Optimizing mate selection: a genetic algorithms approach

Diego de Carvalho Neves da Fontoura
Dr. Sandro da Silva Camargo
Dr. Fernando Flores Cardoso

https://www.embrapa.br/en/international

Embrapa | Brazilian Agricultural Research Corporation
Ministry of Agriculture, Livestock, and Food Supply

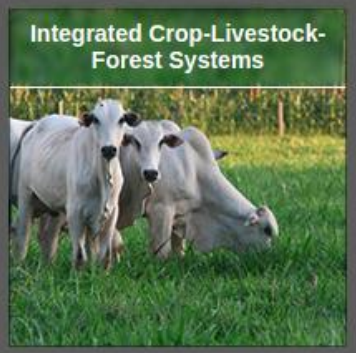
Embrapa | Products, Processes and Services | Library | Events | Projects | News | Multimedia | Access to Information

International

About us

- About Embrapa
- Our Units
- Our Team
- Research & Development

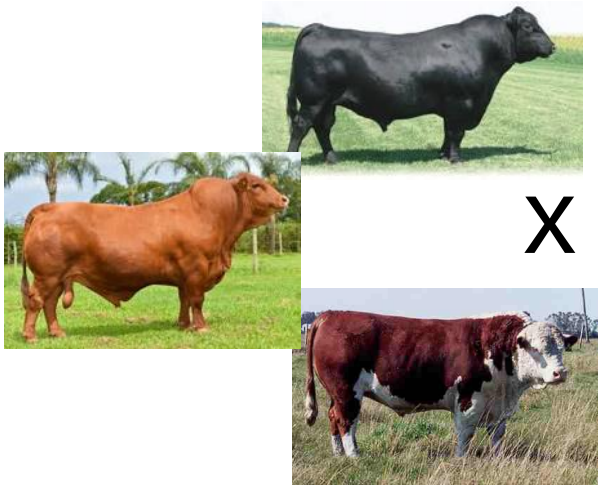
Themes | read more



Brazilian Agribusiness

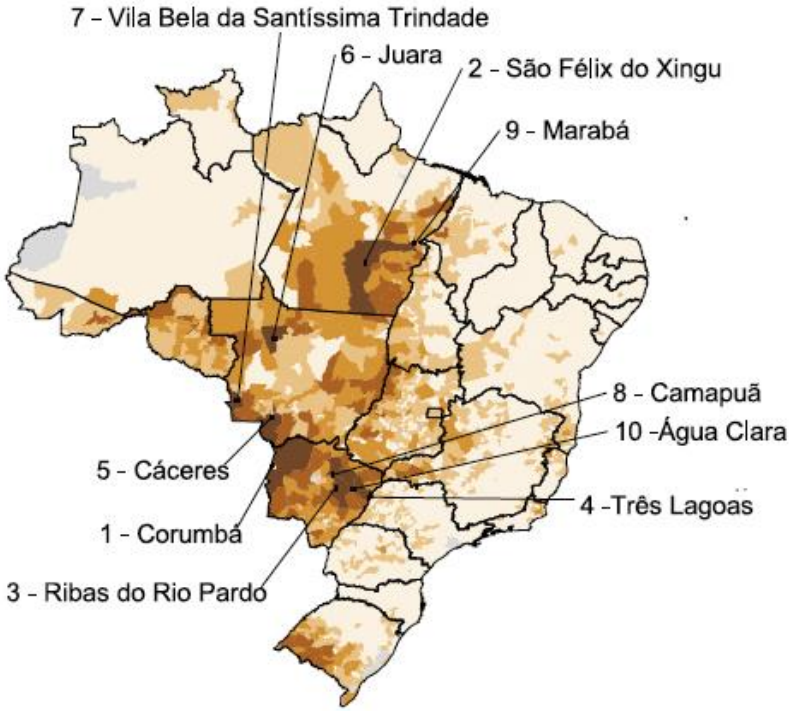
	Sugar	Coffee	Orange juice	Soya	Chicken	Beef	Corn	Pork
Production	38,7 Ml t (1º)	3,1 Ml t (1º)	1,1 Ml t (1º)	113 Ml t (2º)	14,2 Ml t (2º)	8,5 Ml t (2º)	92,8 Ml t (3º)	3,6 Ml t (4º)
Exports	28,9 Ml t (1º)	1,9 Ml t (1º)	1,0 Ml t (1º)	63,6 Ml t (1º)	4,3 Ml t (1º)	1,4 Ml t (2º)	21,8 Ml t (2º)	0,7 Ml t (4º)
Share	48%	25%	76%	43%	38%	19%	22%	10%

Brazilian beef cattle industry



X

- > 200 M heads
- Tropical environment
- Mostly zebu populations



- Crossbreeding with taurine breeds for fast improvement of early mature and meat

- Limited by the higher susceptibility to ticks and heat

Brazilian Hereford and Braford Association

Avaliação Genética Pampa Plus Hereford & Braford

10 anos

Democratizando o conhecimento!

