



Impact of using artificial insemination on the multiplication of high genetic merit beef cattle in Brazil

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Abstract

Information about the Brazilian beef cattle industry is provided and the effects of massive use of genetically superior bulls, semen and embryos is simulated to show their important contribution to that industry, as a way to improve the low productivity levels observed in Brazil, one of the leaders in beef exports in the world. Any increase on the use of better genetics will cause a very significant economic impact in the Brazilian beef industry. Amounts as high as US\$ 342 million/yr may be reached in the near future with the growing utilization of fixed time artificial insemination (FTAI), considering only the direct effects of weaning and yearling weights. These values will be even higher if reproductive traits are considered as selection criteria. The indirect effects, which are clearly underestimated in this simulation study, are much more important than the direct ones. The increase on the income of the industry could reach significant amounts, without the need of opening new areas for cattle grazing or destroying forests and devastating the environment.

Keywords: beef industry, cattle, environment, FTAI reproduction.

Introduction and objectives

Brazil is the largest South-American country with 190.8 million inhabitants (Instituto Brasileiro de Geografia e Estatística - IBGE, 2011). It has an area of 8,514,876.6 km², equivalent to 47% of South American territory, and possess close to 12% of the fresh water reserves of the planet. It grows at 1.4% rate per year, with a gross national product (GNP) in 2011 of US\$2,250 billion (R\$4,143 billion) and a per capita product of US\$11,792.00 (IBGE, 2012a, b), being considered the world's 7th economy. Close to 15.6% of the population (29.3 million people) still live in rural areas, while around 23% of the population works for the Brazilian agribusiness.

Brazil has relatively low prices for land and labor and no extreme weather conditions, which helps to build the competitive edge for Brazilian agricultural and animal products. As a counterbalance, socio-economic problems, unsolved for centuries, span several dimensions and reach hazardous levels (Ferraz and Felício, 2010).

Brazilian livestock and agriculture production

is meaningful. According to data from Food and Agriculture Organization and the U.S. Department of Agriculture, based on 2005 crops and 2004 exports, the country is an important producer of livestock, besides beef (Ferraz and Felício, 2010). As related to broiler, Brazil is responsible by 15.5% of world production and 40.7% of exports. In the pork business, the country accounts to close to 3% of world's production, but is the 4th major exporter, embracing 15% of the international market. The country is the top exporter for several agricultural products like soybean (24% of world's production and 33.4% of total trade), sugar cane (32.5% of total production and 42.4% of exports), orange juice (29.7% of total production and 57% of exports) and coffee (28.3% of total production and 23% of exports). Brazilian agribusiness was responsible for 31% of the GNP, 37% of the jobs and 42% of the total exports in 2003. More details on the Brazilian economy can be found in www.ipeadata.gov.br.

More recent data indicate that the agribusiness sector of Brazilian economy is responsible for 22.74% of GNP (Centro de Estudos Avançados em Economia Aplicada - CEPEA/USP, 2012; Agência Brasil, 2012). The superavit of the Brazilian agribusiness in 2011 was close to US\$77.4 billion, while the country's superavit reached only US\$29.8 billion (Agência Brasil, 2012). The most representative part of the Brazilian agribusiness in terms of net income is the beef industry, followed by the sugar cane, soybean, milk and cotton (Confederação da Agricultura e Pecuária do Brasil - CNA and CEPEA/USP, 2012).

Livestock production in Brazil is extremely significant. The different livestock population sizes are: beef and dairy cattle (209.5 million animals; IBGE, 2011), swine (32.39 million), and goat and sheep (9.09 million and 14.18 million, respectively; Ferraz and Felício, 2010). Important information about the Brazilian beef and dairy business can be found in Ferraz and Felício (2010), and Fries and Ferraz (2006).

