Pak. j. life soc. Sci. (2019), 17(1): 1-6 E-ISSN: 2221-7630; P-ISSN: 1727-4915

Pakistan Journal of Life and Social Sciences

www.pjlss.edu.pk

RESEARCH ARTICLE

Inbreeding Effect on Productive, Reproductive and Lifetime Traits of Nili-Ravi Buffaloes

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ARTICLE INFO

Received: Apr 25, 2019
Accepted: May 27, 2019

Keywords
Inbreeding depression
Nili-Ravi buffaloes
Performance traits
Regression

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ABSTRACT

This study was conducted to determine the effect of inbreeding on productive, reproductive and lifetime traits in Nili-Ravi buffaloes. For the purpose, pedigree records of 3165 animals from four institutional herds located in Punjab province of Pakistan were used to estimate the extent of inbreeding and its consequences on productive, reproductive and lifetime traits. Inbreeding was included in a linear fixed model either as a class variable or a continuous variable. A mild proportion of the Nili-Ravi buffaloes and bulls were inbred i.e. 15 % and 12%, respectively. It was observed that the level of inbreeding significantly altered (P<0.05) the 305-days milk yield (305-DMY), total milk yield (TMY) and services per conception (SPC). On the other hand, inbred class did not affect (P>0.05) the lactation length, age at first calving, dry period, service period, calving interval and lifetime traits. In conclusion, the 305-DMY, TMY and SPC were adversely affected by the inbreeding coefficients. The inbreeding reduced the production, prolonged the reproductive processes and limited the lifetime traits.

INTRODUCTION

The animals which are mated/bred with closely related animals as compared to an average random mating population which means that these animals are mated with animals having one or more common ancestors are called inbred animals and this phenomenon is called Inbreeding. The extent of inbreeding can be calculated as inbreeding coefficient which interprets the rate of loss of heterozygosity in the herd or population per generation (Huisman et al., 2016). The impact of inbreeding on hereditary assessment is considered twofold; one is the inbreeding straightforwardly influences the hereditary expression i.e. inbreeding changes the breeding values of individual thereby wrongly increasing covariance between breeding values of the parents and individual thus phenotypic variance among sibling of individual is decreased. Secondly, inbreeding generally affects the evaluation in adverse manner. Inbreeding depression is one of the main causes of inbreeding which decreases the strength of phenotypic expression and more pronounced in case of reproductive traits (Miglior et al., 1992). Dairy animals with high level of inbreeding are more vulnerable to involuntary culling, likely show up within the information less regularly than the cows that were not inbred. Furthermore, it is also reported that inbreeding depression does not cause large reduction in milk yield in a cow with average inbreeding. However, when the inbreeding coefficient was greater than 12.5%, the magnitude of inbreeding depression showed higher decrease in vigor than anticipated based on a linear regression (Miglior et al., 1992).

Most of the studies estimating inbreeding effects on performance related parameters on animals' phenotype have focused on production related traits. Previously, in an Egyptian buffalo herd, lactation period, milk yield, and age at first calving were investigated for inbreeding. Age at first calving was more adversely affected by inbreeding as compared to lactation period and milk yield (Feres et al., 2018; Troianou et al., 2018; Filho et al., 2015). Thevamanoharan (2002) could not trace any inbred animal because pedigrees were traced back to one generation. Animal identities were perhaps not resolved with the individual history sheets. He concluded that there was no inbreeding depression in the Nili-Ravi herd. The effect of inbreeding was carried out on the first lactation traits and inbreeding depression was evident in most of the traits but animals with more than 12.5 percent inbreeding were worst affected (Musingi et al., 2018; Bashir et al., 2009). Scanty research in buffaloes especially in institutional herds in Punjab, Pakistan on inbreeding estimation and its impact on various traits related with production and reproduction is the motivation of the current study. Therefore, the present study was planned to evaluate the influence of inbreeding on different traits of economic importance using the regression technique.

MATERIALS AND METHODS

Records on performance and Pedigree of Nili-Ravi buffaloes (n= 3165) from four Livestock Experiment Stations (LES) situated at Haroonabad, District Bahawalnagar; Chak Katora, District Bahawalpur; Khushab, District Khushab and Livestock Production Research Institute Bahadurnagar, District Okara in Punjab, Pakistan were utilized for this study.