Associação Brasileira de Hereford e Braford

Labegen – Laboratório de Bioinformática e Estatística Genômica

GENE PLUS

Embrapa Pecuária Sul

Hereford & Braford Genetic Evaluation Program - PAMPAPLUS

Embrapa

unipampa Universidade Federal do Pampa

PampaPlus - EPDs

BW Birth Weight	**WW** Weaning Weight	**WWm** WW Maternal - Milk	**TM** Total Maternal
YW Yearling Weight	**PWG** Post Weaning Gain	**MCW** Mature Cow Weight	**SC** Scrotal Circumference
MSC Muscling Score	**HSC** Height Scores	**BCS** Body Capacity Score	**CBC** Cow Body Score
	NSC Navel Size Score	**EP** Eye Pigmentation	

Breeders' decisions

Selection!

- Which animals to breed?
- How many offspring from each animal?
- How are the chosen bulls combined with the selected cows?

Matings!

PampaPlus – Index (IQG)

TM 30%

YW 15%

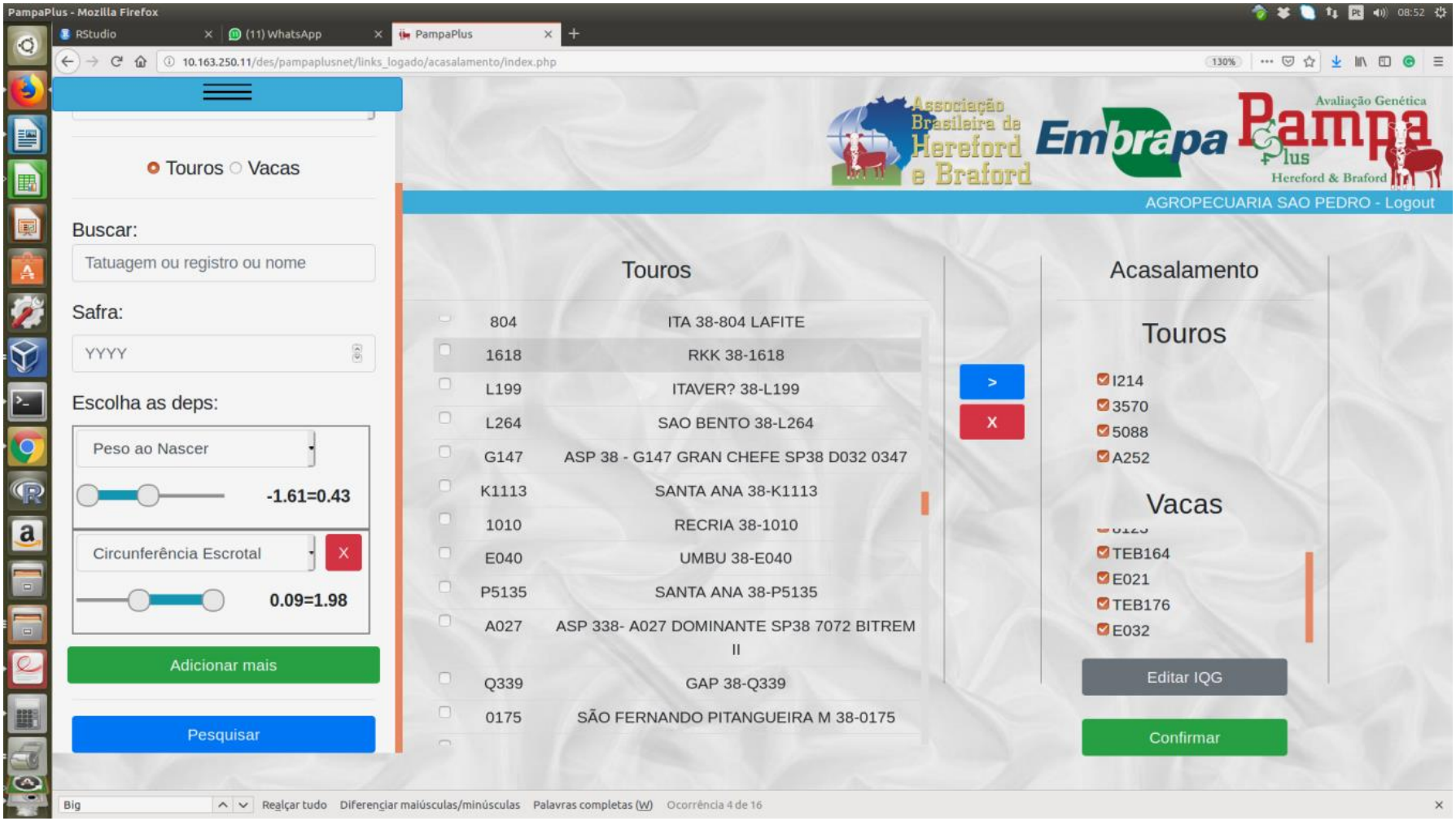
PWG 15%

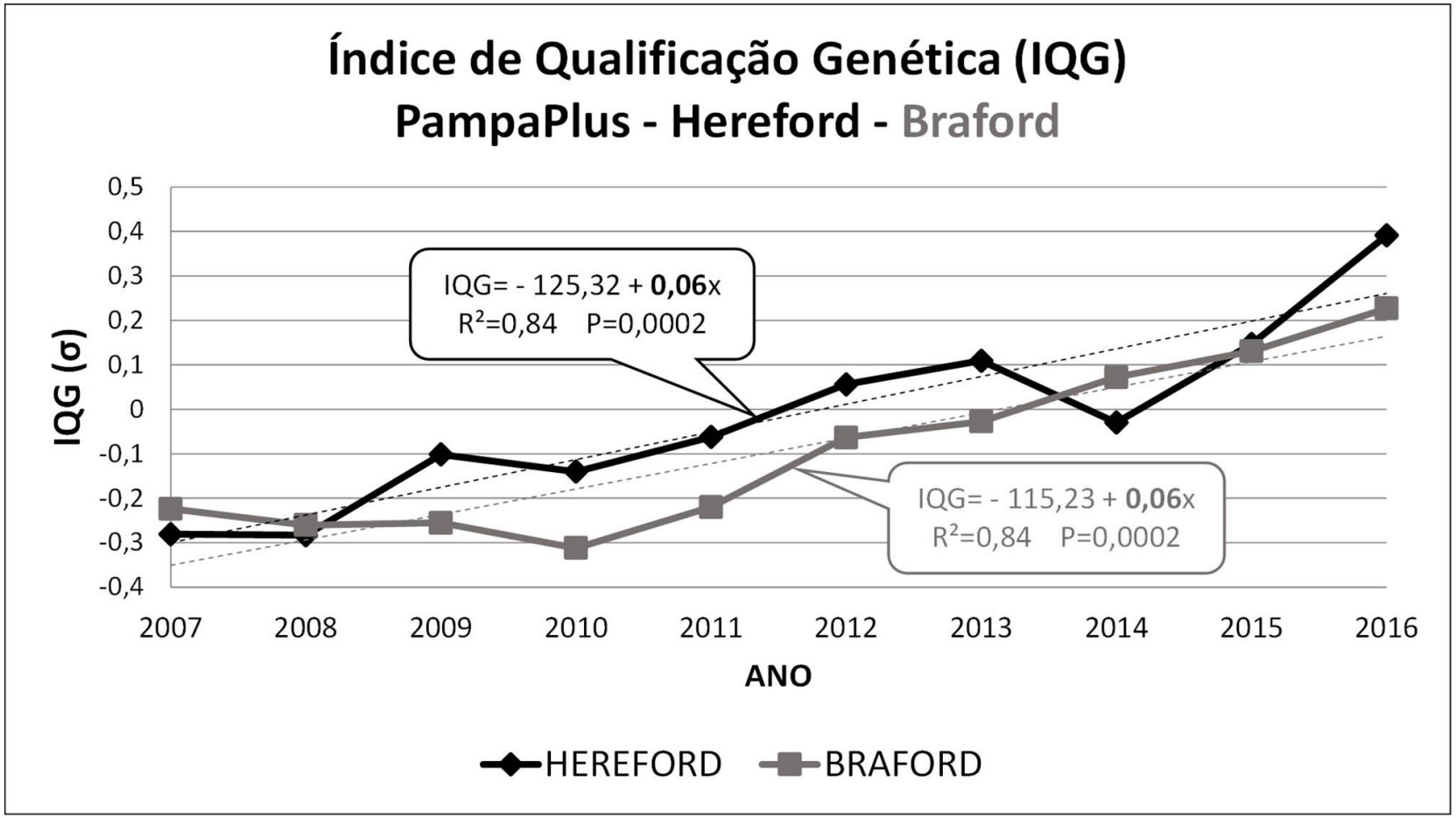
SC 15%

MSC 12.5%

HSC 12.5%

Mating tool


