



IT Solutions
for Animal Production



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Genetic parameters of summarizing performance traits for evaluating selection approaches for dressage and show jumping sport performance in riding horses

Kathrin F. Stock¹, Janou Mayer², Peer Eitenmüller², Inge Workel²

¹ IT Solutions for Animal Production (vit), Verden (Aller), Germany;

² Oldenburger Pferdezuchtverband e.V., Vechta, Germany

*E-mail: friederike.katharina.stock@vit.de



Session 48
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Outline

- ❖ background:
demands on breeding programs for sport horses
- ❖ aim and approach
 - ◆ summarizing performance traits (progeny-based sport statistics)
 - ◆ indicator traits (breeding programs)
- ❖ results and discussion
- ❖ conclusions



Background |



- well-known challenge of sport horse breeders
 - importance of the ability of sport horses to perform on advanced level
 - late availability of phenotypic data on key aspects of the breeding goal
- additional traits in the routine national genetic evaluation for riding horses in Germany:
highest level achieved in dressage (HEK-D) and show jumping (HEK-J)
 - introduced in 2019 according to Welker et al. (2018)
 - simplified, summarizing trait definition esteemed by breeders



Background II

- well-known challenge of sport horse breeders
 - importance of the ability of sport horses to perform on advanced level
 - late availability of phenotypic data on key aspects of the breeding goal
- additional traits in the routine national genetic evaluation for riding horses in Germany: **highest level achieved** in dressage (HEK-D) and show jumping (HEK-J)
 - introduced in 2019 according to Welker et al. (2018)
 - simplified, summarizing trait definition esteemed by breeders
- routine phenotypic data collection by the studbooks
 - starting at foal age, including assessments under rider
 - linear descriptive phenotypic data as valued input in breeding programs of riding horses
- How do the refined indicator traits relate to simplified cumulative figures as used for studbook rankings and sport-focused progeny statistics (stallions, mares)?



Indicator traits vs. summarizing performance traits

■ indicator traits

- routinely collected in breeding events by the studbooks
- broadly available for systematic analyses
- supposed to allow identification of mares and stallions with highest probabilities of producing top performers in sport

■ quality criteria (progeny):

- (1) start a career in sport
- (2) perform successfully in competitions up to advanced level

summarizing performance traits

- % progeny in sport of all progeny
- highest level achieved by progeny

➤ aim:

estimation of **genetic parameters for summarizing performance traits** reflecting these target measures (suitability, capacity, potential; dressage and show jumping competitions)

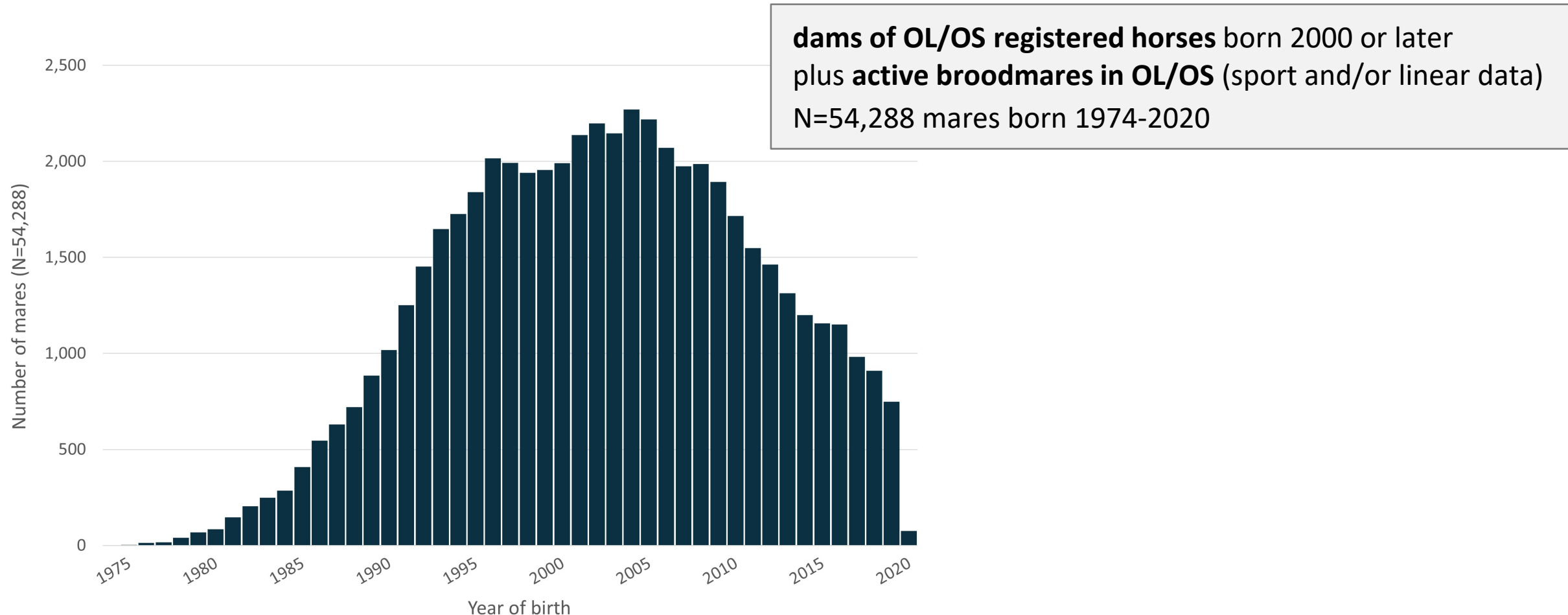
→ **validation of criteria currently used to support selection decisions and mating planning**

