




REPORT

GENETIC ASSESSMENT OF THE LINEAL MORPHOLOGICAL TRAITS



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The main objective of ANCCE, commissioned to develop the Purebred Spanish Breeding Program, after approval by the Ministry of Agriculture, Fisheries and Food in 2004 and under the Technical Management of the MERAGEM Research Group, is to improve the morphology, conformation and functionality of the PRE horse. To do this, it is necessary to carry out performance tests and genetic assessments on horses for each one of the three aptitudes contemplated in the Breeding Program: Dressage, Conformation and Aptitude for Riding.

This Program was designed respecting all the mandates as established in legislation APA1018/2033 and RD2129/2008. Likewise, the opinions of representatives from the various breeder associations, riders, breeders, judges and specialists in the equine and equestrian sectors were borne in mind when drafting the project.

With this article, Mercedes Valera, Technical Director of the research group, will ensure that we better understand aspects related to the genetic assessment of morphology, starting from the lineal morphological score.

Text: Mercedes Valera

Within the scope of the Purebred Spanish Horse (PRE) Breeding Program, the selection criteria and the genetic assessment have been established for:

Functional Traits have been derived through information obtained from the participation of the horses in the “Young Horses Selection Tests” (PSCJ) for Dressage and in federation tests. This information is used to perform the Genetic Assessment for the Functional Aptitude in Dressage and the horses, depending on their Genetic Value and its level of reliability, could achieve the genetic categories of “Young Recommended Breeding Stock” and “Improver Breeding Stock.”

Conformational Traits are derived from the phenotype data collected on the Lineal Morphological Score record sheet, when horses are measured. In this case, the purpose is to genetically and individually assess a series of morphological traits so that the breeder has information about the “correction” capacity of a given horse for each morphological trait. Similarly, when the various traits are combined in a genetic index, it provides a pondered value based upon the relationship of the morphological trait with the functional capacity, with which a Genetic Index for the Conformation for Dressage may be obtained.



“ The Genetic Values for the various conformation characteristics enable the breeder to select the sire stallions that could correct defects in their progeny ”

In this report I shall focus on explaining the Genetic Assessment of the lineal morphological traits, since in the 2010 Catalog of Young Recommended Breeding Stock for Dressage there is a detailed explanation of the genetic assessment of functional traits for Dressage. You can view the catalog on the ANCCE web-site: www.ancce.com

THE GENETIC VALUE OF A HORSE

The genetic value of an individual, for a series of individual traits—in this case morphology—is a global reflection of the expression of an undetermined number of genes which influence that trait. This value—given there is a lack of sufficient molecular information to estimate it directly—has to be estimated from the phenotype assessment of the lineal morphological features, both of the individual horse, as well as any relative that has participated in the performance tests (the closer the relationship, the more influence it has on the score). Therefore, it is essential to have all possible genealogical registers of its relatives. In other words, the genetic value of a horse is highly influenced by the number of relatives in performance tests, as well as by the degree of kinship between them.

The idea of determining the genetic value of a horse is to allow the breeder to choose the best horses—from the genetic point of view—to be the parents of the next generations. Nevertheless, there may be

a greater or lesser degree of discrepancy between the phenotype (conformation) of the horse (what the breeder sees or perceives directly when observing the horse) and what is expected of it (the capacity of a horse to transmit certain traits to its descendants depending on the

horse with which it is mated). Due to this, an important concept is included in the genetic assessments: the permanent environmental effect (any effect that the horse has suffered throughout its life, especially in its early years, which has a conditioning effect on the expression



Poseída RH, Young Recommended Mare for 2011 - 2012, owned by Yeguada Tomás Osborne

of its phenotype, but not on that of its descendants).

For a horse to be genetically assessed, ideally, the actual horse participates in performance tests. However, a genetic assessment may be performed with the information contributed by its relatives, even though no data is available for the horse itself.

