



Optimizing age at first freezing in relation to fertility of Murrah breeding bulls

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ABSTRACT

The optimization of age at first freezing in Murrah breeding bulls has been studied which will help in early selection of bulls for improving the reproductive performance in the herd. The data pertaining to age at first freezing (AAFF), conception rate based on first AI (CRFAI), overall conception rate (OCR) and birth weight (B.WT) of 57 Murrah bulls during 1993 to 2014 belonging to 14 sets of Network Project on Buffalo Improvement at ICAR-National Dairy Research Institute, Karnal, Haryana were adjusted against environmental influence and subsequently analyzed. Simple and multiple regression models were developed for prediction of CRFAI and OCR of Murrah breeding bulls. By judging of three developed models (I to III) it was observed that Model III having age at first freezing and birth weight fulfill the accuracy of model, i.e. high coefficient of determination, low mean sum of square, due to error (MSSE), low conceptual predictive value (Cp value) and low Bayesian information criterion (BIC). The results revealed that optimum age at first freezing of Murrah bulls should be 2.5–3.0 years for 4.98% better conception rate based on first AI and 3.92% better overall conception rate in comparison to Murrah bulls with more than 3.5 years of age.

Key words: Age at first freezing, Conception rate based on first A.I., Murrah bull, Overall conception rate

Murrah is one of the best indigenous buffalo breed of India with superior genetic potential for milk production and extensively used to upgrade the non-descript buffalo stock in India. Due to less importance given to the selection of Murrah bulls for better reproductive performance, there may be possibility of serious deterioration in fertility of Murrah buffaloes. Fertility levels are the result of a combination of genetic potential and environmental factors including nutrition, health, and bull management (Hamilton, 2009). Age of the bull also has an effect on the semen parameters, which in turn is reflected in terms of fertility in the herd. Service sire's age affect conception rate (CR) in dairy cattle (Kuhn *et al.* 2006). Optimizing age of breeding bulls for fertility will improve the selection criteria and use of such breeding bulls at right age will enhance the herd performance (Kuhn and Hutchison, 2008). The purpose of the present study was to optimise the age at first freezing of Murrah bulls, which would help in the selection of the bulls at earlier age, improve the accuracy of predictions of bull's conception rate and would aid in designing more effective breeding programmes.

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MATERIALS AND METHODS

Karnal is situated at an altitude of 235 to 252 meters (748 feet) above the mean sea level at 29.68°N latitude and 76.98°E longitude in eastern zone of Haryana which comes under the Trans-Gangetic plain agro climatic zone of India. The climate that prevails is subtropical in nature. The temperature in summer months (April to June) ranges between 24°C - 44°C. Karnal experiences moderate rainfall in the months of July and lasts till September. Winters are extremely cold. The temperature ranges from 4°C to 32°C in winter months (October, November, December and January). Each year was sub-classified into four major seasons viz., winter (December to March), summer (April to June), rainy (July to September) and autumn (October to November), depending on prevalent meteorological factors as recorded in CSSRI, Karnal (Singh 1983). The study was conducted on records of 57 Murrah bulls maintained under 14 sets of Network Project on Buffalo improvement at NDRI centre. On standardization and normalization of traits the number of bulls remained in the analysis were 57 for age at first freezing and same for birth weight. The traits under study were age at first freezing (AAFF), conception rate based on first AI (CRFAI), overall conception rate (OCR) and birth weight (B.WT) of Murrah breeding bulls.

Statistical analysis

The data were classified into various sub-classes to analyse the effect of non-genetic factors as season and

period of birth, parity and age of dam for birth weight (B.WT), period and season of freezing for age at first freezing and period and season of AI, parity, stages of lactation and age of buffalo for conception rate based on first AI and overall conception rate of breeding bulls, respectively. Reproduction and growth traits of Murrah bulls were adjusted for significant non-genetic factors by using fixed linear models. Since the data were non-orthogonal, the least-squares technique suggested by Harvey (1990) was used to estimate the effect of non-genetic factors on various traits.

