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Genetic improvement in dairy cows. The essence of true animal production

El mejoramiento genético y la producción de leche. La esencia de una realidad de producción animal

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Abstract

The dairy production has been one of the biggest areas of development of the Zootechnics. This one meets genetic breeding, achievements in the milk production, disposition of the udder, speed of milking, variation in the chemical composition, milk performance in by-products; likewise, the advance in the nutrition to attend to the requirements of high volumes of milk, evolution in the production systems, technological innovations for milking, cleaning and quality insurance of the final product, use of biotechnology for the optimization of production and reproduction, generation of new breeds and study of possible productive features of local genetic resources. The objective of this document is to present, in the 80 years of the Faculty of Agricultural Sciences, a brief synopsis of the dairy production, as an honoring to the professionals and producers that have taken part in the development, especially of the racial bovine groups Lucerna and Harton del Valle.

Key words: Animal production, bovines, domestication, genetic, milk production.

Resumen

La producción lechera ha sido una de las grandes áreas del desarrollo de la Zootecnia. En ella se reúne el mejoramiento genético, logros en la producción de leche, disposición de la ubre, velocidad de ordeño, variación en la composición química, rendimiento lácteo en subproductos; así mismo, el avance en la nutrición para atender los requerimientos de los altos volúmenes de leche, evolución en los sistemas de producción, innovaciones tecnológicas en el ordeño, higienización y aseguramiento de calidad, uso de biotecnologías para la optimización de la producción y la reproducción, generación de nuevas razas y estudio de posibles bondades productivas de recursos genéticos locales. El objetivo de este documento es: en los ochenta años de la Facultad de Ciencias Agropecuarias, presentar una breve sinopsis de la producción lechera, como un homenaje a los profesionales y productores que han participado en su desarrollo, en especial de los grupos raciales bovinos Lucerna y Hartón del Valle.

Palabras clave: Bovinos, domesticación, genética, Hartón, zootecnia.

History of milk production

Agriculture Discovery, allowed in human san evolutionary jump by moving from being nomads that collect to sedentary collectors; previously, animal domestication that starts at the neolithic with dogs, sheep and goats (Arias and Armendariz, 2000), allowed to have sufficient protein resources throughout the year. Through domestication, the man showed its hegemony over the animals and dominated species that could be used for their benefit; this was a turning point towards modern civilization, as the man left his vegetarian habits passing to use of animal protein in their diet, which led to greater and faster brain development (ILRI, 2005).

The difference in the base sequence of the genome between humans and their closest living relative, the chimpanzee, is only 1%. In this small percentage changes that allowed developments, such as the expansion of the brain, morphological and functional changes in the wrist and thumb of the hand (which undoubtedly were useful in the milking), and physiology and biochemistry of the body occurred facilitating the digestion of new food to our ancestors. This allowed, 9,000 years ago, that adults could consume milk (capacity that was restricted only to infants of other mammals), bringing the rise of the need for milk and livestock development (Alva, 2015).

Aurochs, seems to be the common ancestor of today's cattle, it originated the *Bos primigenius primigenius* (Euroasiatic aurochs), *Bos primigenius namadicus* (Indian aurochs) and *Bos primegenius africanus* (African aurosh) (Clutton, 1987). By genetic technics of mitochondrial DNA (only transmitted by the mother), it has been possible to establish that in the origin of cattle species no more than 100 individuals participated, this, with no doubt, indicates the low genetic diversity of dairy cattle.

Cattle distributed around the world according to population migrations, each region breed a particular breed in Europe, Africa and Asia; thus, two big genetic trees appear: the one from European origin (*Bos taurus taurus*) and the Asiatic one (*Bos taurus indicus*) (Loftus *et al.*, 1994). Centuries later, with the Spanish colonization (15th century) and they came to America and later, thanks to the expansion of the British Empire to Oceania. Currently dairy cattle are present on all continents.

According to Schmidt and Van Vleck (1975), the first evidence on the use of cattle in domestic life, milking and milk use are around 10,500 BC, in the near east; this comes from the first settlements of farmers in Europe; first, tabloids of clay with references to human groups in an attitude of extracting milk from cows; subsequently cave paintings with scenes of milking were found corresponding to the Sahara Desert. Finally, in 4,300 years old Egyptian tombs it is found what appears to be remains of coagulated milk, now known as cheese. In the 13th century Marco Polo tells that the Tartars caught mare's milk, dried it in the sun, separated butter and then drank it mixed with water.

