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Abstract 3347

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Genetic Parameters for Linear Type and Gaits Traits in the Belgium Warmblood Horse (BWP)

Maïté Rustin[1,2], S. Janssens[2], N. Buys[2] & N. Gengler[1,3]

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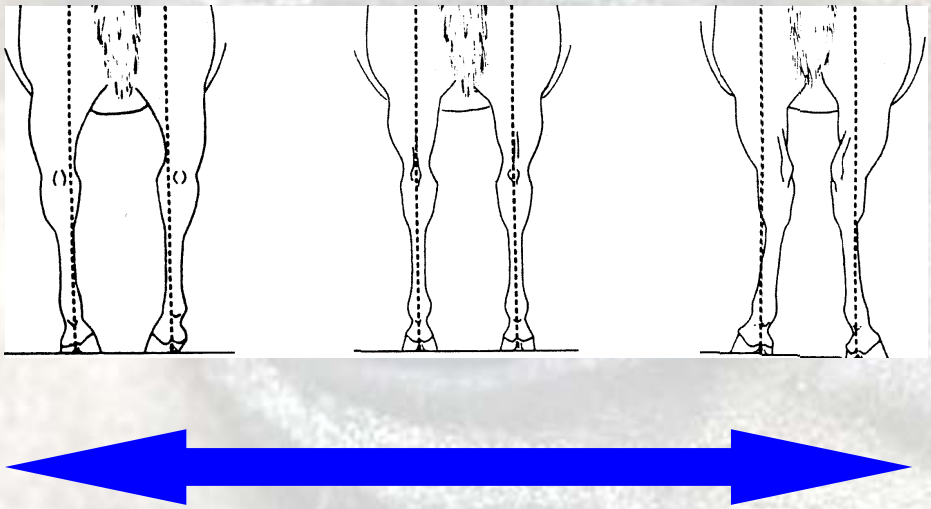
Introduction: Horse Conformation

Horse conformation and its gaits are important for:

- Aesthetics
- Functionality
- Durability
- Health and wellness
  - → **Factors in relation with horse riding abilities**
  - → **Indirect selection**
  - → Method of assessment: **Linear scoring**

Introduction: Linear Scoring

= Quantitative description of individual trait by using linear scale covering a biological range



Breeding Objectives

BWP breeding objectives for conformation and gaits:

- Correct build
  - → Rectangular frame
  - → Big outlines
  - → General muscularity
  - → Satisfactory force in vigorous limbs
- Good basic paces
  - → Ample and supple

Objectives

Since 2003, BWP Studbook has introduced the linear scoring in its breeding program

Provide practical management tools to breeders in order to **select for horses riding abilities**

Require estimation of **Breeding Values**

First step to develop a genetic evaluation system

= Estimation of genetic parameters

Linear Scoring : Data

- 27 linear body traits (17 type traits and 10 limbs traits)
- 6 linear gait traits
- Height at the withers
- Linear scale between -20 and 20 with increment of 5 and 0 corresponding to theoretical mean of BWP population

→ Measured on 987 mares aged in majority between 3 and 3.5 years old by 15 appraisers

Statistical Model

- **4** animal models differing in their fixed effects

Model 1

$$y = LOC + AGE + APP + a + e$$

- Fixed effect **LOC** for date of assessment x place of assessment
- Fixed effect **AGE** for class of age in month (8)
- Fixed effect **APP** for the appraiser
- Random animal additive effect **a**
- Random residual effect **e**

Model 2

$$y = LOC + AGE + (APP \times AGE) + a + e$$

- Fixed effect **LOC** and **AGE**
- Fixed effect **APPxAGE** for the appraiser combined with age of mares (3 or >4 years old)
- Random effect **a** and **e**

Model 3

y = LOC + AGE + (APP x AGE) + (APP x YR) + a +e

- Fixed effect **LOC**, **AGE** and **APPxAGE**
- Fixed effect **APPxYR** for the appraiser combined with year of assessment
- Random effect **a** and **e**

Model 4

y = LOC + AGE + (APP x AGE) + (APP x YR) + ORI + a +e

- Fixed effect **LOC**, **AGE**, **APPxAGE** and **APPxYR**
- Fixed effect **ORI** for origin of mares (BWP or no BWP parents)
- Random effect **a** and **e**

Statistical Model

- Choice of the model based on :
  - → magnitude of heritabilities
  - → predictive ability for missing observations
  - → parsimony considerations
    - **→ Model 1**

y = LOC + AGE + APP + a + e

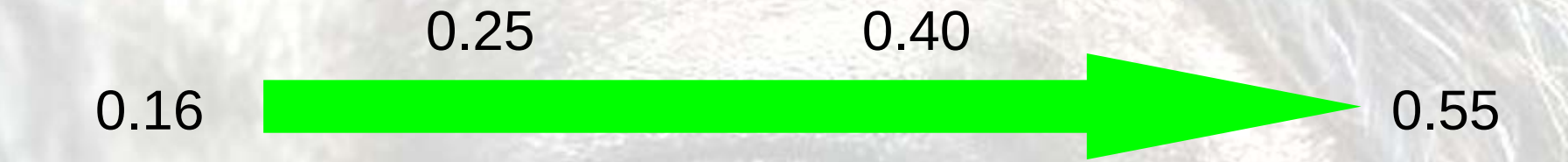
(Co)Variance Components Estimation

- Multi-trait estimation
- Canonical transformation and EM-REML algorithm (*Misztal et al*, 1995)
- Methods applied for linear scoring in dairy cattle

