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Alternative consideration of social interaction models in animal breeding

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Feed-a-Gene

IRTA
RESEARCH & TECHNOLOGY
FOOD & AGRICULTURE

- **In general, animals are reared in groups.**

http://www.upc-online.org/pp/winter2012/enriched_cages_loophole.html

Social interactions generates positive (cooperation) or negative (competition) effects

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- In general, animals are reared in groups.
- In classical breeding programs the social interactions are ignored
- Social interactions between individuals generate an additional level of heritable variation in socially affected traits.(Bijma and Wade, 2008; Bijma, 2010).
- Social effects could affect the direction or magnitude of selection response.

- In general, animals are reared in groups.
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- Social interactions between individuals generate an additional level of heritable variation (Griffing, 1967;Bijma and Wade, 2008).
- Social effects could affect the direction or magnitude of selection response.

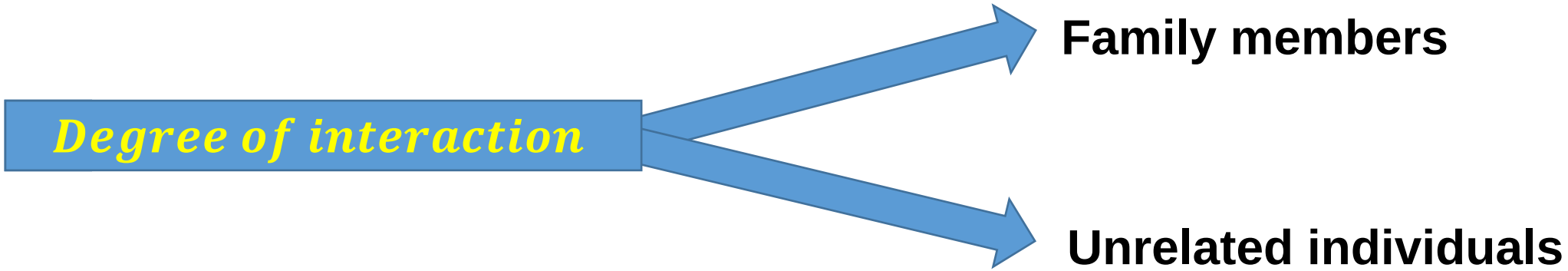
But

Difficulties associated to social interaction models

- Collinearity between direct and social genetic effects (Chen et al., 2009; Cantet and Cappa, 2008)
- Collinearity between pen and social effects (Chen et al., 2009; Cantet and Cappa, 2008).
- Lower than expected response to selection (Ellen et al., 2014).

Efforts are needed to improve the implementation of social model

Alemu *et al.* (2014 and 2016)



Social interactions didn't vary between related versus unrelated mink

Could feeding behavior traits help to improve the performance of social interaction models?

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Feeding behavior traits:

- **Feeding rate (FR)**

  Feed intake per minute

- **Number of visits(NV)**

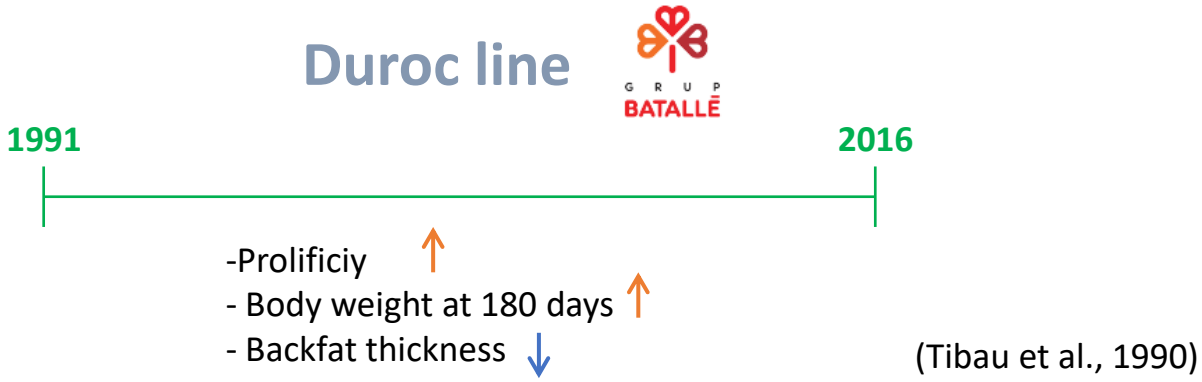
  Number of visits to the feeder per day