Some highlights of the Brazilian beef industry:

- The population size is around 210 million heads of cattle;
- 80% of the population has influence of zebu cattle (*Bos indicus*), according to the Brazilian Zebu Breeders Association (ABCZ, www.abcz.com.br);
- Although around 80% of the Brazilian cattle population has *Bos indicus* contribution, only less than 7,000 purebred Zebu animals have been

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imported from India in the last century. The importation from India was forbidden in 1962. The Brazilian *Bos indicus* population was, mostly, upgraded from *Bos taurus* cows, brought to South America by Portuguese and Spanish colonizers;

- The beef breed with the largest number of animals in Brazil is Nelore (standard/horned and polled), followed by Guzerat and Gir. Indubrasil, a *Bos indicus* Brazilian breed originated from crossbreeding among other Zebu breeds, decreased sharply in numbers while another local pooled breed, Tabapuã showed a steady increase;
- Purebred *Bos taurus* is raised in Southern Brazil, a region of temperate climate. Portion of the meat produced by these animals is exported and portion supplies special domestic market niches;
- Crossbreeding is moderately used in all regions of the country, but the highest the *Bos taurus* contribution is, the poorer is the adaptability to tropical environment, especially to ectoparasites (flies and ticks), which causes important impact in production costs;
- The major taruine breeds used in beef crossbreeding are Angus and Red Angus, Simmental, Charolais, Polled Hereford, Limousin and Braunvieh, among others;
- Synthetic breeds, like Brangus, Bradorf, Canchin/Charbray and Santa Gertrudis are also used. In the last decade, *Bos taurus* breeds, adapted to tropical environment, like the Brazilian Caracu, showed renewed interest. Breeds like Senepol and Bonsmara were introduced more recently, as well as composite programs (e.g.: Montana Tropical) which started to grow in the country;
- Uses 140 million hectares of land (all other crops, together, use 75 million hectares) distributed among 1,8 million farms;
- Generates around 7 million direct or indirect employments (Pineda, 1997), corresponding to 8.3% of the 82 million current job posts;
- Around 39.5 million heads were slaughter in 2011 and only 8.6% were finished in feedlots (ABIEC, 2012; Nogueira, 2012), ratifying the importance of pasture production system in the country;
- Brazilian beef production is the second largest in the planet. It produced 9.1 million tons of carcass weight equivalent (cwe) in 2011, while the USA produced a little over 12 million tons, EU-27 produced around 8.1 million tons, Australia and Argentina produced between 2 to 3 million tons and India, which did not appear in statistics before, produce around 2.5 million tons cwe (Associação Brasileira das Indústrias Exportadoras de Carne - ABIEC, 2012);
- The number of beef processing plants and abattoirs is around 750, but is under fast shrinking. Some large industrial plants, processing more than 2,000 animals/day, with modern equipment are in operation, mainly in midwestern part of country;
- Regional distribution of the Brazilian herd is 19.7% in North, 13.8% in Northeast, 18.5% in the Southeast, 13.6% in South and 34.4% in the Center-West (Midwestern region; IBGE, 2011);
- More than 180 million head are located in areas free of foot-and-mouth disease (FMD) and are regularly vaccinated;
- Roughly 170 million animals are used for beef production and 40 million for dairy and/or dual-purpose;
- Cattle population has around 70 million cows, 55 million of them used in beef production and the rest in dual purpose or dairy production;
- Artificial insemination (AI) studs sold 11.9 million doses of semen in 2011 (around 7 million doses for beef breeds and 4.9 million for dairy purpose). Close to 57% of the beef doses of semen were produced locally in Brazilian AI studs and 43% imported. Semen sales rank by breed was: Nelore (horned and polled) close to 3.3 million, Aberdeen Angus 1.8 million and Red Angus 0.57 million semen doses, followed by several other *Bos indicus* and *Bos taurus* breeds (Associação Brasileira de Inseminação Artificial - ASBIA, 2012). Statistics on Brazilian cattle population size and productivity can be found in Ferraz (1996, 1998); Velloso (1996) and Ferraz and Felício (2010);
- Considering 1.5 doses/beef cow bred, on average, 4.67 million beef cows were inseminated, representing 11.8%, one of the largest proportions in the world's beef industry;
- There are close to 3 million beef bulls in service, which points to the need of around 450,000 young replacement bulls/yr. All the genetic evaluation programs in the country together sell around 15,000 genetic superior bulls/yr, less than 3.5% of the needs for replacement bulls. This means that more, better and larger breeding programs are needed;
- The Brazilian beef industry exports over US\$1.1 billion in leather and US\$1 billion in shoes, produced in 4,200 shoe companies and 560 tanning plants.

The Brazilian beef market

Domestic market absorbs close to 7.57 million tons/yr cwe, with a per capita consumption of 39 kg cwe/person/yr (Conselho Nacional da Pecuária de Corte - CNPC, 2011). This means that 82% of total production is absorbed by the internal market.

