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Selection indexes for genetic improvement of yearling weight in Egyptian buffaloes

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Abstract

Estimates of genetic and phenotypic parameters for body weight at birth, 3, 6, 9, and 12 months of age, and for preweaning and postweaning average daily gain were computed and used to construct 14 selection indexes to improve the 12-month weight in Egyptian buffaloes. The full index incorporating body weight at birth, 3, 6, 9 and 12 months of age had the highest correlation with aggregate breeding value (r_{TI}=0.63). The correlation fell to 0.62 when body weight at birth and 3 months were omitted from the index. Selection for body weight at 12 months of age alone is expected to be 76.2 % as efficient as selection for the full index.

The maximum expected genetic gain in 12-month body weight was 8.85 kg/generation when all five body weights were included in the index; this decreased to 8.09 kg/generation when body weights at birth, 3 and 6 months were excluded and further decreased to 6.94 kg/generation when selection based on yearling weight only. From the practical standpoint, selection on I_5 involving body weight at 9 month of age can be considered as the best for improving body weight at 12 month since its application is earlier, less expensive, higher accuracy than any index excluding body weight at 12 month and giving reasonable amount (+5.39 kg) improvement in yearling weight as compared to direct selection (+6.94 kg).

Keywords: Egyptian buffaloes, yearling body weight, daily gain, phenotypic and genetic parameters, heritability, selection indexes

Zusammenfassung

Züchterische Verbesserung der Jährlingsgewichte bei Ägyptischen Büffeln mittels Selektionsindizes

Es wurden genetische und phänotypische Parameter für Geburts-, 3-, 6-, 9- und 12-Monatsgewichte sowie der täglichen Zunahmen Ägyptischer Büffel ermittelt und für die Konstruktion von 14 Selektionsindizes zur Erhöhung der 12-Monatsgewichte genutzt. Der Gesamtindex, welcher die Gewichte aller Altersetappen enthielt, zeigte die größte Beziehung zum Gesamtzuchtwert. (r_{Ti}=0,63). Dieser Wert verringerte sich auf 0,62, wenn die Werte für Geburts- und 3-Monatsgewicht nicht einbezogen wurden. Das 12-Monatsgewicht allein zeigt mit 76,2 % einen höheren Erwartungswert als der Gesamtindex. Das Maximum des erwarteten genetischen 12-Monate-Gewichtszuwachses von 8,85 kg je Generation wurde erreicht, wenn alle fünf Körpergewichte einbezogen wurden. Es verringerte sich auf 8,09 kg/Generation, wenn Geburts-, 3- und 6-Monatsgewichte genutzt wurden, und auf 6,94 kg/Generation bei Nutzung des Jährlingsgewichts allein. Nach praktischen Erwägungen erwies sich der I_5, d. h. die Einbeziehung des 9-Monatsgewichtes als der effektivste da er früher verfügbar, weniger teuer und genauer ist als wenn auch 12 Monatsgewichte einbezogen wurden. Die einfachere Erfassbarkeit von I_5 erreicht mit +5,39 kg/Generation brauchbare Zuwächse gegenüber einer direkten Selektion nach den Jährlingsgewichten (+6,94 kg/G).

Schlüsselwörter: Ägyptische Büffel, Jährlingsgewichte, tägliche Zunahmen, phänotypische Parameter, genetische Parameter, Heritabilität, Selektionsindizes

