Estimation of economic values in three breeding perspectives for longevity and milk production traits in Holstein dairy cattle in Iran

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ABSTRACT

The objectives of this study were to estimate economic values (EVs) for three production traits (milk, fat and protein yields) and longevity and to develop a national selection index. The proposed Iranian selection index was compared with selection indices of three other countries in the world. A simple and appropriate model was used to describe the Holstein dairy cattle industry under an Iranian production system. Production parameters and economic data were collected from two Holstein dairy farms in Tehran province. The EVs were estimated at farm level for three breeding perspectives (maximized profit, minimized costs, and economic efficiency) and two restrictions in production system (fixed herd size and fixed total input).
The average absolute EVs on profit perspective and herd size restriction for milk, fat, and protein yields (based on $/kg) and longevity ($/month) were 0.11, 0.89, -0.20, and 6.20, respectively. The average absolute EVs under minimized costs per unit of product interest for milk, fat, protein yields and longevity were -0.30, -3.43, 0.88 and -20.40, respectively. The average absolute EVs under maximized economic efficiency for milk, fat and protein yields and longevity were 0.34, 2.73, -0.99 and 36.33, respectively. Relative emphasis for three production traits and longevity were 59.7, 14.3, -3.0 and 23.1, respectively.
The comparison of the proposed Iranian index with those countries where most of the semen and embryos are imported points out that developing a national selection index to improve cow profitability and optimum generic trends is necessary. Sensitivity analysis indicated that the influence of milk payment changes on EVs was the greatest as its influence on fat and protein EVs is substantial. EVs for milk and fat yields, with respect to price changes (milk, feed and non-feed), were the least sensitive and most sensitive, respectively.

Key words: Breeding objectives, Economic values, Milk production traits, Longevity, Holstein.

RIASSUNTO

STIMA DEI VALORI ECONOMICI ATTRAVERSO L'ANALISI DELLE CARATTERISTICHE PRODUTTIVE E DELLA LONGEVITÀ, CON TRE PROSPETTIVE GESTIONALI DIVERSE, IN VACCHE DA LATTE DI RAZZA HOLSTEIN ALLEVATE IN IRAN

L'obbiettivo di questo studio è stato la stima dei valori economici (EVs) prendendo in considerazione tre caratteristiche produttive (latte, grasso e proteine prodotte) e la longevità, al fine di sviluppare indici di selezione nazionali. L'indice di selezione iraniano è stato confrontato con altri indici di selezione proposti da altri tre paesi. Un modello semplice e appropriato è stato usato per la descrizione del sistema produttivo di vacche da latte di razza Holstein allevate in Iran. I parametri produttivi e i dati economici sono stati raccolti in due aziende in provincia di Tehran. I valori economici (EVs) sono stati stimati a livello aziendale per tre prospettive diverse di allevamento (massimo profitto, minimi costi ed efficienza economica) e con due restrizioni nel sistema produttivo (numero di animali e input totali).

La media assoluta degli indici economici (EVs) con la prospettiva di massimo profitto e la restrizione del numero fisso di animali è stata rispettivamente 0,11, 0,89, -0,20 e 6,20 per le produzioni di latte, lipidi e proteine (stime in $/Kg) e longevità ($/mese). La media assoluta degli indici economici (EVs) minimizzando i costi per ogni singola unità produttiva interessata è stata rispettivamente -0,30, -3,43, 0,88 e -20,40 per quanto concerne le produzioni di latte, lipidi, proteine e la longevità. La media assoluta degli indici economici (EVs) considerando la massima efficienza economica è stata rispettivamente 0,34, 2,73, -0,99 e 36,33 per le produzioni di latte, lipidi, proteine e per la longevità. L'enfasi economica relativa per le tre caratteristiche produttive e per la longevità è stata rispettivamente di 59,7, 14,3, -3,0 e 23,1.

Il confronto dell'indice iraniano proposto con quello di altri paesi dove la maggioranza del seme e degli embrioni è importato evidenzia come risulti necessario sviluppare un indice di selezione nazionale al fine di migliorare la resa economica dell'allevamento di vacche da latte. L'analisi della sensibilità ha indicato che l'influenza delle variazioni del pagamento del latte sui valori economici è stata la più forte in quanto l'influenza sugli EVs di grasso e proteine è notevole. I valori economici della produzione di latte e di grasso prodotti, con riferimento ai cambiamenti di prezzo (latte, alimento e non-alimento), sono stati rispettivamente i meno e i più sensibili.

Parole chiave: *Obbiettivi di produzione, Valori economici, Parametri di produzione lattea, Longevità, Holstein.*

Introduction

The total cattle population of Iran is over seven million heads, and the Holstein population is about 700,000 heads. Herd size varies from 20 to 3000 dairy cows and 305-d milk yield varies from 6000 to 12,500 kg averaging over 7000 kg. Production (milk, fat and protein yields) and functional (longevity, calving ease, somatic cell count, reproductive and conformation) traits have been collected systematically in the Holstein dairy cattle population of Iran by Animal Breeding Center (ABC). However, the EVs for these traits have not yet been estimated. Independent culling levels are widely used in Iran. For example in progeny testing, Estimated Breeding Value (EBV) for milk yield should be over 1400 kg and conformation traits apparently would be satisfied. However, this approach may not be optimal because genetic relationships among traits and their economic values are not taken into account. Despite remarkable changes in selection indices in different countries in the last fifteen years (Van Raden, 2002; Miglior *et al.*, 2005) the main emphasis in selecting bulls and cows in Iran is focused on estimated breeding value of milk yield.

