IT-Solutions for
Animal Production

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Genetic trends for performance and functionality in specialized breeding programs of riding horses

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Session 33
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Outline

- specialization in sport horse breeding
- patterns of genetic trends in specialized breeding programs for riding horses
  - sources of information
  - results
- implications for sport horse breeding

Specialization in horse breeding

- development of breeding goals
  - from multi-purpose riding horse
  - to discipline-specific sport horse
  - ➢ distinct sections or programs of studbooks or studbook-wide (split / formation of new studbooks)
- narrowing of breeding goal = less traits relevant for selection
  - possible increase of breeding progress, potentially with higher risk of 'extreme breeding'
  - possible side effects on other traits (correlated selection responses)
  - ➢ monitoring: **performance-related and functional conformation traits**

Study approach

- active broodmares reflecting the two Oldenburg breeding populations specialized on dressage (D / OL) and jumping (J / OS)
- routine genetic evaluations → estimated breeding values (EBV)
  - EBV for sport traits from the national genetic evaluation for riding horses in Germany (FN)
    - rank-based → individual ranking among all starters
    - level-based → highest level achieved (lifetime summary)
    - ➢ dressage (DR, DL) and show-jumping (JR, JL)
  - EBV for linear conformation and performance traits from the genetic evaluation of the Oldenburg studbooks (OL+OS)

Routine genetic evaluation I


EBV for sport performance: dressage (D), show-jumping (J)

- sport data 1995-2021 (national /FN, international/FEI)
- 5.9m starts of 272k horses for D, 13.5m starts of 318k horses for J
- 2 traits per discipline: ranking (R) and highest level achieved (L)

single- / multiple-trait repeatability linear animal models:

$y_{ijklop} = \mu + COMP_i + SEX_j \times AGE_k + RIDER_l + animal_o + pe_o + e_{ijklop}$ (DR, JR)

$y_{jmnop} = \mu + Sex_j + L\_AGE_m + L\_YEAR_n + animal_o + e_{jmnop}$ (DL, JL)

fixed effects: COMP = individual competition, SEX = stallions / gelding / mare, AGE (L_AGE) = competition age (age at achieving highest level) in years, RIDER = rider category or individual rider, L_YEAR = year of achieving highest level; random effects: animal = additive genetic effect, pe = permanent environmental effect of the animal

- genetic trends in competition performance (competitiveness / success in sport as ultimate breeding goal)
  - OL: dressage → DR, DL
  - OS: show-jumping → JR, JL

Routine genetic evaluation II



EBV for linear traits (LIN-EBV)

- OL+OS linear data 2012-2021
- 31,332 linear profiles of 29,107 horses
- 46 traits: conformation, special remarks, gaits, jumping

single- / multiple-trait repeatability linear animal models:

$y_{ijknop} = \mu + SB_i + EVENT\text{-}TEAM_j + AGE\_M_k + SEX_l + animal_o + e_{ijklop}$ (foals)

$y_{ijmnop} = \mu + SB_i + EVENT\text{-}TEAM_j + AGE\_Y_m + PTYPE_n + animal_o + pe_o + e_{ijmnop}$ (adults)

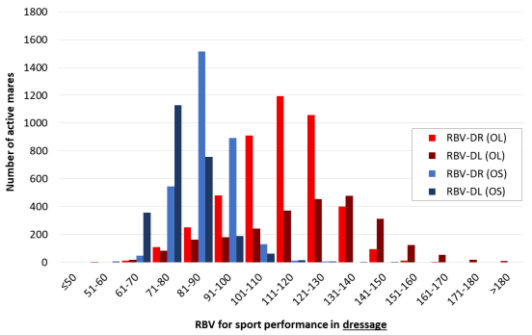
fixed effects: SB = studbook (OL, OS), EVENT-TEAM = date, place, assessor, assistance, SEX = male / female, AGE_M (AGE_Y) = age in months (years), PTYPE = presentation type (assessment in hand, free, under rider); random effects: animal = additive genetic effect, pe = permanent environmental effect of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

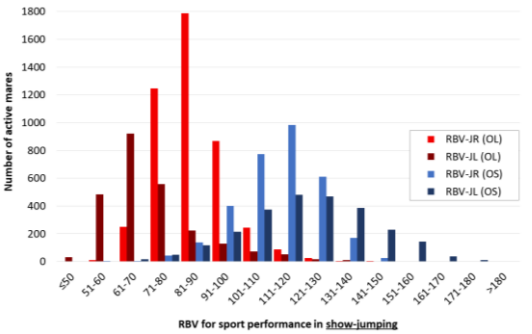
- genetic trends in distinct aspects of conformation and performance
  - functionality vs. 'side effects' of performance-oriented selection
  - basic abilities to perform (successfully)

