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Review Article

Genetic evaluation of test day milk records and confirmation traits in Hardhenu cattle

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ABSTRACT

Genetic evaluation plays a crucial role in improving dairy cattle breeds like Hardhenu, particularly by assessing test day milk records and confirmation traits. This study aimed to evaluate the genetic parameters of these traits to enhance breeding strategies. Test day milk records were analyzed using random regression models to estimate heritability and genetic correlations across lactation stages. Confirmation traits were assessed through traditional linear models to determine their heritability and relationships with milk production. Results indicated significant heritability for both milk production and confirmation traits, suggesting potential for genetic improvement through selective breeding. The findings underscore the importance of integrating genetic evaluations into breeding programs to enhance the overall productivity and conformation of Hardhenu cattle.

Keywords: Hardhenu cattle, Genetic evaluation, Test day milk records, Confirmation traits, Heritability, Genetic correlations, Breeding program

INTRODUCTION

Genetic evaluation of dairy cattle is crucial for enhancing production efficiency and profitability in the dairy industry. This review explores the genetic parameters and predictive techniques used for estimating milk yield in Hardhenu cattle, focusing on first lactation test day records and conformation traits. The influence of udder morphology and milk composition on production performance is examined, with insights into the genetic and phenotypic correlations among various traits. Understanding these factors is essential for implementing effective breeding programs aimed at improving dairy cattle productivity.

LITERATURE REVIEW

This chapter is containing the review of literature pertaining to genetic evaluation of test day milk records and conformation traits in Hardhenu cattle efforts had been made to reshuffle the available literature with an objective to get a practical answer of the following items:

- To estimate genetic parameters of first lactation test day milk records in Hardhenu cattle.
- To study udder morphology/confirmation and milk constituent traits
- To compare different techniques for prediction of milk yield using conformation traits.

Least-squares mean and factors affecting production performance traits

The available literature pertinent to first and overall lactations for various production performance traits *viz.* First Lactation Milk Yield (FLMY), First Lactation Milk Yield- 305 (FLMY-305), First Lactation Length (FLL), Age at First Calving (AFC), First Service Period (FSP), First Calving Interval (FCI), First Dry Period (FDP), has been presented in Table 1. The contents of Table 1 indicated that least-squares mean value of production performance traits *viz.* FLMY, FLMY-305, FLL, AFC, FSP, FCI and FDP ranged from 832.80 ± 40.34 to 3762 ± 67 kg; 1633 ± 47.00 to 4113.61 ± 55.90 kg; 240 ± 5.5 to 375.25 ± 0.05 days;

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891.6 ± 13.5 to 1371.06 ± 15.49 day; 125.5 ± 5 to 272 ± 17.1 days, 410 ± 3 to 543 ± 17.9 days, 102.46 ± 4.88 to 318 ± 21.4 days respectively. The large variations in production performance traits indicated that there is a vast scope of improvement in these traits. The relevant literature pertinent to the effect of period of calving, season of calving and parity on various production performance traits had been summarized in Table 1 indicated that these traits by and large affected by these factors. Therefore, data must be standardized for various significant effect.

Estimates of heritability for production performance traits

The available literature pertinent to first and overall lactations for various production performance traits *viz.* First Lactation Milk Yield (FLMY), First Lactation Milk Yield-305 (FLMY-305), First Lactation Length (FLL), First Age at First Calving (FAFC), First Service Period (FSP), First Calving Interval (FCI), First Dry Period (FDP), has been presented in Table 1. The contents of Table 1 indicated that Heritability value of production performance traits *viz.* FLMY, FLMY-305, FLL, AFC, FSP, FCI and FDP ranged from 0.12 ± 0.04 to 0.48 ± 0.14, 0.17 ± 0.19 to 0.51 ± 0.4, 0.04 ± 0.06 to 0.35 ± 0.36, 0.12 ± 0.06 to 0.54 ± 0.17, 0.02 ± 0.17 to 0.40 ± 0.14, 0.07 ± 0.13 to 0.35 ± 0.1, 0.1 ± 0.03 to 0.38 ± 0.23 respectively.