The aim of selection in animal breeding is the choice of parents whose progeny will retrieve the highest economic profit under the given production circumstances. Therefore, the breeding objective should be described by a profit function that takes genetic values as input and produces profit as outcome (Goddard, 1998). The first step in the design of a breeding programme is to define the traits that influence all sources of income and costs and to calculate their economic values. In the second step the selection criteria are determined (Wolfova *et at.*, 2001).

When several traits are included in the breeding goal, economic values are used to combine EBV for the individual component traits into an overall EBV for economic merit. Different methods are available to calculate economic values. Two approaches of deriving economic weights can be distinguished: 1) a positive approach that involves the use of historical prices; and 2) a normative approach that involves the use of a profit function or bioeconomic model (Hazel and Lush 1942; Hazel 1943; Groen, 1990; Van Arendonk, 1991; Wilton and Goddard, 1996; Forabosco *et al.*, 2005).

Three different interests of selection or breeding perspectives can be distinguished (Harris, 1970): a) to maximize profit (=revenues-costs), b) to minimize costs per unit of product, and c) to maximize revenues/costs. In animal breeding, mainly the first and second interest are considered (Groen *et al.,* 1997).

The objectives of this study were to estimate economic values (EVs) for three production traits (milk, fat and protein yields) and longevity and to develop a national selection index. The proposed Iranian selection index was compared with selection indices of three other countries in the world. In the present study, a normative approach was used and economic values were derived from three breeding perspectives.

Material and methods

Production and milk market systems

Holstein cattle are the dominant breed that has been raised in intensive production systems, open shed and free stall barns. because agricultural land size and ranches are constrained. In Iran, most milk is produced by Holstein cows and is sold in free markets. The more intensively managed systems feed cows rations relatively high in concentrates and dry alfalfa or corn silage. In Iran as in the other Middle East countries the alfalfa, corn and barley have been cultivated.

Large-scale dairy farmers produce nearly all of their females and their own female replacements but purchase semen from relevant companies. All semen which is used is either provided by Animal Breeding Center of Iran (ABCI) or is imported into the country and must have permission from ABCI. Small-scale producers on the other hand produce virtually all the product but in most situations, they depend on the large-scale producers for some replacement heifers and genetic improvement. Therefore, large-scale producers should use a breeding objective that has been defined for their small-scale counterparts. In this study breeding objectives were determined based on information of large-scale farms.

Currently in Iran, the payment for milk is based on volume of milk and composition. However, most Iranian dairies give little attention to milk components, especially protein and somatic cell count. Indeed, the milk pricing system has traditionally been based on a price per kg of base milk and a percentage differential premium based on the fat and protein content of milk. There are large differences in milk payment systems among Iranian dairies. Marketing plays an important role in price of base milk. Base milk (BM) is defined as one kg of milk with 3.2% fat and 3% protein. However, the accessory payments for each percent of fat and protein are the same in the milk markets. In this study the price of base milk was US$ 0.30/kg on average with US$0.01/kg standard deviation. Bonuses of 244 cents (2.44 US$) and 111 (1.11 $) cents per each percent (kg) of milk fat and milk protein were paid, respectively (Table 2). Production parameters and economic data were collected from two large Holstein dairy cattle farms in Tehran province representing the dairy farming situation in Iran. Production and economic parameters (as separate and average of two farms) are summarized in Table 1 and 2, respectively

Bio-economic model

A simple model (Equation 1) was used to describe Holstein dairy cattle industry's return and costs in Iran in 2005. Production parameters and economic data were collected from two Holstein dairy farms in Tehran, Iran. The average net revenue from an average cow during her lifetime can be interpreted as the opportunity cost of postponed replacement. Van Arendonk (1991) demonstrated that the relative value of longevity was overestimated when opportunity costs of postponed replacement were not accounted for. In this model, it was assumed that capital gain was equal to opportunity costs. Capital gain is defined as an increase in the value of property (inflation). Capital gain occurs when a heifer is sold at a price higher than the one originally paid for it, assuming no growth. This simplicity was applied in the model because of the difficulty in calculations.

Revenues and costs related to male calves and bulls were omitted because they related to another part of cattle business.

Table 1. Production parameters for commercial dairy production applied in the bio-economic model.

Trait	Herd size	N	Milk yield (kg)	Fat yield (kg)	Protein yield (kg)	Longevity (months)
Farm1	3380	1515	9477	326	296.6	45.7
Farm2	1088	513	1025	369	319.8	39.5
Mean	2234	1014	9863.5	347.5	308.2	42.6
SD	1620.7	708.5	546.6	30.4	16.4	4.4

N: number of productive cows including lactating and dry cows.
SD: Standard deviation.

Table 2. Economic parameters ($) for commercial dairy production applied in the bio-economic model.

	PBM	PAFY	PAPY	CBM	CAFY	CAPY	a
Farm1	0.29	2.44	1.11	0.19	1.55	1.40	1525.68
Farm2	0.30	2.44	1.11	0.19	1.56	1.23	474.18
Mean	0.30	2.44	1.11	0.19	1.55	1.31	999.93
SD	0.01	0.00	0.00	0.00	0.01	0.23	743.52

SD: Standard deviation.
PBM: Price (currently)/kg base milk (BM) with 3.2% fat and 3% protein; PAFY: Accessory payment for each kg milk fat; PAPY: Accessory payment for each kg milk protein; CBM: Base milk costs; CAFY: Accessory cost for each kg milk fat; CAPY: Accessory cost for each kg milk protein; a: Net rearing replacement costs of a cow.