Identification numbers of buffaloes with records were used to trace their pedigrees back to the base population. All the known relationships were considered which, in few cases, comprised information for more than 10 generations. The detection of inbreeding is possible only when minimum number of two ancestors on both the sire and dam part of the pedigree is known. Inbreeding coefficients were estimated for all breeding animals in the data set according to the algorithm (Quaas, 1976). The same algorithm was used for estimating additive relationships among a restricted number of breeding bulls and buffaloes. Inbreeding coefficient and additive relationship were computed in relation to the population of ancestors with known pedigrees. Annual trend in inbreeding was estimated by averaging inbreeding coefficient of each animal within each year. The inbreeding coefficient was divided into five classes (Tohidi et al., 2002) and distribution of records with respect to level of inbreeding presented in Table 1.

Table 1: Distribution of animals in different inbred classes

Class	Level of inbreeding	No. of Animals	Percentage
1	F=0	2692	84.5
2	$0 \leq F < 6.25$	243	8.1
3	$6.25 < F < 12.5$	165	3.9
4	$12.5 < F < 18.75$	44	2.5
5	F>18.75	21	0.9

Statistical analysis

The effect of inbreeding on various performance traits was studied using inbreeding classes as a fixed effect in the model with other effects. The following statistical model was assumed for the analysis of productive, reproductive and lifetime traits to estimate the effect of level of inbreeding.

$$Y_{ijklm} = \mu + HY_i + SOC_{ij} + Age_{ijk} + IB_{ijkl} + \varepsilon_{ijklm}$$

Where,

Y_{ijklm} = observation in the factor

μ = the population mean

HY_i = fixed effect of herd-year (1-104)

SOC_{ij} = Season of calving (Winter, Spring, Summer and Autumn, 1,2,3 and 4, respectively)

Age_{ijk} = Parity code (1-30) (Bashir et. al., 2009)

IB_{ijkl} = Inbreeding classes (1, 2, 3, 4, 5)

ε_{ijklm} = The random error associated with each observation

Regression analysis

The analysis was carried for the estimation of the effect of the inbreeding on the productive and reproductive traits. The prediction equation was as follow;

$$Y_i = \alpha + \beta X_i + \varepsilon_i$$

Where

Y_i = is the i^{th} observed value of dependent variable;

α = is the population Y intercept, the value of Y at X^0

β = is the slope of line through the means of the Y population

X_i = is the i^{th} observed value of independent variable

ε_i = is the random error of the observed value Yi with mean zero and variance σ^2

The analysis was carried out using the SAS/STAT (1990).

RESULTS AND DISCUSSION

Pedigrees of the animals were traced back to the base population of Nili-Ravi buffaloes in all herds to calculate the level of inbreeding in these animals. The results of the analyses of the pedigree records of 2881 animals having identification for the extent of inbreeding revealed that 472 animals (14.97 percent) were inbred with an average inbreeding coefficient of 0.073 (7.3 percent) and the maximum level of inbreeding was 0.37 (37 percent). Out of 189 sires 22 sires (11.64 percent) were found inbred having average inbreeding coefficient 0.086 (8.61 percent) with the maximum inbreeding coefficient 0.29 (29.27 percent). The level of inbreeding in Nili-Ravi buffaloes was comparable as reported by Filho et al. (2015), Bashir et al. (2009) and Ahmad et al. (1987). The present study revealed that the level of inbreeding was increasing with the time. The main factor may be attributed to the inbred bulls which were used for the artificial insemination. Other reason for low level of inbreeding in the present herds was incompleteness of pedigrees especially for animals born in early years. About 53 percent of the population was without pedigree records.

The inbreeding trend in different years presented in Fig. 1. The dependent variable was the inbreeding coefficient while year of birth was the fixed effect. The inbreeding coefficient was 2.5 percent in 1971 followed by the 1993 (2.09%). The minimum inbreeding coefficient was observed in (0.16%) 1981. The inbreeding coefficient of the four institutional herds showed that the maximum inbreeding (15%) was observed at LES, Haroonabad, LES, Chak Katora and LES, Khushab whereas at LPRI, Bhadarnagar only 5% inbreeding was observed. The Fig. 1 showed that the inbreeding coefficient was increasing after 1981 which might be due to the use of inbred bulls.

