

From the Editors—Animal selection: The genomics revolution

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Guest Editors

The rapid improvements in high-throughput single nucleotide polymorphism (SNP) genotyping technologies, ever-denser SNP arrays accompanied by reduced costs for genotyping and for sequencing, open the possibility of using genomic information in livestock selection. The industry is thus facing the new paradigm of “genomic selection,” in which genomic information may reduce costs and accelerate genetic gain by reducing generation intervals.

Genetic markers, or SNP, are highly abundant in the genome, and high-throughput molecular technologies allow the inheritance of hundreds of thousands of such markers to be traced through generations for currently less than US \$200 per animal. Even if the mutations themselves do not directly affect the phenotype, they can track for the variability of causal mutations in their vicinity. By summing the effects assigned to each SNP, we can create a numeric value (genomic breeding value) that allows the genetic potential of a breeding animal to be assessed. This is an enormously valuable tool for choosing breeding animals as parents of the next generation. In addition, genomic selection may allow the identification of superior individuals for traits not currently considered in animal breeding plans because of technical difficulties. For example, the fatty acid composition of dairy and beef food products, increased disease resistance (and thus increased animal welfare), and decreased methane emissions in cattle help to address the needs of consumers and society for sustainable and cost-effective food production. The animal breeding industry is currently adapting selection procedures in each species to include this innovative tool. This is causing a worldwide restructuring of the animal breeding industry. As an example in dairy cattle, large international consortia are being formed to develop joint precompetitive research and tools. For similar reasons, in the future, genomic selection might help close the gap between countries with greater and lesser production.

The scope of this issue of *Animal Frontiers* is to provide a worldwide overview and various perspectives on intermediate-term scenarios resulting from the application of genomic tools in different livestock species.

Genomic selection has already had a huge impact in genetic selection-related industries. Such industries have had the same structure for at least 3 decades. Subsequent to the research conducted by animal geneticists in the 1960s and 1970s, mainly by Charles Henderson and his group, animal selection remained the same for many years. Of course, new traits were included and new species were selected in addition to dairy cattle, but the industry structure generally remained the same. During these years, genetic selection also incorporated new computer technologies and animal reproduction discoveries to improve the identification of superior animals. The genomic revolution created large changes in this structure. New actors

appeared on the scene. In this issue of *Animal Frontiers*, relevant technicians and scientists were invited to focus on the impact of the genomic revolution on the genetics industry and to forecast future developments.

Dairy Cattle

Jonathan Schefers and Kent Weigel of the University of Wisconsin discuss how the introduction of genomic technology affects the animal breeding plans in dairy cattle (Schefers and Weigel, 2012). They describe the factors affecting genetic gain and how the genomic approach will improve the rate of genetic progress in comparison with traditional selection schemes. They also discuss how genomic technology will affect female population management and selection and how reproductive technology combined with genomic tools may affect the rate of genetic progress in the dairy cattle population. For this reason, many breeders are already applying genomic selection both when purchasing semen and when deciding the animals in the herd on which to use reproductive technologies. Genomic testing is used not only by farmers, but also by artificial insemination companies to decide which young bulls must be purchased as well as which animals can make positive genetic contributions to the next generation.

André Eggen, from Illumina Inc. in San Diego, California, focuses on the development of genomic tools in the recent past and how the new paradigm applies in the agricultural sector, including livestock (Eggen, 2012). The author transports the reader into the new genomic era and the utilization of its tools, describing how the new model is shifting industrial applications in the animal breeding sector and in what ways the new genomic technologies will enter the agro-genomic industrial business. Eggen (2012) explains that the breeding structure will change the traditional scheme of progeny testing for young bulls to select the best future sires. Traditionally, the genetic values of young bulls had been estimated only by analyzing the data of relatives, namely parents; however, in the genomic paradigm, testing the DNA gives a much more accurate first estimation of their genetic value. Selection for traits that were typically difficult to measure can also be part of the selection scheme when using genomic techniques. The females that traditionally have had genetic value estimations with low accuracy have finally become important in the selection scheme with genomic tools because of the greater accuracy able to be obtained through genomics.

