations between gestation period with kidding interval, service period and dry period which were very low.

Keywords: Genetic correlation, Heritability, Reproductive traits**,** Sirohi goat

Introduction
In the Indian, goat rearing is one of the important branch of livestock in term of the number on animals and the value of the products such as meat, milk and fiber [1]. India is a rich repository of goat genetic resources in the form of 28 well defined breeds by National Bureau of Animal Genetic Resources, India [2]. As per 19th Livestock census, India [3] 26.40% of the livestock population is goats. Goat is a multipurpose animal and mostly reared by poor, marginal and nomadic farmers under the most primitive managemental systems [4]. The goat population of Rajasthan is more than 21.66 million and the ranks first in country with 16% share in total goat population of India Animal Husbandry Department, Rajasthan [5]. Sirohi goat is the predominant goat breed of Rajasthan. The aim of breeding programs is to maximize the rate of genetic progress for economic traits in livestock species. Reproductive traits are the most important traits in all animal production systems. Reproductive efficiency is one of the most important factors affecting production rate in livestock [6]. Therefore, improvement of these traits leads to more efficient goat productions, which are influenced by environmental, developmental, genetic and managemental factors [7]. In the selection process, non-genetic factors that hinder the selection of superior animal to be parent of the next generation by masking the actual breeding worth of these individuals selection Eltawil *et al.* [8]. Thus, identifying those non-genetic factors could help to look for appropriate ways to eliminate biases caused by them and hence more accurate estimation of genetic parameters would be possible. Hence, the reliable estimates of genetic parameters are needed for constructing breeding programs in this breed of goat. Thus, the objective of this study was to estimate the non-genetic and genetic parameters of reproductive traits for Sirohi goat which are essential for developing efficient selection programs for the improvement of reproduction.

Material and Methods
Study area
The study area is located in southern part of Rajasthan, India and situated at 582m above mean sea level (24˚35" N and 73˚43'' E) characterized by semi-arid climatic conditions with undulated topography having an average rainfall of 800 mm mainly during monsoon season from July to September. Similarly, the temperature ranges from 2.3 °C to 42.3 °C. Breeding bucks properly tagged were reared and maintained at LRS under All India Co-ordinated Research Project on goats (AICRP), Vallabhnagar, Udaipur during off breeding season and

distributed amongst identified farmers during breeding seasons. The kids born out of such mating were tagged and their pedigree records were maintained at LRS, Vallabhnagar.

Feeding and management

Animals were allowed to graze freely during day time and during night confined to sheds. Sorghum straw, tree leaves, straw of different pulses and grasses were fed to goats under field conditions. Green and dry fodder was fed to goats by some goat keepers as per availability under field conditions. Goats were vaccinated against enterotoxaemia and Peste des petites ruminants by livestock assistant of project.

Ethical permission

Data were collected from the farmers' flock and animals for closely monitored and were provided managemental inputs as per the farmers. So the ethical permission was not mandatory in case of field data.

Data description

Data for the present study were collected from Sirohi farmers' flocks maintained under AICRP on Sirohi goat at Livestock Research Station, Vallabhnagar, Udaipur. Data on Sirohi goats were collected for age at first conception (AFC) (days), weight at first conception (WFC) (kg), age at first kidding (AFK) (days), weight at first kidding (WFK) (kg), kidding interval (KI) (days), service period (SP) (days), gestation period (GP) (days) and dry period (DP) (days) over a period of 12 years *i.e.* 2004 to 2016. The environmental effects studied were cluster, period and season of birth and dam's body weight at kidding. The data were classified into five clusters viz. Vallabhnagar (Udaipur), Railmagra, Devgarh and Nathdwara (Rajsamand) and Bhadsoda (Chittorgarh). The duration of kidding was divided into 4 periods each consisted of 3 years, viz. P_1 (2004-07), P_2 (2007-10), P_3(2010-13) and P_4 (2013-16) and year was divided into 3 seasons viz. rainy (Jul–Oct), winter (Nov– Feb) and summer (Mar- Jun).

