Contributions of genetic improvement programs for dairy livestock farming

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ABSTRACT

Genetic improvement programs have played a fundamental role in the evolution of dairy farming, promoting significant increases in productivity and milk quality. This study analyzes the main contributions of these initiatives, highlighting the techniques used, such as genetic selection and artificial insemination, and their impacts on production efficiency and animal health. Furthermore, the challenges faced by livestock farmers in implementing these programs and the future perspectives of the sector are discussed. The results indicate that genetic improvement, combined with appropriate management practices, can provide significant gains in terms of production volume, milk quality, disease resistance and animal longevity, contributing to the sustainability and competitiveness of dairy farming. This summary encapsulates the objectives, main results, and implications of the study, offering a clear and concise overview of the contributions of genetic improvement programs to dairy farming.

Keywords: Animal production, Genetic improvement, Dairy farming.

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INTRODUCTION

Genetic improvement plays an extremely important role in increasing the productivity of any animal species. However, its purpose needs to be directly related to the environmental conditions in which it is intended to use certain species. In dairy farming, this is no different. Currently in Brazil, it is common to find production systems with great imbalance between genetics and environmental conditions. There are dairy herds where the producer is able to provide optimal environmental conditions to the animals, such as management, health and nutrition, however, the low genetic capacity of these animals prevents a better response when we talk about production and profitability. The opposite is also true when we find production systems with precarious environmental conditions, but often with animals of high genetic capacity, restricting the expression of the animals' genetic potential.

Milk production in Brazil is a traditional practice. It is known that the national production represents the fifth largest producer of this product in the world and in almost all Brazilian municipalities there is at least one milk producer. However, productivity is below what would be necessary for the activity to provide sustainability, especially economic, for most dairy farmers. One way to effectively contribute to the evolution of this activity is by applying genetic improvement procedures, such as the rational use of selection and mating systems. Selection represents the choice of males and females that will be used for reproduction, while mating systems represent the strategies adopted in defining which males will be mated with which females. Through these two tools, it is possible to modify, over time, the gene frequencies of alleles of economic interest in herds and, thus, optimize the expected results, contributing to the increase of productivity and profitability of milk production systems in Brazil.

In the past, selection techniques and mating systems were practiced within herds, through empirical methods, without the use of trait information measured by more precise procedures. With the creation of the National System of Agricultural Research in Brazil in 1976, agricultural research institutions began to contribute with guidance on the use of new technologies for the sector. In the same period, there was also a great evolution in the use of new reproductive biotechniques, with the expansion of the use of Artificial Insemination (AI), Fixed Time Artificial Insemination (FTAI) and In Vitro Fertilization (IVF). In view of the above, the objective of this chapter is to demonstrate how genetic improvement is capable of contributing to the development of national dairy farming.

DEVELOPMENT

The genetic improvement programs developed in Brazil were initially coordinated by the Brazilian Agricultural Research Corporation (Embrapa), from 1975 to 1992, in several dairy farms and research centers in the Southeast of the country (FREITAS et al., 1992; LEMOS et al., 1992).

These programs involved the planning and implementation of two research projects on crossbreeding strategies between dairy breeds and on progeny testing of crossbred European−zebu bulls. The projects were part of the technical assistance program of the *Food and Agriculture Organization* (FAO), which involved the production and distribution of semen, production and distribution of females of different Holstein-Zebu genetic compositions in collaborating herds, monitoring of zootechnical records, control of milk production, processing of samples for analysis of milk fat and development of a *software* for the organization and recording of all information. The objectives of the projects were to promote and coordinate the implementation of a national selection program for milk production, to obtain experimental material for studies aimed at improving the methodology for the selection of dairy cattle and to provide an opportunity for technicians to know directly the problems encountered in the practical application of a breeding program (FREITAS et al., 1992).

Among the favorable precedents for the execution of genetic improvement projects in Brazil, the lack of genetic evaluations in national dairy bulls, used in artificial insemination, and the new norms of the Ministry of Agriculture, Livestock and Supply (MAPA), requiring progeny tests so that sires could be used, were mentioned. In addition, breeders were interested in using genetic material of proven quality. At that time, there was very little information on the productive, reproductive and economic performance of crossbred animals raised under Brazilian conditions, especially in the Southeast, Northeast and North regions of the country (HAYES et al., 2009).