Results : Heritability

- Condition
- Shoulders orientation
- Substance of legs
- Hind legs traits
- Hocks traits
- Heels and hoof
- Model
- Height at withers
- Neck traits
- Withers traits
- Croup traits
- Length traits
- Forelegs traits
- Pasterns
- Trot traits
- Head
- Loins
- Volume of legs
- Walk traits
- Back Force

Results : Heritability



- Condition
- Shoulders orientation
- Substance of legs
- Hind legs traits
- Hocks traits
- Heels and hoof
- Model
- Height at withers
- **Neck** traits
- Withers traits
- **Croup** traits
- Length traits
- **Forelegs** traits
- Pasterns
- **Trot** traits
- Head
- **Loins**
- Volume of legs
- **Walk** traits
- **Back** Force

Results : Heritability

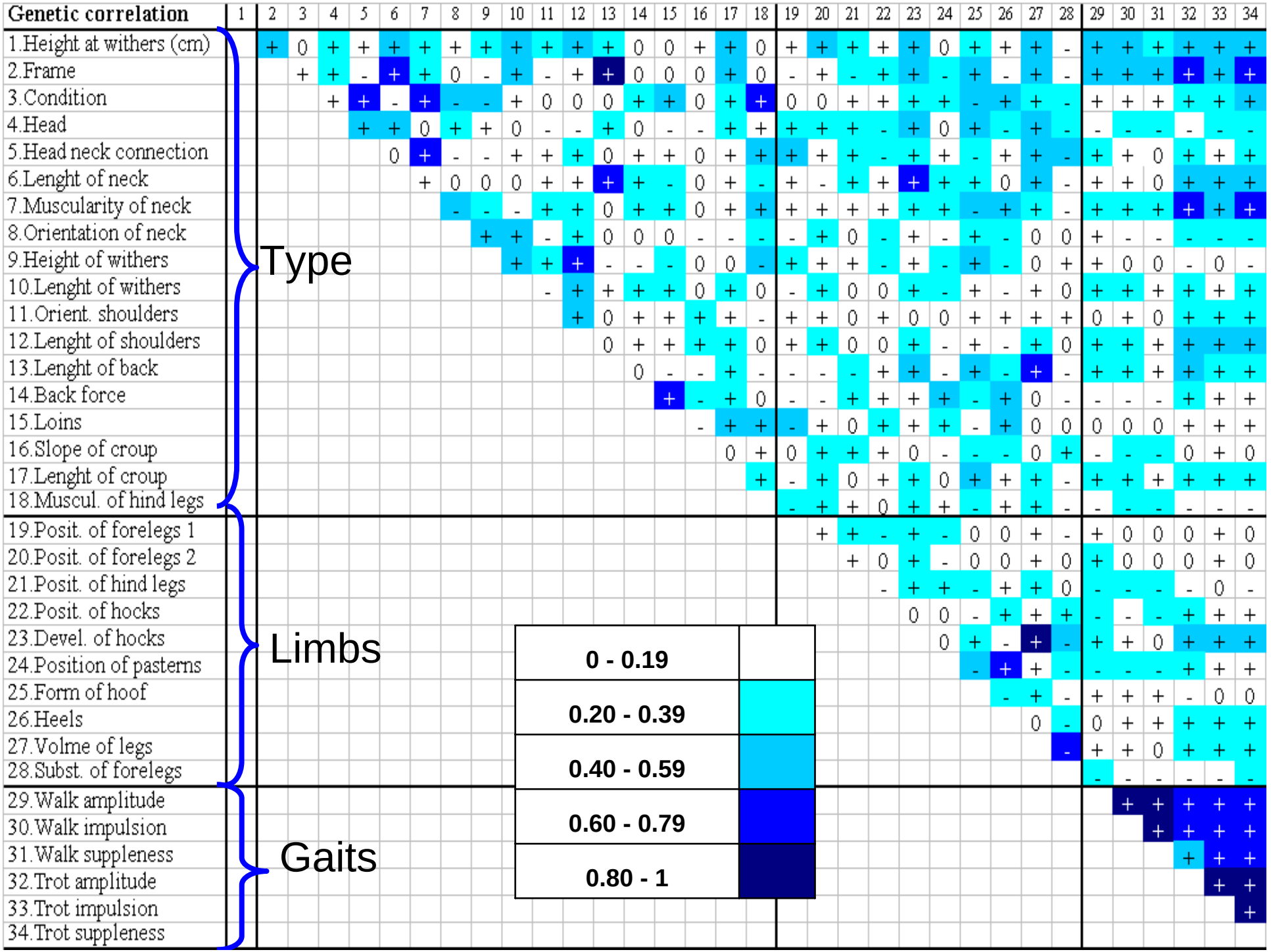
- Mean of all traits = 0.33

  → **Non negligible part of phenotypic variations observed in population is heritable**

