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STOCHASTIC SIMULATION OF DIFFERENT BREEDING SCENARIOS OF OPEN NUCLEUS STRATEGY FOR GENETIC IMPROVEMENT OF IRANIAN NATIVE BUFFALOES

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ABSTRACT

A stochastic simulation model of an open nucleus scheme was used to study the consequences of the different scenarios of open nucleus breeding strategy based on Iranian buffalo population's parameters and structure which were provided by Livestock Breeding Center of Iran from years 2003 to 2010. Traits of milk production (MP) milk fat production (MF), age at first calving (AFC) and interval between first and second calving (CI) were selected. The genetic gain was calculated for 10 generations. For animals in the base population a vector of breeding values (bv_i) were calculated. After genetic evaluation of base population, selection indices were used for selecting the parents. Superior males and females were selected as nucleus animals under given criterions. Dimension of nucleus was three times bigger than herd sizes. The highest value for aggregate genotype (H) was represented in scenario 18 by value of 3332.174±41.023. Also, cumulative genetic gain in open nucleus after 10 generations of selection in scenario 18 were 5798.056±72.134 kg, 7.993±0.694 kg, -3.711±0.359 months and -3.730±0.885 days for milk yield, milk fat, AFC and CI, respectively. Trend of Genetic gains were increasing and positive for productive traits including milk yield and milk fat in all of scenarios in open nucleus strategies accross ten generations. Conversely, for traits of age at first calving (AFC) and interval between first and second calving (CI) genetic trends were decreasing and negative because of their negative economic values. Also average inbreeding coefficient of each scenario was ascending across generations and its value was between 0.049±0.05 to 0.111±0.012.

Keywords: breeding strategy, open nucleus, buffalo, computer simulation.

INTRODUCTION

In animal breeding programs, After In animal breeding programs, breeding goals, it's very important to consist suitable breeding program and strategy for achieving the difined targets. Open nucleus strategy an open nucleus breeding program, where animals from the general population Have the chance of being selected as a part of the nucleus, has been proposed for faster genetic improvement. Because this scheme is not restricted to animals already in the nucleus (as is the case with a closed nucleus), it allows for greater selection intensity and is often quoted as the preferred method of operation for quick genetic gain. This scheme can be recommended as an alternative to the progeny testing scheme, and can be achieved either by grouping high production animals at the farmer level (Group Nucleus Breeding Structure), or by assembling all animals at a highly organized location (Central Nucleus Breeding System) (IAEA, 2004).

There are about 459 thousand head of buffaloes in Iran which its ranking among 43 countries in the world is 16) IAEA, 2004). Buffalo is characterized by outstanding features such as high percentage of Milk fat, rapid weight gain, high relative strength against some diseases, optimal use of low-quality food and producing some special products such as Mozzarella. Compared with cow's milk, buffalo milk has a higher percentage of all components, such as protein and fat. The mean protein and fat percentages reported for buffalo milk varies from 4.13 to 4.55% (Macedo et al., 2001; Rosati and Van Vleck, 2002) and from 6.87 to 8.59% (Tonhati *et al*., 2000; Rosati and Van Vleck, 2002), respectively. In spite of its higher fat percentage, milk and mozzarella cholesterol content is lower for buffalo than for cow's milk (275 vs 330 mg and 1562 vs 2287 mg, respectively) (Zicarelli, 2004). This is of major interest, together with some studies that report a larger number of small fat globules in buffalo milk as compared to bovine and sheep milk (Martini et al., 2003).

In a study genetic gain, aggregate genotype value and inbreeding in closed nucleus, open nucleus and sire referencing strategies was to compared with computer simulation and to introduce suitable strategy for Baluchi sheep breeding. Results of simulation showed that for all traits, genetic gain resulted from sire referencing strategy were higher than closed and open nucleus strategies. But, inbreeding coefficient in open nucleus was lower than closed nucleus and sire referencing strategies (Abbasi, 2005). In other study, dairy cattle breeding schemes assuming a multi-trait breeding goal were studied using stochastic simulation. The schemes studied included open vs. closed nuclei, selection for total merit vs. Milk production, use of early predictors for milk production and different daughter group sizes. Results indicated that higher daughter group sizes resulted in slightly higher economic gain, and the distribution of the gain were changed so the genetic gain for milk production were lowered and the genetic gain for cost reducing traits increased. For different schemes inbreeding increased from 0.98% up to 1.50% per year.

