Indian Journal of Animal Sciences **89**(9): 1017–1020, September 2019/Short communication
https://doi.org/10.56093/ijans.v89i9.93787

Evaluation of reproductive traits of Chokla sheep under semi-arid conditions of Rajasthan

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Received: 26 January 2019; Accepted: 18 February 2019

Key words: Age at first lambing, Arid, Chokla sheep, Rajasthan, Reproduction

The Chokla sheep is heralded as the finest carpet wool producer of India. It plays an important role in supporting the livelihood of the sheep rearers in its native arid and semi-arid tracts of Rajasthan. The breed has been described in detail by Jain *et al.* (2009). The reproductive performance is one of the most important aspects of sheep husbandry upon which the economics of the sheep farming is dependent (Gowane *et al.* 2014). Formulation of effective selective breeding programmes requires the knowledge of the reproductive performance of the breed and the effect of various non-genetic factors influencing it. Analysis of performance over the course of the flock's history could yield valuable information regarding the effectiveness of the breeding and managemental interventions. Such information is scanty in literature for Chokla sheep and this study attempts to supplement that gap by evaluating the reproductive performance of Chokla sheep and the factors affecting it at an organised farm in semi-arid conditions of Rajasthan.

The study analysed the performance of 1,172 ewes born to 228 sires and bearing 3,879 offspring over a period of 22 years (1994–2016). The data from 1994 to 2012 were collected from ICAR-CSWRI, Avikanagar station at Malpura district of Rajasthan. The data from 2013 to 2016 were collected from ICAR-CSWRI, Arid Region Complex at Bikaner district of Rajasthan due to the relocation of the flock in 2013. The management of the flock and climatic conditions are described in detail by Narula *et al.* (2010) and Gowane *et al.* (2014). From the data, 8 reproductive traits were derived and analysed. The traits were, age at first service (AFS); age at first successful service (ASS) i.e. the first service which resulted in a lambing; age at first lambing (AFL); weight at first service (WFS); weight at first successful service (WSS); ewe's weight at lambing (WL); lambing interval (LI) and service period (SP). WL, LI and SP were computed as averages for all the lambings in the ewe's lifetime. The duration of study was divided into seven periods, viz. P_1 (1995–97), P_2 (1998–2000), P_3 (2001–03), P_4 (2004–06), P_5 (2007–09), P_6 (2010–12) and P_7 (2013–14) and two seasons of birth of ewes (Winter, November-April and Summer, May–October). The influence of inbreeding coefficient of ewes was assessed by distributing it into four classes (Class 1, 0%; Class 2, < 1.25%; Class 3, 1.25% - 5% and Class 4, > 5%), the ewe's weight at birth was also distributed into four classes (Class 1, 2.3 kg; Class 2, 2.3 ≤ 2.8 kg; Class 3, 2.8 ≤ 3.4 kg and Class 4, > 3.4 kg). WFS, WSS and WFL (weight at first lambing) were considered as covariates for AFS, ASS and AFL respectively. The genetic effect of the sires of the dams under study was analysed by considering it as a random effect. Pedigree Viewer 6.5 software (Kinghorn and Kinghorn 2003) was used to calculate inbreeding coefficients. For significant effects, the differences between pairs of levels of effects were tested by Duncan's multiple range tests as modified by Kramer (Duncan 1957). The GLM procedure of SAS (SAS 2011) was used to analyze the data.

The overall least squares mean was estimated to be 572.39±6.59 days (Table 1). The present finding was in close agreement with the reports of Dixit *et al.* (2002) and Akhtar *et al.* (2008) who reported the estimates as 580±13.00 and 593.3±265.87 days in Bharat Merino and Hissardale sheep respectively. Lower estimate of 461.7±10.4 days for AFS was reported by Mandal *et al.* (2011) in Muzaffarnagari sheep while higher estimates for AFS have also been reported by Babar and Javed (2009) and Gowane *et al.* (2014) in Lohi and Malpura sheep respectively. The overall least squares mean for ASS was estimated to be 635.71±9.36 days. Higher estimate of 689.48±5.28 days was reported by Gowane *et al.* (2014). The overall least squares mean

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Table 1. Least-squares means (±SE) for age at first service, age at first successful service and age at first lambing