- **Occupation time (OT)**

  Minutes in the feeder per day

- **Time between consecutive visits (INT)**

Database



(Tibau et al., 1990)

Animals	663
Pedigree	5013
Batch	6
Pen	57

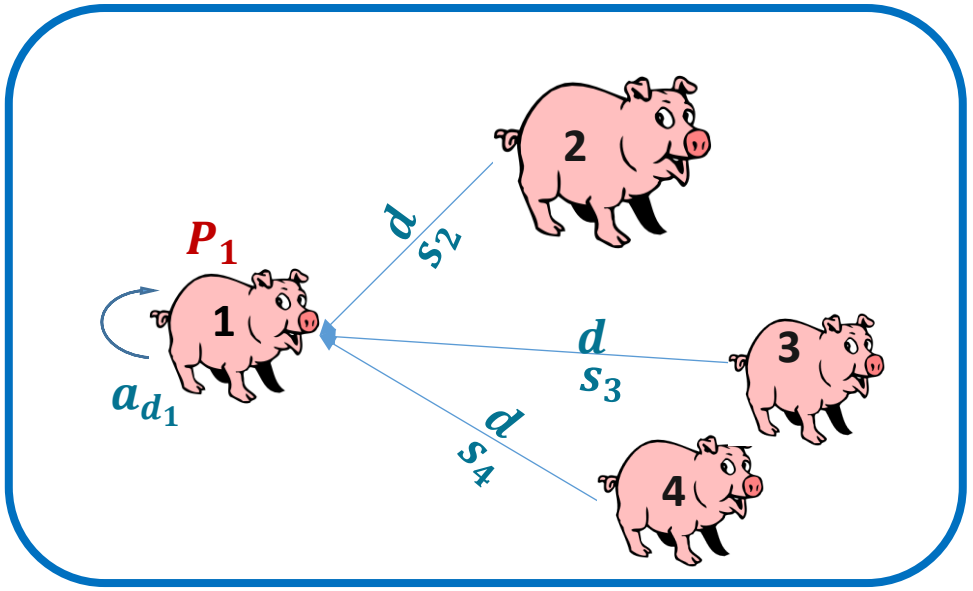
	Mean	Minimum	Maximum	SD
Initial age	71.48	53	85	7.09
Final age	175.3	103	197	11.95
Number of animal per pen	11.9	7	14	1.65
Average daily gain (ADG, kg/d)	0.84	0.50	1.07	0.10

SD: Standard deviation

Social model with equal degree of interaction (SAM)

$$y = Xb + Z_p p + Z_a a_D + Z_s a_S + e$$

The elements of Z_s are 1 for each pair of animals sharing the same pen and 0 if not

