# Efficiency of Different Selection Indices for Desired Gain in Reproduction and Production Traits in Hariana Cattle

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**ABSTRACT :** An investigation was conducted on 729 Hariana cows maintained at Government Livestock Farm, Hisar, from 1973 to 1999, with an objective to compare the efficiency of various selection indices for attaining desired genetic gains in the index traits. The various traits included were age at first calving (AFC), service period (SP), calving interval (CI), days to first service (DFS), number of services per conception (NSPC), lactation milk yield (LY), peak yield (PY), dry period (DP). Except for LY, PY and AFC the heritabilities of all other traits were low. Desirable associations among reproductive traits are supportive of the fact that any one of these traits incorporated in simultaneous selection is expected to cause correlated response in other traits. Production traits (LY and PY) were positively correlated, while DP had low negative genetic correlation with LY, and high genetic correlation with PY. Thus, DP can be taken as additional criteria in selection index for better over all improvement. Almost all production traits except DP had low negative correlation with AFC, SP, DFS and CI meaning that reduction in reproduction traits up to certain level may increase production performance. While, the correlation of NSPC with LY and PY was moderate positive. Among four trait indices $I_{23}$: incorporating PY, AFC, SP and NSPC and among three trait indices $I_1$: incorporating LY, AFC and SP were the best as these required least number of generations (4.87 and 1.35, respectively) to attain desired goals. Next in order of preference were PY or LY along with DP and SP as the best indices ($I_{20}$ and $I_{16}$) of which, index with PY may be preferred instead of LY as it produced considerably high correlated response in LY and reduction in NSPC as well. ***(Asian-Aust. J. Anim. Sci. 2003. Vol 16, No. 6 : 789-793)***

**Key Words :** Selection Indices, Desired Gain, Heritability, Phenotypic and Genetic Correlation, Production and Reproduction Traits, Hariana Cattle

## INTRODUCTION

Several steps are involved in the process of designing an efficient breeding programme. For any dynamic breeding programme it is necessary to know about the changes occurring in a given population over the years to assess its efficiency in order to suggest appropriate breeding strategies to maximize genetic gain. Emphasis in most dairy cattle breeding programmes is on increasing milk production. Due to antagonistic relationship between milk production and reproduction, it is desirable to broaden the breeding goals by including important reproduction traits.

The efficiency of production of dairy cattle depends upon optimum combination of reproduction and production traits. This can be possible through multi trait selection indices based on early expressed traits. It is desirable to select the animals for a combination of traits with an objective to improve overall genetic worth instead of selection for single trait. The relative economic value of component traits in aggregate genotype is the basic requirement of selection index. The estimation of economic value is a cumbersome process and it rapidly changes with the change in market trend. A selection index for attaining pre-determined desired genetic gain which does not require to define aggregate genotype and estimation of relative economic values of component traits was suggested by Pesek and Baker (1969). Later, Yamada et al. (1975) suggested a selection index, which attains pre-determined breeding goals in a minimum number of generations of selection. A practical advantage of this type of index is that the number of generations required to attain the desired goals can also be estimated. Khanna and Jaiswal (1994), Sharma (1995) and Singh (1998) developed and compared the efficiency of several indices to attain the desired goals in minimum number of generations in crossbred cattle, Murrah Buffaloes and Sahiwal cattle, respectively. The information available on these aspects is scanty on Hariana cattle. The present investigation was carried out to suggest an appropriate selection index for desired gain in reproduction and production traits.

## MATERIALS AND METHODS

The data for the present investigation were compiled from the history and pedigree sheets of Hariana cows maintained at Government Livestock Farm in Hisar. The records on 729 daughters of 38 sires (18.6 average number of daughters per sire) over the period from 1973-1999 were collected. The reproduction traits included were age at first calving (AFC), days to first service (DFS), service period (SP) and calving interval (CI) in days and number of services per conception (NSPC). The production traits were

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Received July 11, 2002; Accepted November 21, 2002

**Table 1.** Observed and desired mean and desired gain of different traits

| Traits | Observed mean | Desired mean | Desired gain |
|---|---|---|---|
| Age at first calving (days) | 1,435.45 | 1,360 | -75 |
| Service period (days) | 145.77 | 100 | -45 |
| Calving interval (days) | 432.83 | 390 | -45 |
| Days to 1st service | 120.20 | 75 | -45 |
| No. of services/conception | 1.46 | 1.20 | -0.25 |
| Lactation milk yield (kg) | 1,197.08 | 1,400 | +200 |
| Peak yield (kg) | 7.02 | 9.0 | +2 |
| Dry period (days) | 191.12 | 145 | -45 |

lactation milk yield (LY) and peak yield (PY) in kg and dry period (DP) in days.

