

Patterns of growth and development in warmblood horses

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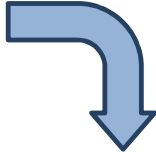
Introduction

Genetic background...



Environmental factors...

- ✓ Management practices
- ✓ Exercise
- ✓ **Nutrition**
- ...



Large influence on growth patterns of the horse

Horse feeding systems

Nutrient requirements and recommended allowances for growing animals have been established based on:

- age
- body weight (BW)
- expected mature BW
- growth rate (ADG).



Major importance that accurate growth curves are known



Introduction

Linear regression models have been widely used to characterize growth patterns



Thoroughbred

(Hintz *et al.*, 1979;
Thompson, 1995;
Pagan *et al.*, 1996;
Brown-Douglas *et al.*, 2005; ...)

Other breeds...

(Bigot *et al.*, 1988;
Saastamoinen, 1990;
Trillaud-Geyl *et al.*, 2004;
Valette *et al.*, 2008;
Fradinho *et al.*, 2008; 2012)

SF, AA, FT,
Finnhorse,
Lusitano,...

Longer periods and for larger volume of data, models which are **non-linear in their parameters**:

- adjust better to data;
- easier biological interpretation.

(Staniar *et al.*, 2004;
Onoda *et al.*, 2011;
Kocher & Staniar, 2013;
Heugebaert *et al.*, 2010,
Fradinho *et al.*, 2016; 2020)

(Thoroughbred,
SF, AA, FT,
Lusitano, ...)

Growth and development of warmblood foals has been studied (Vervuert *et al.*, 2005; Mack *et al.*, 2014)



Limited information on growth patterns until a mature size, under field conditions.





To characterize growth and development patterns in a population of warmblood horses (Hanoverian and Oldenburg breeds), from birth to 5 years of age.



Materials & Methods

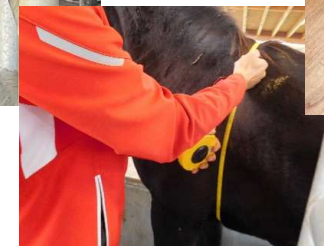
- 81 foals (Hanoverian and Oldenburg) (42 colts and 39 fillies);
- Born between 2015 and 2023 – reference stud farm in the south-western region of France (Haute-Garonne);
- Periodically weighed and measured (height at withers, girth and cannon bone circumference).



Electronic digital scale
(precision 0.5 kg)



Aluminium
measuring
stick
(precision
0.5 cm)

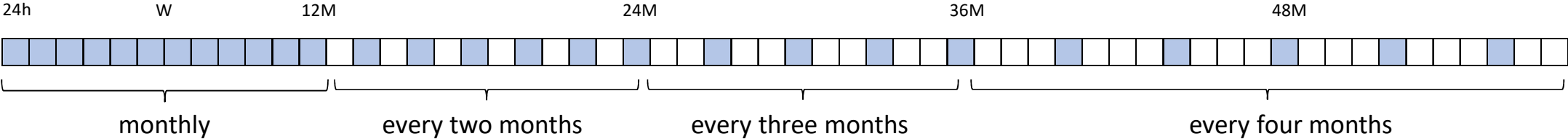


Flexible
measuring
tape



Materials & Methods

- Monitored between birth and five years of age (when horses were already on regular work)



- Measurements were taken by the same operator, in a total of 2,852 records.





- Management conditions were identical for all animals;
- Foals were kept on pasture with their dams until weaning (on average at six month of age);
- After weaning, foals were managed according to their age and were separated by sex;
- Diets were adjusted for the different needs of each growth stage according to INRA recommendations (INRA, 2012).



