BEEF CATTLE GENETIC PROGRAMMES IN BRAZIL

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INTRODUCTION

Brazil has 8.5 million km², close to 12% of the water reserves of the planet, a population of 180 million people with a growth rate of 1.4% p.y., gross national product (GNP) of US$520 billion, per capita income of US$3,050 and a budget surplus of US$40 billion, in 2005. Close to 23% of population works with agriculture and animal production. Brazil has relatively low prices for land and labor and no extreme weather, which helps to compound 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.

Brazilian livestock and agriculture production is meaningful. According to FAO (2006) and USDA (2006) data, based on 2005 crops and 2004 exports, the country is responsible for 16% of world beef production, but is the largest exporter, accounting for close to 26% of global exports. Similar figures can be observed in the broiler (15.5% of production and 40.7% of exports, the largest exporter) and pork industries (close to 3% of world’s production, the 4th exporter, with 15% of international market). The country is the larger exporter of several agriculture products like soybean (24% of world’s production and 33.4% of total trade), sugar cane (32.5% of production and 42.4% of exports), orange juice (29.7% of production and 57% of exports), and coffee (28.3% of 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.

Livestock production in Brazil is significant. The population size of different livestock is: beef and dairy cattle (191.37 million animals (Scot Consultoria, 2006)), swine (32.39 million; CONAB, 2006), goats and sheep (9.09 million and 14.18 million; FAO, 2006). According to another source (Anualpec, 2005), the beef herd reached 176 million head in 2003 and decreased to around 165 million animals by the end of 2005.

The beef cattle business in Brazil: It is a business that involves close to 7.5 million jobs and generates more than US$25 billion in revenues. There are 4,200 shoe companies, 560 tanning plants, 750 abattoirs, 200 million hectares of pastures and 2.2 million farms/ranches (Rosa, 2006). The same source indicates that 45.4 million animals have been harvested in 2005, which corresponds to an extraction rate of 24%. Regional distribution is: 12% in North, 13% in Northeast, 21% in the Southeast, 15% in South and 39% in the Center-West. More than 160 million head are located in areas free of foot-and-mouth disease (FMD), with vaccination. Roughly 150 million animals are used for beef production and 40 million for dairy and dual-purpose. There is close to 70 million cows and 3 million bulls what leads to a need of around 450,000 young replacement bulls per year. Between 5 and 7% of beef cows are inseminated. Since less than 5% of these replacement bulls were selected based on EPDs or performance data one can conclude that more, better and larger breeding programs are needed.

According to the Zebu Breeders Association of Brazil (ABCZ), between 75 and 80% of the Brazilian herd has Bos indicus contribution, even though only less than 7,000 purebred Zebu animals have been imported from India in the last century. The importation from India was forbidden around 1962. The beef breed with the larger number of animals in Brazil is Nellore.
(standard/horned and polled), followed by Guzerat and Gir. Indubrasil, a Brazilian breed originated from crossbreeding among other Zebu breeds decreased sharply in numbers while another local breed, Tabapuã showed a steady increase. Crossbreeding is used in all regions of the country, but the higher the percentage of Bos taurus contribution, the poorer the adaptability to tropical environment, especially to ecto parasites (flies and ticks) and the lower the reproductive performance. The major European breeds that are used in beef crossbreeding are Angus and Red Angus, Simmental, Charolais, Polled Hereford, Limousin, Braunvieh, and Marchigiana, among others. Synthetic breeds, like Brangus, Braford, Canchin/Charbray, Santa Gertrudis are also used. In the last decade, Bos taurus breeds, adapted to tropical environment, like the Brazilian Caracu, showed renewed interest, or breeds like Senepol, Tuli and Bonsmara were introduced and, also, composite programs (e.g.: Montana) started to grow in the country.