Introduction

The buffaloes are nearly equal in number to Egypt's native cattle (c. 3.5 m vs. 3.6 m). They are used as the main sources of red meat and milk. Little efforts have been made to improve their genetic potentiality for meat production and they suffer limited literature on genetic parameters of growth-related traits with no available reports on use of selection to improve their growth characteristics. MOURAD and KHATTAB (2009) constructed selection indexes for improving some productive traits in Egyptian buffaloes and BHAT (1992), AMIN (2003), SENO *et al.* (2006), KHAN *et al.* (2007) and KUMAR *et al.* (2008) discussed breeding strategies for production of buffaloes for milk production. Studies on cattle have shown that yearling weight is a highly heritable character and positively phenotypically and genetically correlated with other weights at either ends of growth curve which would indicate that this weight could be changed genetically by selection (ATIL *et al.* 2005). Yearling weight may be viewed as a simple form of a selection index combining birth weight, weaning weight and post-weaning gain. Buffalo growth around 12 month of age is directed towards muscling and away from fatness, a characteristic which is appreciated by Egyptian consumers. In Egypt, rearing buffalo males intended for meat production has rationally been and will continue to be performed at 12 months as demonstrated by the success of the Egyptian national project for rearing/fattening buffalo calves »Beetello«. Improvement of performance traits in multiple traits simultaneously is an increasing important breeding goal in buffalo and other livestock species (SHAHIN *et al.* 2000a, b). Selection index is an objective method of selection for a linear function of several traits at once which summarize overall genetic merit. The objective of this study were to estimate the genetic and phenotypic parameters for growth traits, to incorporate these estimates in construction selection indexes for improving 12 month weight in Egyptian buffaloes and to calculate genetic responses for selection.

Material and methods

Source of data and animal management

The data were collected on 244 buffalo calves (148 females and 96 males) from 192 buffalo cows sired by 27 bulls that had complete information and their sires having 5 progeny and more. Animals were maintained at El-Nattafe El-Gidid and El-Nattafe El-Kadim Experimental Stations (Mahalet Mousa in Kafr El-Sheikh Governorate, in the Delta region, Egypt) belonging to Animal Production Research Institute, Ministry of Agriculture. The Egyptian buffaloes are grey-black in colour with short curved horns, the weight of adult male is 600 kg, and for the adult female is 500 kg. The Egyptian buffalo males possess outstanding beef type body conformation. The newborn calves were fed 7 days with the dam's colostrums then they were fed twice daily on fresh milk and weaned at 105 day of age or 100 kg live body weight. After weaning, calves were fed according to the prevailing nutritional regime for beef production in Egypt: 1 kg concentrates plus 0.50 kg dry roughages per 50 kg live body weight.

Traits considered

Birth weight and body weights at 3 month intervals to 12 months were recorded. They were furthermore used to obtain alternative growth traits, namely pre-wean average daily gain, and wean to 12 months daily gain »post-weaning average daily gain«.

Statistical analyses

Estimates of variance components for traits in this study were obtained using least squares and maximum likelihood program (HARVEY 1990), according to the following model:

$$Y_{ijklm}=\mu + S_i + A_j + X_k + O_l + (AX)_{jk} + (XO)_{kl} + e_{ijklm} \quad (1)$$

where Y_{ijklm} is the observation on the *m*-th animal of the *i*-th sire, *j*-th year of calving, *k*-th sex of calving and *l*-th season of calving, μ is the Overall mean, S_i is the Random effect of sire, (i=1, 2, ..., 27), A_j is the fixed effect due to year of calving, (j=1, 2, ..., 6), X_k is the Fixed effect due to sex of calf, (k=1, 2) where 1=male and 2=female, O_l is the Fixed effect due to season of calving, (l=1, 2, 3, 4) where 1=winter, 2=spring, 3=summer and 4=autumn, $(AX)_{jk}$ is the interaction between year of calving and sex of calf, $(XO)_{kl}$ is the interaction between sex of calf and season of calving and e_{ijklm} is the random error assumed N.I.D. (0, σ^2_e).