- Intermediate between subjective assessment (0.24 for BWP mares, *Janssens S.,1995*) and zoometrical measurement (0.35 to 0.94 for Andalusian, Molina et al.,1999)

Results: Genetic Correlations

- Between -0.60 and 0.98
- Majority between -0.30 and 0.30
- Moderate to very high correlations


Genetic correlation
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31 32 33 34
1.Height at withers (cm)
2.Frame
3.Condition
4.Head
5.Head neck connection
6.Lenght of neck
7.Muscularity of neck
8.Orientation of neck
9.Height of withers
10.Lenght of withers
11.Orient. shoulders
12.Lenght of shoulders
13.Lenght of back
14.Back force
15.Loins
16.Slope of croup
17.Lenght of croup
18.Muscul. of hind legs
19.Posit. of forelegs 1
20.Posit. of forelegs 2
21.Posit. of hind legs
22.Posit. of hocks
23.Devel. of hocks
24.Position of pasterns
25.Form of hoof
26.Heels
27.Volme of legs
28.Subst. of forelegs
29.Walk amplitude
30.Walk impulsion
31.Walk suppleness
32.Trot amplitude
33.Trot impulsion
34.Trot suppleness
Type
Limbs
Gaits
0 - 0.19
0.20 - 0.39
0.40 - 0.59
0.60 - 0.79
0.80 - 1

