Robustness of Selection Indices in Murrah Buffaloes

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ABSTRACT : Data pertaining to first lactation records of 316 Murrah buffaloes, progeny of 47 sires, maintained at NDRI Farm for a period of 18 years were analysed to construct selection indices and to examine their robustness by changing the relative economic values of different economic traits. A total of 120 selection indices were constructed for three sets of relative economic values (40 for each set) considering different combinations of seven first lactation traits viz. age at first calving (AFC), first lactation 305 day or less milk yield (FLMY), first lactation length (FLL), first calving interval (FCI), milk yield per day of first lactation length (MY/FLL), milk yield per day of first calving interval (MY/FCI) and milk yield per day age at second calving (MY/ASC). The three sets of relative economic values were based on economic values of different traits, 1% standard deviation of different traits and regression of different traits on FLMY. The 'optimum' indices for the first two sets had five traits each namely AFC, FLMY, FLL, FCI and MY/ASC giving improvement in aggregate genotype of Rupees 269.11 and Rs. 174.88, respectively. The accuracy of selection from both indices was 70.79 and 69.39%, respectively. The 'best' selection index from the third set of data again had five traits (AFC, FLMY, FLL, FCI and MY/FLL) giving genetic gain of Rs. 124.16 and accuracy of selection of 71.81%. The critcal levels or break-even points for FLMY for varying levels of AFC and FCI estimated from the "optimum index" suggested the need of enhancement of present production level of the herd or reduction of AFC or FCI. It was concluded that economic values of various first lactation traits were the most appropriate to construct selection indices as compared to other criteria of assigning relative economic weights in Murrah buffaloes. ***(Asian-Aust. J. Anim. Sci. 2003. Vol 17, No. 2 : 159-163)***

Key Words : Accuracy of Selection, Aggregate Genotype, Break Even Points, Murrah Buffaloes, Relative Economic Values, Robustness of Selection Indices

INTRODUCTION

Selection index, one of the multi-trait criteria of selection of females having optimum combination of production and reproduction traits, is practised for bringing about simultaneous improvement in more than one trait (Joshi and Tripathi, 1986; Nath and Sharma, 1997; Kaushik and Khanna, 2003). It is a function of economics of the herd as well as the prevailing genetic status pertaining to relevant traits. The most appropriate criterion of selection of animals would be an index that would combine most of the economic traits in such a manner that discrimination amongst individuals on the basis of their genetic worth is maximised. Further, the relationship between the index value and aggregate genetic worth of an individual is maximised by selection index as relative economic values, genetic and phenotypic variances and covariances among different traits are used for the construction of selection indices (Hazel, 1943; Karam et al., 1953). Therefore, this investigation was undertaken to construct selection indices and to compare their robustness by varying relative economic values of different first lactation production and reproduction traits in Murrah buffaloes.

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MATERIALS AND METHODS

A total of 316 first lactation records of Murrah buffaloes maintained at NDRI Farm were analysed to generate parameters for construction of selection indices. These buffaloes were progeny of 47 sires and data were spread over a period of last 18 years. Each sire was used for about three years under progeny testing programme. The traits considered were age at first calving (AFC), first lactation 305 day or less milk yield (FLMY), first lactation length (FLL), first calving interval (FCI), milk yield per day of first lactation length (MY/FLL), milk yield per day of first calving interval (MY/FCI) and milk yield per day age at second calving (MY/ASC). The least squares analysis of variance was done by fitting fixed model for milk yields having periods and seasons of calving as fixed effects and data were adjusted for significant non-genetic factors to estimate genetic parameters. The selection indices were constructed using relative economic values, genetic and phenotypic variances and covariances of different traits as described by Karam et al. (1953). The genetic variances and covariances were estimated as described by Becker (1968) after adjusting the data for significant non-genetic factors by paternal half-sib correlation method. The model was simply one-way classification model with sires in the model and variance was partitioned into between sires and progeny within sires or error variance. The economic weights used for different economic traits were the values reported by Gandhi et al. (1999). The cost of rearing heifers up to age at

Table 1. Relative economic values assigned to various economic traits by different criteria

Traits	Set-I	Set-II	Set-III
Age at first calving (days)	-1.5000	-0.8824	-0.0083
First lactation 305 days or less milk yield (kg)	1.0000	1.0000	1.0000
First lactation length (days)	4.0900	0.5892	0.0802
First calving interval (days)	-4.0900	-1.0061	-0.0598
Milk yield/first lactation length (kg)	1.0000	0.0029	0.0022
Milk yield/first calving interval (kg)	1.0000	0.0027	0.0020
Milk yield/age at second calving (kg)	1.0000	0.0008	0.0006

Table 2. Phenotypic and genetic variance-covariance matrix used for construction of selection indices