R=N×[M×PBM+(FY-FYB)×PAF+(PY-PYB)×PAPR] (Equation 1)

C=N×[M×CBM+(FY-FYB)×CAFY+(PY-PYB)×CAPY+a/L]

Where

R=	Annual herd revenues
C=	Annual herd costs
N=	Number of productive cows including lactating and dry cows
M=	305-day milk yield
PBM=	Price (currently)/kg base milk (BM) with 3.2% fat and 3% protein
FY=	305-day milk fat yield (kg)
FYB=	BM fat content (kg)
PY=	305-day milk protein yield (kg)
PYB=	BM protein content (kg)
PAFY=	Accessory payment for each kg milk fat
PAPY=	Accessory payment for each kg milk protein
CBM=	Base milk costs
C AFY=	Accessory cost for each kg milk fat
CAPY=	Accessory cost for each kg milk protein
a=	Net rearing replacement costs of a cow;
L=	N/n; Herd life (year).
n=	Number of replacement heifers per year.

Revenues came from milk, surplus pregnant heifer, culled cow and manure sales. It should be noted that net heifer rearing costs were calculated as rearing costs per heifer minus revenues from sold breeding heifers divided by total reared heifers. Net heifer rearing costs minus culled cow price (salvage value) was defined a. Costs were divided into feed and non-feed costs. Non-feed costs included labor, veterinary, breeding, housing, fuel and insurance costs. A normative approach was used to estimate feed costs of lactating and dry cows. Net energy lactation (NE_l) and metabolizable protein (MP) requirements for maintenance, lactating, pregnancy and body weight changes for a mature cow with an average weight of 650 kg according to NRC (2001) were accounted for. The nutrient requirements for growth were ignored and the feed costs were calculated based on the requirements of a mature cow. It was also assumed that feed consumption was determined by the amount of feed required by a mature cow. To calculate feed costs for heifers and female calves, a positive method in that average consumption of each feed (forage or concentrate) was multiplied by their average cost was used.

It should be noted that costs related to per kg of base milk with 3.2% fat and 3% protein were taken into account in CBM calculations. To calculate the costs related to fat and protein yields, levels of the traits were not taken into account. It was calculated just for each kg milk fat and protein and was called accessory cost for each kg milk fat and protein. As cited, Iranian dairies did not pay for BM fat and protein contents. Therefore accessory payments for "FY-FYB and PY-PYB" were calculated.

Derivation of economic values and relative emphasis

The EV of trait i can be obtained as the first partial derivative of the profit or efficiency function evaluated at the current population mean for all traits. The profit function method avoids double counting because of the use of partial derivatives (Groen, 1989a; Dekkers, 1991). The EVs were estimated at farm level for three breeding perspectives (namely, to maximize profit, to minimize costs per unit of product, and to maximize economic efficiency (revenues/costs)) and considering fixed number of dairy cow as restriction system.

The general equations for the calculation of economic values in three breeding perspectives are presented in the Appendix. Equations used to derive economic values for milk production traits and longevity on the basic situations for three breeding perspectives are summarized in Table 3.

Differences in production models, defini-

Table 3. Equations used to derive economic values for milk production traits and longevity on the basic situations for three breeding perspectives.

Trait	Perspective	Restriction	Equation*
Milk yield	Maximized profit $	Herd size	$PBM - CBM$
		Total input	$PBM - CBM(R_1/C_1)$
	Minimized costs	Herd size	$M[(CBM/R_1)-(PBM/R_1)(R_1/C_1)]$
		Total input	+++
	Economic efficiency	Herd size	$M[(PBM/C_1^2)-(CBM/C_1)(R_1/C_1)]$
		Total input	+++
Fat yield	Maximized profit $	Herd size	$PAFY - CAFY$
		Total input	$PAFY - CAFY\,(R_1/C_1)$
	Minimized costs	Herd size	$M[(CAFY/R_1)-(PAFY/R_1)(R_1/C_1)]$
		Total input	+++
	Economic efficiency	Herd size	$M[(PAFY/C_1^2)-(CAFY/C_1)(R_1/C_1)]$
		Total input	+++
Protein yield	Maximized profit $	Herd size	$PAPY - CAPY$
		Total input	$PAPY - CAPY\,(R_1/C_1)$
	Minimized costs	Herd size	$M[(CAPY/R_1)-(PAPY/R_1)(R_1/C_1)]$
		Total input	+++
	Economic efficiency	Herd size	$M[(PAPY/C_1^2)-(CAPY/C_1)(R_1/C_1)]$
		Total input	+++
Longevity	Maximized profit $	Herd size	a/L^2
		Total input	$(R_1/C_1)/(a/L^2)$
	Minimized costs	Herd size	$-(M/R_1)/(a/L^2)$
		Total input	+++
	Economic efficiency	Herd size	$(M/C_1^2)/(a/L^2)$
		Total input	+++

** R_1: annual returns of each animal; C_1: annual costs of each animal; PBM: Price (currently)/kg base milk (BM) with 3.2% fat and 3% protein; PAFY: Accessory payment for each kg milk fat; PAPY: Accessory payment for each kg milk protein; CBM: Base milk costs; CAFY: Accessory cost for each kg milk fat; CAPY: Accessory cost for each kg milk protein; a: Net rearing replacement costs of a cow; L: Herd life (year):N/n; N: Number of productive cows including lactating and dry cows; n: Number of replacement heifers per year.*

Appendix

In a free market, the economic value of a trait (y), ay, contributing to economic merit would be taken as (Gibson, 1989b);

$$a_y = \frac{1}{N}(\frac{\partial P}{\partial y}) = \frac{1}{N}(\frac{\partial R}{\partial y} - \frac{\partial C}{\partial y}) \quad \text{(Equation 4)}$$

Where R (revenues) and C (costs) are functions of traits of interest and N is an enterprise scaling factor or number of animals. In minimized costs per unit of product (C/R) and maximized economic efficiency (R/C) breeding perspectives, the efficiency function was defined as E=C/R and E=R/C, respectively. Then

$$a_y = M \times \frac{\partial E}{\partial y} \quad \text{(Equation 5)}$$

Derived economic values multiplied by M to convert production level into animal level. Because the main goal of efficiency function is to maximize R/C or to minimize C/R per unit production.

