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OLDENBURGER PFERDEZUCHTVERBAND E.V.

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Implications of across-studbook genetic correlations between linear traits for sport horse breeding

F. Sperrle [1,2], Å. Viklund [3], E. Thorén-Hellsten [4], W. Schulze-Schleppinghoff [5], K.F. Stock [1,2*]

[1] IT Solutions for Animal Production (vit), Verden (Aller), Germany, [2] Institute for Animal Breeding and Genetics, University of Veterinary Medicine Hannover (Foundation), Hanover, Germany, [3] Dept. of Animal Breeding and Genetics, Swedish University of Agricultural Sciences, Uppsala, Sweden, [4] Swedish Warmblood Association (SWB), Flyinge, Sweden, [5] Oldenburger Pferdezuchtverband e.V., Vechta, Germany;
*E-mail: friederike.katharina.stock@vit.de

Background

- breeding progress and success of studbooks depending on strong and competitive breeding programs
  - trait definitions (clear, objective)
  - routine data collection and use

- implementation of linear systems for riding horses
  - conformation and performance (gaits, jumping, behavior)
  - foals and/or adult horses (broodmares, stallions, young riding horses)
  - substantial improvement of phenotype data quality
    if accompanied by appropriate data quality management
    (regular training of judges, fine-tuning regarding linear trait definitions, ...)

Study approach

- increased importance of linear profiling in sport horse studbooks (worldwide inventory)
  → expected increase of genetic evaluations and genomic applications for linear traits
- extensive exchange of genetic material across studbooks
  → transparency and knowledge about comparability of (new) traits and genetic proofs as crucial factors in international sport horse breeding

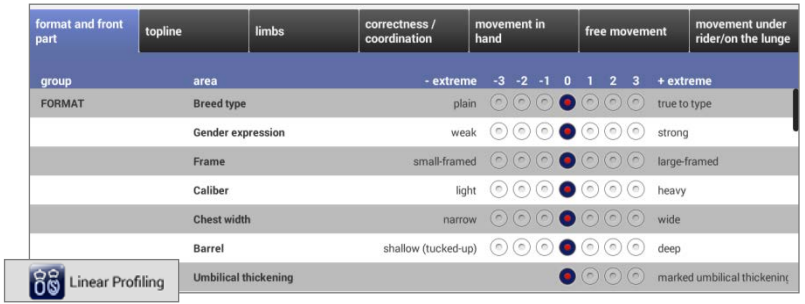
➢ across-studbook genetic correlation study on linear traits using estimated breeding values

Data

- estimated breeding values (EBV) from prototypes of genetic evaluations for linear conformation and performance traits
  - Oldenburg studbooks (OL, OS)
  - Swedish Warmblood studbook (SWB)
- different linear systems, recording context, documentation in the field, ..., but considerable overlap of (analogous / similarly defined) linear traits
- important for interpretation of comparisons:
  - differences in scale orientation
    e.g. body direction [uphill - downhill] vs. [downhill - uphill]
  - risk of 'translation losses' when preparing an English cross reference
    e.g. walk: cadence [even - uneven] vs. rhythm [regular - irregular]

Linear profiling: Oldenburg studbooks

- comprehensive linear scheme, equally used for linear descriptions of foals, mares (studbook inspection, mare performance test) and stallions
  - 7-point linear scale (-3 to +3)
  - defect traits / special remarks regularly included (reduced scale: 0 to +3)
- mobile system for electronic recording
  - tablet PC with own software
  - concentration of active documentation (deviations from average expression)