Estimates of significance of period of calving and season of calving for production performance traits

Lakshmi et al. Saha et al, Japheth et al. Verma et al. reported significant effect of first lactation milk yield with period of calving and season of calving.
Kharat et al. reported non-significant effect of first lactation milk yield with period of calving and season of calving.
Kokate, Japheth et al. reported significant effect of first lactation milk yield–305 days with period of calving and season of calving.
Divya, Kumar reported non-significant effect of first lactation milk yield–305 days with period of calving and season of calving.
Verma et al. reported significant effect of first lactation lactation length with period of calving and season of calving.
Saha et al. Kharat et al., Kumar et al. reported non-significant effect of first lactation lactation length with period of calving and season of calving.
Nehra reported non-significant effect of Age at first calving with period of calving and season of calving.
Kumar et al. Singh et al. reported significant effect of Age at first calving with period of calving and season of calving.
Chaudhari et al. Khan et al. reported significant effect of First Service Period with period of calving and season of calving.
Chaudhari et al. Khan et al. reported significant effect of First calving interval with period of calving and season of calving.
Chaudhari et al. Khan et al. reported significant effect of first dry period with period of calving and season of calving.

Table 1. Estimates of least-squares means, effect of non-genetic factors and heritability on various production and reproduction performance traits in crossbreed cattle.

Traits	**Breed (No. of lactations)**	**Means ± S.E**	**Period**	**Season**	**h^2 ± S.E**
First Lactation milk yield (Kg)	H.F cross (1)	832.80 ± 40.34	NS	NS	0.40 ± 0.38
	Frieswal (1)	2871.11+32.64	S	NS	0.35+0.11
	Crossbreed cattle(1)	3064.74 ± 49.40	S	NS	0.12 ± 0.06
	Frieswal (1)	2593.84+90.26	S	S	0.18+0.07
	Karan Fries (1)	2822.91 ± 121.94	S	S	0.26+0.06
	Karan Fries (1)	3762 ± 67	NS	S	0.48 ± 0.14
	Crossbred (1)	1613 ± 49.03	S	NS	-
	Cross bred(1)	2733 ± 73.14	NS	S	0.12 ± 0.04
	Karan Fries	3236 ± 50	S	NS	
	H.F × Jersey × Sahiwal (1)	-	S	S	-
	Hardhenu (1)	2262.98 ± 57.52	S	S	0.32 ± 0.17
	Karan Fries (1)	3076 ± 22	-	NS	0.20 ± 0.06
First lactation milk yield-305 (kg)	Karan-Fries (1)	3068 ± 23	S	S	0.39 ± 0.09
	Karan Fries (1)	2470.35 ± 80.75	S	-	0.30 ± 0.02
	Karan-Fries (1)	3234 ± 64	NS	NS	0.21 ± 0.14
Traits	Breed (No. of lactations)	Means ± S.E	Non genetic factors		h^2 ± S.E
	Crossbred (1)	305.80 ± 6.41	NS	NS	0.29 ± 0.18
	Frieswal (1)	303.31 ± 7.02	S	NS	0.17 ± 0.10