Cheese preparation was surely discovered by several communities simultaneously. In the old Egypt, cattle was cared and milked to obtain milk, meaning that the cheese discovery was closely linked to milk management, this was stored in skin, ceramics or wood containers; because of the residues, poor hygiene and weather conditions, the milk was quickly fermented; the next step was to extract the whey from the curd to make some kind of fresh cheese without rennet, tangy and acid.

In ancient Greece, the use of milk was common in both food, and sketches of cosmetology. Hippocrates, father of medicine around 400 BC, prescribed fresh milk as an antidote to poisons. Also, the bathrooms in milk were common as it was associated to powers attributed to maintaining youth. In mythology it was believed that in the origin of the "Milky Way", the stars came from the drops of milk that the mother goddess let out when she was nursing. The Old Testament makes an epic reference to milk when talking about the Promised Land for Jews, says "... land flowing with milk and honey".

The American cattle

In America, cattle arrived in the second journey of Colon, at the end of the 15th century (Gomez and Rueda, 2011). It is possible that some nuclei could come from the Canary Islands, however, most of the population comes from the European continent, being Spain the distribution center. The departure port was Cadiz in Andalucia; therefore, it is considered that breeds from Andalucia and Extremadura (Retinta, Berrendas and Rubio Gallego) could be the origins of the creole cattle breeds in South

America. The first cattle were small and robust, characteristics required for the long trip from Spain. The settlement was fast, from La Española island (today Santo Domingo) where the first cattle specimens arrived. From there, were dispersed to most of the Caribbean and north of South America countries. Other routes for the cattle settlement in South America were localized towards the south of the continent and from Central Brazil (Bahia) coasts.

Rodrigo de Bastidas was the first colonizer who introduced cattle to Colombia. In 1524, the crown gives him a royal decree, which allows him to bring to the port of Santa Maria (now Santa Marta), 200 cows, pigs and horses, from the La Española Island. By 1531, Francisco Pizarro heads south from what is now Panama, carrying horses and cattle; in this second route also apparently come to Colombia cattle. A route that certainly peopled the inter-andean valleys was employed by Sebastian de Belalcazar, important distributor of cattle in various regions of the country.

Cattle, unknown to the natives, were populating the plains of the Caribbean and the Orinoco; sometimes as a product of the requirements of the Crown to colonists, in which to found a settlement was necessary to guarantee a number of cattle, pigs and poultry to feed the population; in other cases, the strong presence of the church who handled important areas of land and considered the cattle as a source of labor and wealth generation; thus in the savannas of the Meta River, stands the Sanmartinero, landbreed originated in cattle brought to the area by the Jesuits. The rough road conditions and the enormous distances in the processes of colonization, gave the natives cattle survivors adaptation, rusticity and gentle temperament.

The native Colombian cattle (Costeño con Cuernos, Romosinuano, Blanco Orejinegro, Chinosantandereano, Sanmartinero, Hartón del Valle, Casanareño and Caqueteño), owe their name to their phenotypic characteristics or place of origin; they were the predominant breeds in the country until the second decade of the 20th century. Their adaptation to hot and humid weather, low quality forages and low genetic selection, allowed these breeds to develop their productive potential without major manipulations (Sourdis, 2008).

The onset of milk production was slow, mainly because the absence in the native population tradition of use of the cow, the dairy use was late; the first cattle were used for traction and work and, as a source of meat. Dairy consumption focused on fresh milk and processing into products (cheese, butter, cream, yogurt and buttermilk) only occurs in industrially late 20th century.

In 1872 was recorded the first importation of Holstein breed cattle; this breed will be the origin too most of the dairy cows in the country; other breeds such as Brown Swiss (comes in 1928), Ayshire (comes in 1910), Jersey (imported in 1946) and other racial groups were crossed with creole bovine, generating multiple racial combinations currently known as multiracial groups, which are also composed of *Bos taurus indicus* cattle.

By 1915, specimens from the Zebu breed came from Brazil, since then, big changes in the cattle composition and their productive use started. In the 70s, Gyr cattle arrived to the country, a zebu dairy breed from India, its arrival changes the dairy crosses in Colombia; according to Asocebu (2014), "*Colombia has around 40 million of hectares dedicated to livestock,, more than 60% of them are lower than 1000 masl with temperatures around 23 °C ad 32 °C. From 26.300.000 of cattle in the national count, at least 95% have zebu genetics*". Zebu cattle give an important condition and particularity to our dairy production type, the cross between zebu breeds (*Bos taurus indicus)* and breeds from Europe (*Bos taurus taurus)*, gives origin to the know "double-purpose" which is not a breed but a production type or model where grazing, milking with calf and raise of all the born animals is the purpose of the farm.