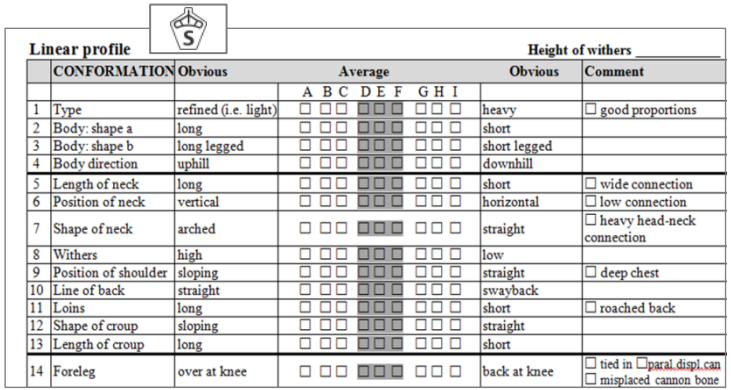


- linear data available for genetic analyses: 2012-2016*, N=11,016 horses
  - N=6,953 linear profiles of foals
  - N=4,345 linear profiles of adult horses (mares, stallions)

* cut-off date: 4th Juli 2016

Linear profiling: Swedish WB studbook

- linear scheme of medium size for linear descriptions of young horses
  - 9-point linear scale (A to I → 1 to 9)
  - defect traits / special remarks as additional traits (Y/N)
- paper protocols for recording
  - trait-by-trait documentation
  - future development (since 2015):
    tablet PC (adjusted Oldenburg mobile system),
    concentration of active documentation
    (deviations from average expression)



Linear profile Height of withers _____

	CONFORMATION	Obvious	Average A B C D E F G H I	Obvious	Comment
1	Type	refined (i.e. light)		heavy	☐ good proportions
2	Body: shape a	long		short	
3	Body: shape b	long legged		short legged	
4	Body direction	uphill		downhill	
5	Length of neck	long		short	☐ wide connection
6	Position of neck	vertical		horizontal	☐ low connection
7	Shape of neck	arched		straight	☐ heavy head-neck connection
8	Withers	high		low	
9	Position of shoulder	sloping		straight	☐ deep chest
10	Line of back	straight		swayback	
11	Loins	long		short	☐ roached back
12	Shape of croup	sloping		straight	
13	Length of croup	long		short	
14	Foreleg	over at knee		back at knee	☐ tied in ☐ paral displ can ☐ misplaced cannon bone

- linear data available for genetic analyses: 2013-2014, N=1,889 observations (3-year-olds at young horse tests)

Sire EBVs for linear traits

- genetic evaluations for linear traits based on:
  - OL/OS: linear data on foals and adult horses (→ uni- and bivariate analyses)
  - SWB: linear data on 3-year-olds (→ univariate analyses)
- BLUP-EBV from linear animal models
  - $y_{ijk} = \mu + F_i + a_j + e_{ijk}$ and $y_{ijk} = \mu + F_i + a_j + pe_j + e_{ijk}$

Sire group characteristics	Progeny group	No. of linearly described progeny per sire within studbook	
		OL/OS (N_{sires}=1,627)	SWB (N_{sires}=331)
All stallions: linearly described progeny in OL/OS or SWB	foals	7.7 (max. 181) / N_{sires}=864	-
	≥2.5-year-olds	3.4 (max. 101) / N_{sires}=1,114	5.7 (max. 69)
Stallion sample (N=132): linearly described progeny in OL/OS and SWB	foals	18.2 (max. 174) / N_{sires}=87	-
	≥2.5-year-olds	11.9 (max. 101) / N_{sires}=119	4.4 (max. 46)