Factor	N	AFS (Days)	N	ASS (Days)	N	AFL (Days)
Overall mean (μ)±SE	1124	572.39±6.59	1074	635.71±9.36	1112	773±8.77
Period		**		**		**
P1 (1995–97)	94	661.63±31.77[d]	87	795.23±43.29[f]	88	917.19±39.51[f]
P2 (1998–2000)	155	656.64±23.72[d]	151	704.25±32.64[d]	156	831.97±30.31[d]
P3 (2001–2003)	194	668.45±21.82[d]	186	760.86±30.48[e]	191	887.21±28.59[e]
P4 (2004–06)	164	576.86±22.24[c]	159	629.25±31.06[c]	162	791.46±29.21[c]
P5 (2007–09)	244	505.03±22.47[b]	237	572.56±30.91[b]	244	735.95±29.05[b]
P6 (2010–12)	159	513.48±24.79[b]	141	546.35±33.93[b]	156	683.91±32.05[b]
P7 (2013–14)	114	426.40±37.43[a]	113	441.48±49.51[a]	115	564.42±47.62[a]
Season		NS		NS		*
Winter (November–April)	864	580.69±6.59	828	638.34±9.32	856	790.32±8.70[b]
Summer (May–October)	260	564.10±9.72	246	633.08±13.99	256	756.00±12.95[a]
Inbreeding coefficient		NS		NS		NS
Class 1 (0%)	429	573.70±9.17	410	627.27±13.15	420	917.19±12.27
Class 2 (< 1.25%)	349	572.12±8.83	331	644.82±12.56	347	831.97±11.71
Class 3 (1.25–5%)	299	572.92±9.14	288	641.51±12.89	298	887.21±12.17
Class 4 (> 5%)	47	570.82±17.40	45	629.24±24.98	47	791.46±23.14
Ewe's birth weight		*		*		*
Class 1 (≤ 2.3 kg)	157	578.58±10.94[c]	151	658.36±15.56[b]	159	795.07±14.44[b]
Class 2 (2.3–2.8 kg)	300	588.86±8.78[d]	277	648.20±12.58[b]	289	786.56±11.72[b]
Class 3(2.8–3.4 kg)	452	565.55±7.52[b]	440	628.90±10.69[b]	450	763.46±10.05[a]
Class 4 (≥3.4 kg)	215	556.57±9.93[a]	206	607.39±14.23[a]	214	747.56±13.24[a]
Covariate		WFS**		WSS**		WFL**
Average		25.34 kg		25.89 kg		27.05 kg
Regression coefficient		–7.625±0.982		–3.538±1.320		–1.775±1.124
Sire		**		**		**

Means bearing different superscripts between rows and within column differ significantly. AFS, Age at first service; ASS, Age at first successful service; AFL, Age at first lambing; WFS, Weight at first lambing; WSS, Weight at first successful service; WFL, Weight at first lambing. *Significant (P≤0.05); **Highly significant (P≤0.01); NS, non-significant.

for AFL was estimated to be 773±8.77 days. Higher estimate of 838.55±5.34 days was reported by Gowane *et al.* (2014). Lower estimates of 654.99±11.99, 638.91±3.56 and 419.56±11.46 days for AFL were reported by Mandal *et al.* (2011), Mane *et al.* (2014) and Pal *et al*. (2017). There was a trend of significant (P<0.05) improvement over the period of study for all the three age traits (AFS, 35.5%; ASS, 44.4%; AFL, 38.4%) with the best performance coming in period 7. This may be attributed to the improvement in the body condition of the ewes over the periods due to better management, nutrition and selection of better animals. Marked improvement (AFS, 16.95%; ASS, 19.19%; AFL, 17.47%) was observed in P7 when the flock was shifted to CSWRI ARC, Bikaner, which may be the result of the genotype-environment interaction arising due to the suitability of arid climate to Chokla breed. Our findings were in agreement with the reports of Mandal *et al*. (2011), Mandakmale *et al*. (2012) and Gowane *et al*. (2014) who also found significant effect of period of birth of ewes on AFS, ASS and AFL. However, non-significant effect of period on AFS was reported by Dey and Poonia (2005) and Babar and Javed (2009). Season of birth of ewe had a significant (P<0.05) effect on AFL with the ewes born in Summer (May-October), performing better. This may be due to the better availability of pasture early in the ewe's life due to monsoon rains. Mandakmale (2013) also reported significant effect of season on AFL. The birth weight of ewes had a significant effect on AFS, ASS and AFL with ewes heaviest at birth (Class 4) attaining earliest sexual maturity and lambing. This suggests selection for optimum birth weight may lead to superior reproductive performance later in the life of the animal. The covariates (WFL, WSS and WFL) had a highly significant (P≤0.01) effect on their respective traits. The negative regression coefficients pointed towards the earlier attainment of sexual maturity with increasing weights. This finding was in agreement with the results reported by Gowane *et al.* (2014). The random effect of sire of the ewes on AFS, ASS and AFL was highly significant (P≤0.01). The findings suggest that selection of superior sires is imperative for improvement of reproductive performance of the flock. The effect of inbreeding was non-significant for all three age traits.

