GENETIC EVALUATION OF SURTI BUFFALO ON THE BASIS OF REPRODUCTION TRAITS BY ALL REPEATABILITY UNIVARIATE MODELS OF WOMBAT

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ABSTRACT

The data pertaining to variable reproduction traits in Surti buffaloes were collected from network project on buffalo, Livestock Research Station, Vallabhnagar Rajasthan to obtain the genetic parameters of various reproduction traits in Surti buffaloes. The least squares means of various reproduction traits were adjusted for significant non-genetic factors and from these adjusted data, genetic parameters namely heritability and repeatability estimates as well as genetic and phenotypic correlations were estimated in the population. The estimates of least-square means for calving interval, dry period and service period were 491.58±8.56, 195.57±6.87 and 223.60±8.75, respectively. Effect of season and periods were highly significant (P≤0.01) but the effect of sire and parity were non-significant in all three traits. Regression of reproduction traits on age at first calving was negative and non-significant for all traits. Among the reproduction traits, dry period, service period and calving interval had very low heritability estimates it was due to the low additive genetic variances. Fitting maternal effect to repeatability univariate model (Model 2), it increased the additive genetic variance in CI and SP but reduced in DP. Lower repeatability estimates were observed for all reproduction traits under study. Genetic correlations of calving interval with dry period and service period were not estimated and phenotypic correlations of dry period with service period and calving interval were very high and positive.

Keywords: *Bubalus bubalis*, buffaloes, reproduction traits, heritability, repeatability, permanent environment effect, maternal effect

INTRODUCTION

India is basically an agricultural country with 65 to 70% of its population engaged in agriculture and allied occupation. Agriculture is basis of our rural economy and livestock is the back bone of Indian agriculture. Livestock rearing

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provides employment and supplementary income around the year to the vast majority of rural population. Among all livestock buffalo is known as Asian animal because it has 96% of the world's buffalo population and contributes 35% of total milk production in Asia. In India water buffalo is recognized as "milk machine" (Acharya, 1990).

The world population of buffalo is estimated to be 199 million (FAOSTAT, 2012) with more than 96% of the population located in Asia. According to Livestock Census (2012), the buffalo population in India is 108.7 million showing a growth of 3.19% as compared to the previous census. As per BAH&FS (2014) the contribution of buffalo to the total milk production of India (132.4 million metric tonnes) is nearly 51% (67.68 million metric tonnes) and thereby rightly considered as India's milking machine. The present study has been conducted at the National project on buffalo LRS Breeding Farm, Vallabhnagar with the objective of understanding the performance and the influence of various non-genetic factors affecting economic traits of Surti buffaloes and to suggest suitable management practices, selection and breeding strategies for genetic improvement of Surti buffaloes in the southern part of rajasthan.

MATERIALS AND MEDTHODS

Information source for the present study was the Surti herd maintained under Net-work Project on Buffaloes, Livestock Research Station, Vallabhnagar Rajasthan during the year 1987 to 2017. This Farm is situated 582 meter above the mean sea level on 24º35N latitude and 73º 43E longitudes. The climate of the farm is tropical in nature. The monthly average minimum and maximum temperature ranges between 2.3ºC to 42.3ºC. The average rainfall and relative humidity is 660 mm and 31.5%, respectively.

The technical programe of the project involved testing of (6 to 8) bulls in every 18 months. Each bull mated to about 35 to 40 buffaloes, with an aim to produce about 10 to 15 daughters. On the basis of performance of their daughters, two bulls are to be selected from each set. In addition to their extensive use in the field, the selected bulls are to be mated to 70 to 80 elite buffaloes (giving more than 1,200 kg of milk in first lactation or more than 1,500 kg in any other lactation of 305 days or less). To avoid inbreeding the Surti bulls of high genetic merit were also introduced in the herd from Central Cattle Breeding Farm, Dhamrod and Reproductive Biology Research Unit, Anand. In this way, the Surti germplasm at Vallabhnagar farm represented progeny of the Surti bulls of various centres situated in Gujarat state i.e., home tract of Surti buffalo.