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MATERIALS AND METHODS

Records of 4221 Iranian native buffaloes from 621 herds which were collected by the Livestock Breeding Center of Iran from 2003 to 2010 were used to estimate heritability, genetic and phenotypic correlations between milk production, milk fat production, age at first calving and first calving interval using univariate and bivariate animal models by Madad (2011). The reported heritability was (0.46±0.01) for milk production milk fat 0.27±0.17, first calving interval (0.01±0.29), age at first calving 0.21±0.21. Also genetic correlations coefficients between the traits were reported. Other Parameters were consisted of trait Means, heritability coefficients and genetic and permanent environmental correlations. The parameters were estimated by using multi-trait animal model (Table-1) (Madad, 2011).

Table-1. Means, genetic (co)variance components of Milk production, (MP) milk fat production (MF), age at first calving (AFC) and interval between first and second calving (CI) (Madad, 2013).

		Genetic (co) variance components					
Traits	**Means**	**(MP)**	**(MF)**	**(AFC)**	**(CI)**	**h^2 ± SE**	**Economic values**
(MP)	1731.22 kg	34009	-	-	-	0.46± 0.01	0.56
(MF)	114.87 kg	0.51	141.22	-	-	0.27± 0.17	8.25
(AFC)	54.31 months	0.05	0.07	41.62	-	0.21± 0.21	-0.28
(CI)	506.03 days	0.05	0.05	-0.09	286.15	0.01±0.29	-4.9

Economic weights

Taheri (2011) estimated economic values of traits of milk yield and fat percentage by analyzing records, revenues and costs data of 30 Iranian native buffalo herds under the rural system in six cities for a 14-months period of calving interval.

Using profit equation, the economic values for milk production and fat percent in six cities and in the Khuzestan province were calculated as \$ 0.56 and \$ 8.25, respectively. In an other study, Gonza´lez *et al.* calculated economic values of traits of age at first calving (AFC) \$-0.28 and calving interval (CI) \$-4.90 (U.S Dollar/yr) (Dairy, 2004)

Simulation of breeding values and phenotypic observations

In order to simulate multivariate additive genetic (Vg) and environmental effects (Ve), (co)variance matrices having same dimensions as the number of traits, were established. Using a Cohlsky decomposition, lower triangular matrices (Lg) and (Le) under the condition LeL'e=Ve and LgL'g=Vg were calculated. In the next step a vector of random numbers (w) driven from a normal distribution was made and as a result of multiplying lower triangular genetic and environmental matrices to **w** vector, vectors having additive genetic and environmental values for each animal were obtained. For any animal, the effects of herds for given traits were simulated and after adding them to additive genetic and environmental values, the phenotypes of those animas where made.

For animals in the base population a vector of breeding values (bv_i) were calculated as:

$$bv_i = L' * r_1 \quad (1)$$

In the base population a vector of observations (obs_i) for the simulated traits of each animal was calculated as:

$$obs_i = bv_i + C' * r_2 \quad (2)$$

Where r_1 and r_2 were vectors of random numbers from a standardized normal distribution.

Also selection criteria (I) and aggregate genotype (H) equations were:

$$I = b1P_{MP} + b2P_{MF} + b3P_{AFC} + b4P_{CI} \quad (3)$$

$$H = v1a_{MP} + v2a_{MF} + v3a_{AFC} + v4a_{CI} \quad (4)$$

Breeding values for offspring were calculated as follow:

$$BV = 0.5\,(BVs + BVd) + \{0.5\,(1-0.5(Fs + Fd)\}0.5\,(L'g\,w) \quad (5)$$

Where, BV, F, Lg and w are breeding values, coefficient of inbreeding, genetic lower triangular matrix and vector of standard normal numbers, respectively. Subscripts of o, s and d are used to represent progeny, sire and dam, respectively.

Simulated breeding scenarios

In this study the open nucleus strategy of native Iranian buffaloes was considered. Using R software for a computer simulation, the base population having the same parameters of real Iranian buffalos was made. Superior individuals were selected based on selection index method to establish the nucleus herd of this breeding plan. In the next step some commercial herds with different size and different rate of male transition from nucleus into terminal herds were selected among the superior individuals of base

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population. 18 different scenarios were made out of combining various conditions (Table-2).

After genetic evaluation of base population, selection indices were used for selecting the parents.

Superior males and females were selected as nucleus animals under given criterions. Dimension of nucleus was three times bigger than herd sizes. Thus residual superior animals were distributed into commercial herds under 18 different scenarios, including three levels of herd size and herd number and tow levels of transfer rate of sires from nucleus to herds.

RESULTS AND DISCUSSIONS

Genetic gain

Trend of genetic gains was increasing and positive for productive traits including milk yield and milk fat in all of scenarios in open nucleus strategies across ten generations. Conversely, for traits of age at first calving (AFC) and interval between first and second calving (CI) genetic trends were decreasing and negative because of their negative economic values. The highest value for aggregate genotype (H) was represented in scenario 18 by value of 3332.174±41.023 (Table-2) (Figure-1). Also, cumulative genetic gain in open nucleus after 10 generations of selection in scenario 18 were 5798.056±72.134 kg, 7.993±0.694 kg, -3.711±0.359 months and -3.730±0.885 days for milk yield, milk fat, AFC and CI, respectively.