- Several sigmoid growth functions were adjusted (NLIN procedure, SAS) (Brody, Logistic, Gompertz, von Bertalanffy and Richards);

Brody	Logistic	Gompertz
$Y = A (1 - be^{-kt})$	$Y = A (1 + be^{-kt})^{-1}$	$Y = A e^{-be^{-kt}}$
von Bertalanffy	Richards	
$Y = A (1 - be^{-kt})^3$	$Y = A (1 - be^{-kt})^M$	

Variables (Y) are described as a function of time (t = days of age)

Parameters:

A – asymptotic value of y, as age (t) approaches infinity (mature size);

b – degree of maturity when t=0 (parameter that adjusts for a post-natal start of the curve);

k – maturing index (curve parameter that establish the speed at which the variable approaches A);

M – point of inflection in the sigmoid curve ($0 < M < 1$, point of inflection is somewhere before birth).



Materials & Methods

To fit the non-linear regression models, the Marquardt iterative method was used.

Body weight and withers height:

Measure	Model	Parameters				R ²
		A (± SE)	b (± SE)	k (± SE)	M (± SE)	
BW (kg)	Brody	547.5 ± 6.0	0.875 ± 0.005	0.0023 ± 0.0001	-	0.943
	Logistic	494.5 ± 4.0	3.737 ± 0.121	0.0059 ± 0.0002	-	0.918
	Gompertz	510.5 ± 4.5	-1.725 ± 0.029	0.0040 ± 0.0001	-	0.931
	von Bertalanffy	519.2 ± 4.8	0.454 ± 0.006	0.0034 ± 0.0001	-	0.935
	Richards	619.4 ± 18.6	0.985 ± 0.005	0.0012 ± 0.0001	0.598 ± 0.030	0.947
WH (cm)	Brody	164.0 ± 0.4	0.353 ± 0.003	0.0041 ± 0.0001	-	0.942
	Logistic	162.8 ± 0.4	0.516 ± 0.007	0.0053 ± 0.0001	-	0.935
	Gompertz	163.3 ± 0.4	-0.425 ± 0.004	0.0047 ± 0.0001	-	0.938
	von Bertalanffy	163.5 ± 0.4	0.133 ± 0.001	0.0045 ± 0.0001	-	0.939
	Richards	172.6 ± 1.6	0.963 ± 0.009	0.0013 ± 0.0002	0.159 ± 0.009	0.953

Best fit model



Materials & Methods

Girth and cannon circumference:

Measure	Model	Parameters				R ²
		A (± SE)	b (± SE)	k (± SE)	M (± SE)	
G (cm)	Brody	185.5 ± 0.7	0.509 ± 0.004	0.0041 ± 0.0001	-	0.953
	Logistic	182.7 ± 0.6	0.935 ± 0.014	0.0060 ± 0.0001	-	0.942
	Gompertz	183.9 ± 0.7	-0.683 ± 0.007	0.0050 ± 0.0001	-	0.948
	von Bertalanffy	184.4 ± 0.6	0.206 ± 0.002	0.0047 ± 0.0001	-	0.950
	Richards	198.8 ± 2.2	0.971 ± 0.006	0.0014 ± 0.0002	0.241 ± 0.011	0.964
CC (cm)	Brody	20.6 ± 0.2	0.379 ± 0.005	0.0055 ± 0.0002	-	0.895
	Logistic	20.5 ± 0.1	0.580 ± 0.010	0.0072 ± 0.0002	-	0.890
	Gompertz	20.5 ± 0.1	-0.465 ± 0.007	0.0063 ± 0.0002	-	0.893
	von Bertalanffy	20.5 ± 0.1	0.145 ± 0.002	0.0061 ± 0.0002	-	0.894
	Richards	21.0 ± 0.2	0.889 ± 0.039	0.0030 ± 0.0004	0.238 ± 0.033	0.899