In Colombia 80% of the produced milk comes from double-purpose systems, only 6% is obtained from special breeds in semi-intensive systems, the rest comes from breed systems with meat production purpose.

Milk composition and per capita consumption

Milk is the only food at early growth stages in mammals. In fact, its high nutritional quality has made its consumption to be stable and increasing day per day through the centuries, being basic for human diet. Milk chemical composition comprises more than 100 identified components. In principle, milk is composed by carbohydrates (lactose), fat (mainly triglycerides), protein (casein), minerals and vitamins in solution, emulsion or suspension in water. In percentage, milk is 87.6% water, 4.6% lactose, 3.8% fat, 3.2% protein and 0.8% minerals and vitamins, making a complete balance as individual food. The chemical composition of milk is different depending on the cattle breed, nutritional characteristics, season of the year, nursing stage or age, among other environmental factors.

Milk is ideal as food for newly born; their main minerals such as calcium and phosphorus are associated to casein in the milk, their release is controlled during the curdling, while the whey is the first source of hydration since 95% of it is water.

According to FAO (2014), "*Milk as food provides 3% of the energy supply in Asia and Africa, in comparison to the 8 to 9% in Europe and Oceania; 6 to 7% of the protein supply in Asia and Africa, in comparison to 19% in Europe and; 6 to 8% of fat supply in Asia and Africa, compared to Europe, Oceania and America where supplies 11 to 14%".* Currently (2014) is calculated that six thousand millions of people consume milk worldwide and in 2030 the consumption will increase in 125% driven by the Asiatic market.

Milk *per capita* consumption is divided into three large groups: high consumption countries, meaning 150 kilograms or more of milk per year which includes Europe, Argentina, Pakistan, Israel, Australia; middle consumers with 30 to 150 kilograms/year, include India, New Zealand, Japan, Kenya, North Africa and most of American countries and; finally, the low consumers have less than 30 kilograms of milk or milk derivate per year in their diets, and correspond to southeast Asian countries and most of African countries.

In past decades, global production of milk increased significantly; in the last 24 years, this increased 32%, however, the *per capita* consumption of milk decreased in 9%, indicating that the milk production did not follow the population growth; this could be attributed to demographic increase, fall in the milk production in developed countries and increase in the new consumers as the people from southeast Asia (Knips, 2005).

In Colombia the consumption is asymmetric and is about 143 kilograms per habitant/year, from which 1.2 kilograms are cheese. Consumption of both, fresh milk and cheese, are low, which is in part due to the purchasing power and the local idiosyncrasy without tradition for consumption of mature cheese, fermented by-products and long life products. FAO´s recommendation for keeping an adequate nutrition is of 170 kilograms/people/year. The global average is 104 kilograms/year and although it is increasing, there are big differences in the consumption trend at the regional and economic levels. Developed countries consume 3 to 4 times more than the under developed countries.

Global production of milk in 2014 was 780 million of metric tons. The main producing countries are India, USA, China, Pakistan and Brazil. At national level the production reaches 6.5 million of metric tons; three main milk producing areas are identified: the Cundiboyacense Plateau, Atlantic Coast that includes the milk production area of Antioquia and the Southwest basin where Nariño is the main producer.

In the world the milk is associated to small producers. Around 160 million families are responsible of its production, for them the milk is source of economic wellness and food security. These 160 million of homes have as main income the milk production, especially in under developed countries where milk is centralized in family farming that support adverse conditions due to specific geographic areas, wet or hot weather, low quality forages, diseases and limited access to markets and services (Knips, 2005).

In Colombia, 87% of the milk is produced in family units, with less than 25 animals, the local milk production is not highly technified, requires high labor and participation in the gross domestic product.

Development and trends of milk production

Hundreds of years of natural and human selection, genetic derive, endogamy and crossings contributed to the animal diversity of milk producers, allowing the breed of cattle in diverse environments and production systems (ILRI, 2005). For instance, between 1983 and 2003 the global average annual increase per selected Holstein cow was 193 kilograms in USA, 131 in the Nederland's, 42 in Ireland and 35 in New Zealand (Dillon *et al.,* 2006).