The model considered for conception rate based on first AI and overall conception rate of Murrah bulls was considered as,

$$Y_{ijklmn} = \mu + P_i + S_j + PA_k + SL_l + b (AF_m - \bar{A}F) + e_{ijklmn}$$

where,

Y_{ijklmn} , Observation on the n^{th} bull in i^{th} period of AI, j^{th} season of A.I., k^{th} parity of buffalo, l^{th} stages of lactation of buffalo and m^{th} age of buffalo; μ , Overall mean; P_i , Effect of i^{th} period of AI (1 to 14); S_j , Effect of j^{th} season of AI (1 to 4); PA_k , Effect of k^{th} parity of buffalo (1 to 5); SL_l , Effect of l^{th} stage of lactation of buffalo (1 to 3); b , Regression of age of buffalo on the CRFAI; and OCR; AF_m , Age of m^{th} buffalo; $\bar{A}F$, Average age of buffaloes; e_{ijklmn} , Random error $\sim NID(0, \sigma_e^2)$.

The model for age at first freezing was considered as,

$$Y_{ijk} = \mu + P_i + S_j + e_{ijk}$$

where,

Y_{ijk} , Observation on the k^{th} bull in i^{th} period and j^{th} season of freezing; μ , Overall mean; P_i , Fixed effect of i^{th} period of freezing (1 to 14); S_j , Fixed effect of j^{th} season of freezing (1 to 4); e_{ijk} , Random error $\sim NID(0, \sigma_e^2)$.

The model considered for birth weight of Murrah bulls was considered as,

$$Y_{ijkmn} = \mu + P_i + S_j + PA_k + b (AD_m - \bar{A}D) + e_{ijkmn}$$

where,

Y_{ijkmn} , Observation on the n^{th} bull in i^{th} period of birth, j^{th} season of birth, k^{th} parity of dam and m^{th} age of dam; μ , Overall mean; P_i , Effect of i^{th} period of birth (1 to 14); S_j , Effect of j^{th} season of birth (1 to 4); PA_k , Effect of k^{th} parity of dam (1 to 5); b , Regression of age of dam on birth weight of bulls; AD_m , Age of m^{th} dam; $\bar{A}D$, Average age of dams; e_{ijkmn} , Random error $\sim NID(0, \sigma_e^2)$.

The difference of means between sub-classes of periods, seasons, parity and stage of lactation were tested for significance using Duncan's Multiple Range Test (Kramer, 1957). The analysis of variance for season and period of freezing, stage of lactation, age of buffalo and parity affecting different reproduction traits under model were computed.

Model used for prediction of conception rate in Murrah bulls: Simple and multiple regression analysis were performed for prediction of conception rate using SAS package (2011). Three models were developed by using all possible combination of birth weight and age at first freezing for prediction of conception rate as presented in Table 2 and 4. The coefficient of determination (R^2) for each model is estimated and expressed in terms of percentage. Mallow's conceptual predictive value is used for predicted model selection (Mallows 1973). Akaike information criterion (AIC) as developed by Hirot Sugu Akaike (1974) and Bayesian information criterion (BIC) as developed by Schwarz (1978) was also estimated for model selection with different numbers of parameters. The model with lowest AIC value, BIC value, $C_p = < p$, high R^2 and minimum mean sum of squares due to error using combination of birth weight and age at first freezing was judged as optimum model for prediction of conception rate based on first A.I. and overall conception rate in Murrah bulls.

Optimisation of age at first freezing: Three age groups of bulls were considered. The highest conception rate

Table 1. Estimation of intercept and regression coefficients for prediction of conception rate based on first AI and overall conception rate for Murrah bulls

Traits	Conception rate based on first AI			Overall conception rate		
	Intercept	Regression	Coefficients b_1	Intercept b_2	Regression b_1	Coefficients b_2
AAFF	59.44	-6.8116	—	57.65	-5.3942	—
B.WT	13.03	0.7024	—	14.70	0.7393	—
AAFF,B.WT	34.28	-4.8359	0.5491	28.26	-3.0860	0.6414

AAFF, age at first freezing; B.WT, birth weight.

