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## Dairy cattle breeding programme in Brazil development of the Brazilian milking hybrid (MLB)

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The MLB programme (Portuguese standing for Brazilian Milking Hybrid) is described below. This was a research and development programme conducted by the National Dairy Cattle Research Centre of the Federal Research Organisation (EMBRAPA) with the assistance of the FAO/UNDP Project BRA/79/010. Its main objective was to obtain experimental information to design selection criteria for new hybrid cattle breeds, combining dairy, reproduction, growth and adaptation traits, while developing cattle suitable for the dairy production systems of the Brazilian Tropics.

The programme was initiated in 1977 to estimate the genetic parameters for traits sought, a half-sib family structure was convenient, which was obtained by implanting a progeny-testing programme. This was the first dairy cattle progeny-testing programme in the country. It was also the first time that the idea of a multi-breed cattle composite was put to work in Brazil, as only two breeds were previously admitted as founders of new breeds in technical and practical circles.

Cattle (*Bos taurus* x *B. indicus* hybrids).

Most dairy cattle in the tropical regions of Brazil are *Bos taurus* x *B. indicus* hybrids. The gene fraction of each species varies widely, even within farms. Results of a recent survey involving 291 farms and 7 195 cows in the State of Minas Gerais are in figure 1. The predominant breeds were Gir (78 percent of the farms) and Holstein-Friesian (91 percent).

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### Introduction

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### Species involved

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### Breeds involved

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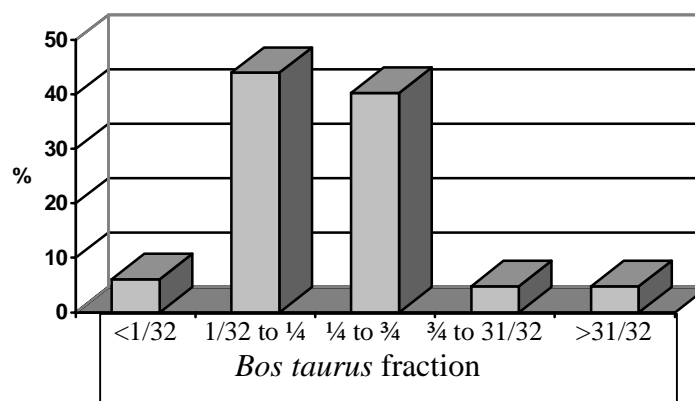


Figure 1. Percentage of cows in *Bos taurus* fraction classes ( $n=7\ 195$ ).  
Source: Madalena et al. (1997).

When the MLB programme was formulated, several institutions and private breeders were separately engaged in projects for developing new synthetic *B. taurus* x *B. indicus* dairy breeds, based on different founder breeds of each species. Borrowing an idea from H. Skjervold in Norway, it was proposed that all those projects merged together in a single progeny testing programme, which would not be possible in the former separate single herd structure. Such merging required that each herd abandoned its previous breed composition and improvement target for a common selection criterion. Thus, any herd keeping dairy records of hybrid cows would be enrolled. Bull dams were selected as the elite top yielders in each herd, irrespective of breed composition (or type or coat colour). Breed composition was not a selection criterion because it was considered that good genes could be obtained from any breed (genes have no breed) and genetic variation was desirable. The composition of the overall population in the initially available 14 herds with dairy records is presented in table 1.

Besides using several founder breeds, the programme aimed at a flexible *B. taurus* x *B. indicus* fraction. Based on previous results, limits for the *B. taurus* fraction were set at 1/2 to 3/4 for bull dams and 1/2 to 7/8 for the young bulls themselves. This contradicted the taboo that new breeds must be of exactly 5/8 *B. taurus* fraction, still prevailing among many farmers although it was a long time since Lush (1927) had shown the irrelevance of blood percentage to predict individual performance.

The programme maintained its gene pool opened for new herds and individual bull calves to join in. It was also intended to introduce foreign germplasm of other tropical dairy breeds via insemination of bull dams but this could not be accomplished.



*Table 1. Average gene percentage of elite dams and sampled bulls in the MLB programme.*

	Dams %	Bulls %
<i>Bos taurus</i>	62	72
Holstein-Friesian <sup>1</sup>	52	64
Brown Swiss	2	5
Other <sup>2</sup>	8	3
<i>Bos taurus</i>	38	28
Guzera	20	21
Gir	12	4
Zebu-type	6	3

Source: Madalena (1989).

