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Genetic analyses of linear conformation and performance traits in Warmblood horses

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Background

- conformation & performance evaluations of studbooks
  → valuating scores
  - PRO: easy to use / fast, clear ranking
  - CONTRA: subjective, loss of detailed information

- high reputation of linear profiling
  - PRO: more objective, specific trait definition, better discrimination
  - CONTRA: requirements of time (increased no. of traits) / personnel

  → intense R&D activities on how to <u>implement linear profiling in the Warmblood horse</u> − different approaches:
  1) simplified linear schemes
  2) documentation assistance for selected events
  3) efficient documentation in (all) regular breeding events

Linear profiling in Oldenburg

- 'quasi-linear' descriptive notes
  - common / necessary (requests to comment on individual horses)
  - personal style (extent, detailedness, form)

- development of own linear system
  - extensive scheme (no compromise concerning spectrum of traits)
  - adherence to individual extent of documentation (own responsibility)
  - linear profile as part of the official assessment (judging commission + documentation assistance, no extra-time)
  - mobile device for recording (tablet PC)

- routine linear profiling at regular breeding events of the Oldenburg horse breeding societies (OL, OS) since 2012

Aims

■ estimation of genetic parameters for linear conformation and performance traits

■ assessment of opportunities / conditions of including linear data from different age groups in future breeding programs

Data

- linear profiles (N=2,902) of juvenile and adult horses presented at regular breeding events of OL/OS in 2012 and 2013
  - foal registrations,
  - mare shows, mare performance tests, stallion inspections & approvals

- uniform linear scheme
  - definition of performance traits considering presentation conditions
  - average expression [0] as default, active documentation of deviations from average expression

Trait group	No. of full scale linear traits [-3 to +3]	No. of half scale linear traits [0 to +3]
Conformation (CONF)	56	15
Movement in hand (HMOV)	15	2
Free movement & free jumping (FMOV)	26	8
Movement under rider (RMOV)	24	7

Genetic analyses

■ trait definition within age group: juvenile (J), adult (A)

■ single records per horse:
N_J=1,755 (885

Distribution of linear traits

Parameter	JUVENILE	ADULT
Conformation traits (N$_J$=21, N$_A$=33)		
Mean	0.06 (-0.16 to +0.72)	0.03 (-0.14 to +0.51)
Std.	0.52 (0.32 to 0.86)	0.50 (0.30 to 0.89)
Performance traits (N$_J$=10, N$_A$=44)		
Mean	0.14 (-0.11 to +0.54)	0.11 (-0.28 to +0.50)
Std.	0.64 (0.34 to 0.92)	0.70 (0.34 to 1.04)

F Trot: Mechanics of front limbs
[straight forelimb - much knee action]
J (N=1,755)
A (N=470)

Breed type
[plain - true to type]
J (N=1,755)
A (N=1,005)

H Walk:
Hind limb activity
[inactive - active]
J (N=1,755)
A (N=953)

Heritability estimates (I)

Legend: JUVENILE (blue), ADULT (red)

Linear conformation traits
mean h²: 0.14 (J), 0.12 (A)
h² > 0.1: N_J=13, N_A=18
→ body J>A, limbs A>J

Heritability estimates (II)

Linear performance traits

mean h²: 0.20 (J), 0.15 (A)

