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Economic selection index using different milk production traits of Holstein and its crossbreds

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Abstract: The study was conducted to estimate the Best Linear Unbiased Prediction (BLUP) breeding values of different milk production traits for Holstein and its crossbreds and to construct an economic selection index or total merit for individual cows from 2 different dairy farms in Chittagong, Bangladesh. The BLUP-estimated breeding values were obtained by AIREML, and an economic selection index was constructed as the sum of the product of the estimated breeding value with the economic value for each trait (lactation milk yield, calving interval, and liveweight). The Holstein × Sahiwal crossbred showed better phenotypic performance in both farms while the same cows showed variable performance when compared to each other. It can be postulated that comparatively better performance might be due to good management and proper feeding, as well as the lactation stage and age of the cows. According to the economic selection index value, the Holstein × Local scored higher when compared to other genotypes. Therefore, the selection of cows of top index value would be beneficial for the production of offspring in the next generation.

Key words: Performance, estimated breeding values, economic selection index

Introduction

The goal of animal breeding is to rank the animals according to their genetic merit for the desired characters and to use them efficiently in breeding. Assessment of the true breeding value of an animal is not possible without assessing the estimated breeding values (EBVs), which are assumed to be the true breeding value of an animal. Breeding values of animals for different traits have been previously estimated by Best Linear Unbiased Prediction (BLUP) procedure, as outlined by Henderson (1). The BLUP procedure using the Individual Animal Model (IAM) has become the worldwide standard for the prediction of breeding values of farm animals (2,3). Parameters in a model of IAM can be estimated using several methods, such as Least Square Methods (LSM), Restricted Maximum Likelihood (REML), and Best Linear Unbiased Predictions (BLUP). It should be noted that both single- and multiple-trait BLUP evaluations were used to evaluate the animals. The multi-trait analysis involves the simultaneous evaluation of animals for 2 or more traits and makes use of the phenotypic and genotypic correlations. BLUP EBVs is a widely accepted approach, which increases the accuracy of estimation, that is, it enables simultaneous estimation of genetic and environmental effects (1,4,5). A number of modern computer software programs, such as ASREML,

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AIREML, BreedPlan, and SAS, are available for the estimation of BLUP EBVs.

Currently, there is no systematic genetic evaluation programme operating in Bangladesh for effective genetic improvement of dairy cattle. Selection is the first attempt for improvement of the genetic make-up of animals. However, estimation of the breeding value for specific traits should be the priority for proper selection of animals for further genetic improvement. Keeping this view in mind, the current study was conducted with the following objectives: (i) to study the productive and reproductive performance of Holstein and its crossbreds in Bangladesh; (ii) to estimate the breeding values of economic importance traits of Holstein and its crossbreds; and (iii) to construct an economic selection index or total merit for individual Holstein and its crossbred cows under farm conditions.

Materials and methods

The study was conducted on the Holstein and its crossbred cows from 2 different herds in the Chittagong metropolitan area of Bangladesh from July to December 2009. Data on various productive and reproductive parameters were collected from the records of the respective farms and also from direct observation by the data collector. From the recorded data the average and standard error of different traits for all genotypes were estimated using PROC MIXED of SAS (6), and the mean differences were compared by the least significant difference test (LSD) (7).

BLUP estimated breeding values for the different milk production traits

Estimated breeding values (EBVs) were obtained from univariate and multivariate analysis by AIREML based on Restricted Maximum Likelihood (REML) and using the Average Information (AI) matrix as second derivatives in a quasi-Newton procedure (8). The individual animal model of analysis was presented as:

$$Y_{ij} = F_i + a_j + e_{ij}$$

where Y_{ij} is the traits yield;

F_i is the vector of fixed effects due to age of the cows, farming, and breed groups; a_j is a matrix relating to breeding value of an animal, distributed with mean 0 and variance $\sigma^2 a$, the genetic variance for the observed traits; and e is the vector of error terms, assumed NID (0, $\sigma^2 e$). In matrix notation the above equation of animal model becomes:

$$Y = Xb + Zu + e$$

where Y is the vector of all observations; b is the vector of fixed effects; u is the vector of breeding values of the animals; and e is vector of residual effects.

X and Z are design matrices connecting to the fixed and random effect, respectively.