Selection indexes for different combinations of growth-related traits were calculated using the parameters estimated in this study. The economic values for 6, 9 and 12 month weights in the present study were assumed to the price of 1 kg for meat at ages 6, 9 and 12 month were 10, 9 and 8 Egyptian pound, respectively. Therefore the relative economic value for 6, 9 and 12 month weight in this study were 1.25, 1.13 and 1 respectively. The selection index equations (I) were defined (CUNNINGHAM and MAHOU [1977]) as:

$$\textit{Index: } I=\sum_{i=1}^{m} b_i P_i = \underline{b}`\underline{p} \quad (2)$$

$$\textit{Aggregate genotypes value: } H=\sum_{i=1}^{n} a_i g_i = \underline{g}`\underline{a} \quad (3)$$

$$\textit{index weight: } \underline{b}=p^{-1} G\underline{a} \quad (4)$$

where $\underline{b}$` is a row vector of **m** index coefficients, $\underline{P}$` is a vector of **m** known phenotypic observations, g` is a row vector of **n** unknown genetic effects, $\underline{a}$` is a row vector of **n** known relative economic values, P is the phenotypic variance-covariance matrix (m × m) and G is generic variance-covariance matrix (m × n).

The expected genetic change after one round of selection for any of the traits considered in selection is calculated as

$$\Delta G_i = r_{G_i I} \cdot i\sigma_{G_i} \quad (5)$$
$$\Delta G_i = b_{G_i I} \cdot i\sigma_I \quad (6)$$

where ΔG_i is the Expected genetic change for the ith trait expressed in absolute units/generation (i=1,2, ... 7), i is the Intensity of selection (assumed i=1), $r_{G_i I}$ is Correlation of the trait with index and $b_{G_i I}$ is the Regression of the trait on the index.

Results

Means, genetic and phenotypic coefficients of variation and heritabilities

Table 1 presents the averages, genetic and phenotypic coefficients of variation and heritability estimates for body weight at various ages and pre- and post-weaning average daily gain. Body weight at 12 months of age averaged 179 kg and ranged from 101 to 275 kg.

The coefficient of phenotypic and genetic variability increased with advancing of age from 3 to 9 months. The phenotypic and genetic coefficient of variability for average daily gain (ADG) 3-12 was higher than that for ADG 0-3 (6.58 vs. 5.10 % and 6.18 vs. 0.82 %).

Table 1
Trait averages, heritability estimates and genetic and phenotypic coefficients of variation
Merkmalsmittelwerte, Heritabilität, Schätzwerte der genetischen und phänotypischen Variationskoeffizienten

Trait	Mean (kg)	Coefficients of variation		Heritability Estimates
		Phenotypic	Genetic	
Body weight at:				
Birth (W0)	33.50	4.42	3.10	0.49
3-month (W3)	77.28	3.75	1.20	0.10
6-month (W6)	113.95	3.87	2.58	0.44
9-month (W9)	148.05	4.30	3.57	0.69
12-month (W12)	179.01	4.10	3.99	0.95
Average daily gain (kg/day) in age periods:				
Pre-weaning (ADG 0-3)	0.49	5.10	0.82	0.02
Post-weaning (ADG 3-12)	0.38	6.58	6.18	0.89

W0 birth, W3 3 month, W6 6 month, W9 9 month, W12 12 month

The heritability estimates for body weight at various ages increased with age of calves from 0.10 at 3 months to 0.95 at 12 months. The heritability estimate of birth weight was higher than that of body weight at 3 months of age and the heritability estimate of post-weaning average daily gain was higher than that for pre-weaning average daily gain.

Genetic and phenotypic correlations

Table 2 gives the genetic and Phenotypic correlations between growth performance traits. As a general trend, after weaning the genetic correlation coefficients among body weights at various ages were positive and high. Most of the phenotypic correlations were generally lower than their genetic counterparts. The genetic correlation between yearling weight with body weights at 3, 6 and 9 months of age were positive and high (>0.90).

