ECONOMIC EVALUATION OF LOCAL (ZIMBABWE) GENETIC IMPROVEMENT SCHEMES IN DAIRY CATTLE COMPARED TO CONTINUOUS IMPORTS FROM INTERNATIONAL SOURCES

N. MPOFU, C. SMITH, W. VAN VUUREN[1] and E.B. BURNSIDE

Centre for Genetic Improvement of Livestock,
University of Guelph, Guelph.
Ontario. Canada N1G 2W1

[1]School of Agricultural Economics and Business,
University of Guelph, Guelph.
Ontario. Canada N1G 2W1

SUMMARY

Strategies based on selection within local populations and others based on importation of semen or embryos were evaluated for genetic improvement of milk yield in dairy cattle in Zimbabwe. Gene flow techniques were used for the evaluation of genetic improvement. A cost-benefit analysis using fixed 1991 prices was used to assess the economic worthiness of the breeding strategy alternatives. The economic criterion used was net present value. The ranking of strategies on genetic criterion differed from that on economic criterion. For the standard set of economic parameters used, progeny testing is economically viable in Zimbabwe. Closed multiple ovulation and embryo transfer nucleus schemes and importing semen to sire replacement cows are not economically viable alternatives. Importing semen to sire sons and importing embryos to produce young bulls are economically viable. The ranking of strategies on net present value was not sensitive to the genetic parameters but was quite sensitive to the economic parameters used.

INTRODUCTION

In Zimbabwe, temperate dairy breeds are used for commercial production of milk. The commercial dairy herd comprises about 100,000 cows and the herd size in the milk recording scheme averages 125 cows. The main breeds are Holstein (77%) and Jersey (10%). The national herd was set up by importing live animals from Europe. The introduction of AI in 1970 offered opportunities for the use in Zimbabwe of highly selected proven foreign bulls. Embryo transfer technology, introduced into Zimbabwe in 1985, offers new breeding opportunities.

Evidence suggests that genetic parameters are similar in Zimbabwe and countries in the temperate zones (Mpofu, 1986). Therefore the same systems of testing and of selection should be applicable to both. The breeding objectives are also similar. Genetic improvement in temperate climates has been mainly through selection of bulls through progeny testing. There is scope for genetic improvement by selection in Zimbabwe since the amount of genetic variation is high (Mpofu, 1986) and the infrastructure for progeny testing already exists. MOET nucleus schemes have been recommended for developing countries by Smith (1988) and Hodges (1991). However, higher and faster genetic gains can be made in developing countries by importing genetic material from dairy populations with a higher genetic mean (Smith, 1988). Imports of genetic material from temperate countries is appropriate for Zimbabwe given the moderate genotype by environment interaction between Zimbabwe and these countries (Mpofu and Schaeffer, 1992).

This paper gives an overview of the results of a deterministic simulation study done to evaluate various breeding strategies for Zimbabwe (Mpofu, 1992). Some of the strategies are based on local selection programs and others are based on imports of genetic material from international sources.

MATERIALS AND METHODS

Description of breeding strategies

Strategies based on selection within local populations and others based on importation of semen or embryos were evaluated for genetic improvement of milk yield in dairy cattle. The local selection programs were; progeny testing in a closed population (PT1), progeny testing combined with semen imports to sire 30% of replacement cows (PT2), progeny testing with foreign bulls as sires of sons (PT3), and a nucleus breeding scheme using multiple ovulation and embryo transfer (NMOET). The initial stock for NMOET is imported. Strategies based on imports were; continual semen imports to sire 30%, 50% and 100% of the AI-bred population (CSI30,CSI50, CSI); semen from elite foreign bulls used on local elite cows to produce a bull team that is used untested (ELITE); and bulls from imported embryos used untested (CEI). For the ELITE strategy, superovulation and embryo transfer is used resulting in a more intense selection for the bull dams.