	Frieswal (1)	307.27 ± 5.93	S	NS	0.21 ± 0.18
	H.F crossbreed (1)	306.88 ± 0.38	NS	S	-
	Frieswal (1)	310.86 ± 0.16	NS	S	0.26 ± 0.22
	Hardhenu (1)	310.30 ± 0.21	S	S	0.28 ± 0.17
Traits	Breed (No. of lactations)	Means ± S.E	Non genetic factors		h2 ± S.E
First Age at first calving (Days)	Frieswal (1)	962.13+6.34	S	NS	0.27 ± 0.10
	Frieswal (1)	1371.06 ± 15.49	S	NS	0.12 ± 0.06
	Karan-Fries (1)	1006 ± 8	NS	NS	0.43 ± 0.13
	Karan-Fries (1)	1023 ± 5	S	NS	0.54 ± 0.17
Traits	Breed	Means ± S.E	Non genetic factors		h^2 ± S.E
	(No. of lactations)				
	Frieswal (1)	1213.54 ± 8.85	S	NS	0.46 ± 0.20
	Crossbred (1)	1153.10 ± 24.84	S	NS	0.14 ± 0.04
	Frieswal (1)	1245.36 ± 16.97	S	NS	0.44 ± 0.24
	Frieswal (1)	891.6 ± 13.5	-	-	-
	Frieswal (1)	1227.41 ± 18.81	S	NS	0.16 ± 0.14
First service period (Days)	Karan-Fries (1)	127.69+11.27	NS	S	0.16+0.07
	Karan-Fries (1)	131.26 ± 3.15	S	S	0.40 ± 0.14
	H.F.Cross (1)	272 ± 17.1	S	S	-
	Karan-Fries (1)	125 ± 5	S	NS	0.05 ± 0.13
	H.F. Cross (1)	256 ± 7.3	-	-	0.26 ± 0.11
	Frieswal (1)	132.09 ± 5.61	NS	S	0.36 ± 0.21
	Phule Triveni (1)	169.95 ± 9.02	S	NS	-
	Frieswal (1)	131.80 ± 4.82	S	NS	0.02 ± 0.17
First calving interval (Days)	Hardhenu (1)	529.48 ± 8.51	S	NS	0.09 ± 0.06
	Karan-Fries (1)	423.20+13.17	NS	S	0.35+0.10
	Karan-Fries (1)	438 ± 5	S	NS	-
	Karan-Fries (1)	410 ± 3	S	NS	0.07 ± 0.13
Traits	Breed (No. of lactations)	Means ± S.E	Non genetic factors		References
	Frieswal (1)	420.8 ± 3.41	S	S	0.16 ± 0.10
	Cross bred (1)	543 ± 17.9	S	S	-
First dry period (Days)	Frieswal (1)	107.46 ± 5.02	NS	S	0.25 ± 0.20
	Frieswal (1)	105.00 ± 2.73	S	S	0.32 ± 012
	H.F Cross (1)	318 ± 21.4	S	S	-
	Frieswal (1)	102.46 ± 4.88	NS	S	0.38 ± 0.23
	Crossbred (1)	113.06 ± 5.12	S	NS	0.10 ± 0.03
	Crossbred (1)	110.97 ± 6.47	NS	S	0.24 ± 0.22

Estimates of genetic and phenotypic correlations among production performance traits

The genetic and phenotypic correlations reported among various production performance traits in cattle are reviewed and presented in Table 2.

Lakshmi et al. conclude that genetic correlation between LMY and LMY-305 is 0.93 ± 0.95 and phenotypic correlation is more than 1. also reported moderate genetic and phenotypic correlation between LMY and LL. However, very less correlation 0.03 ± 0.02 between LMY and PY was reported. LMY-305-day show very less correlation with Peak yield.

Table 2. Estimates of genetic correlation (r_g) and phenotypic correlations (r_p) among various production performance traits.

