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PAST, PRESENT AND FUTURE OF LINEAR EVALUATION SYSTEM IN SPANISH HORSE BREEDS

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EQUINE SECTOR IN SPAIN

Ministerio de Agricultura, Alimentación y Medio Ambiente of Spain (2003)

Organization and Promotion of Equine Sector

- Zoo-technical and sanitary arrangement.
- Promotion and development of equine sector.
- Genetic improvement and conservation of equine breeds.
- Development of complementary actions.

GENETIC IMPROVEMENT OF CONFORMATION TRAITS IN SPAIN

- Conformation defines limits for range of movement and function, and the ability to perform for horses (Mawdsley et al., 1996).
- Indirect selection for performance using conformation traits might be useful because performance traits have low heritabilities and can be measured only late in life (Koenen et al., 1995).
- Traditionally, assessment of conformation is made in subjective way determined by experience of show-judges (Holmström et al., 1990, Valera et al., 2005).
- Subjective judging is defined as judging through the use of an individual feeling as the ultimate criterion for what is deemed good and correct (Magnusson and Thafvelin, 1985).
- So, collected traits can not be used in genetic evaluation of horses.
- Therefore, **application of linear assessment methodologies for the conformation control is compulsory in Spain** to obtain data for breeding evaluation of conformation traits in horses (Orden APA/1018/2003, related to the breeding programs and the performance controls for the genetic evaluation of the equines in Spain).

1.   PERFORMANCE CONTROL: DESIGNNING
(SELECTION OF TRAITS)

- Nowadays in Spain: 6 populations have a linear assessment system for the conformation control.
- Control of body measurements and subjective traits in field tests or visits to the studs.

BREED		N	MEASUR.	SUBJECT.	ANGLES	MOVEM.	END
Pura Raza Español	PRE	2512	49	83	Yes	No	2006
Menorca Purebred Horses	PRMe	347	47	19	Yes	Yes (W/T)	2011
Spanish Arab Horses	PRÁ	171	37	0	Yes	No	2007
Spanish Sport Horses	CDE	128	39	0	Yes	No	2008
Pottoka	POTT	93	27	0	Yes	No	2014
Spanish Heavy Horses	SHH	426	22	0	No	No	2008

More advanced

1. PERFORMANCE CONTROL: DESIGNNING
(SELECTION OF TRAITS)

○ Based on collected conformation data, different statistical and genetic tests were done:

TEST	USE
·Basic Statistics (mean, minimum, maximum, range, mode, CV...) ·Analysis of frequencies	Evaluation of level of **variability**. Distribution of the **classes** within the biological scale.
·t-student ·MANOVA ·Canonical analysis ·GLM	Evaluation of the **influence** of sex, aptitude, age, breeding objective of the stud... on conformation traits. Determination of the **traits related with performance** on different disciplines.
·Phenotypic correlations ·Factor analysis ·Principal component analysis ·Genetic correlations	Evaluation of the **relationship between the conformation traits, and between these and functional and biokinematic traits** for the selection of the traits and to avoid negative response to selection.
·Heritabilities	Evaluation of the **heritability** (for the selection).

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1. PERFORMANCE CONTROL: DESIGNNING
(SELECTION OF TRAITS)

○ **Primary traits:** related with a body measurement, for example: length of head or length of neck.

○ **Secondary traits:** not related with a body measurement (subjective evaluation), for example: harmony or muscular development.

○ <u>**Criteria for the selection of traits**</u>:
  • Adequate **variability** to allow selection and ensure differentiation by the appraisers.
  • No negatively **correlated** traits to avoid negative response to selection.
  • **Related** with performance, functional and biokinematic traits.
  • Adequate **heritability** level to ensure response to selection.
  • Mainly **primary** traits (more objectives and with an easier measurement).

