Genetic assessment of fighting ability in Valdostana cattle breeds

Cristina Sartori and Roberto Mantovani

Department of Animal Science, University of Padua
cristina.sartori@unipd.it

Fighting Ability

- ✓ Capability to win a contest (Parker, 1974)
- ✓ In cows: rigid dominance relations quickly established at grazing when unfamiliar individuals meet (Beilharz & Zeeb, 1982)

Aosta Chestnut & Aosta Black Pied cattle (Valdostana breed)

- ✓ Autochthonous of West Alps
- ✓ Dual Purpose
  - Population (2010): Chestnut n=22,857; Black Pied n=1394
- ✓ Strong attitude to fight:
  "Batailles de Reines"

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“Batailles de Reines”

Introduction

- ✓ Each year: 20 Eliminatories + Final battle
- ✓ 3 Tournaments per day, defined by weight
- ✓ Knock-out battles among couples

Heréns breed Valais, CH / Haute Savoie, FR. Aosta Black Pied & Aosta Chestnut, Aosta, IT

Steps of the study

To sum up the studies carried on fighting ability in Aosta Chestnut and Aosta Black Pied cattle, in terms of:

1. Behavioural evaluation of agonistic performances
2. Genetic assessment of fighting ability
3. Incidence of inbreeding on the trait

General aim => to build up genetic indexes suitable for breeding




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1. Behavioural evaluation of fights

Materials & Methods

(Sartori, Manser and Mantovani, in prep.)

- ✓ Video recording of 4 tournaments performed in 2009 (n = 188 fights)
- ✓ Quantification of the main behaviours expressed during cow fights (JWatcher™ software)
- ✓ Ethogram for cattle escalated conflict

1. Behavioural evaluation of fights

Materials & Methods

(Sartori, Manser and Mantovani, in prep.)

Statistical analyses

- Evaluation of dynamics of conflicts, in terms of:
  - duration
  - agonistic intensity
  - ratio of different behaviours* on total battle

  **non agonistic behaviours; exhibitions; physical fights*

- Mixed linear model for repeated measurements (SAS, 2004)

1. Behavioural evaluation of fights

Results

Friendly

Passive

Defence of resource

Visual display

Vocalization

Looking in eyes

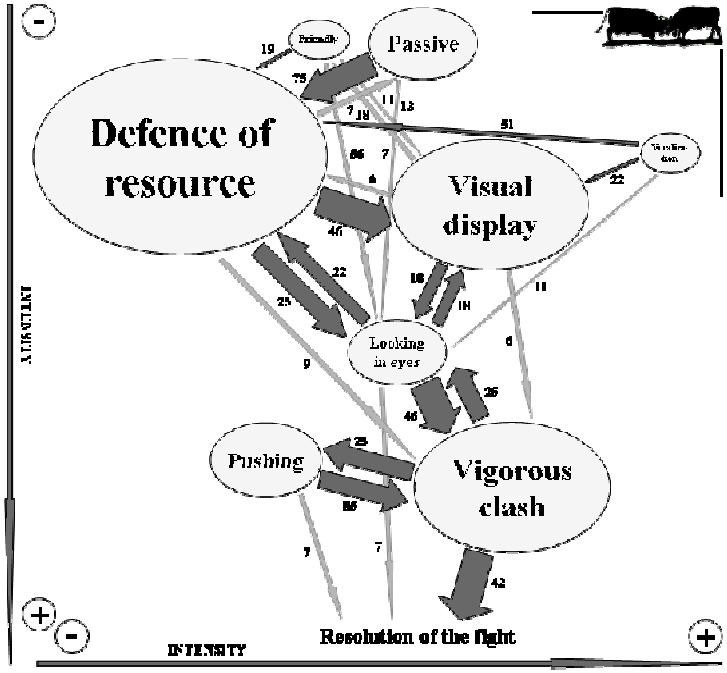
Pushing

Vigorous clash

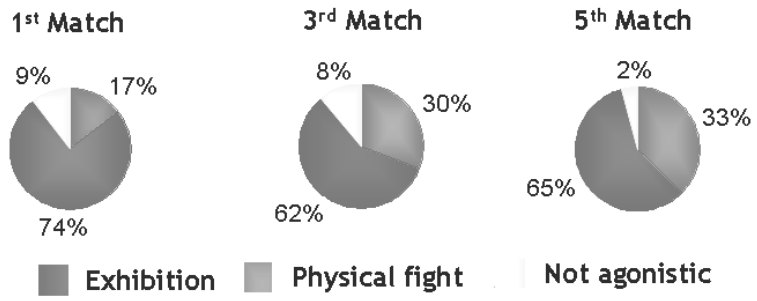
1, 2, …6 = score of intensity
NA = Non agonistic behaviour; E = exhibition; PF = Physical fight

