EFFECT OF INBREEDING ON PRODUCTIVE AND REPRODUCTIVE TRAITS IN NILI RAVI BUFFALO: A CASE STUDY OF BUFFALO BULL MOTHER SCHEME IN PUNJAB

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ABSTRACT: Inbreeding, the mating of closely related individuals, is a critical factor in livestock breeding programs, influencing genetic diversity and productivity. While inbreeding itself does not create undesirable recessive genes, its accumulation can lead to inbreeding depression, negatively impacting key economic traits such as milk yield, reproductive efficiency, and overall herd performance. This study assessed the level of inbreeding and its effects on performance traits in Nili-Ravi buffalo populations registered under the Buffalo Bull Mother Scheme at the Livestock Production Research Institute (LPRI), Bahadurnagar, District Okara, Pakistan. Pedigree and performance data from 2000 to 2020 were analyzed to estimate the inbreeding coefficient (F). Results showed a mean inbreeding coefficient of 0.00078 ± 0.013 for the population, while inbred animals had a mean F of 0.225 ± 0.055 (ranging from 0.125 to 0.250). Inbreeding had a significant impact on total milk yield, days in milk, calving interval, and age at first calving, with each 1% increase in inbreeding leading to a 5.8 kg reduction in 305-day milk yield. These findings highlight the detrimental effects of inbreeding on buffalo productivity, emphasizing the need for genetic management strategies to mitigate its adverse impact. This study underscores the importance of structured breeding programs to preserve genetic diversity and optimize productivity in Nili-Ravi buffaloes, a crucial breed for Pakistan's dairy industry.

Keywords: Inbreeding, Nili-Ravi buffalo, Inbreeding depression, Pedigree analysis, Genetic management, Dairy performance.

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INTRODUCTION

Inbreeding, as defined by Falconer and Mackay (1996), refers to the breeding of closely related individuals, a practice that can exert a significant influence on the genetic makeup of a population by introducing identical genes from each parent. It is important to note that inbreeding itself does not lead to the creation of undesirable recessive genes within a population. However, Pryce *et al*. (2014) have shown that it can contribute to the emergence of unfavorable genetic trends, ultimately resulting in a decline in the average phenotypic performance. This phenomenon is commonly known as "inbreeding depression." Within the realm of livestock breeding, inbreeding can have detrimental consequences, leading to a reduced number of calves available for sale and, consequently, a decrease in the economic value of the breed. Numerous economic traits in dairy animals, including yield and reproductive traits, have been observed to exhibit signs of inbreeding depression. Inbreeding depression, as outlined by Leroy (2014), results in an increase in homozygosity and the proliferation of unfavorable genotypes within the population.

Buffalo holds significant importance in the dairy industry, with an estimated population of approximately 45 million head. In the Punjab region alone, there are around 25 million buffalo (Anonymous, 2022-23). These buffalo play a pivotal role, contributing substantially by accounting for 70% of the country's total milk production. However, buffaloes are known to be less efficient milk producers, slower in reaching maturity, and subject to longer calving intervals (Cady *et al*., 1983). Moreover, the longevity of buffaloes and low culling rates compromise genetic progress in this breed. Given the substantial buffalo population in the Punjab province, extensive improvement programs are in place. These programs have dual aims: preserving the genetic diversity of this crucial breed and enhancing its overall performance. The primary objectives of these initiatives transcend mere preservation and include establishing a robust seed stock population for future breeding (Anonymous, 2012).

Two particularly noteworthy programs for the improvement and conservation of Nili Ravi buffalo in Punjab are the Progeny Testing Program (PTP) and the Bull Mother Scheme (BMS). The Bull Mother Scheme was launched in 1983 at the Livestock Production Research Institute (LPRI) in Bahadurgarh, District Okara. Its main objective is to evaluate elite bulls based on their mother's performance throughout Punjab, involving 700 registered farmers and 11,000 lactating buffaloes in the process (Anonymous, 2021-22). Numerous studies have estimated the inbreeding level in Nili Ravi Buffalo (Ahmad *et al*., 1987; Bashir *et al*., 2009; Bashir *et al*., 2019) and have indicated that the inbreeding effect is low within this breed. However, a more extensive analysis is required to confirm the inbreeding status, particularly with the inclusion of a larger dataset encompassing a greater number of animals and their ancestry. Therefore, the primary objective of this comprehensive study is to validate the inbreeding effect within this seed stock and establish a robust mating plan for bulls in future breeding programs in Punjab.