Study approach

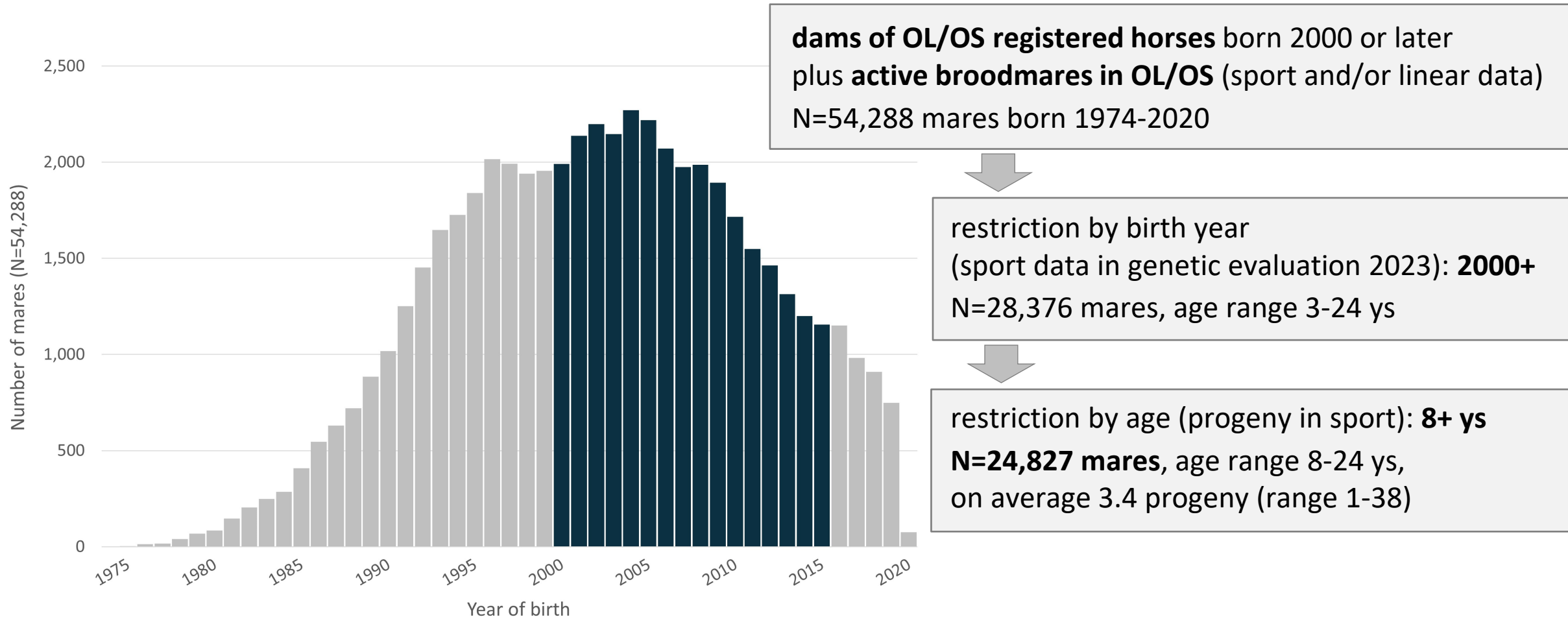
- whole studbook-specific breeding stock as starting point
→ dam population of the Oldenburg studbooks (OL, OS)
- definition of the study population as subset of all dams to account for availability of meaningful quality measures (summarizing performance traits)
 - sport data in the routine genetic evaluation
→ no individual progeny records, but **progeny statistics for mares** (by discipline)
 - minimum age
→ **adult progeny** = potential competition horses
- analyses together with routinely collected linear data
 - foals and adult horses
 - focus on performance-related linear traits