Statistical analysis

To find the various genetic and non-genetic factors on production and reproduction traits, computer package programme, LSMLMW, MODEL2 designed by Harvey (1990)/WOMBAT programme (Meyer, 2007) were used for data analysis.

Effect of genetic and non-genetic factor on reproduction traits

$$Y_{ijklm} = \mu + s_i + A_j + B_k + C_l + b\,(X_{ijklm} - X) + e_{ijklm}$$

Where, Y_{ijklm} = Observation on the m^{th} dam of i^{th} sire, calved in j^{th} period, k^{th} season and l^{th} parity,

μ = overall mean

s_i = random effect attributed to i^{th} sire,

A_j = fixed effect of j^{th} period of calving

B_k = fixed effect of k^{th} season of calving

C_l = fixed effect of l^{th} parity,

b = regression of variable on age at first calving.

X_{ijklm} = age at first calving corresponding to Y_{ijklm}

X = average age at first calving.

e_{ijklm} = residual random error under standard assumption which make the analysis valid, i.e. NID $(0,\sigma^2)$

Estimation of heritability

$$Y_{ij} = \mu + s_i + e_{ij}$$

Where, Y_{ij} = Observation of the j^{th} progeny of the i^{th} sire

μ = Overall mean

s_i = Random effect of the i^{th} sire

e_{ij} = Random error NID $(0, \sigma_e^2)$

σ^2_s = Sire component of variance = (MSS – MSW) / K

$$t = \sigma^2_s / (\sigma^2_s + \sigma^2_w)$$

$$h^2 = 4t$$

Where, t = intra-class correlation among half sibs

Genetic and phenotypic correlations

$$rg_{(XY)} = Cov_{S(XY)} / \sqrt{(\sigma^2_{S(X)})(\sigma^2_{S(Y)})}$$

Where, X and Y are traits of the same individual,

$Cov_{S(XY)}$ = Sire component of covariance between traits X and Y.

$\sigma^2_{S(X)}$ and $\sigma^2_{S(Y)}$ = Sire components of variance for traits X and Y.

Phenotypic correlation was estimated as:

$$rp_{(XY)} = \frac{Cov_{S(XY)} + Cov_{e(XY)}}{\sqrt{(\sigma^2_{s(X)} + \sigma^2_{e(X)})(\sigma^2_{s(Y)} + \sigma^2_{e(Y)})}}$$

Where, $Cov_{e(XY)}$ = Error component of covariance between traits X and Y.

$\sigma^2_{e(X)}$ and $\sigma^2_{e(Y)}$ = Error components of variance for traits X and Y.

RESULTS AND DISCUSSION

The overall least square means along with standard errors for calving interval (CI), dry period (DP) and Service period (SP) in different period, season and parity have been depicted in Table 1.

Least-squares means of different reproduction traits

The overall least squares mean of calving interval was observed to be 491.58±8.56 kg which was higher than the Jain (1990); Tailor (1995); Tailor (2000); Tailor (2004) in Surti buffalo. The overall least squares mean of service period was observed to be 223.60±8.75 kg which was lower than the Tailor (2002); Nagda (2005); Sule *et al.* (2006) in Surti buffalo. The overall least squares mean of Dry period in present study was observed to be 138.66±15.22 kg which was lower than the Basavaiah *et al.* (1983); Govindaiah and Rai (1987); Patel (1994); Tailor (1995); Patholdiya (1997); Tailor (1999); Tailor (2000); Tailor (2001); Tailor (2002); Tailor (2003); Tailor (2004); Nagda (2005) in Surti buffalo.

Effect of season of calving

The effect of season of calving had highly significant ($P \leq 0.01$) influence on all reproduction traits i.e. calving interval, service period and dry period. The averages of all reproduction traits were observed lowest in autumn and highest in summer as shown in Table 1. The good availability of fodder reduces the averages of reproduction traits which are desirable so due to previous rainy season the fodder availability in autumn was good. This result was supported by the finding of Tailor (1995); Pathodiya (1997); Kothari (2004) in Surti buffaloes.