**Brazilian beef production systems.** Different production systems have been developed to cater for differences in environment, technological levels and resources. The extensive grazing system exists in all regions of the country and nearly all cow-calf production is in that system. Most soils are acid and of medium to low fertility and support important grass species like Brachiaria spp. and Panicum spp. (originally from Africa), that show good production and adaptation to Brazilian conditions. Tropical forage quality and availability decreases markedly in the dry season and mineral supplementation is a requirement. In some areas, animal supplementation is needed in the dry season, but a very small number of farmers do so due to cost constraints. Some of the cow-calf operations are changing to a complete, pasture-based turnoff system. Due to fluctuations in feed availability, animals that are raised in that system can lose weight in the dry season. Under controlled mating, the season starts in November/December and ends in late February. Calves are weaned from May to June and are kept on dryland pastures until next rainy season, which, normally, starts next October. In such system, the best (about 50%) animals are finished with 24 to 30 months of age (crossbreds) and the balance at 36 to 42 months. Normally, purebred Zebu have higher dressing percentages and finish 6 to 12 month later then crossbreds but have better fat cover for the market, at the same weights as continental crossbred animals. In Southern Brazil, the rule is to use native and low productivity pastures. Some producers use cultivated winter pastures in rotation with cropland which results in high quality feed that makes animals (with a high percentage of Bos taurus genes) finish earlier than on native pastures.

There is an alternative production system in Brazil, where finishers buy 2 years-old steers and finish them in better pastures, for one year. That system normally requires more investment and management, using mineral and, if needed, feed supplementation.

Ranches that supplement calves during pre-weaning period (creep-feeding) are producing heavier weaned animals that can go directly to three different finishing schemes:

(1) The “super early-maturing” system that send animal to feedlots at 8 months of age and 240 kg live weight, where they stay for 120 days, and are harvested at 420 kg liveweight. These feedlots use a low percentage grain ration, composed of maize, sorghum or grass silage, sugar cane and agriculture by-products. The animals used in that system are in general crossbreds.

(2) The “early-maturing” system, with weaned animal being sent to pastures for a growing phase, where they stay until they are 18 to 24 months-old and then sent to regular feedlots. Both crossbred and purebred animals are used in this system.

(3) The “pasture growing system” where animals are kept on variable quality pastures and are harvested at an age of 30 to 42 months, with liveweights between 450 and 500 kg. The majority are Bos indicus but some crossbred steers are fed in this system.

The proportion of animal that have been finished in 2005 according to production system is presented in Table 1. There is currently a strong movement in ownership concentration of
processing plants with the few companies that share the internal and export market investing strongly in their own feedlots, in order to regulate prices, meat quality and regularity of supply for their plants. However, due to problems in currency parity, sanitary troubles and other risks, the amount of animals kept in feedlots decreased by c. 20% from 2004 to 2005.

Table 1. Number of beef cattle heads slaughtered in Brazil in 2005 (adapted from Anualpec, 2005) and the proportion by production system.

<table>
<thead>
<tr>
<th>Production system</th>
<th>Number of heads (10^6)</th>
<th>%</th>
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<tbody>
<tr>
<td>Pastures</td>
<td>38.69</td>
<td>85</td>
</tr>
<tr>
<td>Winter pastures (crops)</td>
<td>0.913</td>
<td>2</td>
</tr>
<tr>
<td>Semi-confinement</td>
<td>3.054</td>
<td>7</td>
</tr>
<tr>
<td>Feedlots</td>
<td>2.743</td>
<td>6</td>
</tr>
<tr>
<td>Total</td>
<td>45.400</td>
<td>100</td>
</tr>
</tbody>
</table>

Brazilian beef industry has its’ weaknesses and strengths. Among the limitations, there are the sanitary risks of FMD, that is being controlled with vaccination, and other animal health problems intrinsic to business that increases the cost of production. Beef quality also can be included in the weak points, as the high level of Zebu genes decrease tenderness of beef. Also, the proportion of unofficially slaughtered animals in the country is greater than 30% and all that beef goes to internal market. Another weak point of that producing chain is the lack of organization and the low use of genetically evaluated bulls in several layers of the business.