Data basis: study population

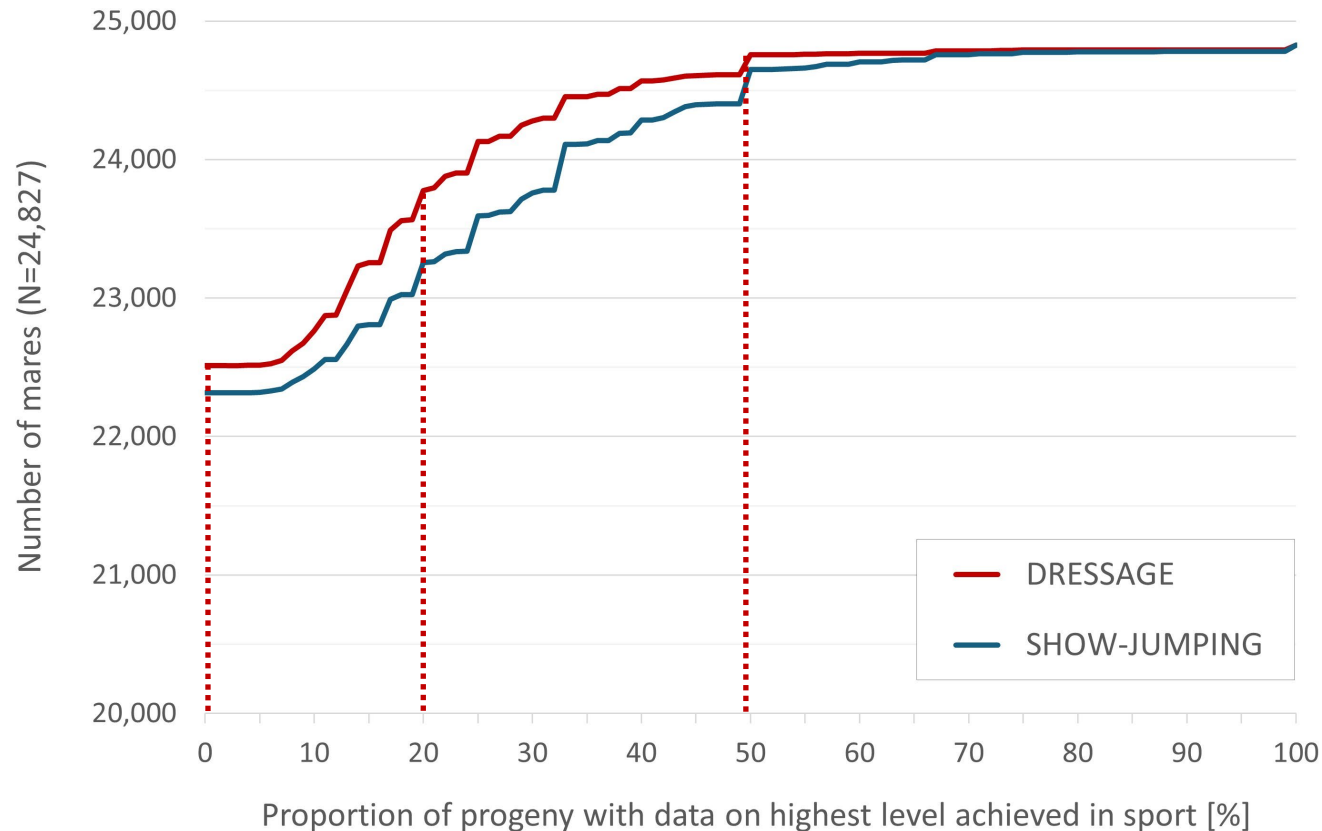


Data basis: study population II



Summarizing performance traits I

➤ proportion of progeny in sport (pPS)

