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Animal Production

OLDENBURGER BREEDING & SPORT

Horse Evaluation Webinar / EquiMais on 4 June 2021:
'Importance of the morpho-functional evaluation in the genetic improvement of horses'

Equine genetic evaluation with special emphasis on linear description

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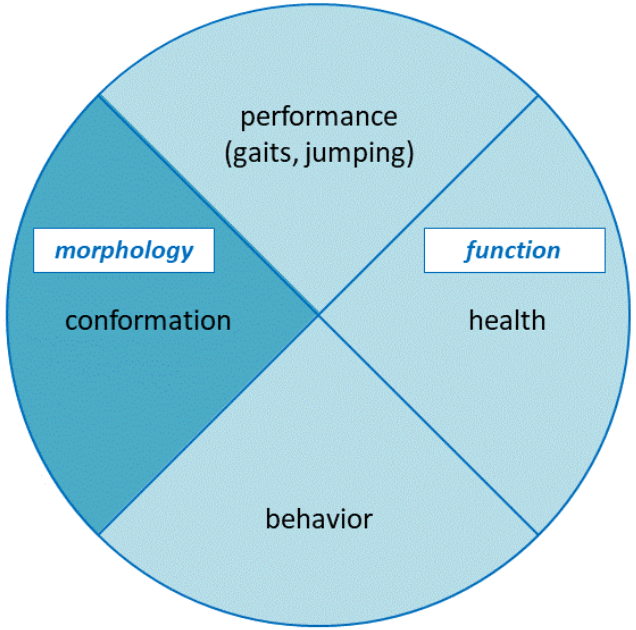
Outline

- breeding goals and breeding programs of sport horses
  - data recording
  - data analyses (incl. genetic evaluation)
- routine linear profiling and genetic evaluation for linear traits
  - advances and challenges for horse breeding
  - data structure, traits and modelling
  - role of genetic linear profiles
- implications for breeding applications

Breeding goals of sport horses

- centered on performance under saddle
- different aspects (interactions)
- meeting the needs of the equine sector
  - specialists rather than generalists
  - internationally competitive horses
  - for professional and amateur riders
  - from top sport to leisure riding

➢ more diverse and more challenging settings than in other livestock species



Breeding programs & data recording

- systematic data recording as basic requirement in animal breeding
- the earlier and the more reliable the data recording,
  the better the chances of lasting success of breeding programs
- clear target definition as key factor for success (= breeding progress)
  - direct measures of breeding goal traits,
    e.g. competition performance on highest level, lifetime performance,
    placings in dressage competitions, ranking points in show jumping competitions
  - indirect measures (indicator traits)
    e.g. quality of gaits, jumping ability and style, functionally important conformational aspects,
    absence of radiographic findings of presumed clinical relevance

Data analysis & use: general aspects

- **high quality data recording** as important first step to be followed by steps of data processing, data analyses, results presentation and use
- influences on the value of the outcome for breeding applications:
  - evaluated sample of horses
    (age, representative of the population)
  - evaluation method
    (information value, reliability, objectivity, proximity to the breeding goal)
  - data distribution and modelling
    (phenotypic variability, reflected differences between individual horses)
  - transparency and overall acceptance of the system
    (trust in the whole system from data recording to selection support tools)

Data analysis & use: specific aspects

- **high quality data recording** as important first step to be followed by steps of data processing, data analyses, results presentation and use
- framework of equine breeding applications:
  - very different types of breeders → challenging job of studbooks
    (heterogeneous target group with wide range of background, knowledge, ambitions)
  - often emotional rather than rational decision making
  - common skepticism towards more sophisticated analyses (departure from phenotypes) → difficult stand and limited use of breeding values

Genetic evaluations for sport horses

- based on <u>two main sources of data</u>
  - routine assessments of studbooks
    - registration, studbook entry, performance test
    - traditionally valuating scores, increasingly linear profiles
  - sport data
    - incl. young horse competitions (valuating scores)
    - from regional to national, increasingly international
- PROs and CONs
  - data quality, information value (specificity of traits), preselection bias
  - proximity to the breeding goal

Genetic evaluations for sport horses II

- in Germany <u>two types of genetic evaluations</u>:

  (1) national genetic evaluation for riding horses (FN-ZWS)
  - across studbooks
  - sport traits (rank-based and highest level achieved) and young horse traits (valuating scores)
  - dressage and show-jumping

  ➢ breeding values for 12 individual traits + 2 young horse indices

  ➢ positive feedback to the two newly introduced traits (since 2019), HEK Dressage and HEK Jumping, reflecting the 'ultimate breeding goal'
  → major disadvantage: late availability of the definite phenotype

Genetic evaluations for sport horses II

- in Germany <u>two types of genetic evaluations</u>:
  - **(1) national genetic evaluation for riding horses (FN-ZWS)**
  - **(2) supplementary genetic evaluations**
    - within studbook
    - conformation and performance (gaits, jumping)
    - different basis: valuating scores (HANN, HOL, TRAK, DSP / BrbA) or linear profiles (OL/OS); mostly young horses ≥ 2 ½ years of age (mares, stallions +/-, geldings +/-), sometimes also foals
  - ➢ different portfolios of breeding values and indices (per studbook)
  - ➢ optimum conditions to be best fit solution for respective breeders

Horse evaluation: requirements

- data recording: informative evaluation criteria
  - clearly and unambiguously defined — *objective*
  - comparable, repeatable (under field conditions) — *precise*
  - informative (individual horse, population) — *specific*
  - breeding goal related, early assessable — *decision-relevant*
- preconditions for data use in breeding:
  reliable measure or indicator of underlying genetics

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traditional valuating scoring
- judgement relative to the breeding goal
- subjective scoring scale
  'very bad' (1) to 'excellent' (10)

linear description (linear profiling)
- assessment relative to biological extremes
- linear scale independent from optimum expression
  (e.g.. 'very short' to 'very long', 'very low' to 'very high')

Horse evaluation: requirements II

strong in type, much gender expression,
noble head, high-set neck, ...,
trot with much knee action, energetic,
very supple, with active hind limbs, ...

overall score of
8.0 or 8.5 or ...?