Although there are a variety of methodologies available to carry out a genetic assessment, in practice, the methodology known as BLUP (Best Lineal Unbiased Pre-

dictor) is used, as it uses a number of information sources in the most efficient way possible:

- Data collected in the performance tests (phenotype)
- Environmental data (judge, stud farm, location where the performance test takes place, age, sex, etc.) that enables the performance data to be corrected
- Genealogical information

The most important traits in the BLUP Animal Model used for the

assessment of breeding stock include:

- Assessment of both males and females, including traits that are expressed in only one sex.
- Genetic assessment (GA) of a horse with the information from the horse itself (where available) and the information of any horse with whom it is genealogically related (any degree of kinship).
- The influence, when estimating the GA of an individual, of the



horses that have any family ties with the horse to be assessed, shall also depend on the degree of kinship for each.

- Family relationships in the genetic assessment models to allow the reliability of the genetic value to be increased. This is very important for those horses that have not yet had any descendants or those with very few, because GA can be considered with a high degree of reliability if the number of relatives in performance tests is high.
- Correcting the genetic assessment for all the environmental effects that could influence the performance of the horse.

Therefore, the BLUP methodology used also allows the relatives of those horses in performance tests to be assessed, even though those relatives have no phenotype information available. The greater the information available to carry out the genetic assessment, the more the estimated genetic value of a horse correlate with the phenotype value expected from its descendants. That is to say, the assessment is carried out both using data from the horse itself, as well as from an elevated number of relatives with performance data (above all direct offspring, siblings and parents), in addition to the fact that the assessed feature has a high degree of heritability.

The reliability of the prediction depends on the heritability of the assessed trait, the amount of available information (data from the horse itself, from siblings, half siblings, parents, offspring, grandparents, cousins, uncles, etc.), its structure (connections between all the horses in performance tests and proximity of the relationship between horses), the regularity of the performance tests of all its relatives, the knowledge of the pedigree (depth and degree of genealogical completeness), etc.

In conclusion, the genetic value indicates a prediction of the genetic

merit and not the phenotype merit. The higher is its level of reliability, the safer the prediction. Due to this, a horse acquires the category of “Improver Breeding Stock” when there is now sufficient information to ensure that it is able to transmit its good conformation or aptitude to its descendants. Therefore,



“ The Genetic Value of a horse is highly influenced by the number of family members involved in performance tests, as well as by degree of kinship between them ”

“Improver Breeding Stock” must exceed a specific level of reliability. A horse achieves the genetic category of “Improver Breeding Stock” when its Global Genetic Index exceeds 100 and its reliability level is equal to or exceeds 60%. Logically, it has demonstrated its reproductive capacity by having offspring registered in the Stud Book (in such case that the said horse is not sterile).

THE ASSESSMENT OF MORPHOLOGY AND CONFORMATION IN EQUINES

In generally, the assessment of morphology (with regards to the ideal concept of beauty) and conformation (suitability of the morphology for a certain aptitude) in equines has been performed in a subjective manner, when a judge assess the greater or lesser proximity of the horse’s morphology to his/her ideal concept for the breed (this without attempting to assess the greater or lesser influence of external factors for the horse itself in the score it receives). This fact, together with it not being descriptive (a head with 7 points may be due to a multitude of possibilities,

very small, very large, very convex, very straight, etc.) and not indicating the direction of the deviation (these same 7 points would be applied to a head that was either too small or too large) have meant that these morphological scores were not suitable for genetic assessments (and in the event they were used,

they have a low degree of heritability and reliability).

Until the “Lineal Morphological Score System” (LMS) was set up, the methods for morphological assessment developed to date in Spain lacked properties suited to the objectives of improvement established in the PRE Breeding Program.