1. Behavioural evaluation of fights

Results



Transition diagram of behaviours obtained from ethograms (JWatcher™, Blumstein & Daniel, 2007)



Least squares means and standard errors of diff. number of fights disputed in the tournament (MIXED Procedure, SAS 2004, Bonferroni adjustment method)

Variable	Match disputed		
	1st	3rd	5th
Duration of match (sec.)	210.1 (28.6)	269.5 (27.9)	242.1 (40.5)
Intensity of match (score)	3.34 (0.11)^{A}	3.79 (0.11)^{B}	4.04 (0.15)^{B}
Non agonistic behavior/total (%)	0.11 (0.03)^{a}	0.12 (0.02)^{a}	0.04 (0.01)^{b}
Exhibition/total (%)	0.74 (0.04)^{a}	0.57 (0.04)^{b}	0.59 (0.05)^{b}
Physical fight/total (%)	0.15 (0.03)^{A}	0.31 (0.04)^{B}	0.37 (0.06)^{B}

A & B = diff. at $P \leq 0.01$ within row; a & b = diff. at $P \leq 0.05$ within row

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General aim => to build up genetic indexes suitable for breeding

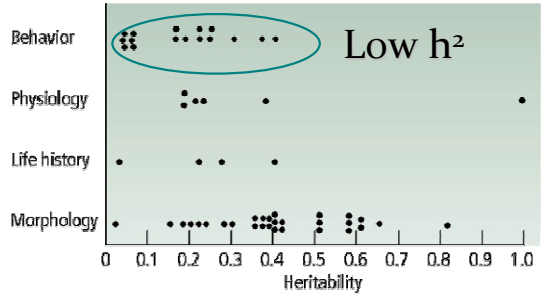



2. Genetic assessment of the trait

Difficulties on genetic analysis of behaviour:

- Great influence **of environment** (Plomin, 1990)

→ **Low heritability** (Mosseau and Roff 1987)



Mark Ridley, 2004. Modified from Hoffman 2000

Genetic investigation of fighting ability:

Data of tournaments 2001-2006

- ✓ Records: 16,509
- ✓ Participants: 5,891 cows
- ✓ Pedigree: 13,456 animals

- ✓ IDs and pedigree of cows
- ✓ winner & looser of each match
- ✓ individual weight, age & herd
- ✓ weight categories
- ✓ level of the battle board

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2. Genetic assessment of the trait

Materials & Methods

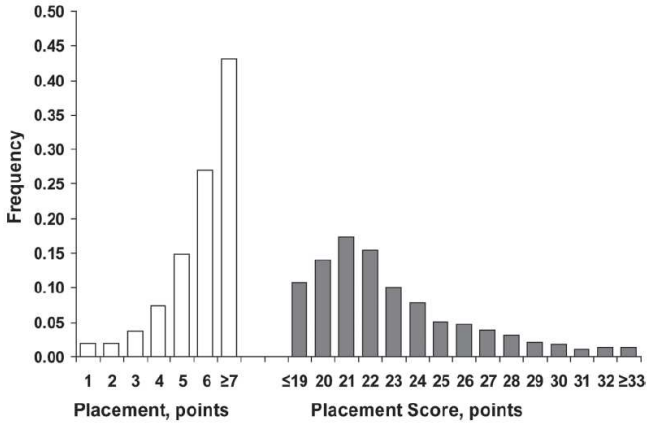
(Sartori & Mantovani, *2009; 2010*)

a. Genetic evaluation

I. Phenotype for fighting ability

Placement Score (PS)

$$PS_{ijkl}=20+ty_i+d_j+2w_k$$



PS = score of cow in a given tournament

ty = type of tournament (ty=0 for heats & ty=7 for final)

d = difficulty coefficient (j=-2: >128, -1: 65-128, 0: 33-64, 1: 17-32, 2: <17 participants)

w = number of wins achieved (k=0,…, 8)

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2. Genetic assessment of the trait

Materials & Methods

(Sartori & Mantovani, *2009; 2010*)

II. Genetic model

$$y = X\beta + W_D p_D + Z_D a_D + e$$

$$V\begin{bmatrix} a_D \\ p_D \\ e \end{bmatrix} = \begin{bmatrix} AVa_D & 0 & 0 \\ 0 & AVp_D & 0 \\ 0 & 0 & IVe \end{bmatrix}$$

Vectors:

y = observations

β = systematic fixed factors,

p_D = permanent environmental effects

a_D = direct additive genetic effects

e = residuals

Fixed factors (b):

Day of tournament (year-battle* weight cat.)