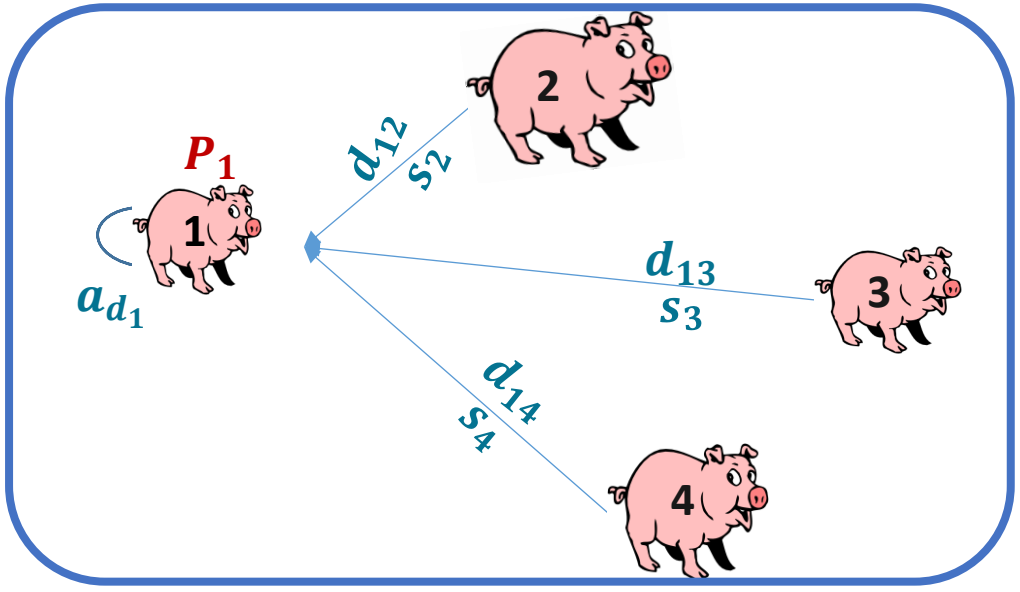


$$P_i = a_{d_i} + \sum_{\substack{j=1 \\ j \neq i}}^{n} d * s_j + e_i$$

Social model with a variable degree of interaction (SAM_i)

$$y = Xb + Z_p p + Z_a a_D + C_s a_{S1} + e$$

The elements of C_s are the specific degree of interaction between each pair of animals sharing the same pen and 0 if not



$$P_i = a_{d_i} + \sum_{\substack{j=1 \\ j \neq i}}^{n} d_{ij} * s_j + e_i$$

Batch number (6 levels) — **Initial age (covariate)**

Final age (covariate) — **Number of piglets per**

Pen (random effect)

Degree of social interaction

Using one behavior trait (FR or NV or OT or INT):

$$d_{ij} = \sqrt{(y_i - y_j)^2}$$

where y_i is the record of animal i for the feeding behavior trait animal and y_j is the record of y behavior trait of animal j.

Using index of all behavior traits

$$d_{ij} = \sqrt{(FR_i - FR_j)^2 + (NV_i - NV_j)^2 + (OT_i - OT_j)^2 + (INT_i - INT_j)^2}$$

The typical element of C_s would be $c_{ij} = \frac{d_{ij} - \widehat{\mu_d}}{\widehat{\sigma}_d}$

Social model with a variable degree of interaction (SAM_i) parameters

$$TBV_i = a_i + c(n-1)s_i$$

$$\sigma^2_{TBV} = \sigma^2_{a_D} + 2c(n-1)\sigma_{a_D,a_S} + c^2(n-1)^2\sigma^2_{a_S}$$

$$\sigma^2_P = \sigma^2_a + c^2(n-1)\sigma^2_s + 2rc(n-1)\,\sigma_{a,s} + \quad rc^2(n-1)(n-2)\sigma^2_s + \sigma^2_e$$

(Duijvesteijn et al., 2012)

$$T^2 = \frac{\sigma^2_{TBV}}{\sigma^2_P} \qquad \text{where} \quad P \neq TBV + e$$

Genetic parameters

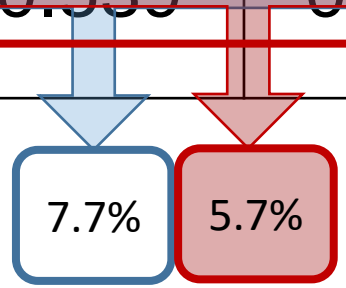
	AM	SAM	SAM_{FR}	SAM_{NV}	SAM_{OT}	SAM_{INT}	SAM_{ALL}
h^2/T^2	0.47(0.15)	0.52(0.29)	0.51(0.14)	0.55(0.13)	0.53(0.14)	0.53(0.14)	0.53(0.12)
T^2_{q1}	-	-	0.51(0.18)	0.75(0.20)	1.29(0.25)	0.65(0.20)	1.24(0.30)
T^2_{q3}	-	-	0.72(0.22)	0.53(0.19)	0.53(0.21)	0.68(0.22)	0.33(0.19)
$r_{g_{a,s}}$	-	-0.39(0.47)	0.31(0.28)	-0.33(0.48)	-0.41(0.21)	0.11(0.31)	-0.65(0.24)

Genetic parameters

	AM	SAM	SAM_{FR}	SAM_{NV}	SAM_{OT}	SAM_{INT}	SAM_{ALL}
h^2/T^2	0.47(0.15)	0.52(0.29)	0.51(0.14)	0.55(0.13)	0.53(0.14)	0.53(0.14)	0.53(0.12)
T^2_{q1}	-	-	0.51(0.18)	0.75(0.20)	1.29(0.25)	0.65(0.20)	1.24(0.30)
T^2_{q3}	-	-	0.72(0.22)	0.53(0.19)	0.53(0.21)	0.68(0.22)	0.33(0.19)
$r_{g_{a,s}}$	-	-0.39(0.47)	0.31(0.28)	-0.33(0.48)	-0.41(0.21)	0.11(0.31)	-0.65(0.24)