But there are strong points too: the cost of production on Brazilian beef is the lowest in the world and the trend is to keep it that way. Although feedlots are growing in Brazil, the Brazilian beef production system still can be considered “grass-fed animals”, since animals are in the feedlot for a very short period and the amount of roughage in feed is very high (e.g.: sorghum, corn or even grass silage). That feeding system eliminates the risk of BSE in the Brazilian beef herd what constitutes a very powerful commercial tool, especially with the worries on food safety. The official efforts in controlling FMD led to the fact that more than 80% of the Brazilian herd being within zones free of FMD, with vaccination. Government and producers are working together on other strategies e.g. traceability. Taken all together, Brazilian beef productivity can be considered low compared to higher input systems but this system generates a product that is healthy, tasty and genuine and has a good chance to stand the test of time.

Genetic progress: Brazilian beef agribusiness is getting organized. A very strong progress can be verified, especially since the 80’s, when several genetic evaluation programs were established and EPDs and focused/oriented mating systems started to be used in beef companies. The results very quickly changed the marketing of genetics in the country. Ferraz & Fries (2004) reviewed the history and comprehensively describe, in English, existing beef (European breeds, zebu and synthetic/composites) breeding programs in Brazil.

GENETIC COMPONENTS
The recent progress of genetic evaluation in Brazil can be attributed to: (1) data quality; (2) data structure; (3) modeling environmental effects; (4) genetic evaluation methodology; (5) modeling genotypic effects; (6) traits and indices; (7) planned matings; and (8) policies.

(1) Data quality. It can only be assured by: (a) using a consistency driven data entry software operated at the ranch level – many options exist under strong market competition; (b) proper initial and yearly refresher course on data collection and transcription; (c) weightings are done, in the majority of the beef breeding programs, after a complete fasting of at least 12-14 hours -
Carvalheiro et al. (1998) have shown that reduction on experimental error corresponds to an increase in $h^2$ of 0.39 to 0.45 – this increase in accuracy is larger than when moving from contemporary comparisons to BLUP (Dempfle et al., 1983); (d) visual scores are attributed relative to the Contemporary Group (CG) average for each trait, yearly refresher workshops take place and continuous audits on evaluators are enforced. To have quality data a higher input of quality human resources are needed. Different reports have shown that about 75% of the costs of beef cattle improvement programs on commercial populations are accrued by labor at the farm level. Brazilian peons/herdsman possesses the needed vocation, pride and pleasure from their lifestyle and work with eager involvement.

(2) Data structure and scale of operation. A complete cycle commercial beef cattle operation must have a scale of 1,000 to 2,000 breeding cows to allow for an upper middle class living standard to the owners. That number of cows is ideal, from a management/investment point-of-view, for the ranch to get involved in an effective breeding program and economical production of superior germplasm. Ranches with few hundred or several thousand cows also participate on a freely chosen private or associative program. Most ranches use Multiple Sires (MS) in some degree; in several cases about 50% of calves are from MS. Most initial/founder cows have no pedigree information. Hence, special caution is needed to make inferences and proper interpretations of EPDs because many disconnected data sets exist and this demands checking (Roso et al. (2004) and Roso & Schenkel (2006)).

(3) Modeling environmental effects and defining CG. In higher input systems of beef production, most environmental differences are reduced/leveled out with supplementation, lowered stocking rates or in the feedlot. Brazil is known for its environmental diversities; strong seasonality effects and fluctuations on grass production; a 39º range of latitudes; and economical constraints that make overstocking a risky strategy. Every region presents some stressful factors for beef production and this compounds the problem of well defining what a CG is and, really, when all animals from a given CG can be compared with justice. Herds which participate in breeding programs for more than 30 years now, still need to make yearly adjustments in their definitions and management operations; most of them generated from conflicts between genetic (strive to show/find differences) and management (aim at market bonuses for uniform products) objectives.

