Genetic of the 3D morphology of jumping horses using geometric morphometrics

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Objective

- Large project which aimed at measuring **morphology** and **gaits** of **jumping** sport horses and at genotyping them.

- This presentation :
  - Objective measurement of morphology
  - Heritability and genetic relationship of morphology with jumping in competition

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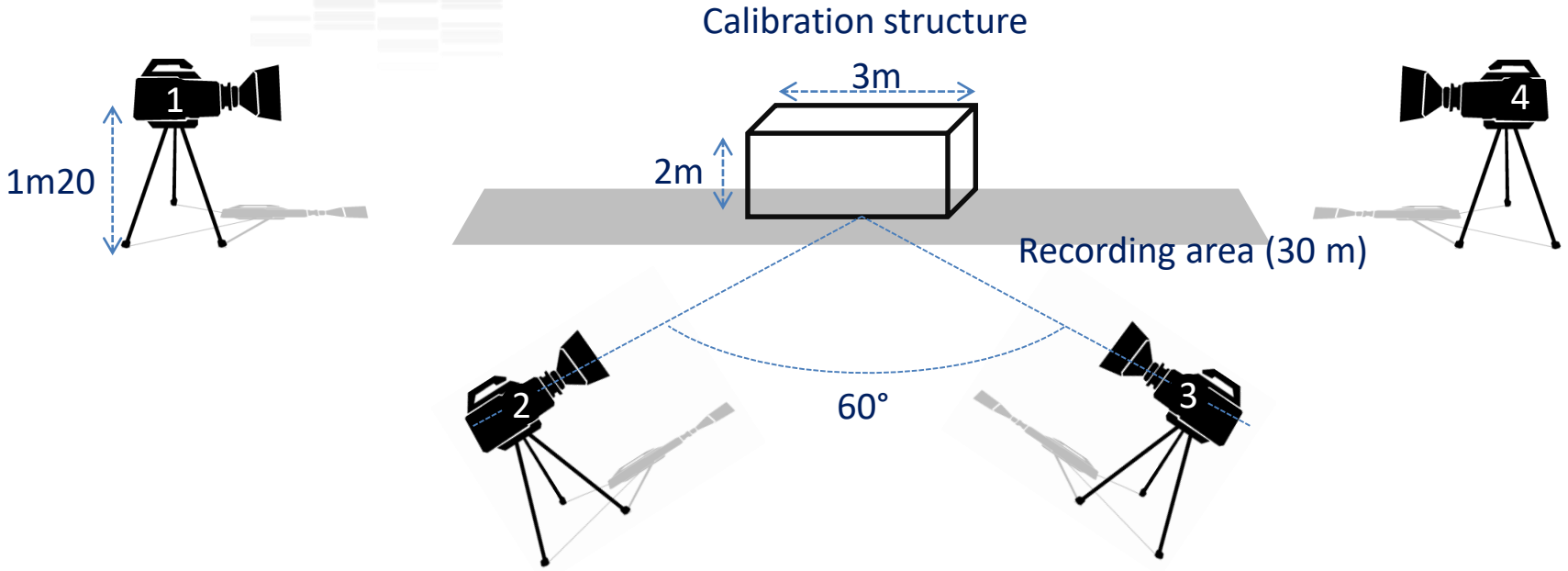
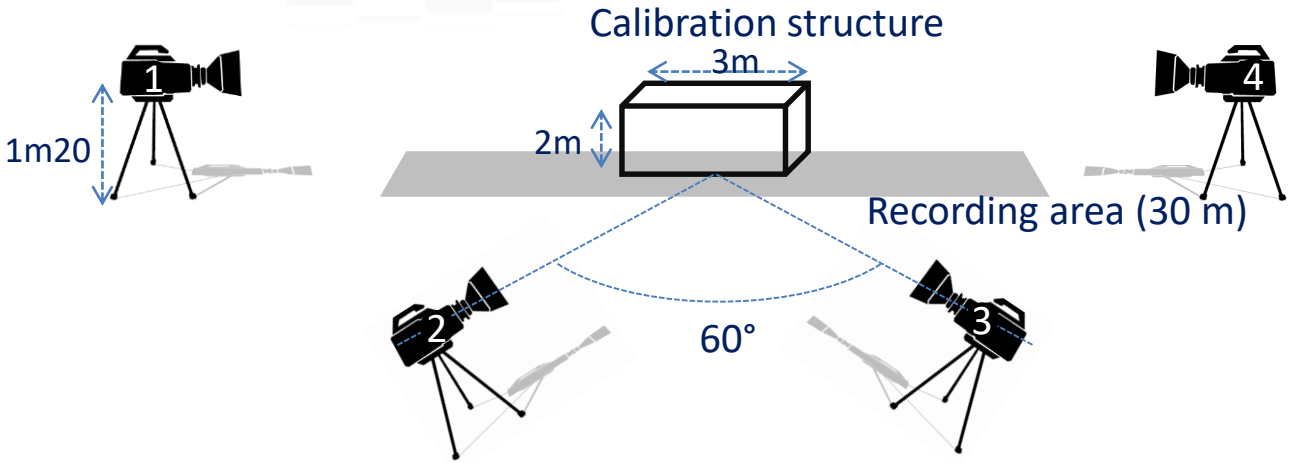
Method and Material