The analysis of variance (Table 2 and 3) revealed that the inbred classes significantly affected (P<0.01) the 305-DMY. The total milk yield (TMY) and gestation period were also affected significantly (P<0.05). Findings of some previous studies partially supported the present study (Filho et al., 2015; Ahmad et al., 1987; Khan, 1986; Iqbal, 1984). In India, Reddy et al. (1983) observed that when the animals were classified into 6 groups according to inbreeding, the only 300-DMY showed significant (P<0.05) group differences for first lactation dairy performance traits.

Contrarily, the research findings of Mahdv (1994) did not coincide with the present study and reported that the inbreeding significantly decreased the lifetime milk yield, number of lactations completed and length of productive life. Ayyat et al. (1997) reported that most of the traits were significantly affected by inbreeding. As inbreeding increased, dry period increased whereas values for milk yield, calving interval and lactation duration decreased. In Venezuela, Vasconcellos and Tonhati (1998) reported that inbreeding only affected the lactation length (LL).

The average of productive, reproductive and lifetime traits against the various degree of inbreeding are presented in the Fig. 2-4. The declining trend in the 305-DMY, TMY and LL was observed with the increasing the level of inbreeding. The average 305-DMY, TMY and LL were 1813.02±15.13 kg, 1936.84±17.76 kg and 282.40±2.12 days, respectively at zero level of inbreeding whereas averages decreased to 1749.76±66.61kg, 1850.13±78.20kg and 275.44±9.34 days, respectively at F≥18.75 percent inbreeding level. The graphical presentation of the all productive, reproductive and lifetime traits revealed that there was no sharp trend which indicated the effect of different levels of inbreeding on these traits.

The regression of 305-DMY, TMY and LL on inbreeding coefficients was –18.18±3.11 kg, -17.65±4.25 kg and –1.77±0.37 days, respectively. This indicated that with each one percent increase in inbreeding coefficient, the 305-DMY, TMY and LL decreased by 18.18±3.11kg, 17.65±4.25kg and 1.77±0.37days (Table 4). The analysis of variance of 305-DMY, TMY and LL showed that the decline due to inbreeding was significant (P<0.05). These findings are supported by Vasconcellos and Tonhati (1998), Ayyat et al. (1997) and Reddy et al. (1983).

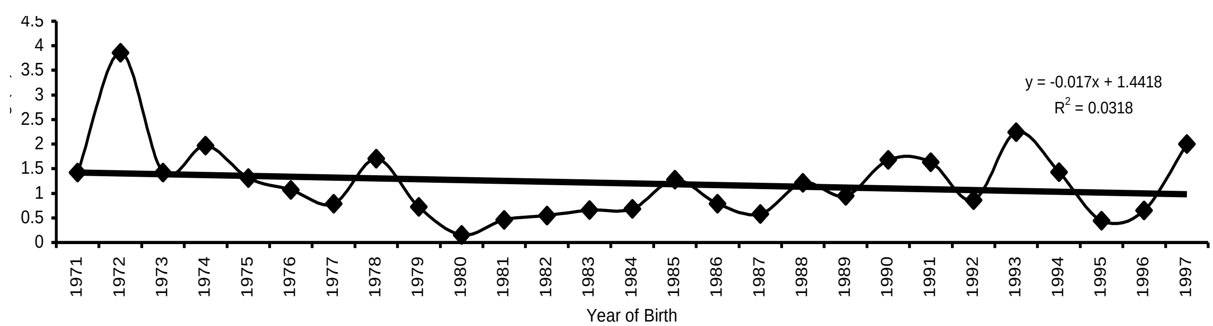

Fig. 1: Level of inbreeding (%) during different years in Nili-Ravi buffaloes.