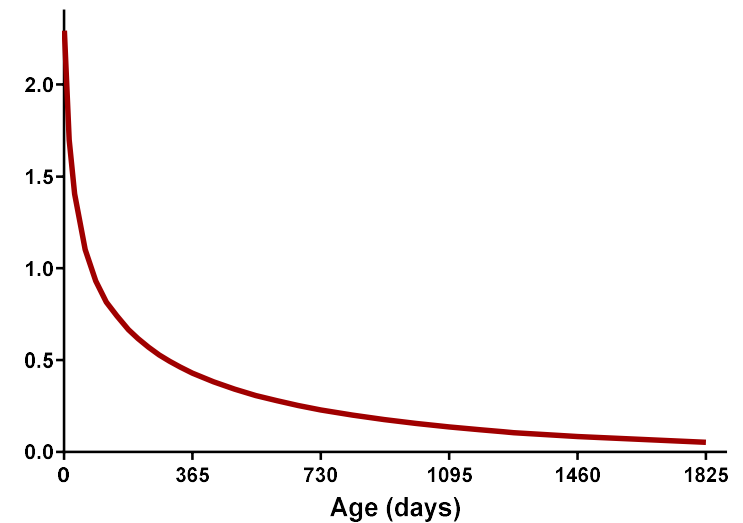


Best fit model



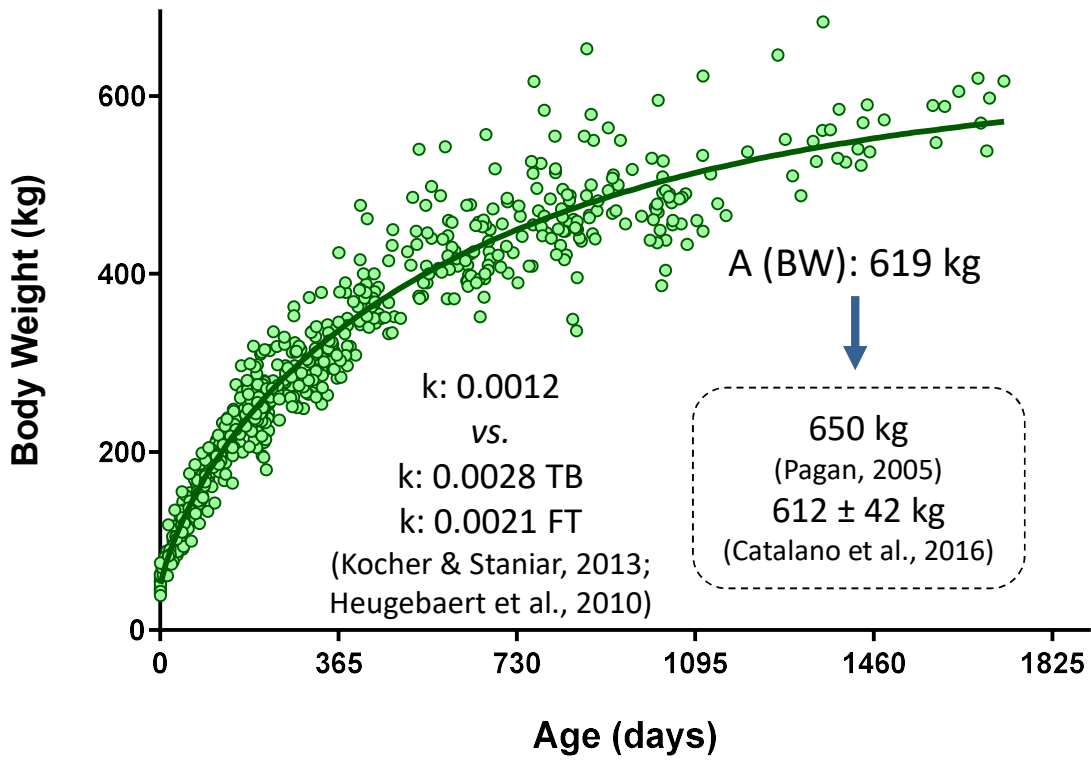
- The effect of sex was also evaluated;
- Growth rates (ADG, g/d or cm/d) → first derivative of the equations:

$$Y' = MAkbe^{(-kt)} (1 - be^{-kt})^M / (1 - be^{-kt})$$



Results & Discussion

Body weight



Proportions of mature BW (%)



Age	(present study)	TB (Kocher & Staniar, 2013)	FT (Heugebaert et al., 2010)	NRC (2007)
6 M	40 (242 kg)	45	44	43
12 M	56 (337 kg)	67	60	64
24 M	75 (450 kg)	88	88	86
36 M	86 (514 kg)	96	97	94
48 M	92 (553 kg)	97	100	-