EBV correlations

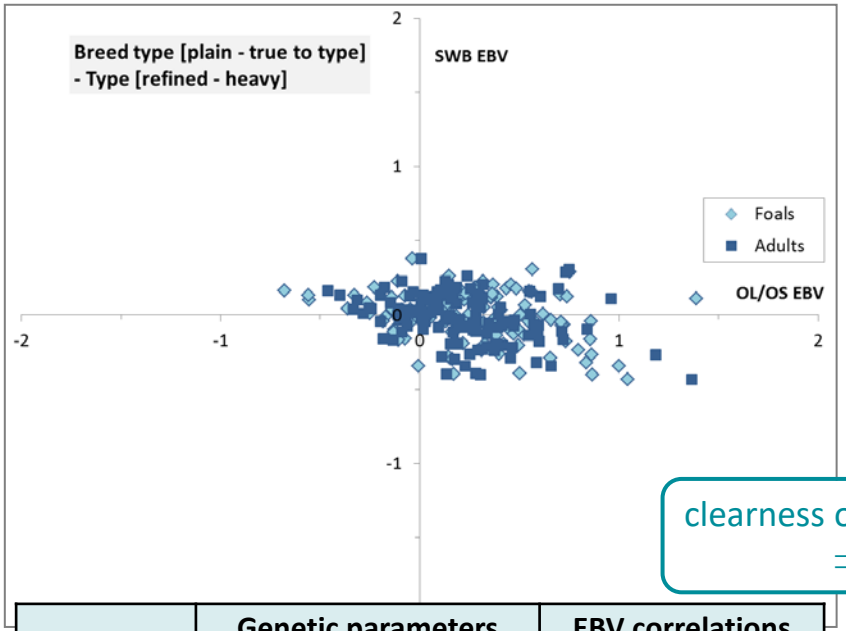
- Pearson correlation coefficients (r) and Spearman rank correlations (ρ)
- 'raw' correlations, i.e. without correction for EBV accuracies, so influenced by:
  - wide range of heritabilities ($h^2 < 0.05$ to $h^2 > 0.70$)
  - few stallions with higher reliabilities in both genetic evaluations

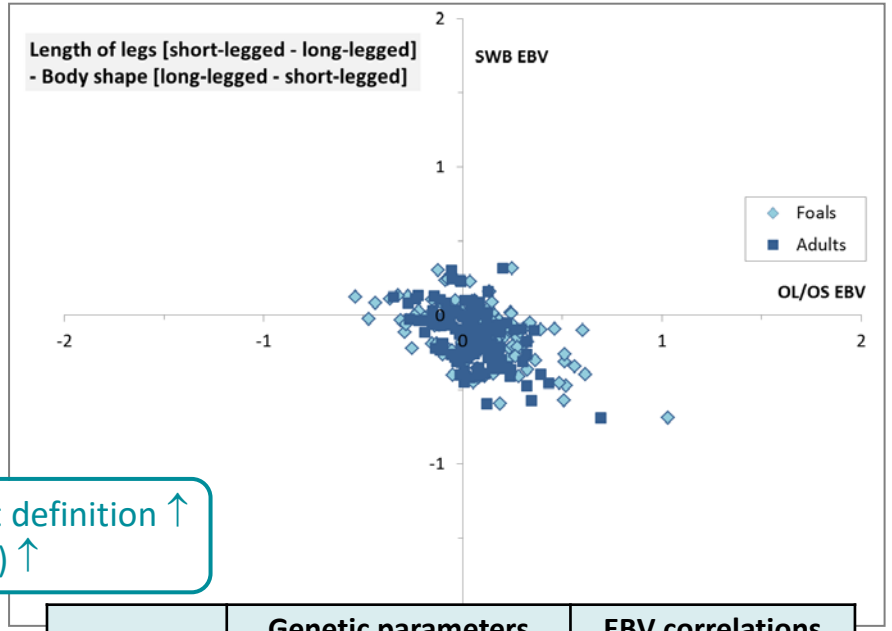
n \ h^2	0.05	0.10	0.15	0.20	0.25	0.30	0.40	0.50	0.60
5	0.06	0.11	0.16	0.21	0.25	0.29	0.36	0.42	0.47
10	0.11	0.20	0.28	0.34	0.40	0.45	0.53	0.59	0.64
15	0.16	0.28	0.37	0.44	0.50	0.55	0.63	0.68	0.73
20	0.20	0.34	0.44	0.51	0.57	0.62	0.69	0.74	0.78
25	0.24	0.39	0.49	0.57	0.63	0.67	0.74	0.78	0.82
30	0.28	0.43	0.54	0.61	0.67	0.71	0.77	0.81	0.84
35	0.31	0.47	0.58	0.65	0.70	0.74	0.80	0.83	0.86
40	0.34	0.51	0.61	0.68	0.73	0.76	0.82	0.85	0.88

Approximation of EBV reliabilities, based on heritability (h^2) and the number of informative progeny (n):