Fit quality – Predictive ability

	AM	SAM	SAM_{FR}	SAM_{NV}	SAM_{OT}	SAM_{INT}	SAM_{ALL}
DIC	1402.07	1348.69	1376.08	1338.59	1304.74	1330.77	1321.54
Pred. Accuracy	0.521	0.530	0.539	0.552	0.561	0.492	0.540



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Percentage of coincidence between top 10% animals

	EBV_{animal}	TBV_{CONST}	TBV_{FR}	TBV_{NV}	TBV_{OT}	TBV_{INT}	TBV_{ALL}
EBV_{animal}	-	0.70	0.79	0.89	0.44	0.76	0.52
TBV_{CONST}		-	0.68	0.68	0.41	0.58	0.52
TBV_{FR}			-	0.83	0.39	0.79	0.59
TBV_{NV}				-	0.41	0.83	0.62
TBV_{OT}					-	0.44	0.48
TBV_{INT}						-	0.65
TBV_{ALL}							-

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Conclusions

- Including social genetic effects improves DIC compared to classical animal model.
- Using specific levels of interaction for each pair of animals improves the accuracy of the estimation of genetic parameters.
- Some small differences between SAM_i models with regard to DIC and prediction ability were found, favoring SAM_{NV} , SAM_{OT} and $SAM_{ALL.}$
- Genetic ranks vary with the model of analysis.

Thank you so much for your attention

Why will these traits be used?

- In pigs, the feeding time and feeding rate are correlated with the competition between animals (Nielsen et al., 1995).

- In goat, the animals in high social rank tended to have higher feeding time and lower times in queuing than goats in the animals in medium and low rank category (Shinde et al., 2004; Jørgensen et al., 2007).

- In cows, in the high social ranking (actor) group spent a significantly greater time at the feeder compared to cows in the low-ranking and the correlation between the displacements initiated and social position of the individual were highly significantly (Val-Laillet et al., 2008)

Material and Methods

Daily occupation time database (seconds / hour)

	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R	S	T	U	V	W	X	Y	Z
1	H1	H2	H3	H4	H5	H6	H7	H8	H9	H10	H11	H12	H13	H14	H15	H16	H17	H18	H19	H20	H21	H22	H23	H24	ID	Date_control
2	0	0	0	783	0	0	709	0	0	0	0	90	236	0	501	270	0	383	141	0	228	0	0	87	UP07@2013-02-27	28/04/2013
3	0	481	0	214	0	234	0	260	142	0	127	0	0	185	0	152	335	320	0	0	115	0	324	0	UP07@2013-02-27	29/04/2013
4	7	193	32	0	361	0	0	128	114	0	254	99	87	0	239	0	621	213	0	251	0	0	6	0	UP07@2013-02-27	30/04/2013
5	0	547	0	0	0	254	37	0	0	489	0	0	170	121	599	0	113	0	56	285	0	370	0	32	UP07@2013-02-27	01/05/2013
6	439	0	0	165	0	113	0	579	0	233	300	0	50	231	0	364	409	0	0	312	162	0	195	123	UP07@2013-02-27	03/05/2013
7	304	208	0	0	0	65	0	756	104	0	0	500	104	55	402	40	0	143	329	145	0	54	219	79	UP07@2013-02-27	08/05/2013
8	0	0	92	483	0	0	251	285	0	241	202	0	250	203	218	28	245	81	176	498	0	0	95	84	UP07@2013-02-27	09/05/2013
9	0	0	456	0	0	125	205	125	260	63	560	0	27	366	131	0	56	249	272	0	278	0	0	281	UP07@2013-02-27	10/05/2013
10	0	0	0	50	0	0	342	0	0	449	40	0	532	7	111	13	207	338	0	178	0	304	0	0	UP07@2013-02-27	11/05/2013
11	203	0	14	0	0	0	0	663	0	129	0	111	192	0	199	514	17	61	241	88	0	181	0	0	UP07@2013-02-27	12/05/2013
12																										

Average across days within animal (min / hour)

