

Embrapa's Animal Genomics Network and Biotechnology for Economically Important Traits

III Research Cooperation Workshop
Strategic Research Cooperation on Horticulture and Animal Science
March 21st to 30th 2013
Suwon, South Korea

Alexandre Rodrigues Caetano, Ph.D.
Embrapa Recursos Genéticos e Biotecnologia



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Embrapa's Animal Genomics

Network – A little History

- Background (2007):
 - Several projects underway designed to apply genomics tools to seek solutions for general and specific issues to Brazilian animal production systems
 - Carcass and meat quality
 - Endo/ectoparasite resistance
 - Low level of integration between research teams
 - Need to pool and integrate human resources and research infrastructure



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Embrapa's Animal Genomics Network – A little History

- Funding from 2008-11
 - US\$1.25million start-up + (US\$1.9 million of pre-funded projects)
- Nine Research Units and 10 Universities and National Research Institutions
- >80 Research Scientists



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Embrapa's Animal Genomics Network – A little History

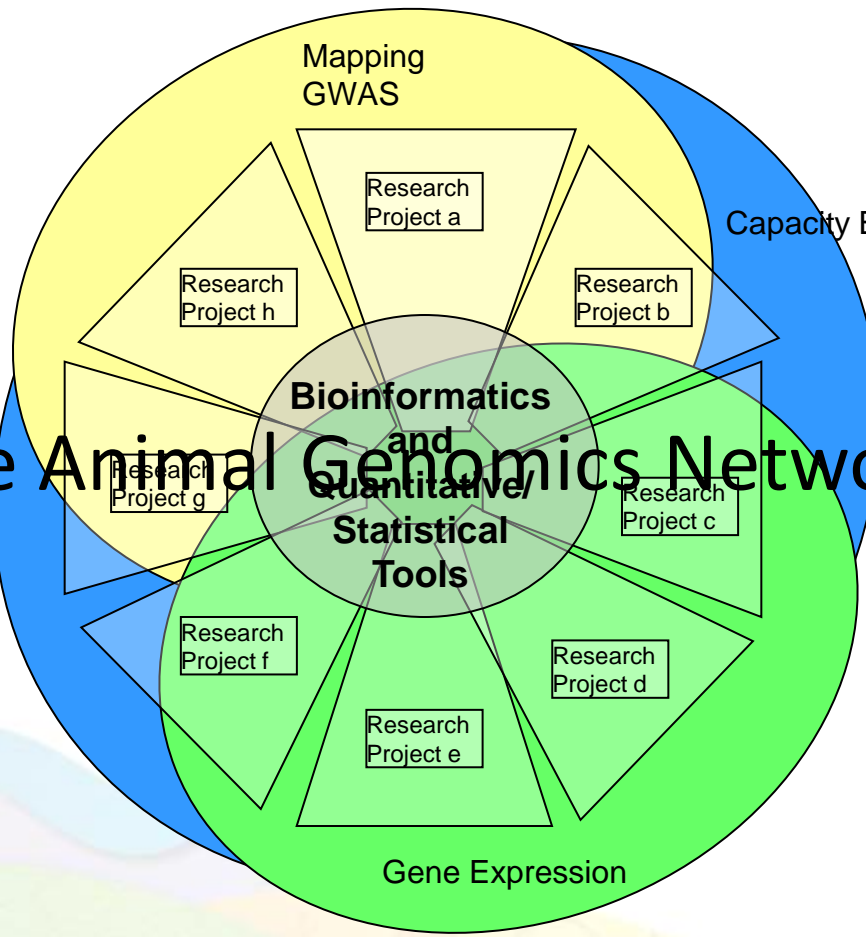
- Major Objectives
 - Create solid environment for multi-disciplinary research teams to interact to work on current research challenges
 - Experimental design, collection of phenotypes and biological samples
 - Molecular data generation
 - Data analysis
 - Establish groundwork for designing new, higher challenging projects



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The Animal Genomics Network



- Multidisciplinary expertise to use and apply core tools and methods
- High complexity experiments with data and samples already collected
- New research tools and methods

- Increased efficiency in research activities lowering costs and increasing outputs
- Access to new technological tools and platforms
- Establishment of a positive synergistic collaborative research environment