Genetic correlation	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34
1.Height at withers (cm)		+	0	+	+	+	+	+	+	+	+	+	+	0	0	+	+	0	+	+	+	+	+	0	+	+	+	-	+	+	+	+	+	+
2.Frame			+	+	-	+	+	0	-	+	-	+	+	0	0	0	+	0	-	+	-	+	+	-	+	-	+	-	+	+	+	+	+	+
3.Condition				+	+	-	+	-	-	+	0	0	0	+	+	0	+	+	0	0	+	+	+	+	-	+	+	-	+	+	+	+	+	+
4.Head					+	+	0	+	+	0	-	-	+	0	-	-	+	+	+	+	+	-	+	0	+	-	+	-	-	-	-	-	-	-
5.Head neck connection						0	+	-	-	+	+	+	0	+	+	0	+	+	+	+	+	-	+	+	-	+	+	-	+	+	0	+	+	+
6.Lenght of neck							+	0	0	0	+	+	+	+	-	0	+	-	+	-	+	+	+	+	+	0	+	-	+	+	0	+	+	+
7.Muscularity of neck								-	-	-	+	+	0	+	+	0	+	+	+	+	+	+	+	+	-	+	+	-	+	+	+	+	+	+
8.Orientation of neck									+	+	-	+	0	0	0	-	-	-	-	+	0	-	+	-	+	-	0	0	+	-	-	-	-	-
9.Height of withers										+	+	+	-	-	-	0	0	-	+	+	+	-	+	-	+	-	0	+	+	0	0	-	0	-
10.Lenght of withers											-	+	+	+	+	0	+	0	-	+	0	0	+	-	+	-	+	0	+	+	+	+	+	+
11.Orient. shoulders												+	0	+	+	+	+	-	+	+	0	+	0	0	+	+	+	+	0	+	0	+	+	+
12.Lenght of shoulders													0	+	+	+	+	0	+	+	0	0	+	-	+	-	+	0	+	+	+	+	+	+
13.Lenght of back														0	-	-	+	-	-	-	-	+	+	-	+	-	+	-	+	+	+	+	+	+
14.Back force															+	-	+	0	-	-	+	+	+	+	-	+	0	-	-	-	-	+	+	+
15.Loins																-	+	+	-	+	0	+	+	+	-	+	0	0	0	0	0	+	+	+
16.Slope of croup																	0	+	0	+	+	+	0	-	-	-	0	+	-	-	-	0	+	0
17.Lenght of croup																		+	-	+	0	+	+	0	+	+	+	-	+	+	+	+	+	+
18.Muscul. of hind legs																			-	+	+	0	+	+	-	+	+	-	-	-	-	-	-	-
19.Posit. of forelegs 1																				+	+	-	+	-	0	0	+	-	0	0	0	0	+	0
20.Posit. of forelegs 2																					+	0	+	-	0	0	+	0	+	0	0	0	+	0
21.Posit. of hind legs																						-	+	+	-	+	+	0	-	-	-	-	0	-
22.Posit. of hocks																							0	0	-	+	+	+	-	-	-	+	+	+
