GENETIC IMPROVEMENT OF MILK PRODUCTION IN EGYPTIAN BUFFALOES THROUGH SELECTION INDEXES
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ABSTRACT

Data relevant to 398 Egyptian buffaloes raised at Mehallet Mousa Experimental Station between 1972-1992 were utilized in this investigation to construct several selection indexes which determine the most suitable combination of age at first calving (AFC), first lactation total milk yield (TMY), first dry period (DP) and first calving interval (CI) in order to realize the most genetic improvement in TMY.

Overall mean of AFC was 1167.12 days, of TMY was 1231.57 kgs, of DP was 315.50 days and of CI was 597.25 days. Heritability estimate of AFC was 0.38, of TMY was 0.43, of DP was 0.32 and of CI was 0.20. Phenotypic correlations were highly significant but mild except those between DP and each of TMY and CI were moderately negative and high positive, respectively. Similarly were the genetic correlations except that between DP and AFC which was moderately positive. The genetic correlation between TMY and each of DP and CI were high negative and very high positive, respectively.

The highest expected genetic improvement (ΔG) for TMY (357.5 kgs) was obtained from the second index (I₂) which incorporated TMY, DP and CI. Also it recorded the highest correlation with the aggregate genotype (rₐ = 1.00) and the highest relative efficiency compared with the basic index (RE% = 125). Whereas the lowest correlation with the aggregate genotype (rₐ = 0.65) and the lowest relative efficiency (RE% = 81) were obtained from I₅ which included TMY and DP.

INTRODUCTION

Genetic improvement in dairy animals may take place either through selection or by adopting particular mating systems. Significant genetic improvement by selection results when the selected animals are superior to the herd average and when the heritabilities of the traits are relatively high. It is important that the traits included in a given breeding programme be of economic importance and are measured objectively. Although selection of dairy animals is based on milk production, their breeding value for others traits such as age at first calving, dry period and calving interval are involved in determining the economics of dairy herds. Therefore, it is necessary for the dairy animal breeder to be concerned with selection for multiple traits simultaneously. Selection index is one of the most effective methods for several traits selection to improve overall economic merit of the animal (Hazel et al., 1994).

In Egypt, the use of selection index for improving milk production in buffaloes has been documented by Ashmawy (1981), Badran and Sharaby
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(1989) and El-Arian et al. (2001). Also in India, many researchers have
constructed several selection indices by incorporating different economic
traits in buffaloes (Johari and Bhat, 1978; Sharma and Basu, 1986;
Charkravary and Rathi, 1990; Gupta et al., 1991 and Dutt and Taneja, 1994).
The objective of this investigation is to construct several selection
indexes incorporating combinations of some important first lactation
economic traits in buffaloes to determine which of them combine best in an
index, maximize the relative efficiency and lead to maximum genetic
improvement.

MATERIALS AND METHODS

Source of data:
Data used in this investigation were from the records of the buffaloes
herd located in Mehallat Mousa Experimental Station, Animal Production
Research Institute, Ministry of Agriculture. The records used were relevant to
398 dairy buffaloes which completed at least their first and second normal
lactations and were free from diseases and disorders. These records covered
the period from 1972-1992. The relevant details of the herd management were
described by El-Arian et al. (2001) and Aziz et al. (2003). Traits under
investigation were age at first calving in days (AFC), first lactation total milk yield
in kilograms (TMY), first dry period in days (DP) and first calving interval in days
(CI).

Relative economic values:
The economic values of the traits were estimated as the change in the
difference between cost and income per unit change in the trait (Kolstad, 1975).
These values, according to the prices of 1991/1992, were L.E. 3/day for AFC,
L.E. 0.40/Kg for TMY, L.E. 1.85/day for DP and 1.57/day for CI.
The economic value of each trait was divided by that of TMY to get the
relative economic value. The relative economic values of AFC, DP and CI were
assigned negative in order to have a logic decline in the magnitude of these
traits. Therefore, the relative economic values were -7.50, 1.00, -4.63 and -3.93
for AFC, TMY, DP and CI, respectively.

Statistical analysis:
Mixed Model LSMLMW program (Harvey, 1990) was used to
estimate the genetic and phenotypic parameters.
Selection indexes were set up using the general index program
SELIND (Cunningham, 1970). The weighing factors (b's) of the general index
were obtained by solving the following equation given by Cunningham (1969):

$ Pb = Gv $ to give $ b = p^{-1} Gv $

where:
$ P $ : the phenotypic variances and covariances matrix.
$ G $ : the Genetic variances and covariances matrix.
$ v $ : the economic weights column vector.
$ b $ : the weighing factors column vector.
$ p^{-1} $ : the original $ p $ matrix inverse.