For the (co)variance of Y the assumption is:

$var(u) = G,$

$var(e) = R,$

and

$cov(u,e) = 0$

which gives

$var(Y) = ZGZ' + R$

and for multivariate animal model

$Var(a) = A\sigma_a^2,$

$Var(p) = G\sigma_p^2,$

$Var(e) = I\,\sigma_e^2,$ and

$Cov(u,p) = Cov(u,e) = Cov(p,e) = 0$

which gives

$var(Y) = ZAZ' + WGW' + R$

The mixed model equation (MME) for the multivariate animal model became:

$$\begin{bmatrix} X'X & X'Z & X'W \\ X'X & Z'Z + A^{-1}\alpha_1 & Z'W \\ W'X & W'Z & W'W + G^{-1}\alpha_2 \end{bmatrix} \begin{bmatrix} \hat{b} \\ \hat{u} \\ \hat{p} \end{bmatrix} = \begin{bmatrix} X'y \\ Z'y \\ W'y \end{bmatrix}$$

where, $\alpha_1 = \frac{\sigma_e^2}{\sigma_u^2}$ and $\alpha_2 = \frac{\sigma_e^2}{\sigma_p^2}$

Construction of economic selection index or total merit

Khan (9) developed a linear profitability model based on the relationship between average values of marketable products (milk and meat), and the expenses incurred in dairy production derived the annual individual cow profit (P) from the differences between income (I) and costs (C). The income was estimated after running the base model, and the economic value (EVs) of milk yield, liveweight, and calving interval was obtained by re-running the base model after changing 1 unit of each trait while maintaining the other traits in the model at a constant level. The estimated EVs are shown in Table1. The economic selection index, animal genetics (breeding value) with input costs and output prices to projected profitability and values, is expressed in dollars. In this study the economic selection index or total merit value of the selection objective of milk production, was calculated as the sum of the product of BLUP-estimated breeding values with the economic value of all traits (milk yield, liveweight, and calving interval). An estimate of T (total merit) was calculated as:

$$\text{Total merit (T)} = a_{MY}EBV_{MY} + a_{CI}EBV_{CI} + a_{Lwt}EBV_{Lwt}$$

where EBV_{MY}, EBV_{CI} and EBV_{Lwt} are the estimated breeding values for lactation milk yield, liveweight, and calving interval and a_{MY}, a_{CI} and a_{Lwt} are the respective economic values.

Results

Productive and reproductive performances of different dairy cattle breed groups from 2 different farms

The productive and reproductive performances of different dairy breed groups from 2 different dairy farms are presented in Table 2. The daily average milk yield and total lactation milk yield of Holstein × Sahiwal crossbred was found to be higher than pure Holstein and Holstein × Local crossbreds on both farms (Table 2).

Estimated breeding values for the different traits

The BLUP-estimated breeding values of lactation milk yield, calving interval, and liveweight for Holstein × Local and Holstein × Sahiwal breed groups on farm 1 and 2 are presented in Table 3. Only the top 5 ranked cows' economic selection index or total merit is shown in Table 3.

The estimated breeding values of lactation milk yield, calving interval, and liveweight on farm 1 for Holstein × Local cows ranged from –414.7 to 160.53 kg, –3.93 to 3.82 days, and –15.92 to 15.96 kg, respectively. In the Holstein × Sahiwal genotype the EBVs of lactation milk yield, calving interval, and liveweight ranged from –119.87 to 164.53 kg, –6.88 to 0.99 days, and –27.92 to 4.03 kg, respectively. The estimated breeding values of lactation milk yield, calving interval, and liveweight on farm 2 for the Holstein × Local genotype ranged from –228.93 to 119.87 kg, –4.92 to 9.40 days, and –19.93 to 38.12 kg, respectively. In the case of the Holstein × Sahiwal genotype the estimated breeding values of lactation milk yield, calving interval, and liveweight ranged from –128.80 to 171.26 kg, –4.16 to 4.63 days, and –16.88 to 18.76 kg, respectively.

Economic selection index or total merit

The economic selection index or total merit for Holstein × Local on farms 1 and 2 ranged from US$–111.68 to US$52.62 and US$–54.71 to US$106.86. For Holstein × Sahiwal genotype total merit ranged from US$1.28 to US$57.61 and US$–24.59 to US$77.53, respectively (Table 3).