Besides BIF recommendations, pre-weaning growth models have to consider non-linear age of calf effects (even within a 90 days range; e.g.: Campos et al., 1988), interactions of age of dam with sex of the calf and seasonality effects on calving date (e.g.: Paz et al., 1998), generally described by spline functions or segmented polynomials (Schenkel, 1989; El Faro et al., 1998) with interactions with latitude (Amaral Neto et al., 2005). Most of these developments have been possible because sophisticated and powerful statistical techniques and programs exist now. A double loss situation exists here: papers dealing with environmental effects are deemed as low prestigious and, for instance, full implications of a concept like variance inflation factor (VIF) and its remedies, are not generally known. Albuquerque et al. (2000) have shown that there is a large confounding between these environmental covariables and CG levels: they comprise 0.67 of the $R^2$ attributed to CG when these effects are not considered. The relationships between these effects, the different average date of birth and weaning age of calves from AI, natural service and clean-up sires, results from sire summaries and the power of CG classes to seize environmental and genetic effects still have to be (better/thoroughly) investigated.

(4) Genetic Evaluation Methodology. Brazilian beef cattle purebred/registered populations generally have more complete information on genealogy and are subjected to lower selection intensities then commercial populations; hence the use of standard MMM seems to be working
well and only occasionally unexplainable results are noticed. Two independent confidential reports indicate a 15% error rate in parentage assignation by genotyping.

Most large commercial beef cattle populations participating in breeding programs in Brazil practice a very strong selection pressure on prospective sires and extensively use Multiple Sires (MS). Schenkel et al. (2002) and Carvalheiro (2004) have shown that solutions from standard MMM will not hold BLUE and BLUP properties under these or even milder conditions (selection and/or unknown parentage). Schaeffer (1999) selection alternative model (SAM) treats sires, which undergo selection, as fixed effects, to relax some of the needed assumptions in an animal model. Re-utilizing the information contained in the residuals from SAM can solve the problem of combining information from ancestral and own performance with progeny data (Fries, 2000). SAM can be adapted to the re-weighted robust estimation process described in Schenkel and Brito (1994) and, to reduce build up of inbreeding, to procedures described by Wu and Schaeffer (2000). Sires with nonuniform progeny have their EPDs penalized using a robust measure of dispersion (Fries et al., 2006) and the result expressed in respect to a given phenotypic target, as proposed by Garrick and Enns (2003). These components are used in routine genetic evaluations at GenSys on well connected data sets (Roso and Schenkel, 2006).

(5) Modeling genotypic (additive and non-additive) effects. Crossbreeding has been used extensively in Brazil since 1934 (Barbosa and Duarte, 1989; Barbosa and Alencar, 1995). Albeit words of caution from Clay Center researchers about other genetic groups and environments, their results established the framework for designs, genetic analysis and applied programs.

Following Arthur et al. (1999), several recent studies have reported significant estimates of epistatic loss effects on pre-weaning gain in crosses between Bos taurus and Bos indicus (Fries et al., 2000; Piccoli et al., 2002; Demeke et al., 2003; Pimentel et al., 2003) and in all traits recorded by Conexão Delta G (a Brazilian open Braford breeding program) with important interactions of genotypic covariables with latitude functions (Cardoso, 2004). Pimentel et al. (2003) have showed that if complementarity and epistatic effects are not fit in the model then “heterosis estimates” will comprise the net sum of dominance, complementarity and epistatic effects. Roso (2005) found significant epistatic effects on a very large Canadian data set with hundreds of Bos Taurus crossbred genotypes. Cardoso et al. (2002) identified significant heterotic and epistatic effects within Brazilian purebred Nelores. There is a perception that after these findings new outline/strategies for crossbreeding and for multibreed evaluation models will be implemented.