h² > 0.1: N_J=9, N_A=24

→ 2x walk, 5x trot, 2x canter
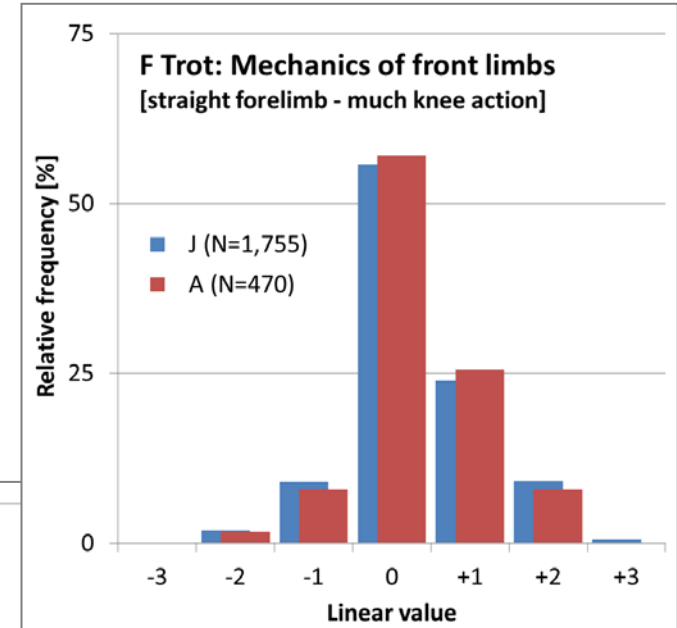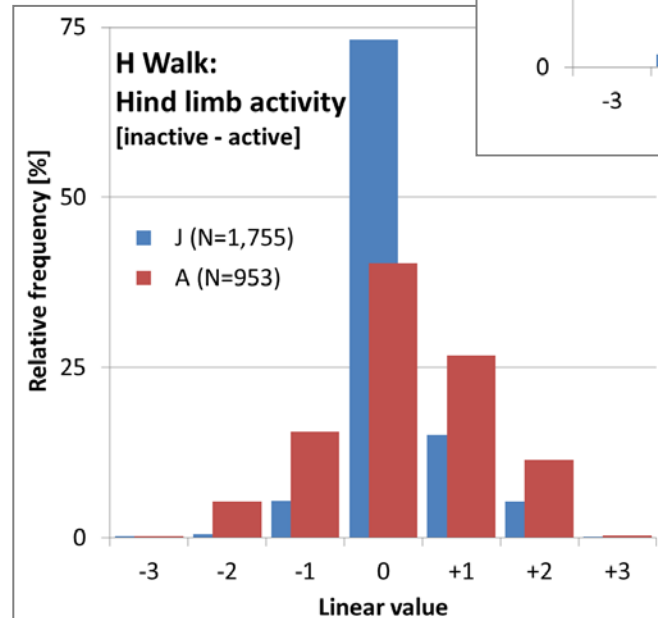