Effect of period of calving

The effect of period of calving had highly significant ($P \leq 0.01$) influence on all reproduction traits i.e. calving interval, service period and dry period. The effect of period was significant because a particular period contains several years with similar environmental adaptations and entirely different with another periods. This result was supported by the finding of Tailor (1995) in Surti buffalo, while Singh *et al.* (1988); Pathodiya (1997) is Surti buffalo found only significant ($P<0.05$) effect on all reproduction traits.

Effect of parity

In the present study we found that the all reproduction traits were not affected by parity. The effect of parity was non-significant. The averages of all reproduction traits were observed lowest in L7 and highest in L1 but in dry period highest in L5 as shown in Table 1. In contrary to that Jain and Tailor (1995); Nagda (2005) found the significant effect of parity on all reproduction traits in Surti buffalo.

Effect of sire

The effect of sire on all reproduction traits was estimated to be non-significant. The other researchers found the similar result like Pathodiya (1997); Kothari (2004) in Surti buffaloes while Saha and Sadana (2000) found significant effect of sire on all reproduction traits i.e. CI, SP and DP in Murrah buffaloes.

Regression of production traits on AFC

The least-squares analysis of variance of data revealed that regression of all reproduction traits on age at first calving were negative and non-significant as shown in Table 1.

Heritability estimation

Repeatability univariate model (Model I) partitioned the total phenotypic variance (σ^2_p=15189) into additive (σ^2_a=0.64) and residual variance (σ^2_e=14651). It did not show heritability because low estimates of additive variance for CI as shown in Table 2. Maternal genetic model (Model II) increase the additive genetic variance with maternal additive variance σ^2_m of 0.02. Model 3 showed substantially higher estimates of additive genetic variance σ^2_a=23 except Model 2nd and heritability was estimated as 0.002±0.1. In Model III and VI, where σ_{am}=9 and 0.03, respectively which were low. The estimation of heritability for maternal effect was not estimable. Model 3rd considered σ^2_a and σ^2_m with correlated direct and maternal effect was used to estimate of variance and covariance components. Maternal heritability was not estimated by Model III and VI. The highest log L value was estimated in Model IV, V and VI equal and the value of repeatability for all models were equal R=0.03. This value of repeatability was in agreement wilh the findings of Amble *et al.* (1970). The low estimates for CI was in agreement with the Kothari, (2004) in Surti buffalo. On the other hand, negative estimates (-0.116±0.083) of heritability for this trait was observed by Patel (1994).

Variance components and genetic parameters for SP are presented in Tables 2. Repeatability univariate model (Model I) partitioned the total phenotypic variance (σ^2_p=14801) into additive (σ^2_a=84) and residual variance (σ^2_e=14229). Heritability was estimated 0.006 by using Model I. Maternal genetic model (Model II) increase the additive genetic variance with maternal additive variance σ^2_m of 0.01. In Model III and VI, where σ_{am} =1 and -0.04, respectively. The estimation of heritability for maternal effect was not estimated by any model. Model 3rd considered σ^2_a and σ^2_m with correlated direct and maternal effect was used to estimate of variance and covariance components. The highest log L value was estimated in Model IV and the value of repeatability for all models were same R=0.03 as shown in Table 2. The permanent environment effect are ranged c^2=0.006 (Model 4) to 0.009 (Model 6). Similar to the present finding, Patel (1994) reported lower estimates of heritability (0.015±0.141) for SP in Surti buffalo. On the other hand, Kornel and Patro (1988) reported higher estimates of heritability at 0.350±0.185 for SP whereas negative estimates (-0.089±0.088) of heritability for this trait was observed by Patel (1994).