It is important to clarify that the LMS is not a classic assessment for morphology, which assigns a series of points to a specific body area of a horse, depending on whether the judge considers that the horse looks more or less like his/her ideal. It is a much more objective system, in which the horse is divided into simple anatomical features for scoring. The job of the judge is to translate the degree to which the horse shows a specific morphological trait on a numeric scale, which corresponds with the biological scale. That is to say, the minimum degree of expression of a trait corresponds to the lowest class and the maximum expression with the highest class, with a number of intermediate degrees. The highest class need not necessarily correspond to the best morphological score; it is possible that the most preferable class is



Universitaria XIV, Young Recommended Breeding Stock 2011 - 2012, owned by Hacienda del Sol Andalusians & bred by Francisco Santiago

the lowest or an intermediate class. Logically the scale must be sufficiently ample for the differences between the individuals to be well marked, at the same time as being differentiable for the judges.

Therefore, upon approving the Breeding Programs for the various Spanish equine breeds, it was essential to approach the development of a methodology able to translate the degree of expression of a morphological trait onto a continuous numeric scale of values according to a fixed model, to provide an objective, descriptive and numeric description of each one of the traits to be genetically assessed. This system—a reference for all breeding programs developed for any species—seeks to obtain objective and useful information to then be incorporated into the genetic assessment of the future breeding stock for selective breeding purposes, but always looking for the most

suitable conformation for a certain competitive aptitude.

When it comes to the assessment for morphology in the sense of beauty, LMS is of no interest nor is it recommended (beauty in the sense of harmony of form is a combination of many morphological aspects in the horse that need not necessarily bear any direct relation with an optimal functional capacity).

In summary, the main objective of this methodology is the collection of morphological information in a usable format for the genetic assessment of breeding stock. In this case, a breeding horse with a high genetic value (e.g. genetic value for “length of the croup”) would indicate that a given is able to transmit much longer croups to its offspring, without implying that that is positive or negative. On the contrary, a horse with a very negative genetic value would imply that,

it is more than probable (according to the precision or reliability of this genetic assessment) that its descendants would have shorter croups. The main application for the use of this assessment of the simple lineal features is in the use of so-called “corrector” horses; in other words, if my stud farm tends to produce overly-long croups, I can look for a sire stallion with a high genetic value for this trait, to obtain a descendant with that trait corrected.

The second clear use of genetic assessments for the lineal morphological features is to combine them in a Global Genetic Index that assesses the most appropriate conformation for a specific function. In this case, the genetic values of the most important features for a certain aptitude have to be compared with the morphology considered ideal for that functionality (e.g. inclination of the shoulder, straightness of the back or inclination of



“ The Lineal Morphology Score Sheet has been designed by a multidisciplinary team made up of Dressage judges, Conformation judges, breeders & numerous specialists in locomotion, ethnology & genetics ”

the croup in the case of Dressage). Thus, a horse with a high genetic value in the Combined Genetic Index (formed by weighting the lineal morphological features included in the index) is the one that is able to transmit a morphology closest to the ideal for a certain functionality (which, in the case of the PRE is Dressage), independently of whether the horse is more or less beautiful or harmonious or whether the horse has participated or not in Dressage tests).

It was necessary to develop a specific methodology for each breed. Within each breed, the necessary specifics of the Genetic Indexes had to be adjusted for each aptitude.

THE LMS IN THE PRE

The MERAGEM Research group, with financing from the Ministry of Agriculture, Food and the Environment, developed the LMS methodology in the PRE over several years. This research required the intervention and collaboration of various PRE breeders, expert riders, morphology judges, Dressage judges as well as specialists in ethnology, locomotion and genetics. There were several stages in the development of the Lineal Morphological Score System:

1. A complete zoometric study of a representative number of individuals from within the Breed. After collecting the field information, a statistical study of the variables was carried out to:

- a. Characterize the Breed from the point of view of its conformation, by interpreting the results obtained in the statistical study of the variables.
- b. Pre-select the variables to be included on the LMS record sheet, depending on the level of variability existent in the population, the heritability values obtained (percentage of the total variation among horses for a particular feature due to inherited genes) and the existent correlation between the different variables.
- c. Determine the biological ranges for each of the classes. It is necessary to objectively define the limits of each established class for each morphological feature, so that the judge is able to classify each feature (morphological variable) within the various classes proposed, with no need measure the horse directly.
- d. Determine the correlation between the morphological traits and the results of the horses in Dressage tests. The objective is to determine those morphological traits have most influence on the functional capacity of the horses, so that once the genetic assessment of the morphological traits has been carried out, individually, the genetic values of certain traits can be weighted in a genetic index that expresses the capacity to transmit to a horse a conformation suitable for a specific functionality (Dressage).