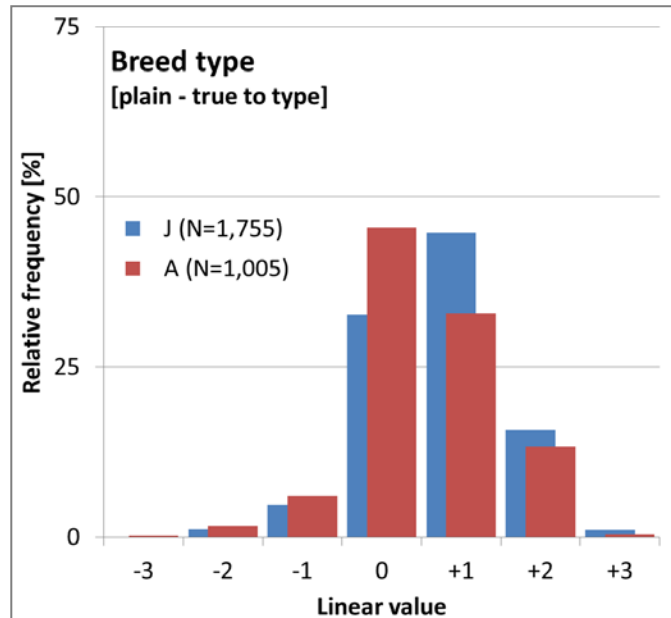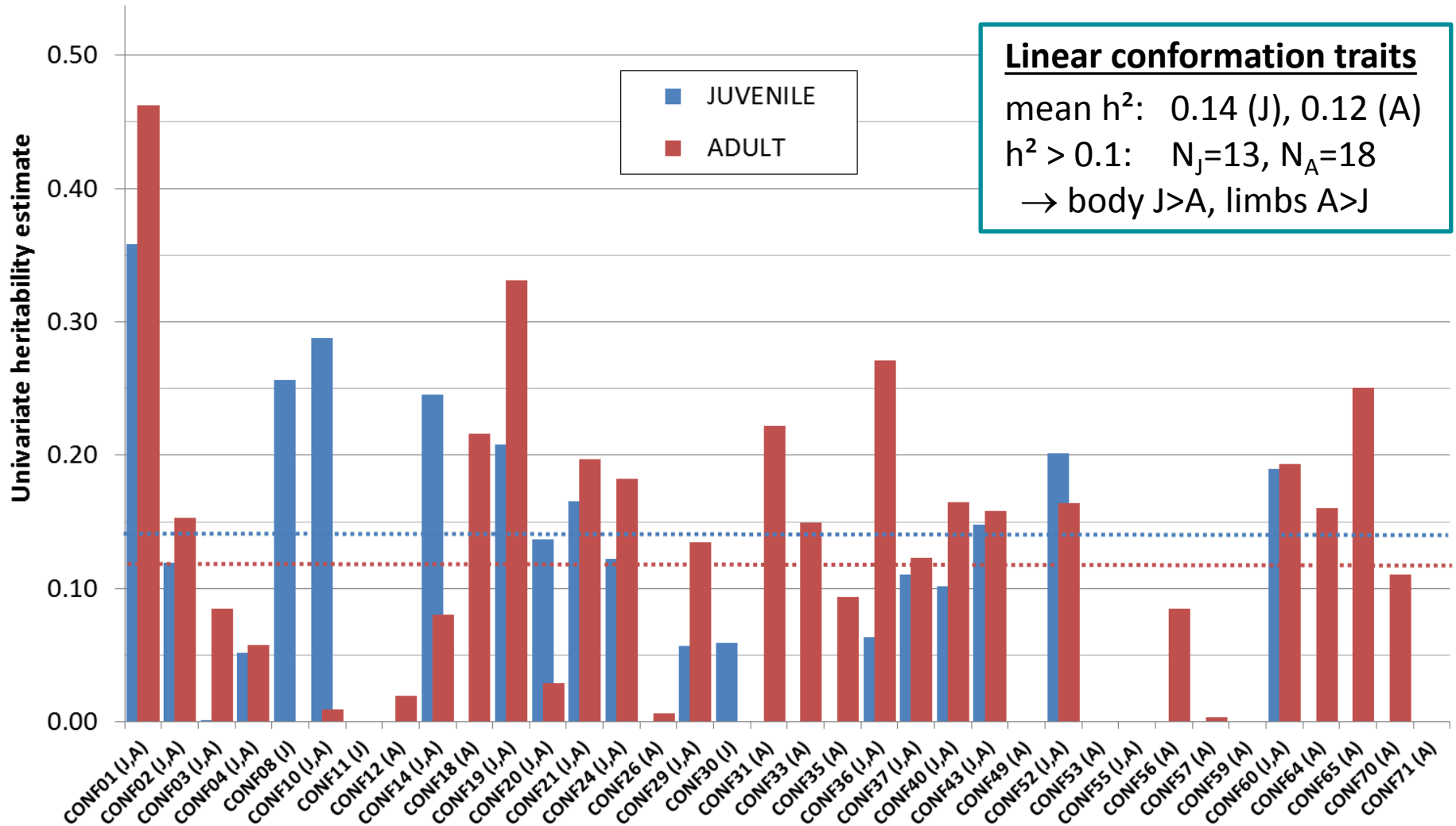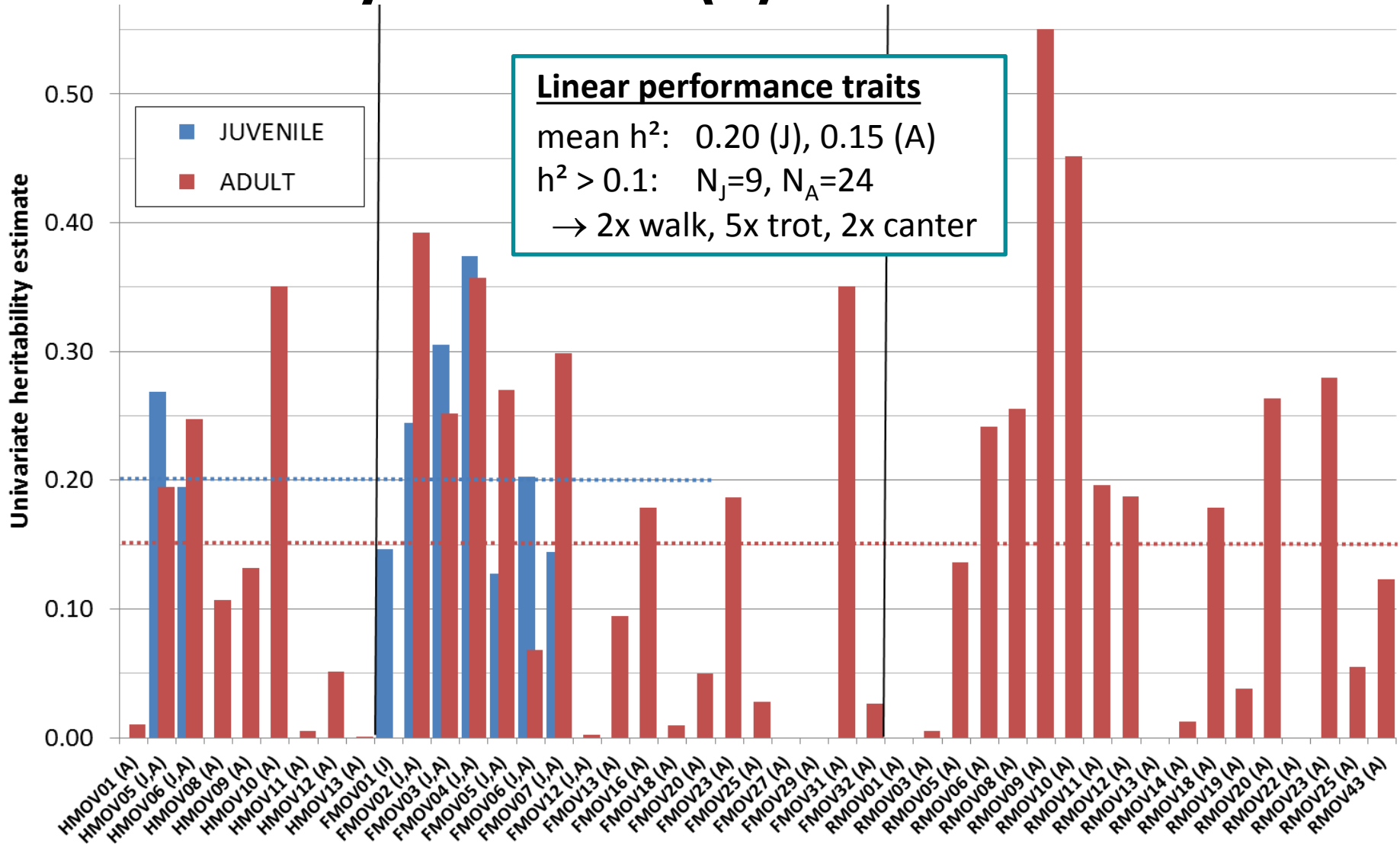
Genetic correlations