objective
precise
specific
decision-relevant

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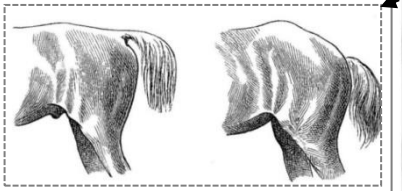
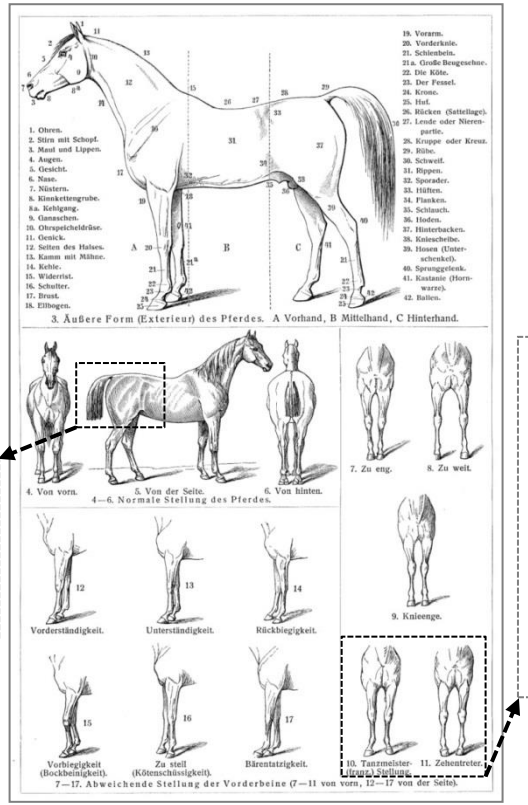
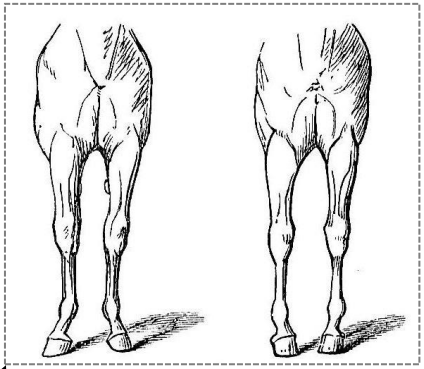
Horse evaluation: requirements III







description of specific aspects
as basic principle of horse evaluation
→ linear description (or linear profiling)
as practice-proven way to do it systematically

source: Meyers Großes Konversations-Lexikon (Band 15), Leipzig 1908.

Linear description: motivation & start

- new role of phenotyping and data-based decision support
  - need of specific information for targeted breeding work
  - advanced methodology requiring high quality data
- ➢ **interest in genomic selection / genomic applications in horses increasing awareness of the importance of horse evaluation**
- obvious limitations of the traditional valuating scoring system vs. long-known advantages of linear recording systems
- ➢ **science-to-practice / practice-to-science initiative to implement linear profiling in sport horse breeding**

Linear profiling in Oldenburg (OL, OS)

2012 → **2013** → **2014**

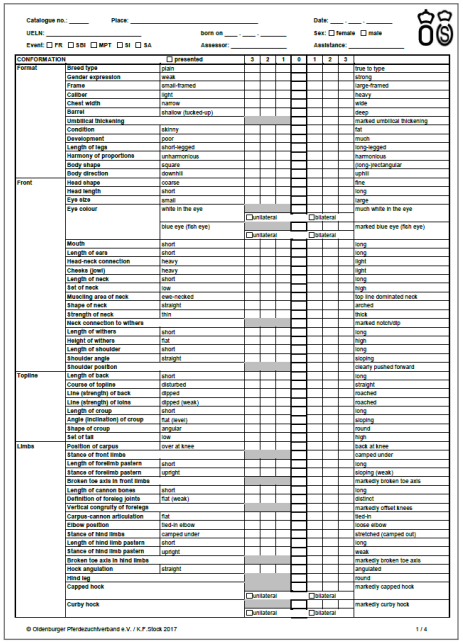
pilot phase I
(selected events, dates, teams)

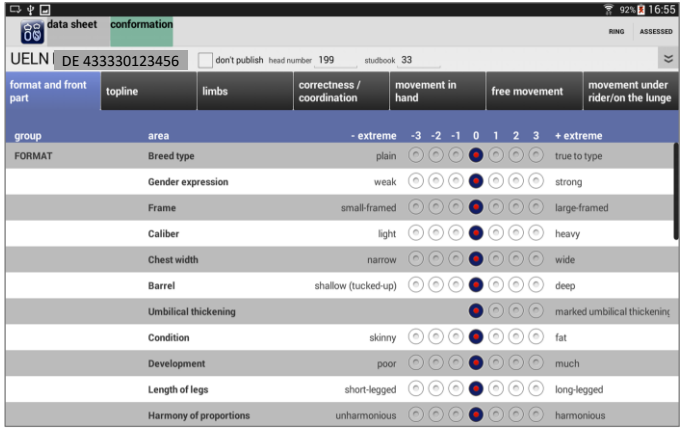
pilot phase II
(broad testing)

(A) development and implementation

- pilot studies related to research projects
  (extra staff for testing and optimizing the system, first data screening)
- application-oriented project work

→ **sound basis for broad implementation**





Linear profiling in Oldenburg (OL, OS) II

2012 2013 2014 2015 2016 2017 2018

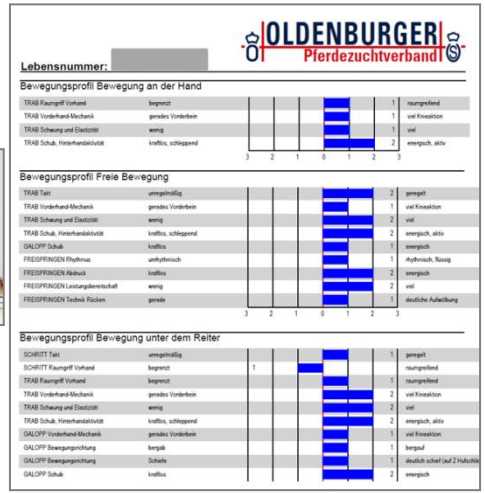
pilot phase I
(selected events, dates, teams)

pilot phase II
(broad testing)

routine application of linear profiling

individual linear profiles (phenotypic profiles; foals, mares)

genetic profiles (stallions)