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External Funding

Projeto	Pesquisador (es) Responsável (is)	PC	Título Projeto	Fonte Financiadora	Edital/processo	Valor R\$	Duração projeto
1	Marco Antonio Machado	4	Mapeamento Fino de QTLs Associados a Resistência ao Carrapato	CNPq	Edital MCT/CNPq 14/2007 Universal	\$27.500,00	2007-2009
2	Marcos Vinicius G. da Silva	4	Predição de valores genéticos usando mapas densos de marcadores moleculares nas raças Gir e Girolando	CNPq	Edital MCT/CNPq 14/2008 Universal	\$117.473,26	2008-2010
3	Marta Fonseca Martins Guimarães	5	Análise da Expressão Gênica em Vacas Gir Infectadas com Streptococcus agalactiae	CNPq	Edital14/2008 Universal - Processo 471914/2008 8	\$31.339,15	2008-2010
4	Alexandre Rodrigues Caetano/ Samuel Rezende Paiva	4	Desenvolvimento e validação de painéis de marcadores moleculares SNP para exclusão de paternidade, certificação e rastreabilidade de Bovinos de Corte e de Ovinos no Brasil	CNPq	Edital 64/2008 - Processo 578592/2008-8	\$497.800,00	2009-2011
5	Marta Fonseca Martins Guimarães	5	Identificação e Caracterização de Genes Relacionados à Resistência à Mastite em Gado de Leite	FAPEMIG	FAPEMIG 03/2009 - PROGRAMA PESQUISADOR MINEIRO - PPM III	\$48.000,00	2009-2011
6	Natália Florencio Martins	6	Workshop em Genômica Animal	CNPq		\$10.000,00	2009
7	Marco Antonio Machado	5	Genômica Funcional da Resistência ao Carrapato em Bovinos da Raça Girolando (Lider do Projeto - Roberto L. Teodoro)	FAPEMIG	Edital: 020/2006 – Pronex MG - 3	\$75.000,00	07/2007 a 07/2010
8	Luciana Correia de Almeida Regitano/ Simone Cristina Méo Niciura	4	Genômica Funcional em espécies de Importância Agropecuária (Lider do Projeto - Reinaldo Otávio Alvarenga Alves de Brito, UFSCAR)	CAPES	CAPES - PNPd 2009	\$258.000,00	2010-2015
9	Fernando Flôres Cardoso	3, 4	Rede Nacional para Desenvolvimento e Aplicação de Tecnologias Genômicas ao Melhoramento Genético Animal	CAPES	CAPES - PNPd 2009	\$516.000,00	2010-2015
10	Samuel Rezende Paiva	4	Desenvolvimento de painéis de marcadores moleculares SNP (Single Nucleotide Polymorphism) para auxiliar programas de conservação e melhoramento de caprinos no Brasil	CNPq	Edital14/2009 Universal	\$88.817,00	2010-2013
11	Concepta McManus Pimentel	4	Genética de paisagem de Ovinos no Brasil: uma avaliação georeferenciada de padrões genéticos para estudos de conservação, caracterização e rastreabilidade de rebanhos	CNPq	Edital CNPq 17/2010	\$107.852,82	2010-2014
12	Concepta McManus Pimentel	4	BOLSA POSDOC Genética de paisagem de Ovinos no Brasil: uma avaliação georeferenciada de padrões genéticos para estudos de conservação, caracterização e rastreabilidade de rebanhos	CAPES	CAPES - PNPd 2009	\$154.800,00	2010-2014
13	Concepta McManus Pimentel	4	Geomapeamento genética de raças de ovinos no Brasil	CNPq	Edital14/2010 Universal	\$104.000,00	2010-2012
14	Concepta McManus Pimentel		BOLSA IC	CNPq		\$13.000,00	2011-2013
15	Concepta McManus Pimentel / Samuel Rezende Paiva	2,4		FAPDF	Pronex-FAPDF-2009	\$799.000,00	2009-2012
16	Marcos Vinicius G. da Silva	3,4	Núcleo de Bioinformática da Embrapa Gado de Leite/FAPEMIG	FAPMG	FAPMG	\$500.000,00	2009-2013
17	Alexandre Rodrigues Caetano	3,4	Rede Nacional de Estudos Genômicos para Aprimorar o Melhoramento Genético Animal e a Produção Pecuária	CNPq	REPENSA - 2010	\$340.000,00	2011-2013
18	Natália Florencio Martins	6	II Worksho da Rede Genômica Animal	CNPq		\$20.000,00	2011-2012
19	Natália Florencio Martins	6	II Worksho da Rede Genômica Animal	FAPDF		\$11.000,00	2011-2013
20	Alexandre Rodrigues Caetano	2,4	Tecnologias Genômicas para a Conservação e Caracterização de Recursos Genéticos, e Avaliação e Melhoramento de Espécies Animais de Interesse para a Agropecuária Brasileira	CAPES	CAPES - EMBRAPA	\$352.800,00	2011-2015
TOTAL						\$4.072.382,23	

US\$2,073,000

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New "SEG" Projects

						SEG	CONTRAPARTIDA	
1	Fernando Cardoso	4	Seleção genômica para resistência ao carrapato bovino (<i>Rhipicephalus microplus</i>) nas raças Hereford e Braford	Embrapa - SEG MP2	06/2009	\$1,047,000.00	\$3,100,000.00	2009-2012
2	Monica Ledur	4	Identificação de genes de interesse para a suinocultura por meio da genotipagem de SNPs em grande escala e comparação de metodologias de seleção em Programa de Melhoramento Genético Nacional	Embrapa - SEG MP2	06/2009	\$1,294,000.00	\$5,257,000.00	2009-2012
3	Marcos V G B da Silva	4	Seleção Genômica em Raças Leiteiras no Brasil - Genomilk	Embrapa - SEG MP2	06/2010	\$1,008,000.00	\$1,000,000.00	2009-2012
4	Paula Kuser Falcão	2	Laboratório de Referência de Bioinformática da Embrapa	-	-	\$1,500,000.00		2009-2012
5	ROBERTO HIROSHI HIGA	2	Prospecção e priorização de genes candidatos por meio de técnicas de mineração de dados e textos	MP3	Chamada 01/2009 PAC?EMBRAPA?Prioridades	\$109,744.31		2011-2013
6	Poliana	2	"Construção de redes gênicas a partir de dados de microarranjos"	MP3	Chamada 01/2009 PAC?EMBRAPA?Prioridades			2011-2013
7	Alexandre Rodrigues Caetano	2,4	Rede de Seqüenciamento de Genomas para Desenvolvimento de Tecnologias Inovadoras para a Pecuária Brasileira	MP2	06/2010	\$1,397,950.00	\$2,500,000.00	2011-14
5	Natália Florêncio Martins	6	Laboratório de Bioinformática do Cenargen	BBSRC-Embrapa	01/2010	\$ 21.800,00		2010-2011
						TOTAL	\$6,356,694.31	\$11,857,000.00
						SEG+CONTRAPARTIDA	\$18,213,694.31	