Herd-Year

Age (in classes)

Weight by weight cat.

P<0.001 for all factors after preliminary ANOVA

EM-REML method, single-trait animal model (Misztal, 2008)

Models comparison: Akaike Information Criterion (AIC; Akaike, 1974)

2. Genetic assessment of the trait

(Sartori & Mantovani, *2009; 2010*)

b. Inclusion of the competitors

I. Competitors within the phenotype

Competitive PS (CPS)

$$CPS_{ijkl}=500+ty_i+2d_j-b_k-(k-CPS_{ijka})$$

CPS = score of cow in a given tournament
(l=individual; a=competitor)

ty = type of tournament **(as in PS)**

d = difficulty coefficient **(as in PS)**

b = highest level achieved **(as for w in PS)**

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2. Genetic assessment of the trait

Materials & Methods

(Sartori & Mantovani, *2009; 2010*)

b. Inclusion of the competitors

II. Competitors within the genetic model

$$y = X\beta + W_D p_D + Z_D a_D + Z_C a_C + e$$

$$V\begin{bmatrix} a_D \\ a_C \\ p_D \\ e \end{bmatrix} = \begin{bmatrix} AVa_D & 0 & 0 & 0 \\ 0 & AVa_C & 0 & 0 \\ 0 & 0 & AVp_D & 0 \\ 0 & 0 & 0 & IVe \end{bmatrix}$$

Vectors:

y = observations
β = systematic fixed factors
$\mathbf{p_D}$ = permanent environmental effects
$\mathbf{a_D}$ = direct genetic effects
$\mathbf{a_C}$ = **indirect genetic effects** (IGEs)
e = residuals

Fixed factors (b):

Day of tournament (year-battle* weight cat.)
Herd-Year
Age (in classes)
Weight by weight cat.

P<0.001 for all factors after preliminary ANOVA

EM-REML method, Competitive animal model, partitioning variance approach (Arango et al., 2005; Bijma et al., 2007)

2. Genetic assessment of the trait

Results

(Sartori & Mantovani, *2009; 2010*)

a. Genetic evaluation

Item	AIC	Trait	Variance components				h^2	SE h^2	r
			Va_D	Va_C	Vp	Ve			
Classical model, no competitors	69.86	PS	0.59	-	1.26	5.91	0.076	0.042	0.239
Classical model, competitor in phenotype	124.9	CPS	13.50	-	86.20	564.0	0.020	0.040	0.150
Competitive model including opponent*	34.86	PS	0.01	0.14	0.03	1.49	0.091	0.043	0.107

V_a = direct additive genetics, V_{ass} = associative genetics; V_p = permanent environmental & V_e = random residual; AIC = Akaike Information Criterion; h^2 = heritability; SE h^2 = standard error of h^2; r = repeatability

2. Genetic assessment of the trait

(Sartori & Mantovani, *2009; 2010*)

b. Inclusion of the competitor

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*indirect genetic effect

More suitable models for genetic analyses

V_a = direct additive genetics, V_{ass} = associative genetics; V_p = permanent environmental & V_e = random residual; AIC = Akaike Information Criterion; h^2 = heritability; SE h^2 = standard error of h^2; r = repeatability

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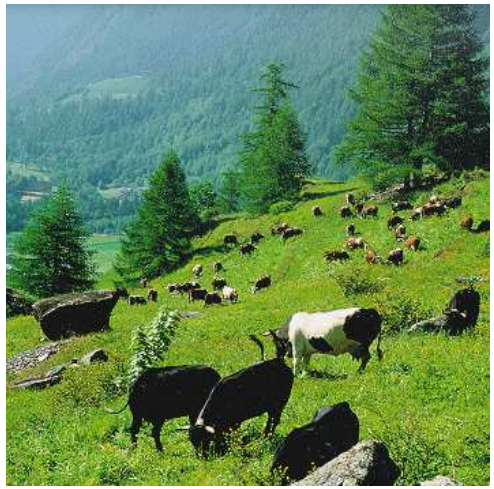
3. Incidence of inbreeding

Materials & Methods

(Sartori & Mantovani, *in peer review*)