P=R-C can be rewritten as $P=N(R_1-C_1)=NP_1$ where P, R_1, C_1 and P_1 are annual profit enterprise, returns, costs, and profit of each animal, respectively.

$\frac{\partial N}{\partial y}$ was considered in equation [2]

in order to study herd size restriction in the profit function.

$$a_y = \frac{1}{N}(\frac{\partial P}{\partial y}) = \frac{1}{N}(\frac{\partial (N \times P_1)}{\partial y}) = \frac{1}{N}(\frac{\partial N}{\partial y} \times P_1 + \frac{\partial P_1}{\partial y} \times N)$$

(Equation 6)

If N was constant, EV of trait y therefore would be as follow:

$$a_y = \frac{1}{N}(\frac{\partial P_1}{\partial y} \times N) = \frac{\partial P_1}{\partial y} \quad \text{(Equation 5)}$$

Because of restriction in total input (forage and concentrate), farmers would reduce herd size in proportion to costs of total input (U, expenditure costs).

If N=U/C1 therefore, $\frac{\partial N}{\partial y} = -\frac{U(\frac{\partial C_1}{\partial y})}{C_1^2}$.

Taking into account restriction in total input, EV of trait y would be:

$$a_Y = \frac{1}{N}[\frac{-\frac{\partial C_1}{\partial y} \times (R_1 - C_1)}{C_1^2} + \frac{\partial (R_1 - C_1)}{\partial y} \times N]$$

(Equation 7)

In minimized costs and economic efficiency perspectives, EVs of traits of interest were the same in two restrictions because N is removed from both of numerator and denominator. Therefore, the derivative of N with respect to y could not be considered.

tions of traits, and assumptions about management system effects on genetic improvement of particular traits make a direct comparison of economic values among different countries very difficult (Wolfova *et al.,* 2007). The relative emphasis of traits were calculated and greatly depend on the genetic standard deviations of the traits, which may differ considerably among populations. Therefore, estimates of the genetic standard deviations for a particular breed and country should be used whenever possible. In order to compare the proposed Iranian selection index with selection indices of other countries, relative emphasis was calculated using equation (2):

Therefore the relative emphasis of traits need to calculate

$$RE_i=(EV_i \times GSD_i \sum_{i=l}^{4}(EV_i \times GSD_i))x100$$
(Equation 2)

Where RE_i, EV_i and GSD_i are relative emphasis, economic value and genetic standard deviation for i^{th} trait, respectively.

Sensitivity analysis

To study the effect of altering production and marketing circumstances on the economic values a sensitivity analysis was carried out. To test the sensitivity of the model, milk payment, feed and non-feed costs were varied by +/-20%. Revenues from culled cows (salvage values) and sold breeding heifers can have an effect on longevity economic value. Therefore, these parameters were also included in the sensitivity analysis.

Results and discussion

It is important to note that the currency used in Iran is the Rial ($1=9000 Rials). Because of rounding errors, a little difference can be seen in reported values in this manuscript.

Economic values of traits in three breeding perspectives

One of the implied objectives of the paper was to estimate EVs in three breeding perspectives. Absolute and relative economic values in three breeding perspectives (profit, economic efficiency and minimized costs per unit of product) for commercial dairy production are presented in Table 4. Negative signs in minimized costs per unit of product interest indicated the economic importance of the trait to decrease costs/revenues ratio while in economic efficiency interest, a negative sign would tend to decrease revenues/costs ratio. Differences among absolute EVs in different breeding perspectives were remarkable. But, relative EVs show a tendency to reduce these differences. For example, absolute EVs for longevity in profit, minimized costs and economic efficiency perspective were 6.20, -20.40 and 36.33, respectively. While in relative terms, they were the same (1) in all perspectives (Table 4).

The absolute economic values of traits as well as their relative values calculated for different countries or breeding companies depend strongly on price parameters and methodology. Even if the same model is used, different market conditions can strongly influence the ratio of economic values between two traits. In situations in which both fat and protein percentages were included in the payment system, the relative economic values for fat and protein yields (or percentages) varied under quota systems from 1:3 (Miesenberger, 1997) to 1:20 (Steverink *et al.*, 1994), in comparison with the scenarios without quotas, where the relation varied from 1:1.3 (Beard, 1992) to 1:3.2 (Wolfova´ *et al.*, 2001). Even negative and less relative economic values were obtained for protein yield without quota systems (1:0.75 found by Vargas *et al.*, (2002) and 1: -4.45 in the present study in which negative economic value was obtained for protein yield). Because of the above-cited limitations, in the present study neither absolute figures nor relative values from the literature are presented. However, some general statements about economic values can be derived from the literature and from the present study. The relative importance of milk production traits (milk yield, fat, and protein) is very sensitive to the payment system (Gibson, 1989b). Economic values of milk and fat yields generally are higher in situations without milk and fat output limitations than in situations with output limitations (Groen, 1989b, 1989c; Pieters *et al.*, 1997; Nielsen *et al.*, 2004; Wolfova *et al.*, 2007).

Table 4. Absolute and relative economic values in three breeding perspective for commercial dairy production.