(B) routine and extension

- monitoring of linear data collection and data quality management
  - quality and coverage of the linear scheme (lacking traits?)
  - use of traits and scale, internal consistency of linear data, ...
    (unclear definitions? topics for training sessions and technical meetings)
- consolidation and improvement of applications

→ **smooth transition** to new routine applications (acceptance↑)
→ **improved services** for the studbooks and for individual breeders

Linear profiling in Oldenburg (OL, OS)

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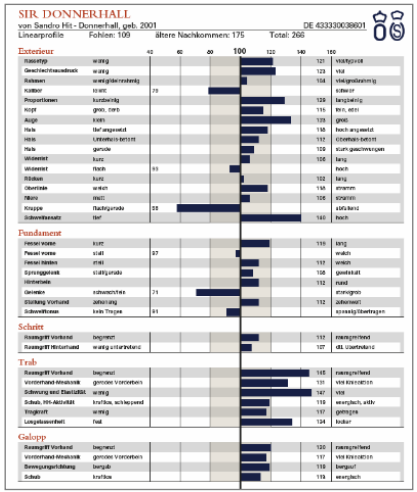

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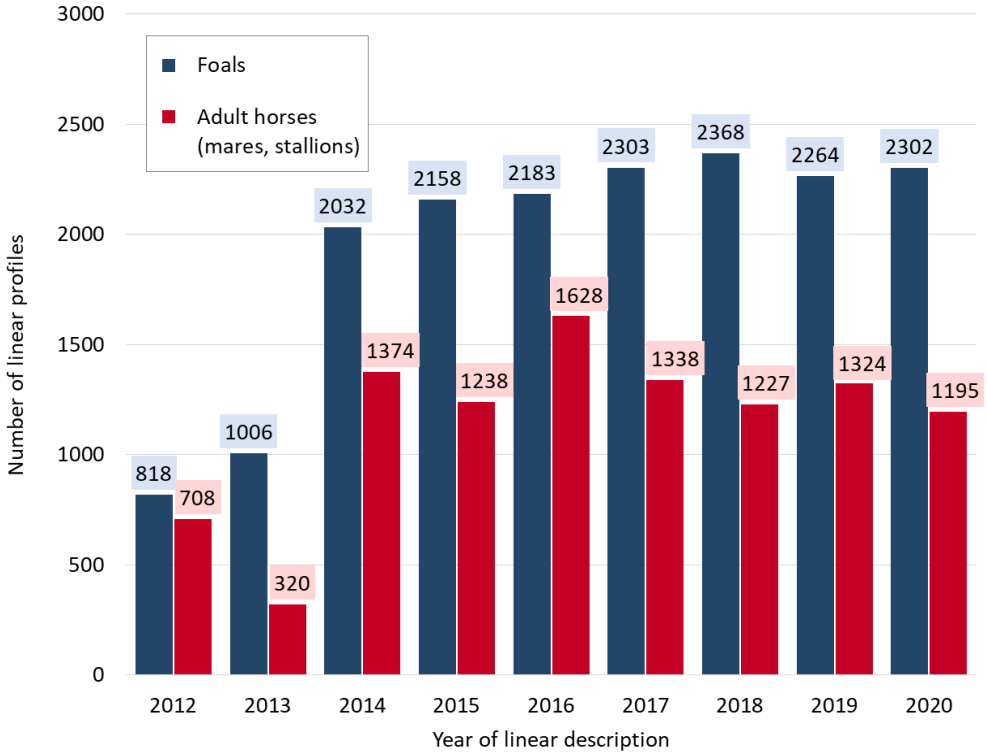
Determinants of the development

- **close collaboration of science and practice**
  as key to fast progress and successful implementation
  - smooth transition from R&D to routine
  - transparency and exchange, flexibility of applications
    → acceptance and use
- **early use of linear data** as important driver of innovation
  - continued engagement for optimization of the whole system (data quality management)
  - high motivation of maximize information output (internal use → publication of consolidated information)

Linear data basis 2012 - 2020

- Oldenburg linear scheme (OL, OS)
  - conformation and performance (gaits, jumping, behavior)
  - 7-point numeric linear scale (-3 to +3)
    defect traits / remarks: reduced scale (0 to +3)
  - foals, mares, stallions
    (registration, studbook inspection, mare performance test, preselection for licensing, selected young horse competitions)
- extension of linear data collection (routine)
  - most/all events since 2015 in Germany and abroad
  - kernel team of experienced assessors
- **in total N=27,786 linear profiles of 26,069 horses**

Distribution of linear data



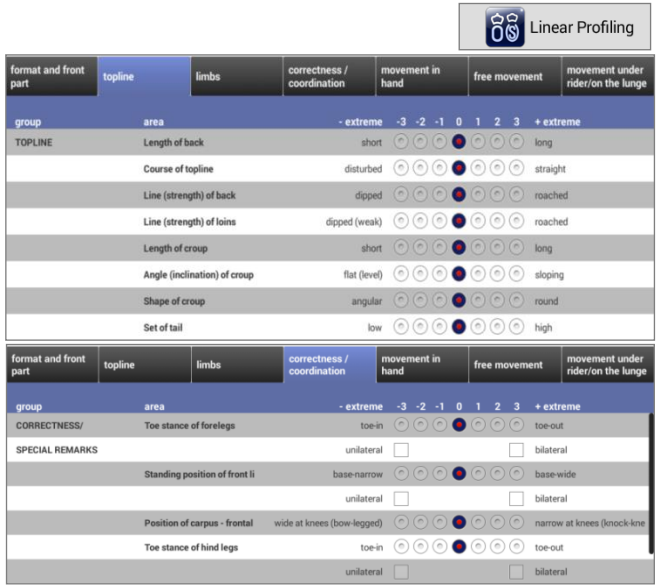
- 27,786 linear profiles
  (foals : adult horse ≈ 2 : 1)
- 26,069 horses
  incl. 1,608 horses linearly described as foal and adult horse
- 2868 sires
  incl. 800 sires with linearly described foals and adult horses (progeny in both age groups)