PampaPlus - Mozilla Firefox
RStudio
(11) WhatsApp
PampaPlus
10.163.250.11/des/pampaplusnet/links_logado/acasalamento/index.php
Touros
Vacas
Buscar:
Tatuagem ou registro ou nome
Safra:
YYYY
Escolha as deps:
Peso ao Nascer
-1.61=0.43
Circunferência Escrotal
0.09=1.98
Adicionar mais
Pesquisar
Associação Brasileira de Hereford e Braford
Embrapa
Pampa Plus
Avaliação Genética
Hereford & Braford
AGROPECUARIA SAO PEDRO - Logout
Touros
804 ITA 38-804 LAFITE
1618 RKK 38-1618
L199 ITAVER? 38-L199
L264 SAO BENTO 38-L264
G147 ASP 38 - G147 GRAN CHEFE SP38 D032 0347
K1113 SANTA ANA 38-K1113
1010 RECRIA 38-1010
E040 UMBU 38-E040
P5135 SANTA ANA 38-P5135
A027 ASP 338- A027 DOMINANTE SP38 7072 BITREM II
Q339 GAP 38-Q339
0175 SÃO FERNANDO PITANGUEIRA M 38-0175
>
X
Acasalamento
Touros
I214
3570
5088
A252
Vacas
TEB164
E021
TEB176
E032
Editar IQG
Confirmar
Big
Realçar tudo
Diferenciar maiúsculas/minúsculas
Palavras completas (W)
Ocorrência 4 de 16