Table 2. Estimation of criterion values, for judging optimum model for conception rate based on first AI in Murrah bulls

Model No.	Traits	P	R^2	MSSe	C_p	AIC	BIC
I	AAFF	2	0.1445	0.1923	2.00	-44.96	-8.08
II	B.WT	2	0.1743	0.1856	2.00	-47.30	-8.67
III	AAFF, B.WT	3	0.2388	0.1660	3.00	-54.67	-8.93

P, number of parameters; R^2 , coefficient of determination; MSSe, mean sum of square due to error; C_p , conceptual predictive value; AIC, Akaike information criterion; BIC, Bayesian information criterion.

corresponding to the lowest age at first freezing of bulls was optimised by judging the predicted conception rates and average error of prediction in the respective age groups.

RESULTS AND DISCUSSION

Birth weight of Murrah bulls was significantly influenced by period of birth ($P < 0.01$). Age at first freezing of semen in Murrah bulls was significantly influenced by period and season of freezing ($P < 0.01$). Conception rate based on first AI and overall conception rate of breeding bulls was influenced significantly by period and season of AI and age of buffalo ($P < 0.01$). The effect of parity and stage of lactation was found non-significant in all of the traits. Least-squares means of birth weight, age at first freezing, conception rate based on first AI and overall conception rate were estimated as 35.09 ± 0.16 kg, 3.38 ± 0.01 years, 40.27% and, 39.50% respectively.

Optimizing age at first freezing in relation to conception rate: The models for prediction of conception rate based on first AI and overall conception rate of Murrah bulls have been developed using simple and multiple regression analysis. The intercept and regression coefficient of each model are presented in Table 1. For judging the optimum model for conception rate based on first AI and overall conception rate of Murrah bulls various criterion values like R^2 , MSSE, Cp, AIC and BIC values for each model were estimated and presented in Table 2 and 3. Looking into the judging of models it was observed that the Model III having birth weight and age at first freezing fulfilled four criterion like high R^2 , low MSSE, low Cp and low BIC value.

For optimizing age at first freezing in relation to fertility (conception rate based on first A.I.) of Murrah bulls, age at first freezing of Murrah bulls was classified into three groups i.e. 2.5–3 years, 3–3.5 years and > 3.5 years (Table 4) and depicted in Fig 1. Average predicted conception rate was found highest (39.50%) for Murrah bulls at 2.5–3 years, and lowest (34.52%) when age at first freezing of Murrah

bulls was > 3.5 years of age with average errors were 5.14 % (2.5–3 years), 14.50 % (3–3.5 years) and 24.66 % (> 3.5 years), respectively.

For optimizing age at first freezing in relation to fertility (overall conception rate) of Murrah bulls depicted in Fig 2. Average predicted conception rate was found highest (41.81%) at 2.5–3 years and lowest (37.89%) at > 3.5 years of age at first freezing of Murrah bulls with average errors were 8.89 % (2.5–3 years), 9.01 % (3–3.5 years) and 17.88 % (> 3.5 years), respectively.

The effect of age on the ability of buffalo male to produce semen has long been recognized (Pant *et al.* 2003). It should be emphasized that “bull age” here refers to age of the bull when their semen was collected and first frozen. So far there has been no report available on optimization of age at first freezing in Murrah bulls. Age of the bull has an effect on the semen parameters, which in turn is reflected in terms of fertility in the herd as revealed by some studies. VanDemark *et al.* (1956) reported that volume of semen increased through the first four years and that sperm concentration was maximized in the second and third year, with only slightly lower concentrations in the fourth year. Taylor *et al.* (1985) studied the effect of bull's age at the time of collection and also found the general pattern of increasing conception rate with increasing age, followed by a decline after reaching a maximum. Results of Taylor *et al.* (1985) for bull ages 8 and greater were variable. There appeared to be some continued decline in fertility after 8 yr of age but at a substantially lower rate than the decline from ages 5 to 8 yr. Saeed (1988), reported the availability of best quality semen at 3–4 years of age and concluded that the age of the buffalo bull affect semen characteristics however that variations in these parameters do exist even in the same age in different localities. Saeed *et al.* (1990) reported that semen of best quality, with regard to sperm morphology, was observed in 3- to 5-year-old Nili-Ravi buffalo bulls whereas Singh *et al.* (2004) reported the same in Murrah bulls.