Table 2
Genetic (below diagonal) and phenotypic (above diagonal) correlations among growth - related traits in Egyptian buffaloes
Genetische (unter) und phänotypische (über Diagonale) Korrelationen der Wachstumsmerkmale

	W0	W3	W6	W9	W12	ADG 0-3	ADG 3-12
W0	-	0.35	0.23	0.19	0.15	−0.26	0.05
W3	0.97	-	0.49	0.35	0.29	0.81	−0.02
W6	0.18	0.98	-	0.68	0.60	0.36	0.49
W9	−0.06	0.89	0.96	-	0.82	0.25	0.75
W12	0.09	0.96	0.97	0.91	-	0.20	0.94
ADG 0-3	−0.97	−0.98	0.99	0.99	0.98	-	−0.05
ADG 3-12	−0.01	0.86	0.97	0.94	0.99	0.99	-

W0 birth, W3 3 month, W6 6 month, W9 9 month, W12 12 month

Selection indexes

The estimates of genetic and phenotypic parameters calculated in the present study were used to construct 14 indices. Table 3 gives the weighing factors (b-values) representing the partial or simple regressions of genetic value for net merit on phenotype for each trait, standard deviation (σ_I), accuracy of selection (r_{TI}) representing the multiple or simple correlation of selection index with genetic value for net merit and relative efficiency (RE).

It appears that the maximum accuracy of selection (r_{TI}=0.63) was obtained using the full index. This magnitude of accuracy did not essentially change (r_{TI}=0.62) when W0 and W3 were ignored from the full index but the accuracy was decreased (r_{TI}=0.58) when W6 was also ignored from the full index. Comparing the three indexes I_4=0.724 W6, I_5=0.512 W9 and I_6=0.537 W12 selection for W12 alone would be more efficient (r_{TI}=0.48) than selection for W9 (r_{TI}=0.40) alone or W6 (r_{TI}=0.35) alone.

The accuracy values were comparable for the index including W12 alone and the indexes combining W12 with ADG 0-3 (I_{12}: r_{TI}=0.48) or with ADG 3-12 (I_{13}: r_{TI}=0.49) or with ADG 0-3 and ADG 3-12 (I_{14}: r_{TI}=0.50).

Table 3
Weighing factors (b-values), standard deviation (σI), efficiencies of selection in absolutes (r_{TI}) and relative (RE) values in indexes used to improve body weight at 12 month
Wichtungsfaktoren, Standardabweichung sowie Effizienz der Indizes (absolut - r_{TI} und relativ - RE) für eine Erhöhung der Jährlingsgewichte

Index No.	Source of Information	b-values W0	W3	W6	W9	W12	ADG0-3	ADG3-12	σ_I	r_{TI}	RE
1	W0, W3, W6, W9, W12	0.037	0.293	0.497	0.375	0.424	-	-	20.44	0.63	100.00
2	W0	0.103	-	-	-	-	-	-	0.57	0.02	3.17
3	W3	-	0.479	-	-	-	-	-	4.48	0.14	22.22
4	W6	-	-	0.724	-	-	-	-	11.35	0.35	55.56
5	W9	-	-	-	0.512	-	-	-	13.06	0.40	63.49
6	W12	-	-	-	-	0.537	-	-	15.61	0.48	76.19
7	W9, W12	-	-	-	0.413	0.470	-	-	18.72	0. 58	92.06
8	W6, W9, W12	-	-	0.504	0.379	0.429	-	-	20.26	0. 62	98.41
9	ADG 0-3	-	-	-	-	-	7.729	-	1.42	0.04	6.35
10	ADG 3-12	-	-	-	-	-	-	15.060	4.76	0.15	23.81
11	ADG 0-3, ADG 3-12	-	-	-	-	-	–25.550	26.040	5.71	0.17	26.98
12	W12, ADG 0-3	-	-	-	-	0.536	4.989	-	15.64	0.48	76.19
13	W12, ADG 3-12	-	-	-	-	0.528	-	11.590	16.03	0.49	77.78
14	W12, ADG0-3, ADG3-12	-	-	-	-	0.525	–21.724	20.943	16.25	0.50	79.37

W0 birth, W3 3 month, W6 6 month, W9 9 month, W12 12 month

Results of the expected genetic changes per generation in body weight at various ages and average daily gain for each round of selection are shown in Table 4. Selection on full index (I_1) gave the greatest improvement in W12 (+8.85 kg). The indexes involving one or two traits beside W12 yielded comparable improvement (I_8: +8.77 kg; I_7: +8.09 kg; I_{14}: +7.14 kg; I_{13}: +7.12 kg; I_{12}: +6.97 kg).