Method : device



Four digital cameras were placed on the sides and at each end of a 30 meters long track

Method : device



- The calibration structure provides the parameters needed for the 3D calculation of the coordinates of the horse's anatomical landmarks.
- After recording of the calibration structure, each horse , led by hand at the walk, is filmed (away and back)

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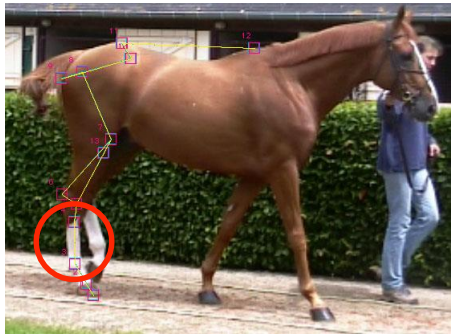
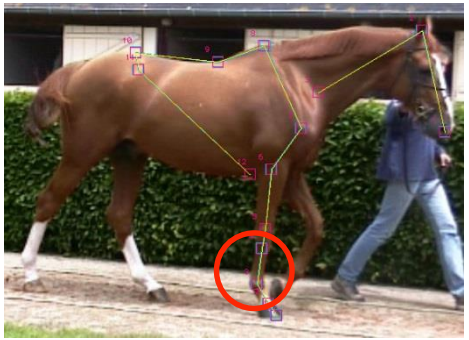
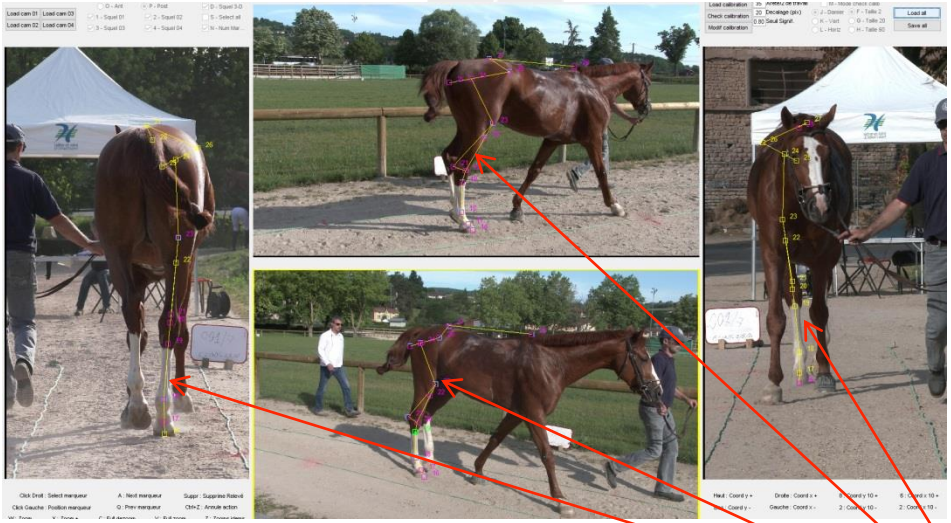
Method : data processing