The projects were conducted with great success and showed consistent results, identifying the best genetic composition of cattle for milk production, to be used in the prevailing management conditions in Central Brazil, and especially in the Southeast region. Since then, the work of genetic improvement of dairy cattle in Brazil has been expanding (HAYES et al., 2009).

In 1985, through a public-private partnership established between Embrapa Dairy Cattle, the Brazilian Association of Dairy Gir Breeders (ABCGIL) and the Brazilian Association of Zebu Breeders (ABCZ), the National Dairy Gir Improvement Program (PNMGL) was initiated, with the involvement of selector producers, collaborating dairy herds and the main state agricultural research companies. such as Minas Gerais (Epamig), Rio Grande do Norte (Emparn), Paraíba (Emepa) and the Institute of Animal Science of São Paulo (IZ), Federal Universities with research activities in agricultural sciences and artificial insemination centers. In its initial phase, the program consisted of the progeny test only for genetic evaluation of bulls for milk production. With the success achieved, new features and technologies were incorporated (MEUWISSEN et al., 2001).

Currently, the progeny test includes, in addition to the genetic evaluation of males and females for milk production, the genetic evaluation for the milk constituents (fat, protein and total solids), individual estimates of average parentage in the population, genotyping for the genes of beta-

casein (A2 milk), kappa-casein and beta-lactoglobulin and genetic evaluation for linear conformation and management traits (STAs) (MEUWISSEN et al., 2001).

The program has become broader, including the evaluation of young bulls to be included in the test for their fertility, conformation and temperament, also called pre-test, the program for evaluating the performance of first-calf females on pasture, called Sustainable Dairy Gyr, and the application of genomic selection techniques, which is in the implementation phase. but it has already contributed, as of 2016, to the correction of the kinship matrix and to the possibility of helping the breeder in choosing the bulls to be enrolled in the test (VANRADEN et al., 2009).

Currently, research on feed efficiency in Dairy Gyr animals is being initiated with a view to the continuous improvement of the program. The success achieved by the PNMGL was unquestionable, leading to the planning of the Guzera Breed Improvement Program for Milk (PNMGuL), initiated in 1994 along the same lines as the PNMGL, involving, in addition to the selector breeders and collaborating herds with crossbred cattle, Embrapa Dairy Cattle, the Brazilian Center for the Improvement of Guzerá (CBMG), a technical arm of the Association of Breeders of this breed, the School of Veterinary Medicine of the Federal University of Minas Gerais and state research companies. The work with the Guzera breed includes, in addition to the progeny test of bulls, an open nucleus for the selection of multiple ovulation and embryo transfer, also called Moet nucleus, and is characterized by the selection of sires of the Guzera breed of dual aptitude, meat and milk (LEMOS et al., 1992).

In the Girolando breed, the program began in 1997 and is conducted by the Brazilian Association of the breed itself, with technical coordination by Embrapa Dairy Cattle, also involving selector producers and the Agricultural Research Company of Minas Gerais (Epamig). In recent years, the Girolando breeding program has shown great evolution, with a huge increase in partnerships, an increase in the number of bulls in testing, greater participation of collaborating herds, as well as an increase in the interest of producers and the incorporation of technologies inserted in the Dairy Gyr program, with innovations, especially with a strong performance in the use of genomics in the selection work. The use of semen from proven crossbred bulls has shown a wide growth in Brazil (VARANDEN et al., 2009).

For the Sindhi breed, there was an initiative of Embrapa Dairy Cattle with the Association of Sindi breeders (ABCSindi) and the Agricultural Research Company of Paraíba (Emepa), where the PNMGL model was also followed, in 2009. At the time, the bulls were chosen to compose the first group to be included in a progeny test for milk production and constituents in this breed. Subsequently, genomic studies were carried out in which the main lineages of this breed were identified. The intention was to avoid, with the implementation of the breeding program, that there would be significant losses of genetic diversity in the breed, which has always had a small population

size, and thus foster the sustainability of the selection program over future generations, and the viability of this breed as an alternative for milk production in Brazil (VARANDEN et al., 2009).