➢ **optimum use of linear data across age groups**

Data collection → Genetic analyses

- mobile data collection (tablet PC) making it possible to:
  - efficiently collect detailed linear data
    (active input of deviations only)
  - routinely work with refined trait definitions and comprehensive linear schema
    (basis of highly valued individual assessment reports, considerable potential for research)
  - directly use maximal information from routine assessments

➢ **standardized detailed information on: conformation, gaits, jumping, behavior**



Genetic analyses

- trait definition
  within age group and trait category

- <u>selected linear traits</u>
  (standard deviation, variance, kurtosis)
  - estimation of genetic parameters
  - genetic evaluation
    = prediction of breeding values

Trait category	No. of traits	
	recorded	gen. eval.
Conformation	73	23
Walk (H, F, R)	6	2
Trot (H, F, R)	11	6
Canter (F, R)	10	4
Jumping (F)	16	10
Special remarks (H, F, R)	8	1
Behavior (H, F, R)	7	0

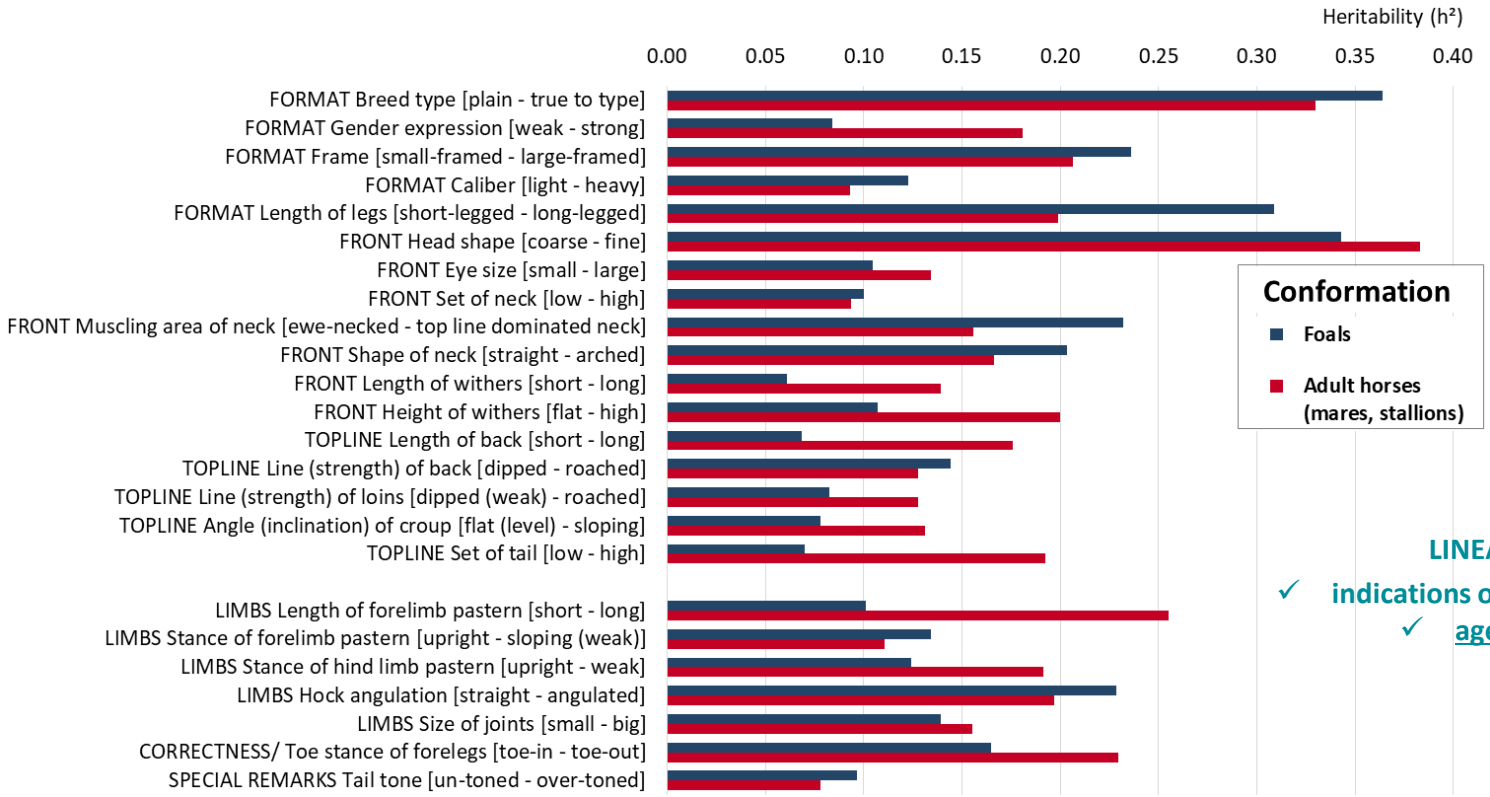
H = in hand, F = free, R = under rider

- single- and multiple-trait linear animal models

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

mares+stallions: $y_{ijmnop} = \mu + SB_i + EVENT\text{-}TEAM_j + AGE\_J_m + PTYPE_n + animal_o + pe_o + e_{ijmnop}$