Table 4
Expected genetic changes per generation in body weights (kg) and average daily gains (kg/day) when using indexes to improve body weight at 12 month (intensity of selection=1.0)
Erwarteter jährlicher Zuwachs für Körpergewichte und tägliche Zunahmen bei Indexnutzung zur Erhöhung der Jährlingsgewichte (Selektionsintensität=1,0)

Index no.	Source of Information	Expected genetic gain in the trait in aggregate genotype W6	W9	W12	Expected genetic gain in related traits W0	W3	ADG 0-3	ADG 3-12
1	W0, W3, W6, W9, W12	3.467	6.421	8.851	0.109	0.837	0.005	0.029
2	W0	0.261	–0.184	0.457	0.725	0.396	–0.004	0.002
3	W3	0.804	1.343	1.954	0.237	0.310	–0.001	0.005
4	W6	1.939	3.526	4.940	0.093	0.480	0.004	0.016
5	W9	2.167	4.389	5.387	–0.041	0.492	0.006	0.019
6	W12	2.663	4.725	6.941	0.088	0.628	0.006	0.023
7	W9, W12	3.161	5.913	8.091	0.041	0.735	0.008	0.027
8	W6, W9, W12	3.428	6.375	8.767	0.071	0.808	0.005	0.029
9	ADG 0-3	0.359	0.821	0.937	–0.117	–0.038	0.129	0.234
10	ADG 3-12	0.798	1.492	2.078	0.029	0.161	0.136	0.188
11	ADG 0-3, ADG 3-12	1.446	1.479	2.228	0.137	0.201	0.090	0.079
12	W12, ADG 0-3	2.632	4.756	6.971	0.081	0.628	0.013	0.036
13	W12, ADG 3-12	2.732	4.864	7.119	0.091	0.638	0.037	0.065
14	W12, ADG0-3, ADG3-12	2.914	4.844	7.135	0.123	0.646	0.029	0.040

W0 birth, W3 3 month, W6 6 month, W9 9 month, W12 12 month

Discussion

The moderate to high estimates of heritability for body weight at various ages other than at 3 months of age reported in this study indicated good prospects for improvement of these live performance traits through selection if these animals are uniformly managed and fed.

The heritability estimate for birth weight as considered in the present study was higher than those reported by other workers (ALIM 1991, MAHDY *et al.* 1999, MOURAD and KHATTAB, 2009 for Egyptian buffaloes), and was lower than estimates reported by THEVAMANOHARAN *et al.* (2001) for Thailand buffaloes, CHAKRAVARTY and RATHI (1989a) and TIEN and TRIPATHI (1990) for Indian buffaloes. MURDIA and CHAUDHARY (1984) found the h^2 estimate for birth weight in Indian buffaloes was −0.02. This small and negative estimate may be attributed to sampling error or genotype-environmental interactions and other factors.

The heritability estimate for body weight at 3 months of age in the present study was much lower than that reported by GURUNG and JOHAR (1983) for Murrah buffaloes, THEVAMANOHARAN *et al.* (2001) for Thailand buffaloes and was similar to that reported by ANGULO *et al.* (2006) for the buffalo in the Colombia (h^2=0.10, Egyptian buffaloes vs. h^2=0.47 for Murrah buffaloes and h^2=0.49, 0.86 for Thailand buffaloes). The discrepancy between these estimate may be attributed to different breeds of buffaloes. The low estimate of heritability for this trait suggested that most of the observed variation in this trait was due to temporary environmental conditions and management. Possibly, good management and feeding lead to much improvement for this trait.