<sup>1</sup> Both Red and White and Black and White.

<sup>2</sup>Red Dane, Simental, Jersey, Caracu, unknown European breed.

A description of dairy production in Brazil was given (Madalena, 1998a). Dairy farms in the tropical part of the country are typically small, low input/low production systems based on hybrid cattle. In the above mentioned survey manual milking in the presence of the calf was practised on 95 percent of the farms and 78 percent of the cows were milked once a day. Nonetheless, a wide variation of practices exists, even within regions, associated not only to geographical differences but also to farm size and the socio-economic factors related to it. For example, once a day milking was practised on 95 percent of the farms selling <50 kg milk/day and on 33 percent of the farms selling >100 kg/day. Most (46 percent) farmers wished to keep the herd intermediate between *Bos taurus* and *B. indicus*, 13 and one percent wished to go pure-breeding of either species and 40 percent had no definite goal in this respect. In the Southeast Region, which produces 45 percent of the country's milk (7 million ton/year), average yield per cow is 885 kg/year.

It has been claimed that such production systems should be substituted altogether by intensive systems based on high yielding Holsteins. However, economic results do not sustain such claims. Capital intensive systems have not had higher net margins nor return on investment than the commonest extensive systems (Holanda Jr. and Madalena, 1998). It is not meant to say that prevailing systems are efficient, on the contrary, there is ample opportunity to improve them, provided new practises are adopted on the basis of cost/benefit, rather than on mere imitation of those in developed countries, where the economic conjuncture is completely different. Optimisation of use of local resources, such as solar energy, C<sub>4</sub> grasses and adapted cattle, may lead to very efficient systems, irrespective of milk yield per cow being much lower than in the intensive systems of temperate countries (Matos, 1996).

## Input level of the production system



## **Numbers of animals**

Initially 6 092 lactations of 2 300 cows in 14 herds were available to select elite dams of bulls to be sampled. This changed over time with some herds leaving the programme and new ones joining in. The programme was dimensioned to progeny test ten sires per year with 30 daughters each.

## **Target and dissemination of improvement**

As a by-product of research the MLB programme produced semen of proven bulls. Being a pilot scheme, semen production would serve only a tiny fraction of the dairy commercial population, but it was assumed that after some years of improvement the elite herds would be transferring genes to other herds, both commercial and multiplier. There was a clear precedent in the now well-established beef breed Canchim, which was developed in the sixties by a Governmental institution and then handed over to private breeders.

## **Breeding goal**

The goal was defined as “the development of a dairy cattle population adapted to the production systems prevailing in the Brazilian Tropics”. Research on formal definition of breeding objectives is very recent in Brazil. A major bottleneck is the paucity of data from farms keeping economic records. An earlier review (Madalena, 1986) failed to find economic evaluations of breeding objectives in tropical countries.

In the above goal definition, “prevailing systems” were considered those used on farms keeping records of hybrid dairy cattle, which by itself implies some improved management. The farms involved practised milking twice a day generally in the presence of the calf and with low concentrate inputs. In the 14 elite herds the average 305-d milk yield was 2 549 kg (mature equivalent) and in 23 herds for testing bulls the corresponding average was 1 793 kg (mostly first and some second lactations). It is conceivable that the best genotypes for such an environment might not be the best in the harshest conditions found in small farms milking once a day. However, it was not possible to test bulls in farms that did not use AI.

## **Breeding plan**

The programme had a conventional progeny testing plan in which the ten bulls sampled every year were to be the progeny of the best sires and dams available at the time.

Initially, until specific matings could be arranged, candidate bull calves were chosen on dam performance only. In a second stage, sires of bulls were both MLB sons of the very best dams and USA and Canadian Holsteins with high milk predicted differences.

After proven bulls became available, it was intended to use the best two tenths of each yearly batch as sires of bulls (a stage never reached). In this way and by the continuous introduction of new herds and bulls inbreeding should have been kept reasonably low.



There were no major deviations from the planned progeny testing programme. However, improvements were gradually introduced in the genetic evaluation procedures. Initially, no suitable software was available to estimate genetic merit, so dam selection was based only on the cows' performance (most probable production ability), but later on specific software was developed (by Jan Dommerholt, 1981) to estimate breeding values on an index based on cow performance (first three lactations), sire and dam breeding values and the herdmate genetic level. Nonetheless, some outside bull calves were also sampled, for opportunity reasons, although their dams could only be evaluated on their crude dairy performance.