Conformation: heritabilities

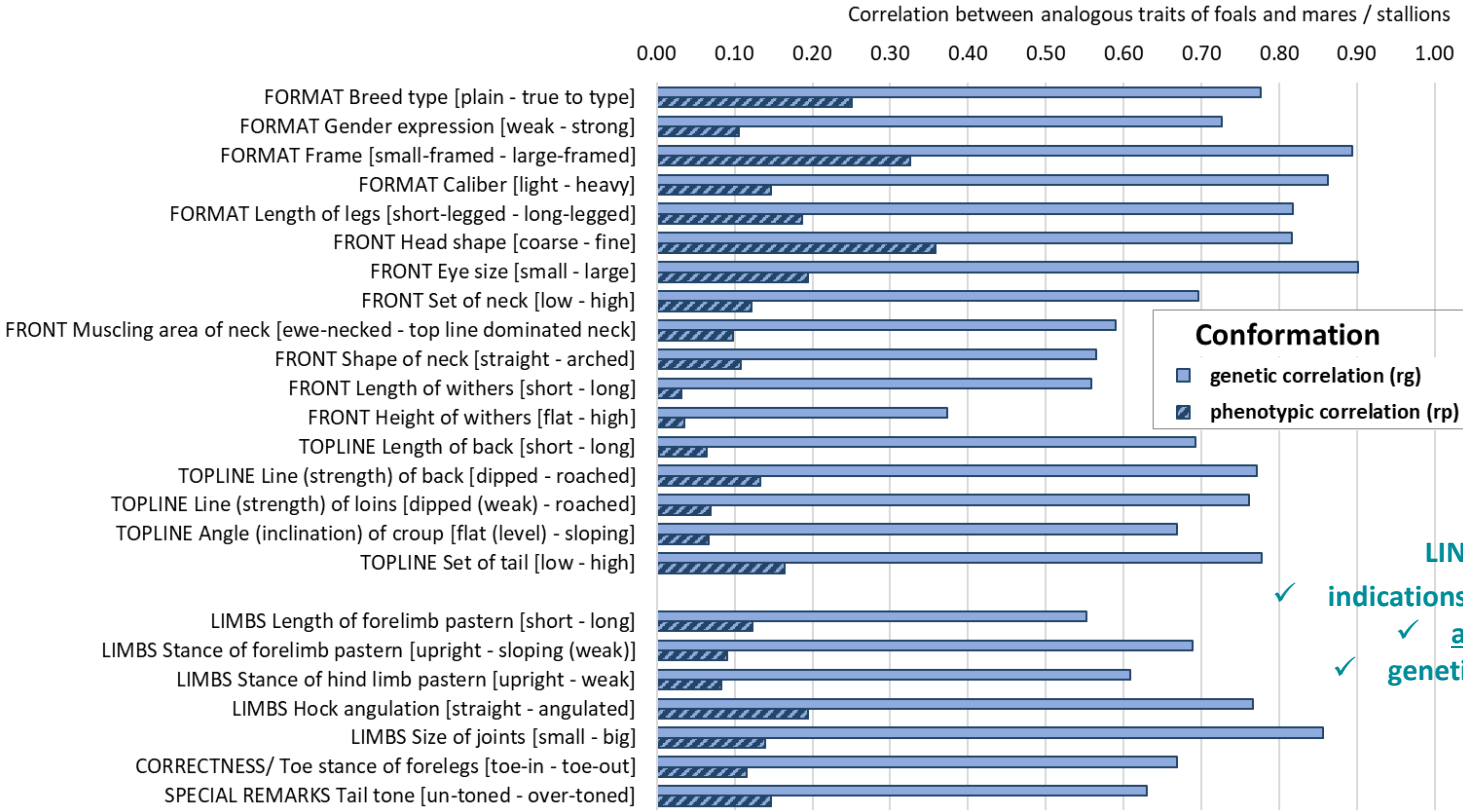


average (min-max) h^2:
0.15 (0.06-0.36) in foals,
0.18 (0.08-0.38) in adults

LINEAR CONFORMATION TRAITS

- ✓ **indications of significant role of genetics**
- ✓ **age groups: similar h^2 patterns**