600 kg 550 kg 590 kg 600 kg

Mature BW

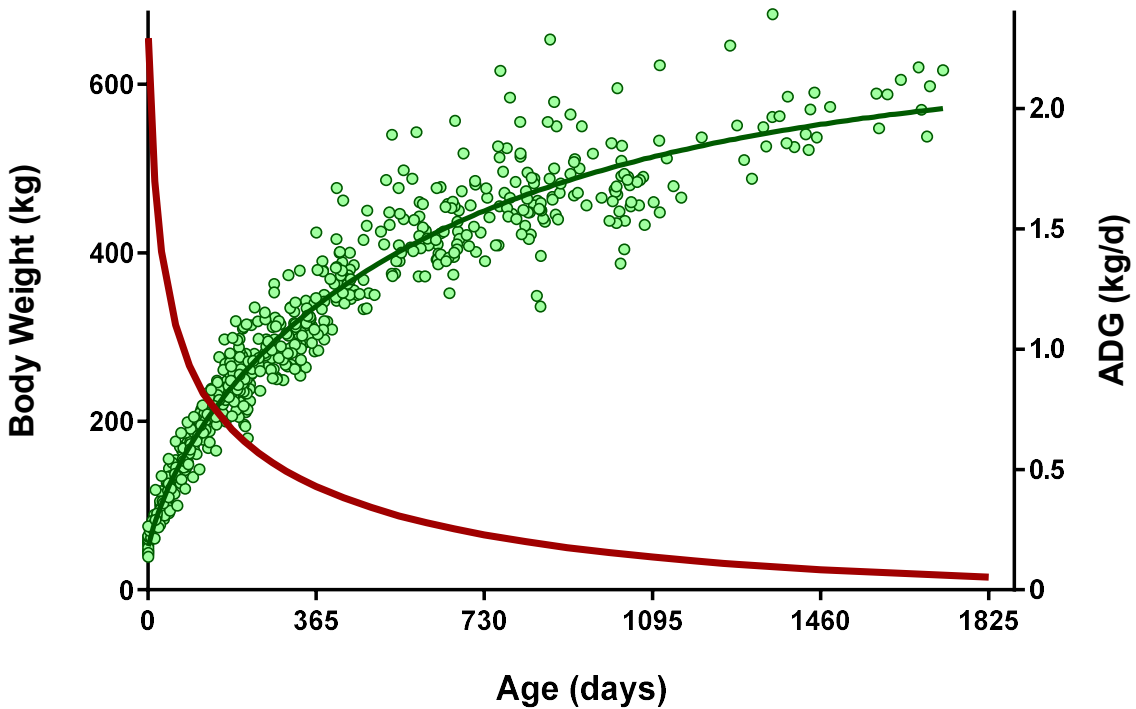
Birth weight: 52 kg
7 mo: 259 kg

Birth weight: 57 kg
7 mo: 263 kg
(Vervuert et al., 2005)

7 mo: 271 kg
(Mack et al., 2014)



Results & Discussion



ADG
(g/day)

Age	(present study)	Sport horses (INRA, 2012)
3-6 M	800	800-900
6-12 M	530	500-550
18-24 M	270	350-400
30-36 M	156	50-100
36-42 M	122	50-100

