INTEGRATION OF LINEAR ASSESSMENT OF CONFORMATION TRAITS IN BREEDING PROGRAMS: POTENTIAL AND LIMITATIONS

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LINEAR ASSESSMENT IN SPAIN

- Nowadays in Spain: 6 populations with a linear assessment system for conformation control
- Conformation control in studs, morphological shows, test for mares and stallions …

<table>
<thead>
<tr>
<th>BREED</th>
<th>PRE</th>
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<tbody>
<tr>
<td>Pura Raza Español</td>
<td>PRE</td>
</tr>
<tr>
<td>Menorca Purebred Horses</td>
<td>PRMe</td>
</tr>
<tr>
<td>Spanish Arab Horses</td>
<td>PRÁ</td>
</tr>
<tr>
<td>Spanish Sport Horses</td>
<td>CDE</td>
</tr>
<tr>
<td>Pottoka</td>
<td>POTT</td>
</tr>
<tr>
<td>Spanish Heavy Horses</td>
<td>SIH</td>
</tr>
</tbody>
</table>

Most advanced

- Evaluation sheets are in constant evolution as the populations
CONFORMATION - DRESSAGE PERFORMANCE

- Back et al. (1996) affirmed that **ideal conformation does not exist**, because a conformation trait could be both advantageous for a certain locomotive characteristic and detrimental to other.
- Dressage performance **does not depend solely on conformation**. A long period of learning and training is required for a horse to achieve the greatest level, which entails a major economic investment.
- Favorable conformation is not the only requirement to obtain good movements, but **a minimum level of conformation is needed** to obtain a good horse.
- Searching traits indirectly related to dressage performance would allow early selection of animals. So, **studs can save money** and use it with animals which have morphological athletic skills.
- Selection of horses which display adequate morphological qualities for dressage would **benefit genetic progress** and allows the **screening of animals** before undergoing training (Koenen et al., 1995; Olsson et al., 2008; Ducro et al., 2009).

BREEDING PROGRAM OF PURA RAZA ESPAÑOL HORSES

*(Resolución del 8 de mayo de 2012 (BOE-A-2012-7035))*

- **Main aim**: the improvement of the morphology, the conformation and the functionality.
  - To obtain healthy animals, without hereditary defects.
  - To improve the morphological characteristics of the breed, according to the standard established for PRE horses.
  - **To improve the conformation for sport performance, mainly in Classic Dressage**.
  - To improve the functional potential of PRE horses for different sports, mainly in Classic Dressage.
  - To maintain and improve the behaviour characteristics.
DESIGNING AN EARLY SELECTION MORPHOLOGICAL LINEAR TRAITS INDEX FOR DRESSAGE IN PRE HORSE

Main interest: to assess the possibility of obtaining an indirect selection criterion that allows a pre-selection of horses to take part in dressage, creating an early morphological selection index which includes conformation and dressage traits.

WHY??

- Increased interest for horses with higher performance in competitions
- Greater economic value of animals with superior dressage performances
- The selection of animals which display adequate morphological qualities for dressage performance would benefit the genetic progress
- The screening of the animals before undergoing training for dressage (pre-selection of animals with more adequate conformation) saves time and money
DESIGNING AN EARLY SELECTION MORPHOLOGICAL LINEAR TRAITS INDEX FOR DRESSAGE IN PRE HORSE

AVAILABLE DATA

- 19,095 PERFORMANCE records
  Collected between 2004-2014 at 469 official dressage test for young horses in Spain
  - 1,545 horses (1,476 males and 69 females)
    Average 12.4 records/animal
  - Aged between 4-6 years old

6 Dressage Traits (average of 3 individual judges):
  walk, trot, canter, submission, general impression and total score

- 1,545 horses

- 687 horses with PERFORMANCE and CONFORMATION data
  with 5,359 common ancestors

- 10,127 linear CONFORMATION records
  Collected between 2008-2013
  - 10,127 horses (4,159 males and 5,968 females)
    1 record/animal (average of 2 appraisers)
  - ≥ 3 years-old

26 Linear Traits (20 appraisers, previously trained and tested, in a scale of 9 classes):
  18 primary traits and 8 secondary traits