Heritabilities, genetic and phenotypic correlations for all the traits were estimated by paternal half-sib correlation method from variance-covariance components estimated in mixed model multivariate least squares analysis (Harvey, 1987) using the following model:

$$Y_{ijk}=U+G_i+PS_j+e_{ijk}$$

where, Y is the record with effects;

U is the overall mean;

$G_i$ is the random effect of $i^{th}$ sire NID (0, $\sigma^2_s$);

$PS_j$ is the fixed effect of period-season (j= ,2…20);

and, e is the random error NID (0, $\sigma^2_e$).

The standard errors of these estimates were calculated according to Swiger et al. (1964), Robertson (1959) and Snedecor and Cochran (1968), respectively.

Several selection indices incorporating three and four traits simultaneously in different combinations were constructed for attaining the prefixed breeding goals as per Yamada et al. (1975). Let Q be defined as m×1 vector of desired gain for all the traits included in the study:

$Q=(Q_1, Q_2, \ldots, Q_m)$.

The desired gain were calculated as the difference between desired and observed means for different traits as given in the Table 1.

In order to attain these desired gains, selection is made on the basis of the index:

$I=b'X$

where, X=n×1 vector of sources of information. In four trait indices these were LY or PY, AFC, NSPC and any one of the DP, SP, CI and DFS; in three trait indices these were LY or PY and any two of the AFC, SP, CI, DFS, DP and NSPC; and.

b=n×1 vector of weighting coefficients computed as:

In case n=m, the weighting coefficients were computed ignoring R (because no relatives are included) as: b=G'Q where G=n×n matrix of genetic variance-covariances between the index traits, and Q=n×1 vector of desired gain for the traits included in the index.

Index coefficients (bi's) for different index traits, considering the same as breeding goals, are presented in table 3.

Expected genetic gain per generation in $i^{th}$ trait is computed as:

$$\Delta G_i = \frac{i_I \, Cov\,(G_i, I)}{\sigma_I}$$

where $i_I$ = selection intensity;

$\sigma_I=(b'Pb)^{1/2}$(standard deviation of the index), and/

P=n×n matrix of phenotypic variance-covariance between the elements of X.

Cov.($G_i$, I)=(G'b) (covariance of the breeding value of trait and the index).

Therefore, $\Delta G_i$ for all traits were obtained as:

**Table 2.** Estimates of heritability (diagonal), genetic (above diagonal) and phenotypic correlations (below diagonal) among reproduction and production traits in first lactation

| Traits | Age at 1st calving (1) | Service period (2) | Calving interval (3) | Days to 1st service (4) | No. of services per conception (5) | Lactation yield (6) | Peak yield (7) | Dry perod (8) |
|---|---|---|---|---|---|---|---|---|
| (1) | 0.18±0.09 | -0.86±0.34 | -0.80±0.35 | -0.35±0.37 | -0.37±0.35 | -0.14±0.30 | -0.74±0.30 | -0.25±0.31 |
| (2) | 0.07±0.04 | 0.08±0.06 | 1.00±0.34 | -0.47±0.34 | -0.31±0.41 | -0.79±0.17 | -0.87±0.16 | 0.92±0.07 |
| (3) | 0.09±0.04 | 0.84±0.02 | 0.08±0.06 | 0.51±0.33 | -0.22±0.43 | -0.79±0.17 | 0.87±0.16 | 0.95±0.05 |
| (4) | 0.00±0.04 | 0.70±0.03 | 0.61±0.03 | 0.15±0.08 | -0.85±0.35 | -0.55±0.23 | -0.58±0.23 | 0.62±0.20 |
| (5) | 0.07±0.04 | 0.35±0.04 | 0.29±0.04 | 0.21±0.04 | 0.16±0.08 | 0.14±0.31 | 0.14±0.30 | -0.11±0.32 |
| (6) | 0.13±0.04 | 0.14±0.04 | 0.15±0.04 | 0.11±0.04 | 0.11±0.04 | 0.20±0.10 | 0.80±0.16 | -0.26±0.48 |
| (7) | 0.11±0.04 | -0.07±0.04 | -0.07±0.04 | -0.09±0.04 | 0.06±0.04 | 0.77±0.03 | 0.20±0.10 | 0.52±0.49 |
| (8) | 0.06±0.04 | 0.77±0.03 | 0.82±0.02 | 0.44±0.04 | 0.30±0.04 | -0.14±0.05 | -0.15±0.05 | 0.14±0.09 |