Table 2: Analysis of variance of some productive and reproductive traits using inbreed classes as variable

Source of variation	305-DMY (kg)	TMY (kg)	LL (days)	DP (days)	AFC (days)	CI (days)	SP (days)
HY	25.95**	22.06**	9.10**	6.53**	8.19**	5.92**	5.27**
SOC	39.56**	36.21**	12.80**	25.79**	3.68*	59.79**	58.47**
AC	5.55**	4.95**	4.25**	9.89**		8.98**	9.43**
InbClass	3.90**	3.98**	1.23^{NS}	1.65^{NS}	1.28^{NS}	0.96^{NS}	1.32^{NS}

**= highly significant (P<0.01); *= significant (P<0.05); ^{NS} = non-significant.

Table 3: Analysis of variance of some reproductive and lifetime traits using inbreed classes as variable

Source of variation	SPC	GP (days)	LTMY (kg)	HL (days)	PL (days)	BE
HY	20.46**	3.61**	5.64**	4.37**	7.23**	3.36**
SOC	21.16**	22.59**	3.28*	1.30^{NS}	0.16^{NS}	1.21^{NS}
AC	14.19**	2.18**	1.58*	9.75**	2.15**	1.31^{NS}
InbClass	2.88*	2.53*	0.42^{NS}	0.35^{NS}	0.14^{NS}	1.44^{NS}

**= highly significant (P<0.01); *= significant (P<0.05); ^{NS} = non-significant.

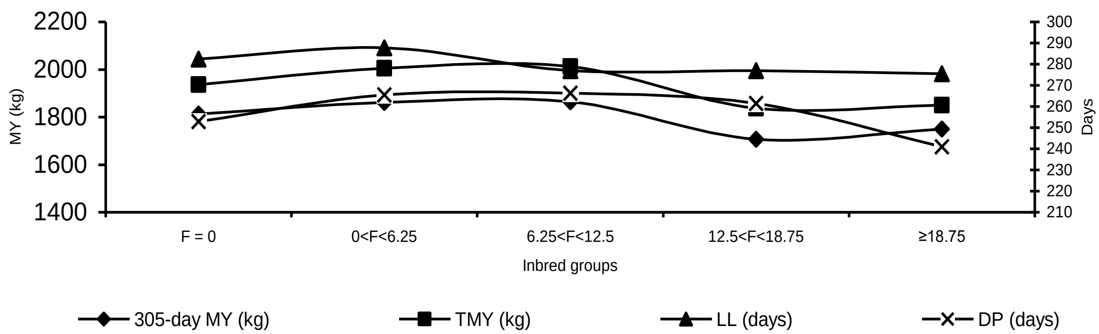

Fig. 2: Average 305-days milk yield (305-DMY), Total Milk Yield (TMY), Lactation Length (LL) and Dry Period (DP) in different inbred groups in Nili-Ravi Buffaloes.

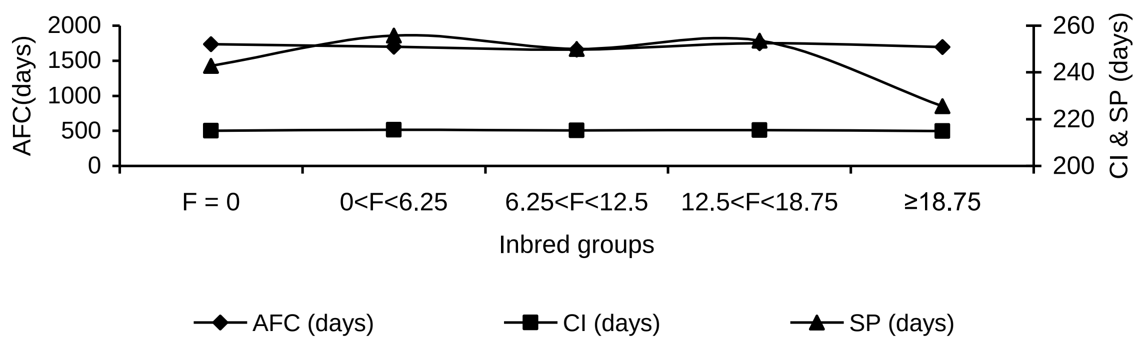

Fig. 3: Average age at first calving (AFC), Calving Interval (CI) and Service Period (SP) in different inbred groups in Nili-Ravi Buffaloes.