Table-2. Genetic progress of traits of milk production (MP) milk fat production (MF), age at first calving (AFC) and interval between first and second calving (CI), aggregate genotype and inbreeding after 10 generations of selection under different scenarios of closed nucleus strategy.

	Scenarios			R											
	HN	SH	Transfer rate of sires from	MP (kg)	SE	MF (kg)	SE	(AFC) months	SE	(CI) days	SE	F	SE	H	SE
۱	۱۰	۱۰	۰/۵	470.186	42.550	20.887	1.668	-6.993	0.854	-10.318	2.296	0.074291	0.006	488.137	37.019
۲	۱۰	۱۰	۱	474.553	44.330	20.331	3.010	-6.351	1.667	-9.494	3.729	0.090337	0.006	481.779	55.454
۳	۱۰	۲۰	۰/۵	678.780	30.589	27.166	2.741	-10.490	1.348	-14.405	3.224	0.084156	0.006	677.761	38.718
۴	۱۰	۲۰	۱	736.787	45.773	27.436	1.907	-12.398	2.468	-18.583	2.489	0.07620	0.009	733.472	44.399
۵	۱۰	۵۰	۰/۵	932.440	31.727	27.096	1.973	-13.979	0.930	-20.720	1.570	0.060037	0.003	851.146	24.997
۶	۱۰	۵۰	۱	973.261	29.314	31.028	2.021	-12.915	0.711	-17.582	1.409	0.037636	0.002	890.778	25.087
۷	۲۰	۱۰	۰/۵	469.840	23.105	18.314	1.092	-8.650	0.695	-13.081	1.530	0.075269	0.005	480.719	16.938
۸	۲۰	۱۰	۱	579.886	23.553	16.421	1.097	-6.427	0.561	-10.065	1.270	0.087567	0.006	511.324	19.320
۹	۲۰	۲۰	۰/۵	873.800	59.776	29.319	2.311	-13.396	1.041	-20.379	2.588	0.085399	0.008	834.822	45.360
۱۰	۲۰	۲۰	۱	1097.516	47.772	28.715	2.310	-12.258	0.923	-18.209	2.543	0.079782	0.008	944.163	36.082
۱۱	۲۰	۵۰	۰/۵	1839.815	142.441	20.934	1.341	-9.410	0.701	-15.162	1.479	0.083069	0.005	1279.929	70.113
۱۲	۲۰	۵۰	۱	1874.833	132.105	21.206	1.115	-9.855	0.646	-13.798	1.478	0.049497	0.005	1295.229	66.120
۱۳	۵۰	۱۰	۰/۵	946.587	49.494	24.476	0.802	-9.837	0.699	-14.726	1.230	0.096703	0.011	806.931	29.679
۱۴	۵۰	۱۰	۱	1371.532	31.885	12.661	0.833	-5.527	0.694	-7.240	0.694	0.095382	0.012	909.536	17.616
۱۵	۵۰	۲۰	۰/۵	1707.378	165.373	20.587	0.777	-8.826	0.712	-11.698	1.093	0.092908	0.011	1185.770	91.150
۱۶	۵۰	۲۰	۱	2797.767	222.607	12.037	0.830	-5.585	0.634	-8.039	0.989	0.111355	0.012	1707.009	124.512
۱۷	۵۰	۵۰	۰/۵	4009.247	139.760	15.982	0.767	-7.191	0.468	-9.861	0.707	0.084055	0.008	2427.366	74.451
۱۸	۵۰	۵۰	۱	5798.056	72.134	7.993	0.694	-3.711	0.359	-3.730	0.885	0.066122	0.008	3332.174	41.023

milk production (MP) milk fat production (MF), age at first calving (AFC) and interval between first and second calving (CI)