Linear trait	JUVENILE (N=1,755)		ADULT (N_{CONF}=1,005; N_{HMOV}=953; N_{FMOV}=470)		JUVENILE - ADULT		
	h^2	SE_{h^2}	h^2	SE_{h^2}	r_g	SE_{rg}	r_p
Breed type	**0.35**	0.079	**0.45**	0.130	**0.58**	0.185	**0.23**
Gender expression	**0.11**	0.057	**0.15**	0.080	**0.54**	0.492	**0.07**
Head coarseness	**0.23**	0.062	**0.06**	0.024	**0.96**	0.241	**0.12**
Stance of forelimb pastern	**0.12**	0.057	**0.13**	0.075	**0.42**	0.429	**0.05**
Hock angulation	**0.22**	0.064	**0.20**	0.093	**0.87**	0.270	**0.18**
Toe stance of forelegs	**0.19**	0.071	**0.26**	0.119	**1.00**	<0.001	**0.22**
H Walk: Length of stride	**0.26**	0.071	**0.19**	0.090	**0.12**	0.277	**0.03**
H Walk: Hindlimb activity	**0.19**	0.058	**0.24**	0.077	**0.19**	0.247	**0.04**
F Trot: Length of stride	**0.29**	0.079	**0.50**	0.220	**0.71**	0.245	**0.27**
F Trot: Mechanics of front limbs	**0.32**	0.073	**0.26**	0.118	**1.00**	<0.001	**0.29**
F Trot: Impulsion	**0.36**	0.070	**0.34**	0.181	**0.97**	0.246	**0.34**
F Trot: Thrust / hind limbs activity	**0.14**	0.052	**0.27**	0.155	**0.77**	0.434	**0.15**