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The expected genetic gain ($\Delta G$) for each trait after one round of selection ($i = 1$) was obtained by solving either of the following two equations (Cunningham, 1969):

$$\Delta G_i = (G_{xi}) \sigma_{Gx}$$

$$\Delta G_x = b G_{xi} \sigma_i$$

where:

- $\Delta G_x$ : the expected genetic gain.
- $r G_{xi}$ : the genetic correlation of the trait with index.
- $i$ : the selection differential in standard deviation units.
- $\sigma_{Gx}$ : the standard deviation of genetic variance of the trait.

$$(\sigma_i) = \sqrt{b' \cdot Pb}$$

- $b G_{xi}$ : the genetic regression of the trait on the index.
- $\sigma_i$ : the standard deviation of the index.

The standard deviation of the index ($\sigma_i$) was obtained as:

where:

- $b$ : the column vector of weighing factors which is going to be solved.
- $b'$ : the transpose of the column vector of weighing factors.
- $P$ : the matrix of phenotypic variances and covariances.

The standard deviation of the aggregate genotype ($\sigma_T$) was estimated as:

$$\sigma_T = \sqrt{v' \cdot GV}$$

where:

- $V$ : is the column vector of economic weights.
- $v'$ : is the transpose of the column vector of economic weights.
- $G$ : is the matrix of genetic variances and covariances.

The correlation between the index and the aggregate genotype ($r_{IT}$) was obtained as:

$$r_{IT} = \frac{\sigma_I}{\sigma_T} = \frac{\sqrt{b' \cdot Pb}}{\sqrt{v' \cdot GV}}$$

The intensity of selection used in estimation of various parameters was assumed to be 0.35, corresponding to 80 percent selection or 20 percent culling.

**RESULTS AND DISCUSSION**

The means of the studied traits (Table 1) are in close agreement with those reported by Ashmawy (1981) and El-Arian et al. (2001) for AFC, El-Arian et al. (2001) and Azziz et al. (2003) for TMY, Mahdy et al. (1999) for DP and CI.
Table (1): The means ($\bar{X}$), phenotypic standard deviations ($\sigma_p$), genetic standard deviations ($\sigma_G$) and relative economic values ($v$) for studied traits.

<table>
<thead>
<tr>
<th>Trait</th>
<th>$\bar{X}$</th>
<th>$\sigma_p$</th>
<th>$\sigma_G$</th>
<th>$v$</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age at first calving</td>
<td>1167.12</td>
<td>167.87</td>
<td>103.26</td>
<td>-7.50</td>
</tr>
<tr>
<td>Total milk yield</td>
<td>1231.57</td>
<td>572.67</td>
<td>374.03</td>
<td>1.00</td>
</tr>
<tr>
<td>Dry period (days)</td>
<td>315.50</td>
<td>150.68</td>
<td>84.99</td>
<td>-4.63</td>
</tr>
<tr>
<td>Calving interval</td>
<td>597.25</td>
<td>134.15</td>
<td>60.64</td>
<td>-3.93</td>
</tr>
</tbody>
</table>

AFC and TMY had relatively high proportion of genetic variance compared with DP and CI. The latter traits might be subject to man-made decisions regarding estrous detection and/or mating arrangements. Estimates of heritability and correlations among the traits are in Table (2). Their values indicate the possibility of traits improvement through genetics by selection. Heritability estimate for AFC (0.38) is higher than reported in the literature except that depicted by El-Arian et al. (2001). For TMY it was quite similar to those documented by Ashmawy (1981) and Badran and Sharaby (1989) and Aziz et al. (2003). However, Mahdy et al. (1999) and El-Arian et al. (2001) reported moderate heritability values for the same trait. Heritability estimate for DP (0.32) and CI (0.20) were higher than those depicted by Mahdy et al. (1999).

AFC and DP had highly significant negative genetic and phenotypic correlations with TMY. Whereas, CI had highly significant positive genetic and phenotypic correlations with TMY, but those between CI and TMY were positive (Table 2). Long dry periods are usually associated with low milk production. The strong negative genetic association between the two traits may reflect an evidence for possible genetic influence on such relationship. Meanwhile, the mild association between TMY and AFC indicated independent hereditary mechanisms for the two traits. The mild and strong phenotypic and genotypic correlations between TMY and CI indicated the expected interference of the environmental factors in determining the phenotypic but not the genetic association between the two traits. Generally, the genetic correlations were higher than the phenotypic and had the same sign except that between DP and CI. Estimates of genetic and phenotypic correlations among the traits were in consonance with those reported by Ashmawy (1981), Mahdy et al. (1999), and El-Arian et al. (2001).