Data of tournaments 2001-2009

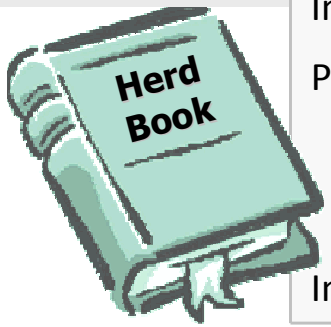
- ✓ Records: 23,998
- ✓ Participants: 8,259 cows
- ✓ Pedigree: 17,724 animals



INBREEDING

F coefficient **Recursive algorithm**
(Inbreeding) ***(Aguilar & Misztal, 2008)***

Reference population:
individuals born in 1990-2009



Item	ABP	AC
Individuals retained for analysis	27,638	106,061
Purebred individuals	27,184	104,854
males	7,764	42,737
females	19,420	62,117
Individuals in Herd Book (2010)	11,958	22,857

ABP= Aosta Black Pied cattle, AC=Aosta Chestnut cattle

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3. Incidence of inbreeding

Materials & Methods

(Sartori & Mantovani, *in peer review*)

a. Comparison among genetic models including inbreeding or not

✓ 4 Models:

✓ Inbreeding (F): fixed effect, in classes (based on Sewalem et al., 2006; $P<0.001$ for F after ANOVA)

Classical model, No F	**Classical model, + F**
Competitive model, No F	**Competitive model + F**

EM-REML method, single-trait animal model - Competitive model, partitioning variance approach - Models comparison: AIC

b. Linear regression of EBVs on F across and within lineages of founders

Founders

✓ individuals without genetic relationships in pedigree other than their heirs *(Gulisija et al., 2006)*

✓ lacking in inbreeding

✓ attained using a recursive procedure

Dataset

✓ 33 lineages

✓ 6,087 participants (184±235 heir fighting cows/line)

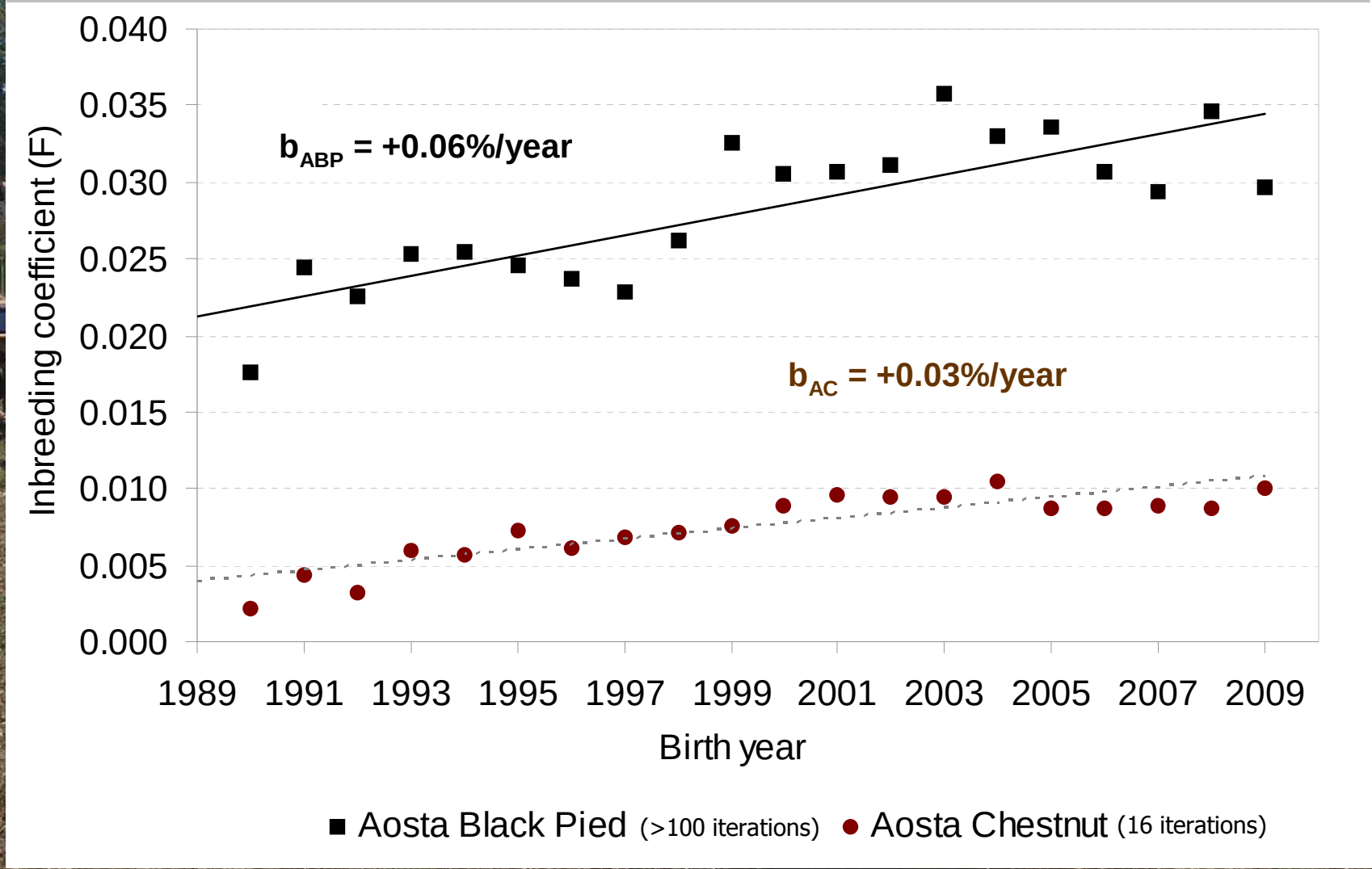
✓ at least 10 fighting cows as offspring