	AFC	FLMY	FLL	FCI	MY/FLL	MY/FCI	MY/ASC
AFC	24,656.1 72,710.8	-8,838.3	-679.9	-839.3	-39.7	-26.4	-32.0
FLMY	-6,216.7	29,658.6 210,645.5	16,611.5	11,609.1	502.3	403.8	147.1
FLL	0.584	884.7	647.54 4,379.6	4,380.8	14.1	15.3	15.8
FCI	1,150.8	168.7	135.7	861.5 12,716.5	-1.1	-56.9	7.6
MY/FLL	-19.8	23.1	0.413	-1.6	0.398 1.8	1.3	0.355
MY/FCI	-22.4	25.7	2.0	2.2	0.075	0.262 1.6	0.332
MY/ASC	-7.0	9.9	.669	-0.256	0.028	0.030	0.042 0.143

Elements above the diagonal are phenotypic covariances. Elements below the diagonal are genetic covariances.
Diagonal elements are genetic and phenotypic (bold) variances.

fist calving was Rs. 19.50/day, while the cost of maintaining a cow was Rs. 53.13/day. The cost of milk was taken as market selling price of milk i.e. Rs 13/kg. The relative economic values for different traits were estimated by taking the cost of milk as unity. Two other weightages for relative economic values namely one percent of standard deviation of different traits and simple regression of various traits on milk yield were used to test the robustness of selection indices (Table 1). The genetic and phenotypic variances and covariances of various traits are given in Table 2. The intensity of selection was assumed to be 0.35 corresponding to 20% culling.

RESULTS AND DISCUSSION

A total of 120 selection indices (40 each for each set of relative economic value) were constructed using various important combinations of seven traits. However, few selection indices having highest acuuracy of selection (R_{HI}) and giving highest genetic gains (ΔH) after dropping one trait every time have been reported for three sets of relative economic values (Table 3a.b.c). When all the seven traits were incorporated in an index, the improvement in aggregate genotype was Rupees 288.75 from the first set of data, while the accuracy of selection was 0.7589. The negative estimates for coefficient of MY/FCI and MY/ASC indicated that it was not desirable to prolong FCI (either by higher service period or dry period), which would also enhance ASC. The negative coefficient further indicated the need of imposing restrictions on these traits. Negative coefficients for MY/FCI has also been reported by Patel (1992) and Kulkarni (1995) in Surti buffaloes. The reported estimates ΔH and R_{HI} were higher than the estimates reported by El-Arian and Tripathi (1990) in Murrah buffaloes, Joshi and Tripathi (1986) in Murrah buffaloes, Singh et al. (1988) in Nili-Ravi buffaloes, Kulkarni (1995) in Surti buffaloes and Nath and Sharma (1997) in Murrah buffaloes. However, Gajbhiye (1987) reported higher rates of genetic gain (Rs. 307.75) than the reported value, while the accuracy of selection reported by him was slightly lower (0.736) than the reported estimate in this investigation.

When the six traits were considered, an index having AFC, FLMY, FLL, FCI, MY/FLL and MY/ASC gave highest improvement in aggregate genotype of Rs. 270.72 with R_{HI} as 0.7119 (Table 3a). The genetic gain and accuracy of selection decreased slightly to Rupees 269.11 and 0.7079 when MY/FLL was dropped from the above index. On incorporating four traits (AFC, FLMY, FLL and FCI) in an index the R_{HI} decreased drastically to 0.5476, while the genetic gain declined to Rupees 208.12 (as compared to an index having five traits). These results revealed that exclusion of production efficiency trait i.e. MY/ASC from an index decreased both the ΔH and R_{HI} to a considerable extent. Further dropping FLL from the above

Table 3a. Selection indices dropping one trait every time (Set-I)

	AFC	FLMY	FLL	FCI	MY/FLL	MY/FCI	MY/ASC	ΔH	R_{HI}
bi	-0.989	1.005	3.951	-3.344	59.623	-262.349	-878.595	288.75	0.7589
Hi	-81.85	85.80	6.60	-13.04	0.101	-0.146	-0.078		
bi	-1.042	0.901	2.636	-1.521	-51.876		-1067.945	270.72	0.7119
Hi	-90.590	86.576	5.763	-6.067	-0.021		-0.103		
bi	-1.055	0.785	3.225	-1.570			-1142.820	269.11	0.7079
Hi	-91.781	78.238	6.702	-6.332			-0.112		
bi	-0.642	0.152	0.824	-0.821				208.12	0.5476
Hi	-85.160	43.724	2.673	-6.289					
bi	-0.643	0.189		-0.614				202.86	0.5475
Hi	-87.423	46.778		-6.099					
bi	-0.575	0.161						176.34	0.5474
Hi	-86.011	47.327							

bi's=index coefficients. Hi's=improvement in individual traits incorporated in an index.