Brazil is one of the largest beef exporters in the world (1.65 million tons cwe in 2010; CNPC, 2011; ABIEC, 2012). In the same year, cwe exports from different countries were: Australia 1.35 million tons, USA 1.4 million tons, India 1 million tons, New Zealand 478 thousand tons, Uruguay 350 thousand tons EU-27 297 thousand tons and Argentina 270 tons,



(ABIEC, 2012). Brazilian beef business was responsible for around 22% of total beef trades in the world.

The low productivity levels of Brazilian beef industry

There are several reasons to explain the very low productivity rates of the Brazilian cattle industry. The first one is how the herd is fed. The large majority of Brazilian beef herds is fed under tropical pastures condition. That also happens with an important percentage of dairy cows, which are in fact beef cows bred for double purpose, being milk a by-product of calf production. Tropical pastures have a clearly limited production season which coincides with the raining season. The dry season lasts 6 to 7 months, and it is characterized by limited availability of feed, that is also poor quality and presents a low percentage of crude protein. During the dry season, cattle typically lose weight, taking the overall productivity, measured as kg of meat per hectare, to very low levels.

Health status can be mentioned as a second major cause of low productivity. Bacterial, viral, protozoa and fungi diseases are distributed throughout the country. Foot and mouth disease, brucellosis and other reproductive abnormalities contribute to decrease the production in very limited areas.

A third important reason is the low educational

level of farmers and ranchers, that challenges the dissemination of new technologies. Associated with this problem, a fourth reason should be emphasized: there are very few efforts of technology diffusion, due to lack of communication among Universities, Research Centers and ranchers. This is a problem that can be attributed to the local institutions, which do not have a clear and strong extension policy.

Among the important reasons of low productivity, the genetic status of the herd can be suggested as the last, but not least important one. The vast majority of Brazilian cattle are Zebu based animals, which had very few selection efforts and, consequently, an average genetic merit lower than *Bos taurus* for beef and milk production. The *Bos taurus* breeds have many decades of selection. Genetic evaluation programs are rapidly becoming very important in the country, with very large efforts directed to Nelore, Dairy Gir, Angus, Hereford, Brangus, Braford and Braunvieh breeds.

Table 1 presents the evolution of several productivity indexes of the Brazilian herd, extracted from Barcellos (2011). This information confirms that important changes are happening in the Brazilian beef industry, but the productivity levels are still low and need to be improved. This opens a unique opportunity for the use of genetically evaluated bulls and cows, leading to quick responses through their progenies and huge increments in efficiency.

Table 1. Evolution of productivity indexes of the Brazilian beef industry.

Index	1996	2006	Variation (%)
Birth rate (%)	51.90	67.80	31
Mortality up to weaning (%)	9.60	6.51	-32
Age at first parity (yr)	4.70	3.36	-29
Age at slaughter (yr)	4.66	3.34	-28
Holding capacity (A.U./ha)	0.52	0.70	34
% of slaughter	17.95	23.23	29

Source: Barcellos (2011).

What is the participation of bull's cost in the cost of a calf?

The participation of a bull's cost in the cost of a calf is highly relevant, because it should be compared with the cost of artificial insemination. If a bull is bought for US\$2,000.00 and has an annual cost of maintenance of US\$500.00, its total cost along six years of work life as a sire is around US\$5,000.00. If that bull produces 100 progeny calves under natural mating, the cost per calf is around US\$50.00 without taking into account its genetic merit or eventual risks such as diseases or reproduction problems.

This is a very high cost, as compared to the sale's price of a calf, which is nowadays around US\$380.00 (13.2%) and there is little warranty about the genetics the bull is going to transmit. The hazard is even worse if one considers the genes that that bull will

spread in the population, which may cause years of regress in the genetic level. For instance, the use of non-genetically evaluated bulls allows their genes, which may not be favorable to productivity (as the ones related to reduced fertility or late maturity), to stay in the population, or even increase in frequency, as the vast majority of females are kept for replacement. This rational is a very strong justification for using AI or genetically evaluated replacement bulls.