- Data processing was performed off-line : the 4 digitized films were synchronized and two sets of reference images on which the metacarpus and metatarsus of the right fore and hind limbs are in vertical positions were selected.





Method : vue of images of the software

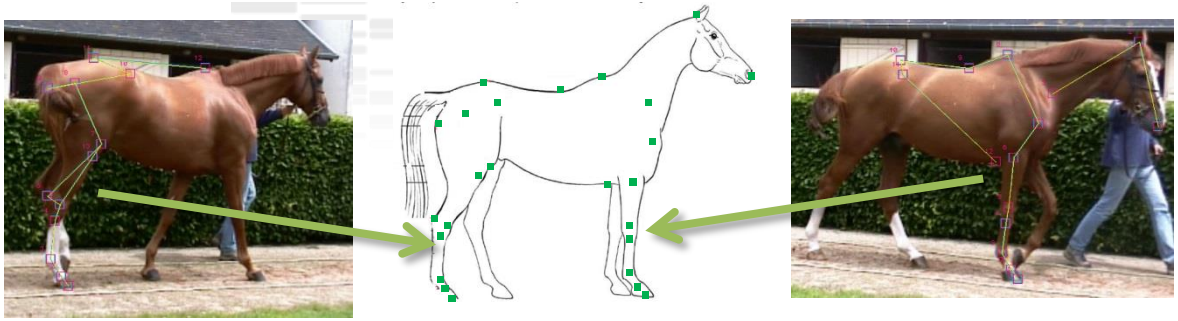


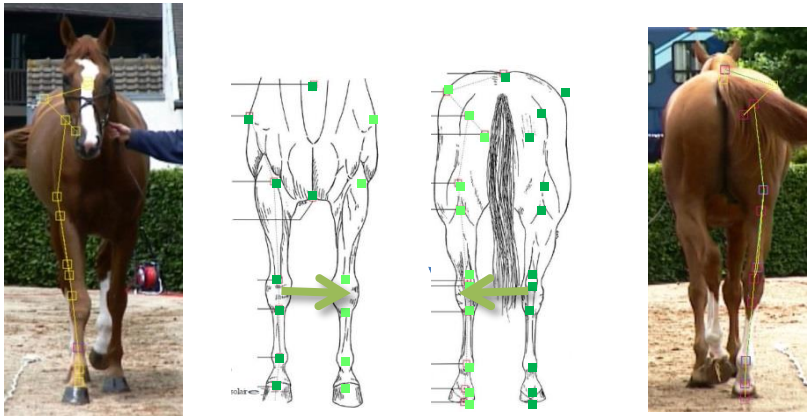
Hind legs

Front legs

A total of 28 landmarks were tracked manually (yellow skeleton, pink marks)
Landmarks are visible simultaneously on the 4 images (moving on one image induce move on all of them)