STEP 1: ESTIMATION OF PRELIMINARY VARIANCES AND BREEDING VALUES

An univariate animal model was applied for the 6 Dressage and 26 Linear Traits

**Genetic Model for the 6 Dressage traits - DT** (Sánchez et al., 2014)

\[ Y_{ijklmnopq} = \text{Age}_i + \text{Sex}_j + \text{Stress level}_k + \text{Training level}_l + \text{Stud of birth}_m + \text{Event}_n + \text{Rider}_o + \text{Rider-Horse inter}_r + \text{permanent environment}_s + \text{Anim}_t + \varepsilon_{ijklmnopq} \]

**Genetic Model for the 26 Linear traits - LT** (Sánchez et al., 2013)

\[ Y_{ijklm} = \text{Age}_i + \text{Sex}_j + \text{Geographical Region}_k + \text{Appraiser*event} + \text{Anim}_m + \varepsilon_{ijklm} \]

PEDIGREE: at least 4 generations of all the animals in control = 37,231 animals
A partial least square procedure using the reduced rank regression factorial extraction method was implemented to investigate the relationship between the 26 LT (as model effects) and the 6 DT (as dependent variable). Wold criterion > 1 was applied to select the variables with a greater importance for projection statistic.

**STEP 2: SELECTION OF LT MOST CLOSELY RELATED WITH DT**

3 STRATEGIES based on different dependent variables:

- **Total Score** = Final score in the reprise
- **Partial Scores** = walk, trot/canter, submission and general impression
- **Gait Scores** = walk, trot and canter

A total of 13 LT selected:

- neck-body junction, width of chest, angle of shoulder, cannon bone perimeter, length of croup and angle of croup.
- width of head, head-neck junction, neck-body junction and lateral angle of knee.
- upper neck line, frontal angle of knee, ischium-stifle distance and lateral hock angle.

DESIGNING AN EARLY SELECTION MORPHOLOGICAL LINEAR TRAITS INDEX FOR DRESSAGE IN PRE HORSE

**STEP 3: ESTIMATION OF GENETIC PARAMETERS TO GUARANTEE THAT GENETIC AND PHENOTYPIC CORRELATIONS ARE CONSISTENT AND COVARIANCE MATRIX IS POSITIVE**

A multivariate animal model was applied for the 6 DT and the 13 LT selected. Only animals with DT and LT were included in the analysis.

- **Genetic Model for the 6 Dressage traits (Sánchez et al., 2014)**
  \[ Y_{ijklmnpq} = A_i + S_{jk} + S_{lm} + T_{il} + E_{k} + R_{ij} + R_{i} + a_{p} + e_{ijklmnpq} \]

- **Genetic Model for the 13 Linear traits (Sánchez et al., 2013)**
  \[ Y_{ijklm} = A_i + S_{jk} + R_{k} + A_{lm} + a_{m} + e_{ijklm} \]

PEDIGREE: at least 4 generations of all the animals in control = 5,359 animals.
DESIGNING AN EARLY SELECTION MORPHOLOGICAL LINEAR TRAITS INDEX FOR DRESSAGE IN PRE HORSE