Milk industry suffered drastic changes since 1900 but, from the Second World War the restructuration was dramatic. This was based on three key pillars: technology development, changes in milk production system and genetic specialization. Technology innovation revolutionized the agriculture and improved the efficiency of milk production through introduction of equipment and machines (milking machines, feeding systems, residues management, cooling tanks, etc.). The change in the production system had a strong effect like innovations, from the milk production based on grazing to confinement systems where the animals are fed according to their nutritional requirements. Last, with the specialization, milk production changed from being an activity, maybe a secondary one in the farm, to be the most important one; contributing also to build dairy regions that are identify by the society (Blayney, 2002).

Towards the end of the 19th century it was demonstrated that the thermal treatments were efficient to destroy bacteria in milk. This was the origin of a method that allowed the product preservation and a fundamental hygienic measurement to protect human health; this is how the milk industry appears (Schmidt and Van Vleck, 1975).

During the last 50 years, the dairy sector in the developed countries has evolved towards biggest farms with more annual milk production per cow. The motor force of this development has been the farmers' capacity to increase their incomes through higher productivity and technology adoption, which often need high capital investment and, simultaneously, the pressure for profitability and cost reduction (Gerosa and Skoet, 2012).

The milk production increase drove technology changes in the sector, allowing important increases in productivity and development of big dairy companies. At small scale, the milk producers in developing countries have stayed on the margin of such developments. This is because most of the milk in these countries is still produced under traditional systems, with low or no mechanization, or lacking technological innovations; few large scale units are found in developing countries, and they are not an important percentage (Gerosa and Skoet, 2012).

Dairy companies in the world confront changes and challenges and permanently are obliged to reconsider their production strategies. The most important challenges are the increasing demand for dairy products together with the concern on milk supply, which grows slower than the demand. On the other hand, there is an increasing number of challenging situations; the consumption needs in combination with the increase in consumers power, among others. In consequence, the industrial effort for fusions, acquisitions and strategic alliances in the dairy sector has been important (Knips, 2005), showing structural changes and adoption of diverse productive strategies in the global dairy sector which allow eligibility for new market requirements and projects on food security (Caja and Medrano, 2006).

In Colombia, the process of development and productive structuration was similar to the rest of the world, although was slower and with less land coverage. Industrialization was built empirically several years ago, and started when influential landowners brought special cattle starting the modernization process in productivity and dairy transformation, also in the food production for the cattle since their nutritional needs were higher (Quintero, 2011).

Ruminants' nutrition: achievements and challenges

Practical nutrition of animals comes from the ancient Rome; Plinio gave precise recommendations on the importance of suitable food to get good productive results, the best quality of young grasses in comparison to mature ones and the effect of legumes on the soil fertility. The practical knowledge on nutrition and animal feeding exists since the animal domestication and, in several cases it is the predominant in extensive livestock systems. With the time it has been perfected and evolved till the 18th century when the scientific bases were settled mainly due to the works of Lavoisier. The advance in nutrition as science has relied on physics, chemistry and biochemistry (Van Soest, 1982; Drackley *et al.*, 2005).

In temperate countries it is important to confine animals to protect them from winter, this allowed, the indirect feeding in quantity and quality to satisfy the nutritional needs of the animal. Thus, the environmental factors that affect the consumption were controlled, and the feeding operations were generalized for confinement during the whole year ensuring a similar or higher feeding than the one required by the animal (hays, silages, silage), together with good availability of concentrated food and by-products of agroindustry of biofuels (alcohol), energy sources (corn in grains) and protein (soybean cake), at good prices. Its sustainability has been questioned and alternatives have been proposed and widely discussed (Kebreab, 2013).

Modern dairy farms in USA are more efficient in comparison to 1944. To produce the same amount of milk (a billion Kg), currently are used 21% of the animals, 23% of food, 35% of water and, 35% of land. Production of manure is 24%, methane 43% and nitrous oxide 56%. Balanced nutrition have allowed the increase in productivity and efficiency (Capper *et al.*, 2009; Drackley *et al.,* 2005).

Nutritional standards (meat cattle, milk cattle, double-purpose) are trustable and precise. They are based in universal layers of Thermodynamics that operate in any geographical location in temperate and tropical zones (McLennan and Poppi, 2012).