ID	Pen	batch	H2	H3	H4	H5	H6	H7	H8	H9	H10	H11	H12	H13	H14	H15	H16	H17	H18	H19	H21	H22	H23	H24
3921	LACT-1-5	LACT-1	5.87	5.93	4.01	3.34	6.45	12.00	11.66	15.28	7.54	8.32	7.99	5.27	3.98	8.69	3.74	7.85	11.58	15.77	7.78	5.96	5.43	3.71
3922	LACT-1-8	LACT-1	4.56	3.49	7.12	6.68	11.22	8.01	22.31	20.55	19.22	9.27	15.25	11.90	15.21	16.04	19.35	23.21	28.29	33.66	5.53	4.62	5.99	3.86
3923	LACT-1-8	LACT-1	7.79	6.73	6.40	11.71	10.97	7.79	10.65	13.17	11.23	10.54	10.05	11.64	12.31	10.61	16.17	16.33	14.66	20.01	10.84	6.94	6.73	9.36
3924	LACT-1-8	LACT-1	4.54	4.75	4.51	4.62	4.91	12.89	13.46	12.03	12.06	5.13	6.84	9.08	10.43	12.15	10.58	9.84	16.21	14.82	5.33	3.14	3.64	2.78
3925	LACT-1-5	LACT-1	9.81	7.08	4.79	7.91	3.47	5.83	7.72	12.35	12.50	11.03	8.88	11.12	14.52	12.91	12.45	13.28	13.79	15.47	5.74	3.37	4.50	5.09
3927	LACT-1-3	LACT-1	12.83	8.48	7.47	3.73	11.16	9.33	8.94	13.96	9.52	9.12	7.02	8.56	8.09	6.44	7.24	13.98	15.77	19.52	10.93	6.06	7.97	8.59

The total daily occupation time

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Material and Methods

The total daily occupation time

ID	H1	H2	H3	H4	H5	H6	H7	H8	H9	H10	H11	H12	H13	H14	H15	H16	H17	H18	H19	H21	H22	H23	H24	Total
3921	9.50	5.87	5.93	4.01	3.34	6.45	12.00	11.66	15.28	7.54	8.32	7.99	5.27	3.98	8.69	3.74	7.85	11.58	15.77	7.78	5.96	5.43	3.71	164.65
3922	5.73	4.56	3.49	7.12	6.68	11.22	8.01	22.31	20.55	19.22	9.27	15.25	11.90	15.21	16.04	19.35	23.21	28.29	33.66	5.53	4.62	5.99	3.86	169.98
3923	9.89	7.79	6.73	6.40	11.71	10.97	7.79	10.65	13.17	11.23	10.54	10.05	11.64	12.31	10.61	16.17	16.33	14.66	20.01	10.84	6.94	6.73	9.36	167.46
3924	2.71	4.54	4.75	4.51	4.62	4.91	12.89	13.46	12.03	12.06	5.13	6.84	9.08	10.43	12.15	10.58	9.84	16.21	14.82	5.33	3.14	3.64	2.78	164.70
3925	9.98	9.81	7.08	4.79	7.91	3.47	5.83	7.72	12.35	12.50	11.03	8.88	11.12	14.52	12.91	12.45	13.28	13.79	15.47	5.74	3.37	4.50	5.09	165.82
3927	13.55	12.83	8.48	7.47	3.73	11.16	9.33	8.94	13.96	9.52	9.12	7.02	8.56	8.09	6.44	7.24	13.98	15.77	19.52	10.93	6.06	7.97	8.59	167.06

The total daily occupation time was used to calculate the specific level of competition between each pair of animals sharing the same pen

Results and discussion

The correlations between the rank of the animals every two consecutive weeks according to each variable

Social Trait	Correlation between ranks on social traits
Feed rate (g/min)	**0.70** to **0.80**
Feeding frequency (visits/day)	**0.72** to **0.97**
Occupation time (min/day)	**0.69** to **0.83**
Time between visits(hour)	**0.71** to **0.80**

- No much change in social ranks of animals during the fatting period
- These variables can show the social interaction between animals

Comparison between used models

A)The determinant of Fisher Information Matrix ($I(\theta)$) where the best model is that maximizing the determinant of $I(\theta)$.