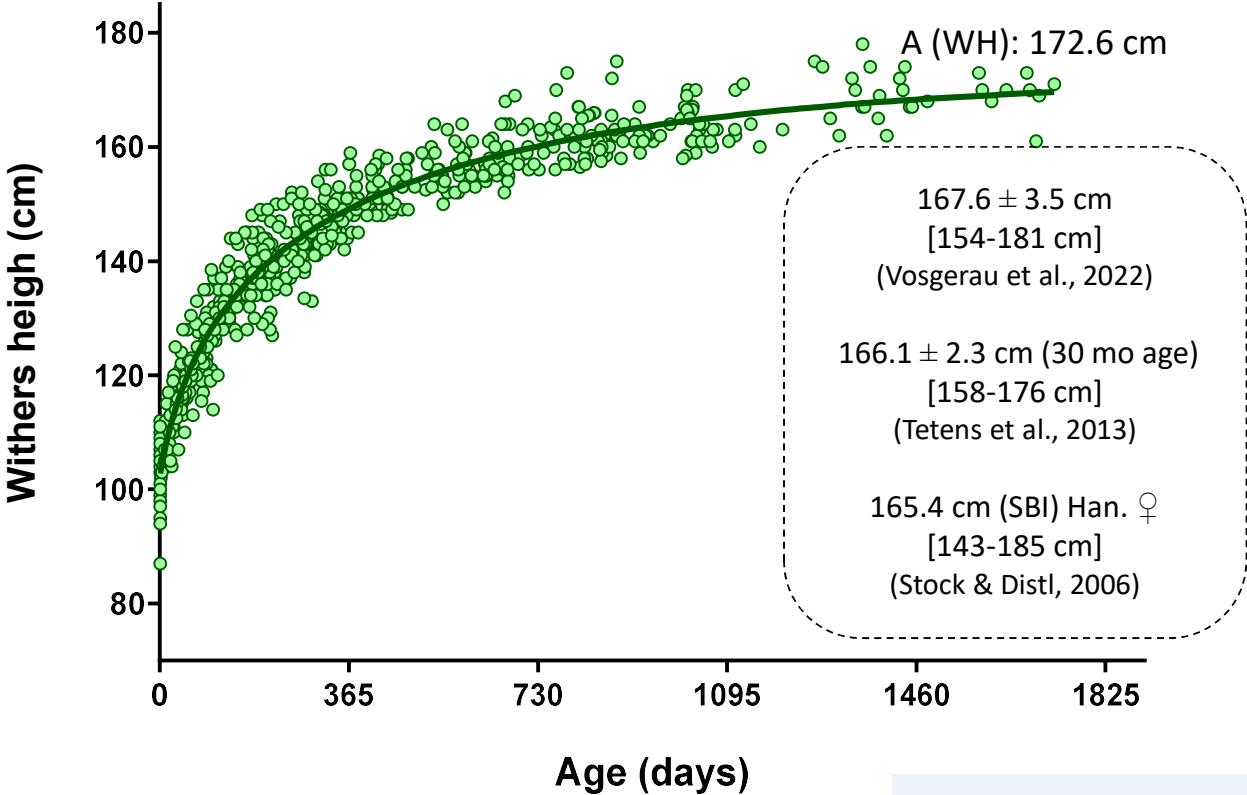
Compatible with a moderate growth
(↓ risk of osteoarticular problems)

600 kg
↑
Mature BW
Moderate growth



Results & Discussion

Withers height



Proportions of mature WH (%)

Age	(present study)	Lusitano (Fradinho et al., 2016)	TB (Kocher & Staniar, 2013)
6 M	80 (138 cm)	82	80
12 M	87	89	87
24 M	93	94	94
36 M	96	97	97
48 M	98 (168 cm)	97	98