Índice de Qualificação Genética (IQG)
PampaPlus - Hereford - Braford
IQG= - 125,32 + 0,06x
R²=0,84 P=0,0002
IQG= - 115,23 + 0,06x
R²=0,84 P=0,0002
IQG (σ)
0,5
0,4
0,3
0,2
0,1
0
-0,1
-0,2
-0,3
-0,4
2007
2008
2009
2010
2011
2012
2013
2014
2015
2016
ANO
HEREFORD
BRAFORD

Contents lists available at ScienceDirect

Livestock Science

journal homepage: www.elsevier.com/locate/livsci

Genetic parameters and trends for traits of the Hereford and Braford breeds in Brazil☆

B.B.M. Teixeira[a,*], M.D. MacNeil[b,c,1], R.F. da Costa[a], N.J.L. Dionello[a], M.J. Yokoo[d], F.F. Cardoso[a,d]

[a] UFPEL/FAEM/Departamento de Zootecnia/PPGZ, Campus Universitário, s/n°, 96010-900 Pelotas, RS, Brazil
[b] Delta G, 145 Ice Cave Rd., Miles City, MT, United States
[c] Department of Animal, Wildlife and Grassland Sciences, University of the Free State, P.O. Box 339, Bloemfontein 9300, South Africa
[d] Embrapa Pecuária Sul, Rodovia BR-153, Km 632,9 Vila Industrial, Zona Rural, Caixa Postal 242, CEP: 96401-970 Bagé, RS, Brazil

Parâmetros	WW	WWm	PWG	SC	MSC	HSC
E(ΔG/year)	1.154	-0.262	0.764	0.038	0.034	0.022
R(ΔG/year)	0.232	-0.052	0.156	-0.002	0.009	0.0046
R/E (ΔG/year), %	20.1	19.8	20.4	-5.3	26.5	20.9

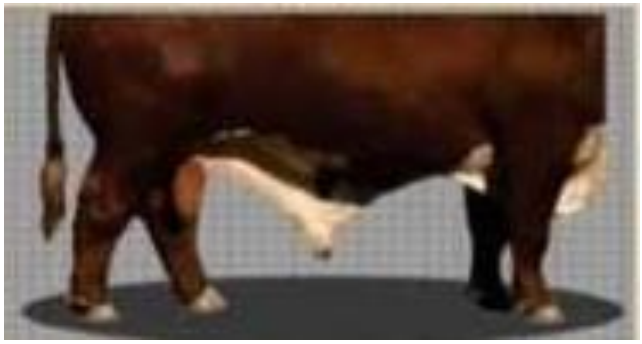
Independent culling traits

BW

Birth Weight

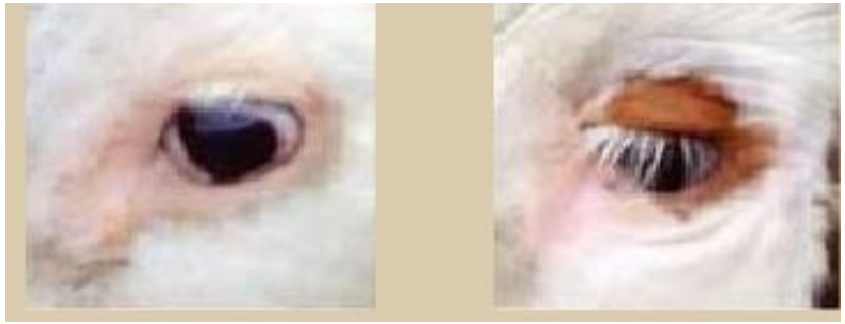
NSC

Navel Size Score



EP

Eye Pigmentation



Getting rid of the uncomfortable red-bars

18/06/2019 pampaplusnet.com.br/visualizar/animal.php?id=431839

Avaliação Genética Pampa Plus Hereford & Braford

PROGRAMA DE AVALIAÇÃO GENÉTICA
HEREFORD E BRAFORD - PampaPlus
Parceria ABHB/Embrapa
Edição Maio/2019

Embrapa

PoloGen — Polo de Excelência em Genética Taurina

Animal

Tatuagem: TE1001	Gênero: M
Nascimento: 02/09/2011	Raça: Braford
Livro: CCG	Registro Def.: 181526
Grau de Sangue: 38	Nome: SERENO 38-TE1001