In the tropical production systems the animals are grazing since they are born, their nutritional needs are known and validated but, the productive levels and production efficiency are still low. The developments reached in New Zealand and Australia are paradigmatic and confirm the rule. To satisfy the needs of the growing population large areas of old forest and tropical forest have been colonized and increased the livestock population (CSIRO, 2007).

Nutrition of grazing ruminants still remains more an art than a science, is based on error and success; despite the large and continuous progress made in recent years. The first version of the nutritional requirements of zebu cattle called BR CORTE was made in 2006, and showed that the requirements of Nellore cattle, raised in the prevailing conditions in Brazil, were lower.

According to the methodology of dynamic systems (DS) (Nicholson, 2015), complex problems can be studied and gather information about where interventions should be done to correct the model structure. The DS is a grazing system that allows formulation of hypothesis, in an integral way, about the nutrient standards, requirements with different production systems, nutrient supply, voluntary intake, the factors that modify it, nutrient levels in grasses, and he high diversity and variability in time, since all is complex and dynamic.

Nutrition of grazing ruminants, different than the feeding operations in confinement, unbalanced diets are predominant; in practice, it is not possible to balance the diet. The voluntary intake of dry matter is unpredictable and the nutrient content is very variable. There is no control on the factors affecting consumption and the nutrient level supply is, in general, deficient and unbalanced, reflecting low production efficiency. This is one of the problems that needs to be solved and fortunately some techniques to solve it are available. Focal near infrared spectroscopy (F-NIRS) can, using feces, determine the nutritional quality (energy, protein) of the consumed diet, is possible also to determine the voluntary intake of dry matter; the method is cheap and can be done in real time (Texas A&M, 2010). The second component in ruminant nutrition (nutrient supply) has limited the use of the achieved developments, this limiting factor is probably solved in the next years. The mathematical component of the equation –the nutritional requirements are well known and solid and, each day is more precise and sophisticated (McLennan and Poppi, 2012).

Thonney and Hogue (2013) demonstrated the intrinsic error in the formulation of balanced diets when determining a consumption level of dry matter, and based on that intake the level of nutrient requirements are determined without considering the contents of the ingredients that, in turn modify the dry matter intake. The method based on the content of Fermented Detergent Neutral Fiber (FDNF) is proposed, it is recognized that the dry matter intake is affected by the different dietary components and that the suitable component levels (non-structural carbohydrates, fermentable detergent neutral fiber, indigestible detergent neutral fiber, raw protein, ether extract and mineral-ashes) can prevent common metabolic problems.

With the increasing issues of a growing population, climate change and increasing inequality it is reasonable to give a twist to animal nutrition and evolve. Recently, FAO (Makkar and Ankers, 2014).

The great achievements of animal production: feed efficiency and high productivity, found in countries with confined feeding operations can be achieved and even overcome in our environment. The genetic potential of animals is important, but generally improved nutrition is responsible for the great advances that allowed in the past to feed the human population in the future surely will be achieved if we can apply scientific knowledge animal nutrition.

Milk production and bST

Under tropical weather conditions the most frequent problems confronted by producers still are low milk production and short length of lactation time, for both pure and mixed cattle, it has been attributed to genetics of the individuals, room temperature and hormonal factors that can affect production (Sitprija *et al.,* 2010).

Among the strategies that have been proposed to solve problems in milk production techniques for estrus synchronization, artificial induction of lactation, practices during the transition period and use of growth hormone (GH) in the middle phase and late lactation are found (Caja and Medrano, 2006).

The GH action as stimulating factor for milk production have been widely studied, by recombinant technologies the hormone was synthesized for its use at large scale in cattle. Commercially it is known as recombinant bovine somatotropin (rbST) that is biologically equivalent to natural GH derived from the pituitary (Settivari *et al.,* 2007).

Several studied with application of rbST have demonstrated that it increases milk production and extends the persistence of the lactation curve, its use is a management tool that improves the production efficiency in livestock farms and, although its use has been under discussion, till now no adverse effects have been found for human health after intake of such milk. However, descriptions of some risks for the animal because of the use of this product are described according to the lactation phase in which the application is done, finding that the animals should be under positive energy balance (Raymond *et al.,* 2009).

Data from a meta-analysis about rbST use on Holstein cattle show a significant increase in milk yield based on the number of births per animal; first birth cows increased their production in 11.3% and several births cows increased in 15.6% during the treatment (Dohoo *et al.*, 2003). The rbST has been also used in heifers under lactation induction by hormone treatments, increasing their production in 15.5% at 305 days of lactation (Macrina *et al.,* 2011).