**Table 3.** Index coefficients ($b_i$) of different selection indices for desired genetic gain

| Index number | Lactation yield | Peak yield | Age at 1st calving | Dry period | Service period | Calving interval | Days at 1st service | No. of services per conception |
|---|---|---|---|---|---|---|---|---|
| $I_1$ | 0.0032 | - | -0.0050 | - | -0.0047 | - | - | - |
| $I_2$ | -0.0051 | - | -0.0056 | - | - | 0.0248 | - | - |
| $I_3$ | 0.0049 | | -0.0042 | - | - | - | -0.0005 | - |
| $I_4$ | 0.0104 | - | -0.0036 | - | - | - | - | -10.2800 |
| $I_5$ | 0.0007 | - | - | - | -0.0183 | - | - | -4.1720 |
| $I_6$ | -0.0033 | - | - | - | - | 0.0309 | - | -7.0276 |
| $I_7$ | 0.0045 | - | - | - | - | - | -0.0192 | -7.8400 |
| $I_8$ | - | 0.3567 | -0.0066 | - | -0.0219 | - | - | - |
| $I_9$ | - | 0.3572 | -0.0068 | - | - | -0.0209 | - | - |
| $I_{10}$ | - | 0.7420 | -0.0060 | - | - | - | -0.0298 | - |
| $I_{11}$ | - | 8.3792 | -0.0013 | - | - | - | - | -24.0065 |
| $I_{12}$ | - | 0.0568 | - | - | -0.0283 | - | - | -3.0173 |
| $I_{13}$ | - | 0.0488 | - | - | - | -0.0275 | - | -3.3273 |
| $I_{14}$ | - | 0.6771 | - | - | - | - | -0.0458 | -7.6544 |
| $I_{15}$ | 0.0012 | - | -0.0106 | -0.0565 | - | - | - | - |
| $I_{16}$ | 0.0003 | - | - | -0.0101 | -0.0121 | - | - | - |
| $I_{17}$ | 0.0009 | - | - | -0.0170 | - | - | -0.0139 | - |
| $I_{18}$ | 0.0089 | - | - | -0.0617 | - | - | - | -13.1063 |
| $I_{19}$ | - | 3.4182 | -0.0051 | -0.0240 | - | - | - | - |
| $I_{20}$ | - | 1.1032 | - | 0.2190 | -0.0202 | - | - | - |
| $I_{21}$ | - | 1.3933 | - | 0.0188 | - | - | -0.0276 | - |
| $I_{22}$ | - | 8.0231 | - | -0.0473 | - | - | - | -25.9420 |
| $I_{23}$ | - | 0.1088 | -0.0074 | - | - | - | - | -3.4530 |
| $I_{24}$ | - | 0.1186 | -0.0078 | - | -0.0275 | -0.0266 | - | -3.8107 |
| $I_{25}$ | - | 0.7444 | -0.0073 | - | - | - | -0.0443 | -8.0201 |
| $I_{26}$ | - | 7.7121 | -0.0078 | -0.0605 | - | - | - | -26.2853 |
| $I_{27}$ | 0.0010 | - | -0.0068 | - | - | - | - | -4.7222 |
| $I_{28}$ | -0.0036 | - | -0.0055 | - | -0.0162 | 0.0300 | - | -7.0113 |
| $I_{29}$ | 0.0049 | - | -0.0056 | - | - | - | -0.0162 | -8.1321 |
| $I_{30}$ | 0.0066 | - | -0.0131 | -0.0849 | - | - | - | -13.8864 |