2. PERFORMANCE CONTROL: BEGINNING
(CONFORMATION CONTROL)

○ The linear assessment for these Spanish Horse Breeds included:

BREED*	PRE	PRMe	PRÁ	CDE	POTT	SHH
N	16,430	472	129	0	164	0
REQUERIMENT	≥ 3 years	≥ 3 years	≥ 3 years	4-6 years No geldings	≥ 3 years	
SCALE	1-9	1-7	1-7	1-7	1-5	1-7
PRIMARY	20	19	29	14	15	10
SECONDARY	11	16	19	11	20	2
MOVEMENT	0	9	9	6	4	0
BEHAVIOUR	0	0	1	0	0	0
OTHERS	0	Coat color and quality	0	0	Coat color	0
WHERE**	ST MC PT	ST MC	YHPT	YHPT	ST	ST FP

• Breed: PRE is Pura Raza Español, PRMe is Menorca Purebred Horses, PRÁ is Spanish Arab Horses, CDE is Spanish Sport Horses, POTT is Pottoka and SHH is Spanish Heavy Horses.

• **Where: ST is studs, MC is morphological contests, PT is performance test, YHPT is young horses performance tests and FP is feeding places.

3. PERFORMANCE CONTROL: TESTING
(EVALUATION OF THE PROCEDURE)

○ The quality of genetic evaluations depends largely on the truthfulness of data collected.

○ In the linear methodology, it depends largely on the quality of the appraisers and the adequacy of the selected traits.

○ In order to obtain suitable information for genetic evaluations, it is essential that appraisers use the full scale and their scores are reliable.

3. PERFORMANCE CONTROL: TESTING
(EVALUATION OF THE PROCEDURE)

○ The evaluation of the procedure included different statistical and genetic tests:

TEST	USE
·**Basic statistics (mean, max., min., range, mode, CV...)** ·**Analysis of frequencies**	Evaluation of the **use of the scale** and **distribution** of the population by classes.
·**Reproducibility (Cervantes et al.,2010; Sánchez et al., 2013)**	*DEF: Probability that two appraisers produced the same appraisal for the same trait and the same horse, estimated as an intra-class correlation between horses, measured by more than one appraiser.* Evidence the **capacity of appraisers** to discern the small differences between classes within the biological scale of the population.
·**Heritabilities and genetic correlations**	Evaluating the **adequate response to selection** for traits. Evidence the **relationship** between morphological traits to reduce the number of evaluated traits and to set up a genetic index.
·**Partial least square regression analysis with request reduced rank regression methodology**	Selection of the **most predictive** linear traits over Dressage traits using breeding values.
·**Canonical analysis** ·**Chi-square test** ·**Regression analysis**	Evidence the **relationship** among traits and selecting a smaller number of traits to create a multi-character index.

3. PERFORMANCE CONTROL: TESTING
(EVALUATION OF THE PROCEDURE)

Basic statistics of 31 linear type traits analyzed in the Pura Raza Español horse population with one record by horse (2512 horses without repeated records).

PRIMARY TRAITS

Trait	Mean	Mode	Range	C.V.
Head length	5.2	5	2-9	19.4
Width of head	3.3	3	2-7	18.4
Space between jaws	3.4	3	1-9	34.9
Commissure of lips	3.0	2	1-9	41.6
Length of neck	5.8	6	1-8	25.3
Neck-body junction	3.7	4	1-9	31.4
Width of chest	4.8	5	2-9	23.8
Height of withers	5.9	7	1-9	27.3
Length of back	5.3	5	2-9	17.4
Length of loin	6.2	7	1-9	16.5
Length of shoulder	5.3	4	2-9	30.8
Angle of shoulder	7.0	7	2-9	13.4
Length of forearm	6.4	7	2-9	16.2
Cannon bone perimeter	5.2	5	2-9	21.7
Length of croup	6.3	7	2-9	15.2
Angle of croup	4.8	7	1-9	42.8
Point of hip-stifle distance	3.7	3	1-8	30.4
Ischium-stifle distance	4.4	5	1-9	22.4
Length of buttock	5.2	6	1-9	17.6
Length of leg	7.1	7	3-9	19.0

SECONDARY TRAITS

Trait	Mean	Mode	Range	C.V.
Head-neck junction	5.0	5	1-9	26.6
Upper neck line	5.5	5	2-9	23.1
Dorsal line	5.0	5	1-8	22.4
Lateral angle of knee	5.1	5	1-8	14.9
Frontal angle of knee	5.3	5	2-8	13.8
Muscular development	5.4	6	2-9	21.0
Rear tendon development	4.9	5	2-9	19.9
Hock from rear	3.9	4	1-7	19.5
Lateral hock angle	4.8	5	2-9	21.9
Breed quality	6.1	7	1-9	22.4
Harmony	5.5	5	1-9	22.6

○ Mean:
  • Between 3-7 in primary traits.
  • Mainly 5 in secondary traits.
○ Complete use of scale in most of traits.
○ All traits CV >10%, sufficient variability.