CEIP: a strong tool to identify genetically superior beef animals

In the 90's, the Brazilian Ministry of Agriculture (MAPA, www.agricultura.gov.br) started a very interesting program to promote the use of genetically superior animals in the cattle industry, called Special Certificate of Identification and Production



(CEIP). This program allowed bulls and cows to receive the same legal treatment as animals registered by Breeders Associations, without necessarily being registered. However, in order to receive the certification, the animal must have come from a program that performs controlled data recording and genetic evaluation, allowing only 20 to 30% of the best animals to be eligible to have the CEIP. Seventeen programs, from several breed groups were allowed to issue CEIPs in 2009 (<http://www.agricultura.gov.br/comunicacao/noticias/2009/10/certificacao-selecao-bovinos-de-alta-productividade>) and about 15,000 animals received the certificate that year.

Objectives

Based on the impressive figures of Brazilian beef industry and due to the very limited number of genetically evaluated bulls to mate the 55 million cows from beef herds, the objective of this paper was to simulate the economic impact in beef production in Brazil if genetically superior bulls, identified through genetic evaluation programs could be disseminated in the herd by means of massive use of AI or natural mating.

Material and Methods

Massive use of AI or genetically evaluated replacement bulls

A simulation process was developed to estimate the direct effects of increasing 25, 50, 75, 100, and 200% the current level of artificial insemination or the use of genetically evaluated replacement bulls. Several well-managed and very productive beef ranches in Brazil work with artificial insemination levels as high as 95%, and some of those farms have more than 10,000 cows. There are several companies and farms in Brazil that apply artificial insemination to more than 20,000 cows/yr.

The total number of beef cows in Brazil is 55 million, and from those, 4.67 million are inseminated. The number of genetically superior bulls in natural

mating programs is about 50,000, and these bulls mate only around 1.0 to 1.5 million cows/yr. A total of 6 million beef cows, mated by genetically superior bulls, were considered in the simulation. A weaning rate of 80% and a post-weaning mortality of 1% were considered. All weaned animals that survived until 18 months were considered as marketed animals.

Besides that, the increasing use of fixed time artificial insemination (FTAI), which reached more than 5,000,000 cows in 2010 (Ferreira, 2011) is causing a massive impact in the level of productivity of the Brazilian beef industry, as the semen used is in the vast majority from genetically evaluated bulls, usually situated among the top 20-30% superior bulls for economic relevant traits. The figures of the 2011/2012 breeding season are not yet available, but probably more than 6.5 million cows have been inseminated using FTAI protocols.

To estimate the impact of using genetically superior bulls in natural mating or AI, only two traits were considered in this study: weaning weight (important for ranchers who sell calves) and yearling weight (a good predictor of weight to market), and the average genetic merit of cows were considered to be zero. The average EPD (expected progeny difference) of the bulls for weaning weight was arbitrarily set to +10.0 and for yearling weight (measured at 18 months of age) set to +19.5 kg (in both cases the average of the 30% better replacement bulls born in 2009 in an existing selection program was considered). The effect of increasing the use of AI or genetically superior replacement bulls was considered the same.

In order to evaluate the economic effect of using higher genetic level animals, price of weaned calves was considered US\$1.85/kg, while price of finished animals was set to US\$1.50, the current prices in the Brazilian industry in June/2012.

Results

The quantitative and economic impact of the simulated increase in the percentage of cows inseminated is shown in Table 2.

Table 2. Increase in production of Brazilian beef industry as a function of the expansion of using artificial insemination or genetic superior replacement bulls in the Brazilian beef herd in 2012.

Trait	Increase on percentage of cows mated by genetically superior bulls or through AI				
	30	50	75	100	200
N° of cows mated by superior bulls (x1000)	7,800	9,000	10,500	12,000	18,000
Rate of cows mated by superior bulls (%)	14.2	16.4	19.1	21.8	32.7
N° of calves weaned (x1000)	6240	7,200	8,400	9,600	14,400
Extra weight of weaned calves sold (1000 kg)	31,200	36,000	42,000	48,000	72,000
Extra value of weaned calves (US\$1000)	57,720	66,600	77,700	88,800	133,200
N° of steers slaughtered (x1000)	3,089	3,564	4,158	4,752	7,128
Extra weight of slaughtered steers (1000 kg)	60,232	69,468	81,081	92,664	138,996
Extra value of slaughtered steers (US\$1000)	90,347	104,247	121,622	138,996	208,494
Extra value of progeny from superior bulls (US\$1000)	148,067	170,847	199,322	227,796	341,694



The use of genetic superior material in the current cows in the Brazilian herd, by means of AI or natural mating, if increased, would cause an increase in revenues between US\$148 to 342 million, considering only direct revenues of 50% from weaned calves or marketed animals. Reproductive traits and other economically relevant characteristics were not included in the simulation.