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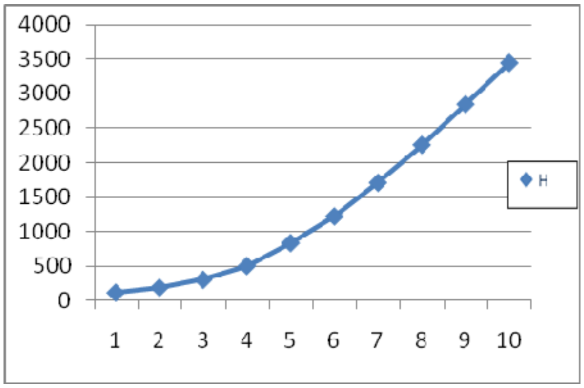
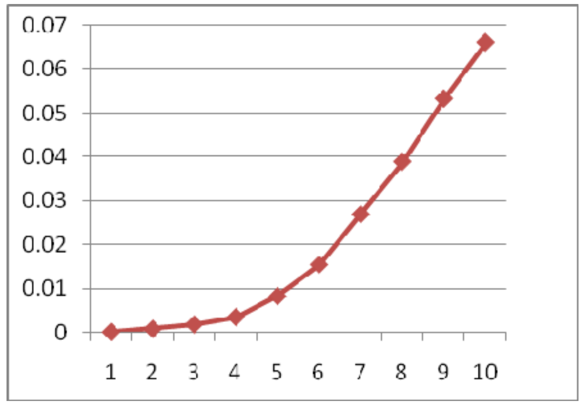
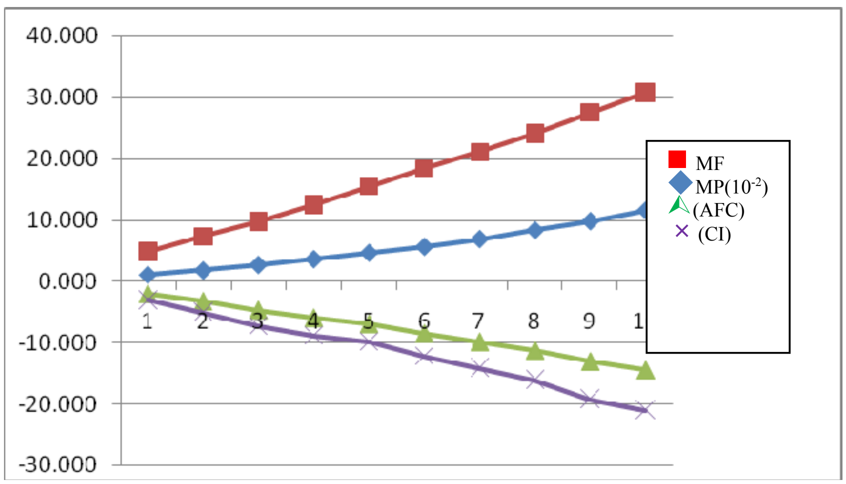


Figure-1. Trend of changes in aggregate genotype in 18'th scenario of open nucleus strategy across 10 generations.



Figur-2. Trend of changes in inbreeding coefficient in 18'th scenario of open nucleus strategy accross 10 generations.



Trend of changes in Breeding values of studied traits including milk production (MP) milk fat production (MF), age at first calving (AFC) and interval between first and second calving (CI) in 18'th scenario of open nucleus strategy across 10 generations Results presented in Table-2 showed a positive effect of the increase of the population size over the genetic progress. Also Results are showing that herds by size of 50, for all of including scenarios, had highest genetic gains. Besides different transfer rates were not effective enough on genetic gains and inbreeding changes. These results are in agreement with similar simulation studies made by Villanueva *et al*. (1995), Banks *et al*. (1998) and also with Weber (1990), who worked with real populations of *Drosophila Melanogaster*. A study by Sorenson *et al*. showed that genetic gain in open nucleus is 3.7 to 6.9 percent more than closed one affected by the number of traits in the selection index, (co) variance components, economic weights, selection intensity, selection methods, population size and number of dams per sire (Sorensen, 1999; Nimbkar and Wrary, 1991).

Results are indicating that scenarios with higher transfer rate of sires from nucleus to commercial herds had more genetic gain in studied traits. Syrstad (1998) proposed that a nucleus herd can supply about 15 selected bulls per 100 cows in the herd per year, enough for a population of several thousand cows. Also Dekkers *et al*. (1996), in cattle found that genetic gain increased when the number of bulls sampled and the size of progeny groups increased, but at a decreasing rate. In addition, the rate of genetic gain was maximized with a progeny group of 57.

Genetic gains were affected by transfer rate of sires from nucleus to commercial herds, herd sizes and herd's numbers. In this study nucleus size for each scenario was three times of its herd size. Selection nucleus size, it is obvious that the greater the size, the better results in genetic terms.

Inbreeding

Average inbreeding coefficient of each scenario was ascending across generations and its value was between 0.049±0.05 to 0.111±0.012 (Scenario of 18 has highest average inbreeding coefficient (Figure-6) Also lowest inbreeding coefficient was for scenario of 5 (Figure-7)) following 10 years of selection for all scenarios of closed nucleus strategies. Results of different simulated scenarios are shown in Table-2.

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Several studies have shown that breeding schemes resulting in high genetic gain generally also result in large increases in inbreeding (Quintonet *et al*., 1992; De Boer and Van Arendonk, 1994; Brisbane and Gibson, 1995). Results of this research confirmed those reports. This study showed that inbreeding coefficient in highest herd size, herd number and transfer rate in closed nucleus was higher than other scenarios.

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