Pai: **SAO MIGUEL 38-9309 TAURA**

Mãe: **NOVA ESPERANCA 38-3026**

Número de reb. c/ filhos: 2 Número de filhos avaliados: 207

Esta ficha de avaliação está disponível para visualização online em:

http://pampaplusnet.com.br/visualizar/animal.php?id=431839

DEPS

Info	DEP	AC	%	Info	DEP	AC	%
PN	0,28	70,0	71,0	PMD	11,00	34,0	93,0
PDd	10,69	73,0	0,1	PES	1,23	60,0	0,1
PDM	-0,93	33,0	68,0	MSC	0,53	72,0	0,1
TMD	4,42		4,0	EST	0,31	74,0	1,0
PS	19,56	73,0	0,1	CRP	0,50	71,0	0,1
GPD	10,80	63,0	0,1	CVD	0,09	27,0	5,0
UMB	0,17	74,0	99,0	POC	0,30	68,0	0,5

Valores Fenotípicos para Escores

Características Raciais : 3,00
Aprumos e Locomoção: 3,00
Características Sexuais: 3,00

Índice Geral : **3,34**

0,10%

Legenda:

PN(Kg) = Peso ao Nascer, **PDd**(Kg) = Peso ao Desmame, **PDM**(Kg) = Peso Desmame Materno, **TMD**(Kg) = Total Materno, **PS**(Kg) = Peso ao Sobreano, **GPD**(g/d) = Ganho Pós-Desmama, **PMD**(Kg) = Peso da Mãe ao Desmame, **PES**(cm) = Perímetro Escrotal, **MSC**(1-5) = Musculatura, **EST**(1-5) = Estatura Corporal, **CRP**(1-5) = Estrutura Corporal, **CVD**(1-5) = Condição Corporal da Vaca ao Desmame , **UMB**(1-5) = Tamanho do Umbigo, **POC**(1-5) = Pigmentação Ocular.

Objetive

To develop a evolutionary computing tool to optimize mating decisions by beef cattle breeders

- Customizable index for herd specific breeding objectives
- Penalty for offspring inbreeding
- Definable minimum and maximum number of offspring per parent
- Penalty for low performance on independent culling traits

Genetic algorithm (GA)

1. Definition of Chromosome
2. Fitness function
3. Restrictions/penalties
4. Initial population
5. Choice of parents
6. Reproduction, Crossover & Mutation
7. Stopping condition

GA Chromosome representation (148 positions = 1 for each dam)

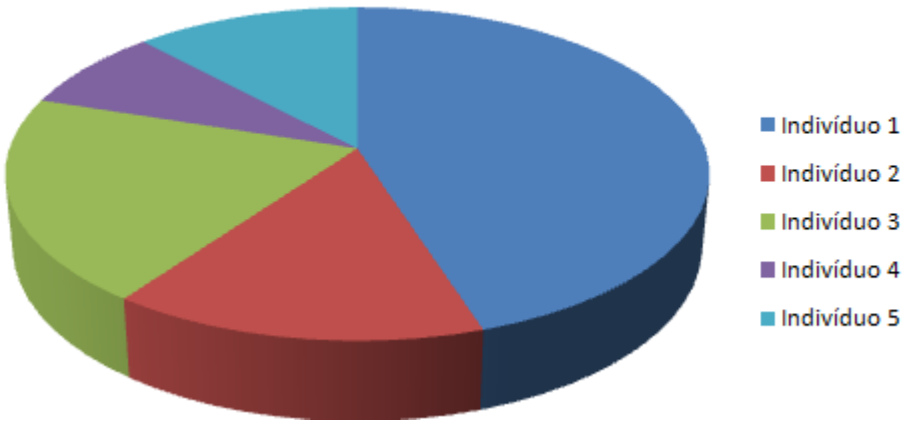
Vaca1	Vaca2	Vaca3	Vaca4	Vaca5	Vaca6	Vaca7	Vaca8	Vaca9	Vaca10
Vaca11	Vaca12	Vaca13	Vaca14	Vaca15	Vaca16	Vaca17	Vaca18	Vaca19	Vaca20
Vaca21	Vaca22	Vaca23	Vaca24	Vaca25	Vaca26	Vaca27	Vaca28	Vaca29	Vaca30
Vaca31	Vaca32	Vaca33	Vaca34	Vaca35	Vaca36	Vaca37	Vaca38	Vaca39	Vaca40
Vaca41	Vaca42	Vaca43	Vaca44	Vaca45	Vaca46	Vaca47	Vaca48	Vaca49	Vaca50
Vaca51	Vaca52	Vaca53	Vaca54	Vaca55	Vaca56	Vaca57	Vaca58	Vaca59	Vaca60
Vaca61	Vaca62	Vaca63	Vaca64	Vaca65	Vaca66	Vaca67	Vaca68	Vaca69	Vaca70
Vaca71	Vaca72	Vaca73	Vaca74	Vaca75	Vaca76	Vaca77	Vaca78	Vaca79	Vaca80
Vaca81	Vaca82	Vaca83	Vaca84	Vaca85	Vaca86	Vaca87	Vaca88	Vaca89	Vaca90
Vaca91	Vaca92	Vaca93	Vaca94	Vaca95	Vaca96	Vaca97	Vaca98	Vaca99	Vaca100
Vaca101	Vaca102	Vaca103	Vaca104	Vaca105	Vaca106	Vaca107	Vaca108	Vaca109	Vaca110
Vaca111	Vaca112	Vaca113	Vaca114	Vaca115	Vaca116	Vaca117	Vaca118	Vaca119	Vaca120
Vaca121	Vaca122	Vaca123	Vaca124	Vaca125	Vaca126	Vaca127	Vaca128	Vaca129	Vaca130
Vaca131	Vaca132	Vaca133	Vaca134	Vaca135	Vaca136	Vaca137	Vaca138	Vaca139	Vaca140
Vaca141	Vaca142	Vaca143	Vaca144	Vaca145	Vaca146	Vaca147	Vaca148		