Genetic evaluations

A deterministic simulation using gene flow techniques (Hill, 1974) was used to estimate the population genetic mean for milk yield over a 25 year period. The genetic parameters used in the analysis were obtained from literature and supplemented with parameters for Zimbabwe and the United States for the genetic correlation and the initial genetic difference between the importing and exporting countries (Mpofu and Schaeffer, 1992). The gene flow model used was;

$$\mathbf{M(t) = P \times [\ M(t\text{-}1) + \Delta_g(t)]}$$

where M(t) is a vector of average genetic merit of animals in each sex-age class at time t, P is the gene transmission matrix and Δg is a vector of the genetic superiority of selected animals. The P matrix is constructed using predecided generation intervals and it is assumed fixed for each strategy. The selection selection differential is calculated as;

$$\Delta g = I\ .\ r\ .\ \sigma_g\ .\ r_g$$

where I is the selection intensity, r is the accuracy of evaluation, σ_g is the genetic standard deviation for milk yield. The genetic correlation between countries r_g is used to adjust the selection differential when imports are involved. A genetic correlation of 0.70 was used. The initial average genetic merit for the Zimbabwean sex-age classes was set to zero at the start of the evaluation period and the mean for the cow population in the exporting country set at 1.25 phenotypic standard deviations above that of Zimbabwe. Continuous selection in both sexes was assumed. The evaluation criterion is the population genetic mean which is a weighted average for lactating cows.

Economic evaluation

An economic analysis was done to measure the economic impact of the breeding strategies on society as a whole. The economic criteria used to assess breeding strategies was net present value. The benefits of genetic improvement were increased milk production predicted from the genetic analysis. The benefits were truncated at 25 years. Production costs for cows were obtained from the National Association of Dairy Farmers while investment and operating costs for the strategies were obtained from private firms and government offices involved in genetic improvement. The analyses were based on 1991 prices. The market prices were adjusted using parameters provided by the Ministry of Agriculture for Food Security Projects to get shadow prices. The standard parameters used were a discount rate of 10% and a relative value for the Zimbabwean dollar of 1:3.

Sensitivity Analysis

The sensitivity of results to the following parameters was investigated; genetic correlation between the exporting country and Zimbabwe, the initial genetic differences between the countries, the discount rate and the relative value of the Zimbabwean dollar.

RESULTS AND DISCUSSION

Genetic ranking

When using the genetic mean at 25 years as the evaluation criterion, the strategies rank; CSI, CEI, NMOET, ELITE, PT2, PT3, CSI50, PT1 and CSI30. The CSI strategy is better than CEI by 10%. CEI and CSI are comparable in that for both strategies, the whole Zimbabwean population is mated to foreign bulls. With CEI, the bulls are used untested whereas with CSI, the bulls are above average tested bulls. With CEI, there is time lag between the date of import of embryos and the use of bulls from these embryos, whereas with CSI the semen is used straight away. When the proportion of replacements sired by foreign bulls is reduced (CSI50, CSI30), response is reduced and CSI30 ranks lower than PT1. The MOET scheme is the best of all strategies based on local selection. The population mean at 25 years with this strategy is higher by a factor of 66%, 6% and 16% for PT1, PT2 and PT3, respectively. The MOET scheme has an advantage of an initial genetic lift from the founder stock of the nucleus herd. Progeny testing is best when combined with semen imports for sires of replacement cows (PT2). PT2 improves on PT1 by a factor of 56% and on PT3 by a factor of 9%. With PT2, a large percentage of cows is mated to proven bulls, 30% to foreign proven bulls and 50% to local proven bulls. In addition, since some cows are mated to foreign bulls, the number of local proven bulls required for the rest of the cow population is small, so selection pressure for bulls is higher with PT2 than with PT1 or PT3. The flow of genes from the foreign population is faster with PT2 than with PT3 as foreign bulls are used straight away with PT2 whereas sons of foreign bulls have to wait for a test in PT3. The ELITE strategy is better than all the progeny testing strategies. The cause of this is the more intense selection for bull dams made possible by the use of superovulation and embryo transfer and the reduced generation interval as bulls are used untested.

Economic ranking

When economic factors are taken into consideration, the strategies ranked; CEI, ELITE, PT3, PT1, PT2, CSI30, CSI50, NMOET and CSI. Progeny testing is an economically viable alternative for Zimbabwe. The net present value for the PT1 strategy was Z$4.57 million. However, greater returns are obtained when test bulls are sired by foreign elite bulls (PT3). The strategy giving the highest net present value (Z$24.8 million) is that based on continual embryo imports to produce young bulls for the base population. However, when the relative value of the Zimbabwean dollar is low and when the initial genetic difference between the exporting country and Zimbabwe is low, the ELITE strategy ranks first. The ELITE strategy should be adopted when bull dams can be reliably evaluated since the young bulls are used untested. Closed MOET nucleus schemes and importing semen for replacement cows (PT2, CSI30, CSI50, CSI) are not economically viable alternatives. This is because investment costs and operating costs are high for the MOET schemes and importing semen for replacement cows involves large volumes of imports and the use of scarce foreign currency.

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