Repeatability univariate model (Model I) partitioned the total phenotypic variance (σ^2_p=9132) into additive (σ^2_a=264) and residual variance (σ^2_e=8742) as shown in Table 2. It showed low heritability (h^2=0.029) because low estimates of additive variance. Maternal genetic model (Model II) decrease the additive genetic variance with maternal additive variance σ^2_m of 201. Model 3 showed substantially lower estimates of additive genetic variance σ^2_a=3.05 except Model 2nd and heritability was not estimated. In Model III and VI, where σ_{am}=23 and 18, respectively which were low. The estimation of heritability for maternal effect was ranged 0.001 (Model 6) to 0.02 (Model 2 and 3). Model 3rd considered σ^2_a and σ^2_m with correlated direct and maternal effect was used to estimate of variance and covariance components. Maternal heritability was not estimated by Model V. The highest log L value was estimated in Model VI and the value of repeatability for all models were ranged R=0.008 (Model 4) to 0.02 (Model 3). The permanent environment effect is similar in all model c^2=0.03. Very low estimates of heritability for DP was reported the 0.017±0.122 (Patel, 1994) and 0.053±0.105 (Kothari, 2004) in Surti buffalo which are in agreement with present study. On the other hand, negative estimates (-0.318±0.040) of heritability for this trait was observed by Kornel and Patro (1988).

The heritability for all reproduction traits was very low, indicating that better management and feeding procedures could be more efficient than selective breeding. Reproduction traits are mainly influenced by non-genetic factors, suggesting that improvement of management conditions may be sufficient to improve performance in these traits.

Genetic and phenotypic correlation

The correlation coefficients were estimated among all reproduction traits. The results of genetic (above diagonal) and phenotypic (below diagonal) correlation among reproduction have been presented in Table 3. The genetic correlations of SP were estimated as 0.92 with DP which was similar with the findings of Tailor (1995) and Kothari (2004). For other traits genetic correlation was not estimable. The phenotypic correlations of SP were 0.90 and 0.90 with DP and CI, respectively. It was

Table 1. Season, period and parity wise Least squares means and standard errors of reproductive traits of Surti buffalo.

Effect	**CI**	**DP**	**SP**
N	493	487	492
μ±S.E.	491.58±8.56	195.57±6.87	223.60±8.75
Sire	NS	NS	NS
Season	**	**	**
Winter (I)	5089.7±12.82^{b} (130)	210.05±10.00^{c} (129)	241.52±12.82^{b} (130)
Summer (II)	517.61±20.35^{b} (42)	216.60±15.92^{bc} (40)	250.71±20.14^{b} (42)
Rainy (III)	487.30±11.20^{ab} (198)	187.05±8.81^{ab} (195)	216.88±11.28^{a} (197)
Autumn (IV)	452.64±12.38^{a} (123)	168.59±9.66^{a} (123)	185.30±12.40^{a} (123)
Period	**	**	**
I (1993-1999)	556.04±31.67^{c} (57)	264.54±24.45^{c} (57)	299.20±31.33^{c} (57)
II (2000-2004)	544.40±16.93^{bc} (169)	227.78±13.11^{bc} (166)	276.13±16.81^{bc} (168)
III (2005-2008)	492.71±14.81^{b} (115)	193.28±11.54^{b} (114)	222.64±14.76^{b} (115)
IV (2009-2012)	413.50±19.71^{a} (99)	138.66±15.22^{a} (99)	142.03±19.54^{a} (99)
V (2013-2017)	451.28±28.81^{b} (53)	153.60±22.11^{b} (51)	178.02±28.44^{b} 53
Parity	**NS**	**NS**	**NS**
I	509.47±15.61 (159)	218.44±12.18 (158)	238.55±15.54 (159)
II	497.74±14.48 (113)	197.03±11.27 (112)	227.89±14.44 (113)
III	491.01±14.78 (83)	197.44±11.66 (81)	216.42±14.81 (82)
IV	503.33±16.96 (58)	197.32±13.26 (56)	236.40±16.84 (58)
V	501.12±20.06 (40)	230.71±16.19 (40)	236.10±20.84 (40)
VI	500.82±27.49 (23)	195.81±21.05 (23)	236.38±27.13 (23)
VII	4307.6±33.03 (17)	159.27±25.29 (17)	173.46±32.56 (17)
AFC	NS	NS	NS
REG.COEFF.	-0.053±0.027	-0.036±0.021	-0.052±0.027

Table 2. Estimates of Variance components and heritability (h^2±SE) for CI, SP and DP.