Conformation: correlations

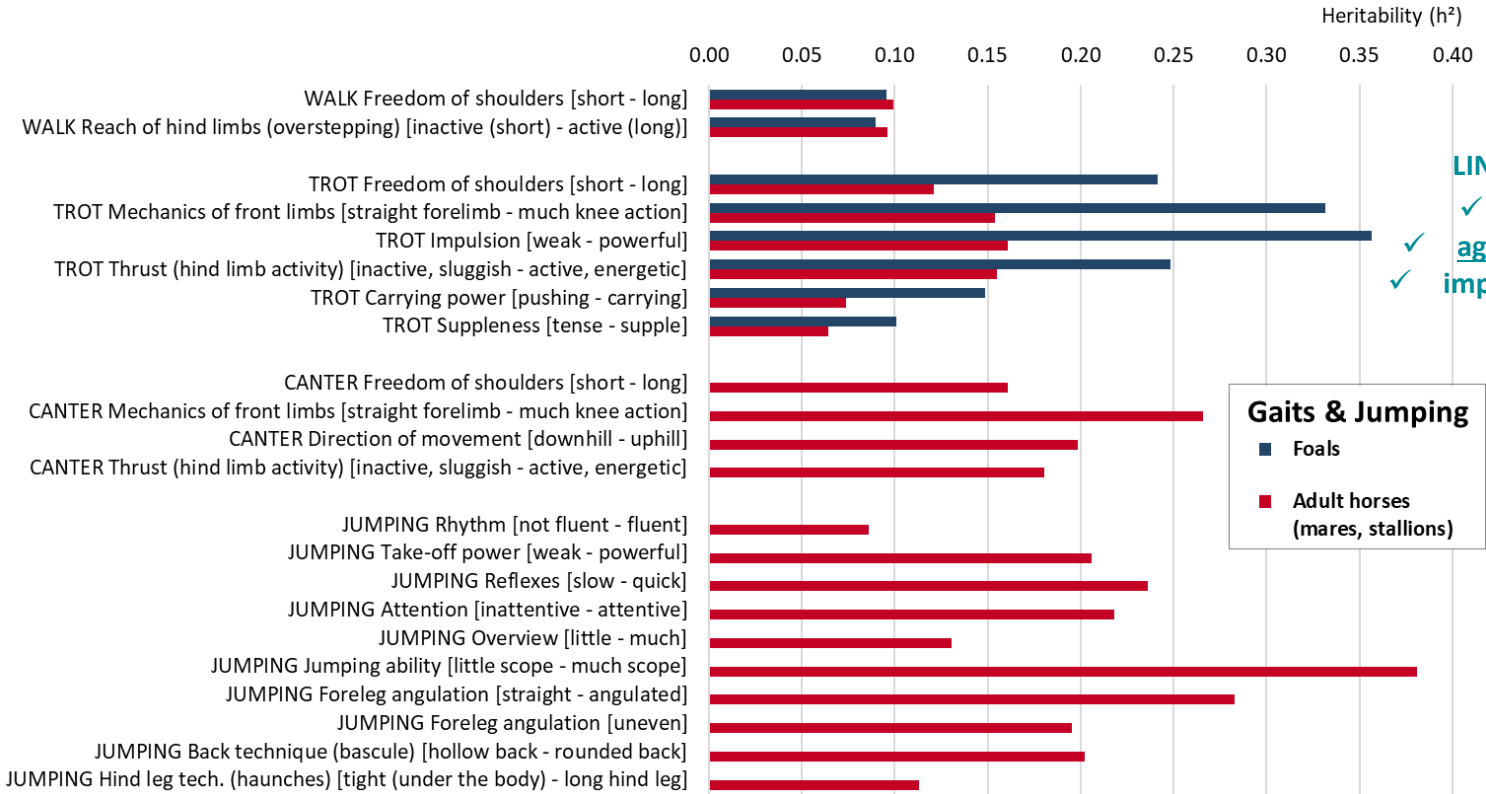


average (min-max) correlations:
r_g = 0.71 (0.37-0.90),
r_p = 0.14 (0.03-0.36)

LINEAR CONFORMATION TRAITS

- ✓ **indications of significant role of genetics**
- ✓ **<u>age groups:</u> similar h^2 patterns**
- ✓ **genetic similarity across age groups (pairs of analogous traits)**

Performance: heritability

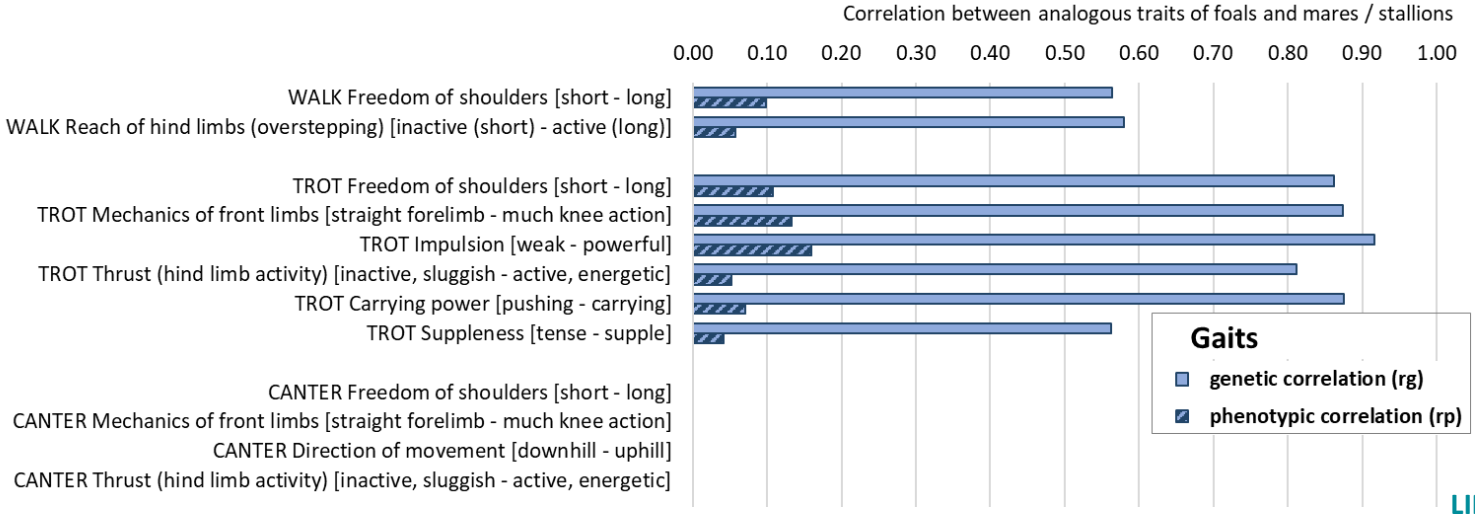


LINEAR PERFORMANCE TRAITS

- ✓ important role of genetics
- ✓ age groups: similar h² patterns
- ✓ impact of evaluation conditions (information density)

average (min-max) h²:
0.20 (0.09-0.36) in foals,
0.17 (0.06-0.38) in adults

Performance: correlations



average (min-max) correlations:
r_g = 0.76 (0.56-0.92),
r_p = 0.09 (0.04-0.16)

LINEAR PERFORMANCE TRAITS

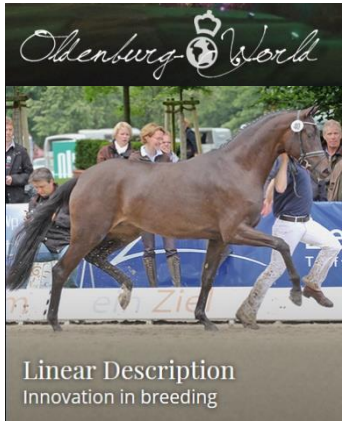
- ✓ important role of genetics
- ✓ age groups: similar h^2 patterns
- ✓ impact of evaluation conditions (information density)
- ✓ genetic similarity across age groups (pairs of analogous traits)

Data structure & modelling

- results of multivariate estimation of genetic parameters indicating
  - similar patterns of heritabilities (linear aspects with higher/lower h^2)
  - genetic similarity across age groups (pairs of analogous traits)
  - genetic similarity across presentation types (adult horses / different conditions)
- multiple-trait repeatability linear animal model (pairs of traits)
- **high value of linear foal data (broad basis, early prediction)!** ✓

Genetic evaluation: development

- 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: phenotypic linear profiles of individual horses



Linear data basis in the Oldenburg studbooks (OL, OS)

- ✓ since 2012 (end of 2020: 27,786 linear profiles of 20,069 horses)
- ✓ conformation and performance (movement, jumping)
- ✓ same linear scheme and 7-point numeric linear scale (-3 to +3) for all horses, i.e. across age groups

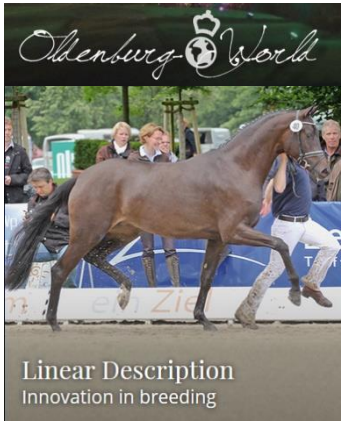
Genetic evaluation: development II

- implementation of linear systems for riding horses
- extension of <u>breeding applications based on linear profiling</u>
  - clearly distinct set of traits (descriptive)
  - potentially powerful tool for breeders