The overall least squares mean for WFS was estimated to be 25.160±0.16 kg (Table 2). Lower estimate of 24.92±0.22 kg for WFS was reported by Dey and Poonia (2005) whereas higher estimates of 29.83±0.32 and 26.05±0.08 kg were reported by Mandal *et al*. (2011) and Gowane *et al*. (2014). The overall least squares mean for WSS was estimated to be 25.85±0.16 kg. Higher estimate of 26.74±0.09 kg for WSS was reported by Gowane *et al*. (2014). The overall least squares mean for WL was estimated to be 28.61±0.21 kg. Lower estimates of WL as

Table 2. Least-squares means (±SE) for weight at first service, weight at first successful service and weight at lambing

Factor	N	WFS (kg)	N	WSS (kg)	N	WL (kg)
Overall Mean(μ)±S.E	1124	25.16±0.11	1074	25.85±0.16	1172	28.61±0.21
Period		**		**		*
P1 (1995–97)	94	21.79±0.76^{a}	87	22.55±0.77^{a}	113	25.86±0.94^{a}
P2 (1998–2000)	155	21.83±0.56^{a}	151	22.59±0.58^{a}	162	26.50±0.74^{a}
P3 (2001–03)	194	23.47±0.53^{b}	186	23.91±0.55^{a}	203	27.54±0.70^{b}
P4 (2004–06)	164	25.72±0.53^{c}	159	26.75±0.55^{b}	166	29.18±0.73^{c}
P5 (2007–09)	244	26.59±0.54^{d}	237	27.06±0.55^{b}	245	29.76±0.73^{d}
P6 (2010–12)	159	26.69±0.60^{e}	141	27.33±0.60^{b}	168	29.75±0.80^{e}
P7 (2013–14)	114	30.00±0.88^{f}	113	30.73±0.89^{c}	115	31.68±1.18^{f}
Season		NS		NS		NS
Winter (November–April)	864	25.25±0.16	828	25.99±0.16	905	28.37±0.21
Summer (May–October)	260	25.06±0.23	246	25.70±0.25	267	28.84±0.31
Inbreeding coefficient		NS		NS		NS
Class 1 (0%)	429	25.22±0.22	410	25.87±0.23	459	29.04±0.29^{a}
Class 2 (< 1.25%)	349	25.10±0.21	331	25.79±0.22	354	28.36±0.28^{b}
Class 3 (1.25–5%)	299	25.45±0.22	288	26.01±0.23	310	28.87±0.29^{c}
Class 4 (> 5%)	47	24.85±0.42	45	25.72±0.44	49	28.17±0.56^{d}
Ewe's Birth Weight		**		**		**
Class 1 (≤ 2.3 kg)	157	24.32±0.26^{a}	151	25.06±0.27^{a}	166	27.41±0.35^{a}
Class 2 (2.3–2.8 kg)	300	24.72±0.21^{a}	277	25.41±0.22^{a}	317	28.14±0.28^{a}
Class 3 (2.8–3.4 kg)	452	25.32±0.18^{b}	440	26.02±0.19^{b}	471	29.01±0.24^{b}
Class 4 (≥3.4 kg)	215	26.26±0.23^{c}	206	26.91±0.25^{c}	218	29.88±0.32^{c}
Sire		**		**		**

Means bearing different superscripts between rows and within column differ significantly. WFS, Weight at first service; WSS, Weight at first successful service; WL, Weight at Lambing. *Significant (P≤0.05); **Highly significant (P≤0.01); NS, non-significant.

24.46 kg and 27.94±0.10 kg were reported by Dey and Poonia (2005) and Gowane *et al*. (2014). Period had a highly significant (P ≤ 0.01) effect on WFS, WSS and WL. Similar to age traits, there was a trend of improvement over the periods (WFS, 37.6%; WSS, 36.27; WL, 22.5%) with the highest weights coming in P7. Improvements in ewe weights between P6 and P7 ranged from 6.4 to 12.4%, pointing towards the suitability of arid climate over semi-arid for Chokla sheep. Selection of better animals, availability of better pasture and optimization of management may be some of the other factors behind the increase of weights over the periods. The results were in agreement with those reported by Gowane *et al*. (2014), who reported significant effect of period of birth on WFS, WSS and WL. However, non-significant effect of period of birth on WFS and WL was reported by Dey and Poonia (2005). Season of birth and inbreeding coefficient of ewes had no significant effect on any weight trait. Ewe's weight at birth had a highly significant (P≤0.01) influence on all the weight traits. The ewes heaviest at birth (Class 4) remained the heaviest throughout their breeding and also attained sexual maturity faster. The effect of sires of dams was also highly significant (P≤0.01) on the weight traits.