Method : synthetic 3D image





We built a synthetic image of the horse in 3D

- Adding Fore and Hind limbs

- Adding left size mirror of right side

Method : analysis of morphology

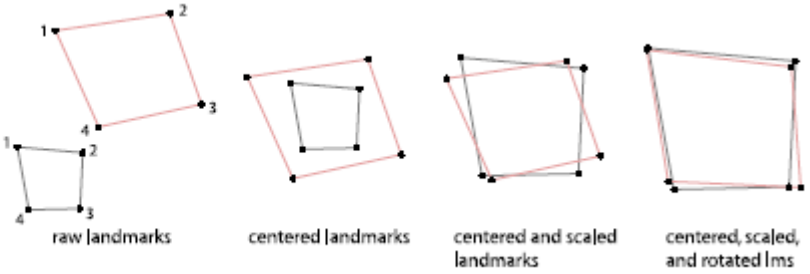
- 1 synthetic image by horse
- Fixed position of head and neck
- 43 points with 3 coordinates = 129 variables
- Correction (GLM) for age / sex / location/ technician / cannon angle
- Procrustes analysis using Geomorph package (Adams, D., Otarola Castillo E. 2013)

Method : analysis of morphology

Advances in Geometric Morphometrics

Philipp Mitteroecker · Philipp Gunz

Fig. 3 The three steps of Procrustes superimposition: translation to a common origin, scaling to unit centroid size, and rotation to minimize the sum of squared Euclidean distances among the homologous landmarks. The resulting landmark coordinates are called Procrustes shape coordinates



→ **procrustes shape coordinates and centroid size**

Method : genetic analysis

Distances and Directions in Multidimensional Shape Spaces: Implications for Morphometric Applications

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[2]*Laboratório de Ciências Ambientais, Centro de Biociências e Biotecnologia, Universidade Estadual do Norte Fluminense, Avenida Alberto Lamego 2000, Parque Califórnia, Campos dos Goytacazes, 28013-600, Rio de Janeiro, Brasil; E-mail: lrmont@uenf.br*

- G matrix between procrustes coordinates and with centroid size were estimated using WOMBAT* (REML) and an animal model
- Eigenvalues and vectors of GP^{-1} were computed with Geomorph package and results are presented on deformation grid.
- Genetic correlation between these principal components and competition data were computed using WOMBAT* (REML) and an animal model

* Meyer, K. (2007). WOMBAT – A tool for mixed model analyses in quantitative genetics by REML, *J.* Zhejiang Uni. SCIENCE B **8**: 815–821. [doi:10.1631/jzus.2007.B0815]

Data : morphology sample

- 4-5 years old jumping horses
- 2092 horses (63% in 2015-2016, 37% in 2002)
- 49% females
- Selle Français (5% Foreign sport horses, 2% Anglo Arabe)
- 24 locations/days
- From 583 sires, 18029 horses in the 4 generations pedigree
- 53 sires with 10 offspring, 426 couples sire/offspring measured

Competition data

- 2 annual criteria : sum of points (depending on ranks and technical difficulty) and ranking (depending on competition in the event)
- All horses with performances in official Jumping Horse Show born from 1997
- 160 056 horses
- 649 491 annual performances
- 352 696 horses in the pedigree (4 generations)