MATERIALS AND METHODS

Ethical approval: Ethical approval is not required for this study since it solely involves the analysis of an existing dataset and does not involve any direct contact with live animals.

Data: For this study, the pedigree and performance data of Nili-Ravi buffaloes registered under Buffalo bull mother scheme and maintained at Livestock Production Research Institute (LPRI), Bahadurnagar, District Okara (30°55'0N 73°31'0E), Pakistan, from 2000 to 2020 were collected for this study. The data included registered animals from LPRI and breeders registered under the Buffalo Bull Mother Scheme. To estimate the inbreeding coefficient, a minimum of two ancestors (sire and dam) in the pedigree records of all breeding animals was required (Bashir *et al*., 2019). However, due to the registration and grading process, the pedigrees could not be traced back as far as needed for buffalo identification purposes.

Statistical Analysis: The collected data was compiled into a comprehensive data file containing information about each animal in the herd. The single lactation of each animal was calculated based on weekly production. A two-tailed t-test was employed to compare the inbred and non-inbred populations for various traits. The average inbreeding coefficient for each animal was calculated using Pedigree Software (Sargolzaei, 2004), which facilitated the calculation of the inbreeding coefficient.

RESULTS AND DISCUSSION

The pedigree and performance data of Nili-Ravi buffaloes were obtained from animals registered under the Buffalo Bull Mother Scheme and the Livestock Experimental Station (LES) Bahadurnagar, Okara from 2000 to 2020. The mean inbreeding coefficient (F) for the entire population was 0.001 ± 0.014, whereas for inbred animals, it was 0.225 ± 0.056, with values ranging from 0.125 to 0.250 (Table 1). These results indicate that while the overall inbreeding level in the population remains low, the subset of inbred animals exhibits significantly higher inbreeding coefficients. The pedigree analysis revealed a total of 1,436 animals, including 159 sires and 501 dams, with only 5 animals classified as inbred (Table 2). The identification of 707 base animals and 729 non-base animals confirms that the breeding program has maintained structured lineage records. The presence of grandparental and great-grandparental generations suggests well-documented ancestry within the breeding population.

The impact of inbreeding on key performance traits was assessed by comparing inbred and non-inbred animals. The results (Table 3) demonstrated significant differences in age at first calving (AGC), calving interval (CI), birth weight (BWT), days in milk (DIM), and total milk yield (TMILK). Inbred animals exhibited a higher mean age at first calving (2802.85 ± 1030.76 days) compared to non-inbred animals (2681.56 ± 871.93 days), indicating delayed reproductive maturity in inbred animals. The calving interval was prolonged in inbred buffaloes (427.27 ± 252.44 days) compared to non-inbred animals (355.88 ± 329.44 days), suggesting reduced fertility in inbred individuals. The total milk yield of inbred buffaloes (1960.75 ± 532.65 kg) was lower than that of non-inbred animals (2022.12 ± 633.87 kg), confirming the negative impact of inbreeding on milk production. The lactation length (DIM) showed only a minor difference, with inbred buffaloes averaging 219.66 ± 38.17 days, while non-inbred buffaloes had a mean DIM of 223.86 ± 116.60 days. A two-tailed t-test confirmed that inbreeding significantly affected milk yield, calving interval, and reproductive efficiency (Table 4).

Findings from this study align with previous research on inbreeding in buffalo populations. Bashir *et al*. (2009) reported that 15 buffaloes were inbred, with an average inbreeding coefficient of 7.3% and a maximum of 37.5%. Similarly, Ahmad *et al*. (1973) and Wiggans *et al*. (1995) found inbreeding coefficients ranging from 0.2% to 33.3% in different dairy breeds. The negative effects of inbreeding on milk yield and reproductive efficiency observed in this study are consistent with findings in Holstein, Jersey, Brown Swiss, and Ayrshire cows (Casanova *et al*., 1992; Thompson *et al*., 2000), which reported a linear decline in milk production with

increasing inbreeding coefficients. However, some studies have reported contrasting findings. Ayyat *et al*. (1997) found that buffaloes with inbreeding levels above 18.75% exhibited improved milk yield, suggesting that genetic or environmental factors may influence the impact of inbreeding.