Table (2): Heritabilities (on the diagonal), phenotypic correlations (above the diagonal) and genetic correlations (below the diagonal) for the traits included in the indexes.

<table>
<thead>
<tr>
<th>Trait</th>
<th>AFC</th>
<th>TMY</th>
<th>DP</th>
<th>CI</th>
</tr>
</thead>
<tbody>
<tr>
<td>AFC</td>
<td>0.38±0.16</td>
<td>-0.13**</td>
<td>0.19**</td>
<td>0.10*</td>
</tr>
<tr>
<td>TMY</td>
<td>-0.30**</td>
<td>0.43±0.17</td>
<td>-0.48**</td>
<td>0.19**</td>
</tr>
<tr>
<td>DP</td>
<td>0.53**</td>
<td>-0.63**</td>
<td>0.32±0.16</td>
<td>0.67**</td>
</tr>
<tr>
<td>CI</td>
<td>0.28**</td>
<td>0.93**</td>
<td>-0.14**</td>
<td>0.20±0.14</td>
</tr>
</tbody>
</table>

* Significant (P<0.05); ** Highly significant (P<0.01).
Seven selection indexes were constructed and appraised in order to
determine the best index which maximizes the relative efficiency and the
genetic progress. I₁ incorporated all four available traits AFC, TMY, DP and CI
and for comparative purposes it was considered the basic index and was
given a relative efficiency of 100%. I₂ to I₄ incorporated three traits, TMY and
other two traits, since one of the supporting traits to TMY was omitted
alternatively. Similarly I₅ to I₇ included TMY and only one supporting trait while
the other two traits were omitted alternatively. For all indexes AFC and DP
contributed negative ΔG while TMY and CI contributed positive ones.

The weighing factors (b’s), expected genetic gain (ΔG), correlation of
index with aggregate genotype (r_{IT}) and the relative efficiency (RE%) of different
indexes to the basic index (I₁) are illustrated in Table (3). I₂ which included TMY,
DP and CI recorded the highest correlation with the aggregate genotype
(r_{IT}=1.00) and had the highest relative efficiency (RE%=125) exceeding that of
the basic index which recorded the second position (r_{IT}=0.80). El-Anan et al.
(2001) depicted that selection index incorporating age at first calving, total milk
yield and lactation period of buffaloes was the best (r_{IT}=0.91). I₃ which included
TMY and DP was the most inferior (r_{IT}=0.65) and (RE%=81). All other indexes
had quite equal r_{IT} and RE%.

Consequently, I₂ was the most efficient and realized the highest
expected genetic gain in TMY (ΔG=357.5 kgs), however I₄ which incorporated
AFC, TMY and CI was the most inferior and realized the lowest expected genetic
gain in TMY (ΔG=167.5 kgs). Ashmawy (1981) found that the index including
age at first calving, total milk yield and lactation period was the best criterion for
selection for the genetic improvement of total milk yield and age at first calving in
buffaloes.

Table (3): Selection indexes (I’s), weighing factors (b), expected genetic
gain (ΔG), correlations of the index with aggregate genotype
(r_{IT}) and the relative efficiency (RE%) of different indexes to
the basic index (I₁).

<table>
<thead>
<tr>
<th>Index</th>
<th>AFC</th>
<th>TMY</th>
<th>DP</th>
<th>CI</th>
<th>r_{IT}</th>
<th>RE%</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>b</td>
<td>ΔG</td>
<td>b</td>
<td>ΔG</td>
<td>b</td>
<td>ΔG</td>
</tr>
<tr>
<td>I₁</td>
<td>-3.2</td>
<td>-59.4</td>
<td>-0.71</td>
<td>284.8</td>
<td>-7.8</td>
<td>-73.2</td>
</tr>
<tr>
<td>I₂</td>
<td>---</td>
<td>---</td>
<td>-0.57</td>
<td>357.5</td>
<td>-6.0</td>
<td>-78.6</td>
</tr>
<tr>
<td>I₃</td>
<td>-3.1</td>
<td>-61.8</td>
<td>0.50</td>
<td>183.3</td>
<td>-1.5</td>
<td>-47.5</td>
</tr>
<tr>
<td>I₄</td>
<td>-3.1</td>
<td>-62.1</td>
<td>0.46</td>
<td>167.5</td>
<td>---</td>
<td>---</td>
</tr>
<tr>
<td>I₅</td>
<td>---</td>
<td>---</td>
<td>0.30</td>
<td>269.0</td>
<td>---</td>
<td>---</td>
</tr>
<tr>
<td>I₆</td>
<td>---</td>
<td>---</td>
<td>0.46</td>
<td>240.5</td>
<td>-0.6</td>
<td>-43.0</td>
</tr>
<tr>
<td>I₇</td>
<td>-3.0</td>
<td>-60.6</td>
<td>0.58</td>
<td>180.9</td>
<td>---</td>
<td>---</td>
</tr>
</tbody>
</table>