2. Once the preliminary LMS record sheet had been designed, it was tested in the field by a team of judges, before using the information obtained in the Genetic Assessment of the horses. This phase is part of the systemic analysis of the assessment of the record sheet itself, and the pre-training of the assessors.

3. Once the definitive record sheet was available, it was necessary to train and select judged to would carry out the LMS during the performance tests. This was undertaken with two training courses for judges. Nevertheless, training and validation of the judges are performed from time to time, to ensure the reliability and uniformity of their scoring.

After several years of fine-tuning this scoring methodology in the PRE horse, the final LMS record sheet was elaborated, which has been being systematically used in the performance tests. At present, this record sheet consists of 29 lineal traits and 2 general traits, with 9 classes for each one. Nevertheless, it must be noted that the Lineal Morphological Score systems are not static, since horse populations (breeds) evolve and the assessment record sheets must do the same. The changes made to the record sheets take place based on the constant validation processes of the system and the judges, as well as the achievement of the breeding objectives on behalf of breeders.

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GENETIC ASSESSMENTS AND BREEDING STOCK CATEGORIES CORNERED THE ONLINE MEETING WITH MERCEDES VALERA



The Technical Director of the PRE Breeding Program, Mercedes Valera, participated in the third online meeting organized by ANCCE. She had the opportunity to respond to almost fifty questions formulated by internet users through the public area of the association web-site.

Given the great interest it sparked, an extract of this meeting is included herein as a complement to the report written by Dr. Valera

Johnny: In Colombia, I have a sire stallion that is TQB and YRBS.¹ What do I have to do so that the achievements, both in Conformation competitions and in Dressage competitions, of this horse and his descendants, are assessed and borne in mind for the future?

Mercedes Valera: the achievements of all horses participating in Dressage tests in which performance tests and lineal assessments are carried out are borne in mind in any genetic assessment being made. The data is accumulative from one assessment to the next. Due to this, the number of horses included in our databases is continually increasing; therefore, it is essential to have "work stations" to be able to carry out the assessments. Nevertheless, it would be a good idea for the offspring of your YRBS sire stallion to participate in Dressage or undergo the lineal morphological score, since, if the results are

good, in addition to the results of other horses that have some degree of relationship with your horse, he could, in the future achieve the category of Improver or even Elite.

Alejandra P.: I am not sure if I understand the difference between an Improver horse and an Elite horse. I imagine that one will have to have more YRBS offspring than other, is that the difference?

M.V.: In the case of the PRE, a horse acquires the category of Elite when it has obtained the category of Improver in Dressage and also in conformation aptitude for Dressage.

Greg. Still: I would like to know what I have to do to increase the reliability of my horse. Right now he is in the 2009 Dressage catalog, in a list of horses with an index greater than 100 and he has 3 asterisks for reliability.

M.V.: I am happy to hear this. The 3 asterisks indicate that your horse has a reliability of between

0.2 and 0.4. For the reliability of your horse to increase and possibly reaching the category of Improver—a reliability equal to or greater than 0.6—there would have to be offspring and relatives (siblings, half siblings, cousins, etc.) of this horse that are participating and obtaining good results in Dressage tests. In this case, the number of relatives must be greater depending on the degree of relationship. Also playing a part, although to a smaller degree, is that your horse continues participating in Dressage tests in which performance tests take place and that he obtains good results.

Yeguada Senillosa. I would like to know how many offspring a horse must have for it to be considered an Improver.