$\Delta G_i = i_I(G'b)/\sigma_I = i_I(G'b)/(b'Pb)^{1/2}$

Number of generations required to attain the goal (t) were calculated as:

$t = \sigma_I/i_I = (b'Pb)^{1/2}/i_I$

The total gain (Q*) in m traits after t generations of selection, under the assumption of no changes in population parameters during the course of selection were calculated as:

$Q^* = t\Delta G_i = G^{*\prime}b$

Where $G^*$=n×m matrix of genetic variance-covariances between index traits and all the traits in the study.

## RESULTS AND DISCUSSION

Estimates of heritability, genetic and phenotypic correlations among reproduction and production traits in first lactation are presented in table 2. The coefficient of heritability of AFC, SP, CI, DFS, NSPC, LY, PY and DP was estimated as 0.18±0.09, 0.08±0.06, 0.08±0.06, 0.15±0.09, 0.16±0.08, 0.20±0.10, 0.20±0.10 and 0.14±0.09, respectively. Except for MY, PY and AFC the heritability of all traits were low. It indicated that index selection along with improved management practices may be useful for improvement in these traits. Similar estimates were reported by Rana (1985) for SP, CI and LY; Pundir and Raheja (1994) for AFC, SP, LY and DP; Dalal (1997) for CI, LY, PY and DP; Dhaka (1997) for LY and PY; and, Singh (1998) for AFC in zebu cattle herds.

The AFC was found to have high negative genetic correlation with SP and CI, and moderate negative correlation with DFS and NSPC (-0.86±0.34, -0.80±0.35, -0.37±0.35 and -0.35±0.37, respectively). The corresponding phenotypic correlations among these traits were 0.07±0.04, 0.09±0.04, zero and 0.07±0.04. These estimates are in conformity to those of Rana (1985) and Singh (1998). The genetic and phenotypic correlations of SP with CI and DFS were positive. This is as expected because SP is the major determinant of these traits. Phenotypic correlation between SP and NSPC was moderately positive indicating that increase in NSPC will increase the SP. Similar trend of genetic and phenotypic correlations among CI, DFS and NSPC with moderate estimates was observed. Desirable association among these traits is supportive of the fact that any one of these traits incorporated in simultaneous

**Table 4.** Genetic gain per generation (direct and correlated) and generations required (t) to attain desired genetic gain in index traits by different selection indices

