REVIEW ARTICLE *Pakistan Vet. J., 22(1): 2002*

PROSPECTS OF MULTIPLE OVULATION AND EMBRYO TRANSFER (MOET) IN GENETIC IMPROVEMENT OF BUFFALOES

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One of the limitations to genetic progress in buffalo, as in cattle, has been the low reproductive rate of females. However, the development of non-surgical embryo transfer (ET) technology has made it possible to further increase the reproductive rate in this species. Initially, incorporating this technology into a progeny testing program was seen as its only role in genetic improvement of dairy cattle. Recently, utilisation of Multiple Ovulation and Embryo Transfer (MOET) in nucleus schemes is being considered to be the potential area where this technology can be used effectively. This paper reviews the development of MOET in cattle and its prospects for the genetic development of buffaloes.

Status of buffalo production

About 95% of the total world population of buffalo is located in Asian and South-East Asian countries supplying more than 50% of the milk and about 90% of the draft power (Misra *et al.*, 1990). They are generally grouped into river (70% of the total population) and swamp (30% of the total population) type. The river buffaloes (chromosome no. = 50) include the 18 milch breeds of India, Pakistan and Egypt, while the swamp group (chromosome no. = 48) consists of many varieties of the swamp breed. Also, river buffalo consists mostly of milch breeds while swamp buffalo is a work animal with good meat production potential and some capacity for milk production (Ganguli, 1997).

Productivity of various buffalo breeds under their own environment and management conditions is variable and thus the claims that which breed would perform best under all conditions are meaningless. Bhat (1992) has presented a comprehensive review on the comparative performance of various breeds and have indicated that mean first lactation milk yield (kg) ranged from 1521 to 1867 for Murrah, 1706 to 2065 for the Nili-Ravi and 1455 to 1681 for Egyptian buffalo. Rosati (1997), on the other hand, claimed that the average milk production of Italian buffaloes is highest (2157 kg) in the world. Contradictory reports to this claim can be found in the literature. Iqbal (1996) however, reported that lactation milk yield in Nili-Ravi buffaloes (n=1426) averaged 2493 kg.

Some of the major problems in buffalo productivity include: low production (~1500 kg with 6-7% butter fat); seasonality in calving; higher than optimal age at first calving (> 40 months); anestrus and repeat breeding (service period > 150 days, calving interval > 450 days, Ganguli, 1997).

Selection programs

Nagarcenkar and Sethi (1988) reported that the selection programs were taken up on some state and institutional farms in some countries (India, Pakistan, Bulgaria, Egypt, Italy). The production characteristics such as age at first calving, milk yield, butter fat percentage, service period, dry period and calving interval show the presence of variability within each breed and that there is scope for improvement through selection.

Milk recording, which serves as core for the development and execution of these genetic selection programs, is being done at a very limited scale. Moioli (1995) presented the results of a survey involving most of the countries with dairy buffaloes. Economic interest in recording milk productivity was evident in India, Italy and Bulgaria while activity is still limited to the institutional and experimental herds in most of the other countries (Khan, 2001).

Basic structure of nucleus

A nucleus (or elite) herd consists of elite males and females to concentrate testing and selection in the herd, selecting at an early age using family information and using MOET to increase genetic response by reducing generation interval and increasing reproductive rate. These are of two kinds: the original MOET scheme and mixed/hybrid MOET schemes. In the original MOET scheme, selection occurs only on pedigree value from the maternal and paternal sides ("juvenile" schemes) or on pedigree values combined with first lactation records ("adult" schemes). Multiple ovulation and egg transfer are then practised on the selected heifers. In the mixed/hybrid MOET scheme, the preceding selection methods are mixed with some bull progeny testing (bulls are a mixture of pedigree and progeny selection). The nucleus can be closed or open. In the closed nucleus, an original choice of the animal is done, in commercial population or outside, in a superior population for instance. The breeding population is closed throughout. The open nucleus on the other hand accepts superior animals from outside the local breeding scheme (other countries, other MOETs, conventional schemes in the same country, etc.).