$r^2 = n / (n + k)$ with $k = (4 - h^2) / h^2$

EBV correlations: conformation (I)



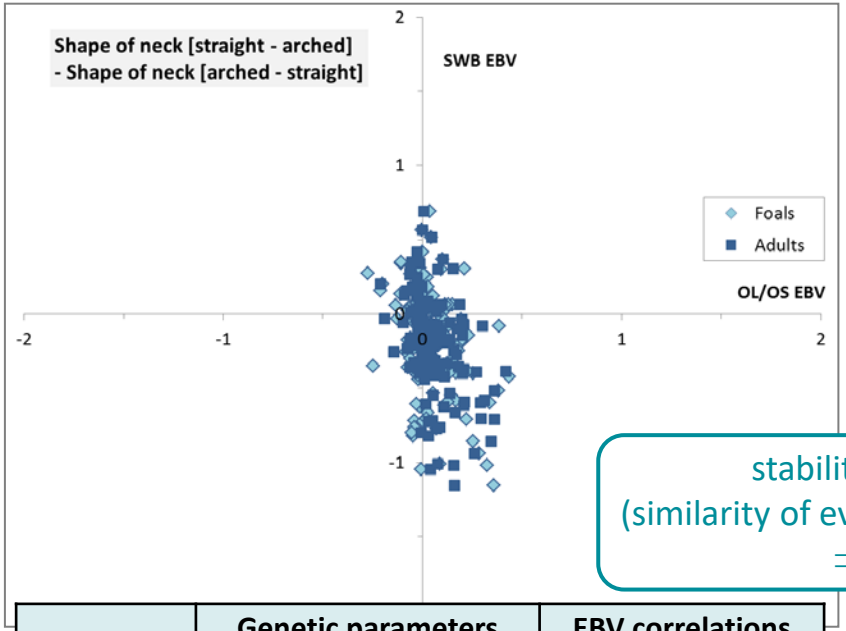


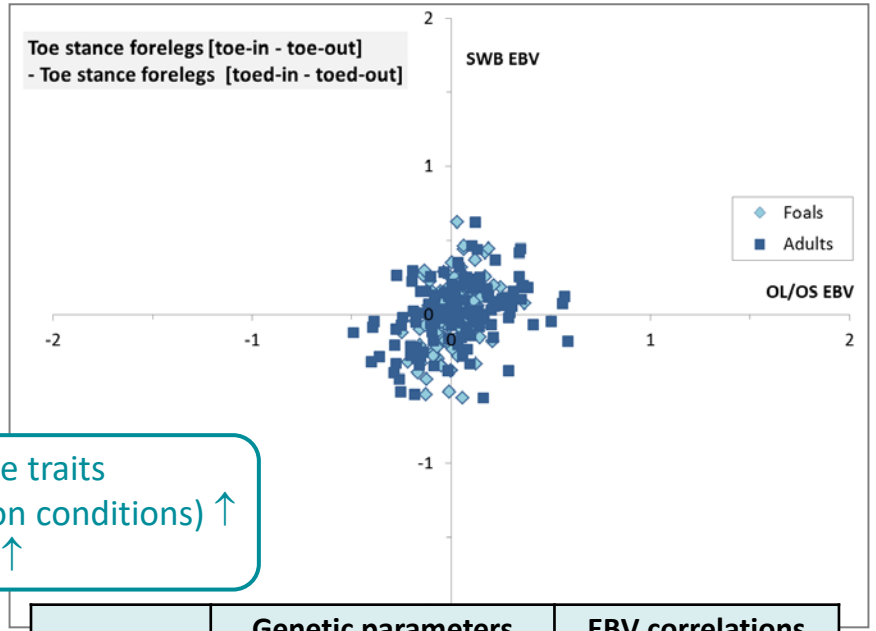
clearness of trait definition ↑
⇒ r (ρ) ↑

Studbook	Genetic parameters			EBV correlations		
	h^2_F	h^2_A	r_{gF-A}		r	ρ
OL / OS	0.37	0.30	0.67	F:	-0.31	-0.27
SWB	-	0.25	-	A:	-0.32	-0.32