Items	Model-1	Model-2	Model-3	Model-4	Model-5	Model-6
Calving interval						
σ^2_a	0.64	18	23	1	2	0.4
σ^2_m		0.02	3		0.02	0.01
σ_{am}			9			0.03
σ^2_c				134	138	145
σ^2_e	14651	14651	14653	14655	14658	14661
σ^2_p	15189	15190	15190	15189	15189	15189
σ^2_R	537	520	502	399	391	383
h^2	NE	0.001±0.07	0.002±0.1	NE	NE	NE
m^2		NE	NE		NE	NE
r_{am}			1			0.39
c^2				0.009±0.05	0.009±0.07	0.01±0.07
R	0.04±0.06	0.03±0.06	0.03±0.08	0.03±0.06	0.03±0.07	0.03±0.09
Log L	-2626.167	-2626.167	-2626.165	-2626.140	-2626.140	-2626.140
Service period						
σ^2_a	84	106	131	68	61	1.7
σ^2_m		0.01	0.007		0.03	0.001
σ_{am}			1			-0.04
σ^2_c				89	103	128
σ^2_e	14229	14229	14225	14229	14236	14239
σ^2_p	14801	14799	14802	14799	14797	14796
σ^2_R	488	464	445	412	398	428
h^2	0.006±0.05	0.007±0.07	0.009±0.11	0.005±0.05	0.004±0.07	NE
m^2		NE	NE		NE	NE
r_{am}			1			-0.9
c^2				0.006±0.04	0.007±0.07	0.009±0.08
R	0.03±0.06	0.03±0.06	0.03±0.09	0.03±0.07	0.03±0.08	0.03±0.09
Log L	-2614.339	-2614.338	-2614.338	-2614.325	-2614.325	-2614.328

Table 2. Estimates of variance components and heritability (h^2±SE) for CI, SP and DP. (Continue.)

Calving interval						
Items	**Model-1**	**Model-2**	**Model-3**	**Model-4**	**Model-5**	**Model-6**
Dry period						
σ^2_a	264	9.4	3.05	43	35	28
σ^2_m		201	172		1	12
σ_{am}			23			18
σ^2_c				278	280	250
σ^2_e	8742	8746	8744	8730	8730	8734
σ^2_p	9132	9127	9127	9125	9125	9124
σ^2_R	126	170	185	73	79	83
h^2	0.029±0.05	0.001±0.07	NE	0.005±0.06	0.004±0.08	0.003±0.1
m^2		0.022±0.05	0.02±0.07		NE	0.001±0.12
r_{am}			0.9			1
c^2				0.03±0.05	0.03±0.08	0.027±0.09
R	0.014±0.07	0.019±0.07	0.02±0.09	0.008±0.07	0.009±0.08	0.009±0.09
Log L	-2470.370	-2470.253	-2470.250	-2470.156	-2470.156	-2470.150

Table 3. Heritability (diagonal), genetic (above diagonal) and phenotypic (below diagonal) correlation among all reproduction traits.

Traits	SP	DP	CI
SP	0.005±0.05	0.92±NE	NE
DP	0.90±0.02	0.003±0.10	NE
CI	0.93±0.07	0.94±0.06	NE

NE Not estimable

observed as 0.93 between CI and DP. The present findings are close association with the finding of Kothari (2004).

CONCLUSION

The effect of season was highly significant (P≤0.01) on all reproduction traits because of availability of fodder was different in different seasons. Effect of period of calving was also highly significant as a particular period contains several years with similar environmental adaptations and entirely different with one another. Parity and sire did not affect the reproduction traits. Heritability estimates were very low for all traits due to low additive genetic variance. It is indicating that better management and feeding procedures could be more efficient than selective breeding. Reproduction traits are mainly influenced by non-genetic factors, suggesting that improvement of management conditions may be sufficient to improve performance in these traits. Introduction of maternal variance has increased the additive genetic variance. All traits were highly correlated to each other but some values were not estimated it may be due to small data size.

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