Perspective		Milk yield (kg)	Fat yield (kg)	Protein yield (kg)	Longevity (months)
Profit($)	Absolute	0.11	0.89	-0.20	6.20
	Relative*	0.02	0.14	-0.03	1
Minimized costs	Absolute	-0.30	-3.43	0.88	-20.40
	Relative	0.01	0.17	-0.04	1
Economic efficiency	Absolute	0.34	2.73	-0.99	36.33
	Relative	0.01	0.08	-0.03	1

**Relative EVs are based on EV of longevity which is the biggest.*

Economic values for milk yield reported in the literature are normally negative (Gibson, 1989a; Groen, 1989b, 1989c; Bekman and Van Arendonk, 1993). In these studies fat and protein yield was paid for and the base price for milk was negative. Most studies have estimated positive economic values for fat yield in systems where payment of milk is based on fat and protein (Gibson, 1989a; Groen, 1989b, 1989c; Bekman and Van Arendonk, 1993; Visscher *et al.*, 1994; Pieters *et al.*, 1997;) and the present study. Negative economic values were obtained for fat yield in quota systems (Pieters *et al.*, 1997; Wolfova, *et al.*, 2007). The economic value of protein yield was, in absolute and relative terms (Tables 4 and 5), different from those estimated by other authors (Gibson, 1989a; Groen, 1989b, 1989c; Bekman and van Arendonk, 1993; Visscher *et al.*, 1994; Pieters *et al.*, 1997; Vargas *et a*l., 2002), which is not surprising given the differences in production systems, market prices, and cost items considered. Due to higher costs than revenues for protein yield in the Iranian milk pricing system, the economic value of protein yield is negative. In the future, the revenues of protein may increase and therefore the economic value of protein yield was set to zero. Among investigated traits, longevity showed the highest absolute, relative and relative emphasis in our study (Tables 4 and 5). The relative emphasis calculated for longevity in the present study (23.1%) was bigger than the appropriate values applied by three other countries. Changing the length of the productive life of cows influences all production traits, for example, milk yield (through age structure of the herd), number of calves available for selling or fattening, revenues from culled cows, and costs for involuntary culling. Much more than the economic values of other traits, its economic value therefore depends on the relationships between revenues and costs, on the current mean value of the trait, and on the milk production level. As a consequence, large differences in the economic value for length of productive life of cows can be found in the literature (Kahi and Nitter, 2004; Wolfova *et al.*, 2007). Longevity (productive life) is phenotypically and genetically related to production traits. The more productive life, the more milk production. If both milk production and longevity are included in the aggregate genotype, index calculations using an appropriate correlation structure account for these aspects. To avoid double counting, increased milk production as a result of productive life should not be accounted for in

Table 5. Economic values and relative values of 4 traits in Lifetime Net income Index (LNI) in 2006[1].

Trait		Genetic standard deviation[2]	Absolute EV($)	Relative EV[3]	Relative emphasis (%)
Milk yield	kg	561.7	0.1	0.02	59.7
Fat yield	"	14.9	0.9	0.14	14.3
Protein yield	"	14.0	-0.2	-0.03	-3.0
Longevity	month	3.5	6.2	1	23.1

[1]Economic and production parameters which were applied in the bio-economic modelling were collected in 2005. LNI was proposed to Animal Breeding Center of Iran in 2006.
[2]From Dadpasand-Taromsari (2006).
[3]Relative EVs are based on EV of longevity which is the biggest.

the economic value of longevity because it is already taken into account in economic value of milk yield. In the present study heifer rearing costs, surplus sold breeding heifer and salvage value (culled cow price) were considered in the estimation of economic value for longevity.

Comparisons among national selection indices

Differences in production models, definitions of traits, and assumptions about management system effects on genetic improvement of particular traits make a direct comparison of economic values among different countries very difficult (Wolfova *et al.,* 2007). Absolute figures on derived economic values depend strongly on price parameters and methodology (Groen *et al.,* 1997). Therefore, in order to compare the proposed Iranian selection index with selection indices of other countries, relative emphasis was calculated and presented in Table 5.

Table 6 shows the relative emphasis on traits in national selection indices. Most semen and embryos used in Iran, are imported from the USA and Canada. These countries have no emphasis on milk yield but have high emphasis on protein and fat yields and a lower emphasis on longevity. Importation of semen and embryos from these countries, therefore, may not be optimal from a genetic point of view.

Sensitivity analysis

The impact of the market situation (milk price, feed and non-feed costs) on EVs of traits in three breeding perspectives is shown separately in Tables 7 to 10. Based on the data presented in the Tables, these statements about sensitivity of EVs can be concluded as follows: linear changes of feed costs caused non-linear changes on EVs, for example in profit perspective and herd size restriction (Table 7), a 20% lower feed costs resulted in an increase in milk yield EV by 27% (0.14 $/kg) and a 20% larger feed costs resulted in a decrease in milk yield EV by 45% (0.06 $/kg). Similar behaviours can be observed for other traits (Tables 8 and 10). The effect of non-feed cost changes on EVs was small. The obtained EVs for fat and protein yields were not influenced by non-feed cost changes in profit perspective and herd size restriction (Tables 8 and 9). The effect of milk payment changes on EVs was the largest and the effect on the EV of protein was remarkable. The EV of fat content and milk yield were the most sensiti-

Table 6. Relative emphasis on longevity and milk production traits in national selection indices.

Country	Index	Milk yield	Fat yield	Protein yield	Longevity	Other traits
Canada[1]	LPI[2]	-	14.3	42.7	7.6	35.4
Great Britain[1]	PLI[3]	-16.4	9.5	49.1	15.0	10.0
Islamic Republic of Iran	LNI	59.7	14.3	-3.0	23.1	0.0
United States of America[1]	NM$[4]	-	22.0	33.0	11.0	34

[1]*Obtained from Miglior et al. (2005).*
[2]*LPI = Lifetime Profit Index.*
[3]*PLI = Profitable Lifetime Index.*
[4]*NM$ = Net Merit$.*

Table 7. Sensitivity analysis for milk yield economic value in three breeding perspectives by +/-20% variation in milk payment, feed and non-feed costs.