GA Chromosome representation and evaluation (1 sire for each dam)

1	2	3	4	5	6	7	8	9	10
8	9	10	11	12	13	14	15	16	17
1	15								
15	16								
1	15								
8	9								
1	4								
1	2								
8	9								
1	2								
8	9								
7	8								
7	8								
8	9								
8	9								

- Position 21 (a gene of the chromosome) defines that dam 21 is to be mated to sire 1
- For each sire x dam combination predicted EPDs, index, and problem levels for culling traits are calculated
- For each chromosome/individual, we add up values for all matings (148 positions/genes in this example) to define the chromosome fitness
- Chromosomes that violate the inbreeding and min/max use of sires are penalized by subtracting their fitness and, therefore, reducing their mating likelihood

Choice of parents – biased roulette wheel



Random choice of parents base on their fitness values

Reproduction (Crossover & Mutation)

Parent A

1	2	3	4	5	6	7	8	9	10
8	9	10	11	12	13	14	6	7	8
1	4	5	6	4	5	6	4	5	6
8	9	10	11	12	13	14	6	7	8
7	8	9	10	11	12	13	14	15	16
7	8	9	10	11	12	13	14	15	16
8	9	10	11	12	13	14	15	16	17
1	15	16	17	15	16	17	15	16	17
15	16	17	15	16	17	15	16	17	13
1	15	16	17	4	5	6	10	11	12
8	9	10	11	12	13	14	15	16	17
8	9	10	11	12	13	14	15	16	6
1	2	3	4	5	6	7	8	9	10
1	2	3	4	5	6	7	8	9	10
8	9	10	11	12	13	14	4		

Parent B

1	2	3	4	5	6	7	8	9	10
8	9	10	11	12	13	14	15	16	17
1	15	16	17	15	16	17	15	16	17
15	16	17	15	16	17	15	16	17	13
1	15	16	17	4	5	6	10	11	12
8	9	10	11	12	13	14	4	5	6
1	4	5	6	4	5	6	4	5	6
1	2	3	4	5	6	7	8	9	10
8	9	10	11	12	13	14	6	7	8
1	2	3	4	5	6	7	8	9	10
8	9	10	11	12	13	14	6	7	8
7	8	9	10	11	12	13	14	15	16
7	8	9	10	11	12	13	14	15	16
8	9	10	11	12	13	14	15	16	17
8	9	10	11	12	13	14	15		

New Parent C

1	2	3	4	5	6	7	8	9	10
8	9	10	11	12	13	14	6	7	8
1	4	5	6	4	5	6	4	5	6
8	9	10	11	12	13	14	6	7	8
7	8	9	10	11	12	13	14	15	16
7	8	9	10	11	12	13	14	15	16
8	9	10	11	12	13	14	15	16	17
1	15	16	17	15	16	17	15	16	17
8	9	10	11	12	13	14	6	7	8
1	2	3	4	5	6	7	8	9	10
8	9	10	11	12	13	14	6	7	8
7	8	9	10	11	12	13	14	15	16
7	8	9	10	11	12	13	14	15	16
8	9	10	11	12	13	14	15	16	17
8	9	10	11	12	13	14	15		