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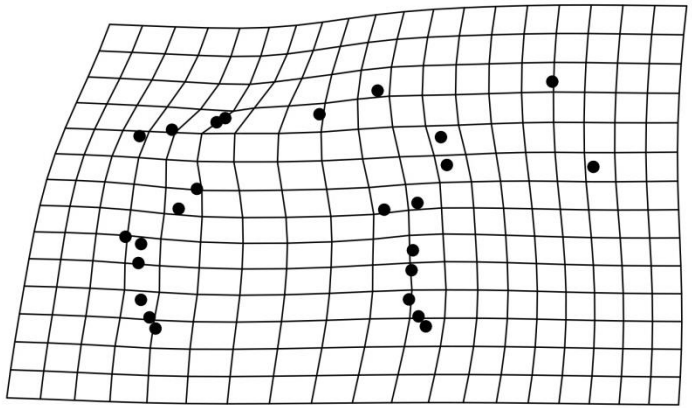
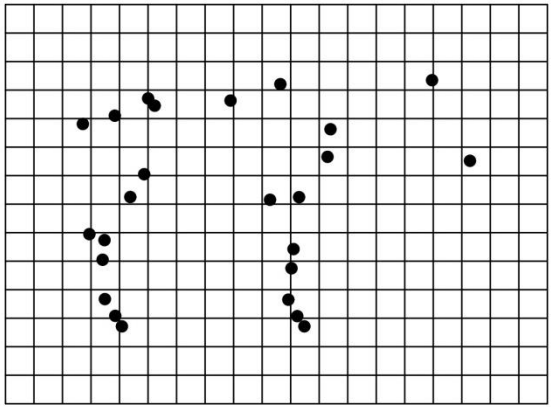
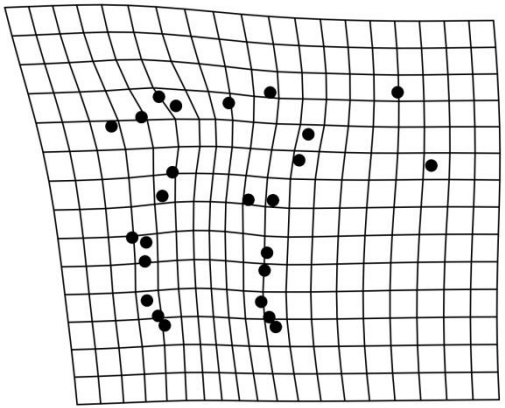
Results

First component : sagittal view





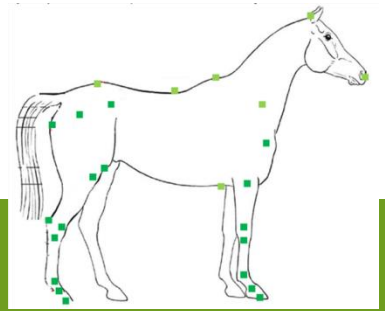


← extreme

Standard

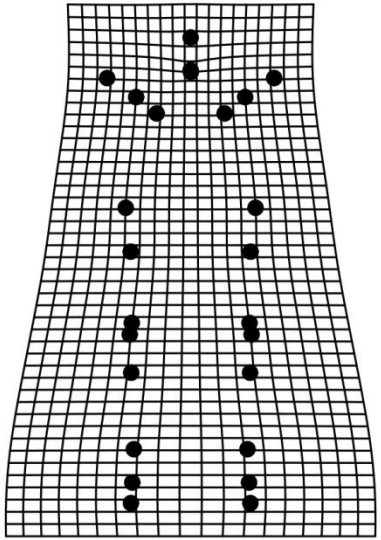
extreme →

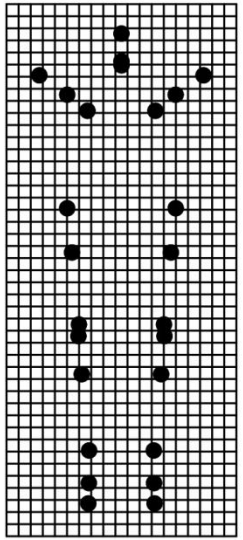
Longer than taller
Sloping shoulder
Bent hocks
Withers higher than croup