✓ EBVs of fighting ability

3. Incidence of inbreeding

(Sartori & Mantovani, *in peer review*)

Genetic trend for inbreeding coefficient (F)



3. Incidence of inbreeding

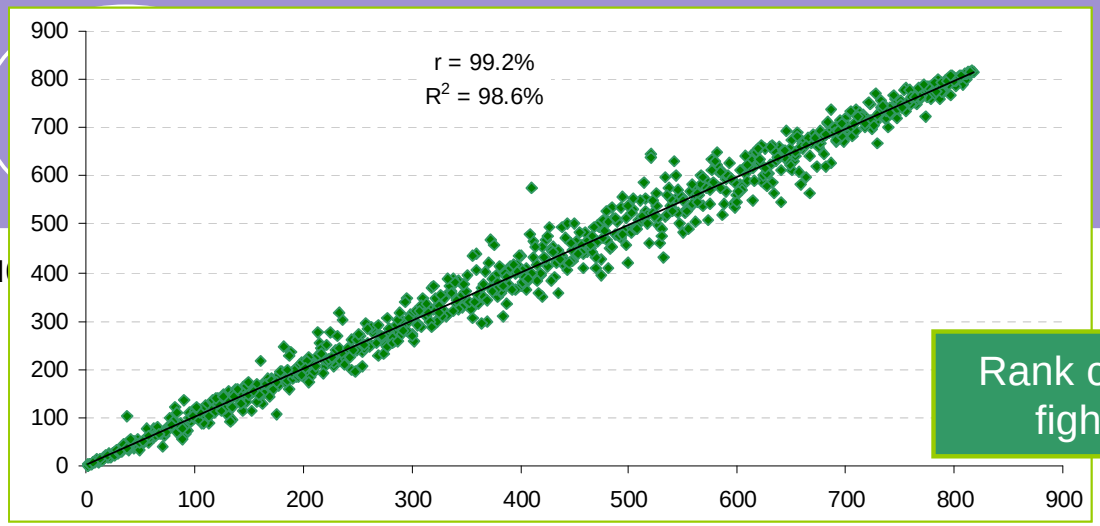
Results

(Sartori & Mantovani, *in peer review*)

Model fitting, variance components & parameters estimates. Average no.competitors per fighting cows = 1.886

Model	Fitting	Variance Components				Genetic parameters		
	AIC	Vp_D	Vp_C	Va_D	Va_C	h^2	SE h^2	rep.
Classical model, no F	111,057	1.025	0.632		5.973	0.083	0.036	0.217
Classical model, with F	108,452	0.844	0.761		6.024	0.100	0.037	0.210
Competitive model*, no F						0.120	0.037	0.131
Competitive model*, with NF						0.120	0.037	0.125