Studbook	Genetic parameters			EBV correlations		
	h^2_F	h^2_A	r_{gF-A}		r	ρ
OL / OS	0.27	0.15	0.85	F:	-0.49	-0.42
SWB	-	0.25	-	A:	-0.50	-0.44

EBV correlations: conformation (II)



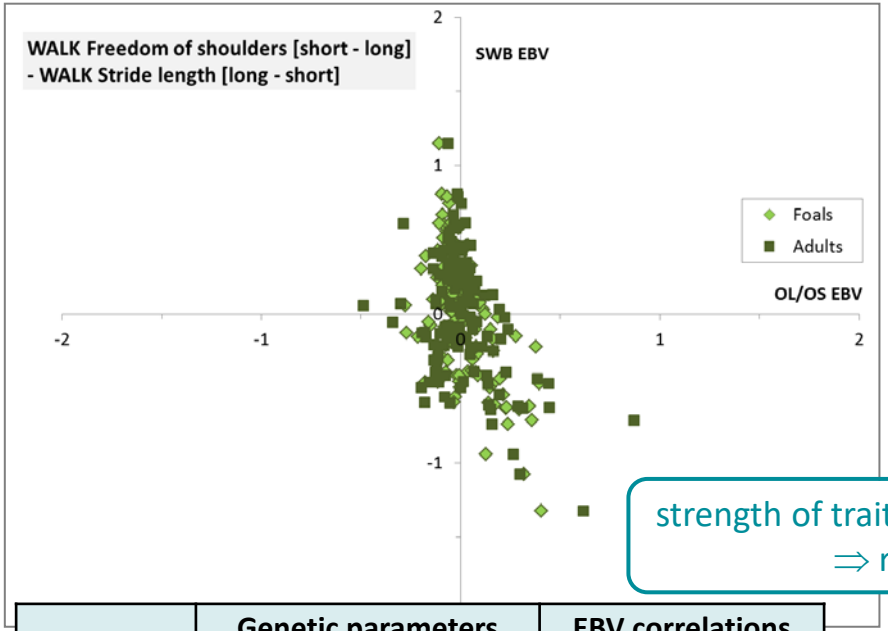


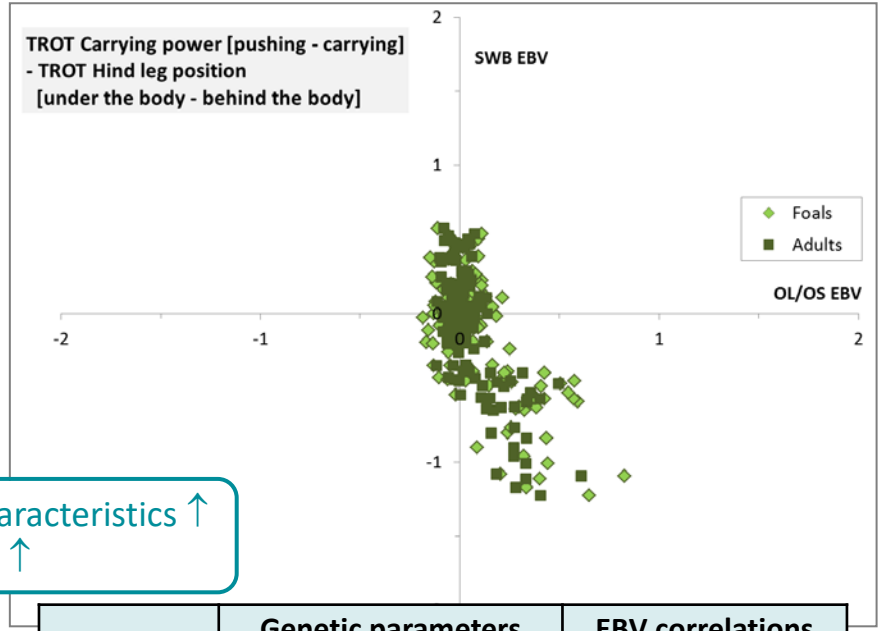
stability of the traits
(similarity of evaluation conditions) ↑
⇒ r (ρ) ↑