One of the main implications of applying genomic selection is that it leads to international cooperation among groups in animal breeding. The Interbull Centre, located at Uppsala University in Sweden, has for many years offered international genetic evaluations to International Committee for Animal Recording members. Their genetic evaluations have used the most advanced techniques of quantitative genetics since they were first available, and now with the genomic technologies becoming available, it

is logical that the expert staff at Uppsala would include this new information in their evaluations. The manager of the Interbull Centre, João Dürr, and one of the founders of Interbull, Jan Philipsson, discuss the worldwide scenario for dairy cattle selection in the future (Dürr and Philipsson, 2012). The authors provide the possible future scenario of dairy cattle international genomic evaluation and describe the expected world scenarios. They show that even with the application of genomic techniques, the Interbull international evaluations are still very important and relevant for both large and small populations.

Beef Cattle

The beef cattle industry is increasing in importance, especially in the southern hemisphere, and Latin America has already become the most vital continent for beef cattle production (Arelovich et al., 2011; Domingues Millen et al., 2011; Galyean et al., 2011; Zinn, 2011). Hugo Montaldo, Eduardo Casas, José Bento Sterman Ferraz, Vicente E. Vega-Murillo, and Sergio Iván Román-Ponce describe the opportunities to enhance beef production in the Latin American context (Montaldo et al., 2012). After a description of the beef production sector, the authors discuss the utilization of genomic selection tools from a short-term view and a long-term perspective, introducing, through genomics, the concept of “selecting for a larger number of traits more related to the economic performance of the animals under specific environments.” This paper shows that, given the specificity of the beef cattle industry, this sector of animal breeding will have a large impact by using genomic techniques.

Poultry

The poultry sector has always been quite different from other sectors of the breeding industry. Only the application of genetic improvements to swine is similar to poultry selection activities. Janet Fulton from Hy-Line International in West Des Moines, Iowa, describes the development of genomic technology and its application in the poultry industry, and she explains the specificity of poultry sector selection and how genomics is applied using different approaches than for other domestic species (Fulton, 2012). She discusses how the novel research in genomics has been applied in poultry breeding and how additional sources of genomic variation may enter poultry selection. Fulton (2012) explains in her paper that even though the sequencing of the chicken genome was publicly released in 2004, major problems still need to be overcome before a deep knowledge of much of the basic information is achieved, which is necessary for major poultry breeding companies to use genomic data to improve poultry selection.

This third issue of *Animal Frontiers* tries to explain the impact of genomic technologies in the animal genetics industry. The structure of this industry had been quite stable for the last 30 years. With the application of DNA analysis in recent years, selection activities worldwide have changed dramatically. For this reason, we can call the application of genomic techniques a real revolution. The authors of this third issue of *Animal Frontiers* all conclude that the application of this technique will have a large impact on the animal industry.

As mentioned in previous issues of *Animal Frontiers*, we welcome feedback and input (including letters to the editor) discussing content in any of the published articles. We are presenting the third issue of *Animal*

Frontiers, and we certainly welcome suggestions for topics for future issues of the magazine and feedback to the editors and managing board to improve the magazine as we move forward.

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About the Authors



Alessandro Bagnato is associate professor of animal breeding and genetics at the Faculty of Veterinary Medicine of the University of Milan. At present, his research activity is mainly focused on the identification of markers associated with quantitative trait loci and on the application of genomic selection in livestock. In close contact with the animal breeding industry and breeders' associations, he is also involved in genetic improvements for production, health, and functional traits in dairy cattle by using genomic technologies.



Andrea Rosati is the secretary general of the European Federation of Animal Science (EAAP) as well as of the World Association for Animal Production. As secretary general, he also manages the International Committee for Animal Recording, the international agency that sets standards for animal identification, performance recording, and genetic evaluation. He has held the current position since 2002, after having managed a DNA laboratory and having worked for the Italian Animal Breeders Association. Rosati earned his BS degree from the University of Perugia

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