H = movement in hand (foals: walk at the side of their dams), F = free movement

Summary of results

- consistent results of uni- and bivariate analyses (mostly $\Delta h^2 \leq 0.02$)

- genetic determination of linear traits in both age groups
  - for majority of trait $h^2 = 0.1 - 0.4$
  - similarities in h^2 pattern, e.g.
    highest estimates for CONF (Breed type) and FMOV (Trot: Impulsion)

- additive genetic correlations of mostly $r_g > 0.5$
  between corresponding traits in juvenile and adult horses

- indications of required further harmonization of application of the linear scheme

preliminary results to be verified with more data

Conclusions & prospects

- feasibility of linear profiling in regular breeding events
  using an extensive linear scheme across age groups
  $\rightarrow$ increased quality of routinely available phenotype data

- usability of linear data for breeding purposes
  - detailed information for breeders
  - subset of traits for future genetic evaluations
    $\rightarrow$ new perspectives for breeding

- further research & development
  - optimization of trait definitions (training of judges, repeatability tests)
  - promotion and support of wider use of linear profiles in horse breeding
  - model development to make best use of improved information basis
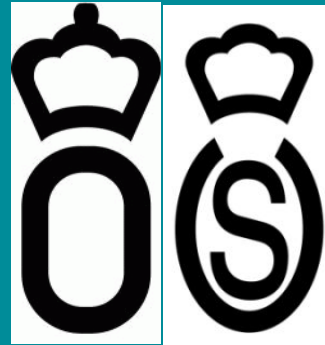
Thank you!

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Distribution of linear traits

Linear trait	JUVENILE (N=1,755)					ADULT (N_{CONF}=1,005; N_{HMOV}=953; N_{FMOV}=470)				
	mean	std	var	min	max	mean	std	var	min	max
Breed type	0.721	0.864	0.746	-2	+3	0.506	0.887	0.786	-3	+3
Gender expression	0.058	0.409	0.167	-2	+2	0.029	0.728	0.530	-3	+3
Head coarseness	0.453	0.825	0.680	-2	+3	0.198	0.845	0.715	-2	+3
Stance of forelimb pastern	0.008	0.769	0.591	-3	+3	0.215	0.718	0.516	-3	+3
Hock angulation	0.275	0.714	0.510	-3	+3	0.161	0.801	0.641	-3	+3
Toe stance of forelegs	0.203	0.558	0.312	-3	+3	-0.137	0.734	0.539	-3	+2
H Walk: Length of stride	0.178	0.652	0.425	-2	+3	0.353	0.878	0.771	-2	+3
H Walk: Hindlimb activity	0.188	0.667	0.446	-3	+3	0.236	1.043	1.088	-3	+3
F Trot: Length of stride	0.029	0.668	0.446	-3	+2	-0.038	0.625	0.391	-3	+2
F Trot: Mechanics of front limbs	0.306	0.845	0.714	-2	+3	0.300	0.793	0.628	-2	+2
F Trot: Impulsion	0.544	0.924	0.854	-3	+3	0.313	0.782	0.612	-2	+3
F Trot: Thrust / hind limbs activity	0.168	0.665	0.442	-2	+3	0.228	0.603	0.364	-2	+2