Several other direct benefits could be added to these results, such as better quality products leading to better prices, benefits from other products or traits not considered here (like leather for instance) etc. However this simple simulation process provides a clear illustration of the impact of using better genetics in beef herds.

Massive use of AI or genetically evaluated replacement bulls - The most important indirect effects

Despite of the direct effects, it is very important to emphasize that the main profits that come out from the use of AI or genetic superior replacement bulls in medium to low management level herds, like the average herd in Brazil, does not come from the direct impact of using genetically proved animals, which certainly increases the production level of the population. The indirect effects are much more important.

To be able to use AI, or to decide to use genetically superior bulls in their herds, ranchers have to reach several pre-established standards in nutrition, health, organization and information, besides the training of human resources. To reach those levels, which are much higher than the current situation in average Brazilian farms, an increase in production should occur, resulting in very important economic effects.

It is not easy to measure gains due to the decrease of losses caused by poor feeding systems, sub-clinic diseases, and lack of organization, information, administration and management. However, it is clearly possible to reach good standards by international conditions. The simulation pointed in Table 2 considered the quantitative and economic impact verified after reaching the goals established for each trait. The criteria to define the goals were arbitrary, but considered as an intermediate level between the average Brazilian farm and the level of ranches from developed countries.

Table 3 presents productivity levels and goals for improving the system in the short term. It is very important to consider that the goals proposed are perfectly reachable. The levels suggested for cows pregnant/cows exposed, mortality, animals slaughtered/total herd, mortality and average carcass weight are being effectively achieved by a significant percentage of ranchers in the country. It is necessary to disseminate knowledge and technology to the small ranchers, through a comprehensive extension service, which should be pushed forward by efforts to increase AI levels and to better choose replacement bulls and heifers.

Several other indirect effects could be proposed and simulated, with very important effects. Leather and shoes industries are only two examples. It is important to point out that the values of the additional production obtained through the increase of levels of nutrition, health, technology, organization and extension, although hard to measure, are expressed in billions of dollars, as the amount of animals involved are very large in Brazil.

Other indirect effects, as meat quality and others related with the consumers, as described by Pineda (1997), would cause substantial changes and add value to the cattle industry. The organization of the industry by integrating all the chain is another effect (Camargo, 1997).

Table 3. Quantitative and economic impact in cattle industry, considering the achievement of goals related to indirect effects of AI.

Trait	Average level in Brazil	Developed countries level	Goal	Growth in production (1000 t)	Value (US\$ million)
Cows pregnant/cows exposed per yr (%)	65	85	75	3,200	4,800
Beef animals slaughtered/total beef herd (%)	23	32	30	12,400	18,600
Mortality from birth to slaughter (%)	8	3	3	360,000	666,00
Increase in average carcass weight (kg)	201	variable	230	1,200,000	1,800,00

The simulations and arguments presented herein could be extended to the other countries of Mercosul or any other country, using their statistics. The impact in any of those countries should be different, as a function of each country's current condition. In a globally integrated economy approach, a strong regional program to increase the use of AI and superior replacement bulls should be adopted, with very important results to the cattle business.

Implications

A critical analysis of the direct and indirect impacts of increasing AI and genetically superior replacement bull's utilization shows that the value of these actions is remarkable. Any increase in the use of genetically superior animals will cause very significant economic effects in the Brazilian beef industry, reaching values as high as US\$342 million with only 200% of



increment which, with the fast growth of FTAI, is going to be reached in near future. This refers only to direct effects of weaning and yearling weights. These values will be largely higher if reproductive traits were considered as selection criteria. The indirect effects, which were clearly underestimated in this simulation study, are much more important than the direct ones. The increase on the income of the industry could reach immense values, without opening new agricultural frontiers, to increase areas for cattle grazing, avoiding cutting trees or devastating the environment. The use of genetic superior animals, embryos or semen is the best way to improve productivity and reduce the impact in the environment, due to the significant increment in production that can be achieved without increasing the number of animals.

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