Studbook	Genetic parameters			EBV correlations		
	h^2_F	h^2_A	r_{gF-A}		r	ρ
OL / OS	0.18	0.16	0.54	F:	-0.32	-0.23
SWB	-	0.48	-	A:	-0.44	-0.46

Studbook	Genetic parameters			EBV correlations		
	h^2_F	h^2_A	r_{gF-A}		r	ρ
OL / OS	0.14	0.24	0.82	F:	0.36	0.38
SWB	-	0.30	-	A:	0.36	0.27

EBV correlations: performance (I)



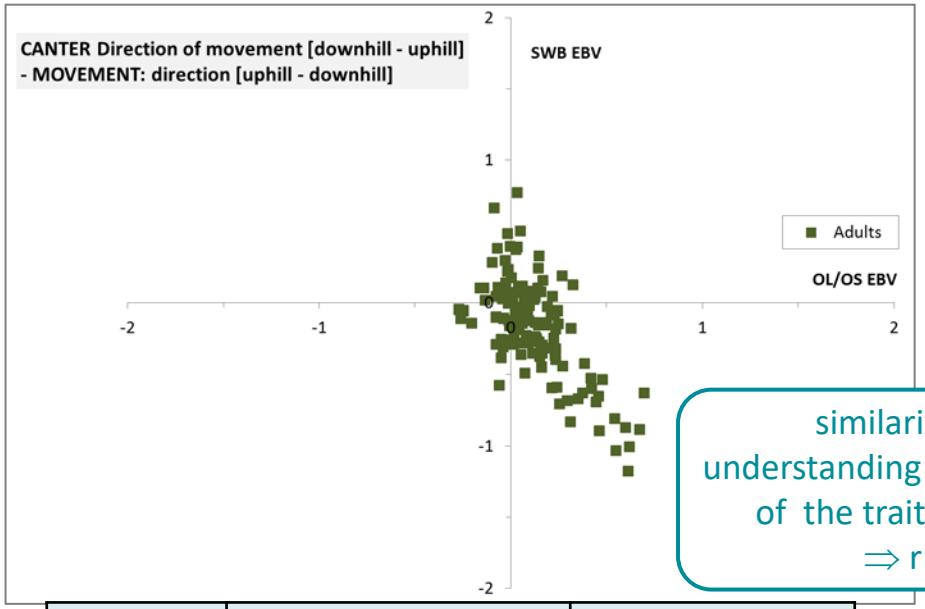


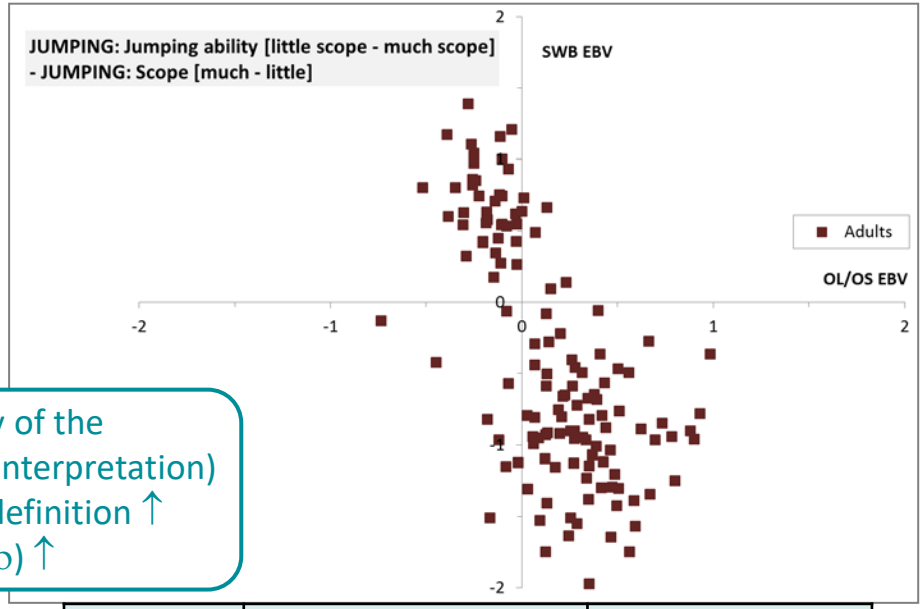
strength of trait characteristics ↑
⇒ r (ρ) ↑