3. PERFORMANCE CONTROL: TESTING
(EVALUATION OF THE PROCEDURE)

Trait	Reproducibility of trait
Head length	0.97
Width of head	0.99
Space between jaws	0.95
Commissure of the lips	0.95
Head-neck junction	0.96
Upper neck line	0.97
Length of neck	0.95
Neck-body junction	0.97
Width of chest	0.97
Height of withers	0.93
Length of back	0.98
Length of loin	0.97
Dorsal line	0.97
Length of shoulder	0.92
Angle of shoulder	0.98
Length of forearm	0.97
Lateral angle of knee	0.99
Frontal angle of knee	0.99
Cannon bone perimeter	0.98
Length of croup	0.98
Angle of croup	0.89
Point of hip-stifle distance	0.96
Ischium-stifle distance	0.97
Length of buttock	0.98
Length of leg	0.95
Muscular development	0.97
Rear tendon development	0.97
Hock from rear	0.98
Lateral hock angle	0.97
Breed quality	0.95
Harmony	0.95

Reproducibility of 31 linear type traits analyzed in Pura Raza Español horses (876 horses with repeated records).

Reproducibility: the probability that two appraisers produced the same appraisal for the same trait and the same horse, estimated as an intra-class correlation between horses, measured by more than one appraiser.

- Reproducibilities >0.90 in all the traits, except angle of croup (0.89).
- Evidence the **capacity of appraisers** to discern differences between classes within the biological scale of the population.
- Secondary traits with CV >30% presented the lower reproducibilities (0.89-0.96).
- Armonization of definition of traits is recommended to avoid differences in the interpretation of the definitions.

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3. PERFORMANCE CONTROL: TESTING
(EVALUATION OF THE PROCEDURE)

The **genetic parameters** were estimated using a multi-trait BLUP animal model (REML methodology):

Model A: $Y_{ijklm} = Ag_i + Sex_j + Reg_k + App_l + a_m + e_{ijklm}$

Model B: $Y_{ijklmn} = Ag_i + Sex_j + Reg_k + App_l + a_m + pe_n + e_{ijklmn}$

where:
Y= the score trait
Ag = the age group of the animal (1,….,9)
Sex = the sex of the animal (1 and 2)
Reg = geographical region where the animal was born (1,.., 48)
App= the combination appraiser*event, (1,.., 61)
a = the effect of the animal (1,…,3,025)
pe= permanent environment of animal (1, ..., 876)
e= the residual error effect

3. PERFORMANCE CONTROL: TESTING
(EVALUATION OF THE PROCEDURE)

SP[3]	DWRH[4]	H[5]	OKH[6]	BWH[7]		PRE[A]	PRE[B]
					Head length	0.35	0.26
					Width of head	0.09	0.08
					Space between jaws	0.18	0.13
					Comissure of lips	0.21	0.09
	0.21	0.24	0.12	0.26	Head-neck junction	0.23	0.14
			0.16		Upper neck line	0.12	0.12
0.31	0.21	0.24	0.12	0.27	Length of neck	0.14	0.16
		0.15			Neck-body Junction	0.10	0.04
0.18			0.13		Width of Cheste	0.16	0.23
	0.19		0.17	0.34	Height of withers	0.21	0.19
	0.18			0.34	Length of back	0.23	0.12
	0.18		0.14		Length of loin	0.14	0.10
	0.16		0.12		Dorsal line	0.19	0.12
0.27	0.16	0.15	0.05	0.31	Length of shoulder	0.22	0.19
0.26		0.09	0.01		Angle of shoulder	0.06	0.01
		0.05			Length of forearm	0.16	0.10
					Lateral angle of knee	0.19	0.09
					Frontal angle of knee	0.08	0.07
			0.28		Cannon Bone Perimeter	0.30	0.22
0.21	0.15	0.23	0.06	0.30	Length of croup	0.17	0.19
0.10		0.09		0.30	Angle of croup	0.15	0.09
					Point of hip-stifle distance	0.08	0.10
					Ischium-stifle distance	0.10	0.09
					Length of buttock	0.18	0.13
					Length of leg	0.16	0.17
	0.16				Muscular development	0.17	0.12
					Rear tendon development	0.13	0.12
		0.10			Hock from rear	0.12	0.05
		0.16			Lateral hock angle	0.09	0.04
					Breed quality	0.20	0.12
					Harmony	0.17	0.08