A major departure from planned action occurred in the research aspects of the programme, as adaptation traits could not be recorded as intended because of lack of funding.

As no formal, quantified definition of the breeding objective could be formulated, milk yield in the prevailing systems was provisionally the only trait included in the goal, until data became available for reappraisal of this point.

Milk yield in a standard 305-d lactation in the existing farming conditions was the sole selection criterion, again until the project had gathered enough data to review it.

A data set of 90 progeny groups was the target planned to estimate heritabilities and genetic correlations among dairy, reproduction, growth and adaptation traits. Traits measured (but not used for selection) were: milk, fat and protein yield, lactation length and age at first calving (in all females) and weights (only in some institutional herds having scales). A procedure to evaluate tick resistance of young bulls before semen collection was adapted from Australian protocols in consultancies with Drs R.W. Hewetson (1980) and K. Utech (1981). Bulls were artificially infested with 20 000 larvae of *Boophilus microplus* ticks and semi-engorged standard larvae (4.5 to 8.0 mm) were counted on the animals' right side on days 19 through 23 after infestation. Some female progeny were also scored for tick counts under natural and artificial infestations. It was not possible to collect data on rectal temperatures and worm eggs per gram as intended.

Dissemination was through frozen semen of proven bulls, lent under contract to commercial AI companies, at their request. Since this was not a commercial programme, no special structure was established to market semen, although the semen production unit was officially qualified to do so and did effect a few sales directly.

## Actual versus planned programme

## Traits in breeding goal

## Traits measured

## Methods of dissemination of improvement



## **Breeding structure**

The structure may be described as a diffuse open nucleus formed by the elite dams screened. Genes would flow from the recorded herds to the rest of the population but new elite dams and sires could come from new herds or from abroad.

New herds with records, the sources of elite bull dams, were continuously being identified and incorporated into the programme as much as possible, due to limitations in financial resources. Incorporating a herd involved a visit, photocopying records, putting them into the computer, correcting errors, running the genetic evaluations, selecting bull dams and further visits to check the computer selection with the herdsman or farmer's opinion (they generally agreed) and to deliver the semen for the selected elite dams.

## **Farmer and Government involvement**

The programme was based on two kinds of farms, those that had records and those receiving semen of sampled bulls. Some farms did both, some were institutional and some private.

Leadership was from the FAO/UNDP/EMBRAPA Project. The National Research Centre financed communications, data processing, semen production and distribution and milk recording in farms testing bulls. A bull rearing unit and semen processing laboratory were set up at EMBRAPA's unit in São Carlos, SP (presently Southeast Livestock Research Centre) by Dr H. Bruschi and operated by Drs J.P. Eler and R.T. Barbosa. Dr Raymond Jondet, from URCEO, Rennes, provided valuable technical consultancies to solve many semen production problems with young hybrid bulls (Jondet, 1981). Equipment for frozen semen production and milk fat and protein analyses were provided by the FAO/UNDP Project, as well as some funds provided by the Nordic project for development of AI.

Farms with records provided the bull calves, which were lent to EMBRAPA but continued to belong to the farmer. These bull calves were very valuable to breeders having their own breed development programme (sometimes going back for up to six generations) but would be sold as veal in common milk-producing farms. Transport to and from the semen collection centre, rearing costs and health exams were met by EMBRAPA. Farms testing bulls received two semen doses per cow free-of-charge, upon an agreement to keep the daughters up to the end of their first lactation allowing monthly dairy recording. Only well organized farms with good AI standards were accepted.

As a by-product of research the MLB programme produced semen of proven bulls, and as it turned out, the by-product became much more popular than the primary research objective. Initially Ministry of Agriculture officials would not license the bulls on the grounds that they were not pedigreed, but later on marketing of semen was allowed. It soon



became apparent that a market existed for that kind of semen (something previously unthinkable) and some AI companies contracted programme bulls (or even used some hybrid bulls from other herds, pedigreed but not progeny tested). Some semen also found its way into neighbouring Paraguay.