The heritability estimate for body weight at 6 months of age as estimated in the present study was similar to the results of CKAKRAVARTY and RATHI (1989a) (h^2=0.44, Egyptian buffaloes vs. 0.45 for Indian buffaloes) and slightly lower than that reported by DAHAMA and MALIK (1989) for Indian buffaloes (h^2=0.50). TIEN and TRIPATHI (1990) working with Murrah buffalo heifers estimated the heritability of body weight at 6 months of age as 0.342.

The heritability estimate for body weight at 12 months of age in the present study was high, indicating response to selection for this trait. This result is in agreement with those cited in the literature. (DAHAMA and MALIK 1989). Other workers (CKAKRAVARTY and RATHI 1989a and TIEN and TRIPATHI 1990) reported lower heritability estimates for yearling weight than that reported in this study.

The genetic inter-age correlations for weights were higher than the phenotypic. The phenotypic correlations of birth weight with subsequent weights found in the present study fall within the estimates reported by BONDOS *et al.* (1995) for buffaloes and SHEHU *et al.* (2008) for Sokoto Gudali cattle. Genetic correlations of weaning weight with subsequent weights at 6, 9 and 12 months were 0.98, 0.89 and 0.96, respectively; those of yearling weight with weights at 3, 6 and 9 months were 0.96, 0.97 and 0.91, respectively (Figure 1). The correlation of yearling weight with post-weaning average daily gain was close to one. These trend are in agreement with those of MAHDY *et al.* (1999) in Egyptian buffaloes and KUMAR *et al.* (1995) and PREETI and CHAKRAVARTY (1999) in Indian buffaloes. The magnitude of these correlations indicates that many of the genes that control yearling weight also control the early growth-related traits in the same direction. The positive genetic association between yearling weight with each of birth weight, pre-weaning gain, post-weaning gain suggested that selection to increase yearling weight would also cause some increase in the other traits.