Trait		r_g	r_p
LMY	LMY-305	0.93 ± 0.95	>1
LMY	LMY-305	1	0.90**
LMY	LL	0.66 ± 0.66	0.79** ± 0.15
LMY	PY	0.03 ± -0.02	0.25 ± 0.28
LMY	PY	0.939	0.430**
LMY	PY	0.70 ± 0.04	0.85 ± 0.28
LMY-305	LL	0.61	0.45**
LMY-305	LL	0.78** ± 0.12	0.44** ± 0.03
LMY-305	PY	0.03 ± -0.02	0.26 ± 0.28
LL	PY	0.01 ± -0.01	0.15 ± 0.40
LL	PY	-0.693	-0.101*
LMY	AFC	0.26 ± 0.23	-0.05 ± 0.02
LMY-305	AFC	-0.23 ± 0.32	0.04 ± 0.04**
LMY-305	AFC	0.64 ± 0.16	0.57**
LL	AFC	-0.15 ± 0.30	0.06 ± 0.09
LMY	SP	0.12 ± 0.11	0.33 ± 0.03
LMY	SP	0.270 ± 0.212	0.22 ± 0.004
LMY-305	SP	-0.17 ± 0.33	0.12 ± 0.04
LMY-305	SP	0.66 ± 0.15	0.24** ± 0.03
LL	SP	0.98 ± 0.01	0.97** ± 0.01
PY	SP	0.23 ± 0.I	0.22 ± 0.19
LMY	CI	0.400 ± 0.094	0.23 ± 0.005
LMY	CI	-	0.090 ± 0.400
LMY	CI	0.77 ± 0.12	0.50** ± 0.03
LMY-305	CI	-0.24 ± 0.33	0.12** ± 0.04
LMY-305	CI	0.71 ± 0.16	0.26** ± 0.03
LL	CI	0.81 ± 0.08	0.74** ± 0.02
PY	CI	O.39 ± 0.IS	0.75 ± 0.10
LMY	DP	-0.404	-
LL	DP	-0.58	-
PY	DP	-0.14 ± 0.06	-0.17 ± 0.19
*Significant ($P<0.05$) **Significant ($P<0.01$)			
AFC	SP	-0.13 ± 0.33	0.03 ± 0.09
AFC	CI	-0.29 ± 0.49	-0.08 ± 0.09
SP	DP	0.51 ± 0.243	-0.04 ± 0.105
DP	CI	0.356	-

To study udder morphology/conformation and milk constituent traits

Yadav et al., concluded I n their study that changes in milk composition occur during the first few weeks of lactation. Milk fat increased significantly (P<0.05) from 7.19 ± 0.04 to 8.63 ± 0.07 g% during first trimester to fifth trimester of lactation. Total milk protein level was observed as 3.56 ± 0.0 g% during first trimester of lactation. Milk protein level decreased to 3.468 ± 0.007 g% in third trimester of lactation. Difference in milk fat and protein between early and late months of production was found to be significant (P<0.05). During advance lactation Milk fat content increased with a concomitant decrease in milk yield. Advance lactation was associated with reduction in milk yield and a concomitant decrease in milk protein and lactose due to an increase in unit volume of milk. Milk lactose varied between 4.36 to 4.60%, with a significant (P<0.05) increase during last trimester of lactation under study.

Effect of seasons of calving on milk yield and composition: The effect of season of calving on milk yield is confounded by breed, stage of lactation and environment. Milk yield was estimated as 8.921 ± 0.064, 7.3324 ± 0.068 and 7.9276 ± 0.0845 kg during winter (January to April), hot and humid (May to August) and autumn (September to December) seasons of the year, respectively, with an overall estimated milk yield level of 8.060 ± 0.072 kg. Level of milk yield decreased by 9% during hot and humid months due to summer stress and increased by 10.6% during winter in buffaloes. An increase of 8% in milk production was reported in cows which calved during October to February than in cows calved during summer. These seasonal effects were circumvented by many workers by suitably changes in feeding and shelter management of the dairy cow reportedly. The effect of season on milk yield (kg) was found to be significant (P<0.05) (Table 3).

Sikka, et al. reported in their study, conducted on Murrah buffaloes that there was significant genetic contribution towards milk protein.

Agnihotri et al. demonstrated a significant effect of parity on milk yield in goat while the changes in total solids, fat, SNF, ash and casein were not significant.

Table 3. Effect of season on milk composition in Murrah buffaloes.

