

GENETIC IMPROVEMENT IN SPORT HORSES

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“Approximately 7,000 years ago man domesticated the horse through a long process of genetic improvement of the temperament (among other characteristics), and as from then has been selecting horses and modifying the “natural” course of the domesticated species aiming at animals with characteristics that have lead them increasingly away from the original “model”, turning horses in general, and sport horses in particular, into “specialized” individuals, grouped into what is generically known as “**breeds**”¹”.

Generally speaking, this selection has been made with very diverse characteristics such as certain coats (Dappled, Piebald, Greys); different stands and biotypes (Ponies); destined to light or heavy work (Criole; Percheron); certain types of skills such as classical break-in (Lipizzans); beauty or morphology (Arab horses); light draft or carriage horses (Hackney). But there is no doubt that the highest pressure for selection has been put on sport disciplines (Thoroughbred Racehorse; Polo Argentino; Quarter Horses; Standardbreds; Warmbloods) where the economic-productive aspects have carried greater weight than the emotional aspect as in the case of pets.

For centuries registers of individual performance and pedigrees, the pillars on which the selection procedures and breeding schemes were based together with conformation, have lead to the commercial success we have today of some groups and breeds of domestic horses.

What is Selection?

Selection is essentially a procedure that consists in choosing individuals for reproduction and designing the breeding or cross-breeding among them. Up until last century this was done—and still is—empirically, that is to say, based on intuition and personal opinions as to affinities or rejections; personal or institutional registers and fads or market demands, with scarce productive registration (performance) or objective statistic elements.

¹ Animal population in which individuals reproduce preferably with one another and sometimes present differential characters when compared with other populations.

Most of the characteristics or features on which horse selection was based were determined empirically, long before knowledge and the application of genetic theories and improvement methodologies appeared on the scene. The outcome was acceptable in most cases, despite the rudimentary tools at hand. As from the 50's – 60's, with the implementation of quantitative genetics, particularly applied to production vegetables and animals, such as milk producing and beef cattle, fowl and pigs, in less than 30 years the productive value has doubled, improving the genetic value of animals used for breeding. Computer programs applied to quantitative genetics and current statistic models make it possible to put in order, analyze and weigh the data obtained on the farm (performance) in such a way that merit or genetic value rankings can be established, estimating inheritability of traits of interest and thus determine the estimated breeding values (EBV) in breeders (additive genetic merit).

What does the success of Selection depend on?

The standard process of genetic improvement in a production program for horses, begins with the selection of the animals used for breeding (mares and stallions), that is to say, those which, from the breeder's point of view, have at least the minimum traits that will allow them to enter their "blood-line" system, i.e. their "own" genetic pool. Then they go on to assign specific matings according to criteria and affinities decided on by the breeder, and later through the monitoring and assessment of the succeeding offspring. Finally, the system receives its feedback from the performance information and the products themselves which will again enter the breeding and assignment system.

In general, in most sport disciplines, a high degree of human physical contact with the animal is required (racehorses, jumping, endurance, etc.) which is why we should consider that sport breeds of horses have many characteristics in common with the aim of that selection, such as **temperament** and **athletic skill** (which will relate to some particular and specific characteristic according to each discipline).

The fact that many of these characteristics are inheritable is, in general, a concept that has been established intuitively, but which is far from mirroring a simple fact which is easy to measure or determine in horses. In general these traits respond to **polygenic inheritance** (resulting from many genes acting simultaneously) or **quantitative traits** which means they respond to the added effects of many genes; to their interaction and at the same time to the environment where they can achieve their expression and actions (phenotype).

It is important to note that in order that the selection process produce positive results, the trait evaluation must have

- a) a medium to high estimate exactitude regarding genetic merit;
- b) genetic variation in the population.

If all population variation is due to environmental factors, it is not possible to impose an improvement program based on selection.

Inheritability is a parameter that contributes towards understanding the relation that exists between genetics and environment, and which explains genetically the phenotype differences (visible and measurable) between animals. It also relates to the exactitude with

which genetic merit may be estimated if only the performance of the selected individual itself were used.

It is important to know the estimated inheritability of traits in selection processes because of athletic skills attributes (where the estimated average inheritability for selectable traits is between 0.20 to 0.40, which is to say they are moderate), and where the environment plays a determining role.