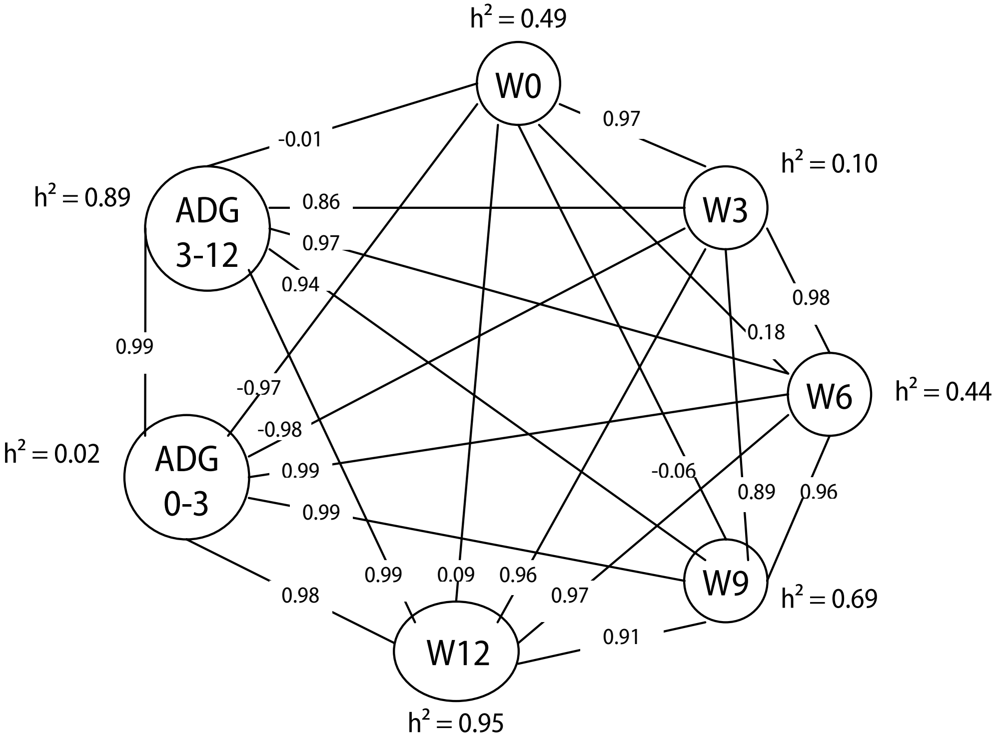

Figure 1
Heritabilities and genetic correlations for growth-related traits in Egyptian buffaloes
Heritabilitäten und genetische Korrelationen bei Wachstumsmerkmalen Ägyptischer Büffel

To the authors' knowledge, no selection indexes are available to select for yearling weight or any other weights in Egyptian buffaloes. Few are available in the literature on improving genetic value of Indian buffaloes. CHAKRAVARTY and RATHI (1990a) constructed partial restriction selection index for genetic improvement of Indian buffaloes. They found that the best index was that which utilized weights at 12, 18 months, age at 1st calving and 1st lactation milk yield. Selection on a restricted index with a partial restriction on W18 resulted in 67 kg more milk per generation than selection on the unrestricted index.

CHAKRAVARTY and RATHI (1990b) constructed unrestricting selection index for genetic improvement of Indian buffaloes. They found that compared with direct selection, an index comprising birth weight and 18 month weight was the best for improving adult weight.

CHAKRAVARTY *et al.* (1991) constructed several selection indices for the genetic improvement of Indian buffaloes. They found that the correlation between the index and the breeding value for aggregate genetic merit was highest for indices incorporating (1) W0, W6, W12 and W18 and (2) age at 1st calving, 1st service period and 300-day milk yield.

It appears from the limited literature given in this section the scarcity of reports investigating the possibility of improving buffalo's growth-related traits through use of selection indexes. The present study showed that , the full index incorporating body weight at birth, 3, 6, 9 and 12 months of age had the highest correlation with aggregate breeding value (r_{TI}=0.63). The correlation fell to 0.62 when body weight at birth and 3 months were omitted from the index. Selection for body weight at 12 months of age alone is expected to be 76.2 % as efficient as selection for the full index.