| Index number | Lactation yield | Peak yield | Age at 1st calving | Dry period | Service period | Calving interval | Days at 1st service | No. of services per conception | T |
|---|---|---|---|---|---|---|---|---|---|
| Three trait indices | | | | | | | | | |
| $I_1$ | 148.26 | (1.99) | -55.59 | (-10.11) | -33.35 | (29.73) | (-25.86) | (0.035) | 1.35 |
| $I_2$ | 69.92 | (-1.96) | -26.22 | (32.96) | (47.09) | -15.73 | (31.99) | (0.003) | 2.86 |
| $I_3$ | 110.52 | (1.94) | -41.45 | (-3.08) | (-36.53) | (41.37) | -24.87 | (0.055) | 1.81 |
| $I_4$ | 21.16 | (0.67) | -7.93 | (1.05) | (-19.79) | (12.21) | (-9.82) | -0.026 | 9.45 |
| $I_5$ | 43.92 | (0.43) | (3.52) | (-7.24) | -9.88 | (-11.02) | (-6.50) | -0.055 | 4.55 |
| $I_6$ | 32.93 | (-0.92) | (-0.65) | (19.89) | (14.80) | -7.41 | (14.08) | -0.041 | 6.07 |
| $I_7$ | 29.23 | (0.50) | (0.11) | (-3.70) | (-17.95) | (0.61) | -6.58 | -0.036 | 6.84 |
| $I_8$ | (236.93) | 0.81 | -30.53 | (-23.25) | -18.31 | (-31.15) | (-20.73) | (-0.021) | 2.46 |
| $I_9$ | (-12.02) | 0.84 | -31.63 | (-25.09) | (-31.19) | -18.97 | (-21.18) | (-0.016) | 2.37 |
| $I_{10}$ | (273.87) | 0.66 | -24.75 | (-18.17) | (-31.50) | (-34.85) | -14.85 | (0.031) | 3.03 |
| $I_{11}$ | (223.88) | 0.08 | -3.08 | (-0.19) | (-31.72) | (-32.65) | (-17.49) | -0.010 | 24.31 |
| $I_{12}$ | (86.60) | 0.46 | (5.41) | (-16.84) | -10.32 | (-19.41) | (-9.17) | -0.057 | 4.36 |
| $I_{13}$ | (-95.29) | 0.44 | (6.26) | (-17.04) | (-18.58) | -9.91 | (-10.14) | -0.055 | 4.54 |
| $I_{14}$ | (104.43) | 0.27 | (2.96) | (-9.88) | (-20.32) | (-22.02) | -6.12 | -0.03 | 7.35 |
| $I_{15}$ | 43.95 | (0.31) | -16.48 | -9.89 | (-37.46) | (-32.69) | (-25.12) | (0.040) | 4.55 |
| $I_{16}$ | 108.81 | (0.68) | (10.76) | -24.48 | -24.48 | (-42.46) | (-11.98) | (-0.011) | 1.84 |
| $I_{17}$ | 92.18 | (0.69) | (10.570) | -20.74 | (-36.83) | (-28.77) | -20.74 | (0.031) | 2.17 |
| $I_{18}$ | 14.27 | (0.39) | (4.22) | -3.21 | (-25.47) | (-8.05) | (-13.95) | -0.018 | 14.01 |
| $I_{19}$ | (423.32) | 0.34 | -12.85 | -7.70 | (-57.78) | (-60.93) | (-37.97) | (0.068) | 5.84 |
| $I_{20}$ | (610.64) | 1.20 | (-15.02) | -27.12 | -27.12 | (-43.75) | (-26.20) | (-0.023) | 1.66 |
| $I_{21}$ | (416.98) | 0.69 | (-9.51) | -15.55 | (-32.87) | (-35.72) | -15.55 | (0.034) | 2.89 |
| $I_{22}$ | (194.19) | 0.07 | (0.28) | -1.67 | (-32.83) | (15.59) | (-18.36) | -0.009 | 27.01 |
| Four trait indices | | | | | | | | | |
| $I_{23}$ | (87.16) | 0.41 | -15.40 | (-12.59) | -9.24 | (-16.89) | (-7.90) | -0.050 | 4.87 |
| $I_{24}$ | (-68.40) | 0.39 | -14.71 | (-6.28) | (-16.58) | -8.83 | (-8.82) | -0.049 | 5.09 |
| $I_{25}$ | (106.61) | 0.26 | -9.71 | (-15.77) | (-19.32) | (-20.73) | -5.83 | -0.030 | 7.72 |
| $I_{26}$ | (184.44) | 0.07 | -2.72 | -1.63 | (-32.54) | (-33.76) | (-18.21) | -0.009 | 27.53 |
| $I_{27}$ | 39.50 | (0.32) | -14.81 | (-5.47) | -8.88 | (-7.29) | (-5.25) | -0.050 | 5.06 |
| $I_{28}$ | 32.50 | (-0.92) | -12.18 | (20.37) | (15.58) | -0.04 | (14.47) | -7.310 | 6.15 |
| $I_{29}$ | 27.95 | (0.50) | -10.48 | (-2.24) | (17.01) | (2.55) | -6.29 | -0.030 | 7.15 |
| $I_{30}$ | 12.63 | (0.26) | -4.73 | -2.84 | (-24.31) | (-14.16) | (-13.38) | -0.016 | 15.84 |

selection is expected to cause correlated response in other traits.