SEG US\$3.156.694



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Scientific Results



PAULO, A. R. R. ; CAETANO, A. R. ; CARVALHO, W. A. ; Ferreira, BR ; SANTOS, I. K. F. M. . Detection of Single Nucleotide Polymorphisms (SNPs) in Bovine Immune-Response Candidate Genes for Mediating Resistance to the Cattle Tick, *Rhipicephalus microplus*. *Animal Genetics*, v. 39, p. 328-332, 2008.

al, M Elisabete J ; Grant, Jason R ; Riggs, Penny K ; Stafuzza, Nedenia B ; Filho, Edson ; Goldammer, Tom ; Weikard

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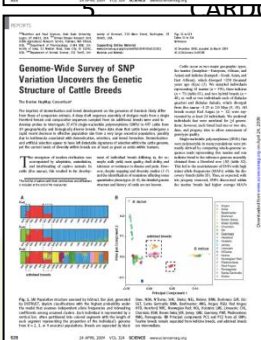
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O, F. R. ; Bunch, R. J. ; Burton, J. ; GORNI, C. ; Olivier, H. . Genome-Wide Survey of SNP Variation Un

covers the Genetic Structure of

Cattle Breeds. *Science*, v. 324, p. 528-532, 2009.

7. Liu, G. E. ; LI, R. W. ; SONSTEGARD, Tad S ; MATUKUMALLI, L. ; SILVA, M. V. G. B. ; Van Tassell, C. P. . Characterization of a novel



Articles in Refereed Journals	28
Abstracts	84
Articles in the media	160
Book chapters	3
Talks	35
Videos	23
MS thesis	15
PhD Dissertations	10

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Alexandre R ; Ga
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522-528, 2009.
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9-1690, 2008.
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nal of Animal Science, v. 38, p. 72-
Hamernik, D. L. ; KAPPES, S. M. ;
eler, D. A. ; Ajmone-Marsan, P. ;
T. S. ; WILLIAMS, J. L. ; Diallo, B. ;
Abbey, C. A. ; Agaba, M. ;

2008 Embrapa's National Award Embrapa – Partnership

2010 Embrapa's National Award Embrapa – Technical Excellence

Embrapa's Animal Genomics Network - II



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Current Context

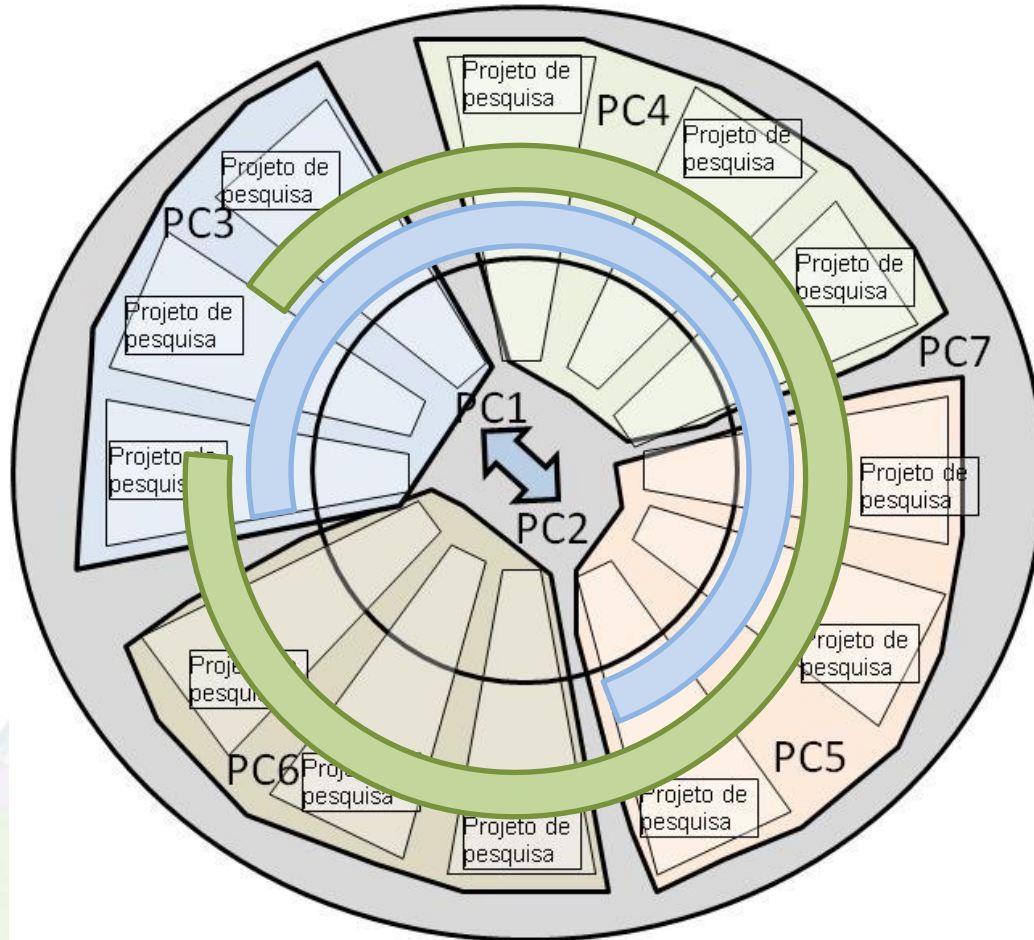
- NextGenSeq
 - New Sequencing and Genotyping tools and approaches
- Animal Breeding: Genomic Selection
- Metagenomics
- New Species
 - Development of breeding populations
 - Lack of genetic management and breeding tools



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AGN - II



NexGenSeq

SNP Genotyping



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Embrapa's Animal Genomics Network- II