Perspective	Restriction	Base	Base milk price*		Base feed costs		Base non-feed costs	
			-20%	20%	-20%	20%	-20%	20%
Maximized profit $	Herd size	0.11	0.05	0.17	0.14	0.06	0.12	0.10
	Total input	0.04	0.03	0.04	0.04	0.03	0.04	0.03
Minimized costs	Herd size	-0.10	-0.12	-0.08	-0.09	-0.10	-0.10	-0.09
	Total input	+++	+++	+++	+++	+++	+++	+++
Economic efficiency	Herd size	0.16	0.13	0.20	0.21	0.11	0.19	0.14
	Total input	+++	+++	+++	+++	+++	+++	+++

**Milk (volume and its components) price not the price of base milk.*

ve and least sensitive, respectively, with respect to changes in the price of milk, feed and non-feed. Revenues from culled cows (salvage values) and sold breeding heifers were also included in the sensitivity analysis. It was not surprising that derived EVs for milk production traits did not influence by +/-20% varying in salvage value and sold breeding heifer price. Only the EV of longevity was affected. The estimated EV for longevity was more sensitive to sold breeding heifer price in comparison with culled cow price (Tables 11 and 12).

Lifetime net income index (LNI)

In this study economic values were estimated for milk production traits and longevity in three breeding perspectives and two kinds of restrictions in the production system. However, to propose a national selection index only one set of economic values should be used. LNI was constructed based on records collected from two well-managed farms in 2005 (Table 5), profit as a breeding perspective and herd size restriction. In this study derived economic values for milk production traits (milk, fat and protein yields)

Table 8. Sensitivity analysis for fat yield economic value in three breeding perspectives by +/- 20% variation in milk payment, feed and non-feed costs.

Perspective	Restriction	Base	Base milk price*		Base feed costs		Base non-feed costs	
			-20%	20%	-20%	20%	-20%	20%
Maximized profit $	Herd size	0.89	0.40	1.38	1.00	0.28	0.89	0.89
	Total input	0.30	0.24	0.36	0.20	10.96	0.22	0.38
Minimized costs	Herd size	-5.92	-2.47	-8.96	-7.78	-1.87	-6.36	-5.52
	Total input	+++	+++	+++	+++	+++	+++	+++
Economic efficiency	Herd size	1.28	1.02	1.54	1.01	0.02	0.95	1.59
	Total input	+++	+++	+++	+++	+++	+++	+++

**Milk (volume and its components) price not the price of base milk.*

Table 9. Sensitivity analysis for protein yield economic value in three breeding perspectives by +/- 20% variation in milk payment, feed and non-feed costs.

Perspective	Restriction	Base	Base milk price*		Base feed costs		Base non-feed costs	
			-20%	20%	-20%	20%	-20%	20%
Maximized profit $	Herd size	-0.20	-0.42	0.02	0.09	-0.70	-0.2	-0.2
	Total input	-0.69	0.55	-0.83	-0.48	-0.87	-0.76	-0.63
Minimized costs	Herd size	1.64	1.87	1.37	0.99	2.61	1.74	1.54
	Total input	+++	+++	+++	+++	+++	+++	+++
Economic efficiency	Herd size	-3.13	-2.51	-3.75	-2.49	-0.31	-3.59	-2.72
	Total input	+++	+++	+++	+++	+++	+++	+++

**Milk (volume and its components) price not the price of base milk.*

and longevity were 0.1, 0.9, -0.2 and 6.2, respectively. The absolute economic value of longevity was grreater than yield traits. LNI does not include health, reproduction, and workability traits. These traits are compounded in the trait longevity. Therefore, longevity plays a role as a summarizing trait and this is the reason why greater emphasis must be used for it. This was different from other countries.

Forage and concentrate prices are approximately the same in Iran. On the other hand, the government does not control forage-concentrate ratio at farm levels. Thus, farmers actually face herd size restrictions. Because farms are in urban areas, license is not given to farmers to develop their own farms. Therefore, EVs that were derived under herd size restrictions were used to construct the national selection index.

Groen *et al.* (1997) argued that under certain conditions (normal profit theory and rescaling theory) all perspectives will lead to the same result. However, in practice, these conditions will never hold. Therefore, the choice of interest in selection and on the basis of evaluation is to be made given the predicted production circumstances for the situation under consideration. So, the actual choice will depend on the system under which the animals are actually selected. For example in Western dairy cattle systems this will be profit (because farmers select the animals) and fixed output (be-

Table 10. Sensitivity analysis for longevity economic value in three breeding perspectives by +/- 20% variation in milk payment, feed and non-feed costs.

Perspective	Restriction	Base	Base milk price*		Base feed costs		Base non-feed costs	
			-20%	20%	-20%	20%	-20%	20%
Maximized profit $	Herd size	6.20	6.20	6.20	6.20	6.20	6.66	5.75
	Total input	8.27	6.61	9.92	9.39	6.53	9.25	7.36
Minimized costs	Herd size	-20.40	-25.50	-17.00	-20.40	-20.40	-21.88	-18.92
	Total input	+++	+++	+++	+++	+++	+++	+++
Economic efficiency	Herd size	36.33	29.06	43.59	46.86	22.98	42.33	31.10
	Total input	+++	+++	+++	+++	+++	+++	+++

**Milk (volume and its components) price not the price of base milk.*

Table 11. Sensitivity analysis for economic values of milk production traits and longevity in three breeding perspectives by +/- 20% variation in sold breeding heifer.