Two items of legislation related to the scheme have now been modified, not necessarily because of it. It is no longer obligatory that AI bulls be pedigreed in Brazil, provided they obtain a special certificate justifying they are from sound genetic improvement programmes. Flexible limits for *Bos taurus* and *Bos indicus* fractions became accepted by the Ministry, when recognising the new Guzolando (Guzera x Holstein) breed.

The Government invested heavily in the development of its research organization, EMBRAPA, which provided the highly trained staff, abroad or in Brazil, at PhD level. The in-service training provided by the FAO/UNDP Project was also of assistance in building up expertise at the National Dairy Cattle Centre in a number of aspects, including the logistic, technical, scientific, relations with breeders and general divulgation of progeny-testing and genetic evaluation concepts.

Research results are essential since many aspects have no precedent in the literature. Some follow.

Late development of quality semen of young bulls was a problem for early testing. Based on 12 625 ejaculates of 156 bulls, the average volume was 4.7 cc, with  $779 \times 10^6$  sperm cells/cc and 46.4 and 22.4 percent pre- and post-thawing motility, yielding 17.8 pre-thawing doses per ejaculate (Abreu, 1999).

In a recent study with MLB data, Freitas *et al.* (1998) found no differences among the progeny of 5/8, 6/8 or 7/8 *B. taurus* bulls, thus justifying the flexible limits adopted in the programme instead of strictly adhering to a fixed blood percentage.

As it turned out, whether the sire of sampled bull was pure-bred or cross-bred, it had no detectable effect on the granddaughters' yield (Freitas *et al.*, 1998).

Because of the wide between and within herd variation in cross-bred types, from extreme *B. indicus* to extreme *B. taurus*, the type of mate would be a source of bias of progeny-tests. To make adjustment for it, the *B. taurus* fraction of mates (in eights) was assigned by visual inspection when not

## Technical support

## Semen production

## *Bos taurus* fraction of bulls

## Sires of bulls

## *Bos taurus* fraction of mates



recorded and treated as an environmental fixed effect. In addition, bulls had mates assigned seeking uniformity of the *B. taurus* fraction distributions within farms. An effort was also made to have every bull represented at each farm, because farms differed in management and in breed composition. The relevance of these procedures was also supposed to be evaluated later on, when enough data would be available.

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**Lactation length**

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The cause for lactation termination was not usually recorded for the herds providing elite dams. It was initially thought that in the absence of information, discarding short lactation records (<120d) would eliminate abnormal terminations. Later work showed this procedure to be correct for individual cow selection, but not for sire progeny testing. Because in non-improved populations lactation length is heritable and its genetic correlation with yield approaches one, deleting short lactation records removes more genetic than environmental variation among the sire progeny groups. Adjusting for lactation length has a similar, but more pronounced effect. The result is a drastic reduction in the heritability and the genetic progress for milk yield (Madalena, 1988). This also applies to the comparison among cross-bred groups and is a main source of literature discrepancies on estimates of heterosis and recombination losses (Madalena, 1994).

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**Genetic and phenotypic parameters for milk and component yield**

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Parameters for dairy traits in the MLB programme are given in Table 2. Data included all lactations, irrespective of length and cause for terminating record. However, Freitas *et al.* (1995), analysing a similar data set, reported  $h^2 = 0.14$  when lactations <120 day duration were deleted and  $h^2 = 0.06$  when yield was furthermore adjusted for lactation length, thus confirming the bias caused by these procedures.

The estimate of heritability of 305-d milk yield was similar to the literature average of  $h^2 = 0.25$  reported by Lôbo *et al.* (1999a) for tropical countries. Genetic parameters for dairy traits were also similar to those found in temperate regions, so the contention that genetic improvement would not be possible in hybrid breeds is not at all sustained by the experimental evidence.

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**Tick resistance**

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As it may be seen in table 2, heritability of tick burden was rather high and in line with the literature. The low genetic correlations between tick resistance and dairy traits indicate that there are no important genetic antagonisms between those traits.

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**Reasons for introducing the scheme**

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The scheme was introduced because improved tropical dairy breeds could meet the farmers' preference for hybrid cattle without resorting to cross-breeding, difficult under the prevailing natural mating practice and several private and public projects were being conducted to develop such breeds.