- Funding 2013-16
 - US\$2.5million
- Ten Research Units and 15 Universities and National Research Institutions
- >90 Research Scientists



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Major Research Projects Underway



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Development of GS Tools for Tick-Resistance Traits in Braford Cattle

Project Leader: Fernando Cardoso



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Development of GS Tools for Tick-Resistance Traits in Braford Cattle

- Genetic evaluations for traditional traits
 - Growth
 - Reproduction
- Need to include tick resistance and carcass and beef quality traits



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Development of GS Tools for Tick-Resistance Traits in Braford Cattle



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Development of GS Tools for Tick-Resistance Traits in Braford Cattle

Variance Components ^A	NTICK	LTICK	NTICK	LTICK
	n = 2,821 animals (all CG)		n = 2,164 animals (GC>5 ticks)	
σ_a^2	19.90	0.035	29.89	0.046
σ_e^2	85.29	0.094	97.66	0.089
$h_g^2 \pm \text{s.e.}$	0.19 ± 0.049	0.27 ± 0.060	0.23 ± 0.063	0.34 ± 0.077
σ_a^2	16.22	0.026	24.39	0.032
σ_e^2	87.67	0.101	101.48	0.098
$h_g^2 \pm \text{s.e.}$	0.16 ± 0.046	0.20 ± 0.054	0.19 ± 0.059	0.25 ± 0.070

^A σ_a^2 =Additive genetic variance, σ_e^2 =Environmental variance

Cardoso et al, (2006)

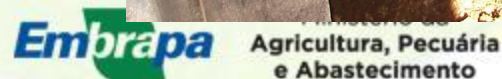


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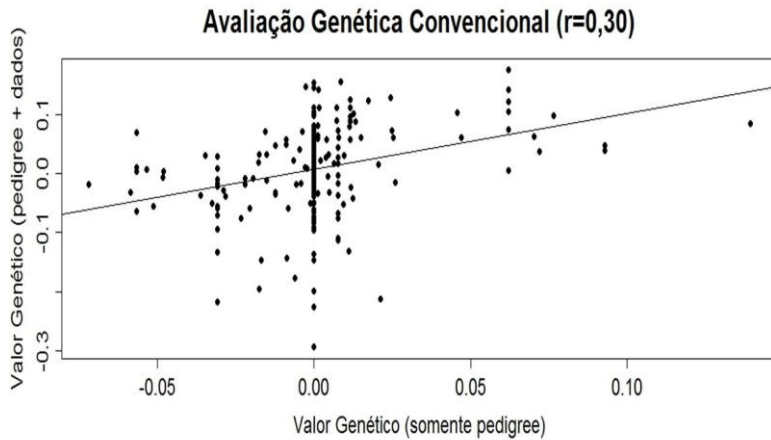


- Tick counts on over 4000 animals
- DNA collected
- Genotyping of 2000 animals in 2011

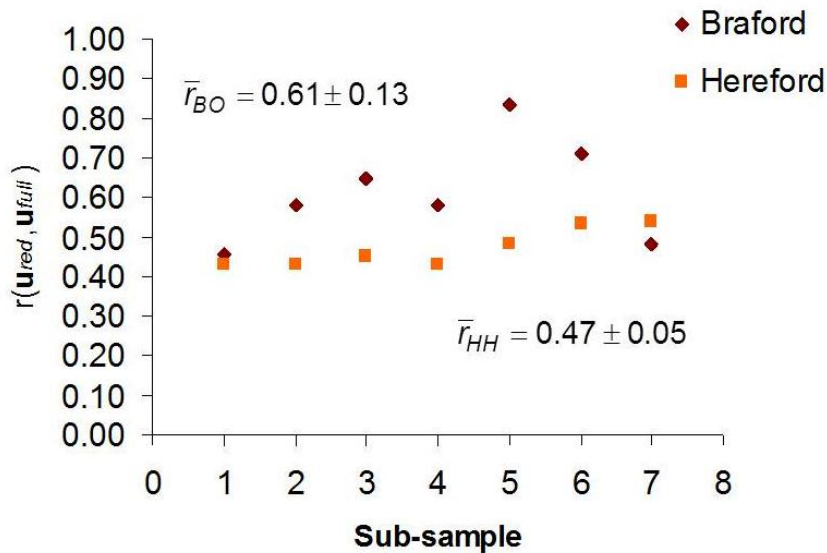
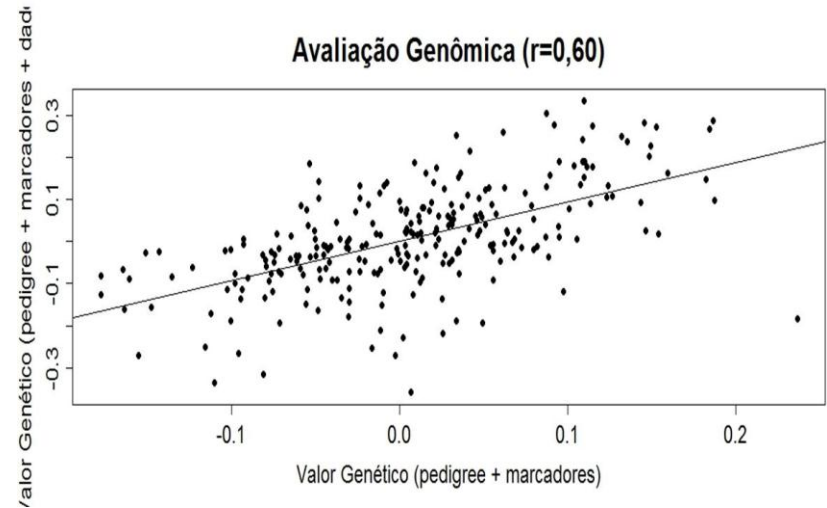