Perspective	Restriction	Trait*							
		MY		FY		PY		LONG	
		-20%	+20%	-20%	+20%	-20%	+20%	-20%	+20%
Maximized profit $	Herd size	0.11	0.11	0.89	0.89	-0.20	-0.20	2.58	9.83
	Total input	0.06	0.09	0.48	0.71	-0.56	-0.36	3.52	11.14
Minimized costs	Herd size	-0.16	-0.26	-5.02	-3.87	1.41	1.05	-8.64	-32.16
	Total input	+++	+++	+++	+++	+++	+++	+++	+++
Economic efficiency	Herd size	0.24	0.31	1.94	2.55	-2.37	-1.39	15.98	41.57
	Total input	+++	+++	+++	+++	+++	+++	+++	+++

** MY: Milk yield; FY: Fat yield; PY: Protein yield; LONG: Longevity.*

Table 12. Sensitivity analysis for economic values of milk production traits and longevity in three breeding perspectives by +/- 20% variation in salvage value (price of culled cows).

Perspective	Restriction	Trait*							
		MY		FY		PY		LONG	
		-20%	+20%	-20%	+20%	-20%	+20%	-20%	+20%
Maximized profit $	Herd size	0.11	0.11	0.89	0.89	-0.20	-0.20	4. 85	7.55
	Total input	0.07	0.08	0.56	0.64	-0.49	-0.42	6.10	8.94
Minimized costs	Herd size	-0.22	-0.19	-4.22	-4.61	1.16	1.30	-24.45	-16.05
	Total input	+++	+++	+++	+++	+++	+++	+++	+++
Economic efficiency	Herd size	0.29	0.27	2.38	2.19	-1.67	-1.99	34.93	25.43
	Total input	+++	+++	+++	+++	+++	+++	+++	+++

** MY: Milk yield; FY: Fat yield; PY: Protein yield; LONG: Longevity.*

cause a quota system is valid in the European Union). However, for poultry it will be return on investment or cost price because here large industries make the selection and no quota or input limitations exist (Groen A.F., personal communication).

In this study profit as an interest of selection was chosen because it may be easier for farmers to understand and to compare the proposed index with other countries where profit perspective is applied. It was not the purpose of this study to determine the appropriate perspective. It seems that economic efficiency will be the appropriate perspective. More studies are needed to determine the approporiate perspective under the Iranian production system.

Paired t-test showed that not only absolute EVs (P>0.40) but also relative EVs (P>0.31) between two farms were not significant (Table 13). It should be noted that the currency which is used in Iran is the Rial ($1=9000 Rials). Because of rounding errors, a little difference can be seen in reported values in this paper. It is important to cite that Estimated EV for longevity was significantly different at two farm levels. This was due to net rearing costs of a cow (Table 2), especially salvage value (see Equation 1). Commercial dairy farm 2 was high in milk production traits compared to commercial dairy farm 1 (Table 1). A culled cow from commercial dairy farm 2 with a high price was purchased as a breeding cow by small-scale dairy farmers.

Despite differences between herd size, herd life and production trait levels, marketing, management and breeding policies, differences between EVs on two herds for all breeding perspectives were not statistically significant. In the future, protein content of milk may become more important. Thus, the average absolute EVs at two farms on profit perspective convert in to relative EVs and protein EV assumed zero.

$$LNI=0.02EBV_M+0.14\ EBV_F+1EBV_L$$
(Equation 3)

was suggested to the Animal Breeding Center of Iran to select cows and bulls for

Table 13. Absolute and relative economic values in profit perspective and herd size restriction for two commercial dairy productions.

Trait	Commercial dairy farm 1		Commercial dairy farm 2		Commercial dairy farm on average	
	Absolute EV	Relative EV	Absolute EV	Relative EV	Absolute EV	Relative EV
Milk yield	0.10	0.01	0.12	0.03	0.11	0.02
Fat yield	0.90	0.10	0.89	0.24	0.90	0.14
Protein yield	-0.29	-0.03	-0.12	-0.03	-0.21	-0.03
Longevity	8.76	1.00	3.65	1.00	6.21	1

Estimated EV for longevity was significantly different at two farm levels. This was due to net rearing costs of a cow (Table 2), especially salvage value (see Equation 1). Commercial dairy farm 2 was high in milk production traits compared to commercial dairy farm 1 (Table 1). Culled cow from commercial dairy farm 2 with a high price was purchased as a breeding cow by small-scale dairy farmers.

progeny test based on LNI at current economic situation.

Conclusions

Results obtained in this study provide important information about economic values of traits in three breeding perspectives that can be considered in a breeding goal for Holstein dairy cattle in Iran. The economic values found for milk production traits indicate that major weight should be given to fat in relation to protein. The current payment system used in Iran has a higher price for fat compared to protein. This pricing system deviates from that in a large number of other countries. Therefore, the economic impact of protein yield on the direction of genetic improvement will be limited. Protein yield should not be omitted as a trait in the breeding objective even in the case when it is not paid for. It can be only omitted in the selection criteria.

Currently, most of the semen entering the country is coming from the USA and Canada where the selection indices give twice as much emphasis to protein compared to fat, no emphasis on milk yield and a lower emphasis on longevity. Therefore, developing Lifetime Net Income Index by adding other functional traits to improve cow profitability and optimum generic trends are necessary. More studies are also needed to determine the appropriate perspective under the Iranian production system.

Sensitivity analysis indicated that the influence of milk payment changes on EVs was the greatest as its influence on fat and protein EVs is substantial. EVs for milk and fat yields with respect to price changes (milk, feed and non-feed) were the least sensitive and most sensitive, respectively. The results of this study showed that the relative EVs of traits are robust with respect to changes in the market.