Statistical Analysis

The data were analyzed using Mixed Model Least-squares Maximum Likelihood programme of Harvey, [9]. Heritability and genetic correlation were estimated by paternal half-sib correlation method. Effect of sire was estimated using mixed model incorporating sire as random effect. Whereas, cluster, period and season of birth were estimated as fixed effect. Dam's weight at kidding was estimated by considering it as co-variable. Following statistical model was used to analyze the data.

$$Y_{ijklmnop} = \mu + A_i + B_j + C_k + D_l + b\left(DW_{ijklmno} - \overline{DW}\right) + e_{ijklp}$$

Where,

Y_{ijklp} = *Performance* record of the pth progeny of ith sire belonging to jth cluster, kth season of birth and lth period of birth.

μ = Population mean

A_i = Random effect of ith sire

B_j = Fixed effect of jth cluster (j = 1,2,3,4,5,7,8)

C_k = Fixed effect of kth season of birth (k = 1, 2, 3)

D_l = Fixed effect of lth period of birth (l = 1, 2, 3, 4)

e_{ijklp} = Residual random error associated with Y_{ijklp} and assumed to be identically and independently distributed with mean zero and constant variance.

$b\left(DW_{ijklmno} - \overline{DW}\right)$ = The regression of the trait on dam's weight at kidding

Duncan's multiple range test as modified by Kramer, [10] was used to make pair wise comparisons among the least-squares means.

Results and Discussion

The overall least squares means for female reproductive traits of Sirohi goats' viz., AFC, WFC, AFK, WFK, KI, SP, GP and DP are presented in Table 1. The least squares means of various reproductive traits were related with Singh and Roy [11] in Jamunapari goat, Rai and Singh [12] in Jakharana goats, Kumar *et al.* [13], Pathodiya *et al.* [14], Kumar *et al.* [15], and Yadav *et al.* [16] in Sirohi goats and Patel and Pandey [17] in Mehsana goat.

Age at first conception

The overall least squares mean for age at first conception was estimated as 513.83±20.94 days. Similar estimates are reported by Kumar *et al.* [15], Singh *et al.* [18] and Das *et al.* [19] in Sirohi, Beetal and Assam Local goats, respectively. Lower estimates reported in Sangamneri goats by Deokar *et al.* [20], Mehsana goats by Singh *et al.* [21], Surti goats by Sabapara *et al.* [22], Mahbubnagar goats by Ekambaram *et al.* [23] and in Sirohi goats by Yadav *et al.* [16]. However, comparatively higher estimates were also reported in Sirohi and Mehsana goats by Kumar *et al.* [13] and Patel and Pandey [17] respectively.

Weight at first conception

The overall least squares means for weight at first conception was estimated as 27.84±0.42 kg. Lower estimates were reported in Sirohi goats by Kumar *et al.* [13, 15] and in Mehsana goats by Patel and Pandey [17]. Higher estimates were reported by Kumar *et al.* [24] and Maroof *et al.* [25].

Age at first kidding

The overall least squares mean for age at first kidding was found to be 657.20±20.48 days. The results are in conformity with Das *et al.* [19] in Assam Local goats and in semi-intensive management system of Jakhrana goats by Rai & Singh *et al.* [12]. Lower estimate was reported by Hossain *et al.* [26], Maroof *et al.* [25], Deokar *et al.* [20], Rao *et al.* [27], Sabapara *et al.* [22], Hassan *et al.* [28] and Yadav *et al.* [16]. However, comparatively higher estimate was reported by Kumar *et al.* [13, 15], Kumar *et al.* [24] and Patel and Pandey [17] in Sirohi, Kutchi and Mehsana goats, respectively.

Weight at first kidding

The overall least squares means for weight at first kidding was estimated as 30.57±0.40 kg. The present finding is in close agreement with the reports of Kumar *et al.* [13] in Sirohi goat. Lower estimates were observed in Black Bengal goat by Hossain *et al.* [26], Ganjam goats by Rao *et al.* [27] and in Sirohi goats by Kumar *et al.* [15]. Higher estimate in Kutchi goats was reported by Kumar *et al.* [24] and in Mehsana goats by Patel and Pandey [17].

Kidding Interval

The overall least squares means for kidding interval was estimates as 292.03±4.14 days. Lower estimates of kidding interval were reported by Deokar *et al.* [20] in Sangamneri goats and Ekambaram *et al.* [23] in Mahabubnagar goats.