Initial Results

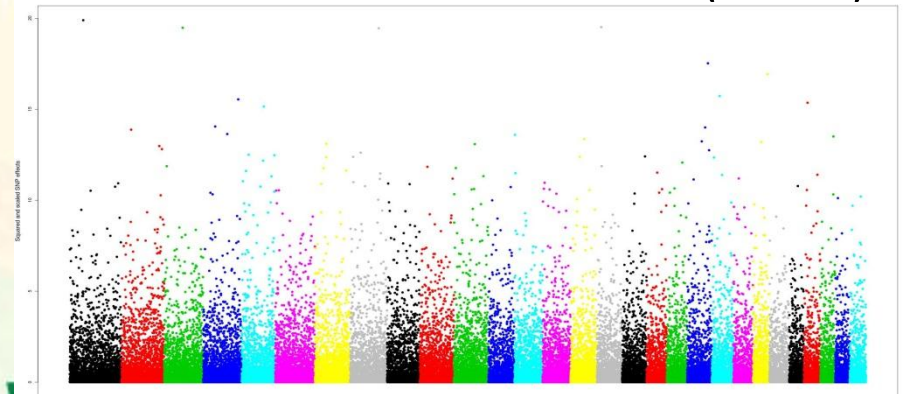
Predição convencional (média dos pais)



Predição genômica

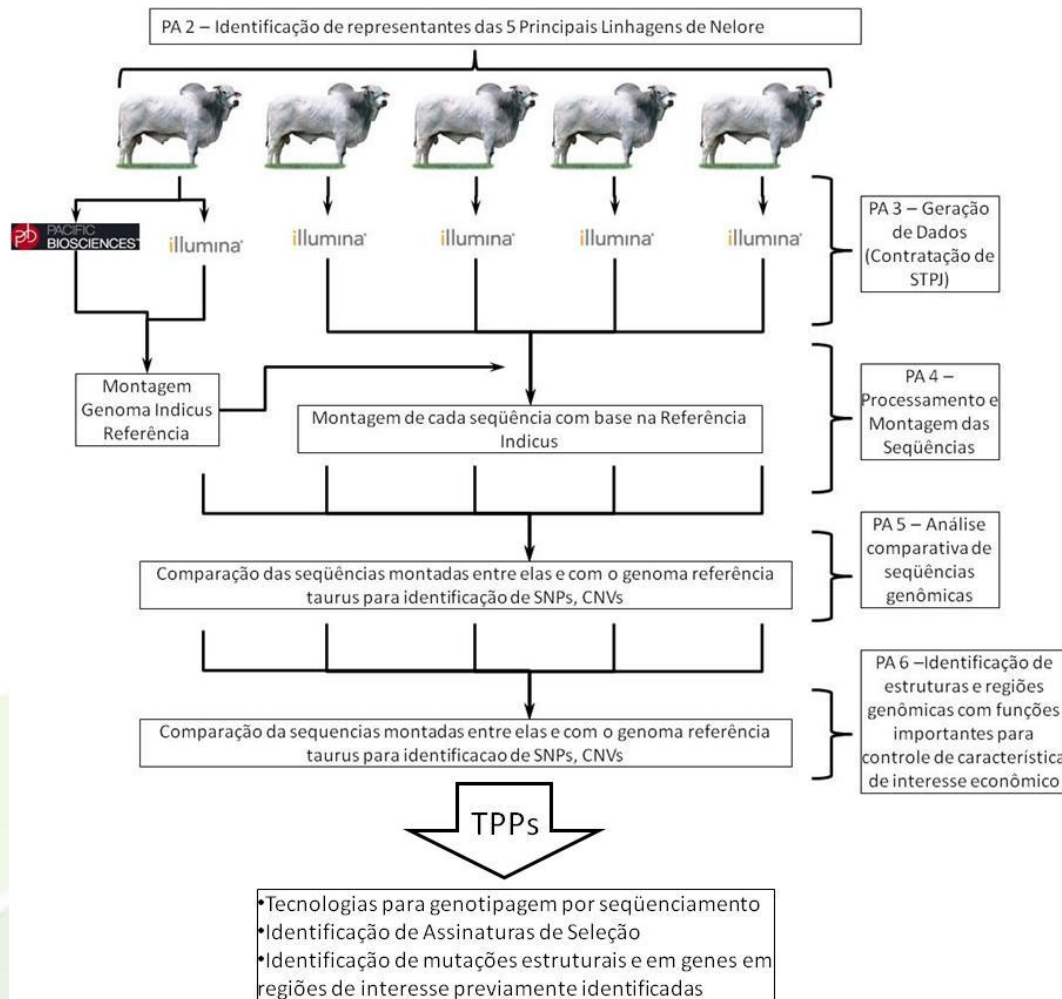


SNPs effects for tick resistance (GWAS)



MP2 – Genome Sequencing Network

Project Leader: Alexandre Caetano



- Development of capacity to assemble and analyze genomes on a routine basis
- Genotype by sequencing
- Integration with Embrapa's genetic evaluation programs



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MP2 – Genome Sequencing Network

Library Ave. Insert Size	# of Libraries	# Reads	# of bp	Fold Coverage	Application
300	8	609,017,028	61,510,719,828	25.63	contig and scaffolding
700	8	592,138,918	59,806,030,718	24.92	contig and scaffolding
3kb	8	253,796,928	9,136,689,408	3.81	scaffolding
5kb	8	308,768,814	11,115,677,304	4.63	scaffolding
10kb	8	243,264,538	8,757,523,368	3.65	scaffolding
TOTAL		2,006,986,226	150,326,640,626	62.64	