*Table 2. Heritabilities (in the diagonal), genetic (above the diagonal) and phenotypic correlations (below the diagonal) in inter se hybrid Bos taurus x B. indicus in Brazil.*

	Milk yield	Fat yield	Protein yield	Lactation length	Log tick burden
Milk yield <sup>1</sup>	<b>0.23</b>	0.91	0.92	0.95	0.06
Fat yield <sup>1</sup>	0.87	<b>0.29</b>	0.96	0.94	0.07
Protein yield <sup>1</sup>	0.86	0.81	<b>0.21</b>	0.72	-0.14
Lactation length <sup>1</sup>	0.78	0.73	0.70	<b>0.10</b>	-0.13
Log tick burden <sup>2</sup>	0.13	0.12	0.17	0.16	<b>0.49</b>
	kg			days	
Mean	1 793	61	47	248	1.621
$\sigma_P$ <sup>3</sup>	743	28	21	64	0.672
Repeatability	0.51	0.48	0.44	0.29	0.62
Observations	2.321	1.743	1.738	2.209	1.955

Source: Conceição Jr. (1997).

<sup>1</sup>Truncated at 305 days.

<sup>2</sup>Log (2 x count +1) .

<sup>3</sup>Phenotypic standard deviation.

The project evolved from a meeting organized by the National Dairy Centre to coordinate research, where it was seen that several institutions were separately directing efforts to breed development. The idea of joining efforts was readily accepted by most institutions and received strong support from the EMBRAPA Board of Directors, which made the programme really happen. The farmers' satisfaction with the progeny performance contributed greatly to maintaining interest.

However, when the programme started operating smoothly the authorities changed and the initial support was lost. Ironically, by this time it was apparent that several thousand hybrid dairy recorded cows could be recruited, the programme operational expenses could be met by semen sales and it had gained favourable opinion in the agricultural press and in technical circles. The programme had been formally terminated but a total of 121 sires were progeny tested. Summaries for milk and fat were published in 1995 for the first 68 sires and the information from the rest is available although not yet processed.

**What made it happen (and cease)**



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**What changes should be made?**

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**Private sector involvement**

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This is the more important element to guarantee continuity. The MLB programme showed in actual practise that progeny-testing of dairy bulls was a feasible and commercial proposition and in its track other progeny testing schemes were or are being developed, the eldest being that in the milking Gir, run together since 1985 by EMBRAPA and the breeder association (ABCGIL). This has been a successful partnership, as it allied the technical proficiency of the research staff with the operational ability of the private sector, thus overcoming the clumsiness inherent to public administration.

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**Investment level and legal framework**

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As mentioned above, there is a basis for a breed development scheme run on a much larger size than the pilot small-scale described, but this would require a larger investment. An appropriate legal framework is needed in a scheme directed at the commercial exploitation of genetic improvement. The lack of such organization was felt in several aspects. For example, lay off bulls had to be returned to their owners and there were cases in which they could not be recovered for semen production after becoming proven. The breeders' association structure has been instrumental in organizing testing but a more centralised organization would be better for selection decisions.

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**Defining breeding objectives**

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Although this should be the very first step in a selection programme, it continues ill defined, mainly because research institutions are not aware of its importance and do not devote efforts to this end. Some recent results indicated negative economic values for milk protein and fat, a question that calls for a national discussion of the different sectors of the dairy industry on the pricing of milk components, to avoid selecting in the wrong direction (Madalena, 1999). Other studies, unfortunately based on data of just one farm keeping detailed economic records, indicated that reducing cow weight was even more important than increasing milk yield, even in a dual purpose system, so liveweights at young ages had negative index weights. Milk flow, herd-life, mastitis and age at first calving were important components of the overall economic merit (Vercesi Filho *et al.*, 1999, Lôbo *et al.*, 1999).

There seems to be no reason to worry about milk let down since milking in the presence of the calf is the method preferred by farmers. Recent results have shown that twice a day suckling increased saleable milk by 10 percent over artificial rearing, while practically not affecting the calving to conception interval nor the growth of the calf (Campos *et al.*, 1993). Calf health costs more than triplicate with artificial rearing (Ugarte, 1992). Therefore, it remains to be proved whether artificial rearing is any better than restricted suckling in tropical systems. The same may be said to the related question of machine milking, which may or may not be convenient, depending on circumstances (Madalena, 1993).