Trait (attribute)	Inheritability
Working skill	0.19 - 0.27
Jumping (free)	0.47
Jumping (mounted)	0.32
Temperament	0.25
Speed	0.25-0.43
Standing	0.63
Body weight	0.28

Table 1. Estimated inheritabilities (average) of traits (attributes), important in sport horses.

What does a Genetic Improvement Program consist of?

The base of an improvement program consists in:

- a) identifying the desired traits;
- b) estimating their inheritability and
- c) establishing genetic merit rankings (genetic evaluation) which will allow you to select the animals for breeding and to which among the herd they will be mated, with a predictive value which is more acute than sole intuition.

In traits of low inheritability (0.10 – 0.20), the data on close relatives (pedigree) and the performance of their progeny mainly, become increasingly important in relation to the predictive value of genetic merit (prediction exactitude).

All this data allows us to establish the **Estimated Breeding Value (EBV)** of the individuals, of each horse, which is also a permanently varying value, as added data is included through the different batches of their progeny.

In order to methodically put this data in order, the tool that is most used in genetic improvement programs is the **BLUP (Best Linear Unbiased Prediction)** system, developed during the 50's and applied to milk producing cattle. This is a method that weighs and adjusts values in relation to the genetic value and the environmental influence, improving acuteness (exactitude) of the predictive values. The animal model of this methodology allows us to use information from all the sources of bloodlines existing in the individual, and corrects them simultaneously according to the influence of diverse environmental effects (age of mother or receptor mare; pasture; food and sanitation management, etc.). At the moment it is the system chosen for the few breeds of horses that implement formal improvement programs such as jumping horses in Europe, which has been used for over 40 years.

What is the current situation of Genetic Improvement Programs in Sport Horses?

In 1998 the European Association for Animal Production (EAAP), worried about the demand for objective information on pedigrees and performance destined to genetic improvement programs in sport horses, mainly jumping and dressage horses, put together a work group called **Interstallion Committee**, which together with the **World Breeding Federation for Sport Horses (WBESH)** and the **International Committee for Animal Recording (ICAR)**, designed a joint program whose main objectives are:

- To describe selection objectives, performance tests and genetic evaluation methods, communicating the results in an accessible manner to all breeders and professionals in the industry.
- Make known the results of all the official competitions in each member country, in such a way that the information on horses in particular, may be loaded and weighed immediately.
- Recommend improvements in the national genetic evaluation programs based on scientific results.

Additionally, in 2001 it commended the task of starting to carry out systematic studies on inheritability of traits selected by breeders as desirable, and specific performance evaluation tests, by means of two PhD Theses, the first of which has just been edited and recently presented in Uppsala, Sweden (*Emma Thoren Hellsten, International Sport Horse data for Genetic Evaluation, 2008*)

However, the most important advances in genetic improvement have occurred in racehorses. Considering that the Thoroughbred Racehorse is a breed whose register has been closed since 1791, and ever since, selection pressure has fallen to **only one trait: performance**, the selection process has given important results in terms of response, where the roof (measured in terms of speed and time data during races), is becoming increasingly difficult to surpass. Race speed times in the most important Classic races in the world have practically not undergone any significant variation in the last 50 years, which indicates that **genetic progress** in this breed is increasingly less and slower as a result of **selection** programs. Here the **environment** (raising) plays an extremely important role, since each time a Thoroughbred Racehorse foal is born, an athlete is born whose selection process has been in existence for over 300 years.

Quoting two prestigious and experienced investigators of this breed: “in the case of the Thoroughbred Racehorse, it is possible to presume that all foals are born with a great potential for becoming high-performance athletes and that the noxious effects of the environment play an important role in limiting that potential” (Rossdale P; Jeffcott L. Genetics, Genomics and Environment. Equine Veterinary Journal, 2005).

Patrick Cunningham, Animal Genetics Professor at Trinity Collage, Dublin, Ireland, and one of the post prestigious benchmarks in genetics applied to horses, maintains that most breeders are interested in the trait known generically as **racing performance**. The important thing is to define what this term means, and then how it may or should be

measured, since statistical analysis is one of the bases of quantitative genetics and therefore of improvement programs.

Racing performance in the Thoroughbred Racehorse may be measured in terms of percentage of races won vs. races run; racing speed times; money won, etc., or the combination of many of these in indexes such as Timeform, which although its value as an indicator is a mute point, it is one of the most used nowadays.