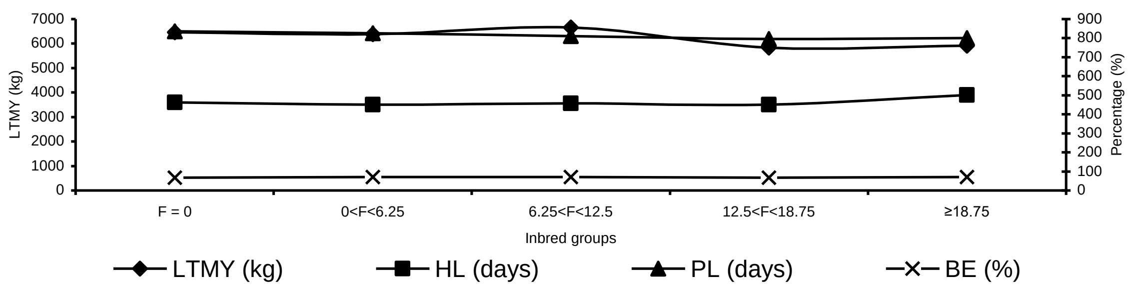

Fig. 4: Average Lifetime Milk Yield (LTMY), Herd Life (HL), Productive Life (PL) and Breeding Efficiency (BE) different inbred groups in Nili-Ravi Buffaloes.

Table 4: Estimates of inbreeding depression when only inbreeding coefficient was in the regression model

Trait	*Inbreeding Depression	Standard Error	t-value	Pr > |t|
305-day milk yield (kg)	-18.18	3.11	-5.83	0.0001
Total milk yield (kg)	-17.65	4.25	-4.15	0.0001
Lactation length (day)	-1.77	0.37	-4.85	0.0001
Dry period (day	1.21	0.44	2.72	0.0065
Age at first calving (day)	3.19	2.41	1.32	0.1878
Calving interval (day)	1.19	0.45	2.62	0.0080
Service period(day)	1.44	0.50	2.87	0.0041
Services per conception (No.)	0.04	0.01	10.38	0.0001
Gestation period (day)	0.12	0.03	4.41	0.0001
Lifetime milk yield (kg)	-75.50	44.80	-1.68	0.0927
Herd life (day)	-2.31	9.92	-0.23	0.8156
Productive life (day)	-5.07	3.31	-1.53	0.1258
Breeding efficiency (%)	-0.28	0.11	-3.38	0.0007

*Change in the trait due to 1 percent change in Inbreeding.

Ahmad et al. (1974) reported that the milk yield in the first lactation was adversely affected by inbreeding in dairy cattle whereas Galal et al. (1977), Nandagawali et al. (1997, 1996) and Tohidi et al. (2002) supported the results of the present study narrating that the reduction of 17.65 kg milk took place per 1% increase in inbreeding. Miglior (1994) also reported negative impact of inbreeding on milk yield in cattle.

The data in Table 4 revealed that all the productive, reproductive and lifetime traits were affected negatively by the inbreeding and the effect was significant, except the age at first calving, lifetime milk yield, herd life and productive life. The results of this study were supported by Hofmannova et al. (2019), Smith et al. (1998) and Nandagawali et al. (1996) who reported that the results of fixed and mixed animal models differed. The mixed model estimates of depression per 1% of increase in inbreeding were 5.07 days for productive life. The inbreeding coefficients triggered several losses in productive and reproductive traits of dairy Gyr cattle (Filho et al., 2015). The evaluations of future inbreeding proposed that observed inbreeding could be even lower which indicated a constant need to monitor rate of increase in inbreeding over the time (Ewa et al., 2018).

Inbreeding is not a serious problem in the Nili-Ravi buffaloes in Pakistan. The performance of inbred buffaloes slightly decreased for the productive, reproductive and lifetime traits. Comparison of the reported results with the results of present study showed that the influence of inbreeding on productive, reproductive and lifetime traits was low, which could be attributed to less/minute level of inbreeding and large number of non-inbred buffaloes. A linear regression and simple fixed effect model was used for the analysis, the estimation of inbreeding depression, simple models are able to supply good and reliable estimates. Based upon findings of this study, the effect of inbreeding on productive, reproductive and lifetime traits require further in-depth research.

Authors' contribution: MKB executed the plan, designed by the MKB and SR and collected the data, and drafted this manuscript reviewed by the MIM and MQB. However, MSK and MKB helped for analysis and data interpretation.

Acknowledgements: The authors acknowledge the L&DD Dept, GOP and staff of LESH, LESCK, LESK and LPRIBN for the provision of data.

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