23.Devel. of hocks																								0	+	-	+	-	0	+	0	+	+	+
24.Position of pasterns																									-	+	+	-	-	-	-	+	+	+
25.Form of hoof																										-	+	-	+	+	+	-	0	0
26.Heels																											0	-	0	+	+	+	+	+
27.Volme of legs																												-	+	+	0	+	+	+
28.Subst. of forelegs																													-	-	-	-	-	-
29.Walk amplitude																														+	+	+	+	+
30.Walk impulsion																															+	+	+	+
31.Walk suppleness																																+	+	+
32.Trot amplitude																																	+	+
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0.20 - 0.39
0.40 - 0.59
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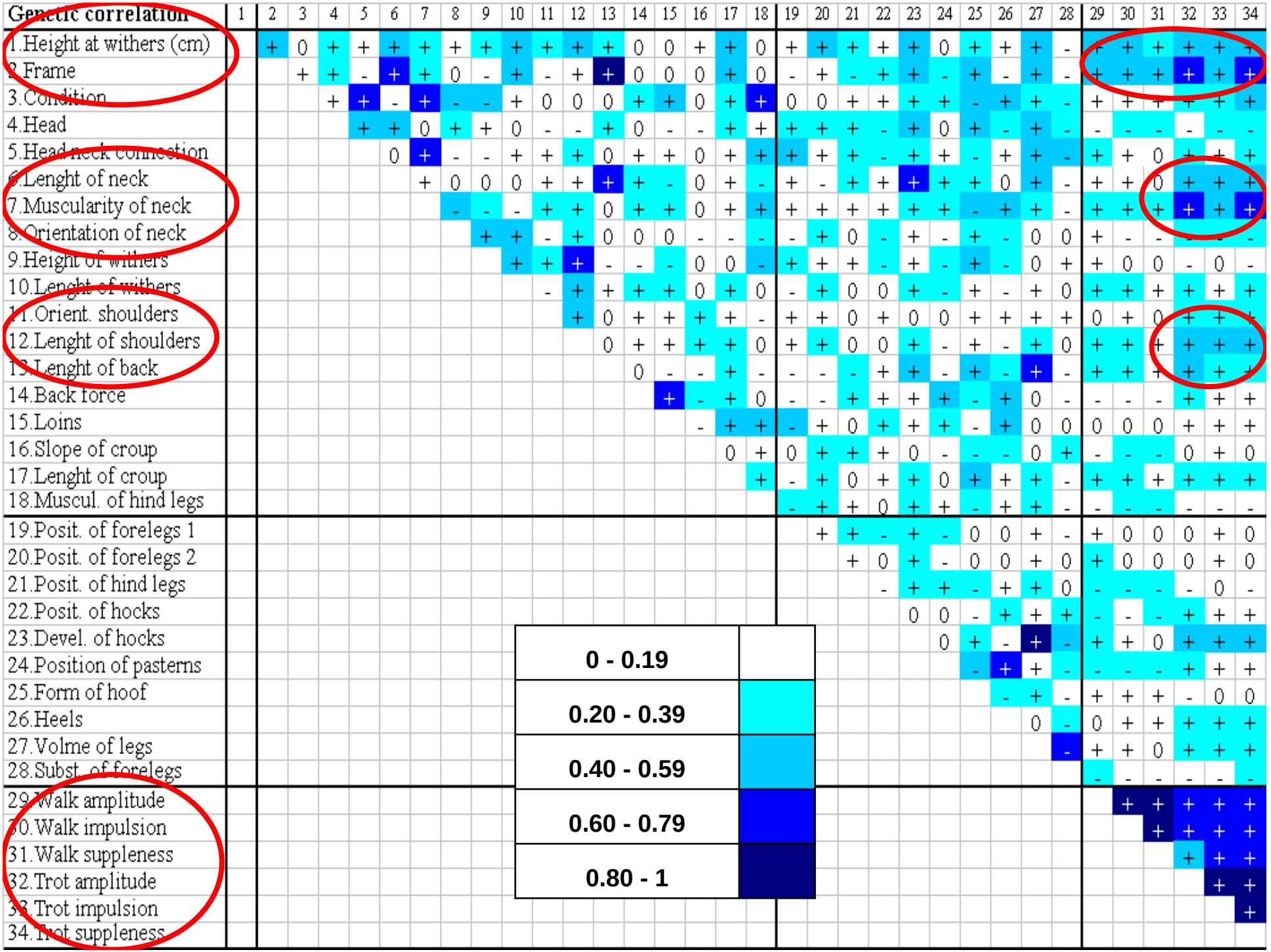
0.80 - 1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1.Height at withers (cm)		+	0	+	+	+	+	+	+	+	+	+	+	0	0	+	+	0	+	+	+	+	+	0	+	+	+	-	+	+	+	+	+	+
2.Frame			+	+	-	+	+	0	-	+	-	+	+	0	0	0	+	0	-	+	-	+	+	-	+	-	+	-	+	+	+	+	+	+
3.Condition				+	+	-	+	-	-	+	0	0	0	+	+	0	+	+	0	0	+	+	+	+	-	+	+	-	+	+	+	+	+	+
4.Head					+	+	0	+	+	0	-	-	+	0	-	-	+	+	+	+	+	-	+	0	+	-	+	-	-	-	-	-	-	-
5.Head neck connection						0	+	-	-	+	+	+	0	+	+	0	+	+	+	+	+	-	+	+	-	+	+	-	+	+	0	+	+	+
6.Lenght of neck							+	0	0	0	+	+	+	+	-	0	+	-	+	-	+	+	+	+	+	0	+	-	+	+	0	+	+	+
7.Muscularity of neck								-	-	-	+	+	0	+	+	0	+	+	+	+	+	+	+	+	-	+	+	-	+	+	+	+	+	+
8.Orientation of neck									+	+	-	+	0	0	0	-	-	-	-	+	0	-	+	-	+	-	0	0	+	-	-	-	-	-
9.Height of withers										+	+	+	-	-	-	0	0	-	+	+	+	-	+	-	+	-	0	+	+	0	0	-	0	-
10.Lenght of withers											-	+	+	+	+	0	+	0	-	+	0	0	+	-	+	-	+	0	+	+	+	+	+	+	+
11.Orient. shoulders												+	0	+	+	+	+	-	+	+	0	+	0	0	+	+	+	+	0	+	0	+	+	+