H = movement in hand (foals: walk at the side of their dams), F = free movement

Trait group	Subgroup	Until 2012	As of 2013
Conformation	format / overall evaluation	7 (0)	13 (1)
	front / head & neck	12 (1)	14 (2)
	topline	6 (0)	8 (0)
	limbs	14 (3)	24 (8)
	correctness	11 (3)	12 (4)
Movement in hand	walk	5 (1)	6 (1)
	trot	6 (0)	7 (0)
	behavior	2 (1)	4 (1)
Free movement and free jumping	trot	6 (0)	7 (0)
	movement pattern	4 (3)	5 (4)
	canter	4 (0)	7 (1)
	free jumping	7 (1)	12 (3)
	behavior	1 (0)	3 (0)
Movement under rider	walk	5 (1)	6 (1)
	trot	6 (0)	7 (0)
	movement pattern	5 (3)	6 (4)
	canter	4 (0)	7 (1)
	jumping	7 (1)	12 (3)
	behavior	3 (1)	5 (1)
Total		115 (22)	165 (35)

Trait distributions (all → subset)

Conformation traits (CONF; N_J=71, N_A=71)

Parameter	JUVENILE			ADULT		
	mean	**min**	**max**	**mean**	**min**	**max**
Mean	0.020	-0.164	+0.721	0.017	-0.137	+0.506
Std.	0.261	0	0.864	0.346	0	0.887
Variance	0.110	0	0.746	0.160	0	0.786

Performance traits (HMOV, FMOV, RMOV; N_J=27, N_A=88)

Parameter	JUVENILE			ADULT		
	mean	**min**	**max**	**mean**	**min**	**max**
Mean	0.055	-0.105	+0.544	0.079	-0.279	+0.495
Std.	0.313	0	0.924	0.540	0	1.043
Variance	0.174	0	0.854	0.369	0	1.088

Conformation traits (CONF; N_J=21, N_A=33)

Parameter	JUVENILE			ADULT		
	mean	**min**	**max**	**mean**	**min**	**max**
Mean	0.061	-0.164	+0.721	0.028	-0.137	+0.506
Std.	0.524	0.323	0.864	0.496	0.301	0.887
Variance	0.301	0.105	0.746	0.272	0.091	0.786

Performance traits (HMOV, FMOV, RMOV; N_J=10, N_A=44)

Parameter	JUVENILE			ADULT		
	mean	**min**	**max**	**mean**	**min**	**max**
Mean	0.140	-0.105	+0.544	0.109	-0.279	+0.495
Std.	0.638	0.337	0.924	0.697	0.340	1.043
Variance	0.440	0.113	0.854	0.523	0.115	1.088