Routine genetic evaluation for linear traits in the Oldenburg studbooks (OL, OS)

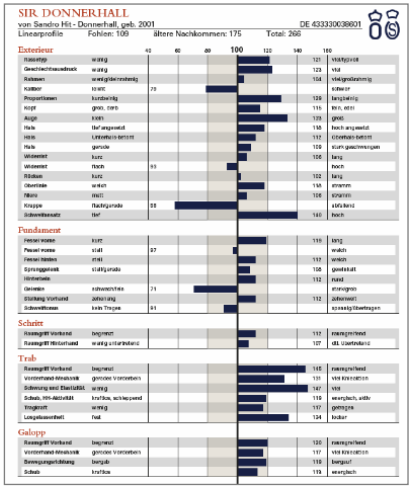
✓ since 2017, annually in October / November

✓ conformation and performance (46 traits)



Genetic linear profiles: content

- relative breeding values
  - mean of 100, genetic standard deviation of 20
    (orientation as in the linear scheme)
  - base definition: sires born after 1994
    with at least 3 linearly described adult progeny
    (GE 2020: N=527 sires)



- genetic stallion profiles: two groups

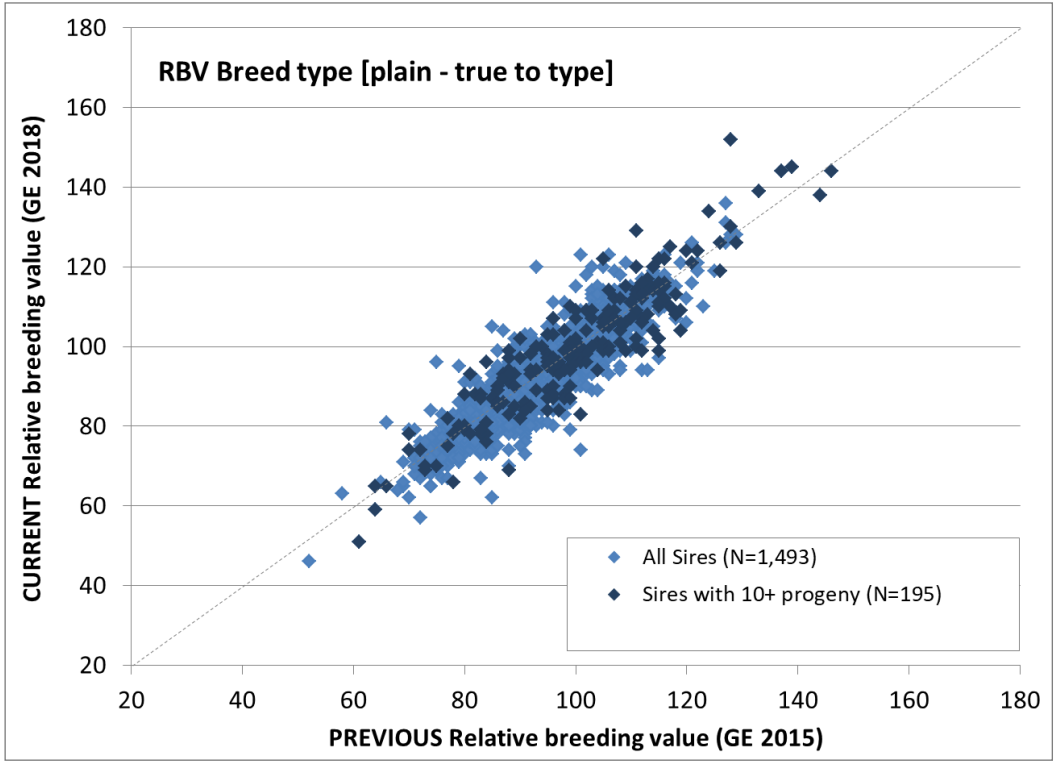
(1) frequently used sires (≥ 20 linearly described progeny; age ≥ 7 years)
→ index as weighted combination of EBV: 40% EBV_{Foal} + 60% EBV_{Adult}

(2) young sires (maximum age of 6 years, minimum of 8 foals)
→ EBV for linear traits in foals, i.e. EBV_{Foal}

Genetic linear profiles: use

- expectations?
  - reliable 'filtering out' of genetic dispositions
    (better than phenotype-based progeny statistics)
  - earlier, more objective and more helpful information for breeders
- concrete questions?
  - Can we use genetic profiles of young stallions with
    few linearly described foals (first crop) for support of mating decisions?
  - Will the genetic linear profiles change over time? If so, how much?
  - Can we predict the progeny phenotypes by the genetic linear profiles
    of their fathers? How well?

Changes over time? Example I



Explanation:

comparison of results from GE test run with truncated data (GE 2015) with regular GE run using all data (GE 2018) for:

- all sires with progeny already in GE 2015 (on average only 6 progeny)
- sires with more reliable EBV (10 or more progeny already in GE 2015)