12.Lenght of shoulders													0	+	+	+	+	0	+	+	0	0	+	-	+	-	+	0	+	+	+	+	+	+
13.Lenght of back														0	-	-	+	-	-	-	-	+	+	-	+	-	+	-	+	+	+	+	+	+
14.Back force															+	-	+	0	-	-	+	+	+	+	-	+	0	-	-	-	-	+	+	+
15.Loins																-	+	+	-	+	0	+	+	+	-	+	0	0	0	0	0	+	+	+
16.Slope of croup																	0	+	0	+	+	+	0	-	-	-	0	+	-	-	-	0	+	0
17.Lenght of croup																		+	-	+	0	+	+	0	+	+	+	-	+	+	+	+	+	+
18.Muscul. of hind legs																			-	+	+	0	+	+	-	+	+	-	-	-	-	-	-	-
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21.Posit. of hind legs																						-	+	+	-	+	+	0	-	-	-	-	0	-
22.Posit. of hocks																							0	0	-	+	+	+	-	-	-	+	+	+
23.Devel. of hocks																								0	+	-	+	-	+	0	0	+	+	+
24.Position of pasterns																									-	+	+	-	-	-	-	+	+	+
25.Form of hoof																										-	+	-	+	+	+	-	0	0
26.Heels																											0	-	0	+	+	+	+	+
27.Volme of legs																												-	+	+	0	+	+	+
28.Subst. of forelegs																													-	-	-	-	-	-
29.Walk amplitude																														+	+	+	+	+
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31.Walk suppleness																																+	+	+
32.Trot amplitude																																	+	+
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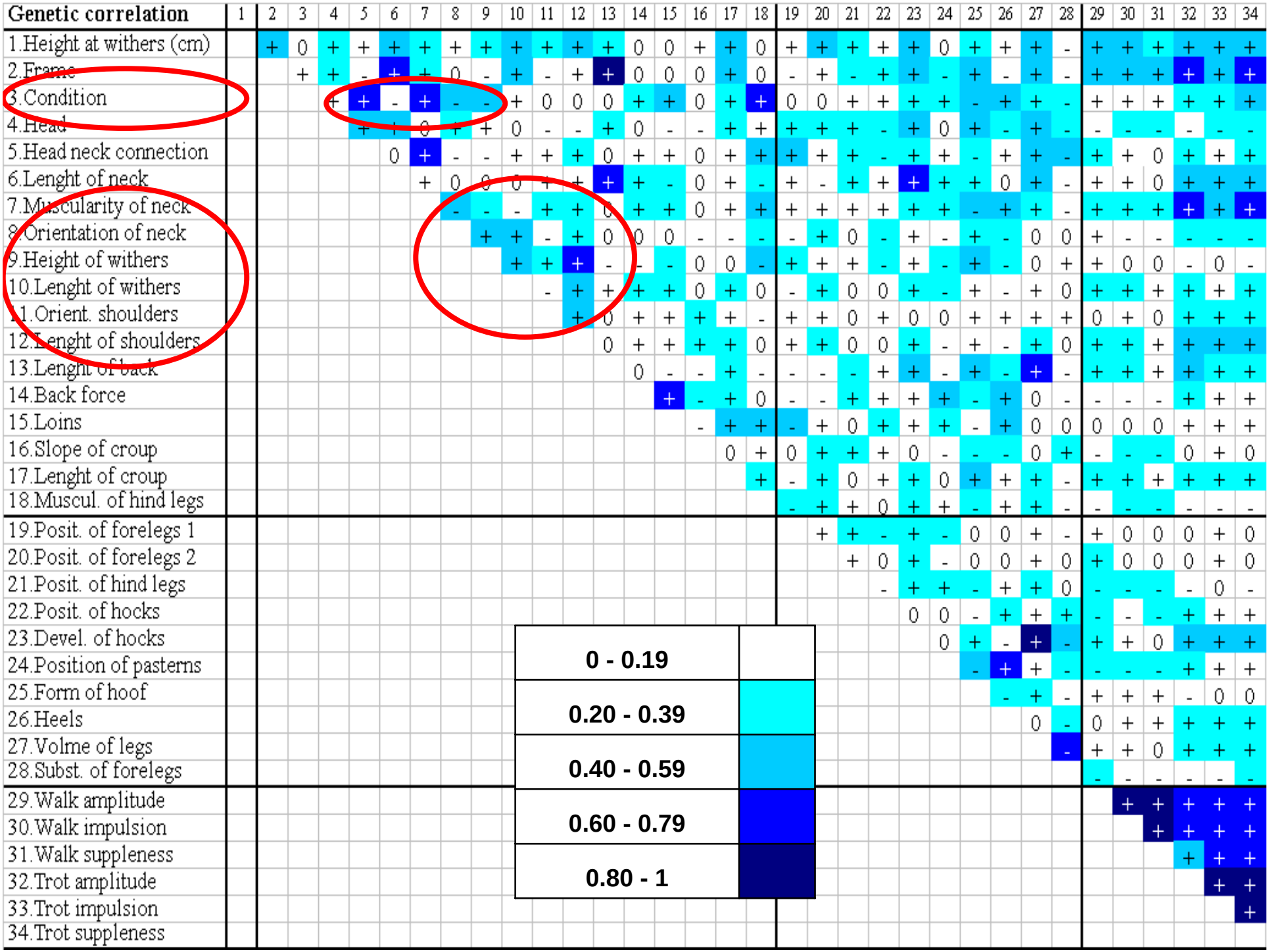
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2.Frame			+	+	-	+	+	0	-	+	-	+	+	0	0	0	+	0	-	+	-	+	+	-	+	-	+	-	+	+	+	+	+	+
3.Condition				+	+	-	+	-	-	+	0	0	0	+	+	0	+	+	0	0	+	+	+	+	-	+	+	-	+	+	+	+	+	+
4.Head					+	+	0	+	+	0	-	-	+	0	-	-	+	+	+	+	+	-	+	0	+	-	+	-	-	-	-	-	-	-
5.Head neck connection						0	+	-	-	+	+	+	0	+	+	0	+	+	+	+	+	-	+	+	-	+	+	-	+	+	0	+	+	+
6.Lenght of neck							+	0	0	0	+	+	+	+	-	0	+	-	+	-	+	+	+	+	+	0	+	-	+	+	0	+	+	+