*inclu



Rank correlation among EBVs of fighting cows' sires; n=818

Single-trait ENREML (Misztal et al., 2008), mixed linear model, linear form

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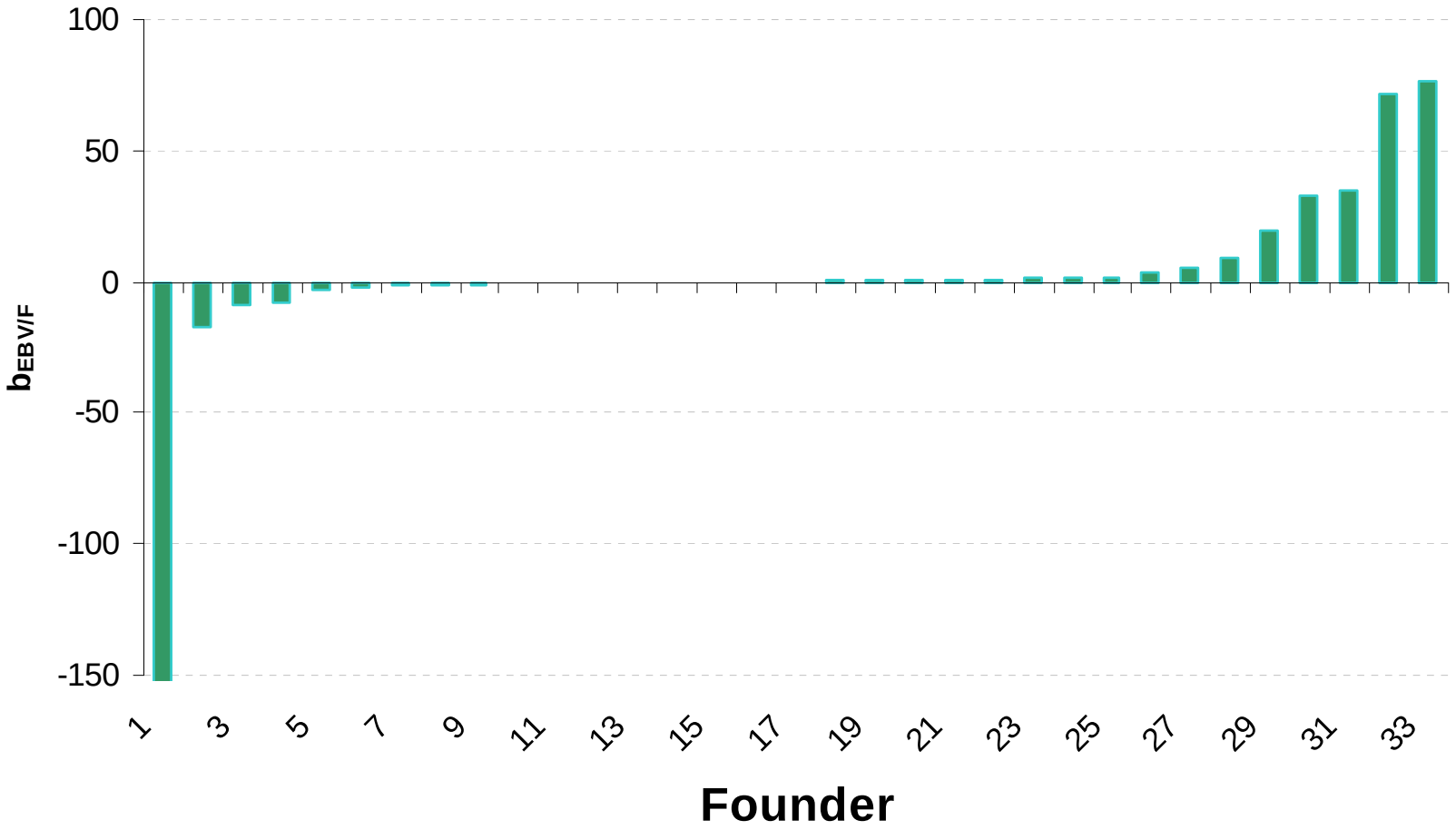
3. Incidence of inbreeding

(Sartori & Mantovani, *in peer review*)

Within lineage (n=33 with a mean of 184 fighters/lineage) regression coefficients between fighting ability & inbreeding coefficient (F)



Conclusions

- Traditional cow competitions of Aosta Black Pied (ABP) and Aosta Chestnut (AC) cattle vary in intensity during a battle and in the course of a competition
- Fighting ability can be investigated via quantitative genetics as Placement score Tournament, herd, age & weight affect the trait, which h^2 is about 8%
- Fighting ability expresses in a social contest, and conspecifics may be included in the genetic model as indirect genetic effects
- ABP and AC cattle show low levels of inbreeding (2.7% ABP; 0.8% AC), which influence on fighting ability is slight

…Further step

Genetic correlation among fighting ability and milk & meat yields

Thank you for your attention!

Acknowledgements

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AREV

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