Assembly Trial	kmer	Contig Min. Length	Min. Cov.	Merge Similar Seq.	Gap Fill	# Contigs	# Scaffolds	Scaffolds & Singletons	Total bp in scaffolds	Total bp in Scaffolds & Singletons	N50	N90
3	31	33	5	3	no	16,449,697	113,688	13,248,260	2,870,266,187	3,971,749,367	49,152	69
4	31	33	5	3	yes	3,264,898	85,301	643,319	2,845,793,213	2,973,209,467	140,663	17,140
5	31	200	5	3	yes	3,264,898	15,103	1,329,311	2,568,202,558	2,731,148,060	649,030	54,144
7	31	200	15	3	yes	3,313,110	19,609	1,403,878	2,556,466,909	2,730,476,662	551,053	36,831
6	31	300	15	3	yes	3,313,110	17,591	1,709,630	2,507,860,974	2,755,501,738	518,083	11,067



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GS in Zebu Dairy Breeds in Brazil

Project Leader: Marcus Vinicius Silva

- Genetic evaluations for several breeds
 - Gir, Girolando, Guzerat
- Implement GS in the evaluation programs
 - Gir
 - Girolando
 - Guzerat
- Genotyping data on 5,000-10,000 animals



ASSOCIAÇÃO
BRASILEIRA
DE CRIADORES
DE BOVINOS
DA RAÇA
HOLANDESA

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Integration of Brazil into the Sheep Hapmap and Genome Sequencing Consortium

Project Leader: Samuel Paiva

The sheep HapMap and Breed Diversity Experiment



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Bergamasca

Rabo Largo

Corriedale

Somali

Morada Nova

Santa Ines

Pantaneira

Crioula Lanada

Ile de France



GS in Holstein Breed in Brazil

Project Leader: Claudio Napolis

- Implement GS in the national evaluation program
 - Genotyping data on 1,500 animals
 - Collaboration with Europe and US to exchange genotyping data on imported bulls
- Integrate Brazil as a member of Interbull
 - Make necessary adjustments on data collection and analysis procedures
- Work with National Holstein Association to integrate new variables into current business model



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MP2 – Nelore Genomic Selection

Project Leader: Luiz Otávio Campos da Silva

- Implement Genomic Selection into Embrapa's Nelore genetic evaluation and breeding program (Geneplus)
- Focus on reproduction, carcass and meat quality
- Genotyping of 5 a 10,000 animals



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Genomic Selection in Swine

Project Leader: Monica Ledur

Sadia

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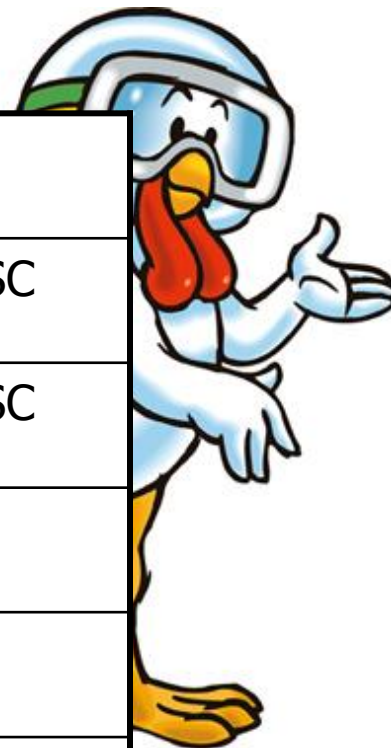


Sadia

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Sadia

Rezend

Nucleus Unit	Location
Unit 9 (340 sows)	Ponte Serrada – SC
Unit 10 (550 sows)	Ponte Serrada – SC
Unit 11 (550 sows)	Irani – SC
Unit 12 (340 sows)	Irani – SC
Unit 13 (550 sows)	Irani – SC
Unit 14 (550 sows)	Irani – SC
Backup (380 sows)	Uberlândia - MG



➤ Total – 3.260 sows



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GOVERNOS
BRAS
PAÍS RICO É PAÍS SEI

Sadia
HOT
POCKET

Deline
cremoso
Sadia

GRANJAS NÚCLEO

UNIDADE 9



UNIDADE 10



UNIDADE 11



UNIDADE 12



Genomic Selection in Swine

- Genotyping of 5000 animals with the Illumina swine 60K
- Data:
 - Growth
 - Feed efficiency
 - Carcass and meat quality
 - Reproduction



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Embrapa's Animal Genomics Network – II Proposed Research Actions



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PC3 – Genomic Selection

PA 3.1 GS in Zebu dairy Breeds

PA 3.2 -Development of GS Tools for Tick-Resistance Traits in Braford Cattle

PA 3.3 – GS in local ovine breeds

PA 3.4 – GS in dairy goats

PA 3.5 – GS in Holsteins



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PC4 – Gene Mining and Identification

PA4.01-Gwas in **Chickens** for identification of genes of economic interest

PA4.02 – Identification of **bone integrity genes in broilers**

PA4.03 – Identification of genes that affect **production traits in Canchim cattle**

PA4.04- Identification of genes that control **pol/horn presence in Zebu cattle**

PA4.06 -Identification of genes that control **pol/horn presence and cryptorchidism in Morada Nova sheep**

PA4.10 – Identification of genes associated with **gastrointestinal parasite resistance in goats**



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PC5 – New Species

PA 5.1 – Sequencing and de novo assembly of **Cachara** (*Pseudoplatystoma reticulatum*)

PA 5.2 - Sequencing and de novo assembly of **tambaqui** (*Colossoma macropomum*)

PA 5.3 Sequencing and de novo assembly of caprine **Lentivirus**

PA 5.4 – SNP identification in **cachara and pintado**

PA 5.5 – SNP identification in **pacu-tambaqui**.