Table 1. The economic value (US$ per unit) of different traits (9).

Traits	Genotypes	
	Holstein × Sahiwal	Holstein × Local
Milk yield (kg)	0.32	0.32
Liveweight (kg)	-0.39	-0.27
Calving interval	-0.82	-1.32

Table 2. Productive and reproductive performance of different dairy cows on different farms.

Traits	Farm 1			Farm 2		
	Genotypes			Genotypes		
	H	H × L	H × S	H	H × L	H × S
Productive performance						
Lactation yield	$1881^{a} \pm 56$	$2226^{b} \pm 85.6$	$2341^{b} \pm 74.1$	$2488^{c} \pm 49.4$	$2687^{d} \pm 74.1$	$3360^{k} \pm 60.5$
Lactation length	$295^{ab} \pm 0.93$	$298^{ab} \pm 1.11$	$301^{b} \pm 1.11$	$295^{ab} \pm 0.75$	$303^{b} \pm 1.24$	$292^{a} \pm 1.01$
DAMY	$6.4^{b} \pm 0.34$	$4.4^{a} \pm 0.40$	$6.6^{b} \pm 0.37$	$6.9^{b} \pm 0.27$	$8.9^{c} \pm 0.45$	$11.5^{d} \pm 0.37$
Lwt	$317^{a} \pm 5.06$	$357^{ab} \pm 6.62$	$308^{a} \pm 7.84$	$435^{c} \pm 5.28$	$366^{ab} \pm 8.8$	$350^{ab} \pm 7.2$
Reproductive performance						
Calving Interval	412 ± 4.27	407 ± 5.05	410 ± 4.61	411 ± 3.41	414 ± 5.65	409 ± 4.62
GP	272 ± 0.19	276 ± 0.22	276 ± 0.20	272 ± 0.15	275 ± 0.25	275 ± 0.20
SPC	1.43 ± 0.06	1.40 ± 0.07	1.50 ± 0.06	-	-	-

Legend: H = Holstein, S = Sahiwal, L = Local, DAMY = daily average milk yield, GP = gestation period, SPC = service per conception, and Lwt = liveweight.

Discussion

Productive and reproductive performances of different dairy cattle breed groups from 2 different dairy farms

The daily average milk yield and total lactation milk yield of Holstein × Sahiwal crossbred was found to be higher than pure Holstein and Holstein × Local crossbreds on both farms. Similar findings were reported by Khan (9), Hossain (10), and Khan and Khatun (11). In addition, many findings (12,13) from tropical countries have also shown that the first cross of temperate breeds with tropical breeds produces more milk in a tropical environment. It was also noted that on farm 2 all breed groups showed comparatively better results than on farm 1. This could be due to better management, proper feeding, lactation stage of cows, location of the farms, etc. In addition, the higher production could be due to the effect of genotype × environment interactions on a particular farm. The differences in lactation milk production between breeds has been reported by Fathi Nasri et al. (14); differences in milk production between breed groups, seasons, and management systems have been reported by Val-Arreola et al. (15) and Pérochon et al. (16).

There were no significant differences found in service per conception, calving interval, and gestation period between breed groups or farms. However, significant differences were observed in the liveweight of Holstein cows between farms. Higher liveweight of cows could be attributed to differences in management and feeding on the 2 farms. Khan (9) reported similar findings regarding the liveweight of Holstein genotypes.

Estimated breeding values for the different traits

The breeding values of different traits were estimated by using univariate and multivariate individual animal models, and the EBVs obtained were similar to the values obtained by Katkasame et al. (17). However, the EBVs of milk yield were higher than Buiyan et al. (18) and Khan (19), who had previously estimated the breeding values of

Table 3. Estimated breeding values for different traits and economic selection index of individual dairy cows of different dairy breed groups on different farms.