Service period is one of the most important parameters for fertility traits and a short service period is ideal for increased productivity (Çilek and Tekin 2007). The optimization of service period will also result in an optimized lambing interval (Cilek 2009).

The overall least squares mean for LI was estimated to be 371±6.87 days (Table 3). Higher estimates of LI as 638.91±3.56 and 439.18±4.84 days were reported by Mane *et al*. (2014) and Gowane *et al*. (2014). Lower estimates of LI as 283.13±0.95 and 247.66±4.88 days were reported by Dass (2007) and Poonia (2008). The overall least squares mean for SP was estimated to be 228.31±6.62 days. Lower estimates of SP as 93.24±0.88 and 152.31±0.08 days were reported by Dass (2007) and Babar and Javed (2009) in Pugal and Lohi sheep, respectively. The lower estimates for LI and SP were usually reported in the herds following unrestricted breeding. All the genetic and non-genetic effects had no significant effect on LI and SP. This may be due to the controlled seasonal breeding at the farm masking the effect of all other factors. Similar results were reported by Dey and Poonia (2005) and Mandakmale *et al*. (2013) for LI.

SUMMARY

The study analysed the records of 1,172 ewes maintained at ICAR–Central Sheep and Wool Research Institute at Avikanagar and Bikaner, Rajasthan over a period of 22 years (1994-2016). Eight reproductive traits were assessed, namely age at first service (AFS; 572.39±6.59 days), age at first successful service (ASS; 635.71±9.36 days), age at first lambing (AFL; 773±8.77 days), weight at first service (WFS; 25.16±0.11 kg), weight at first successful service (WSS; 25.85±0.16 kg), weight at lambing (WL; 28.61±0.21 kg), lambing interval (LI;371±6.87days) and service period (SP; 228.31±6.62 days). The effects of period of birth of ewe, ewe's birth weight and sire were significant for all the traits except LI and SP with an improvement of 17.47% –

Table 3. Least-squares means (±SE) for service period and lambing interval

Factor	N	SP (Days)	N	LI (Days)
Overall Mean (μ)±SE	805	228.31±6.62	834	371±6.87
Period		NS		NS
P1 (1995–1997)	89	243.73±23.08	92	422.59±23.48
P2 (1998–2000)	135	249.57±17.77	135	408.36±18.72
P3 (2001–2003)	152	215.58±17.04	154	368.73±18.28
P4 (2004–2006)	118	215.65±17.46	121	352.22±18.95
P5 (2007–09)	178	212.14±20.60	187	355.58±21.58
P6 (2010–12)	104	231.91±23.83	110	369.75±24.53
P7 (2013–14)	29	229.58±38.61	35	323.41±36.15
Season		NS		NS
Winter (November–April)	651	226.92±6.10	672	373.96±6.32
Summer (May–October)	154	229.69±9.427	162	369.08±9.88
Inbreeding Coefficient		NS		NS
Class 1 (0%)	360	231.68±7.97	368	369.20±8.39
Class 2 (< 1.25%)	234	232.40±8.35	244	377.93±8.83
Class 3 (1.25–5%)	180	229.10±8.70	190	376.34±9.14
Class 4 (> 5%)	31	220.04±15.68	32	362.61±16.67
Ewe's Birth Weight		NS		NS
Class 1 (≤ 2.3 kg)	111	232.68±10.01	115	373.99±10.57
Class 2 (2.3–2.8 kg)	226	229.58±8.11	232	375.96±8.51
Class 3 (2.8–3.4 kg)	339	222.37±7.06	352	361.34±7.35
Class 4 (≥3.4 kg)	129	228.60±9.22	135	374.77±9.70
Sire		NS		NS

Means bearing different superscripts between rows and within column differ significantly. LI, Lambing interval; SP, Service period. *Significant (P≤0.05); **Highly significant (P≤0.01); NS, non-significant.

37.6% observed over the period of study. Season of birth of ewe had significant effect on AFL. AFS, ASS and AFL were significantly influenced by their respective covariates (WFS, WSS and WL). The statistically significant improvement over the periods suggest that through suitable selective breeding policy and good managemental measures, the reproductive performance of the flock can be enhanced. The optimization of ewe weights could reduce the age of sexual maturity and the ewe's weight at birth may serve as an indicator for future performance in this regard. Selection of superior sires may improve the genetic potential of the flock with respect to the reproductive traits.

ACKNOWLEDGEMENTS

The authors express their gratitude to the entire staff at ICAR-CSWRI Avikanagar and ICAR-CSWRI ARC, Bikaner for their help in data collection and database management. We sincerely thank the Director, CSWRI for permitting the use of the data for this study.

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