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Computation of Heritability for Production and Reproduction Traits in Frieswal Cattle under Field Progeny Testing

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Authors' contributions

This work was carried out in collaboration among all authors. Author OS performed the statistical analysis and wrote material and methods, Author RSB designed the study, Author CVS wroted the abstract and introduction, Author CBS provided the data to perform the study, Author AKE managed the literature searches. All authors read and approved the final manuscript.

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ABSTRACT

Aims: To study the genetic parameter (heritability) for production and reproduction traits in Frieswal cattle under field progeny testing programme**.**
Place and Duration of Study: G B Pant University of Agriculture and Technology, Pantnagar, Uttarakhand, India, between March, 2023 and March, 2024.
Methodology: The present study was conducted on 1163 Frieswal cattle comprised of five different sets maintained at six field units over a period from 2013-2021. The traits considered were age at sexual maturity (ASM), age at first calving (AFC), gestation period (GP), test day peak yield

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(TDPY), 305 days milk yield (305D-MY), fat percentage (FP), lactation length (LL), calving interval (CI), service period (SP), number of services per conception (NSPC), dry period (DP). The data were analyzed for the estimation of heritability by the software WOMBAT.

Results: The heritability estimates of the traits namely; ASM, AFC, GP, TDPY, 305D-MY, FP, LL, CI, SP, NSPC and DP were 0.469±0.082, 0.467±0.082, 0.259±0.067, 0.248±0.059, 0.354±0.013, 0.413±0.069, 0.389±0.071, 0.394±0.071, 0.452±0.072, 0.072±0.046 and 0.08±0.06, respectively.

Conclusion: Therefore, the heritability estimates were found to be low to high magnitude for different reproduction and production traits and further it has been concluded that, this study will aid breeders in selecting high-performing animals for future generations, taking into account the genetic factors that influence milk production and reproductive traits during early lactation.

Keywords: Frieswal; heritability; production traits; reproduction traits.

1. INTRODUCTION

Frieswal is a synthetic strain of cattle developed by crossing Holstein Friesian (62.5%) and Sahiwal (37.5%) at military dairy farms with an objective of milk yield of 4000, 4500 and 5000 kg milk yield in first, second and third lactation, respectively, with 4% fat in a standard lactation length of 305 days [4]. The progeny-testing initiative commenced during the Third Five-Year Plan at the cattle breeding farm in Hissar, focusing initially on Hariana cows. This programme aimed to guarantee the production and recognition of high-quality bulls with known genetic merit. Rather than relying solely on the yield of their dams, the programme evaluated bulls based on the actual performance of their progeny [12]. The genetic makeup of a population can be examined by assessing the comparative significance of hereditary influences and environmental factors on the performance of individuals within that population [19]. To evaluate the performance and variation concerning both genetic and non-genetic influences, it's essential to obtain estimates of phenotypic and genetic parameters. This enables the utilization of genetically determined variations for enhancing traits and exploring potential associations between different characteristics [52]. Assessing the extent of additive genetic variability in economically important traits provides insight into the potential for genetic enhancement of those traits through selective breeding [5].The present investigation was conducted to compute the heritability among different production and reproduction traits in Frieswal cattle under field progeny testing.

2. MATERIALS AND METHODS

2.1 Source of Data and Data Collection

Data of 1163 first lactation records of Frieswal cows sired by 69 sires spread for 9 years (2013-2021) maintained at Animal Genetics and Breeding Division, GBPUA&T, Pantnagar, under the pre-existing All India Coordinated Research Project (AICRP) on progeny testing were used for present investigation. The Field Progeny Testing (FPT) programmefor Frieswal cattle in the Udham Singh Nagar district of Uttarakhand was launched by ICAR-CIRC, Meerut (Uttar Pradesh). This district is situated in the Tarai region of the Kumaon division, positioned approximately between 29º 1' N latitude and 79º 31' E longitude, with an average elevation of approximately 521 meters.

2.2 Data Editing

Records of animals with known pedigree and normal lactation were taken into account. Any instances of culling, mid-lactation disposal, abortion, stillbirth, or pathological conditions impacting lactation yield were regarded as abnormalities and thus excluded from the analysis. Animals producing less than 1500 kg of milk and having a lactation length shorter than 200 days were also not included in the study.

2.3 Traits Studied

A total of eleven traits viz., 305-days milk yield (305D-MY), Test day peak yield (TDPY), Fat percentage (FP), Lactation length (LL), Age at sexual maturity (ASM), Age at first calving (AFC), Gestation period (GP), Calving interval (CI), Service period (SP), Dry period (DP) and Number of services per conception (NSPC) were studied.