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REFERENCES

Beard, K.T., 1992. Studies on breeding objectives and selection indices applicable to the Australian dairy cattle industry. PhD Diss., University of New South Wales, Sydney, Australia.

Bekman, H., Van Arendonk, J.A.M., 1993. Derivation of economic values for veal, beef and milk production traits using profit equations. Livest. Prod. Sci. 34:35-56.

Dadpasand-Taromsari, M., 2006. Comparison between different methods of genetic parameters estimations and genetic evaluation for productive life in Holstein dairy cattle of Iran. PhD Diss., University of Tehran, Karaj, Iran.

Dekkers, J.C.M., 1991. Estimation of economic values for dairy cattle breeding goal: bias due to suboptimal management polices. Livest. Prod. Sci. 29:131-149.

Forabosco, F., Bozzi, R., Boettcher, P., Filippini, F., Bijma, P., Van Arendonk, J.A.M., 2005. Relationship between profitability and type traits and derivation of economic values for reproduction and survival traits in Chianina beef cows. J. Anim. Sci. 83:2043-2051.

Gibson, J.P., 1989a. Economic weights and index selection of milk production traits when multiple production quotas apply. Anim. Prod. 49:171-181.

Gibson, J.P., 1989b. The effect of pricing systems, economic weights, and population parameters on economic response to selection on milk components. J. Dairy Sci. 72:3314-3326.

Goddard, M.E., 1998: Consensus and debate in the definition of breeding objectives. J. Dairy Sci. 81:6-8.

Groen, A.F., 1989a. Cattle breeding goals and production circumstances. Degree Diss., Agricultural University, Wageningen, The Netherlands.

Groen, A.F., 1989b. Economic values in cattle breeding. I. Influences of production circumstances in situations without output limitations. Livest. Prod. Sci. 22:1-16.

Groen, A. F., 1989c. Economic values in cattle breeding. II. Influences of production circumstances in situations with output limitations. Livest. Prod. Sci. 22:17-30.

Groen, A.F., 1990. Influences of production circumstances on the economic revenue of cattle breeding programmes. Anim. Prod. 51:469-480.

Groen, A.F., Steine, T., Colleau, J., Pedersen, J., Pribyl, J., Reinsch, N., 1997. Economic values in dairy cattle breeding, with special reference to functional traits. Report of an EAAP-working group. Livest. Prod. Sci. 49:1-21.

Harris, D.L., 1970. Breeding for efficiency in livestock production: defining the economic objectives. J. Anim. Sci. 30:860-865.

Hazel, L.N., 1943. The genetic basis for constructing selection indexes. Genetics. 28:476-490.

Hazel, L.N., Lush, J.L., 1942. The efficiency of three methods of selection. J. Hered. 33:393-399.

Kahi, A.K., Nitter, G., 2004. Developing breeding schemes for pasture based dairy production systems in Kenya I. Derivation of economic values using profit functions. Livest. Prod. Sci. 88:161-177.

Miesenberger, J., So¨lkner, J., Essl, A., 1998. Economic weights for fertility and reproduction traits relative to other traits and effects of including functional traits into a total merit index. Interbull Bull. 18:78-84.

Miglior, F., Muir, B.L., Van Doormaal, B.J., 2005. Selection Indices in Holstein Cattle of Various Countries J. Dairy Sci. 88:1255-1263.

National Research Council, 2001. Nutrition requirements of dairy cattle. 7th rev. ed. Natl. Acad. Sci., Washington, DC, USA.

Nielsen, H.M., Groen A., Pedersen, J., Berg, P., 2004. Stochastic simulation of economic values and their standard deviations for production and functional traits in dairy cattle under current and future Danish production circumstances. Acta Agr. Scand. A-An. 54:113-126.

Pieters, T., Canavesi, F., Cassandro, E., Dadati, Van Arendonk, J.A.M., 1997. Consequences of differences in pricing systems between regions on economic values and revenues of a national dairy cattle breeding scheme in Italy. Livest. Prod. Sci. 49:23-32.

Steverink, M.H.A., Groen, A.F., Berentsen, P.B.M., 1994. The influence of restricting nitrogen losses of dairy farms on dairy cattle breeding goals. Neth. J. Agr. Sci. 42:21-27.

Van Arendonk, J.A.M., 1991. Use of profit equations to determine relative economic value of dairy cattle herd life and production from field data. J. Dairy Sci. 74:1101-1107.

Van Raden, P.M., 2002. Selection of dairy cattle for lifetime profit. pp 127-130 in Proc. 7th World Congr. on Genet. Appl. Livest. Prod., Montpellier, France.

Vargas, B., Groen, A.F., Herrero, M., Van Arendonk, J.A.M., 2002. Economic values for production and functional traits in Holstein cattle of Costa Rica. Livest. Prod. Sci. 75:101-116.

Visscher, P.M., Bowman, P.J., Goddard, M.E., 1994. Breeding objectives for pasture based dairy production systems. Livest. Prod. Sci. 40:123-137.

Wilton, J.W., Goddard, M.E., 1996. Selection for carcass and feedlot traits considering alternative slaughter end points and optimized management. J. Anim. Sci. 74:37-45.

Wolfova, M., Pribyl, J., Wolf, J., 2001. Economic weights for production and functional traits of Czech dairy cattle breeds. Czech J. Anim. Sci. 46:421-432.

Wolfova, M., Wolf, J., Kvapilík, J., Kica, J., 2007. Selection for profit in cattle. I. Economic weights for purebred dairy cattle in the Czech Republic. J. Dairy Sci. 90:2442-2455.