However, higher estimates of kidding interval were reported by Das *et al.* [19], Kumar *et al.* [24], Maroof *et al.* [25] and Yadav *et al*. [16].

Service period

The overall least squares means of service period was found to be 142.03 ± 4.14 days. The lower estimate was reported in Sangamneri goats by Deokar *et al*. [20]. Higher estimate of service period was reported in Sirohi goat by Pathodiya *et al*. [14] and Yadav *et al*. [16].

Gestation period

The overall least-squares means of gestation period was estimated as 149.95 ± 0.07 days. The present finding was in close agreement with the reports of Maroof *et al.* [25], Pathodiya *et al.* [14], Rao *et al.* [27], Fahim *et al*. [29] and Patel and Pandey [17]. The lower estimate was reported in Sirohi does by Mishra *et al.* [30], Kutchi goats by Kumar *et al.* [24], Sangamneri goats by Deokar *et al.* [20] and in Black Bengal goats by Mia *et al.* [31]. However, comparatively higher estimate was reported by Hassan *et al.* [28] and Yadav *et al*. [16].

Dry period

The overall least squares means of dry period was estimated as 144.00 ± 4.09 days. The lower estimate was reported in Mehsana goats by Singh *et al.* [21] and in Mehsana goats by Patel and Pandey [17]. However, higher estimates were reported in Sirohi goats by Pathodiya *et al.* [14] and Yadav *et al*. [16].

Fixed effect

Effect of sire

Random effect of sire was highly significant ($P \leq 0.01$) on all traits under this study except gestation period, which was non-significant Table 1. Hossain *et al.* [26] and Yadav *et al.* [16] reported sire had significant effect on all reproductive traits except gestation period.

Effect of cluster

Cluster-wise variation was highly significant ($P \leq 0.01$) on all reproductive traits. Pathodiya *et al.* [14] reported non-significant effect of cluster on kidding interval and Singh *et al*. [21] reported significant effect on age at first conception.

Age at first conception and age at first kidding were lowest in Vallabhnagar cluster and highest in Bhadsora cluster. It indicates that animals in Vallabhnagar cluster get early sexual maturity than Badhsora cluster. Weight at first conception and weight at first kidding were highest in Bhadsora cluster. Kidding interval, Service period and Dry period were lowest in Bhadsora cluster and highest in Devgarh cluster. Hence, Dry period was highest in Nathdwara cluster. Perusal of data indicates large variation amongst cluster which is obvious due to variation in feeding, housing and health care.

Effect of Period of birth

Effect of period of kidding was highly significant ($P \leq 0.01$) on age at first conception and age at first kidding. However, significant effect of period on gestation period was found Table 1. The present finding was in close agreement with reports of Yadav *et al*. [16] in Sirohi goats. Mishra *et al.* [30] observed non-significant effect of year of kidding on kidding interval, Singh *et al.* [18] for age at first conception and kidding interval, Kumar *et al.* [13] on age at first service, weight at service, age at first kidding and weight at first kidding, Pathodiya *et al.* [14] on kidding interval, Rumi *et al.* [32] on age of first conception, age of first kidding, gestation period and kidding interval.

Age at first conception and age at first kidding was highest in period of 2004-07 and almost lowest in period 2013-16. Results indicated that days of early maturity in animals had decreased with advancement of periods. Gestation period was also highest in period 2007-10, which might be due to the differences in plane of nutrition, availability of top feeds, cropping pattern and climatic conditions.

Effect of Season of birth

Influence of season of birth highly significant ($P \leq 0.01$) on age at first conception, age at first kidding, kidding interval, service period, gestation period and dry period while weight at first conception and weight at first kidding was non-significant Table 1. Pathodiya *et al.* [14] reported significant effect on kidding interval. Yadav *et al*. [16] reported significant effect on service period, kidding interval and dry period.

Rainy season kidding had lowest age of first conception and age of first kidding, whereas highest in summer season. Summer season had lowest kidding interval, service period, gestation period and dry periods. The seasonal variation seems to be results of photometry as their breeding seasons are restricted to February-April and September-November because these are peak breeding seasons.

Effect of regression of dam's weight at kidding

Regression of dam's weight at kidding was observed non-significant for all reproductive traits Table 1. Similar observations were reported as follows. Mishra *et al.* [30] observed non-significant effect of dam's weight with gestation period.