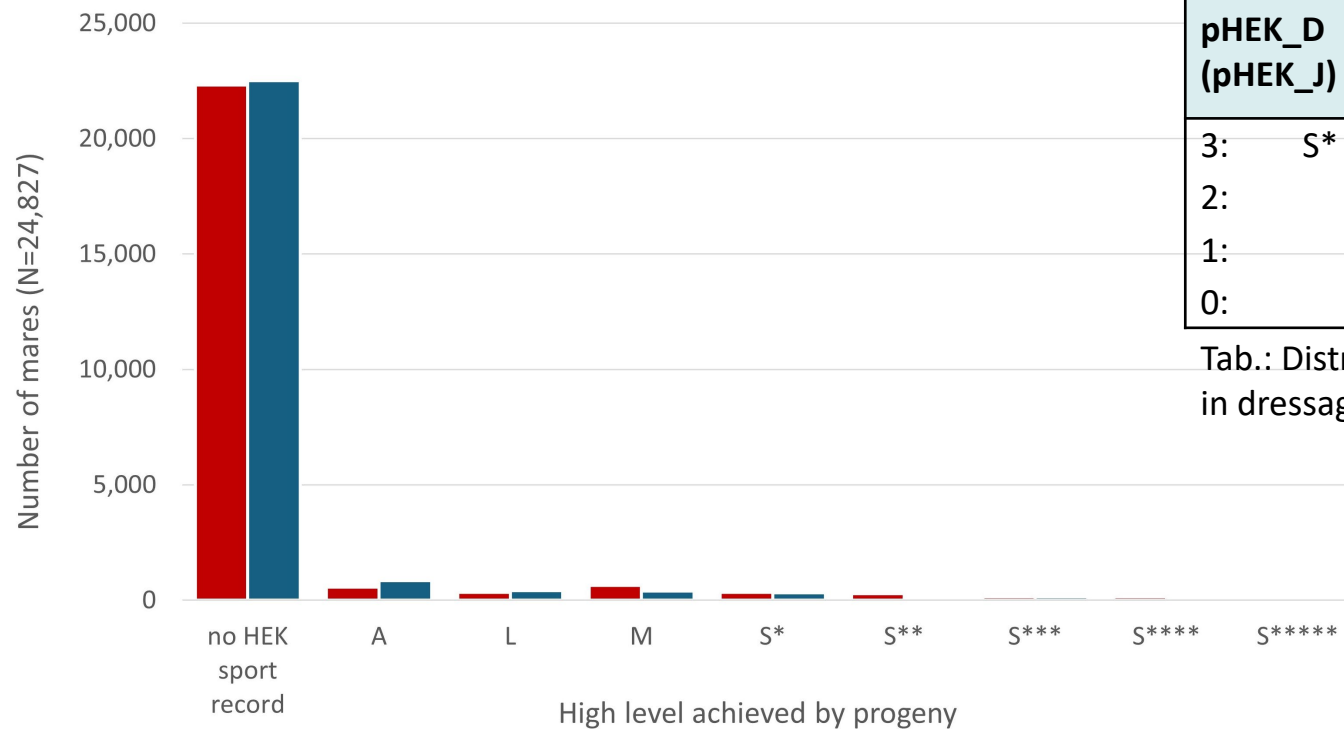


pPS_D (pPS_J)	Dressage		Show jumping	
	N	p%	N	p%
3: >50%	216	0,9%	423	1.7%
2: ≥20 <50%	1,045	4.2%	1,378	5.6%
1: >0 <20%	1,056	4.3%	1,711	2.9%
0: 0%	22,510	90.7%	22,315	89.9%

Tab.: Distribution of mares by the proportion of their progeny with data on highest level achieved in sport (pPS_D, pPS_J)

Summarizing performance traits II

- proportion of progeny in sport (pPS)
- highest level achieved by progeny (PHEK)



pHEK_D (pHEK_J)	Dressage		Show jumping	
	N	p%	N	p%
3: S* to S ***** / advanced	643	2.6%	965	3.9%
2: M / moderate	403	1.6%	643	2.6%
1: L or A / low	1,271	5.1%	904	3.6%
0: no HEK sport record	22,510	90.7%	22,315	89.9%