Table 3b. Selection indices dropping one trait every time (Set-II)

	AFC	FLMY	FLL	FCI	MY/FLL	MY/FCI	MY/ASC	ΔH	R_{HI}
bi	-0.609	0.910	0.284	-1.128	-91.087	-75.144	-524.637	190.25	0.7549
Hi	-77.797	113.459	1.559	-7.176	-0.1136	-0.038	-0.069		
bi	-0.624	0.881	0.093	-0.606	123.023		-578.811	188.03	0.7462
Hi	-80.064	112.742	1.053	-4.028	-0.1679		-0.077		
bi	-0.656	0.606	1.301	-0.721			-755.715	174.88	0.6939
Hi	-88.538	88.946	4.427	-5.171			-0.115		
bi	-0.383	0.187	0.287	-0.226				133.65	0.5303
Hi	-81.353	57.247	0.379	-4.812					
bi	-0.384	0.167		-0.313				132.54	0.5306
Hi	-81.979	55.016		-5.153					
bi	-0.366	0.151						124.78	0.5101
Hi	-79.927	54.252							

bi's=index coefficients. Hi's=improvement in individual traits incorporated in an index.

Table 3c. Selection indices dropping one trait every time (Set-III)

	AFC	FLMY	FLL	FCI	MY/FLL	MY/FCI	MY/ASC	ΔH	R_{HI}
bi	-0.199	0.775	0.902	-0.440	-127.302	-386.536	-242.116	130.58	0.7553
Hi	-39.370	130.219	1.918	-3.199	-0.293	-0.042	-0.048		
bi	-0.207	0.760	1.096	-0.171	-143.729		-269.983	129.74	0.7504
Hi	-40.642	129.545	2.321	-0.811	-0.334		-0.054		
bi	-0.115	0.683	1.862	-0.006	-167.610			124.16	0.7181
Hi	-30.221	124.347	5.398	-0.038	-0.398				
bi	-0.072	0.175	0.469	-0.006				72.41	0.4188
Hi	-39.543	72.150	2.048	-1.544					
bi	-0.071	0.175	0.460					72.31	0.4181
Hi	-39.358	72.140	1.979						
bi	-0.071	0.138						67.53	0.3914
Hi	-38.824	67.210							

bi's=index coefficients. Hi's=improvement in individual traits incorporated in an index.

index. the R_{HI} was almost the same though the ΔH decreased to Rupees 202.86. The accuracy of selection almost remained unchanged when two traits namely AFC and FLMY were included in an index. though the genetic gain decreased to Rupees 176.34.

The following index with R_{HI} of 70.79% and ΔH of Rupees 269.11was considered to be optimum as R_{HI} and ΔH given by this index were near to the corresponding estimates given by an index incorporating all the seven traits :

I=-1.0551 AFC+0.785 FLMY+3.225FLL-1.570 FCI-1142.820 MY/ASC

This index would bring about improvement in aggregate genotype by declining AFC by 91.78 days. enhancing FLMY by 78.24 kg. improving FLL by 6.70 days. decreasing FCI by 6.33 days and reducing negligibly MY/ASC by 0.11 kg. Most of the workers (Gajbhiye, 1987; Singh et al., 1988; El-Arian and Tripathi, 1990; Gupta et al., 1991; Patel, 1992; Kulkarni, 1995; Nath and Sharma, 1996)

on the other hand reported 'best' indices in buffaloes incorporating three or four traits. However. Joshi and Tripathi (1986) reported 'optimum' selection index having seven traits viz. AFC. WFC. FLTMY. ASC, MY/FLL, MY/FCI and MY/ASC in Murrah buffaloes. On the other hand. Kaushik and Khanna (2003) has recently reported that an index having age at first calving. lactation milk yield and service period was the best selection index giving lowest generation interval in Hariana cattle.

The second set of selection indices was constructed considering 1% standard deviation of different traits as their respective economic values (with the assumption that standard deviations are free from units). The relative weights for different traits were calculated assuming standard deviation of milk yield as unity (Table 1). The genetic gain from the index having all the seven traits was Rupees 190.25 with accuracy of selection of 0.7549 (Table 3b). The decrease in genetic gain from this index as compared to similar index from set-I was attributed to comparatively lower relative economic values for all the traits under this set of data. However. R_{HI} was almost similar as compared to set-I (0.7549 versus 0.7589). When six traits were considered. an index having AFC. FLMY. FLL, FCI. MY/FLL and MY/ASC gave maximum accuracy of selection (0.7462) and genetic gain (Rupees 188.03). On further dropping MY/FLL. The R_{HI} decreased to 0.6939 and ΔH declined to Rupees 174. 88. This decrease in aggregate genotype was significantly lower than the value reported from the selection index incorporating the same traits under set-I (Rupees 174.88 versus Rupees 269.11). On the contrary, the R_{HI} values were comparable (0.6939 versus 0.7079). On including four traits in an index. (the index having first four traits AFC, FLMY, FLL and FCI) gave maximum ΔH and R_{HI} (Rupees 133.65 and 0.5303). Further dropping FLL from the above index reduced neither ΔH nor R_{HI}. Similar findings were also reported from the first set for the same index having these three traits (Table 3a) as well as other workers (Gajbhiye, 1987; Kulkarni, 1995). Among differeent combinations of two traits. the index having AFC and FLMY improved the aggregate genotype by Rupees 124.78 with the accuracy of selection of 0.5101.