Heritabilities estimated in Pura Raza Español horses for 31 linear traits without and with repeated records (dataset A and B, respectively).

A PRE = Pura Raza Español (12,381 horses - dataset A - without repeated record).

B PRE = Pura Raza Español (3025 horses - dataset B - with repeated record).

3 SP = Shetland Ponies (Van Bergen et al., 1993).

4 DWRH = Dutch Warmblood Riding Horse (Koenen et al., 1995).

5 H = Haflinger horse (Samore et al., 1997).

6 OKH = Old Kladrub horse (Jakubec et al., 2009).

7 BWH = Belgian Warmblood horse (Rustin et al., 2009).

- h^2 for primary traits ranged 0.06-0.35, and 0.08-0.23 for secondary ones.
- h^2 are in range with values obtained in other horse breeds.

3. PERFORMANCE CONTROL: TESTING
(EVALUATION OF THE PROCEDURE)

Genetic correlations estimated in Pura Raza Español horses for 31 linear traits without and with repeated records (model A and B, respectively).

MODEL A — 51.2% ($p < 0.05$)

MODEL B — 63.1% ($p < 0.05$)

45.0% of them were rg ≥0.50

39.8% of them were rg ≥0.50

rg≥0.90 for : breed quality-harmony and ischium-stifle distance-length of croup

3. PERFORMANCE CONTROL: TESTING
(EVALUATION OF THE APPRAISERS)

○ The evaluation of the appraisers included different statistical tests:

TEST	USE
・**Basic statistics (mean, max., min., range, mode, CV...)** ・**Analysis of frequencies**	Evaluation of the use of the **scale.**
・**Reliability (Cervantes et al.,2010)**	*DEF: Probability that the score given by the appraiser is in accordance with the measured value (body measurement), evaluated only for primary traits.* Evidence the **capacity of appraisers** to measure the animal "with their eyes".
・**Repeatability (Cervantes et al.,2010; Sánchez et al., 2013)**	DEF: *Probability of awarding the same appraisal for the same trait and the same horse in two different appraisals by the same appraiser.* Evidence the **capacity of appraisers** to repeat a measure for the same animal.

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3. PERFORMANCE CONTROL: TESTING
(EVALUATION OF THE APPRAISERS)

Repeatability of appraisers of the Pura Raza Español horse population (876 horses with repeated records).

Trait	Repeatability of Appraisers								
	1	3	4	5	6	9	10	11	12
Average	0.95	0.99	0.98	0.96	0.98	0.97	0.99	0.98	0.96
Maximum	1.00	1.00	1.00	1.00	1.00	0.99	1.00	1.00	1.00
Minimum	0.61	0.96	0.96	0.90	0.95	0.91	0.97	0.96	0.86

Repeatability: the probability of awarding the same rating for the same trait and the same horse in two ratings by the same appraiser.

○ Repeatabilities ranged between 0.61 and 1.00.

○ Average repeatability of the appraisers was acceptable (>0.95).

○ Some problems were detected for the appraiser 1, with a minimum repeatability of 0.61.

4. PERFORMANCE CONTROL: GENETIC EVALUATION

Frequency	Annually
Number of evaluations	6
h2 of primary traits	0.06-0.35
h2 of secondary traits	0.08-0.23
h2 of movements	0.27-0.32
h2 of other traits	0.08-0.40

- Genetic evaluation of linear conformation traits in Pura Raza Español horses is done annually.
- Including only a record by horse in the evaluation.
- Each year, breeding values are published in a Breeding Catalogue including the estimation of some indexes.