PA 5.6 – SNP identification in **shrimp (P. vannamei)**

PA 5.7 – Bovine tick (**Rhipicephalus Boophilus microplus**) transcriptome analysis

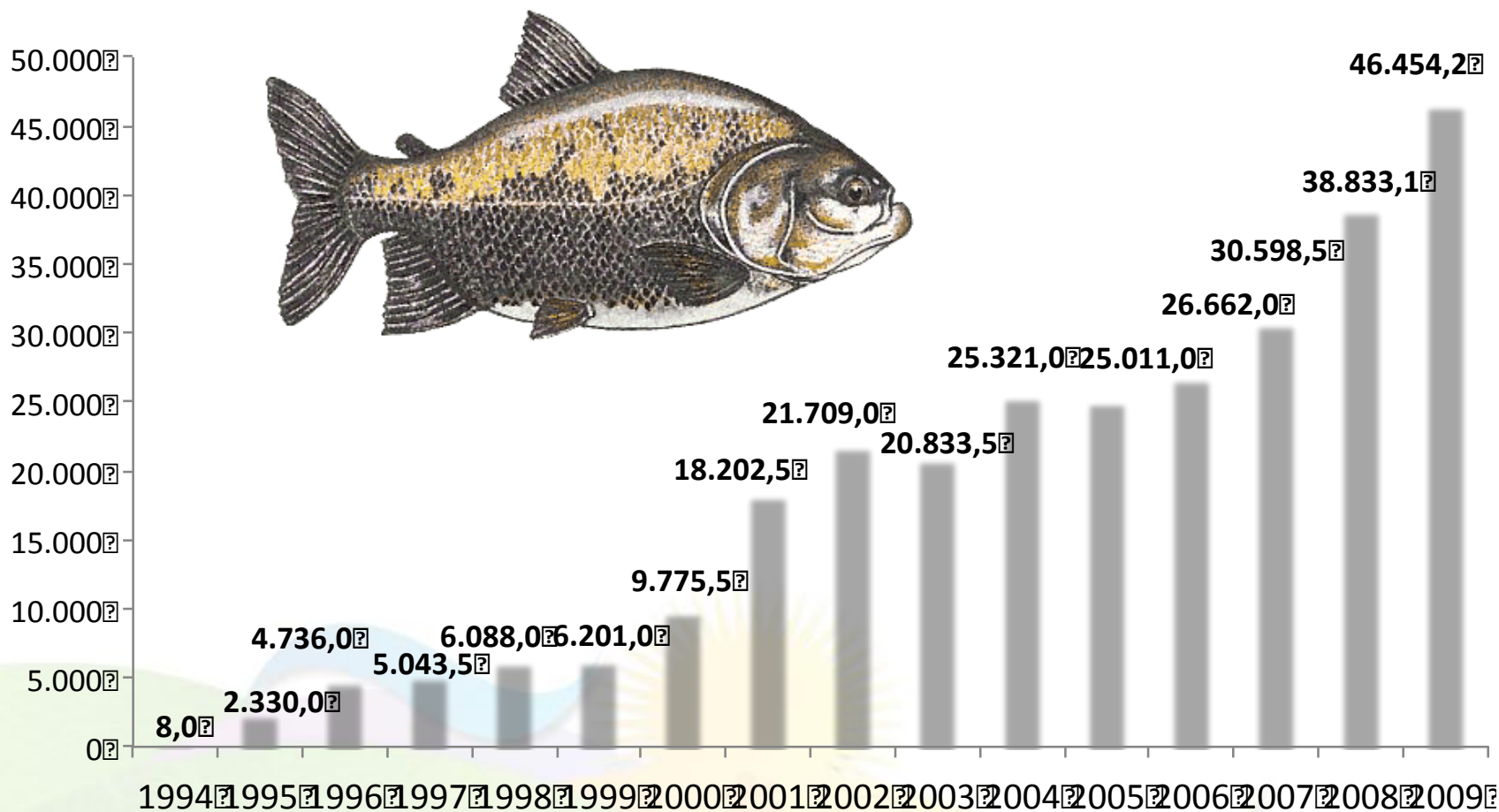
PA 5.8 - **Haemonchus contortus** transcriptome analysis



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National Production of Tambaqui