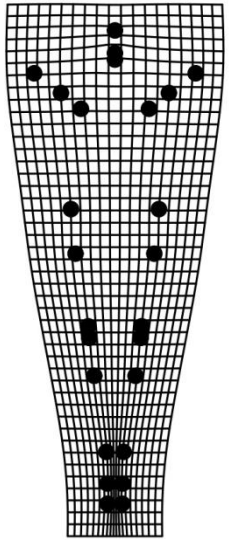


Taller than longer
Vertical shoulder
Strait hocks
Croup higher than withers

Second component : back view



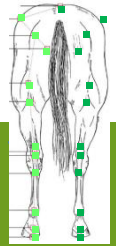




← extreme

Spread hind legs
Valgus

Standard



extreme →

Tied hind legs
Varus

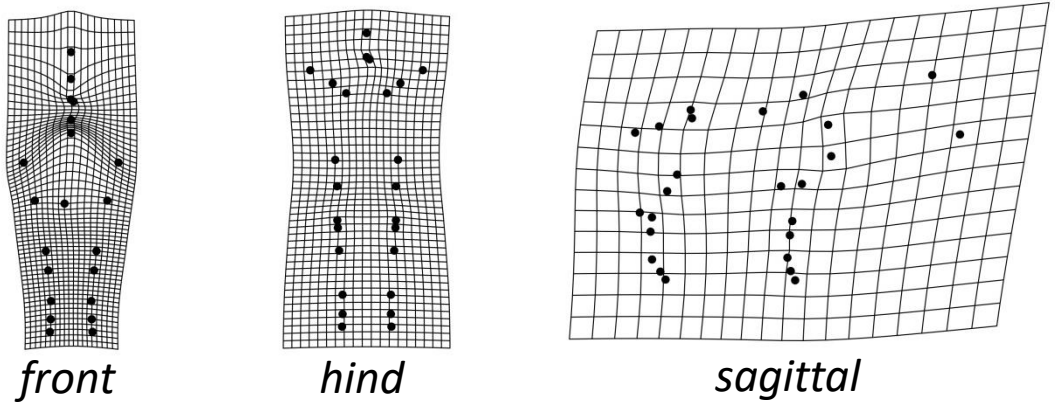
Heritability and Genetic correlation with jumping performances

heritability of centroid size : 0.18
heritability of the different components : 0.06 to 0.25

genetic correlation with jumping performances :

- r_g = 0.28 with centroid size
- r_g not significantly different from 0, the larger was : r_g=0.08 (± 0,07) with this component:

Large at shoulders
Neck in high position



front *hind* *sagittal*

Conclusion

- Method can be improved with an easier identification of anatomical points monitoring by image recognition and automatic calculation (for example edge of joint preferred to center of the joint)

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- Usefulness of morphometry method even with skeletal data rather than shape data and 3D rather than 2D

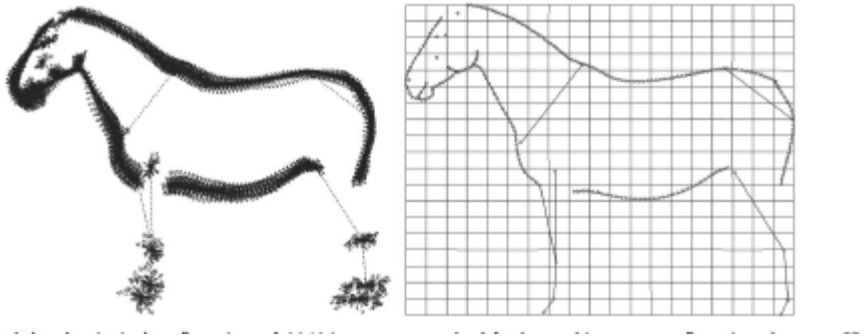
The use of novel phenotyping methods for validation of equine conformation scoring results

T. Druml†, M. Dobretsberger and G. Brem

RESEARCH ARTICLE

Repeatability, reproducibility and consistency of horse shape data and its association with linearly described conformation traits in Franches-Montagnes stallions

Annik Imogen Gmel[1,2]*, Thomas Druml[3], Katrin Portele[1,4]¤, Rudolf von Niederhäusern[1], Markus Neuditschko[1,3]



Conclusion

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- Usefulness of morphometry method even with skeletal data rather than shape data and 3D rather than 2D

- A good method to describe variability of morphological traits compared to traditional equine conformation because it takes into account relationship between each part of the body

- More to be done to find adequate description of the morphotypes with traditional language

Conclusion

- Selection point of view :
  - Heritable traits that can be selected : coming EBVs with the help of genomic to reach sufficient reliability for all stallions
  - No relationship with jumping : in accordance with most of studies for already selected population for jumping.
  - Free to produce horse with different morphology for different riders and different style of equitation and able to jump!