The importance of a national breeding policy—Case for the Malawian Dairy Industry

Mizeck G. G. Chagunda (2002)

Department of Animal Science, University of Malawi, Bunda College of Agriculture, Lilongwe, Malawi

Introduction

Malawi, a tropical country in the semi-humid tsetse-free ecological zone of south-east Africa, has a total area of 118,480 sq. km of which 94,080 sq. km is land and 24,400 sq. km is water. Of the total land area, 18% is arable land, 20% is permanent pastures and 39% is forests and woodlands, while the rest is used for other purposes including roads and buildings. The economy is predominantly agricultural with about 90% of the population living in rural areas. Agriculture accounts for 45% of GDP and 90% of export revenues (World Factbook 1999). Malawi has a livestock population of approximately 810 thousand cattle, 850 thousand goats, 255 thousand pigs and 100 thousand sheep (Malawi Government 1997). The Malawi Zebu, predominantly a beef animal, constitutes 90% of the cattle population in Malawi.

Altitude of the arable region ranges from 52 to about 1632 m above sea level. Mean annual temperature is about 21ºC. The warmest month is November, with an average maximum temperature of about 30°C. The coldest is July with an average maximum temperature of about 23°C. The highest average minimum temperature is about 18.4°C (in December) while the lowest average minimum temperature is about 10.1°C (in July). The rainfall pattern is unimodal, confined to the period from early November to April with a peak in January; it ranges from about 541 to 1719 mm per year.

Dairy farming in Malawi is practised on governmental, large-scale (private) and smallholder farms. Smallholder farmers raise about 96% of the cattle in Malawi (Zimba 1991). Commercial milk production in Malawi started as a result of an increasing demand for liquid milk in the southern region of Malawi (with Blantyre as the major commercial town). This led a few farmers to import high yielding dairy cattle from South Africa and Zimbabwe. For instance, between 1952 and 1954, more than 54 exotic dairy cattle were imported into the country (Malawi Government 1952, 1954). The commercial farms marketed the milk direct to the consumers. Leslie's Dairies near Blantyre were the first to pasteurise and market fresh milk in Malawi. There, the milk plant started operating in 1961, batch pasteurising 2500 litres of milk per day (O'Keeffe 1970). In 1979, the Malawi Government and the Canadian Government through the Canadian International Development Agency (CIDA) approved a dairy development project: the Malawi Canada Dairy Development Project. Consequently, over a period of 5 years, a foundation stock of 400 Canadian Holstein-Friesian heifers was imported to the 5500 hectare Ndata farm in the southern region of Malawi and the 2250 hectare Katete farm in the central region. In 1988, the project was combined with Malawi Milk Marketing to form Malawi Dairy Industries Corporation (MDI) a statutory organisation involved in producing, processing and marketing milk and milk products. Since 1997, Ndata and Katete farms have been privatised under the national privatisation programme. Apart from these farms, there are about 12 other large-scale private dairy farms in Malawi. At present,

there is no institutionalised and co-ordinated recording system in Malawi, hence farmers keep on-farm records in various formats.

Data for 1997 (Malawi Government 1997) indicate that there are about 3600 smallholder farmers who use over 6000 Holstein-Friesian × Malawi Zebu cows and about 1700 smallholder farmers who use an unknown number of Malawi Zebu cattle for commercial milk production in the peri-urban setting in the three milk-shed areas, i.e. Blantyre, Lilongwe and Mzuzu. Although smallholder farms play an important role in milk production in Malawi, genetic evaluation studies are currently difficult if not impossible to carry out because of the lack of systematically kept records (Chagunda 1996). Large-scale dairy farms account for about 2200 milking cows. The predominant genotype on the large-scale dairy farms is the Holstein-Friesian although some of these farms also have Ayrshire and Jersey cattle.

The total milk production from both the large-scale and the smallholder subsectors is estimated to be 34 million kg per year (Banda and Mwenifumbo 1998). Using the figures of total milk available on the Malawi market and the country's human population of about 10.5 million, Banda and Mwenifumbo (1998) estimated the average milk consumption of 3.2 kg/capita per year. Official estimates from FAO (1994) put Malawi's per capita consumption at 6.9 kg. Whichever estimate one chooses, the level of milk consumption is extremely low when compared with Africa's average of 15 kg/capita per year, highlighting the need for improvement.

This paper discusses consequences of some sectoral breeding strategies with respect to the importance of a national breeding policy for dairy production in Malawi.