Local genetic groups: Harton del Valle and Lucerna

Adaptation is defined as the changes that allow the animal to reduce its physiological setbacks produced by the environmental components of its surroundings. One of the main qualities given to the Harton del Valle and Lucerna breeds is its genotypic and phenotypic adaptation capacity that have given them their higher survival.

Lucerna breed is a genetic effort for combining breeds from the north of Europe with creole ones to get a racial group adapted to tropical conditions. Rusticity, higher potential and aptitude for milk production in comparison to other breeds were achieved (3,000 liters per lactation). It was the first breed in Iberoamerica and recognized as synthetic breed in 1983.

Studies indicate that the breed composition is 40% Holstein, 30% Harton del Valle and 30% Shorthorn Lechero. The physiological qualities of the breed are seen by its vigorous and healthy constitution, high adaptability, rusticity, grazing abilities, disease resistance and excellent fertility in hot weather, together with outstanding longevity and low mortality (Durán *et al.,* 2009).

Harton del Valle is a creole bovine coming from the cattle introduced by the Spanish conquers and subjected to a long natural selection process, that gave it adaptation which is reflected in its capacity to survive under hot, wet or dry environments, with low quality food and water scarcity, high fertility with 365-390 days of interval between births and birthrates over 90%, lower susceptibility to parasite diseases and better production of meat and milk. Milk production and lactation length are close to 2,100 liters in 280 days under specialized milking, or 1,450 liters and 270 days with milking and standing calf (Casas and Valderrama, 1998). The producers use this breed mainly as double-purpose 60% and for milk production 30%; it is common that the breed is used in genetic breeding of racial crosses “tri-cross”, where the Harton gives rusticity and dairy quality.

From the genetic group of Harton del Valle its genetic diversity has been studied in general and specific researches on variability of genes for milk proteins like κ-casein, β-lactoglobuline and α-lactoalbumine have been done; similarly, the possibility of presence of genes for resistance to prevailing pathogens in the country, among them the ones associated to mastitis (Rosero *et al.*, 2012); also, the lactation curve has been characterized together with the chemical composition of milk that shows high values for total solids, which is with no doubt the genetic value of this breed group .

Perspectives for animal genetic breeding in the tropics

During centuries, breeders have manipulated efficiently the animal genotypes with productive goals, using the fact that among the species, breeds and populations are the natural variations (Eggen, 2012). The observed performance or phenotype of the individual is the result of the interaction between genotype and the specific environment where it grows. Due to this, researchers, through quantitative genetics have tried to separate the phenotype components: additive genetic, non-additive, environmental and their interactions, and as such to predict the genetic merit of an animal taking as basis the phenotypic records of individual performance and pedigree (Berry *et al.,* 2011; Goddard, 2012).

Currently, for genetic evaluations in bovine the performance information is analyzed together with the pedigree by flexible and precise statistical methodologies such as mixed models (Martínez *et al.,* 2012; Montaldo *et al.,* 2012), with the use of the animal model, this is a lineal model of each one of the fixed effects (e.g. year, season) and the random genetic and no-genetic effects that contribute to the individual phenotype for one or more characteristics. This information is combined with a series of matrices that define the covariance of the effects of individuals in the population (Hill, 2012).

Use of mixed models provides the BLUP (Best Linear Unbiased Prediction), a statistical tool that simultaneously determines the best linear unbiased estimators of fixed effects ad genetic values, in this way the breed values of the individuals for the different characteristics of economic importance are obtained (Martínez *et al.*, 2012; Montaldo *et al.,* 2012). BLUP methodology have allowed the genetic evaluation at large scale among populations, increase in the precision of selection and consanguinity control (Nguyen and Ponzoni, 2006). The BLUP animal model approach is one of the main methodologies used for genetic evaluations in bovine in several countries (Montaldo *et al.,* 2012).

Despite that the traditional methods for animal breeding have been successful, their efficiency is reduced when the characteristics to breed can only be measured in one sex (milk production), after death (meat quality), late in the animal life (longevity) or if its measurement is costly (methane production, food efficiency) (Goddard and Hayes, 2009; Eggen, 2012). Therefore, to breed these characters other techniques have been proposed focused on the identification of genes that determine their expression and, the later selection of animals carrying the favorable alleles (Goddard and Hayes, 2009).