Tab.: Distribution of mares by the highest level achieved by their progeny in dressage and show jumping sport (PHEK_D, PHEK_J)



Combined dataset: (9+21) + 2x2 traits

Linear trait	Foals			Adult horses		
	N	mean	std.	N	mean	std.
Tail tone [un-toned - over-toned]	23,975	-0.013	0.427	21,583	-0.040	0.408
WALK Freedom of shoulders [short - long]	23,830	0.116	0.619	16,005	0.081	0.695
WALK Reach of HL (overstepping) [inactive (short) - active (long)]	23,830	0.206	0.603	16,005	0.174	0.721
TROT Freedom of shoulders [short - long]	23,830	0.278	0.866	20,973	0.182	0.751
TROT Mechanics of FL [straight forelimb - much knee action]	23,830	0.387	0.960	20,973	0.226	0.830
TROT Impulsion [weak - powerful]	23,830	0.451	0.959	20,973	0.264	0.905
TROT Thrust (HL activity) [inactive, sluggish - active, energetic]	23,830	0.510	0.893	20,973	0.389	0.852
TROT Carrying power [pushing - carrying]	23,830	-0.020	0.748	20,973	-0.042	0.645
TROT Ground covering [little - much]	23,830	0.109	0.603	20,973	0.039	0.514
CANTER Freedom of shoulders [short - long]				9,853	0.110	0.730
CANTER Mechanics of FL [straight forelimb - much knee action]				9,168	0.233	0.851
CANTER Direction of movement [downhill - uphill]				9,853	0.135	0.763
CANTER Thrust (HL activity) [inactive, sluggish - active, energetic]				9,853	0.383	0.824
JUMPING Rhythm [not fluent - fluent]				4,103	0.204	0.906
JUMPING Take-off power [weak - powerful]				4,103	0.326	0.917
JUMPING Reflexes [slow, inflexible - quick, flexible]				4,348	0.157	0.682
JUMPING Attention [inattentive - attentive]				4,348	0.108	0.642
JUMPING Overview [little - much]				4,103	0.211	0.862
JUMPING Jumping ability [little scope - much scope]				4,348	0.235	1.106
JUMPING Foreleg angulation [straight - angulated]				4,348	-0.066	1.049
JUMPING Back technique (bascule) [hollow back - rounded back]				4,348	-0.033	1.019

HL = hind limb(s), FL = front limbs

9 linear traits for young horses (yLIN)
 21 linear traits for adult horses (aLIN)
 2 summarizing performance traits
 for each of 2 disciplines

Cumulative sport trait	Dressage		Show jumping	
	mean	std.	mean	std.
pPS	0.161	0.569	0.191	0.606
PHEK	0.153	0.516	0.205	0.669

Tab.: Distribution of the proportion of progeny in sport (pPS) and highest level achieved by progeny (PHEK) in 24,827 mares with OL/OS registered progeny

Tab.: Distribution of selected linear traits in 35,018 horses linearly described as foals (N=23,975) and/or adult horses (N=19,548) between 2012 and 2023

Genetic analyses

- estimation of genetic parameters uni- / multivariately in linear animal models
 - summarizing performance traits
 - indicator traits and summarizing performance traits
 - PEST and VCE6 software
- tri- or bivariate analyses per discipline
 - dressage: 12 gait traits (foals: N=8) and one special remark + pPS_D, PHEK_D
 - show-jumping: 4 gait traits, 8 jumping traits and one special remark + pPS_J, PHEK_J

summarizing performance traits (sport):

$$y_{ijpq} = \mu + SBb_i + AGES_Y_j (SB_i) + animal_p + e_{ijpq}$$

fixed effects: SBb = studbook (OL, OS) with registered progeny,
 AGES_Y = age in years (relative to the progeny sport statistics;
 <9 ys, 9-12 ys, 13-16 ys, > 16ys);
 random effects: animal = additive genetic effect, e = residual

indicator traits (linear profiling):

$$y_{klmnpq} = \mu + SB_k + EVENT-TEAM_l + AGE_M_m + SEX_n + animal_p + e_{klmnpq} \text{ (foals)}$$

$$y_{klnopq} = \mu + SB_k + EVENT-TEAM_l + AGE_Y_n + PTYPE_o + animal_p + pe_p + e_{klnopq} \text{ (adults)}$$

fixed effects: SB = studbook (OL, OS), EVENT-TEAM = date, place, assessor, assistance, SEX = male / female,
 AGE_M (AGE_Y) = age in months (years), PTYPE = presentation type (assessment in hand, free, under rider);
 random effects: animal = additive genetic effect, pe = permanent environmental effect of the animal, e = residual