For example, if we measure the performance only in terms of speed time during races, inheritability is approximately 20%, but if we consider the handicaps, the value increases to 30%. This indicates that most of the variation observed among horses is **ENVIRONMENTAL** and not genetic. However, considering this concept from the opposite point of view, we see that the fact that 20 to 30% of the difference in performance among horses is due to genetics, it justifies working on this with selection programs (Cunningham, 2000).

Selection intensity is the measure of how much pressure we exert in order to discard animals of a lesser genetic merit as breeders. In general it is much greater in sires than in mares. In the Thoroughbred Racehorse it is 6% for sires and 54% for brood mares (Cunningham, 2000). This means that of the total population of males available in one generation, 94% of them and 48% of females respectively are discarded, and therefore do not leave their genes in the population.

Strengths of the system in general and of horse selection in particular.

Even when there is not much history to support the theory, good results may be expected from an improvement program in polo ponies. In this respect some positive aspects should be considered as well as others that are not so positive when the time comes for designing an improvement program:

- There are good genealogical registers (pedigree), which often include several generations.
- **Economically important traits** may be registered and selected equally in both sexes in a high proportion in all the population.
- **Low reproductive rate.** This refers to the fact that a mare may naturally produce between 5 and 10 offspring throughout its productive life. This, which in general is considered as a disadvantage in animal improvement systems, in this particular case can be compensated and improve through the use of embryo transfers, where these values may be multiplied by 5 or more during the whole of the mare's productive life.
- **Long generation intervals.** The generation interval is defined as the age of the parents, (in this case, of the mothers) up until the birth of their offspring. In horses in general, in natural reproduction systems, the average is 10-12 years, considering ranges that go from 5.5 in Thoroughbred Racehorses, because their sports career is very short, and 14 years in high-performance jumping horses. But this could be shortened significantly through the use of Embryo Transfers, where the generation interval in polo ponies can be as short as 3.5 years, that is to say, 2 years less than in

Thoroughbred Racehorses, in individuals with a much longer sports career. The enormous advantage of a short generation interval is that it makes it possible to obtain information on the performance of the progeny much more quickly and so be able to assess the parents while they are still capable of breeding.

There are extremely great economic value differences that depend on the genetic merit achieved (an inducement towards having good animals).

Is it possible to implement a genetic improvement program in polo ponies?

Taking into account the Strengths and Weaknesses of this production system, we may suggest the following recommendations:

- Carry out a corporate analysis and define the characteristics or traits that make for a good polo-playing horse or mare.
- Obtain **objective, measurable and verifiable** performance **DATA**, particularly regarding the traits or attributes that you consider will define or be characteristic in a first class polo pony.
- Put in order the genealogical registers in a database available to all breeders.
- The application of artificial insemination and embryo transplants substantially improve the precision of genetic analysis, increasing the mare's rate of breeding and shortening the generation interval, but they naturally do not "improve" anything from the genetic point of view, they only multiply the individuals more efficiently.
- The problem of overlapping generations could be solved efficiently if the BLUP methodology or other similar ones are used in genetic evaluation.
- The use for oneself and the sale of animals for breeding or of genetic material with an estimated breeding value (EBV's) would substantially improve selection in general of all the National and International population of Polo ponies.
- The design and application of a data-capturing protocol (measurements) by the AACCP would make it possible to minimize the problems of interference by the enormous differences in environmental factors among breeders as regards the expression of the true phenotype for each trait that is selected.
- The universe of good to excellent performance polo ponies in terms of genetic base and breeding conditions, and the amount of individuals make it possible for Argentina to present a very favourable scenario as regards real and manifest genetic progress.
- It is convenient to remember that the environment, that is to say the breeding and raising, taken from the first day of gestation; raising; break-in and training with all its variables, plays an extremely important role (60-70% of the variation between each individual at least) in the expression of the genome of an individual, and therefore also in its sport performance.

And as a final consideration, let us remember that the horse genome has recently been decoded, and as from that, functional genomics or molecular marker assisted selection (Genomic Breeding), as is being projected in other productive species, has become reality in basic investigation projections and is being currently applied, and is proposed simply as another tool which will contribute towards genetic

improvement programs for horses in the near future, in an increasingly more efficient (and complex) manner.