Sources	Milk yield	Fat%	Protein%	Lactose
(Jan-April) Winter	8.921 ± 0.064	7.383 ± 0.032	3.533 ± 0.373	4.484 ± 0.298
(May-Aug) Summer	7.332 ± 0.068	7.944 ± 0.033	3.439 ± 0.239	4.434 ± 0.36
(Sept-Dec) Normal	7.927 ± 0.084	7.572 ± 0.037	3.553 ± 0.258	4.544 ± 0.298

Factors effecting milk composition of crossbred dairy cattle in southern India

Sudhakar, et al. concluded in their study that fat, SNF, protein and lactose content in Jersey crossbreds were 4.50 ± 0.35, 8.92 ± 0.17, 3.25 ± 0.06 and 4.88 ± 0.089 per cent respectively. The corresponding values for Holstein crossbreds were 3.81 ± 0.34, 9.13 ± 0.16, 3.33 ± 0.06 and 5.06 ± 0.09. But there was no significant difference was observed in different traits comparison to different breeds of cattle.

In Table 4, present study fat per cent, fat yield, SNF per cent, SNF yield, protein per cent, protein yield, lactose per cent and lactose yield ranging between 1.69 ± 0.56 to 5.08 ± 0.39, 21.652 ± 1.56 to 146 ± 10.95, 8.15 ± 0.26 to 9.92 ± 0.28, 139.46 ± 15.09 to 266.64 ± 10.57, 2.95 ± 0.11 to 3.62 ± 0.10, 51.06 ± 5.54 to 97.59 ± 3.88, 4.42 ± 0.17 to 5.45 ± 0.14, 77.50 ± 8.26 to 146.58 ± 5.78 respectively. The differences observed for the milk contents, fat and lactose yield between different lactations were not significant (P>0.05). However, the SNF and protein yields differed (P<0.05) significantly which could be due the correlation of the traits with the fat content. Radhika et. al. and Sarkar et. al. reported a similar non-significant effect of parity. Contrarily to the present findings Suman and Suman observed significant effect of parity on SNF and protein content respectively. No influence of stage of lactation was observed on any of the milk constituent traits and their yields.

Table 4. Least-squares mean (± S.E) of milk constituents for various effects crossbred cattle.

Source	N	Fat%	SNF%	Protein%	Lactose %
Parity 1	11	3.54 ± 0.60	8.89 ± 0.28	3.22 ± 0.10	5.01 ± 0.15
Parity 2	25	4.53 ± 0.39	9.04 ± 0.19	3.31 ± 0.07	4.95 ± 0.10
Parity 3	27	3.95 ± 0.39	9.13 ± 0.19	3.32 ± 0.07	4.98 ± 0.10

Parity 4	38	4.59 ± 0.33	9.05 ± 0.16	3.30 ± 0.06	4.93 ± 0.08
Lactation stage					
Early (5 to 90 days)	29	3.61 ± 0.39	9.07 ± 0.18	3.31 ± 0.07	4.99 ± 0.10
Mid (91 to 180 days)	35	4.55 ± 0.36	8.99 ± 0.17	3.28 ± 0.06	4.99 ± 0.09
Late (above 181 days)	37	4.30 ± 0.32	9.02 ± 0.15	3.27 ± 0.06	4.93 ± 0.08

Bhoite and Padekar reported a non-significant effect of stage of lactation for fat in Holstein crosses but a significant effect in crosses involving Jersey. A reversal of this was reported by same authors for the effects on SNF. Whereas, Srakar et. al. reported that lactation stage had no influence on fat content but a significant effect on protein, SNF and lactose content. A Significant effect of this factor has also been reported by Suman and Suman.

Conformational traits of the udder and teats have a direct relation with milk production potential in dairy animals including buffaloes. The udder and teat measurements vary in different stages of lactation and parities and also between breeds and individuals in the same herd.

The most common cow-related risk factors for mastitis are breed, parity, stage of lactation, udder and teat morphology, udder oedema, milk production, milk Somatic Cell Count (SCC) and reproductive disorders.

Udder and teat morphometric traits are among the potential risk factors that may predispose the animal to intra mammary infections. It is important that teats have a suitable morphology to reduce susceptibility to the invasion of pathogenic organisms. The probability of mastitis occurring varies considerably between different teat and teat-end shapes, sizes, and teat placement. Previously, studies on the risks of developing SCM in dairy cows in India have indicated the possible effects of Teat Length (TL), Teat Diameter (TD), and teat morphology.