Simulation work

Nicholas (1979) was the first to examine the possible impact of a MOET nucleus scheme in dairy cattle improvement. He presented some basic simulation results on the rates of gain from MOET in a 500-cow herd. In the three schemes outlined, females were selected on their dam's first lactation record, with a short generation interval of just two years but with a very low accuracy of 0.25. Males were selected on their dam's first record (pedigree selection scheme) or on a family index utilising full-sib, half-sib and dam records, with a generation interval of 3.6 years (sib selection scheme). In the third scheme the nucleus herd supplied 30 young bulls for progeny testing and nucleus replacements were bred both from young males selected on their dam's first lactation record and from the two progeny tested sires. Each selected male was mated to 8 donors. The genetic response was substantially higher from all three schemes than from a progeny testing program in the herd and could even be as high as from a national progeny testing scheme. Later, a more detailed study was published (Nicholas and Smith, 1983). The two alternative nucleus schemes, the juvenile and adult scheme, with selection before or after the first lactation records, respectively were compared. It was suggested that the adult scheme would yield 0.129 s.d units per year(approx. 30% higher than conventional progeny testing scheme).

In MOET-hybrid schemes (MOET x conventional progeny testing scheme) the generation interval for females is quite low and the nucleus herd is used to produce all young bulls needed for progeny testing (Colleau, 1985). The success in the MOET schemes depends on the success of ET and reduction of generation interval. With the hybrid schemes, the bull to cow and bull to bull pathways are unaffected by the variability in the ET rates. It was also shown that the reduction in genetic variance for the juvenile MOET scheme was almost negligible compared with that for the progeny testing and MOET hybrid schemes, due to the lower accuracy of selection of animals for both sexes. In another simulation study, Colleau, (1989) presented that overall potentiality of the hybrid scheme is likely to exceed that of the conventional schemes.

The simulated study of adult MOET (Juga and Maki-Tanila, 1987) pointed out that the genetic gains in the schemes such as those of Nicholas and Smith (1983) would be substantially lower than predicted when population under study are assumed not to improve at a constant rate. For example, with four sires selected, eight donors mated to each sire and eight progeny per donor, the response was reduced by over 33%. Woolliams and Smith (1988) showed that higher rates of genetic gain (by up to 80%) could be made in MOET nucleus schemes compared with a national progeny testing scheme by using information on the sire's family, instead of only the dam's.

Keller *et al.* (1990) presented reduction in selection response per year due to adjusting for population size and structure and selection dis-equilibrium ranged from 13-35% for 0% depression to 15-90% for 0.5% depression per 1% increase in inbreeding. In a juvenile closed nucleus scheme however, inbreeding rather than reproduction rate established the limit to genetic response for a given population size (Leith *et al.*, 1991). As the effect of inbreeding using factorial and nested mating designs was the same, Luo *et al.* (1994) suggested incorporation of progeny testing in the closed nuclei.

Schrooten and Van Arendonk (1992) using stochastic models compared close and open nucleus schemes and reported that annual genetic progress was 4-6% higher in open MOET nucleus schemes as compared to progeny testing schemes. The response was reduced by 1-2% when the nucleus was closed. Dekkers and Shook (1990) however, found very small advantage of open over closed nucleus schemes and suggested that the nucleus size would determine the difference. The lower simulated responses achieved in the studies using stochastic models as compared to deterministic models were reported due to reduction in the between-family genetic variances due to selection (Ruane, 1991).

Commercial application

These and many similar studies compelled the start of nucleus schemes at commercial level in the 80's. Although, the primary objective of these nucleus schemes was to improve the rate of genetic gain by implying the developments in reproductive technologies such as sexing and cloning of embryos, *in vitro* maturation and fertilisation of eggs, a wider application could be in the selection of traits such as feed efficiency that were difficult to measure at field level and breed conservation. So far the success seems to be quite variable and most of the results published are for non-zebu cattle. Penna *et al.* (1998) however, have reported progress on Brazilian dual purpose zebu breed of Guzera. The results summarised for the period 1994-1997 indicate feasibility of MOET selection schemes in zebu cattle. The schemes aims at obtaining 12 families with at least 8 full-sibs (both sexes) per year. The nucleus is open and allows incorporation of elite cows screened from the whole population of the breed to be brought in. The selection criteria being the milk records when available (minimum of 3000 kg in a 305-d lactation with minimum 450 kg of body weight), information provided by the farmers and limited confirmatory milk recording. Selection of bulls is made on the basis of dam and other relatives absolute milk yield. A limited scale progeny testing program has also been reported. The overall success rate is 4.1 pregnancies per flush (n=41) with 11.3 recipients per donor. The net cost per pregnancy still being very high (US$ 600). The main challenges for genetic soundness remain to enlarge the nucleus (requiring a commercial success) and keep it open which implies that milk recording and genetic screening be intensified.