CowID	Farm 1									
	H × L					H × S				
	LMY	CI	Lwt	EIndex	Rank	LMY	CI	Lwt	EIndex	Rank
10001						164.53	–1.95	–7.93	57.61	1
10002						162.03	0.62	2.52	52.35	2
10013						–119.87	–6.88	–27.92	23.14	4
10027						78.53	0.85	3.43	26.06	3
10047						63.52	0.85	3.43	21.26	5
10003	160.53	–0.93	–3.77	52.62	1					
10012	23.35	–0.18	–0.73	7.52	5					
10019	96.22	2.71	11.00	41.44	2					
10028	39.71	–3.93	–15.92	35.01	4					
10044	113.66	0.96	3.88	37.70	3					
	Farm 2									
20008						–102.19	–2.50	–10.13	–24.59	5
20020						171.26	2.96	12.01	66.18	3
20021						219.29	2.38	9.66	77.53	1
20022						–128.8	4.62	18.76	–13.44	4
20047						163.5	–4.16	–16.88	74.82	2
20009	119.87	6.89	27.92	106.89	1					
20010	121.45	–0.99	–4.03	40.29	5					
20019	107.56	–4.92	–19.93	69.32	2					
20023	134.02	9.43	–38.12	43.5	4					
20024	49.69	5.63	22.81	61.66	3					

Legend: H = Holstein, S = Sahiwal, L = Local, LMY = lactation milk yield, CI = calving interval, Lwt = liveweight, and EIndex = economic index.

Red Chittagong Cows (a local breed available in the Chittagong region of Bangladesh) for lactation milk yield. The higher breeding values in the current study might be due to heterosis effects among the crossbreds. Similar effects were reported by Hossain et al. (20) and Hirooka and Bhuiyan (21) for higher EBVs of Holstein × Local crossbreds. Furthermore, breeding values may differ on the basis of information sources in an animal model and between selections within breed. Ap Dewi et al. (22) and Khan et al. (3) reported that similar factors are responsible for breeding value differences.

Economic selection index or total merit

The economic selection index of the selection objective of milk production was calculated as the sum of the product of BLUP-estimated breeding values. The breeding values are weighted based on the economic value of all traits, an approach that is similar to the base selection index in literature from the 1970s as well as Fernandez-Perea and Alenda Jimenez (23) and Schneeberger et al. (24). The Holstein × Local genotype scored higher on farm 2 than farm 1. However, the Holstein × Sahiwal genotype had similar scores at both farms. The economic selection index, animal genetics, and the input costs and output prices projected profitability and represent a favorable combination of genetics and economics (23). Therefore, individual cows were ranked according to the economic selection index or total merit, and the highest ranking cows could be selected for the production of offspring. Schneeberger et al. (23) and Miglior et al. (25) found that a total economic merit index provided greater economic returns for animal evaluation than a single trait merit index.

This study indicates that the Holstein × Sahiwal crossbred was the better of the 2 genotypes at both farms. All genotypes performed comparatively better on farm 2. The selection of cows based on the higher economic selection index or total merit values would be beneficial for the production of breeding bulls and replacement females in Bangladesh. This study will assist researchers, policy makers, and farmers in planning further research and cattle rearing under farming conditions in the country.

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References

1. Henderson, C.R.: Sire evaluation and genetic trends. Proceedings of animal breeding and genetics symposium in honour of Dr. Jay L. Lush, 1973; Pp: 10-41.
2. Cilek, S., Kaygisiz, A.: Breeding values estimation of dairy cattle using test dairy milk yields for Brown Swiss cows reared at Ulas state farm. J. Anim. Vet. Adv., 2008; 7: 703-706.
3. Khan, M.S., Bilal, G., Bajwa, I.R., Rehman, Z., Ahmad, S.: Estimation of breeding values of Sahiwal cattle using test day milk yields. Pakistan Vet J., 2008; 28: 131-135.
4. Akbas, Y., Kaya, I., Uzmay, C., Yakupoglu, C., Unver, Y.: Breeding value estimation of dairy cattle using test day milk yields. Verband deutsch-turkischer Agrar-und Naturwissenschaftler e. V., Deutsch-Turkische Agrarforschung-6. Symposium, Giessen, Germany, 27 September-2 October 1999.
5. Ducrooq, V.: Genetic evaluation techniques in dairy cattle. INRA Prod. Anim.1990; 3: 3-16.
6. SAS®, User's Guide. Statistics. 8th edn. Cary (NC): SAS Institute Inc., 2000.
7. Steel, R.G.D., Torrie, J.H., Dickey, D.A.: Principles and procedure of statistics- A biometrical approach. PP 139-177. McGraw-Hill Co., Inc., NY and London, 1997.
8. Johnson, D.L.: Genetic evaluation of different species by AIREML, 1993.
9. Khan, M.K.I.: Development of models for genetic improvement of dairy cattle under cooperative dairying conditions in Bangladesh. PhD thesis, Massey University, New Zealand, 2009.
10. Hossain, M.S.: Genetic evaluation of fertility and milk production traits of crossbred cows at Baghabarighat milk shed area. PhD Thesis, Dept. of Animal Breeding & Genetics, Bangladesh Agricultural University, Mymensingh. 2006; Pp: 89-103.
11. Khan, M.K.I., Khatun, M.J.: Performances of F_1 crossbred cows at Baghabarighat milk shed area. Bangladesh J. Anim. Sci., 1998; 27: 183-186.
12. Syrstad, O.: Dairy cattle crossbreeding in the tropics: Performance of secondary crossbred populations. Livest. Prod. Sci., 1989; 23: 97-106.
13. Cunningham, E.P., Syrstad, O.: Crossbreeding *Bos indicus* and *Bos taurus* for milk production in the tropics. FAO Anim. Healt. Prod. paper 68, Rome, Italy. 1987.