M.V.: For a horse to be an Improver, it has to have a genetic index greater than 100 and with reliability being equal to or greater than 0.6. Both the value of the index and the reliability can be achieved through relatives that

¹ Translator's note: YRBS = Young Recommended Breeding Stock

participate (in performance tests), preferably offspring; logically, the closer the relationship the better. And, a higher degree of kinship is achieved with the participation of parents, offspring and siblings by the same sire and dam. If the degree of the kinship is not very high, the participation of many relatives in tests will be necessary.

Anonymous: *In the PRE, why are assessments only made for Dressage and Conformation, and for Vaquera or Carriage Driving?*

M.V.: I am delighted to receive this question. One of the clarifications carried out in the Breeding Program is that when there is enough data (horses in performance tests) a genetic assessment will be broached for other disciplines. The problem with Doma Vaquera or Carriage Driving is that the number of horses participating in those disciplines is still low. I believe that it is better to focus on the disciplines where PRE participation is high, as well as on conformation. There are breeds, such as the Spanish Sport Horse, in which assessments are carried out for different disciplines, but they have a large participation in all of them.

PRE Breeder: *I am very interested in the morphology of the PRE and especially if I can improve the functionality of my horses with morphology. When I see the morphology catalog, I see a lot of information and I am not sure about what I have to look for when choosing a sire stallion for my mares. Do I look at the value of the global morphological index for dressage?*

M.V.: That is a good parameter to bear in mind. My recommendation is that you make your first choice of a sire stallion for your mares by using that value. But, in second place, you have to analyze what each horse, individually, transmits: that is to say, if the horse transmits, for example, very short shoulders and your mares also transmit very short



“ An Improver breeding stock has a genetic index greater than 100 and a reliability equal or greater than 0.6 ”

shoulders, you will produce foals with very short shoulders. If you choose a stallion that transmits long shoulders and you match up it with your mares that I have suggested have short shoulders, you will have a greater probability of producing offspring with average shoulders. Remember, that what your mare transmits is not what you see visually. To know what your horses transmit, they must have been assessed genetically.

Anonymous: *I am the owner of a horse that participated in the Final of the Young Horse Selection Tests. His result was “Very Good”, but he did not appear in a catalog. Now the horse is seven years old, is injured and unable to participate in Dressage tests. I would be interested in him appearing in a catalog of sires stallions, but, due to his age, he can no longer achieve the category of Young Recommended Breeding Stock. How could he achieve some merit so that he would appear in one of these catalogs?*

M.V.: Logically, your horse can no longer contribute merits when being assessed. Nevertheless, the participations of any horse that it is related to your horse will be able to contribute to him achieving a good genetic index, with enough reliability for him to achieve the category of Improver or Elite. In any case, I will take advantage to remind you that the genetic assessment indicates what a horse transmits, and not what the horse is. What a horse

is arises from the conjunction of its genetics and a specific environment (feeding, training, handling, etc.). A horse could have very good results, but that does not necessarily mean that it transmits them.

Breeder: *I would like to know what a Global Genetic Index is.*

M.V.: It is an equation in which different partial genetic values are pondered. For example, three genetic values enter into the Dressage index: Genetic Value of the score in the test, Genetic Value of the placing and Genetic Value of the conformation and movements. The genetic values of 16 conformation variables constitute the global index of morphology for Dressage. The information offered by these indexes is extremely valuable because it integrates into a single parameter the global value of a horse for a specific aptitude and therefore, it informs about the capacity it has of transmitting that aptitude to its descendants.

Veterinarian: *How is it possible that there is a mare that has obtained the category of Improver with only one offspring?*

M.V.: Well, because there are many of her relatives in performance tests. In short, for the horses that have achieved the category of Improver, there are more than 150 relatives with performance tests. As mentioned previously, it is not necessary that the horse has many offspring in tests; the reliability can be increased by the contributions of other relatives. Logically, if she had more children, it is very probable that her reliability would be even greater.

Ricardo from Malaga: *What is the meaning of “repeatability” when looking at a catalog of sire stallions?*

M.V.: Repeatability is synonymous to reliability. It is information that indicates the level of confidence we should grant the genetic value