MOET in buffalo

Although, lack of large scale recording in buffaloes qualifies for the use of MOET schemes in this species, developments in reproductive techniques are far behind from that in cattle. Kamonpatana (1990) reported that the embryo transfer technology has been attempted in six countries (Bulgaria, India, Malaysia, Pakistan, Thialand and U.S.A) but success has been limited. On an average, the success rate has only been 1.16 embryo recovered per donor, and the rate of qualified embryos per donor was 0.51. The conception rate of 14% was at the rate of 0.06 conceptions per donor and resulted in 0.03 calvings per donor. Report of Misra *et al.* (1990) indicated that superovulation and embryo recovery in more than 70 buffaloes resulted in pregnancy rate of 25% from fresh (n=35) and 33% from frozen (n=9) embryos, respectively. Mutha-Rao (1994) recorded 712 transferable viable embryos out of 497 flushings and 46 calves born out of 469 transfers.

MOET nucleus schemes

There has not yet been any report on the successful launching of any nucleus scheme in buffaloes and the main reason for this has been the limited economic feasibility of the embryo transfer in buffaloes. Most of the work reported has been using experimental animals.

Dimov and Dimitrov (1990) reported that when MOET was applied in the open nucleus breeding systems (ONBS), the relative genetic gain in buffaloes would be 50% more if combined with the progeny testing programs as compared to progeny testing programs alone. The simulated scheme involved 75000 buffaloes with A.I to be used on 30% of the population and nucleus had 430 females. Twenty embryos were expected from each nucleus female every year with six alive calves born. The nucleus was expected to be replaced every 12-14 months. The recommendations of FAO workshop on the application of MOET for buffaloes (Stean and Alexiev, 1990) were to give research and development for use of biotechnology in buffaloes a high priority with an initial emphasis on MOET technique. It was suggested to use MOET technique with progeny testing programs.

For Indian cattle, using deterministic models Sethi and Jain (1993) inferred that the genetic gains in traits like milk yield can be increased by about 6% when MOET is employed in the progeny testing programs. This gain can be further increased by 1% when information on full and half-sisters of the sires is used in the progeny testing schemes. For crossbred populations, Taneja *et al.* (1992) concluded that the annual genetic gain in milk by application of MOET ranged between 35% and 49%, depending upon the number of bulls used. The expected annual rate of genetic progress in the adult MOET scheme was 2.07% of the herd mean which was 56% higher than the conventional breeding scheme. Due to risk of inbreeding, open nucleus breeding schemes were suggested for Indian situation (Sethi and Jain, 1993a). In a recent study, Capasso *et al.* (1997) predicted that in a closed nucleus scheme for Italian buffaloes, expected genetic trend in mozzarella cheese improved from 14 kg to 58 kg. The main factor causing improvement being reduction in generation interval from 6.3 to 3.2 years which is difficult to achieve practically especially in the absence of artificial insemination and other risks for the closed nucleus. The buffalo productivity is far away to reach the improved parameters being used to predict better response from nucleus schemes.

Prospects and limitations

So far, the low selection intensity and low accuracy along with long generation interval in buffaloes has resulted in very low genetic gains. Although, the results from Nucleus Schemes of cattle implemented or in the phase of implementation are to come, feasibility for buffaloes is still farther. Theoretically, the open nucleus schemes seem promising with the advantages of higher genetic response, bull performance testing (e.g. growth rate, feed efficiency, disease resistance), better control of the breeding program, better recording, higher genetic parameters in a single herd, selection on other criteria (e.g. efficiency of milk production), lower national cost, quicker utilisation of new technology such as cloning etc.

Development in MOET is encouraging but slow in buffalo. it would take some time to adopt and implement any such program in developing countries like Pakistan where AI facilities are being used on less than 5% of the population (Malik and Ahmad. 1997). Other limiting factors are the availability of technology, cost of implementation, and disease and inbreeding risk to a single herd. Smaller populations could even face random genetic drift and reduced selection intensities. Minimum administrative restrictions, availability of new funds to establish such units and long term commitment would also be needed to run such units. The exact structure of any nucleus scheme thus, can not be generalised for buffalo but would depend on recording and evaluation system available. McGurik (1989) has suggested a size of 250 cows for developing countries. The technology can be concentrated in centres using facilities and skills of the specialists. The ET technology is in the phase of development and far away from application at field level. Also, the estimated cost of Rs 1460 for each embryo transfer (Ullah and Anwar, 1998) is very high. Recording of animals at field level and their genetic evaluation would still be required to keep the nucleus open or to adopt any hybrid scheme. Further, justification of using ET to amplify reproduction of genetically superior animals is difficult unless there is some mechanism of identifying them.

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