Metric Tons

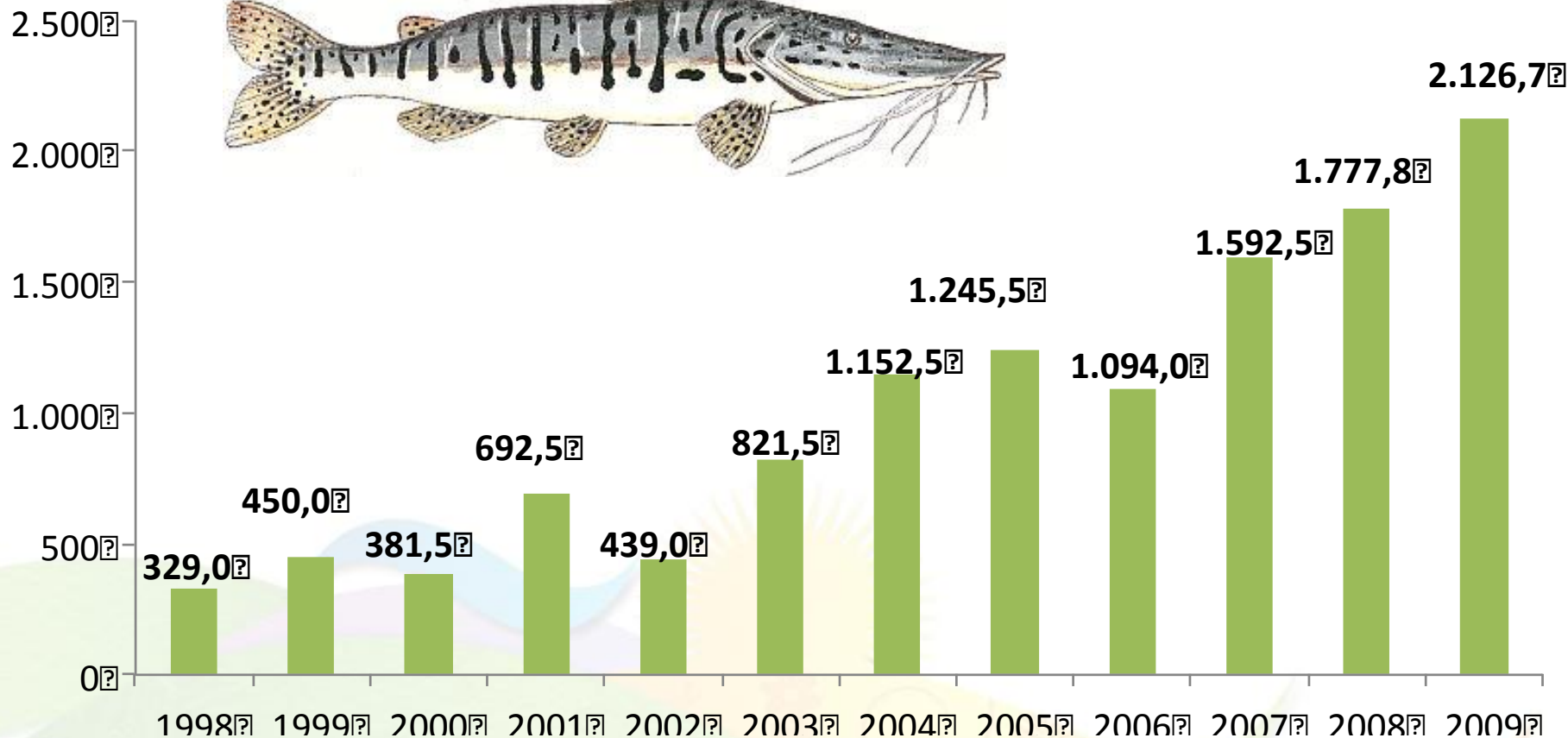
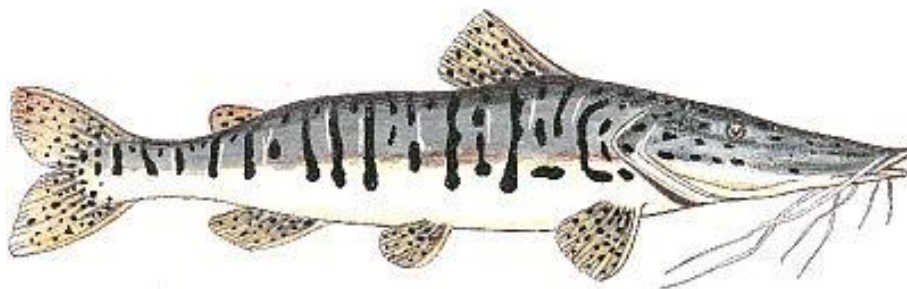
Source: IBGE



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National Production of Cachara



Metric Tons

Source: IBGE



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PC6 - Metagenomics

PA 6.2 – Metagenomics of Morada Nova ruminal flora for identification of molecules and microorganisms of biotechnological interest

PA 6.3 – Udder metagenomics in sheep with focus on mastitis resistance

PA 6.4 – Broiler intestinal metagenomics with focus on the identification of beneficial and pathogenic organisms

PA 6.5 – Metagenomics of swine respiratory viruses

PA 6.6 – Comparative studies of microbiota from chicken house bedding and healthy and diseased animals for improvement of management systems

PA 6.7 – Study of the microbiota in swine and avian effluents.



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Major Opportunities

- Collaboration on data analysis
- Development of new collaborative projects
- Capacity building



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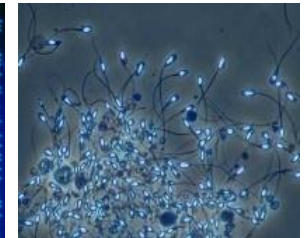
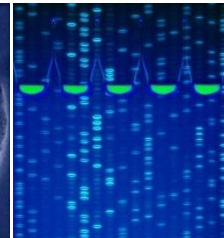
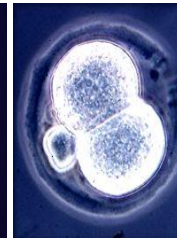
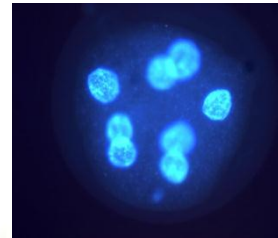
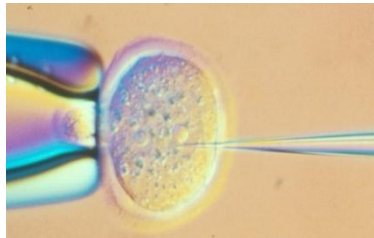
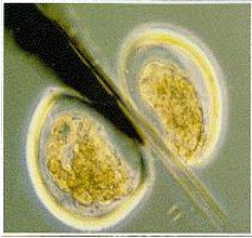
provided by Hoard's Dairyman



Photo Courtesy of:
Manitoba Agriculture and Food



Thank you !!!



alexandre.caetano@embrapa.br