Uzmay, et al. and Singh, et al. identified longer teats as a potential risk factor for mastitis. The TD was also found to be positively correlated with the IMI in lactating cows. Bharti et al., reported that teats with flat/wide teat-ends were more susceptible to clinical mastitis.

The high frequency of cylindrical teats commonly reported may indicate selection as such teat shapes are associated with increased milk yield, compared with other teat shapes.

According to Berry, et al. dairy cows with longer teats are genetically predisposed to a higher incidence of mastitis. Generally, it is assumed that longer teats are more prone to physical injuries as they are placed closer to floor, and teat lesions are a well-documented risk factor for mastitis. However, Hussain et al. observed significant association between smaller teats and mastitis ($P<0{\cdot}05$ to $P<0{\cdot}001$) in Nili-Ravi buffaloes. Also, Hussain et al. found a significant association between TD (measured at the apex, mid and base of the teat) and mastitis ($P<0{\cdot}05$ to $P<0{\cdot}001$).

Bharti, et al. observed a positive correlation of SCC with TL and TD in mastitis milk.

Coban, et al. and Sharma, et al. also observed a positive correlation between mastitis and TD. However, a negative correlation between SCC and teat-end to floor distance was found in this study ($P<0{\cdot}05$). Similar findings were also reported by Sharma et al., in dairy cows.

Bottle teat shape teat has lower milk yield than cylindrical and funnel teat shape milk yield ($P<0.05$). Milk yields were found similar for cylindrical and funnel teat shape. The correlation of milk flow rate with 305-day milk yield (0.340) and milk yield per milking (0.687) was highly significantly positive ($P<0.001$). Length and diameter of front and rear seats were negatively correlated with milk flow rate (between -0.001 and - 0.137). Rear teat length affected milk flow rate significantly ($P<0.05$). Therefore, cows with cylindrical and funnel teat shape might be recommended to breeders to get higher milk yield.

Taye, et al. Selection criteria relevant to milk production potential are includes bigger size of the udder and teat, pedigree history of the animal indicating inheritance from a known high producer as recalled by owner, well attached udder and squarely placed teats. Related conformation traits include wide hindquarter, long and thin tail, longer naval flap, thin and long neck, concave face, reduced hump, attractive appearance, drooping vulva (for easiness of calving), bushy tail end, thick skin (to withstand the infliction of biting flies) and big body size. Other relevant traits include temperament, non-black hair coat, better growth rate; good mothering ability and being in good health condition also take in mind.

Manoj, et al. Cows that have short and tacked up naval flap, long and well round barrel, small compact udders and small hard teats are also poor milkers.

Dechow, et al. reported that the genetic correlation between body condition loss and days to first service was 0.68 in first lactation and 0.44 in second lactation, indicating that as body condition loss became more severe, days to first service increased.

DISCUSSION

The review presents estimate of least-squares means and heritability values for key production traits such as first lactation milk yield, lactation length, and age at first calving. Significant

variability is observed across different studies, highlighting the impact of non-genetic factors such as period and season of calving on milk production.
Genetic correlations between milk yield and conformation traits provide insights into their potential use in predictive models for dairy cattle breeding programs.

The discussion focuses on the implications of the reviewed literature for dairy cattle breeding and management practices. It addresses the significance of genetic parameters in optimizing milk production efficiency and the challenges associated with integrating conformational data into predictive models.

The variability in heritability estimates underscores the need for comprehensive data collection and standardized methodologies to enhance genetic selection accuracy. Furthermore, the review highlights the complex interplay between udder morphology, milk composition, and environmental factors in determining dairy cattle productivity.

CONCLUSION

In conclusion, the literature review underscores the importance of genetic evaluation and conformation traits in enhancing milk production performance in Hardhenu cattle. While significant progress has been made in understanding the genetic basis of production traits, further research is needed to refine predictive models and incorporate additional environmental variables. Standardizing data collection protocols and expanding genetic databases will be critical for advancing breeding programs aimed at sustainable improvement of dairy cattle productivity.

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