Summary of results

- relevant genetic basis of summarizing performance traits
 - heritability range of $h^2 = 0.044 - 0.068$ ($SE_{h^2} \leq 0.02$)
 - $h^2_{PHEK} > h^2_{pPS}$
- overall minor discipline differences
 - $h^2_{PHEK_D} \approx h^2_{PHEK_J}$, $h^2_{pPS_D} > h^2_{pPS_J}$
 - $r_{g\ PHEK_D} > r_{g\ pPS_D}$, $r_{g\ PHEK_J} \approx r_{g\ pPS_J}$
- moderately positive additive genetic correlations to discipline-related linear traits
 - dressage: yLIN r_g up to 0.39 ($SE \leq 0.08$),
 aLIN r_g up to 0.51 ($SE \leq 0.09$) → 7 of 12 linear gait traits
 - show-jumping: aLIN r_g up to 0.81 (SE mostly ≤ 0.15) → 8 of 8 linear jumping traits



Genetic correlations: indicator traits DRESSAGE

➤ direction of movement, activity and strength of hind limbs

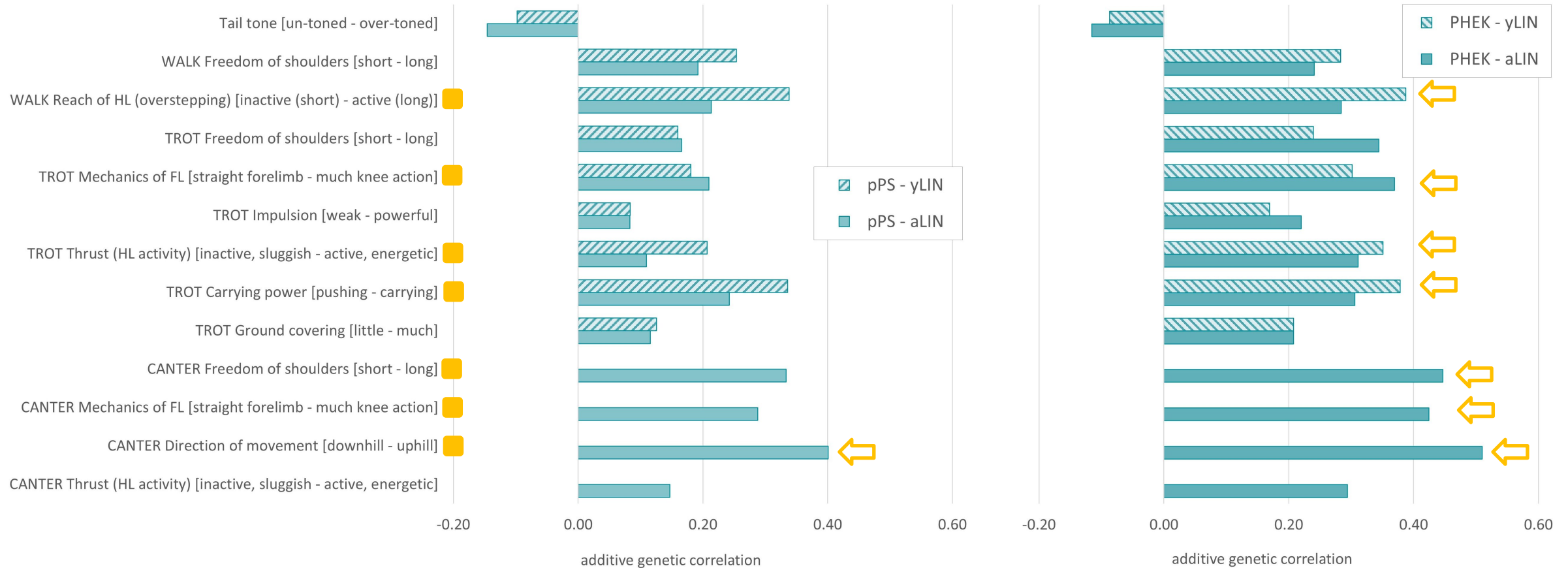


Fig.: Additive genetic correlations (r_g) of dressage-related linear traits with summarizing performance traits ($SE \leq 0.09$; $r_g \geq 0.35$ highlighted).