Table 1: Least-squares means and S.E. for reproduction traits in Sirohi goats

Traits Factors	AFC (Days)	WFC (kg)	AFK (Days)	WFK (kg)	KI (Days)	SP (Days)	GP (Days)	DP (Days)
Overall mean (μ)	513.83±20.94 (958)	27.84±0.42 (958)	657±20.48 (958)	30.57±0.40 (958)	292.03±4.14 (1969)	142.17±4.18 (1969)	149.95±0.07 (1969)	144.00±4.09 (1969)
Sire	**	**	**	**	**	**	NS	**
Cluster	**	**	**	**	**	**	**	**
Vallabhnagar	448.62 ± 37.79^{a} (110)	28.71 ± 0.58^{d} (110)	569.82 ± 37.71^{a} (110)	32.14 ± 0.55^{d} (110)	280.38 ± 7.44^{a} (191)	129.63 ± 7.47^{ab} (191)	151.02 ± 0.25^{c} (191)	132.71 ± 7.35^{b} (191)
Railmagra	455.39 ± 35.98^{a} (158)	23.93 ± 0.56^{a} (158)	604.88 ± 35.88^{a} (158)	26.96 ± 0.54^{a} (158)	283.46 ± 6.73^{a} (283)	133.96 ± 6.76^{bc} (283)	149.75 ± 0.22^{b} (283)	143.82 ± 6.64^{b} (283)
Devgarh	558.22 ± 30.44^{b} (575)	27.60 ± 0.51^{c} (575)	705.85 ± 30.24^{b} (575)	30.24 ± 0.48^{c} (575)	317.06 ± 5.53^{bc} (1038)	167.69 ± 5.56^{d} (1038)	149.98 ± 0.16^{b} (1038)	159.36 ± 5.46^{c} (1038)
Nathdawara	500.98 ± 47.46^{a} (69)	25.79 ± 0.69^{b} (69)	622.23 ± 47.51^{a} (69)	28.61 ± 0.66^{b} (69)	306.83 ± 8.26^{b} (219)	158.45 ± 8.28^{d} (219)	149.03 ± 0.29^{a} (219)	165.15 ± 8.15^{c} (219)
Bhadsora	605.94 ± 73.14^{bc}	33.15 ± 0.99^{e}	785.46 ± 73.46^{c}	34.88 ± 0.95^{e}	272.43 ± 7.43^{a}	121.12 ± 7.45^{a}	149.97 ± 0.25^{b}	118.97 ± 7.33^{a}

	(46)	(46)	(46)	(46)	(238)	(238)	(238)	(238)
Period of birth	**	NS	**	NS	NS	NS	*	NS
2004-2007	665.79±35.02 (575)	27.52±0.55 (575)	821.16±34.90 (575)	30.42±0.53 (575)	288.06±6.06 (882)	137.50±6.09 (882)	149.99±0.19^{b} (882)	132.89±5.98 (882)
2007-2010	559.06±30.33 (242)	27.85±0.50 (242)	712.88±30.12 (242)	30.26±0.48 (242)	295.05±6.02 (293)	145.70±6.05 (293)	150.23±0.18^{b} (293)	146.40±5.95 (293)
2010-2013	416.95±36.09 (121)	27.78±0.56 (121)	554.62±35.98 (121)	30.36±0.54 (121)	297.16±5.33 (481)	147.81±5.37 (481)	150.14±0.15^{b} (481)	151.18±5.27 (481)
2013-2016	413.51±65.83 (20)	28.20±0.91 (20)	541.92±66.08 (20)	30.36±0.87 (20)	287.85±6.64 (313)	137.66±6.66 (313)	149.44±0.21^{a} (313)	145.54±6.55 (313)
Season of birth	*	NS	**	NS	**	**	**	**
Rainy	488.81±22.22^{a} (331)	27.71±0.43 (331)	628.17±21.81^{a} (331)	31.22±0.41 (331)	301.36±4.38^{b} (828)	151.44±4.43^{b} (828)	150.16±0.09^{b} (828)	152.06±4.33^{b} (828)
Winter	516.24±22.12^{b} (479)	27.84±0.43 (479)	656.96±21.70^{ab} (479)	30.52±0.40 (479)	309.99±4.58^{c} (757)	159.55±4.62^{b} (757)	150.04±0.10^{b} (757)	161.72±4.53^{c} (757)
Summer	536.44±24.61^{b} (148)	27.95±0.45 (148)	687.81±24.27^{b} (148)	30.62±0.43 (148)	264.74±4.96^{a} (384)	115.51±5.00^{a} (757)	149.65±0.13^{a} (757)	118.23±4.90^{a} (757)
Reg.	0.76±1.84^{NS}	0.035±0.02^{NS}	0.80±1.85^{NS}	0.02±0.02^{NS}	-0.139±0.44^{NS}	-0.11±0.44^{NS}	0.015±0.017^{NS}	-0.2±0.43^{NS}