The breeding strategy based on continuous germplasm importation on large-scale dairy farms

In an effort to improve milk production, the last two decades of dairy cattle management has been oriented towards increasing milk yield per animal. Two elements in this process have been the dependence of the breeding policy on Holstein-Friesian bull semen from the temperate, continental region of Canada and the selection of sires based on milk yield only. One concern about such a breeding strategy is that it ignores the existence of interactions between genotype and environment. This kind of interaction, reflected in differential expression of genotypes in different environments (Mathur and Horst 1994), has implications on the selection and use of bulls, as ranking of bulls differs in different countries.

In general, results on the phenotypic performance of Holstein-Friesian cattle on different large-scale farms within Malawi have varied. For example, Chagunda (2000), in a study conducted on three large-scale farms in central and southern Malawi, reported average milk yields (standard deviation = s.d.) of 3139 kg (s.d. = 1067), 3390 kg (s.d. = 1186) and 3615 kg (s.d. = 1318) for lactations 1, 2 and 3, respectively. In another study, Wollny et al. (1998) reported an average of 5589 kg/cow per year in a study carried out on one farm in southern Malawi. These variations have not only been reported on the phenotypic performance but also on genetic parameters. For example, Chagunda (2000) reported a heritability for milk yield of 0.16 (s.e. = 0.06) while Wollny et al. (1998) reported a value of 0.21 (s.e. = 0.04).

Apart from the within country variation, there is also variation for these cattle between countries. Makuza and McDaniel (1996), for instance, reported an average milk yield of 4791 kg for first lactation cows in Zimbabwe while Jairath et al. (1995) reported 5152 kg (s.d. = 1945) for first lactation milk yield in the Holstein-Friesian population in Canada. With regard to genetic parameters, between populations and also between breeds, differences are observed or expected. For example, Makuza and McDaniel (1996) estimated heritability for milk yield

of 0.35 in Zimbabwe while Rege (1991) estimated a heritability of 0.32 in Kenya. Further still, Carabano et al. (1989) reported a heritability of 0.16 for Holstein–Friesian populations in Zimbabwe, Kenya and Spain. A possible explanation for the low values of heritability estimates in milk yield is the sizeable influence of environmental conditions, related to management and nutrition, on milk yield. Such influences may limit the expression of genetic potential of superior cows, hence restricting differences in yield due to genetic value among animals (Carabano et al. 1989). In turn, this increases the random residual variance, consequently reducing the proportional impact of the additive genetic variance when determining heritability values. Another factor that may contribute to lower estimates of genetic variance is inaccurate pedigree recording.

Since the large-scale farms basically depend on the importation of foreign Holstein-Friesian germplasm, mainly from Canada, Chagunda (2000) tested the importance of genotype by environment interaction in the performance of Malawian and Canadian daughters of the same sires. The estimated genetic correlation between these two populations was 0.44. This value is substantially less than 0.8, which according to Robertson (1959), is the threshold genetic correlation and below which genotype by environment interaction is considered of biological and agricultural importance. If the genotypes and environments have strictly additive absolute effects, the product-moment correlation between performances of the same genotype (G) in different environments (E) is unity or close to unity ($r_G = 1$) and analysis of variance yields an estimate of interaction of zero ($\sigma^2_{GE} = 0$), so that the intra-class correlation is also unity ($r_G = \sigma^2_G /(\sigma^2_G + \sigma^2_{GE}) = 1$) (Dickerson 1962). The results of Chagunda (2000) indicated a significant genotype by environment interaction for milk yield for Malawian and Canadian bred Holstein-Friesian cows, but raised in the two respective countries.

In addition, the correlation between the ranking of bulls in Malawi and Canada was 0.037 and was not significantly different from zero ($P > 0.05$), indicating strong re-ranking of the Canadian sires when their daughters performed in Malawi.

The interaction of genotype and environment complicates selection because it reduces accuracy of the predictions made from phenotypic performance of a given set of genotypes in one environment from that made in other different environments (Dickerson 1962). Therefore, genotype by environment interaction needs to be taken into consideration in dairy breeding decisions in Malawi. This is in agreement with Petersen (1975), who noted that a deviation of the genetic correlation from unity is likely to be a more serious concern in breeding programmes than differences in heritabilities when considering sire selection in different environments. For such situations, Smith (1988) suggested a breeding strategy with an initial period of semen importation and a later switch to a local selection programme. Mpofu et al. (1993), in their simulation study of possible breeding strategies for commercial dairy cattle in Zimbabwe, showed that continual semen importation for 30% of the population would be better than a closed progeny testing scheme. The imported semen from elite bulls could then be used to sire sons that could be used on cows in the importing population. In practice, this would have to be supported by reproductive techniques such as reliable artificial insemination programmes.