**Genetic parameters (heritabilities and genetic correlations) for 6 DT and 13 LT**

<table>
<thead>
<tr>
<th>Heritability</th>
<th>Walk</th>
<th>Trot</th>
<th>Canter</th>
<th>Submission</th>
<th>General impression</th>
<th>Total score</th>
</tr>
</thead>
<tbody>
<tr>
<td>Width of head</td>
<td>0.21</td>
<td>0.27</td>
<td>0.33</td>
<td>0.31</td>
<td>0.30</td>
<td>0.30</td>
</tr>
<tr>
<td>Head-neck junction</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Upper neck line</td>
<td>0.44</td>
<td>-0.12</td>
<td>-0.13</td>
<td>-0.13</td>
<td>-0.12</td>
<td>-0.13</td>
</tr>
<tr>
<td>Neck-body junction</td>
<td>0.36</td>
<td>0.24</td>
<td>0.06</td>
<td>0.16</td>
<td>0.12</td>
<td>0.15</td>
</tr>
<tr>
<td>Width of chest</td>
<td>0.14</td>
<td>-0.22</td>
<td>-0.17</td>
<td>-0.20</td>
<td>-0.29</td>
<td>-0.25</td>
</tr>
<tr>
<td>Angle of shoulder</td>
<td>0.31</td>
<td>-0.20</td>
<td>-0.30</td>
<td>-0.22</td>
<td>-0.10</td>
<td>-0.20</td>
</tr>
<tr>
<td>Lateral angle of knee</td>
<td></td>
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<td></td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>Frontal angle of knee</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Cannon bone perimeter</td>
<td>0.22</td>
<td>0.44</td>
<td>0.20</td>
<td>0.16</td>
<td>0.24</td>
<td>0.26</td>
</tr>
<tr>
<td>Length of croup</td>
<td>0.16</td>
<td>0.10</td>
<td>0.22</td>
<td>0.08</td>
<td>0.12</td>
<td>0.13</td>
</tr>
<tr>
<td>Angle of croup</td>
<td>0.53</td>
<td>0.21</td>
<td>0.12</td>
<td>0.13</td>
<td>0.24</td>
<td>0.19</td>
</tr>
<tr>
<td>Ischium-stifle distance</td>
<td></td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>Lateral hock angle</td>
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</tbody>
</table>

Heritabilities ranged 0.12-0.53 for LT and 0.21-0.33 for DT, suitable for genetic selection

Genetic Correlations between LT and DT ranged 0-0.46 (moderate-low magnitude)

DESIGNING AN EARLY SELECTION MORPHOLOGICAL LINEAR TRAITS INDEX FOR DRESSAGE IN PRE HORSE

**STEP 4: ESTIMATION OF GENETIC RESPONSE TO DIFFERENT INDICES**

*Selection index* provided a natural connection between the net merit of an animal's genotype and its relationship to profitability.

Classic selection indices theory of Hazel and Lush (1943), and its reformulation for the use of breeding values of Gutiérrez et al. (2014)

**Type 1:** Selection Criteria based only on breeding values for dressage traits

**Type 2:** Selection Criteria based only on breeding values for linear traits

**Type 3:** Selection Criteria based on breeding values for linear and dressage traits

Each DT was given the same economic weight in the index, to study relative genetic responses starting with genetic parameters.

For the comparison of computed responses:
- A selection intensity of 1 was assumed (as a constant)
- The global genetic expected response was calculated when 3-5 objectives were included in the same indices (as the average)
# Designing an Early Selection Morphological Linear Traits Index for Dressage in PRE Horse

**Expected Genetic Responses for the Morphological Selection Indices Related to Dressage Aptitude in the Pura Raza Española Horse**

<table>
<thead>
<tr>
<th>Objective</th>
<th>Index</th>
<th>Criteria</th>
<th>Walk</th>
<th>Trot</th>
<th>Canter</th>
<th>Submission</th>
<th>General</th>
<th>Impression</th>
<th>Total</th>
<th>Score</th>
<th>Mean</th>
</tr>
</thead>
<tbody>
<tr>
<td>Type 1</td>
<td>TS</td>
<td>PS</td>
<td>1.80</td>
<td>1.80</td>
<td>0.76</td>
<td>0.76</td>
<td>2.97</td>
<td>2.97</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Type 2</td>
<td>TS</td>
<td>10 LT</td>
<td>1.04</td>
<td>1.03</td>
<td>0.98</td>
<td>0.98</td>
<td>2.02</td>
<td>2.02</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Type 3</td>
<td>TS</td>
<td>10 LT+PS</td>
<td>0.12</td>
<td>0.15</td>
<td>0.18</td>
<td>0.18</td>
<td>0.16</td>
<td>0.16</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Type 1</td>
<td>PS</td>
<td>8 LT</td>
<td>0.13</td>
<td>0.16</td>
<td>0.18</td>
<td>0.18</td>
<td>0.16</td>
<td>0.16</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Type 2</td>
<td>PS</td>
<td>8 LS+TS</td>
<td>0.10</td>
<td>0.15</td>
<td>0.15</td>
<td>0.15</td>
<td>0.15</td>
<td>0.15</td>
<td></td>
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</tr>
<tr>
<td>Type 3</td>
<td>PS</td>
<td>7 LT</td>
<td>0.04</td>
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<td>0.03</td>
<td>0.03</td>
<td>0.03</td>
<td>0.03</td>
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<tr>
<td>Type 3</td>
<td>PS</td>
<td>7 LS+TS</td>
<td>0.12</td>
<td>0.15</td>
<td>0.17</td>
<td>0.17</td>
<td>0.17</td>
<td>0.17</td>
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</tbody>
</table>

TS: Total score; PS: Partial score; walk = trot = canter = submission = general impression. GS: Gait Score = walk + trot + canter.