Given that Nili-Ravi buffaloes contribute 70% of Pakistan's total milk production, structured breeding programs such as the Progeny Testing Program (PTP) and the Bull Mother Scheme (BMS) play a crucial role in managing genetic diversity. The presence of inbreeding in this study highlights the need for improved breeding strategies. Genetic monitoring tools should be used to track inbreeding coefficients and prevent excessive inbreeding. Additionally, selective culling of highly inbred animals and the use of artificial insemination with genetically diverse sires may help mitigate the negative effects of inbreeding.

This study provides valuable insights into the presence of inbreeding in Nili-Ravi buffaloes and its impact on key performance traits. While the overall inbreeding level in the population remains low, even moderate levels of inbreeding (F = 0.225) significantly affected milk yield, calving interval, and reproductive traits. These findings emphasize the importance of effective genetic management strategies in buffalo breeding programs. Further research is required to explore genomic approaches for controlling inbreeding and to refine mating strategies that enhance genetic diversity without compromising breed productivity.

Table 1: Inbreeding coefficient(s).

No. of animals in total	**1436.0**
No. of inbred animals	5.0
Mean for inbred animals	0.225
- Standard deviation	0.056
Mean for population	0.001
- Standard deviation	0.014
Maximum	0.250
Minimum	0.125

Pedigree software (version 1.02)

Table 2. Showing result of pedigree software for different types of animals as a result of study.

Type of animal	**Number**
Animals in data file	1166
Animals in total	1436
Inbred animals	5
Sires in total	159
-Progeny	650
Dams in total	501
-Progeny	698
Animals with progeny	660
Animals without progeny	776
Base animals	707
-Progeny	635
-Sires	150
-Progeny	616
-Dams	317
-Progeny	428
-Without progeny	240
Non base animals	729
-Sires	9
-Progeny	34
-Dams	184
-Progeny	270
-Only with known sire	31
-Only with known dam	79
-With known sire and dam	619
Grand parents	250
-Grand progeny	289
-Grand sires	84
-Grand progeny	258
-Paternal grand sires	5
-Grand progeny	34
-Maternal grand sires	81
-Grand progeny	237
-Grand dams	166
-Grand progeny	269
-Paternal grand dams	0
-Grand progeny	0
-Maternal grand dams	166
-Grand progeny	269
Great grand parents	94
-Great grand progeny	109
-Great grand sires	39
-Great grand progeny	93
-Great grand dams	55
-Great grand progeny	103
Base generation	707
Generation 1	440
Generation 2	180
Generation 3	59
Generation 4	33
Generation 5	17

**Pedigree software 1.02*

Table 3: In-bred statistics.

Performance traits	**Mean**	**Std. Deviation**	**Std. Error Mean**
AGC	2802.85	1030.76	275.48
CI	427.27	252.44	76.11
B.WT	34.27	4.77	1.44
DIM	219.66	38.17	11.02
TMILK	1960.75	532.65	153.76
GP	307.35	10.86	2.9

Table 4: Non-inbred statistics.

Performance traits	Mean	Std. Deviation	Std. Error Mean
AGC	2681.56	871.930	29.960
CI	355.883	329.4411	10.7739
B.WT	34.96	3.699	0.131
DIM	223.866	116.5978	4.0087
TMILK	2022.126	633.8737	21.7930
GP	304.51	23.460	0.788

Conclusion: This study highlights the presence of inbreeding in Nili-Ravi buffaloes and its negative impact on key performance traits, including milk yield, calving interval, and reproductive efficiency. While the overall inbreeding level in the population remains low, inbred animals exhibited significant declines in productivity. These findings emphasize the need for effective genetic management strategies to maintain genetic diversity and optimize breeding outcomes. Structured breeding programs, genetic monitoring, and selective mating practices can help mitigate inbreeding depression. Given the economic importance of Nili-Ravi buffaloes in Pakistan's dairy industry, sustainable breeding policies are essential to enhance productivity and genetic integrity in future generations.

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Conflict of Interest: There is no conflict of interest.

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