The selection strategy on large-scale farms puts emphasis on increasing milk yield. However, it underplays the importance of reproductive traits, which are indicators of livestock adaptation in a particular environment. In the study by Chagunda (2000), the inclusion of calving interval in the selection criteria increased the expected genetic gain (to 55.9 and 94.4% for milk yield and calving interval, respectively) above that expected when selection is only on milk yield.

Although the major income source for dairy farms in Malawi is from the sale of milk, in trying to improve dairy production, emphasis need not only be placed on milk yield. The reduction in

genetic gain for milk yield with the increased genetic gain in reducing the calving interval is beneficial to the farmer in the long run. The reduced calving interval means that within a given productive lifetime, a cow would produce more calves than when the calving interval is long. This would result in more replacement animals for the herd as well as more lactations per cow productive lifetime. These benefits would offset the loss that is envisaged because of the reduction in milk yield per lactation, which results from inclusion of calving interval in the selection criteria. This agrees with Meuwissen and Woolliams (1993) who indicated that as milk production increases, other traits become increasingly important, especially health and fertility traits. Neglect of fitness traits that are also adaptation traits may have serious economic implications for dairy producers. If the primary goal of a dairy producer is assumed to be maximisation of return on investment, a continuous increase in milk production without regard to other traits may not be the most economically useful way to reach the goal (van Raden and Wiggans 1995). Variables used to denote the fertility of a dairy cow are calving interval or days open, conception or non-return rates, or number of inseminations to obtain pregnancy (Groen et al. 1997). Although these traits depend directly on the insemination and replacement policy of the farmer, they are strongly related and have great bearing on the adaptation of the animals to a particular environment.

The crossbreeding strategy for dairy production on smallholder farms in Malawi

Efforts to launch crossbreeding programmes to establish a supply of dairy cows for distribution to smallholder farmers date back to the late 1950s. After forty years of substantial governmental and international donor support, approximately 8000 crossbred cows of various grades of Holstein-Friesian × Malawi Zebu produce, on average, less than 1000 kg/cow per year. In a study of the economic situation of smallholder dairy farms using the Malawi Zebu and its crosses for dairying in the Mzuzu milkshed area, Mwale et al. (1999) indicated that there are dependencies between genotype and management level under the prevailing smallholder conditions. A lower efficiency was observed for back cross Holstein–Friesian × Malawi Zebu as compared with F_1 (Holstein–Friesian × Malawi Zebu) under low or medium levels of management. When no labour costs were included (a typical scenario under the smallholder set-up), gross margin analysis indicates that the Malawi Zebu cow could be the most efficient genotype in a low-input low-output system.

Conclusion

The high variation in performance of Holstein–Friesians in large-scale herds within and outside Malawi indicates that considerable improvement could be achieved by improving the production environment. The most effective management practices need to be exploited to circumvent the environmental constraints on genetic expression of yield in Malawi. The pedigree recording system also needs to be improved so as not to limit the estimation of genetic variance.

The existence of genotype by environment interaction between the daughters of the same sires performing in Malawi and Canada implies that suboptimal genetic progress is being achieved by selecting sires ranked according to Canadian environmental conditions for performance in Malawi. There is need, therefore, to revise the breeding strategy to find the most suitable bulls for the production system in Malawi. Development of national genetic evaluations would be a prerequisite in this process.

Including calving interval in the selection index would result in more genetic progress, for both milk yield and calving interval, than is currently the case where selection is based only on milk yield. Although there is an antagonistic relationship between milk yield and calving interval, results indicated that the reduction in milk yield was not so drastic as to offset the potential benefits of reducing calving interval.

Selection based on estimated breeding values obtained from daughter performance in Malawi would result in more genetic progress than would sire selection based on Canadian breeding values. To improve the national breeding programme, a nucleus breeding scheme involving the large-scale dairy farms is proposed. In the proposed nucleus scheme, some of the activities would be:

- development of comprehensive selection criteria and an implementation and monitoring system for the national herd and
- the breeding of bulls that are appropriate for the existing production systems including the smallholder system.

Co-ordinated performance recording would bring timely feedback for the improvement of the programme and also provide information on lifetime productivity, real costs of providing a crossbred dairy cow to the farmer and a risk assessment.

References

Banda J.W. and Mwenifumbo C. 1998. *Dairy production and marketing*. Working Paper, National Livestock Development Master Plan. Ministry of Agriculture and Irrigation, Malawi Government, Lilongwe, Malawi.34 pp.

Carabano M.J., van Vleck L.D., Wiggans G.R. and Alenda R. 1989. Estimation of genetic parameters for milk and fat yields of dairy cattle in Spain and the United States. *Journal of Dairy Science* 72:3013–3022.