160 cm (PSL Studbook) 169 cm



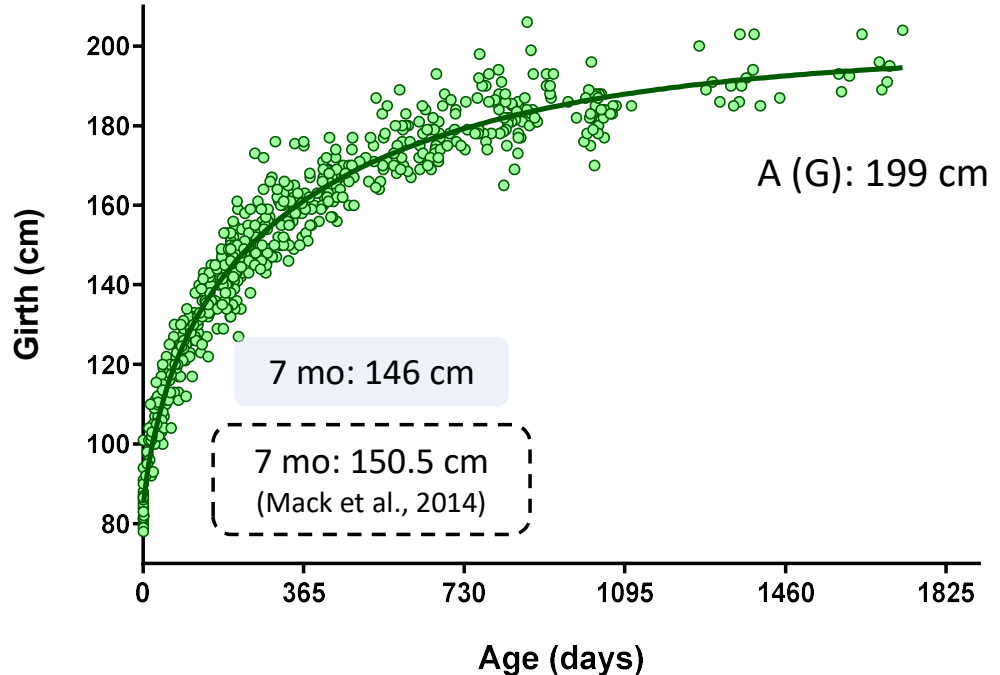
Mature WH

- between-breed similar pattern
- precocity of bone tissue development

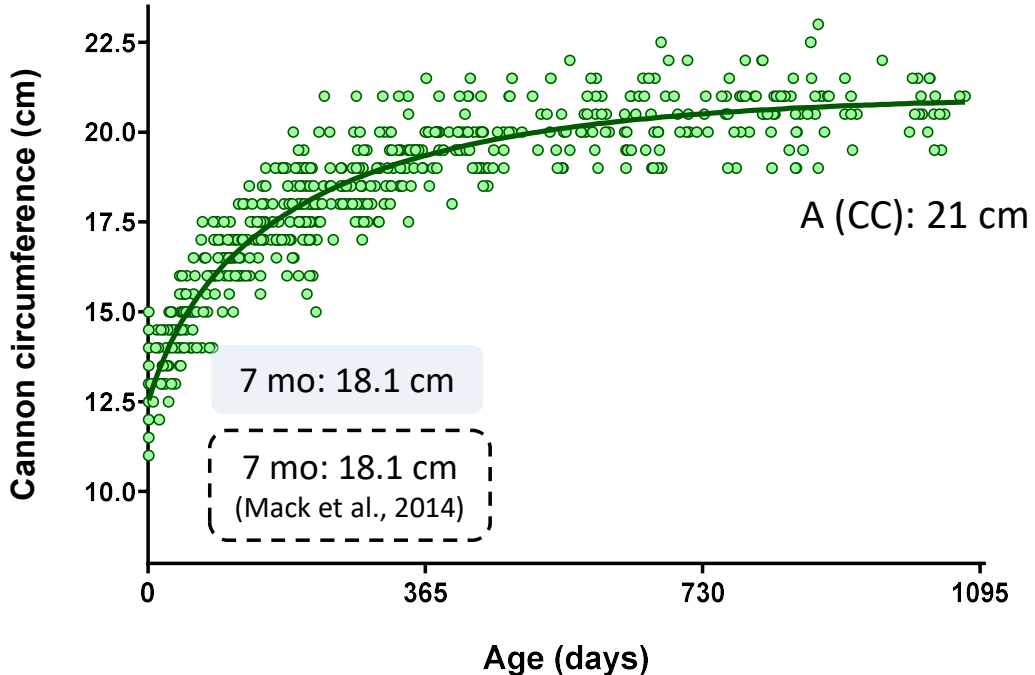