Experimental results now available indicate a large economic superiority of the  $F_1$  and suggest a strong recombination loss for milk yield (Madalena *et al.*, 1990a,b). Farmers have now grasped this superiority and a commercial market has developed for  $F_1$  females in Brazil (Madalena, 1998b) as is also the case in Venezuela and Colombia (J. Ordoñez and A. Restrepo, personal communications). Production of  $F_1$  females has an economic basis both using AI or MOET (Madalena, 1993, Teodoro *et al.*, 1996).

Nonetheless, it must be recognised that not all farmers will be able or willing to buy  $F_1$ s or to use a cross-breeding system and some may prefer the simplicity of using a hybrid bull. In fact, in the survey on farm dairy practices mentioned above, a census by breed indicated that 40 percent of the bulls were hybrid (Madalena *et al.*, 1997). The strong development of the new hybrid breed Girolando (Gir-Holstein) founded in 1989, registering more than 6 000 animals per year, supports the commercial acceptance of this type of animal. In 1998 16 700 doses of semen of this breed were sold, amounting to 6 percent of the semen of tropical dairy breeds. The Breeders' Association has recently implanted a small-scale progeny-testing scheme and is seeking to strengthen it.

Although the Girolando is formally a Gir x Holstein hybrid, many founder cows are in fact of non-descript origin and have genes from other breeds as well. Thus, the multi-breed composite concept is being applied in practice, even if it is still not formally recognised. However, beef composites have had a strong commercial irruption in Brazil, so it is likely that the concept will also become accepted in the dairy industry as well.

The need for distinct breeding programmes in Brazilian Holsteins, milking zebu breeds (Gir and Guzera) and new synthetic breeds developed from hybrids has been recognised (Touchberry, 1979). Although selection in Holsteins for performance in the tropics has not received attention, programmes have/are been established in the other breeds, so the lessons and experience gained from the MLB programme were not entirely lost, although one generation of selection is being wasted.

It is felt that consolidation and expansion of the progeny-testing schemes in the Brazilian tropical dairy breeds will continue, as farmers progressively learn to distinguish supplies of genetic materials that genuinely improve economic performance in their production systems. The export market is also very important and will also favour modern breeding programmes, given the comparative Brazilian advantages in the logistics involved. How fast will developments occur basically depends on the investors perception that selection programmes are good business in the tropics, as they have been everywhere else.



## Genetic change

## References\*

The MLB programme did not reach the stage where genetic progress could be measured, as almost all bulls sampled were of the initial generation.

**Abreu, C.P.** 1999. (Factors Affecting Semen Production of Hybrid Bulls). MSc. Thesis, School of Veterinary Sciences, Fed. Univ. of Minas Gerais, Belo Horizonte

**Campos, O.F., Lizeire, R.S., Deresz, F., Matos, L.L., Rodrigues, A. A. and Moreira, P.** 1993. (Suckling versus artificial rearing of Holstein-Zebu cross-bred calves). R. Soc. Bras. Zootec. 22:413-422 and 22:423-431.

**Conceição Jr., V.** (Study of the relationships between tick resistance and productive traits in the bovine species). Ph. D. Thesis, School of Veterinary Sciences, Fed. Univ. of Minas Gerais, Belo Horizonte, pp. 105.

**Dommerholt, J.** 1981. Sire and dam evaluation programme. Consultancy Report, IICA-EMBRAPA, Brasília, DF.

**Freitas, A.F., Wilcox, C.J. and Roman, R.M.** 1995. Genetic parameters for milk yield and composition of cross-bred dairy cattle in Brazil. J. Dairy Sci. 81: 2306-2311

**Freitas, A.F., Wilcox, C.J. and Costa, C.N.** 1998. Breed group effects on milk production of Brazilian cross-bred dairy cows. J. Dairy Sci. 81: 2306-2311.

**Holanda Jr., E.V. and Madalena, F.E.** 1998. (Expensive milk production is not worthwhile). Cad. Téc. Esc. Vet. UFMG, 25: 13-18.

**Hewetson, R.W.** 1980. Consultancy report. IICA/EMBRAPA, Brasília, DF.

**Jondet, R.** 1980-1981. Frozen semen processing in São Carlos. Consultancy report. IICA/EMBRAPA, Brasília, DF.

**Lôbo, R.N.B., Madalena, F.E. and Vieira, A.R.** 1999a. Average estimates of genetic parameters for beef and dairy cattle in tropical regions. Anim. Breed. Abstr. (submitted).