Both the genetic and phenotypic correlations between LY and PY were very high and positive. Therefore, any one of these traits is sufficient in simultaneous selection to improve these traits. However, DP having low negative genetic correlation with LY and high positive genetic correlation with PY may be taken as an additional criterion in selection index for better over all improvement. Data presented in Table 2 further indicated that all production traits except DP have low correlation with AFC, SP, DFS and CI, suggesting that the reduction in reproduction traits up to certain level may increase production performance. While, the correlation of NSPC with LY and PY was moderate positive, which indicated that higher yielding cows require more number of services per conception. Low negative correlation of NSPC with DP is not of much importance.

Direct and correlated expected genetic gains per generation ($\Delta G_i$) in various traits and required number of generations (t) to attain these have been given in table 4. These results were compared in terms of multiple of unit intensity of selection. Only three and four trait indices were constructed using these traits in several combinations. Either lactation yield or peak yield was taken as index trait. Similarly only one of the reproduction traits (SP, CI and DFS) was taken as index trait and these were not considered simultaneously in the index. The breeding goals assigned were for LY: +200 kg; for PY: +2 kg; for AFC: -75 days; for DP, SP, CI and DFS each: -45 days and for NSPC: -0.25. For indices $I_1$ to $I_7$ (3 traits) lactation yield was combined with any two of the reproduction traits (AFC, SP, CI, DFS and NSPC). For indices $I_8$ to $I_{14}$ (3 traits) peak yield was combined with any two reproduction traits in same combinations as in previous case. For indices $I_{15}$ to $I_{18}$ (3 traits) lactation yield was combined with any one reproduction trait (except CI) along with DP, in different combinations. For indices $I_{19}$ to $I_{22}$ (3 traits) peak yield was combined with any one reproduction trait (except CI) along with DP, in different combinations. For indices $I_{23}$ to $I_{26}$ (4 traits) PY, AFC and NSPC along with any one of the rest of the reproduction traits were combined in various combinations. For indices $I_{27}$ to $I_{30}$ (4 traits) LY instead of PY in the same combinations as above, were constructed. The corresponding index traits were taken as breeder's goal also.

The comparative efficiency of these indices was judged on the basis of number of generations required to attain the pre-determined goals and the expected and correlated genetic gain per generation in individual traits. Table 4 revealed that the index $I_1$ required minimum number of generations (1.35) to attain the pre-determined genetic gain with per generation genetic response in LY, AFC and SP as 148.26 kg, -55.59 and -33.35 days, respectively and correlated response in PY as 1.99 kg, DP as -10.11 days, CI as 29.73 days and NSPC as 0.035. While, in index $I_{19}$ the number of generation required was 5.84 and correlated response in milk yield was 423.32 kg per generation with desired direct responses in PY, AFC and DP as index traits. In index $I_{20}$, direct genetic gain per generation in PY, DP and SP as 1.20 kg, -27.12 and -27.12 days respectively, along with the expected correlated response corresponding to LY, AFC, CI, DFS and NSPC as 610.64 kg, -15.02, -43.75, -26.20 days and -0.023 per generation. This index resulted into desirable response in all the traits including NSPC and the number of generations required to attain desired gain was also as less as 1.66. Among other indices based on various combinations, the three trait indices, in general, required less number of generations as compared to four trait indices. Among three trait indices $I_{20}$ and $I_1$ gave the desired change. Index $I_6$, selection on the basis of LY, DP and SP was found as the next best.

Khanna and Jaiswal (1994) observed that index using AFC, FLMY and FCI was over all more efficient than the index-incorporating lifetime traits (BE and PE) in crossbred cattle. Sharma (1995) obtained index with AFC, FLMY and MY/FCI as best three trait index in Murrah buffaloes. Singh (1998) compared several indices for Sahiwal cows and indicated that index comprising AFC, FLMY, FDP and FSP among 4 trait and AFC, FLMY and FSP among 3 trait indices were the best in terms of lowest number of generations required to attain the desired gain.

It may be inferred that the index $I_1$ incorporating LY, AFC and SP was the best as it required least number of generations to attain desired goals. Next in order of preference were PY or LY along with DP and SP as the best indices ($I_{20}$ and $I_{16}$). Among these indices, index with PY may be preferred instead of LY as it produced considerably high correlated response in LY and reduction in NSPC as well. Additionally PY is a single day milk yield, which can easily be recorded by farmers.

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