Studbook	Genetic parameters			EBV correlations		
	h^2_F	h^2_A	r_{gF-A}		r	ρ
OL / OS	0.10	0.11	0.46	F:	-0.58	-0.41
SWB	-	0.38	-	A:	-0.50	-0.22

Studbook	Genetic parameters			EBV correlations		
	h^2_F	h^2_A	r_{gF-A}		r	ρ
OL / OS	0.14	0.08	0.78	F:	-0.67	-0.71
SWB	-	0.47	-	A:	-0.49	-0.52

EBV correlations: performance (II)



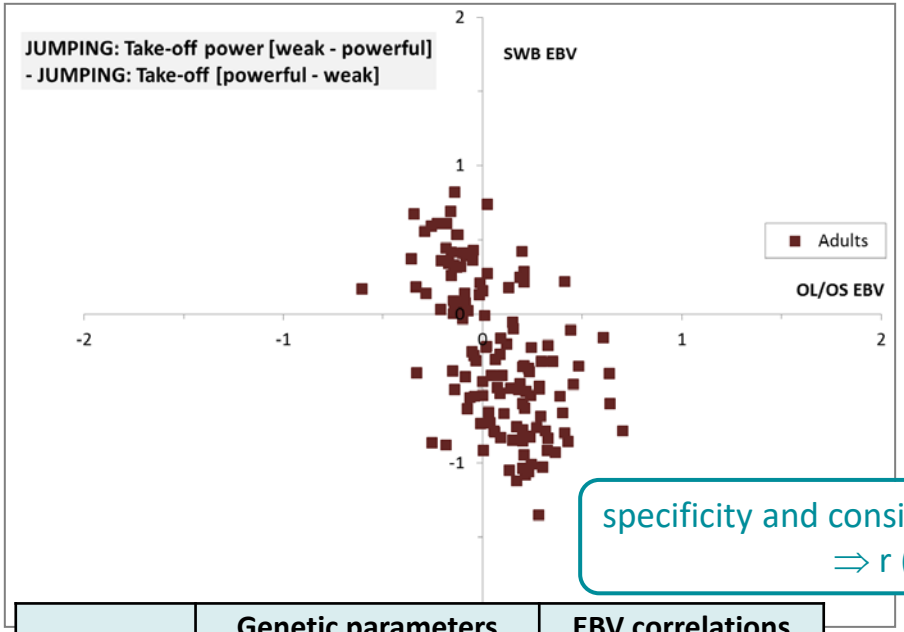


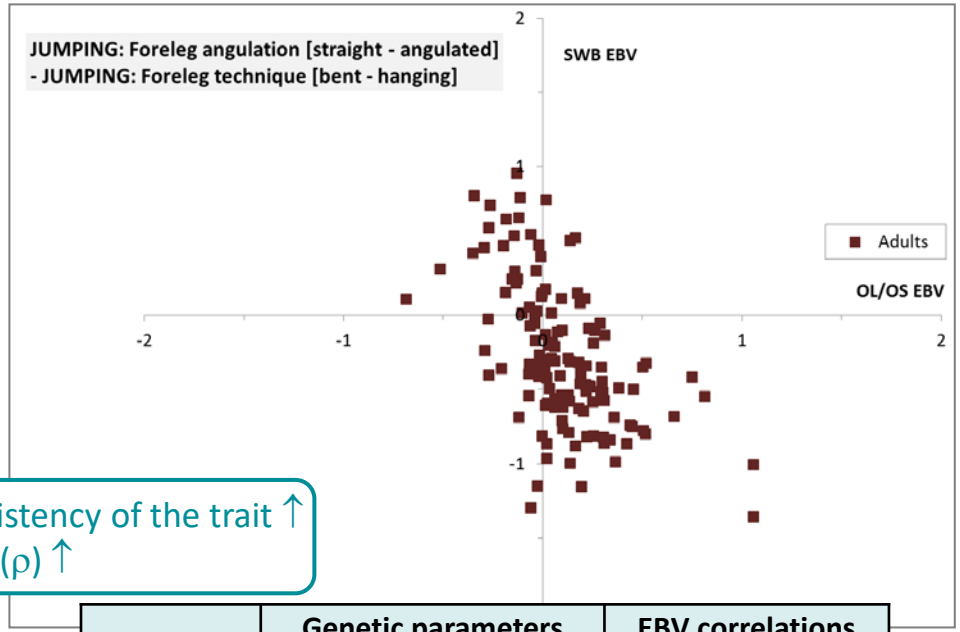
similarity of the understanding (interpretation) of the trait definition ↑
⇒ r (ρ) ↑

Studbook	Genetic parameters	EBV correlations	
	h^2_A	r	ρ
OL / OS	0.17	0.67	-0.55
SWB	0.42		

Studbook	Genetic parameters	EBV correlations	
	h^2_A	r	ρ
OL / OS	0.35	-0.65	-0.65
SWB	0.70		

EBV correlations: performance (III)





specificity and consistency of the trait ↑
⇒ r (ρ) ↑

Studbook	Genetic parameters	EBV correlations	
	h^2_A	r	ρ
OL / OS	0.27	-0.55	-0.57
SWB	0.42		

Studbook	Genetic parameters	EBV correlations	
	h^2_A	r	ρ
OL / OS	0.26	-0.56	-0.58
SWB	0.40		

Summary of results & Discussion

- plausible correlation patterns within and across studbooks
  - positive impact of objectivity and clearness of trait definition
    → 'easy' and 'not so easy' linear traits
    e.g. EBV correlations higher for *length of legs* or *length of neck* than for *type*, higher for *croup length* than *croup shape*, relatively low for *hock angulation*
  - reflection of similarity of assessment and stability of linear traits
    e.g. aspects of *shape of neck*, *strength of back* and/or *loins*; *height of withers*
- strong support of comparability of important linear traits across studbooks
  - several EBV correlations of 0.5 to > 0.7 and few < 0.3 between analogous traits (despite the still low EBV reliabilities)
  - similar breeding goals and high motivation to better capture them as drivers of consistency