Data basis

- performance in sport competitions:
  7,751 mares with sport EBV (N_{OL} = 4,531, N_{OS} = 3,220)
- linear conformation, gaits, special remarks, jumping:
  14,278 mares with LIN-EBV (N_{OL} = 9,713, N_{OS} = 4,565)
- genetic trends: course of average genetic potential over time
  - reference to relative breeding values (RBVs; mean 100, std 20)
  - minimum reliability of considered EBVs
    → information basis in the respective genetic evaluation from 2021
  - inclusion criteria for mares: own performance and/or at least 2 offspring
    (N_{sportD} ≈ 1,600, N_{sportJ} ≈ 2,000, N_{LIN-D} = 9,243, N_{LIN-J} = 4,346)

Specialized breeding programs (OL, OS)

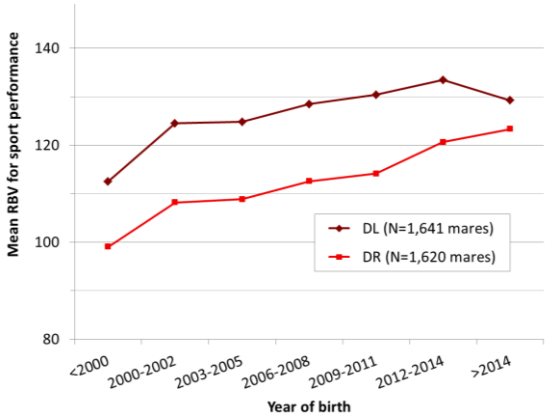


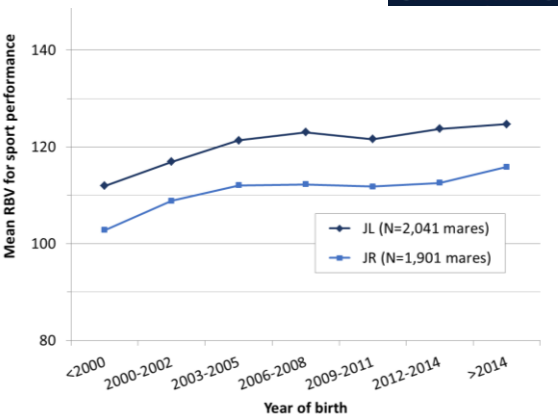


Sport trait	OL (dressage)			OS (jumping)		
	n	mean	std	n	mean	std
DR	4,527	113.4	15.2	3,151	87.3	8.0
DL	2,503	122.6	22.4	2,533	79.9	9.8
JR	4,527	85.5	11.0	3,151	111.7	13.0
JL	2,503	71.8	15.3	2,533	120.8	20.3

distribution patterns of RBVs for sport traits:
➢ **clearly different genetic levels regarding the target sport traits in the specialized mare populations of OL / dressage** (red) **and OS / jumping** (blue)

Genetic trends: sport traits





- **substantial genetic improvement for the target sport traits in the specialized mare populations, i.e. OL / dressage and OS / jumping** (+ 13 to 24 points)

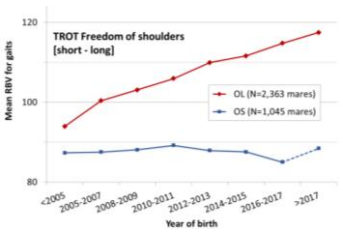
Genetic trends: linear traits (overview)

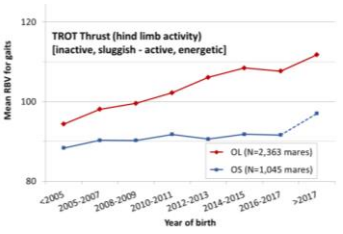
Linear trait	gen. trend OL	gen. trend OS
Breed type [plain - true to type]	***	***
Gender expression [weak - strong]	***	***
Frame [small-framed - large-framed]	***	***
Caliber [light - heavy]	***	n.s.
Length of legs [short-legged - long-legged]	***	***
Head shape [coarse - fine]	***	***
Eye size [small - large]	n.s.	n.s.
Set of neck [low - high]	***	*
Muscling area of neck [ewe-necked - top line dom. neck]	n.s.	n.s.
Shape of neck [straight - arched]	***	n.s.
Length of withers [short - long]	+	*
Height of withers [flat - high]	***	***
Length of back [short - long]	***	n.s.
Line (strength) of back [dipped - roached]	***	n.s.
Line (strength) of loins [dipped (weak) - roached]	n.s.	+
Angle (inclination) of croup [flat (level) - sloping]	***	n.s.
Set of tail [low - high]	***	+
Length of forelimb pastern [short - long]	***	***
Stance of forelimb pastern [upright - sloping (weak)]	n.s.	n.s.
Stance of hind limb pastern [upright - weak]	*	n.s.
Hock angulation [straight - angulated]	n.s.	***
Size of joints [small - big]	***	+
Toe stance of forelegs [toe-in - toe-out]	n.s.	n.s.
Tail tone [un-toned - over-toned]	n.s.	*