2.4 Statistical Analysis

The paternal half-sib correlation (intra-sire correlation among daughters) method as described by Becker [8] was used to estimate the heritabilities of different traits. The following statisticalmodel was used:

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

Where,

Y_{ij} = Adjusted value of j^{th} progeny of i^{th} sire, μ = Overall population mean, S_i = Effect of i^{th} sire, e_{ij} = Random error, assumed to be normally and independently distributed with mean zero and constant variance i.e. NID (0, σ_e^2)

The standard error of heritability is determined by following the procedure outlined by Swiger et al [56]:

$$SE = \frac{4\sqrt{2(n-1)(1-t^2)(1+(k-1)t^2)}}{\sqrt{K^2(N-S)(S-1)}}$$

Where,

t = intra-class correlation,
S = number of sire,
N = total number of observation
K = average number of progeny per sire

3. RESULTS AND DISCUSSION

Table 1 shows the heritability estimates for various production and reproduction traits in Frieswal cattle under the field progeny testing programme.

3.1 Age at Sexual Maturity (ASM)

This trait was observed to have moderately high heritability, indicating that a considerable portion of the variation in age at sexual maturity among Frieswal cattle is due to genetic factors.Selective breeding can be employed to target early sexual maturity, which can lead to earlier breeding age and increased lifetime productivity in the herd.There is little or scanty literature available on the estimation of this genetic parameter of age at sexual maturity. Vargas et al [58] in Brahman cattle, Smith et al [54] and Martínez-Velázquez et al [38] in crossbred cattle have reported almost similar estimates. MacNeil et al [37] found even higher estimates than the ones observed in the present study. However, Ali et al [1] reported a lower estimate in crossbred cattle than found in the present study.

3.2 Age at First Calving (AFC)

Similar to age at sexual maturity, age at first calving also exhibited a moderately high heritability, suggesting that genetic factors significantly influenced the timing of the first calving. Early calving age is desirable for efficient dairy production, as it allows for more lactation cycles over the lifetime of the cow. Banerjee [6] reported almost similar estimates in Frieswal cattle. Chamwazi et al [11], Kaur et al [26] and Pardo [43] reported lower estimates in crossbred cattle, and Zhu et al [62] in Holstein Friesian cattle. Bhaduria and Kathpatal [10] and Kumar [31] reported a low estimate of Frieswal cattle. Bansal et al [7] reported a very low estimate in Sahiwal cattle than in the present study.

3.3 Gestation Period (GP)

Heritability estimate for the gestation period was found to be relatively low compared to production traits, indicating that genetic factors play a smaller role in determining the length of pregnancy.Management practices such as nutrition and health care may have a more substantial impact on the gestation period compared to genetic selection.The heritability estimate of the gestation period in the present study was in agreement with the reports of Al-Samarai et al [2], Das et al [13] and Kumar et al [27] in Holstein Friesian and crossbred cattle, respectively. Ratwan et al [47] also reported a similar estimate in Sahiwal cattle. Selvan et al [50], Lomole [36] and Ratwan et al [48] reported a lower estimate in Sahiwal cattle than the present study. Olson et al [42] and Easa et al [18] reported a higher estimate in Holstein Friesian cattle.

3.4 Test Day Peak Yield (TDPY)

Test day peak yield also exhibited moderate heritability, suggesting that genetic factors contribute to a significant extent to the maximum milk yield recorded on a single test day during lactation.Selective breeding for higher peak yields can lead to increased overall milk production in the herd. Ratwan et al [49] and Girimal et al [21] in crossbred cattle and Nawaz et al [41] inHolstein Friesian cattle reported similar estimates. Girimal et al [21] in Sahiwal cattle and Deshpande and Bonde [15] in Frieswal cattle reported higher heritability estimates than found in the present study. Radwan et al [45] and Ratwan et al [48] reported lower estimates in Holstein Friesian and Sahiwal cattle, respectively. Lakshmiet al [34] and Kumar et al [32] reported a lower estimate in Frieswal.

3.5 305 Days Milk Yield (305D-MY)

Relatively higher heritability of 305 days of milk yield indicated that genetic factors played a

Table 1. Heritability for Production and Reproduction Traits in Frieswal Cattle (N=1163)

S.N.	Traits	h^2±S.E.	Abbreviation
1	Age at Sexual Maturity	0.469±0.082	ASM
2	Age at First calving	0.467±0.082	AFC
3	Gestation Period	0.259±0.067	GP
4	Test Day Peak Yield	0.248±0.059	TDPY
5	305 Days Milk Yield	0.354±0.013	305D-MY
6	Fat Percentage	0.413±0.069	FP
7	Lactation Length	0.389±0.071	LL
8	Calving Interval	0.394±0.071	CI
9	Service Period	0.452±0.072	SP
10	Number of Services Per Conception	0.072±0.046	NSPC
11	Dry Period	0.080±0.060	DP

substantial role in determining the total milk production over a standardized lactation period. Selective breeding for higher milk yield can result in improved productivity in Frieswal cattle.[3], [21] and [26] reported similar estimates in PhuleTriveni and crossbred cattle, respectively. [53] reported a similar estimate in Karan Fries cattle. Divya et al [16], Parveen et al [44], Ratwan et al [48] and Dash et al [14] reported lower estimates in Karan Fries and Sahiwal cattle, respectively. Easa et al [18] reported a similar estimate in Holstein Friesian cattle. Kumari [33] and Singh and Gurnani [52], however, reported a high estimate in crossbred and Karan Fries cattle, respectively.