In conclusion, AFC, DP and CI are influential traits for appraising milk
production of Egyptian buffaloes. These traits are highly related to milk
production since DP form a considerable value of the lactation behaviour and
days in milk form also a considerable part of CI. The adverse effect of late
AFC may be neutralized by high degree of evolution of milk secretory system
during growth, therefore, AFC did not have crucial effect on the index.

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REFERENCES


تحسن الوراثي لإنتاج اللبن في الجامعة المصرية بواسطة دلالات الانتخاب
محمد حسن حمود - حمد محمد شافعي
1- قسم الإنتاج الحيواني - كلية الزراعة - جامعة الإسكندرية
2- معهد بحوث الإنتاج الحيواني - وزارة الزراعة

أجري هذا البحث على البيانات الخاصة بعدد 398 جاموسية تم تربيتها خلال الفترة من
عام 1972-1993 بمحطة بحوث مطقة موسي - التابعة لمحمية بحوث الإنتاج الحيواني - وزارة
الزراعة. وقد استهدف البحث عمل مجموعة من دلالات الانتخاب متضمنة بعض التوليفات من
الصفات الاقتصادية الأربع موضوع البحث وهي العمر عند أول وفاة، ونتاج اللبن الكلي لموسم
الحلب الأول، وفترة الجفاف الأولى والفترة بين الوالدين، وذلك لمعرفة نسبة هذه الدلالات
للتحسين الوراثي لإنتاج اللبن.

ولقد أوضحت النتائج مايلي:
1- المتوسط العام للصفات: كان بالنسبة للعمر عند أول وفاة 117±12 يوم، ونتاج اللبن
الكلي 123±15 كجم، وفترة الجفاف 31±0 يوم، وفترة بين الوالدين 64±3 يوم.
2- المكافئ الوراثي: كان تقدير من اللفترة للعمر عند أول وفاة 0.38، ونتج اللبن الكلي 0.33،
وقد رأى أنجف 0.32، وفترة بين الوالدين 0.20.
3- الارتباط الوراثي والمحوري: كان علالي المعنوية بين كل صفتين من الصفات موضع الدراسة وفقاً
تعابا، وفترة الحمل عند أول وفاة والفترة بين الوالدين حيث كان معنويًا قليلاً.
4- معدل التحسين الوراثي: كان أكبر معدل تحسين وراثي متوقع لإنتاج اللبن الكلي (0.35
كمجم) عند استخدام الدليل الثاني المتضمن صفات إنتاج اللبن الكلي، وفترة الجفاف والفترة بين
الوالدين.
5- ارتباط الدليل بالقيمة الوراثية الكلية: كان أكبر ارتباط للدليل بالقيمة الوراثية الكلية في حالة
الدليل الثاني (0.10) بينما كان أقل ارتباطاً في حالة الدليل السادس (0.05) المستمر على
إنتاج اللبن وفترة الجفاف.
6- الكفاءة النسبية لدلالات الانتخاب: أوضح أن الكفاءة النسبية لدلالات الانتخاب مقارنة بالدليل الأول
المتضمن كل الصفات تراوح ما بين 41-125% من التحسين الوراثي كما لو استخدم الدليل
الأول المتضمن الصفات الأربعة موضوع البحث.

ووصفت عامة أوضحت نتائج هذا البحث أنه في برنامج الترقب للتحسين الوراثي لإنتاج اللبن
في الجامعة المصرية يمكن استخدام دلالات الانتخاب التي تتضمن بعض الصفات الاقتصادية
الآخرين مثل العمر عند أول وفاة وفترة الجفاف والفترة بين الوالدين.