Prospects

- next steps: increase of the power of the EBV correlation analyses by extending the basis of linear data used for genetic evaluation
  - OL / OS complete breeding season 2016
  - SWB young horse linear data 2015+
- opportunities for refined comparative analyses
  - depth of the linear data allowing even more specific trait definitions (assessment conditions of performance: in hand, free, under rider) → more precise comparisons
  - ongoing R&D work on the new genetic evaluations: modelling, single- vs. multiple-trait settings, ...

Perspectives

- results of the comparisons of EBV for linear traits across studbooks as valuable supplements of data quality management
  - improved identification of more challenging linear traits → increased awareness as basis of improved education and training, targeted data checking
  - increased opportunities for studying the effects 'real life' data structures
- strengthening of initiatives for improved phenotyping as a whole
  - high value of early and comprehensive linear profiling (incl. foals)
  - increased motivation for continued activity in the dialogue across studbooks (meetings / workshops for exchange of experiences, joint training of judges, ...)
  - promising starting point for future across-studbook collaboration in R&D and routine: linear traits as target traits in genomic applications

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OLDENBURGER PFERDEZUCHTVERBAND E.V.

Contact information
(vit, Genetic evaluation division / R&D):
PD Dr. habil. Kathrin F. Stock
E-mail: friederike.katharina.stock@vit.de
Phone: +49-4231-955 623 (Fax: -9623)
Mobile: +49-176-60931357
Info: *http://www.equinephenotypes.org*

Thank you!

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