3.6 Fat Percentage (FP)

Fat percentage in milk was observed to have moderately high heritability, suggesting that genetic factors influence the proportion of fat content in the milk produced by Frieswal cattle. Selective breeding can be employed to enhance milk composition, targeting higher fat content if desired by the market. Stoop et al [55] reported a similar estimate in Holstein Friesian cattle. Junior et al [24] in Holstein Friesian cattleand Jayawardana [23] in crossbred cattle reported higher estimates of heritability than found in the present study. Wongpom et al [61]and Valsalan et al [57] have reported lower heritability estimates in crossbred cattle.

3.7 Lactation Length (LL)

Lactation length had a moderately high heritability estimate (Table 1), which indicated that genetic factors significantly influenced the duration of milk production during a lactation cycle.Selective breeding for longer lactation lengths can lead to increased milk production efficiency in the herd. Chamwazi et al [11], Verma et al [59], Kumar et al [30] and Kaur et al [26] reported lower estimates in crossbred cattle. [18]reported higher estimates in Holstein Friesian cattle. Raja [46] and Kumaret al [28] reported a higher estimate of Sahiwal cattle.

3.8 Calving Interval (CI)

The calving interval exhibited a moderately high heritability (0.394±0.071). Similar findings have also been reported by Chamwazi et al [11] in crossbred cattle. Moderately high heritability for calving interval suggested that genetic factors play a significant role in determining the time between consecutive calvings.Selective breeding for shorter calving intervals can improve reproductive efficiency and overall herd productivity. Kumar [29] and Mukharjee Mukharjee [40] reported low estimates in Frieswal cattle. Easa [18] and Kaur et al [26] also reported lower estimates in Holstein Friesian and crossbred cattle. Dubey and Singh [17] and Moges [39] reported a high heritability estimate of calving interval in crossbred cattle.

3.9 Service Period (SP)

The heritability value of the service period was observed to be as 0.452±0.072 which was moderately high. Gaur [20] and Lodhi et al [35] also found similar estimates in Frieswal and crossbred cattle, respectively. The service period is a reproductive trait that is lowly heritable, however, the high estimate in the present study indicated a greater influence of genetic factors on this trait in Frieswal cattle. Mukharjee [40] in Frieswal cattle Kaur [26] in crossbred cattle, Easa [18] in Holstein Friesian and Ratwan et al [48] and Dash et al [14] in Sahiwal cattle reported low estimates.

3.10 Number of Services Per Conception (NSPC)

This trait being reproductive, was found to have low heritability (0.072±0.046), which suggested that genetic factors had a minor role in determining the successful conception. Guo et al [22], Ben et al [9] and Zhu et al [62] have reported similar heritability estimates in Holstein Friesian cattle. Ratwan et al [47] reported a higher estimate in Sahiwal and Lomole [36] reported a slightly higher estimate in Sahiwal cattle than the present study. Zhu et al [62] reported a lower estimate in Holstein Friesian cattle than in the presentstudy. Vinothraj et al [60] reported a low estimate and Kumar et al [32] reported a high estimate in crossbred cattle. Now-a-days, the artificial insemination technique is adopted for inseminating cattle, therefore, number of services depend upon the skill of AI workers in recognition of appropriate heat and deposition of semen at an appropriate site in the female reproductive tract. In addition to this, other managemental practices such as reproductive health may also have a more significant impact on this trait compared to genetic selection.

3.11 Dry Period (DP)

The dry period had an extremely low heritability (Table 1). Kannan [25] in Sahiwal cattle and Ratwan et al [48] in Sahiwal cattle reported similar estimates of heritability. Kaur et al [26] reported higher estimates in crossbred and Raja [46] reported high estimates in Sahiwal cattle. The heritability estimate in the present study suggested that genetic factors had negligible influence on the length of the dry period.Management practices such as nutrition and udder health management are crucial for determining the optimal dry period length in dairy cows.

4. CONCLUSION

In summary, understanding the heritability of production and reproduction traits is essential for designing effective breeding programmes aimed at improving overall productivity, and reproductive efficiency. By focusing on traits with higher heritability, such as milk yield, fat percentage, and reproductive performance, breeders can make more informed decisions to genetically enhance the traits of interest in the population.

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COMPETING INTERESTS

Authors have declared that no competing interests exist.

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