Results & Discussion

Girth

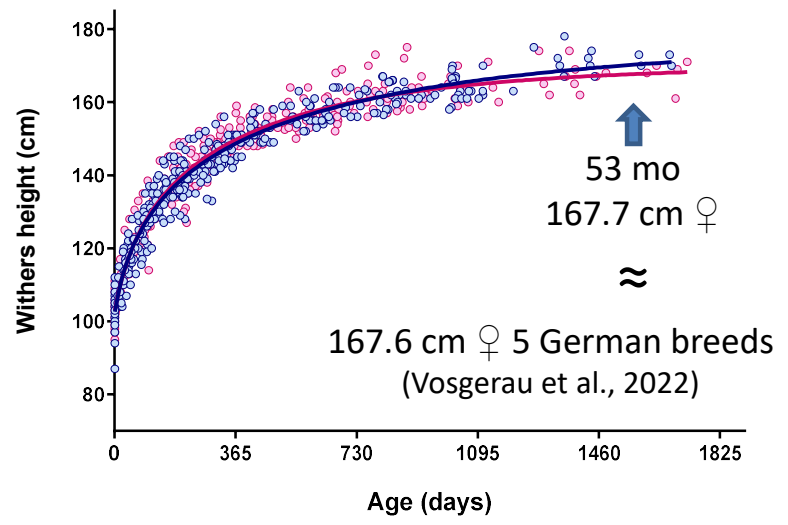
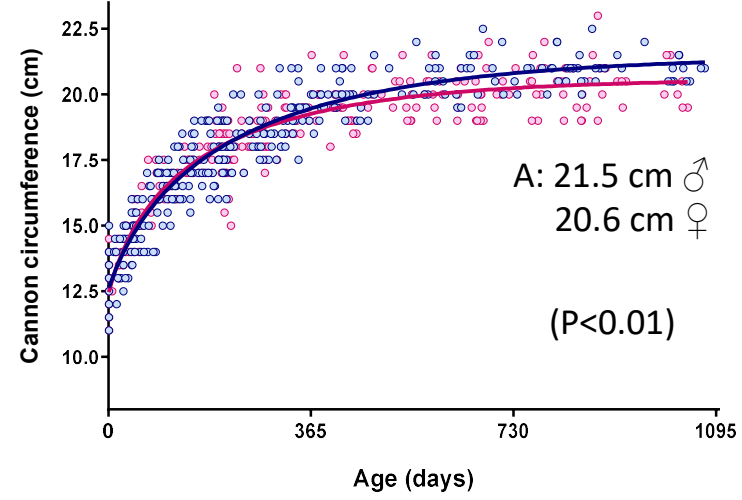
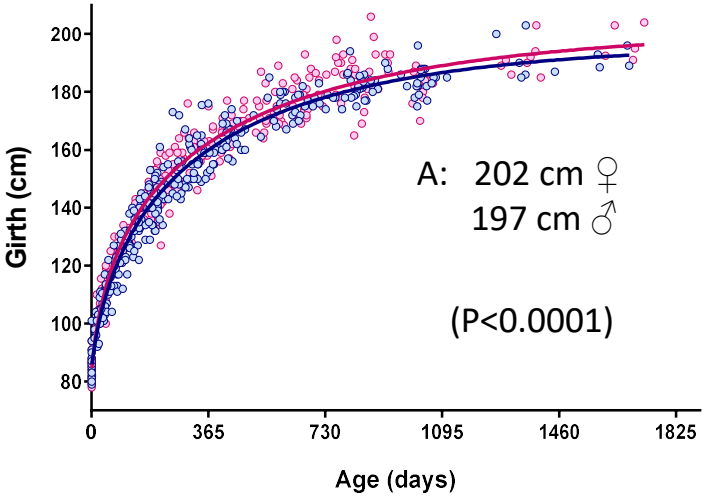
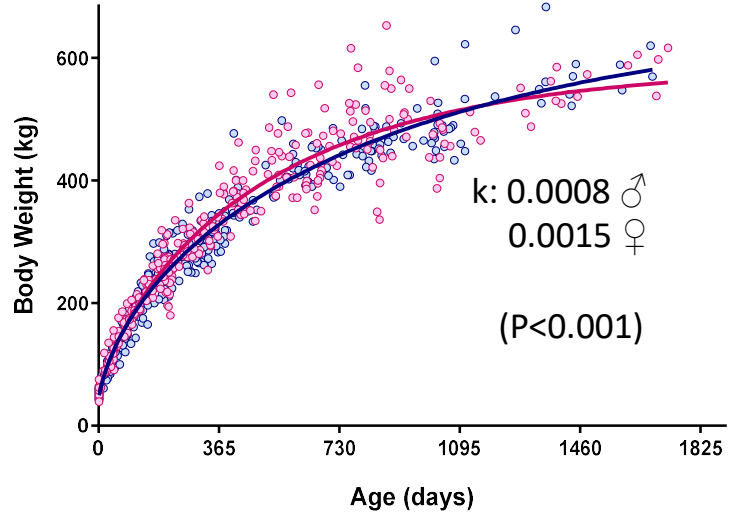