An index having same five traits as set-I was reported to be optimum. The index was:

I=-0.656 AFC+0.606 FLMY+1.301 FLL-0.721 FCI-755. 715 MY/ASC

The ΔH and R_{HI} from this index were Rupees 174.88 and 0.6939.

The third set of selection indices was constructed using relative economic values of different traits estimated as simple regression of these traits on milk yield. On incorporating all the seven first lactation traits in an index. the improvement in aggregate genotype was Rupees 130.58 with accuracy of selection of 0.7553. This estimated genetic gain was 45.22% of set-I and 68.64% of set-II from the index having all the seven traits. On dropping MY/FCI from the above index, the ΔH and R_{HI} decreased slightly (Table 3c). When five traits were considered. an index having AFC. FLMY. FLL. FCI and MY/FLL gave maximum accuracy of 0.7181 with a little decrease in aggregate genotype. The ΔH and R_{HI} decreased drastically when four traits namely AFC. FLMY. FLL and FCI were incorporated in an index (Rupees 72.41 and 0.4188). There was almost no change in either ΔH or R_{HI} when FCI was excluded from the above index. On further dropping FLL from the above index, ΔH and R_{HI} further declined to Rupees 67.53 and 0.3914.

The following index with ΔH of Rupees 124.16 and ΔH and R_{HI} as 0.7181 was considered to be optimum:

I=-0.115 AFC+0.683 FLMY+1.862 FLL-0.006 FCI-167.610 MY/FLL

The selection index is the measure of net economic value of the total genotype affecting the important economic traits. The index values estimated for all the buffaloes in this investigation were negative indicating thereby net economic merit of all these animals was leading to economic losses. Since the main objective of the Farm is to produce genetically superior germplasm to be used in the associated herds as well as under field conditions for

Table 4. Critical levels or break-even points for FLMY at varying levels of AFC and FCI

Levels for FCI (days)	Levels for AFC (months)				
	44	46	48	50	52
400	2,967.62	3,049.62	3,131.62	3,213.62	3,295.62
425	2,994.34	3,076.34	3,158.34	3,240.34	3,322.34
450	3,022.52	3,104.52	3,186.52	3,268.52	3,350.52
475	3,050.70	3,132.70	3,214.70	3,296.70	3,378.70
500	3,078.87	3,160.87	3,242.87	3,324.87	3,406.87
525	3,108.51	3,190.51	3,272.51	3,354.51	3,436.51
550	3,138.14	3,220.14	3,302.14	3,384.14	3,466.14
575	3,169.23	3,251.23	3,333.23	3,415.23	3,497.23
600	3,199.44	3,281.44	3,363.44	3,445.44	3,527.44

bringing about genetic improvement, the economic consideration is not of much relevance. However, for the purpose of determining the levels of production that would give sufficient returns to meet the expenses of rearing and maintaining the animals, a simulation exercise was done to determine the levels of milk production that should be achieved at prevailing levels of age at first calving and first calving interval. For this purpose 'optimum' index from set -I was considered. The average levels of age at first calving ranged from 44 to 52 months and that for first calving interval ranged from 400 to 600 days. A standard first lactation length of 305 days was assumed.

It was assumed that increase in first calving interval and age at second calving was due to increase in first dry period and accordingly MY/ASC was estimated considering average first lactation total milk yield of 1,907.07 kg i.e. herd mean. The levels of MY/ASC estimated for different levels of first calving interval ranged from 1.111 kg for 400days to 0.995 for 600 days. The different levels of first lactation 305 days or less milk yield for "no profit-no loss" basis for varying levels of age at first calving and first calving interval were estimated. For the present AFC (1,315.79 days) and FCI (450.02 days), the average critical level of FLMY was 2,987.29 kg. It was evident from the Table 4 that if any of AFC and FCI or both increase, the yield of the herd has to be increased to neutralize the extra expenditure incurred on rearing of animals (Table 4). Hence, this is desirable to reduce these reproductive parameters within the biological limits to enhance the milk yield to overcome expenditure on milk production. It was further concluded that economic values of different traits were more effective for assigning relative economic weights to different traits as compared to relative economic weights taken as 1% of standard deviation of different traits or regression of different traits on milk yield for construction of selection indices for having higher aggregate genotypic values.

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