Distribution of linear traits (I)
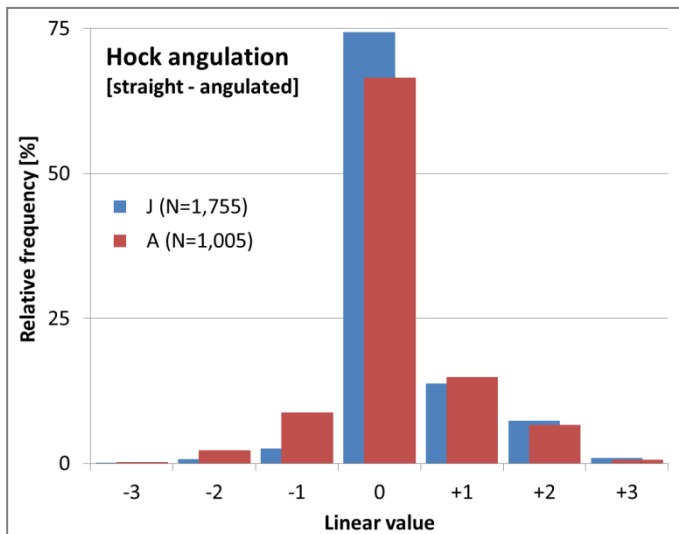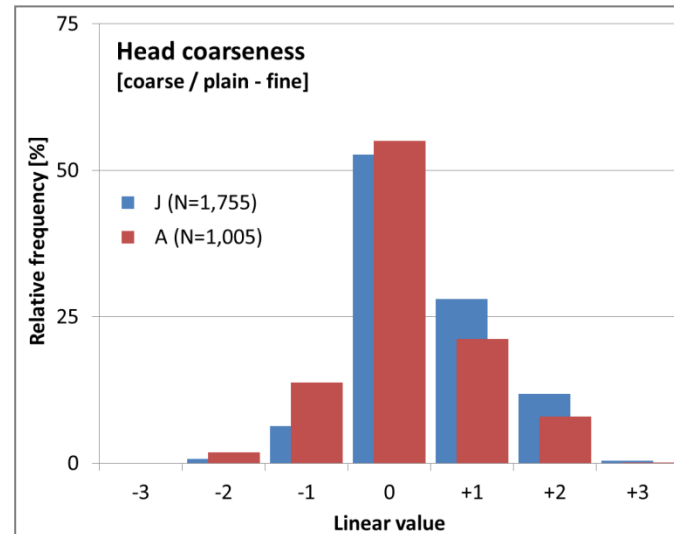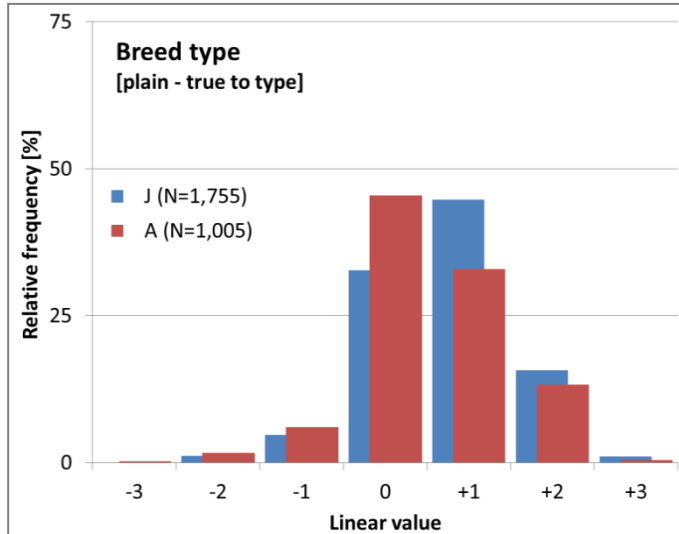
Breed type [plain - true to type]

Head coarseness [coarse / plain - fine]

Hock angulation [straight - angulated]

### Conformation traits (CONF; N_J=21, N_A=33)

Parameter	JUVENILE			ADULT		
	mean	min	max	mean	min	max
Mean	0.061	-0.164	+0.721	0.028	-0.137	+0.506
Std.	0.524	0.323	0.864	0.496	0.301	0.887
Variance	0.301	0.105	0.746	0.272	0.091	0.786

Distribution of linear traits (II)

Performance traits (HMOV, FMOV, RMOV; N_J=10, N_A=44)

| Parameter	JUVENILE			ADULT		
	mean	**min**	**max**	**mean**	**min**	**max**
Mean	0.140	-0.105	+0.544	0.109	-0.279	+0.495
Std.	0.638	0.337	0.924	0.697	0.340	1.043
Variance	0.440	0.113	0.854	0.523	0.115	1.088