Cannon circumference



Results & Discussion

Effect of sex



- Richards' function showed to be the best fit equation to describe growth and development of this population of horses;
- Considering BW, average daily gains observed at standard ages were comparable with moderate growth levels proposed for other sport breeds;
- Growth rates regarding height at withers were similar among breeds (confirming the precocity of skeletal tissue development);
- Sexual dimorphism was observed for BW, G and CC but not for WH;
- The present study shows that non-linear functions can be used to accurately describe growth and development in warmblood breeds.



**Thank you for
your attention!**



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Patterns of growth and development in warmblood horses

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Introduction: Non-linear functions have been used to characterize growth and development in some horse breeds. These functions adjust better to data and may have an easier biological interpretation. The objective of the present study was to characterize growth and development patterns in a population of warmblood horses (Hanoverian and Oldenburg breeds), from birth to 5 years of age.

Materials and methods: A total of 2,852 records for body weight (BW), withers height (WH), girth (G) and cannon circumference (CC) were obtained from 81 foals (42 colts; 39 fillies) born and raised in a reference stud-farm in the south of France. Data were regularly collected between birth and 5 years of age, when horses were already on regular work. Several sigmoid growth functions were adjusted to BW, WH, G and CC data sets using the NLIN procedures of SAS. However, the Richards equation $y = A(1 - b \cdot \exp(-kt))^M$ was chosen for further analysis because it was the best fit model for all the variables. The effect of sex was also evaluated.

Results: The mature BW was 619.4 ± 18.6 kg and the mature size was 172.6 ± 1.6 cm for WH, 198.8 ± 2.2 cm for G and 21.0 ± 0.2 cm for CC. According to average values found in literature, the proportions (%) of mature BW at 6, 12, 24, 36 and 48 months of age were, respectively, 40, 56, 75, 86 and 92 %. The proportions (%) of mature WH considered in the breeding programs for the two breeds, at the same ages were 82, 89, 95, 99 and 100%. In the present study, sexual dimorphism was not observed for WH. However, significant differences were found between males and females ($P < 0.001$) in what concerns BW, G and CC models. Growth rates were in the range of those found for a moderate growth in other sport breeds.

Conclusion: Growth and development in the warmblood horse can be accurately described by non-linear functions.

Key words: body weight, withers height, girth, cannon circumference, growth, non-linear functions.



Norwegian University
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European Workshop
on Equine Nutrition

EQUINE NUTRITION: THE PAST, THE PRESENT & THE FUTURE



11th European Workshop on Equine Nutrition

July 1st – 4th, 2024, Norway

EWEN 2024

"EQUINE NUTRITION: THE PAST, THE PRESENT &
THE FUTURE"

The European Workshop on Equine Nutrition (EWEN) is held in Norway the 1st to 4th of July 2024. The event is taking place in Oslo and at the Norwegian University of Life Sciences (NMBU) in Ås.

The organizing and scientific committees welcome all researchers and industry partners. We are grateful for all scientific contributions, our invited speakers and our sponsor for supporting this important event.

We hope that everyone will have an unforgettable experience enjoying good company, exciting science and workshops at the 11th EWEN in Norway.

On behalf of the committees

Rasmus Bovbjerg Jensen



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