Genetic correlations: indicator traits SHOW-JUMPING

➤ supporting the sometimes questioned value of free jumping assessment

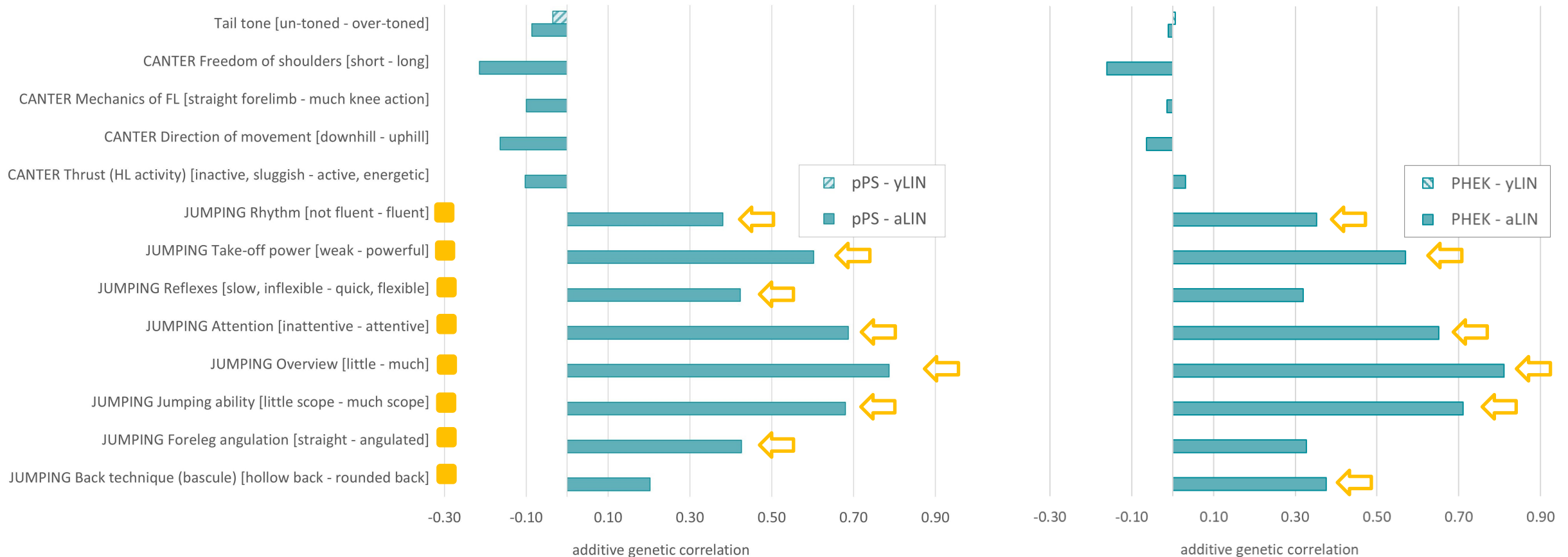


Fig.: Additive genetic correlations (r_g) of show jumping-related linear traits with summarizing performance traits ($SE \leq 0.09$; $r_g \geq 0.35$ highlighted).

Conclusions

- suitability of simplified, summarizing performance traits for the purpose of evaluating breeding programs of sport horses
 - derived from progeny statistics with reference to dressage and show-jumping competitions
 - helping to bridge the gap between sources of information available in sport horse breeding
- additive genetic correlations patterns between indicator and sport-derived traits supporting the value of refined phenotyping (incl. foals) and reflecting the potential of genetic evaluation for linear traits as selection tool in breeding programs for sport horses





IT Solutions
for Animal Production



contact: PD Dr. Kathrin F. Stock
(E-Mail: friederike.katharina.stock@vit.de ; phone: +49 4231 955623)

IT Solutions for Animal Production (vit)
Heinrich-Schröder-Weg 1, 27283 Verden, Germany

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Thank you!



photo: OLDArt