Table 3. Estimation of criterion values, for judging optimum model for overall conception rate in Murrah bulls

Model No.	Traits	P	R^2	MSSE	Cp	AIC	BIC
I	AAFF	2	0.1188	0.1510	2.00	-60.92	-12.07
II	B.WT	2	0.2533	0.1390	2.00	-66.39	-13.44
III	AAFF, B.WT	3	0.2877	0.1256	3.00	-73.08	-13.5

Table 4. Optimum age at first freezing and predicted conception rate based on first and overall AI of Murrah bulls in relation to birth weight

AAFF (years)	No. of bulls	B.WT (Kg)	CRFAI (%)	Average prediction error (%)	OCR (%)	Average prediction error (%)
2.5–3	5	35.13	39.50	5.14	41.81	8.89
3–3.5	22	34.24	37.37	14.50	40.20	9.01
> 3.5	11	32.57	34.52	24.66	37.89	17.88

B.WT, birth weight; AAFF, age at first freezing; CRFAI, conception rate based on first A.I; OCR, overall conception rate.

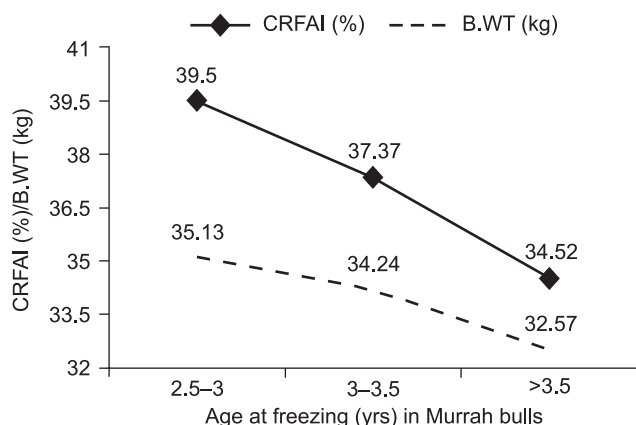


Fig. 1. Optimum relation between B.WT, AAF and CRFAI in Murrah bulls.

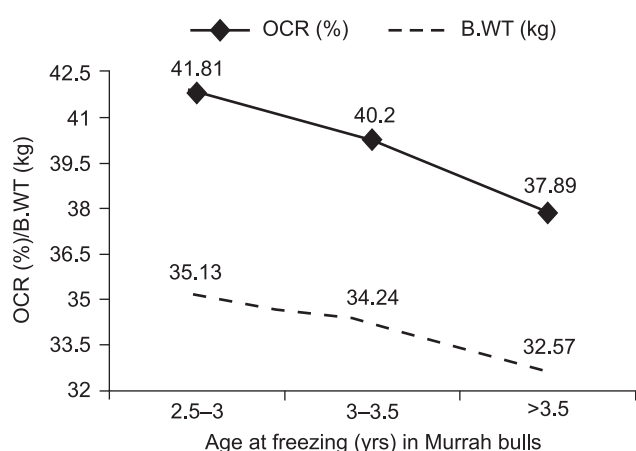


Fig. 2. Optimum relation between B.WT, AAF and OCR in Murrah bulls.

The overview of results, depicts a negative association of conception rate with age at first freezing and to obtain maximum conception rate of Murrah bulls, age at first freezing of semen should be around 2.5–3 years under our management regime. The present study will strengthen the selection of bulls at early age and may help to achieve the objective of number of frozen semen doses required from a breeding bull at the start of the set of breeding bulls to be tested under progeny testing programme. At the same time, however, it is worthwhile to bear in mind that more detailed data collection under improved energy based feeding and management could possibly lead to further reduction of age at first freezing and improvement in predictions of conception rate of Murrah bulls. Technology such as bar coding of semen straws may enhance the possibility of

accurate freezing dates which will increase the accuracy of predictions.

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