Chagunda M.G.G. 1996. *Evaluation of the Malawian artificial insemination program for small and large-scale dairy farms*. MSc thesis. University of Malawi, Zomba, Malawi.89 pp.

Chagunda M.G.G. 2000. *Genetic evaluation of the performance of Holstein–Friesian cattle on large-scale dairy farms in Malawi*. PhD thesis. George August University of Goettingen, Germany. 114 pp.

Dickerson G.E 1962. Implications of genetic–environment interaction in animal breeding. *Animal Production* 4:47–63.

FAO (Food and Agriculture Organization of the United Nations). 1994. Yearly Handbook, The development and transfer of biotechnological methods for diagnosis of tick-borne pathogens with special refrence to *Cowdria ruminantum* and *Theleria annulata*. FAO*, Rome, Italy. pp. 126–135.

Groen A.F., Stein T., Colleau J.J., Pedersen J., Pribyl J. and Reinsch N. 1997. Economic values in dairy cattle breeding, with special reference to functional traits. Report of an EAAP-working group. *Livestock Production Science* 49:1–21.

Jairath L.K., Hayes J.F. and Cue R.I. 1995. Correlation between first lactation and lifetime performance traits of Canadian Holsteins. *Journal of Dairy Science* 78:438–448.

Makuza S.M. and McDaniel B.T. 1996. Effect of days dry, previous days open, and current days open on milk yields of cows in Zimbabwe and North Carolina. *Journal of Dairy Science* 79:702–709.

Malawi Government.1997. *Annual livestock census*. Department of Animal Health and Industry, Ministry of Agriculture and Livestock Development, Lilongwe, Malawi. 79 p.

Malawi Government. 1952. *Policies and plans for the development of the livestock industry of Nyasaland (Malawi)*. Department of Veterinary Services, Zomba, Malawi. 36–45.

Malawi Government. 1954. *Annual report of the Department of Veterinary Services and Animal Industry.* Government Print, Zomba, Malawi (Nyasaland)..38–39.

Mathur P.K. and Horst P. 1994. Methods for evaluating genotype-environment interactions illustrated by laying hens. *Journal of Animal Breeding and Genetics* 111(4):265–288.

Meuwissen T.H.E. and Woolliams J.A. 1993. Response of multi-trait selection in open nucleus schemes for dairy cattle breeding. *Animal Production* 56:293–299**.**

Mpofu N., Smith C. and Burnside E.B. 1993. Breeding strategies for genetic improvement of dairy cattle in Zimbabwe. I. Genetic evaluation. *Journal of Dairy Science* 76:1163–1172.

Mwale S.E., Wollny C., Banda J.W., Chagunda M.G.G. and Bruns E. 1999. Evaluation of Malawi Zebu and its crosses on smallholder dairy farms in Mzuzu, northern Malawi.:.Paper presented at *'Tropentag 99',* held at Humboldt University of Berlin, Berlin, Germany, 14–15 October 1999.

O'Keefe M.G. 1970. *Report to the Government of Malawi on the development of the dairy industry. Improvement of Livestock and Dairy Industry, FAO/UNDP Special Fund Project MLW5.* FAO, (Food and Agriculture Organization of the United Nations) Rome, Italy. 2, 31 pp.

Petersen P.H. 1975. Genotype–environment interaction in milk production under Danish and Bulgarian-Czechoslovakian conditions. *Animal Production* 21:101–108.

van Raden P.M. and Wiggans G.R. 1995. Productive life evaluation: Calculation and economic value. *Journal of Dairy Science* 78:631–638.

Rege J.E.O. 1991. Genetic analysis of reproductive performance of Friesian cattle in Kenya. I Genetic and phenotypic parameters. *Journal of Animal Breeding and Genetics* 108(6):412–423.

Robertson A. 1959. The sampling variance of the genetic correlation coefficient. *Biometrics* 15:469–485.

Smith C. 1988. Genetic improvement of livestock using nucleus breeding units. *World Animal Review* 65:2–10.

Wollny C.B.A., Namwaza A.G, Makamba T.S.W. and Küttner K. 1998. Zum Stand der Rinderzucht in Malawi. *Archive fuer Tierzucht. Dummerstorf* 41(1/2):33–44.

World Factbook. 1999. *World factbook home page*. http://www.odci.gov/cia/ publications/factbook/mi.html. (Accessed 21 January 2000).

Zimba A.W.C. 1991. Breeding strategies for livestock. In: Munthali T., and Msiska (eds), Proceedings of the first national workshop on livestock production in Malawi, held at Chancellor College, Zomba , Malawi, 3–9 January 1988. pp. 45–53.