To date, the evolution of the program still comes up against the lack of herds that perform dairy controls, so that the bulls can have a sufficient number of progeny measured and, consequently, can be genetically evaluated. Pure breeds of European origin, such as Holstein, Jersey and Brown Swiss, despite not having a defined program of genetic improvement currently being carried out at the national level, benefit from the spectacular genetic evolution achieved in developed countries, as a result of the high intensity of selection practiced over time. The benefits result from the use of imported genetic material, including semen and embryos, and sometimes from the importation of animals. In addition, especially in the Holstein breed, there is structured work of the Association of Breeders of the breed providing excellent support to its Members. As a consequence, the evolution in the milk productivity of these breeds in Brazil is very expressive and consistent. In the past, there was a system of genetic evaluation of Holstein bulls, with publication of bull summaries, which was discontinued. Thus, currently, these breeds still lack a system of genetic evaluation of bulls and cows that allows the correct classification of these animals in the production conditions of Brazil (VARANDEN et al., 2009).

In this sense, there is an action started in 2012, but not yet concluded, by Embrapa Dairy Cattle with the Brazilian Association of Holstein Breeders and artificial insemination companies for Brazil's affiliation to ICAR/Interbull and for the establishment of national genomic prediction equations. Over the years, it has been observed that the application of knowledge of quantitative genetics, statistical methodologies, selection methods and mating systems has marked a new era in animal genetic improvement in Brazil, allowing substantial gains in quantitative and qualitative traits of economic importance, such as milk production. Currently, we are living in the era of genomics applied to selection work, which will certainly lead to a reduction in the generation interval, correction of pedigree errors and improvement of genetic improvement work. It is expected that the development of dairy farming will continue to occur consistently, reaching new levels in production, reproduction, and useful life of animals, bringing, as a consequence, economic return and sustainability to the national dairy activity (MEUWISSEN et al., 2001).

Genomic selection (GS) proposed by Meuwissen et al. (2001) uses high-density marker panels to predict genomic breeding values. This method is based on the assumption that part of the markers would be in disequilibrium of linkage with quantitative trait loci (QTLs), making it possible to predict genomic breeding values. The use of genomic information increases genetic gain by substantially reducing the generation interval and increasing prediction accuracy for young animals (HAYES et al., 2009). These advantages, associated with the rapid development of molecular biology techniques that enable high-density genotyping at lower and lower costs, have led to the rapid

adoption of SG in the selection of the Holstein breed by several countries. In genomic selection, a reference population is genotyped with a panel of high-density SNP-like (single-base polymorphism) markers and phenotyped for the traits of interest (MEUWISSEN et al., 2001). By means of statistical procedures, these data are used to construct a prediction equation that will allow the obtaining of genomic genetic values for individuals who are genotyped, but who do not have a phenotype (candidates for selection).

Using Holstein breed data from 26 traits and a panel of approximately 50,000 markers, VanRaden et al. (2009) showed that the reliability of the predicted values was 50% for the genomic predictions and 27% for the traditional method, i.e., an average increase of 23% for the various traits. These data show the great potential of OS in the genetic improvement of dairy cattle, since the increase in the prediction accuracy of young bulls will result in greater annual genetic gain. SG is already a reality in international dairy cattle breeding and is already being incorporated into national genetic improvement programs, which will undoubtedly contribute to increasing the productivity of the dairy herd.

FINAL THOUGHTS

Milk production and productivity have shown remarkable growth in the last 30 to 40 years in Brazil. Growth in productivity has exceeded 100% and in production it is close to 500%. Productivity is still low, not exceeding 1,600 liters per cow per year considering all herds, most of which are made up of non-specialized animals and with an inappropriate management system for efficient milk production. However, when considering the productivity among the herds participating in the main genetic improvement programs in the country, as well as the productivity in the European breeds, it is clear that productivity is much higher, and it is perfectly possible to double the productivity of the national dairy herd in a very short interval, provided that producers have at their disposal policies to encourage the increase of production. through the adoption of quality-based payment measures, expansion of technical assistance with a view to the adoption of technologies in management, health, reproduction and, above all, the massification of the use of artificial insemination and other reproductive biotechniques that allow large-scale use of semen from proven bulls. Considering the information presented, as well as the future implementations of new selection procedures and crossbreeding systems, the contribution of genetic improvement programs to dairy farming is unquestionable and remarkable in Brazil.

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