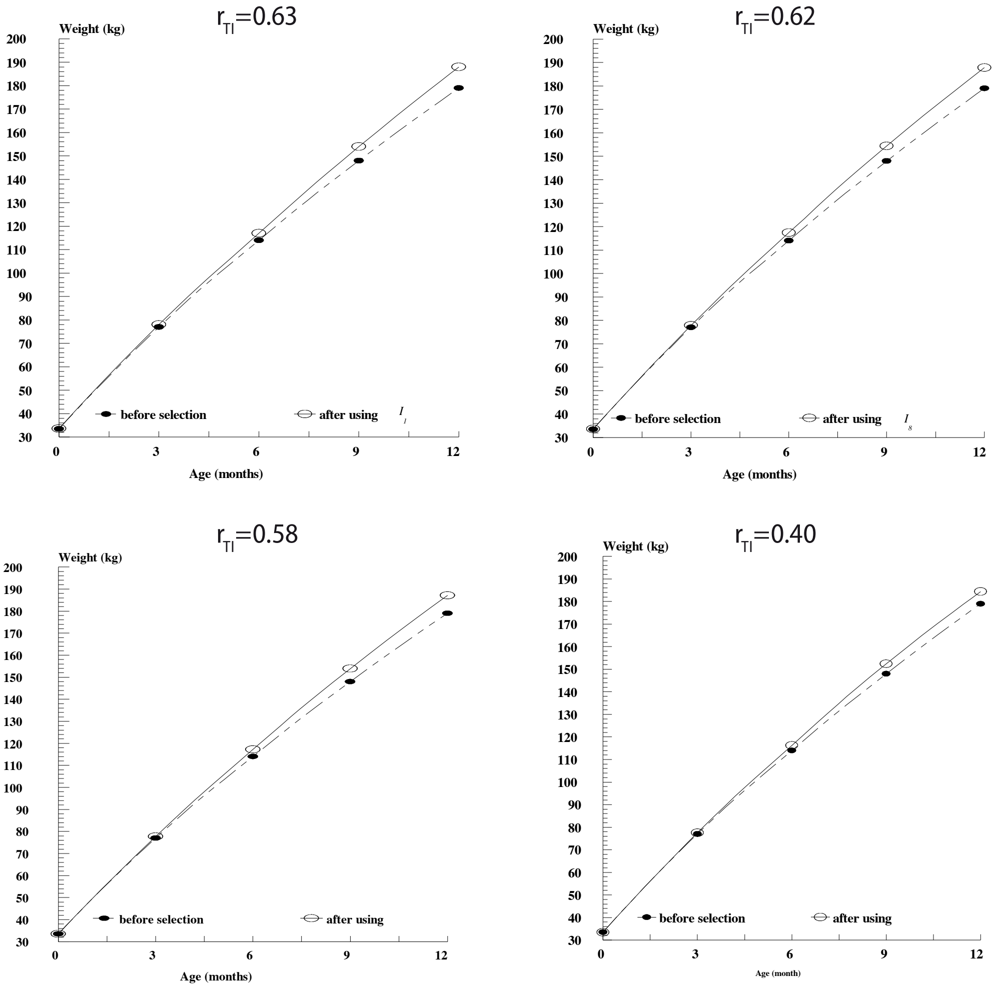

Figure 2
Expected body weights (⊖) after one round of selection on indexes I_1, I_8, I_7 and I_5 compared with those of the original population (•)
Erwartete Körpergewichte bei Indexnutzung gegenüber Gewichten der Originalpopulation

Selection on single-trait indexes yielded progressive improvement in body weight at 12 months of age (selection on W0: +0.46 kg, on W3: +1.95 kg, on W6: +4.94 kg, on W9: +5.39 kg, on W12: +6.94 kg). Selection for yearling weight would resulted in desirable correlated increase in all its components; birth weight increased by 0.09 kg, body weight at 3, 6 and 9 months of age increased by 0.83, 2.66 and 4.73 kg, respectively. The direct genetic response in body weight at 12 months of age was higher than those reported by CHAKRAVARTY and RATHI (1989b) for Indian buffaloes (6.94 kg vs. 3.74 kg).

Selection for rapid rate of gain usually increases both birth weight and mature size. Increases in birth weight contribute to increased calving difficulty and subsequent perinatal death loss. Increased mature size increases the nutrient requirements for maintenance. In the present study all selection indexes showed that the increase in birth weight would not exceed 0.73 kg, excluding any risk of dystocia (calving difficulty). This is contrary to the result of CHAKRAVARTY and RATHI (1989b) who found that selection on body weight at 12 months of age resulted in an increase by +2.38 kg increase in birth weight in Indian buffaloes.

The maximum expected genetic gain in 12 month body weight was 8.85 kg/generation when all five body weights were included in the index; this decreased to 8.09 kg/generation when body weights at birth, 3 and 6 months were excluded and further decreased to 6.94 kg/generation when selection based on yearling weight only. From the practical standpoint, selection on I_5 involving body weight at 9 months of age can be considered as the best for improving yearling weight since its application is earlier, less expensive, higher accuracy than any index excluding yearling weight (Table 3) and giving reasonable amount (+ 5.39 kg) improvement in yearling weight (Table 4) as compared to direct selection (+6.94 kg).

Compared the growth curve when selection on the most accurate indexes (I_1, I_8, I_7 and I_5) and the original one. The curves resulting from selection did not diverge from the original ones till month 3, after which the divergence increased progressively to reach its maximum at month 12 (Figure 2).

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