USING OPEN NUCLEUS BREEDING SCHEME FOR MULTIPLE GENERATIONS FOR GENETIC IMPROVEMENT OF MILK PRODUCTION IN EGYPTIAN BUFFALO

BY

AHMED ISMAEL SAYED ISMAEL

B. Sc. Agric. Sci. (Animal Production), Fac. Agric., Cairo Univ., 2003

THESIS

Submitted in Partial Fulfillment of the Requirements for the Degree of

MASTER OF SCIENCE

In

AGRICULTURAL SCIENCES
(ANIMAL PRODUCTION)

Department of Animal Production
Faculty of Agriculture
Cairo University
EGYPT

2010

APPROVAL SHEET

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ABSTRACT

Populations of buffaloes with one milk record for each buffalo were generated using Monte Carlo simulation procedure of SAS (2004) with assumed mean (0) and variance (1). Four different sizes of populations (*z*): 10000, 25000, 50000 and 100000 animals were obtained. Four generations of progeny were obtained by selection of sires and dams of the next generations. Mating ratio (male: females) were designed to differ from 1:25 to 1:100 in natural mating (NM) and from 1:1000 to 1:5000 in artificial insemination (AI). The objective of using different mating ratios was to compare between different selection intensities among males. Genetic gain per generation and annual genetic gain were calculated.

Genetic gain increased significantly (P<0.05) with the increase in generation number (*G*) being 282, 389, 457 and 488 kg milk for *G1*, *G2*, *G3* and *G4*, respectively. The annual genetic gain (G/Y) ranged from 48 kg/yr for *G1* to 83 kg/yr for *G4*. The annual genetic gain ranged from 64 kg/yr for z=10000 to 73 kg/yr for z=100000. Increasing nucleus size (*p*) from 0.05 to 0.10 increased genetic gain significantly (P<0.05) from 390 to 418 kg milk. Non-significant differences in genetic gain among different proportions of males born used as sires (*a*) were observed. The main variables affecting the fraction of base sires born in nucleus (*w*) were *z*, *p* and *a*.

Annual genetic gain ranged from 50 to 66 kg milk/yr in NM and from 80 to 82 kg milk/yr in AI. Applying open nucleus breeding scheme for multiple generations of selection could accelerate the rate of genetic gain of milk production in Egyptian buffalo and increased the average milk yield from 15% in *G1* to 26% in *G4*.

Inbreeding coefficient increased significantly (P<0.05) with the increase in generation number (*G*) in both the nucleus and the base populations.

Significant increase in inbreeding coefficient (P<0.05) were observed between mating ratios (*MR*) in natural mating (NM) and artificial insemination (AI) in both the nucleus and the base populations.

Key words: Open nucleus breeding scheme, genetic gain, simulation, inbreeding, Egyptian buffalo.

ACKNOWLEDGEMENT

I wish to express my deepest appreciation and most honest gratitude to Dr. ***Samy Abou-Bakr Mohmoud,*** *Professor of Animal Breeding, Faculty of Agriculture, Cairo University, for his proper selection of the subject, valuable suggestions, kind supervision and infinite support.*

My appreciation also goes out to Dr. ***Manal Ahmed Elsayed****, Associate Professor of Animal Breeding, Faculty of Agriculture, Ain Shams University, for generous help, sincere guidance and supervision on this work.*

Any word fails to express my gratitude and deep indebtedness to Dr. ***Sameh Abd-Elfattah Abd-Elsalam****, lecturer of Animal breeding, Faculty of Agriculture, Cairo University, for his kind help, fruitful advice, encouragement, constructive and generous provision of all facilities for producing this work without this materialistic support this work would have been aborted.*

My deepest thanks to ***Dr. Mohamed Abdel-Aziz Ibrahim****, Associate Professor of Animal Husbandry, Faculty of Agriculture, Cairo University, for his kind assistance in statistical analysis.*

A very special appreciation is due to the members of Cattle Information System/Egypt (CISE), Faculty of Agriculture, Cairo University, for their kind help.

No words would be sufficient to express my deepest thanks to my colleagues, for their co-operation and assistance during this work.

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INTRODUCTION

Livestock production in developing countries is generally characterized by small herd-size (particularly in mixed crop/livestock systems), uncontrolled mating, (lack of national identification, pedigree and performance recording) and absence each of progeny testing stations and artificial insemination networks. These characteristics limit the implementation of effective genetic improvement programs. To overcome these problems, nucleus breeding schemes have been suggested, in which genetic improvement is centrally organized in a population maintained in research institutes or government farms (Galal, 1986; Terrill, 1986 and Solomon *et al*., 2009).

Nucleus breeding schemes (NBS) have been suggested to rise above some of the technical constraints linked to implementation of a breeding scheme for low-input extensive production systems (Smith, 1988 and Dempfle, 1993).

An open nucleus breeding system has been defined as a breeding system in which nucleus female replacements are selected from both the nucleus and the base, but male replacements are only selected from nucleus born animals (Cunningham, 1979).

Often the base is managed for commercial production and the nucleus to breed superior sires. Hopkins (1978) highlighted that using more efficient selection strategies and short generation lengths in the nucleus would increase rates of gain.

The main idea in the open nucleus breeding scheme is, there is a small number of genetically superior animals in each population which, if gathered together, will form a nucleus whose average genetic merit is higher than that in any of the associating herds. In forming a nucleus breeding unit, individuals should come from many sources so as not to restrict the initial genetic base (Cunningham, 1979).