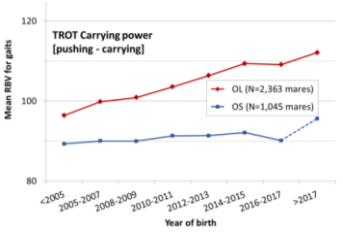
	Linear trait	gen. trend OL	gen. trend OS
Walk	Freedom of shoulders [short - long]	***	***
	Reach of HL (overstepping) [inactive (short) - active (long)]	***	n.s.
Trot	Freedom of shoulders [short - long]	***	n.s.
	Mechanics of FL [straight forelimb - much knee action]	***	+
	Impulsion [weak - powerful]	***	**
	Thrust (HL activity) [inactive, sluggish - active, energetic]	***	**
	Carrying power [pushing - carrying]	***	**
	Suppleness [tense - supple]	***	**
Canter	Freedom of shoulders [short - long]	***	***
	Mechanics of FL [straight forelimb - much knee action]	***	n.s.
	Direction of movement [downhill - uphill]	***	n.s.
	Thrust (HL activity) [inactive, sluggish - active, energetic]	***	**
Jumping	Rhythm [not fluent - fluent]	n.s.	***
	Take-off power [weak - powerful]	***	***
	Reflexes [slow, inflexible - quick, flexible]	***	***
	Attention [inattentive - attentive]	***	***
	Overview [little - much]	***	***
	Jumping ability [little scope - much scope]	***	***
	Foreleg angulation [straight - angulated]	***	n.s.
	Uneven forelegs [markedly uneven]	***	*
	Back technique (bascule) [hollow back - rounded back]	***	***
	HL technique (haunches) [tight (under the body) - long HL]	***	n.s.

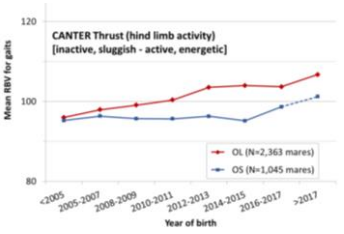
+ P < 0.1, * P < 0.05, ** P < 0.01, *** P <0.001

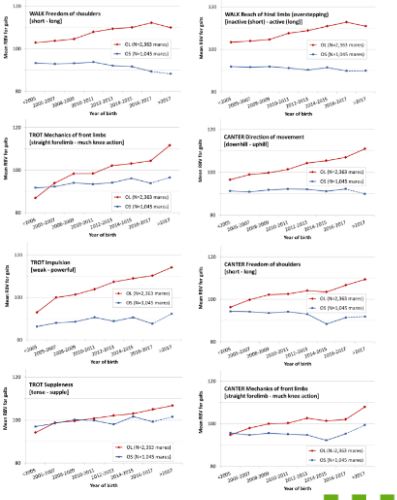
Genetic trends: gaits











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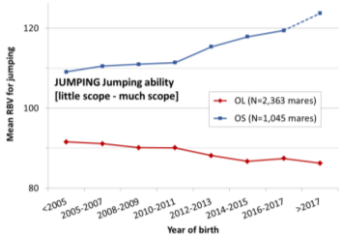
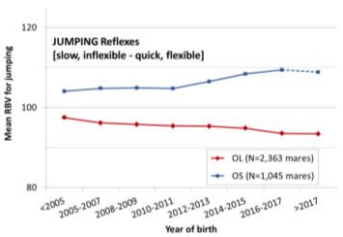
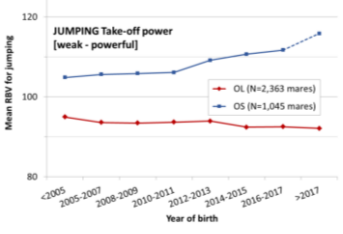
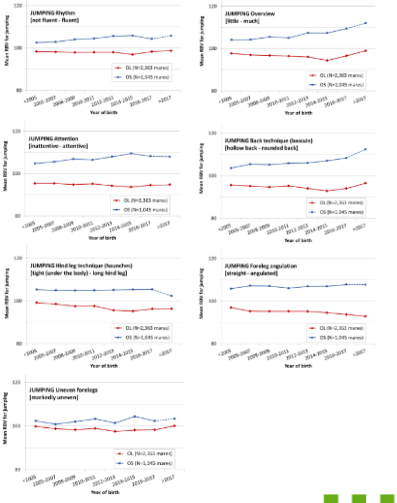
Genetic trends: jumping