**Lôbo, R.N.B., Penna, V.M. and Madalena, F.E.** 1999b. (Evaluation of a selection scheme for dual purpose Zebu cattle). Rev. Soc. Bras. Zoot., (submitted).

---

*\*Translated titles into parenthesis*



**Lush, J.L.** 1927. Percentage of blood and Mendelism. *J. Hered.* 18: 351-359.

**Madalena, F.E.** 1986. Economic evaluation of breeding objectives for milk and beef production in tropical environments. *Proc. 3<sup>rd</sup> Wld. Congr. Genet. appl. Livest. Lincoln*, 9: 33-43

**Madalena, F.E.** 1988. A note on the effect of variation on lactation length on the efficiency of tropical cattle selection for milk yield. *Theor. Appl. Genet.* v. 76 pp. 830-834.

**Madalena, F.E.** 1989. Cattle breed resource utilisation for dairy production in Brazil. *Proc. International Symposium on Utilisation of Animal Genetic Resources in Latin-America. Brazil. J. Genet.* 12(3) Suppl. pp. 183-220.

**Madalena, F.E.** 1993. (The Sustainable Utilisation of F<sub>1</sub> Females for Tropical Dairy Cattle production). *FAO Anim. Prod. Hlth. Paper* 111, pp. 98.

**Madalena, F.E.** 1994. Considering lactation length in tropical dairy cattle breeding. *Proc. 5<sup>th</sup> Wld. Congr. Genet. appl. Livest. Prod.* 20: 328-331.

**Madalena, F. E.** 1998a. Experiences with performance recording of dairy cattle in Brazil. In: *Internat'l Workshop on Animal Recording for Smallholders in Developing Countries*. K.R. Trivedi (ed.). ICAR Tech. Series N° 1, pp. 235-246.

**Madalena, F. E.** 1998b. Hybrid F<sub>1</sub> *Bos taurus* x *Bos indicus* dairy cattle production in the State of Minas Gerais, Brazil *Proc. 6<sup>th</sup> World Congress on Genetics Applied to Livestock Production*, 27: 199-202.

**Madalena, F. E.** 1999. (Economic values for selection of milk fat and protein). *R. Soc. Bras. Zoot.* (submitted).

**Madalena, F.E., Lemos, A.M., Teodoro, R.L., Barbosa, R. T. and Monteiro, J. B.N.,** 1990a Dairy production and reproduction in Holstein-Friesian x Guzera crosses. *J. Dairy Sci.* 73: 1872-1886.

**Madalena, F.E., Teodoro, R.L., Lemos, A.M., Monteiro, J. B.N. and Barbosa, R. T.** 1990b. Evaluation of strategies for cross-breeding of dairy cattle in Brazil. *J. Dairy Sci.* 73: 1887-1901.

**Madalena, F.E., Abreu, C.P., Sampaio, I.B.M. and Ferreira Sobrinho, F.** 1997. (Cross-breeding practices on dairy farms of the Central Farmers Cooperative of the State of Minas Gerais). *R. Bras. Zootec.* 26: 924-934.



**Matos, L.L.** 1996. (Pasture milk production) In (Proc. Symp. On Special Topics in Animal Science), 34<sup>th</sup> Meet.. Brazil. Soc. Anim. Prod.), SBZ, pp. 169-193.

**Teodoro, R.L., Madalena, F.E. and Smith, C.** 1996. The value of dairy Bos taurus-Bos indicus embryos for milk production in poor environments. J. Anim. Breed. Genet. 113: 471-482.

**Touchberry, R.W.** Report on Dairy Cattle Breeding Consultancy. IICA/EMBRAPA, Brasília, DF.

**Ugarte, J.** 1992. Crianza de terneros. In: Avances en la Producción de Leche y Carne en el Trópico Latinoamericano. (S. Fernandez-Baca, ed.). FAO, Santiago de Chile, pp. 261-306.

**Utech, K.** 1981. Consultancy report. IICA/EMBRAPA, Brasília, DF.

**Vercesi Filho, A.E., Madalena, F.E., Ferreira, J.J. and Penna, V.M.** Pesos econômicos para seleção de gado de leite. Rev Soc. Bras. Zoot. (submitted). 1999.