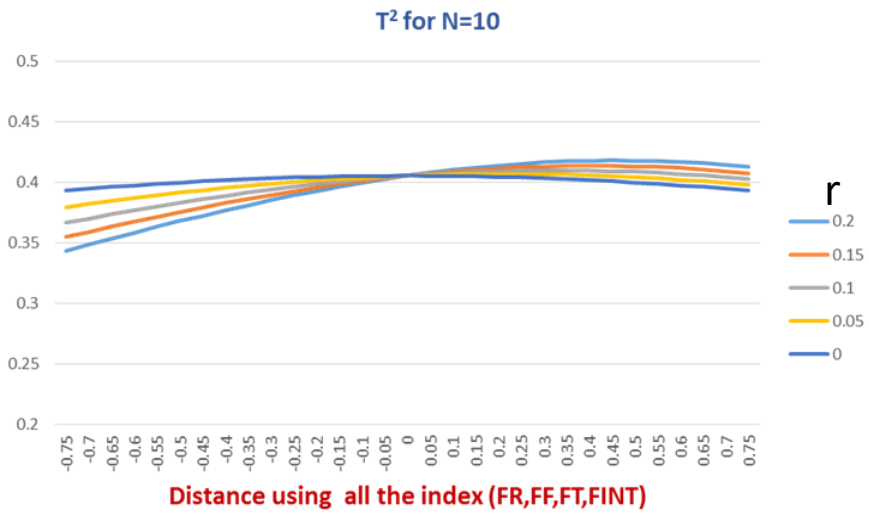
B)The accuracy of the estimates with examining the standard deviation (SD) of genetic parameters.

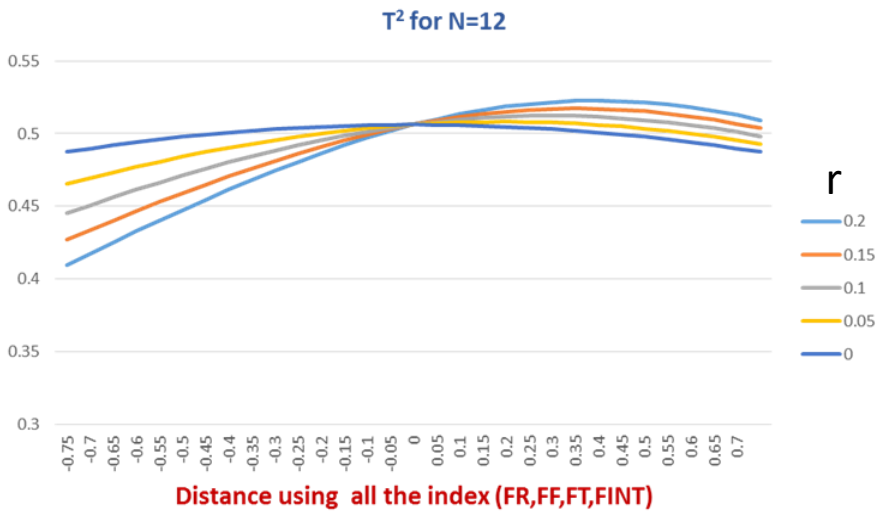
C)The deviance Information Criterion (DIC).

D)Cross validation.

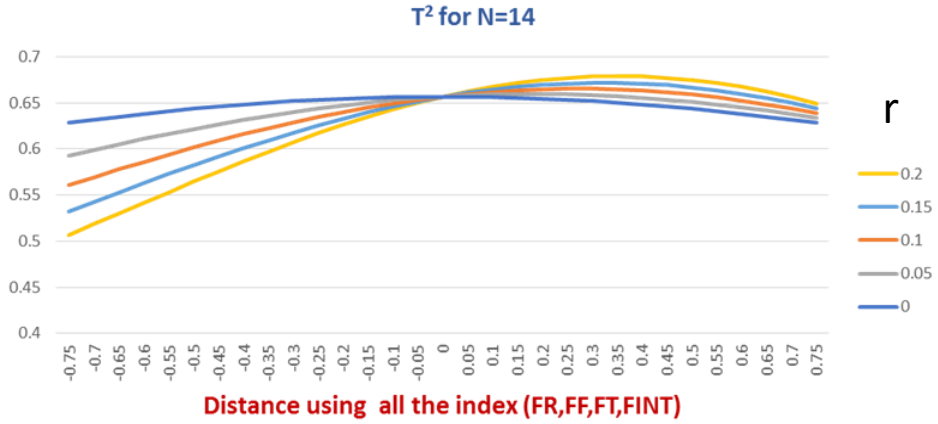
E)The percentage of coincidence between top 10% of the population depend on TBV.