Nucleus stocks should be open continuously to introduction of superior individuals of higher genetic merit from any source. This would help to reduce inbreeding levels (Mueller and James, 1984).

The establishment of two-tier open nucleus breeding system is recommended to maximize genetic improvement, reduce inbreeding rate and reduce the total cost of recording in smallholder system (Bondoc and Smith 1993).

This thesis aims at calculating the amount of genetic gain resulted from using the open nucleus breeding scheme for multiple generations for genetic improvement of milk production in Egyptian Buffalo, also investigating the factors affecting the expected genetic gain and the inbreeding coefficient in the open nucleus breeding scheme herds.

REVIEW OF LITERATURE

1. Nucleus breeding schemes

According to the statistics of FAOSTAT (2007) the Egyptian buffaloes contribute about 2.7 and 8.4% of the world buffalo's milk and meat, respectively. The contribution of Egyptian buffaloes in the world buffalo’s milk decreases year after year and the increase of total milk production of Egyptian buffaloes may be due to increasing buffalo population size.

Table 1. Changes of buffalo population in Egypt from 1961 to 2007.

Year	Buffalo population (as a total)	Milk Production (MT)	(%) Compared with 1961
1961	1,501,000	761054	100
1970	2,009,000	1005000	132
1980	2,346,583	1248000	164
1990	2,897,467	1250000	164
2000	3,379,410	2030305	267
2007	3,977,000	2300000	302

After FAOSTAT online statistical service, 2009
M.T: metric ton= 1000 kg

Lack of effective sustainable breeding programs for local breeds is a reason that such breeds lose their competitive advantage, especially where production systems or external conditions are subjected to change (Hiemstra *et al*., 2007).

In the formation of a nucleus breeding scheme, the best males and females owned by the cooperating breeders are combined in a nucleus. Usually these animals are actually gathered together to form a nucleus herd or flock. Once the nucleus is formed, sires used in the entire scheme are produced in the nucleus where pedigree and performance records are accurately kept, genetic prediction techniques used, and the most intense selection takes place. The advantages of nucleus scheme derive from the initial genetic gain achieved when the elite nucleus population is formed. If nucleus animals are well chosen, the average genetic merit of the nucleus should be much higher than the average merit of contributing herds. Additional gains result from increased accuracy of selection and increased selection intensity (Bourdon, 2000).

The nucleus breeding systems are used when a set of outstanding breeding sires are not available initially, and one wants quickly to produce better sires from nucleus herd formed with the best dams (Hopkins, 1978).

Nucleus breeding schemes offer the potential for higher genetic progress than would be obtained by traditional within-herd selection (Smith, 1988).

In Nucleus breeding schemes, recording needs only to be implemented on a small number of farms or in one or several large private or institutional herds that can be considered as the nucleus. An NBS can, therefore, be relatively small in size and still have large impact, if well organized and operated properly (Syrstad, 1989).

a. Open nucleus breeding scheme

Open nucleus systems are hierarchical breeding systems in which animals may be transferred between levels in both directions. The simplest open nucleus system has two mating groups; a nucleus of elite animals, and a base in which the general herd is mated. In general, there may be more than two levels, and there may be several herds in the one level. A typical group breeding scheme consists of a nucleus and 10 to 15 contributing base herds. The Australian Merino Society scheme has three levels; a central nucleus, 122 ram breeding cooperatives, and more than 1000 contributors (Mueller and James, 1984).

The germ plasm flows bidirectional from the nucleus to cooperating herds and from cooperating herds to the nucleus. Females that have proven themselves superior in cooperating herds are transferred to the nucleus (Bourdon, 2000).

The open nucleus breeding scheme offers a simple procedure for producing and disseminating breeding stock of known value (Cunningham, 1979 and 1987; Hinks, 1978 and Jasiorowski, 1991).

Some of the best animals of lower tiers contribute to the nucleus as well, given that their breeding value could be estimated and compared with breeding values in the nucleus. Such individuals would migrate upwards to the nucleus. A nucleus that is open to imports from lower tiers or from sister tiers is indicated as open nucleus (Van der Werf, 2000).

In India, small size of herds faces a difficulty to faster rate of genetic improvement using the usual breeding schemes. To overcome this limitation, cooperative group breeding scheme is considered as alternative to conventional breeding schemes. In this scheme, a sire breeding nucleus herd is established to breed replacement sires for itself and the associated herds. Female replacements are reared in both the nucleus and base herds, and there is transfer of females in both directions at regulated intervals. The nucleus remains open to introduction of new genes from the surrounding area and this scheme termed as open nucleus breeding system (Dixit and Sadana, 1999a).

Opening the nucleus to replacements from the village herds might improve the genetic progress and, more important, its chances of success because it encourages more farmer participation (Bondoc and Smith, 1993).

The best nucleus animals are selected as parents of the next generation of nucleus animals. Animals born from elite mating (i.e. nucleus-born animals) that are not selected as parents for the nucleus will be used as parents for the lower tier. Hence, the expected mean of the nucleus should be higher than that of the lower tier (Van der Werf, 2000)

There are some examples of open nucleus breeding schemes that have been initiated in West Africa. In 1984, a sheep improvement program was initiated in Côte d’Ivoire to improve growth and live weight of the indigenous Djallonké sheep (Yapi-Gnaorè, 2000).