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**Potential of LT**

1. **Rapid, simple and cheap** performance control. It does not require previous preparation of animals. Therefore, all population can be controlled.
2. **Objective** system (mainly for primary traits). The appraiser does not compare the animal with the ideal individual.
3. **Descriptive** system which includes all variability of the population for each trait. Therefore, all the differences between the animals are controlled.
4. **Positive** system which determines the characteristics that an individual can transmit to the next generations. Therefore, it is interesting for breeders to obtain a general improvement of conformation and to correct punctual defects.
5. **Informative** system. It evidences the sense of deviation. Therefore, it can be used for the evaluation of each trait and for the genetic evaluations.
6. **Flexible system in time and space.** Breeding evaluations can be useful also if breeding objectives or conformation changes in time.
POTENTIAL OF LT

1. These characteristics ensure higher heritability values than other conformation evaluation systems.

2. Although the use of LT index had a relatively lower response, it is essential for the early pre-selection of young horses without DT but with an adequate conformation to be trained for specific disciplines with high costs of preparation and training in terms of time and money (e.g., Classic Dressage).

3. The use of linear assessment also allows the increase of reliability of traits related with other performance controls and the increase of the number of animals available for selection with an acceptable genetic response, which optimize the breeding program in terms of time and money.

4. The inclusion of negative characteristics and defects, with interest for the breeders, allows the knowledge of their incidence and the selection to avoid them:

   Fe. In the PRE horses: cresty neck, invert neck, melanoma, vitiligo and white leg marks are included.

   In Menorca Horses: quality of coat color, white marks and leg defects are included.

LIMITATIONS OF LT

In the designing of the sheet

1. Previous analysis of phenotypic data are needed (to control limits, distributions, variability, relationships...) Although the correct pre-selection of traits related with performance from the beginning is very difficult (impossible?).

2. Some conformation traits are not suitable to be included as primary traits (low variability, difficult to be objectively measured...), because sometimes characteristics with interest for breeders are complex. Therefore, an objective evaluation is more difficult.

3. A clear definition of traits is needed to ensure correct collection of data, mainly for secondary traits and the number of classes has to be adjusted to obtain major discrimination with most accurate evaluations to obtain adequate repeatability.

4. The teaching and training of appraisers is compulsory to ensure adequate information from the beginning.

5. The use of linear assessment for pre-selection of young horses has to be supported by other evidences (e.g., adequate results of the ancestors in control).
LIMITATIONS OF LT

In the data collection

1. An excessive number of traits makes difficult the data collection and processing.
2. The correct classification of some traits is difficult if the range of classes is large (e.g., angles).
3. The evaluation of traits related with bone references is more difficult in animals selected for meat production, because bone references are difficult to detect.
4. The maximum homogenization of presentation conditions is needed to reduce environmental effects.
5. The system can not be used during all life of animals (against molecular systems). Therefore, it is necessary to determine the range of age and other conditions for the animals to homogenize the evaluation (if they are very young, maturity is not reached; if they are very old, conformation could be modified by “life conditions”).

LIMITATIONS OF LT

In the use of the data

1. Appraisers have to be periodically tested to verify that information is adequate and system is correct.
2. If traits have a low number of useful classes (used by appraisers), they have to be analyzed as categorical traits, which difficulties their application in selection.
3. Populations are alive elements. Therefore the periodical review of traits and ranges is needed to adapt system to the changes in the population because of selection and other needs.
4. To ensure the adequate use of available data for the selection of general conformation, the creation of indexes is needed. But if animals are selected for different performances, the use of adequate indexes for each performance is needed. And the indexes have to be periodically re-evaluated.
5. If a high number of criteria are included in the evaluation system without testing relationships between them, there is a risk of obtaining a poor global response.
THANK YOU VERY MUCH FOR YOUR ATTENTION