(6) Traits and Indices. Since 1973 visual scores based on the Ankony System (Long, 1973) have been used at different beef breeding programs and went through a series of small adaptations/improvements. These scores show h² estimates similar to growth traits (Eler et al., 1995). Since early 90’s scores went from an absolute scale to one that is relative to the average animal in each CG for each trait. This change has allowed for a even heavier owner/manager participation on evaluations; therefore he is impelled to use resulting reports and rankings. In Costa (2005), almost all references to the subject were from Brazilian authors; which suggests that this subject has been continuously under heavy scrutiny. The importance of using traits that relate to what producers are seeing in their herds everyday and/or when they market their animals cannot be overstated.

A better indicator trait of sexual precocity is scrotal circumference adjusted for age and weight (Dal Farra et al., 1998). To help change prevalent focus on extreme weights, traits like “days to gain 160 kg from birth to weaning” (Ortiz et al. (2004)) are used. Carneiro et al. (2006)
found positive results in the use of temperament scores. Renewed concerns in crossbreeding programs are stressing “adaptation traits” as tick resistance (Cardoso et al., 2006) and hair coat traits (Bertipaglia et al., 2006). Different groups are using real time Ultra Sound measurements; there is a tendency that these groups converge in procedures and may adopt some centralized image processing and management, following the example set by Iowa State University. Considering all born heifers as if they were exposed to breeding, as suggested by Atencio (2000), has allowed to different authors to obtain estimates of heritability that agree with results from direct selection of Nelore heifers for sexual precocity. An index for beef females, combining early sexual precocity, productivity and stayability was proposed by Carvalheiro et al. (2005) and has been implemented by different programs (Pimentel et al., 2006). Most of these traits were demanded/suggested by breeders/producers. Since 1974 empirical indexes are used in most programs to allow breeders to rank sires and breeding animals and to promote heavy culling on low producers.

(7) Planned matings. Simulations by Cardoso et al. (2003) have shown that choosing optimum matings can increase the number of approved young sires in 74% in comparison with random mating, using the same cows and sires with the same intensity. Results from Cardoso (2004) permit choosing the best genotypic composition for each latitude and according to ranch segment specialization. As applied to PAINT, the breeding program from Lagoa da Serra Ltda., planned matings secure the above benefits plus minimizing probabilities of calves with faults in breed traits/pigmentation, and several functional traits. Tactics applied are both positive assortment and compensatory, to produce animals with harmony amongst all desired traits.

(8) Policies and Unified Sire Summaries. Probably no other government decree have contributed more to beef cattle breeding in Brazil then the institution of the “Special Identification and Production Certificate” –CEIP- in 1989, by the Ministry of Agriculture, as proposed by officeholders J.J. Ferreira and W.M. Lacorte. Approved breeding programs can issue CEIPs to their 20% top bulls and these animals have, by law, the same fiscal benefits as if they were purebreds. CEIP is a clear example of the proposed “pull-through” gene flow model (Nicol, 2006). More than twenty such programs are in effect and they are molding two paradigms of beef cattle breeding within every breed: (1) breed association (Figure 1) and (2) CEIPs run by producers, large beef operations, non-traditional free alliances amongst breeders or AI companies (Figure 2).

![Figure 1: The traditional model of gene flow for the Australian beef industry](image1)

![Figure 2: A 'pull-through' gene flow model for the Australian beef industry](image2)

(1) Traditional breed association model (2) CEIP model (Courtesy from Nicol, 2006)
Probably both models will continue to co-exist for a long time, as in poultry and swine industries but, for sure, CEIPs are helping the traditional model to make faster adjustments and it is the only one that can benefit from good genetics arising at any strata from both models.

A range of agents from the private, institutional and governmental sectors deliver a mixture of research, teaching and extension as well as direct consultancy services to industry. No one organization has a monopoly on any facet of beef cattle breeding in Brazil. Perhaps some coordinated efforts could enhance short and long-term results, but only if the current dynamics are preserved in the process.

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