7.Muscularity of neck								-	-	-	+	+	0	+	+	0	+	+	+	+	+	+	+	+	-	+	+	-	+	+	+	+	+	+
8.Orientation of neck									+	+	-	+	0	0	0	-	-	-	-	+	0	-	+	-	+	-	0	0	+	-	-	-	-	-
9.Height of withers										+	+	+	-	-	-	0	0	-	+	+	+	-	+	-	+	-	0	+	+	0	0	-	0	-
10.Lenght of withers											-	+	+	+	+	0	+	0	-	+	0	0	+	-	+	-	+	0	+	+	+	+	+	+
11.Orient. shoulders												+	0	+	+	+	+	-	+	+	0	+	0	0	+	+	+	+	0	+	0	+	+	+
12.Lenght of shoulders													0	+	+	+	+	0	+	+	0	0	+	-	+	-	+	0	+	+	+	+	+	+
13.Lenght of back														0	-	-	+	-	-	-	-	+	+	-	+	-	+	-	+	+	+	+	+	+
14.Back force															+	-	+	0		-	+	+	+	+	-	+	0	-	-	-	-	+	+	+
15.Loins																-	+	+	-	+	0	+	+	+	-	+	0	0	0	0	0	+	+	+
16.Slope of croup																	0	+	0	+	+	+	0	-	-	-	0	+	-	-	-	0	+	0
17.Lenght of croup																		+	-	+	0	+	+	0	+	+	+	-	+	+	+	+	+	+
18.Muscul. of hind legs																			-	+	+	0	+	+	-	+	+	-	-	-	-	-	-	-
19.Posit. of forelegs 1																				+	+	-	+	-	0	0	+	-	0	0	0	+	0	+
20.Posit. of forelegs 2																					+	0	+	-	0	0	+	0	+	0	0	+	0	+
21.Posit. of hind legs																						-	+	+	-	+	+	0	-	-	-	-	0	-
22.Posit. of hocks																							0	0	-	+	+	+	-	-	-	+	+	+
23.Devel. of hocks																								0	+	-	+	-	+	+	0	+	+	+
24.Position of pasterns																									-	+	+	-	-	-	-	+	+	+
25.Form of hoof																										-	+	-	+	+	+	-	0	0
26.Heels																											0	-	0	+	+	+	+	+
27.Volme of legs																												-	+	+	0	+	+	+
28.Subst. of forelegs																													-	-	-	-	-	-
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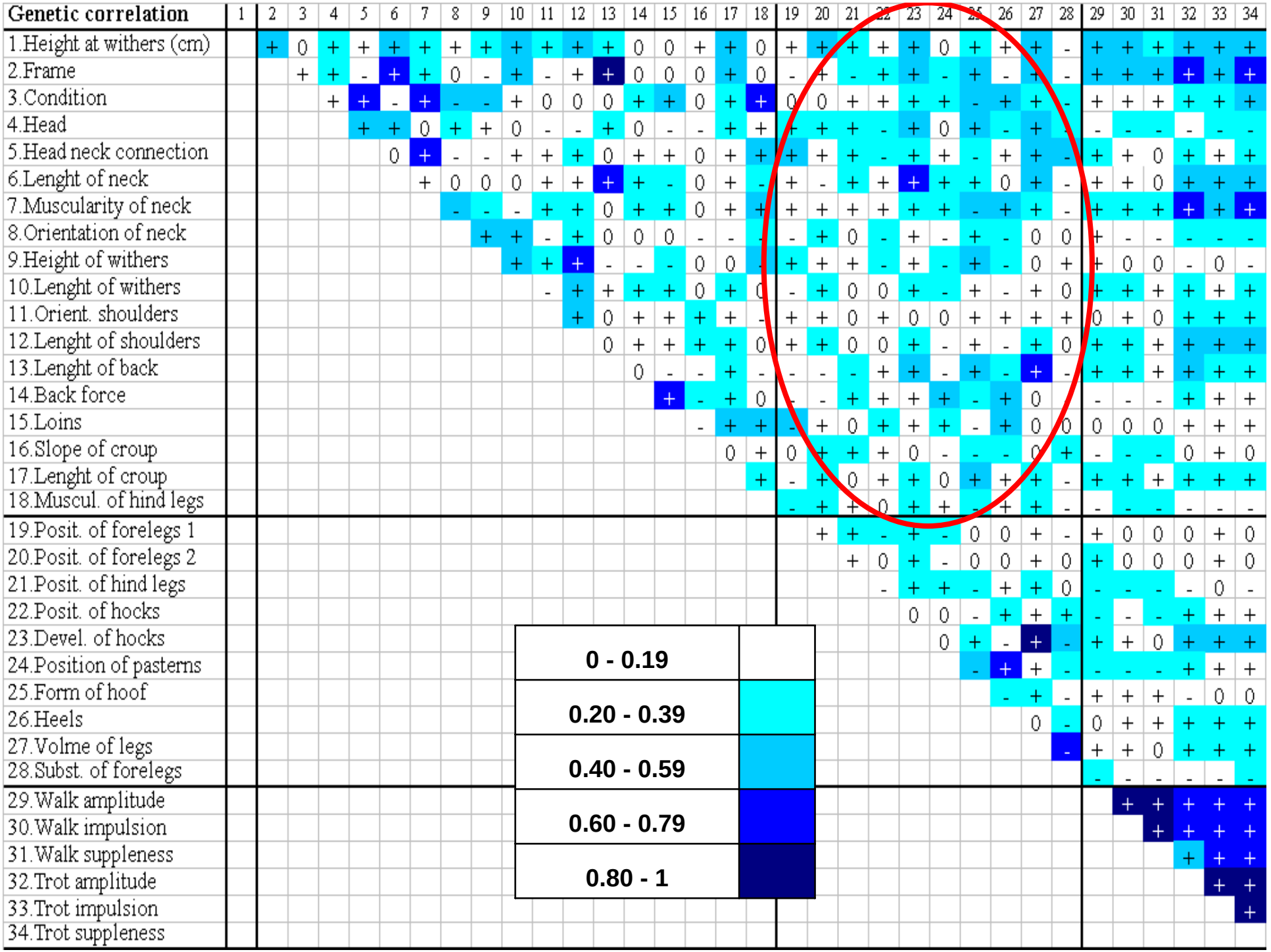
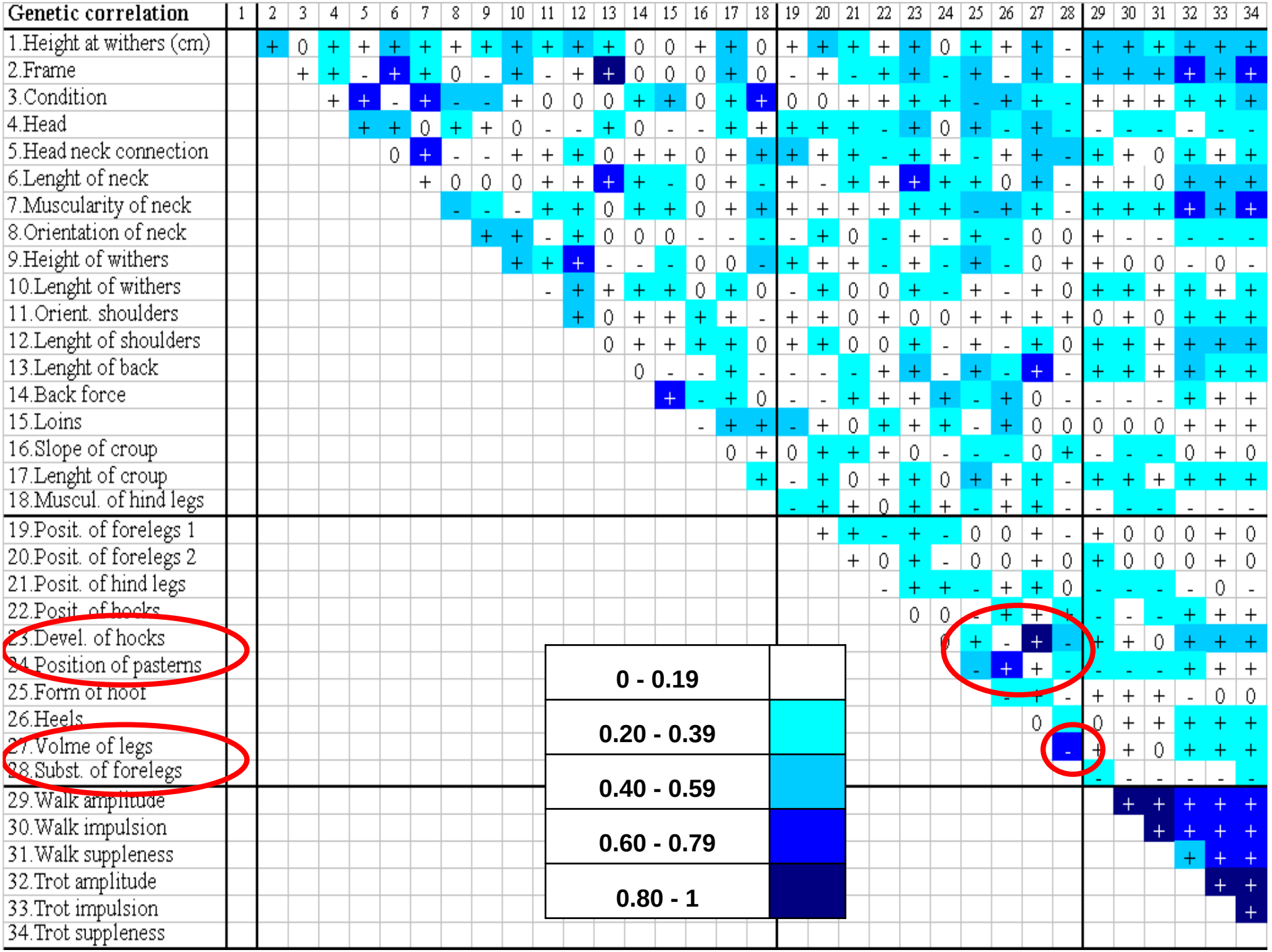
0.60 - 0.79
0.80 - 1