Results and discussion





T^2 as a function of number of mates, relationship between them and social distance (according to overall index)



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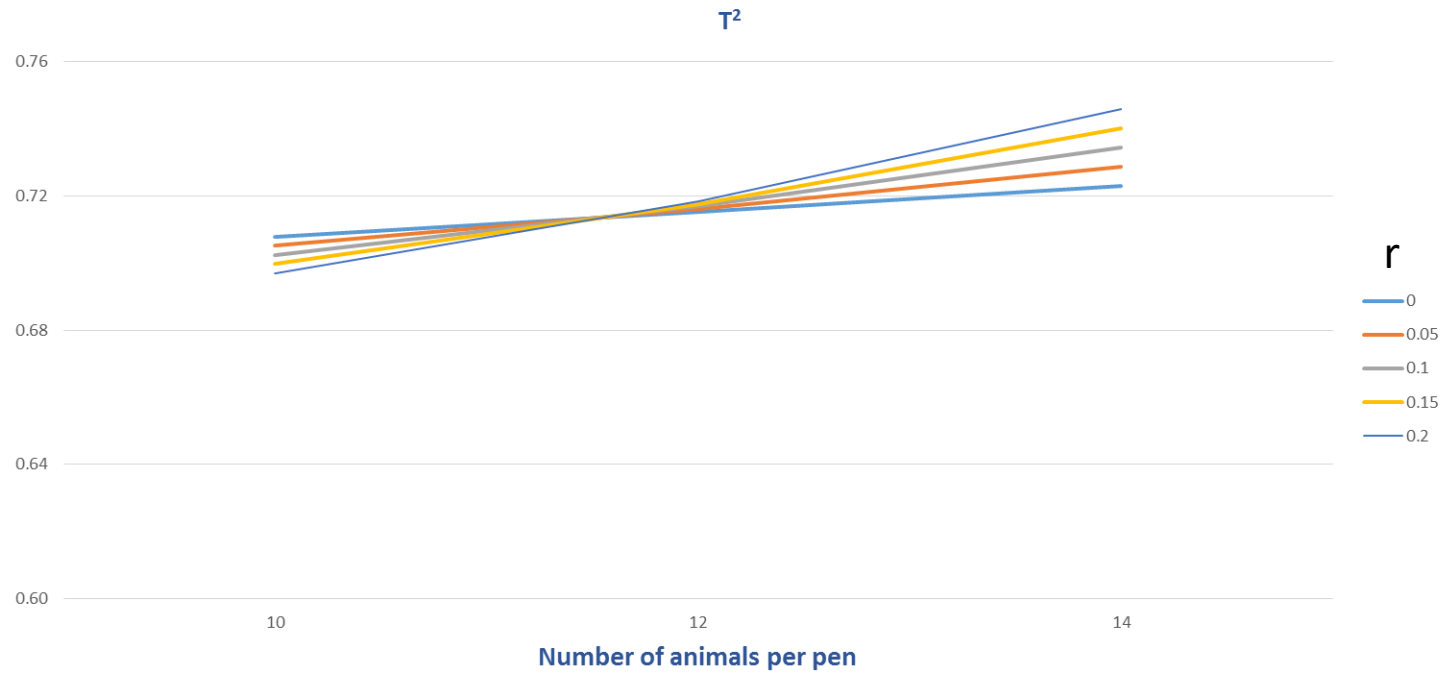
Results and discussion



T^2 as a function of number of mates and relationship between them .

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Conclusions

- Feeding behavior traits could be useful to measure the social interaction between animals sharing a pen.
- Include social effects in analysis models improve DIC of the social models compared with classical animal model.
- Using specific level of competition for each pair of animals improve the accuracy of the estimation of genetic parameters and $|\boldsymbol{I}(\boldsymbol{\theta})|$
- The degree of competition between each pair of animals, numbers of animal per pen and relatedness between group members affect the estimated values of $\mathbf{T^2}$.
- Genetic ranks greatly vary with the model of analysis.