New Parent D

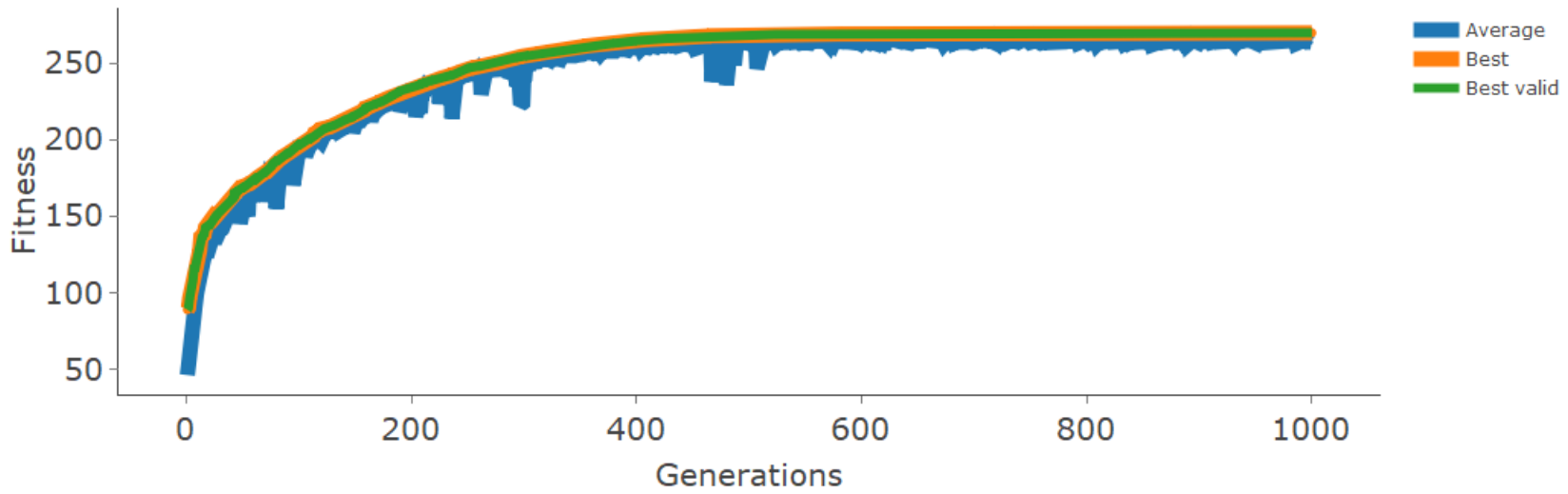
1	15	16	17	4	5	6	10	11	12
8	9	10	11	12	13	14	15	16	17
1	15	16	17	15	16	17	15	16	17
15	16	17	15	16	17	15	16	17	13
1	15	16	17	4	5	6	10	11	12
8	9	10	11	12	13	14	4	5	6
1	4	5	6	4	5	6	4	5	6
1	2	3	4	5	6	7	8	9	10
15	16	17	15	16	17	15	16	17	13
1	15	16	17	4	5	6	10	11	12
8	9	10	11	12	13	14	15	16	17
8	9	10	11	12	13	14	15	16	6
1	2	3	4	10	6	7	8	9	10
1	2	3	4	5	6	7	8	9	10
8	9	10	11	12	13	14	4		

Simulations
(Index-IQG and level of problems-LP)

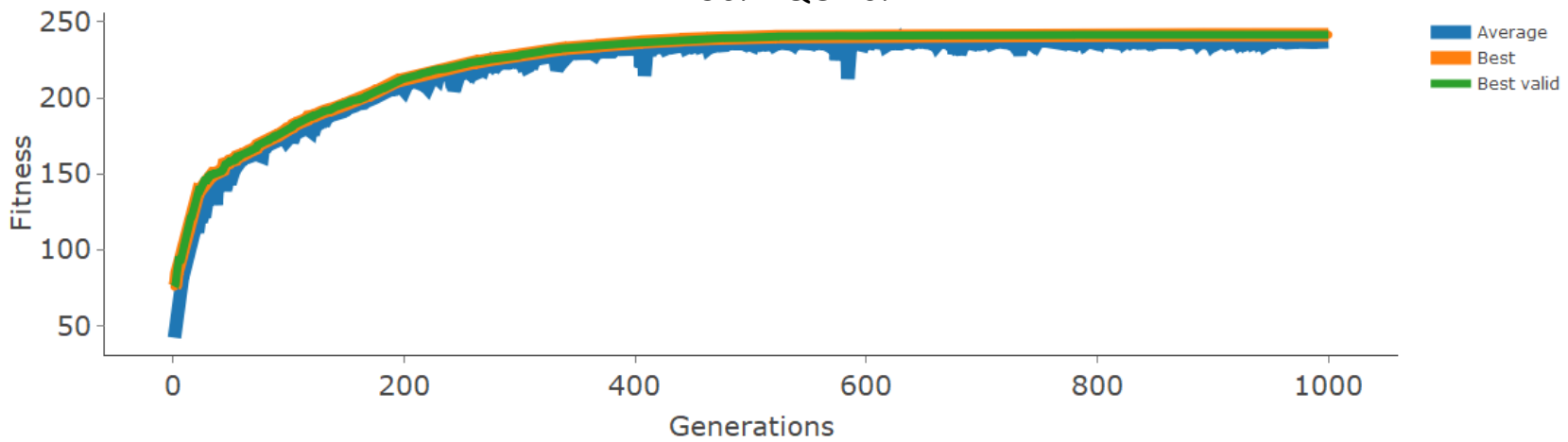
Parameter	Value
Number of Sires	37
Number of Cow	568
Population size	1136
Inbreeding	≤ 3%
Mutation	10%
Stopping generation	1000
Fitness/target function	IQG (100%,90%,80%,70%) LP (0%,10%,20%,30%)
Comment	All bulls can mate with all cows up to the maximum limit of each bull, with no minimum defined