GENETIC INDEXES OF CONFORMATION		FORMULA
Head-Neck	HNI	$0.50 \cdot VG_{\text{head-neck union}} + 0.50 \cdot VG_{\text{length of neck}}$
Body	BI	$0.20 \cdot VG_{\text{height of the withers}} + 0.40 \cdot VG_{\text{length of back}} + 0.40 \cdot VG_{\text{back-loin line}}$
Forelimb	FLI	$0.25 \cdot VG_{\text{length of scapula}} + 0.25 \cdot VG_{\text{angle of scapula}} + 0.25 \cdot VG_{\text{frontal angle of knee}} + 0.25 \cdot VG_{\text{lateral angle of knee}}$
Hindlimb	HLI	$0.15 \cdot VG_{\text{length of croup}} + 0.20 \cdot VG_{\text{angle of croup}} + 0.10 \cdot VG_{\text{ischium-stifle distance}} + 0.15 \cdot VG_{\text{length of leg}} + 0.10 \cdot VG_{\text{muscular development}} + 0.15 \cdot VG_{\text{posterior direction of hock}} + 0.15 \cdot VG_{\text{lateral angle of hock}}$
Global Index for Dressage	GID	**0,1*HNI+0,2*BI+0,2*FLI+0,5*HLI**

5. PERFORMANCE CONTROL: PUBLICATION OF RESULTS

Horse identification and pedigree

In this section, the identification data appears as registered in the PRE Stud Book

HORSE IDENTIFICATION

UELN / STUDBOOK CODE: 000000000000000

MICROCHIP: 000000000000000

SEX: XXXXXX

DATE OF BIRTH: 00/00/00

BREEDER: BREEDER

OWNER: OWNER

PEDIGREE

Breeder Brand

Black
Bay
Gray
Chesnut
Roan
Buckskin
Gray

The names of the horse's forebears to the second generation appear here (parents/grandparents), their brands and the coat colors.

Partial Conformation Genetic Indexes

Based on the 16 individual genetic values of the conformation variables, four partial conformation genetic indexes for dressage are obtained.

The partial conformation genetic index values range from 0 to 10, with 10 being the ideal for that functional conformation.

INDEXES	VALOR	REP.	7	8	9	10
HEAD-NECK	9,13	ooooo				
BODY	8,86	ooooo				
FORELIMB	9,33	ooooo				
HIND LIMB	8,85	oooo				

NUMBER OF RELATIVES VERIFIED AS PARTICIPANTS IN PERFORMANCE TEST
00

NUMBER OF RELATIVES GENETICALLY ASSESSED
000

The genetic index goes hand-in-hand with repeatability, which indicates the precision of the estimation.

This value ranges between 0 and 1; the greater the value, the greater the precision of the horse's genetic index value.

The level of repeatability depends, among other factors, on the heritability factor and the genetic correlations obtained for each trait.

* Very low (< 0.1)
** Low (≥0.1 - < 0.2)
*** Average (≥0.2 - < 0.4)
**** High (≥0.4 - < 0.6)
***** Very High ≥0.6

Global Conformation Genetic Index

The Global Conformation Genetic Index for Dressage consists of 4 partial conformation genetic indexes, which include a total of 16 conformation breeding trait values.

The values of the Global Genetic Indexes for Riding and Dressage are standardized. They range between 80 and 120, with the population average being 100.

All horses with values above 100 will have a conformation improvement value for Riding or Dressage. The closer to 120, the better the improver.

INDEXES	VALOR	REP.	100	105	110	115
CONFORMATION	104,02	☆☆☆☆				

Based upon the established criteria in the PRE Breeding Program, genetically assessed horses may obtain any one of the breeding stock categories contemplated.

ELITE BREEDING STOCK

6. FUTURE OF LINEAR ASSESSMENT IN SPAIN

- **Spanish Arab Horse**: Analysis of linear type traits evaluated in order: to ensure their adequacy, to evaluate the appraisers and to reduce the number of traits.

- **Menorca Purebred Horse**: Continuation of the linear control, including more animals with performance records in Dressage in order to select the traits to be included in the genetic indexes.

- **Pura Raza Español Horse**: Revision of genetic indexes including more information about relationships between conformation and functional performance in Dressage. Movements are included in the new control.

THANK YOU VERY MUCH FOR YOUR ATTENTION