In the last years, the fast evolution of the “omics” techniques have developed new knowledge and tools for genetic breeding programs in bovines (Goddard, 2012). These advances have led to new methods of production that allow permanent increases in animal performance and improves in the efficiency of livestock production in the long term (Eggen, 2012).

Among the “omics” techniques of more application in animal breeding is the assisted selection by molecular markers (MAS) and the genomic selection (Berry *et al.,* 2011).

MAS allows the establishment of a link between heritage of a characteristic of interest and the segregation of genetic markers that are specific and measurable, that are associated to genes that affect the expression of the characteristic (QTL – Quantitative Trait Loci) (Berry *et al.,* 2011). Genetic linkage between markers and a QTL (known also linkage disequilibrium) happens when two loci are closely enough in the genome to avoid recombination during meiosis, in this way the segments in the chromosomes are conserved and inherited from parents to the progeny. For this reason, the selection of markers linked to a QTL results in a productive response on the character of interest (Miller, 2010). Among the genetic markers the SNPs (Single Nucleotide Polymorphism) are found, they are variations in a single base of the nucleotide sequence of DNA and are common mutations happening in the genome (Ángel *et al.,* 2013).

MAS have allowed the breeding of low heritability characters, in case of bovines good results on characteristics such as meat tenderness, milk composition and disease resistance have been obtained (López *et al.,* 2007). Despite that MAS have improved the precision of selection in animals, still there are obstacles that limit the massive use of this technology. The main limiting factor is that a previous knowledge in the genes or markers that are associated on a specific population is required, additionally, the QTL identification cannot explain all the genetic variation of a quantitative character and is for that fact that MAS only explains part of the genetic difference among individuals (Eggen, 2012; Berry *et al.,* 2011).

The development of techniques for DNA genotypification allowed to know the genome sequences of different species at low cost. This has allowed sequence comparison in animals of different breeds getting a large amount of genetic markers like SNPs (Eggen, 2012). This information has been useful for wide genome association studies in different animal species of economic importance (Montaldo *et al.,* 2012). In this way from MAS has come the change to genomic selection, which is based on the principle of using the information of several markers to estimate the values of breed in the animals without knowing the specific location of the genes in the genome. With thousands of SNPs well distributed in the whole genome, it is expected that a SNP close to a particular gen or DNA fragment of interest, in this way linkage between one (or several) SNP and a causal mutation will be evident and can be used to explain a significant fraction of the variation in the observed characteristic (Eggen, 2012).

For establishment of a process of genomic selection, first is necessary to count with a large number of animals with phenotypic (measurements of the characteristics of economic importance) and genotypic (information on the SNP of each animal) information. This information will serve as reference to develop a statistical model which will estimate the effect of each SNP with the character of interest. The result will be a predictive equation that allows the estimation of the genomic breeding value (GBV) of each individual. After it is validated, the equation will be useful to estimate the animals GBV from the genotype, without having any phenotype recording (Eggen, 2012; Montaldo *et al.,* 2012). In this way, the genomic selection allows to reduce the generational intervals (when selecting young animals), increase the selection intensity and the precision in the estimation of breeding values to increase the genetic progress in the population (Miller, 2010; Hill, 2012).

Technologies (MAS or genomic selection) give information used as complement for increasing the selection precision in the programs of traditional genetic assessment. Estimations of breeding values based on phenotypic information and pedigree can be combined with genetic predictions coming from markers or with the GBV of the individual. This approach provides a new level of information that can be integrated in the processes of decision making to identify and select the most promising animals (Miller, 2010).

In developing countries the implementation of these techniques such as MAS, has been difficult because of the few animals' populations with genetic evaluations (Montaldo *et al.,* 2012). In Colombia, research has been done to promote MAS in bovines (Echeverri *et al.,* 2011; Echavarría and Echeverri, 2012); however, the lack of suitable records of phenotype for production characters have limited the use of other techniques such as genomic selection.

At short term, it will be necessary the implementation of trustable recording systems, that will be important to get exact estimates of the SNP associations and, like that, predictive equations of high capacity can be determined to identify the best genotypes in the tropical conditions. In this sense, the genomic information will not only help in the joint study of characters of low heritability for production, it will also help in the genetic assessment of populations with or without pedigree information, in increasing the precision to estimate the breeding values in pure or mixed animals, and in the identification of specific populations for conservation processes, considering some local breeds that are well adapted to the tropic and that can be used in selection or crossing processes to develop valuable genotypes (Montaldo *et al.,* 2012).

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