No. of observation in parentheses; Means with different superscript differ significantly (* Significant $P \leq 0.05$, ** Significant $P \leq 0.01$, NS = Non-significant)

3.2 Genetic and phenotypic parameters for reproduction traits

The results regarding estimated genetic and phenotypic parameters viz. heritability, genetic and phenotypic correlations are presented in Table 2 and 3.

Table 2: Estimates of heritability (on diagonal), genetic correlation (above diagonal) and phenotypic correlations (below diagonal) among reproductive traits in Sirohi goats.

Traits	AFC	WFC	AFK	WFK
AFC	0.142±.036	0.186±0.152	0.984±0.011	0.292±0.145
WFC	0.309±0.03	0.375±0.050	0.128±0.159	0.955±0.016
AFK	0.954±0.009	0.295±0.03	0.13±0.035	0.224±0.154
WFK	0.348±.003	0.866±0.01	0.331±0.03	0.366±0.049

Heritability

The heritability estimates of all the reproductive parameters in the present study were found to be moderate ranging from 0.13±0.035 to 0.375±0.050, except gestation period, which was a low heritability estimate 0.002±0.015. Lower heritability in gestation period was also reported by Nahardeka *et al.* [33] in Assam Local goats and their crossbred with Beetal goats. The low heritability estimate observed for gestation period may be explained by the little genetic variability character, which is influenced by largely environmental variation. Moderate heritability indicating existence of substantial additive genetic variance in the population and can be utilized for improvement of the sought traits. The moderate heritability estimates for age at first conception, weight at first conception, weight at first conception, weight at first kidding, weight at first kidding, kidding interval, service period and dry period indicated existence of large genetic variability which in turn reveals that this traits hardly been subjected to selection programme. Such improvement is likely to curtail the unproductivity life of the individual. These results were in close agreement with the finding of Dash *et al.* [34] in Raigar goats, Haque *et al.* [35] in Black Bengal goats, Patil *et al.* [36] in Osmanabadi goats.

Table 3: Estimates of heritability (on diagonal), genetic correlation (above diagonal) and phenotypic correlations (below diagonal) among reproductive traits in Sirohi goats.

Traits	KI	SP	GP	DP
KI	0.17±0.027	0.997±0.001	a	0.94±0.013
SP	0.993	0.174±0.027	a	0.94±0.011
GP	0.111	0.086	0.002±0.015	0.621±2.022
DP	0.971	0.972	0.081	0.171±0.027

a Estimate not precise

Genetic and phenotypic correlation

It was observed that the genetic and phenotypic correlation between age at first conception with age at first kidding and weight at first conception with weight at first kidding was high. The genetic and phenotypic correlation between kidding interval with service period and dry period was high and positive. Medium and positive genetic and phenotypic correlation reported by Dash *et al.* [34] in Raighar goats.

Conclusion

It can be concluded from present study that the non-genetic factor like cluster significantly affect the all reproductive traits, indicates large variation amongst cluster which is obvious due to variation in feeding, housing and health care. Period and season of birth had significantly affected on age at first kidding which indicating influence of efficient management improves the birth weight thereby reduce age at first kidding which ultimately improves the profitability of the farmers' flock. Summer season born kids had lowest kidding interval, service period and dry period as compared other season therefore, more kidding should be planned in summer season for minimizing the kidding interval, service period and dry period of animals. Moderate heritability of reproductive traits which indicated appropriate attention should be directed to mass selection for the adequate genetic advancement of these traits.

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