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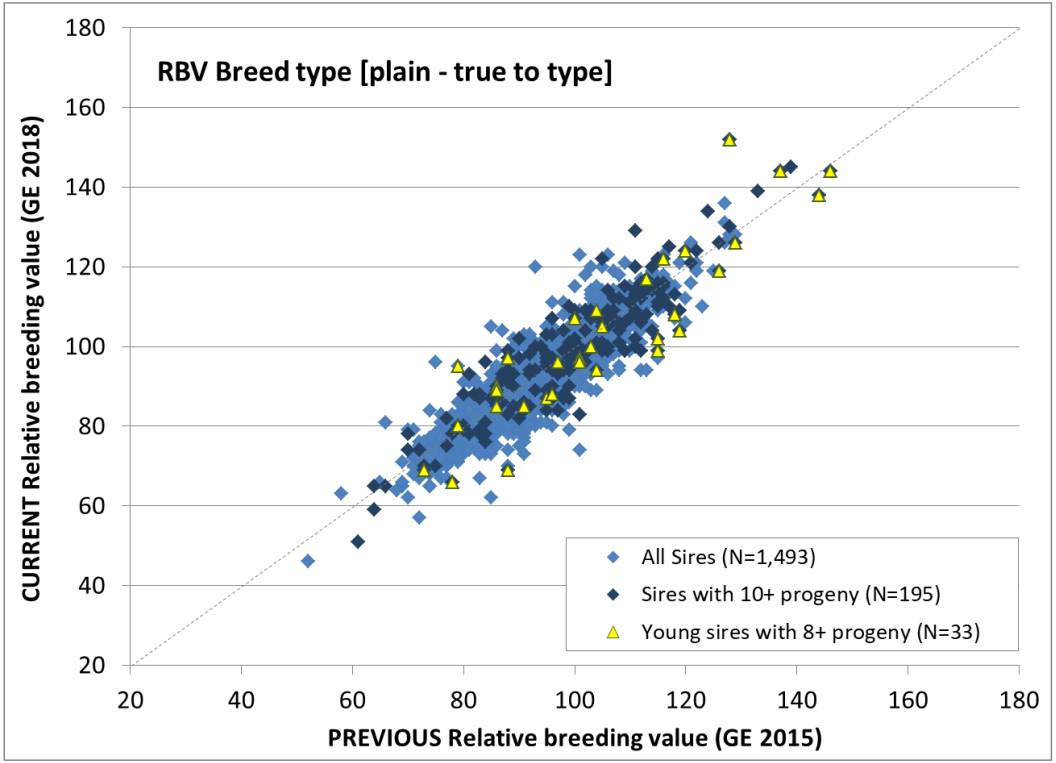

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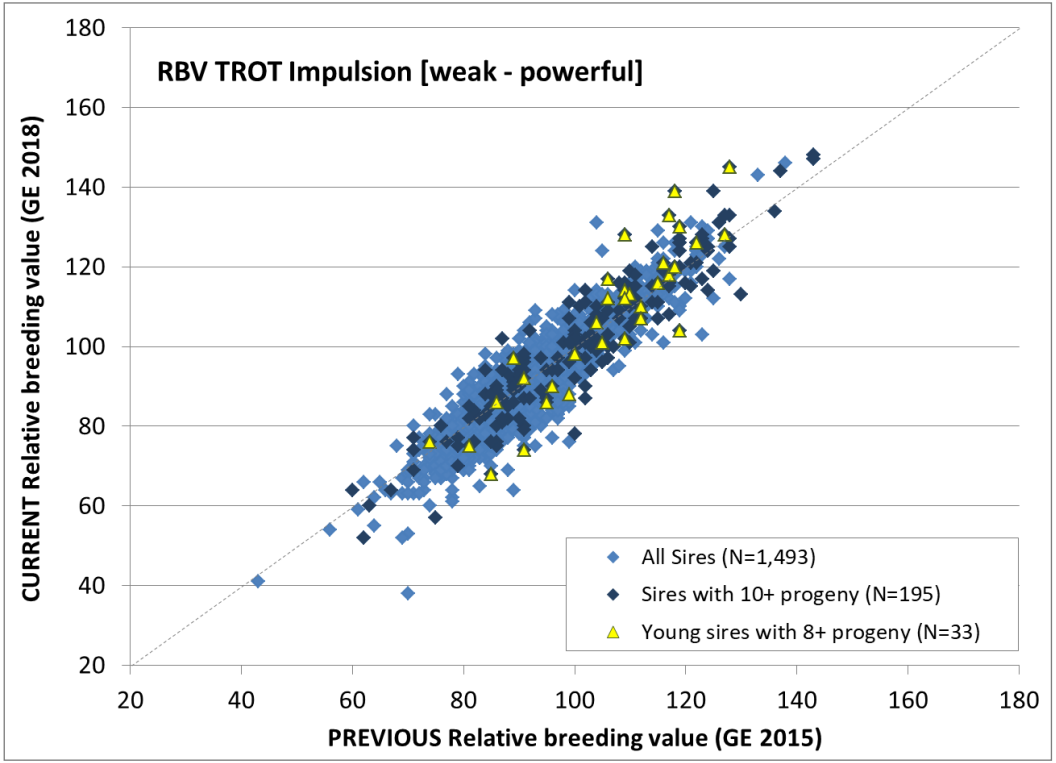
- young sires (max. age of 6 years) in GE 2015

Changes over time? Example II



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- young sires (max. age of 6 years) in GE 2015

Study answers to breeders' questions

- *Can we use genetic profiles of young stallions with few linearly described foals (first crop) for support of mating decisions?* ***YES – they are valuable early indicators.***
- *Will the genetic linear profiles change over time? If so, how much?*
  YES – changes are possible and expected, can be substantial.
  more progeny with linear data → reliability of breeding values ↑ → changes ↓
- *Can we predict the progeny phenotypes by the genetic linear profiles of their fathers? How well?*
  YES – prediction is possible, advanced use of linear data implies continuous improvement.

- support of expectations regarding linear profiling
  - reliable 'filtering out' of genetic dispositions (better than phenotype-based progeny statistics)
  - earlier, more objective and more helpful information for breeders

Conclusions & perspectives

- successful routine implementation of linear profiling as important step towards more sustainable competitive breeding
  - substantial gain in information on conformation and performance
  - increased transparency
  - feasible tool for collection of high quality phenotypic data required to benefit from more targeted breeding applications

➢ **to be accompanied by continuous data quality management for optimum use of linear description**

Conclusions & perspectives II

- successful routine implementation of linear profiling
  as important step towards more sustainable competitive breeding
- high value of refined linear phenotypes
  - specific individual characterization (linear profiles of presented horses)
  - improved genetic characterization (genetic stallion profiles)
  - appropriate basis of future genomic applications (genomic profiles)

➢ **engagement for linear profiling = investment in the future**

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Further information on
linear profiling and related activities:

Equine Phenotypes

TAKE HOME:

- **engagement for linear profiling = investment in the future**
- new and improved phenotypes as suitable targets for new and improved breeding applications
- collaborative approaches to capture the full potential using genetic and genomic tools

Thank you !