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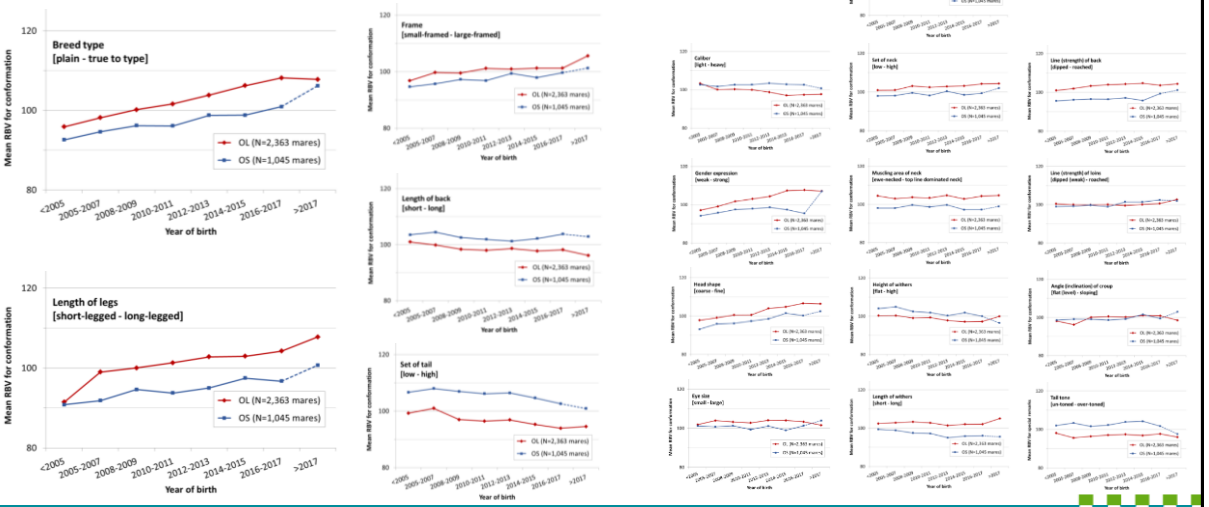
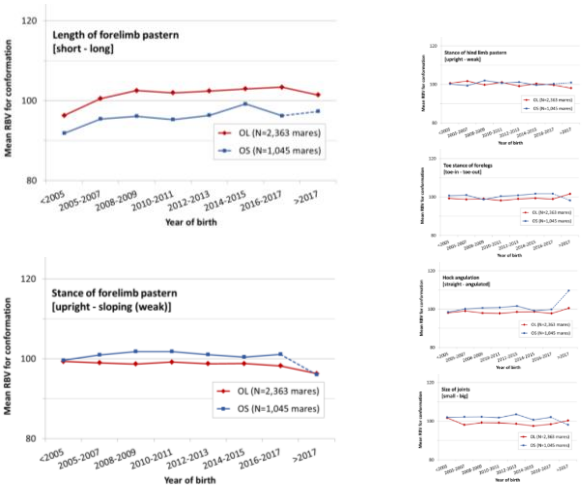
Genetic trends: conformation I



Genetic trends: conformation II



to be considered for data interpretation:

- more / less challenging groups of linear traits
  → impact also on analyses of genetic trends
- genetic correlations between linear traits
  → impact on the pattern of genetic trends

Summary of results & discussion I

- specialization facilitating genetic progress in sport horse breeding: discipline D or J → different genetic levels of active mare populations
- consistent patterns of genetic trends in different subsets of mares
  - inclusion criteria (own and/or progeny performance)
  - 'own' and 'foreign' mares declared as active OL/OS vs. only 'own' mares
- substantial genetic improvement for the target sport traits in the specialized mare populations, i.e. OL / dressage and OS / jumping
  - + 13 to 24 points = 0.6 to 1.2 genetic standard deviations in ~15 years
  - steeper genetic trend in D than in J (birth years: 88-95% 2000-2016)

Summary of results & discussion II

- refined analyses and monitoring using information on distinct aspects of performance and conformation available through linear description
  - in D pronounced genetic development towards more expressive gaits, but also more power from behind and balance
  - in J most obvious genetic progress in scope, followed by take-off power; heterogeneous development of gait quality (W ↓, T =/↑, C ↑)
  - significant, but no extreme developments in conformation
    - D: larger frame, longer legs, shorter back and lower set tail
    - J: larger frame and lighter caliber
  - minor genetic trends in several functionally relevant traits (neck, limbs)

Implications

- specialization facilitating discipline-specific improvements of key traits for competitiveness in sport
- increased responsibility to monitor overall development of the specialized populations
- ➢ importance of covering a wider range of traits than directly related to the breeding focus → possible correlated selection responses
- ➢ 'high-resolution phenotyping' via comprehensive linear description as valuable source of information (genetic and genomic applications) also in the light of sustainable breed management

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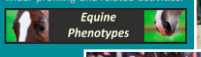
Further information on linear profiling and related activities:



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Thank you !