14. Fathi Nasari, M.H., France, J., Odongo, N.E., Lopez, S., Bannink, A., Kebreab, E.: Modelling the lactation curve of dairy cows using the differentials of growth functions. J. Agric. Sci., 2008; 146: 633-641.

15. Val-Arreola, D., Kebreab, E., Dijkstra, J., France, J.: Study of the lactation curve in dairy cattle on farms in central Mexico. J. Dairy Sci., 2004; 87: 3789-3799.

16. Pérochon, L., Coulon, J.B., Lescourreet, F.: Modelling lactation curves of dairy cows with emphasis on individual variability. Anim. Prod., 1996; 63: 189-200.

17. Katkasame Sanao, Tumwasorn, S., Thanindratarn, B.: Estimation of sire breeding value from lactation of dairy cow using an animal model BLUP at D. P.O. Farm. Kasetsart University, Bangkok 10900, Tailand, 1995.

18. Bhuiyan, A.K.F.H., Shahjalal, M., Islam, M.N., Rahman, A.K.M.A., Keown, J.F.,Van Vleck, L.D., Blake, R.W.: Characterization, conservation and improvement of Red Chittagong Cattle of Bangladesh. A National Workshop 2007 held at BAU during 20 November, 2008: 1-22.

19. Khan, M.K.I.: Study on the economic and genetic evaluations of Red Chittagong cattle for further genetic improvement. Research report, Department of Genetics and Animal Breeding, Chittagong Veterinary and Animal Sciences University, Chittagong, Bangladesh, 2009.

20. Hossain, K.B., Takayanagi, S., Miyake, T., Bhuiyan, A.K.F.H., Sasaki, Y.: Statistical genetic studies on cattle breeding for dairy productivity in Bangladesh: II. Estimation of reciprocal and heterosis effects and optimum crossbreeding system between the local breeds and exotic breeds for milk performance. Asian- Aus. J. Anim. Sci., 2002; 15: 777-782.

21. Hirooka, H., Bhuiyan, A.K.F.H.: Additive and heterosis effects on milk yield and birth weight from crossbreeding experiments between Holstein and the local breed in Bangladesh. Asian-Aus. J. Anim. Sci., 1995; 8: 295-300.

22. Ap Dewi, Saatci, M., Ulutas, Z.: Genetic parameters of weights, ultrasonic muscle and fat depths, maternal effects and reproductive traits in Welsh Mountain sheep. Anim. Sci., 2002; 74: 399-408.

23. Fernández-Perea, Alenda Jiménez, R.: Economic weights for a selection index in Avileña purebred beef cattle. Livest. Prod. Sci., 2004; 89: 223-233.

24. Schneeberger, M., Barwick, SA., Crow, G.H., Hammond, K.: Economic indices using breeding values predicted by BLUP. J. Anim. Breed. Genet., 1992; 109: 108-187.

25. Miglior, F., Muir, B. L., Van Doormaal, B.J.: Selection indices in Holstein cattle of various countries. J. Dairy Sci., 2005; 88: 1255-1263.