Fitness evolution

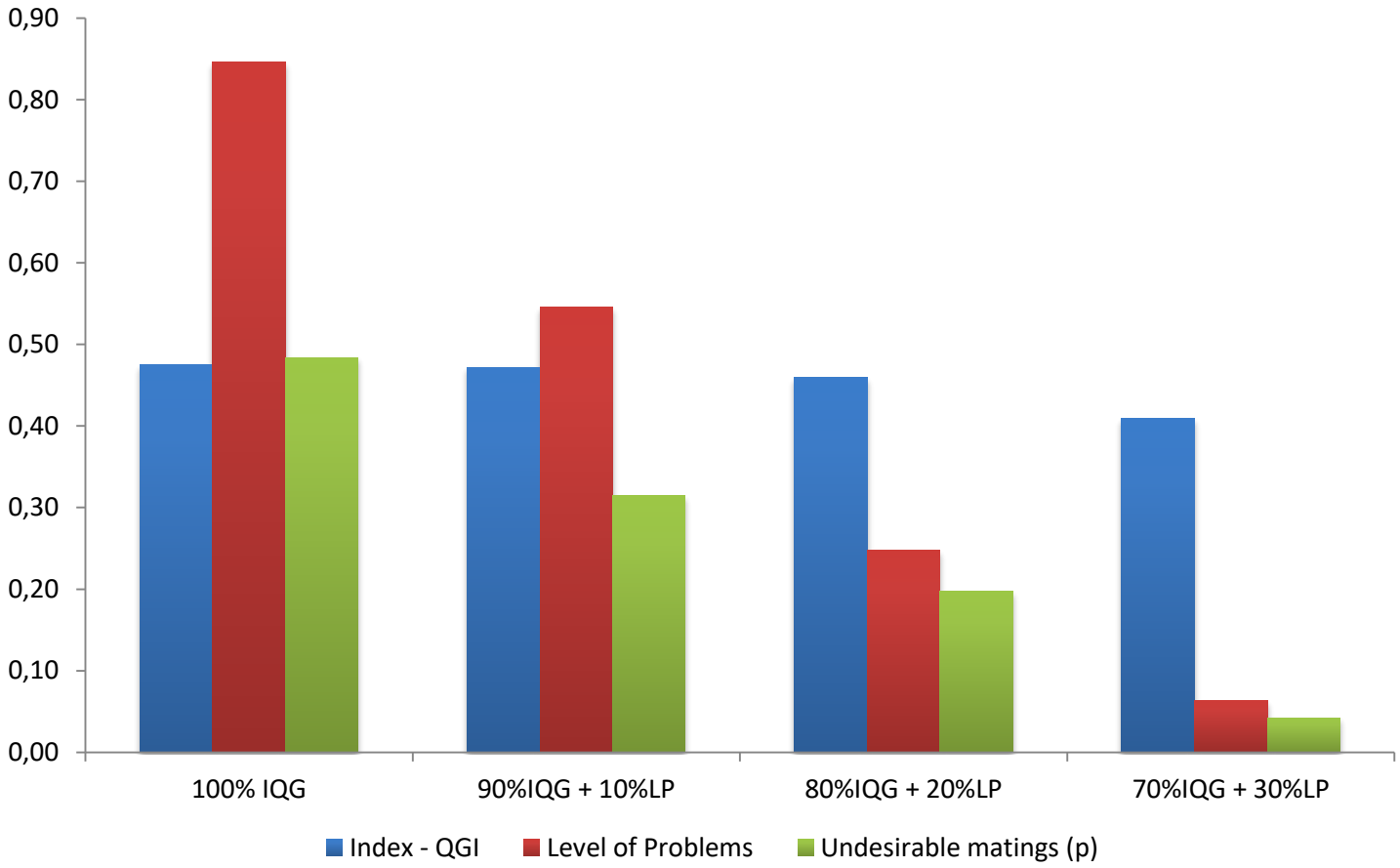
100% IQG



90% IQG 10% LP



Results


0,90
0,80
0,70
0,60
0,50
0,40
0,30
0,20
0,10
0,00
100% IQG
90%IQG + 10%LP
80%IQG + 20%LP
70%IQG + 30%LP
Index - QGI
Level of Problems
Undesirable matings (p)

Final results – mating list

	A	B	C	D	E
1	V1	V2	V3		
2	557	370797	88157		
3	557	440199	88158		
4	557	417984	88161		
5	557	835096	88162		
6	557	89320	88164		
7	557	394077	88166		
8	557	417984	88171		
9	557	370797	88172		
10	557	417984	88173		
11	557	835096	88174		
12	557	363675	88179		
13	557	440199	88181		
14	557	370805	88183		

V1 – herd
V2 – sire
V3 – cow

Final remarks

- Evolutionary computing successfully used to optimize mating decisions by Brazilian Hereford & Braford cattle breeders, combining index, independent level culling traits, inbreeding and offspring size
- Genetic algorithm will be integrated in the Pampaplus mating tool to guide matings and increase genetic gain
- Relative importance of index and level of problems need to be tested in a broader range of scenarios

Thank you!

fernando.cardoso@embrapa.br
+55-53-32404650