Genetic correlation
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31 32 33 34
1.Height at withers (cm)
2.Frame
3.Condition
4.Head
5.Head neck connection
6.Lenght of neck
7.Muscularity of neck
8.Orientation of neck
9.Height of withers
10.Lenght of withers
11.Orient. shoulders
12.Lenght of shoulders
13.Lenght of back
14.Back force
15.Loins
16.Slope of croup
17.Lenght of croup
18.Muscul. of hind legs
19.Posit. of forelegs 1
20.Posit. of forelegs 2
21.Posit. of hind legs
22.Posit. of hocks
23.Devel. of hocks
24.Position of pasterns
25.Form of hoof
26.Heels
27.Volme of legs
28.Subst. of forelegs
29.Walk amplitude
30.Walk impulsion
31.Walk suppleness
32.Trot amplitude
33.Trot impulsion
34.Trot suppleness
0 - 0.19
0.20 - 0.39
0.40 - 0.59
0.60 - 0.79
0.80 - 1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0.80 - 1

Results: Genetic Correlations

- High and moderate correlations = links between traits

  → **Indirect selection response**

Results: Genetic Correlations

- High and moderate correlations = links between traits

  → Study of separate traits

  → Multi-trait estimation

  → provide **more information**

  BUT

  Possible confusion and unexpected selection response

  → **Multiple trait selection** and **development of selection index**

Conclusions & Perspectives

Genetic parameters indicate that the linear scoring:

- provide quantitative and detailed information on distinguishable traits

  →**Easy identification of variations** between animals

- allow for an effective selection of the conformation and gaits, therefore, for horse riding abilities

  →**Implementation of procedures for breeding values estimation**

Study supported through

FNRS

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LEUVEN

Thank you for your attention

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