The Significance of Breeding Values

Scores as an Objective Tool for Selection

More and more breeders are using objective breeding science data to choose the best stallions for their mares. This data is represented in breeding values, which the KWPN has been calculating since 1987 for various traits in its breeding goal, such as sport, conformation, and health. Breeding values are based on data collected from various events and from studies conducted on KWPN-registered horses.

Breeding Values

Everything we can see or measure about a horse is the sum of its genetic ability plus an entire series of environmental influences. For example, if a horse jumps a clear round, that achievement may be partly attributed to its genetic ability and partly to the quality of its training and the skill of its rider. For breeding purposes, only the first factor is important: a horse's genetic ability, as a rider's talent cannot be passed on to a foal.
Breeding values are estimates of genetic ability. The KWPN calculates breeding values for conformation-, sport-, and health traits. Conformation breeding values indicate how a stallion (or mare) passes on conformation traits; sport breeding values indicate how a horse passes on traits for dressage, jumping, or driving (harness horses); and health breeding values indicate to what extent a stallion passes on osteochondrosis.
Furthermore, breeding values are regularly subject to change as more data becomes available every year, which can be used to calculate these values. For example, if 20 of a stallion's offspring are competing in the sport this year, that number may increase to 40 next year. Neither sport nor breeding are static events; rather, they are active entities which demand a dynamic approach.

Genetic Profile

Because breeding is a dynamic event, it is important to look ahead and make the right decisions in choosing a potential partner for a mare. The KWPN's ultimate breeding goal is to produce horses which can perform at the highest level in their discipline; therefore, sport traits are the most important traits in KWPN breeding. Although the other traits are important as well, they in fact serve to facilitate major sport performance. For example, a horse needs correct conformation, functional movement, or good jumping form to perform well. And of course, a horse must be healthy.
All important traits of the KWPN breeding goal are listed per breeding direction in the genetic profile of each stallion. A genetic profile is a convenient tool to analyze all important traits together at a glance and an easy way to compare stallions when trying to select the best partner for a mare.
Choosing a partner for conformation, movement and jumping may be explored further by using breeding values, which are represented in the detail traits of conformation, movement and jumping. A breeding value is estimated for each detail trait on the linear score form. This breeding value indicates a stallion's genetic average with respect to passing on certain traits.

The Average

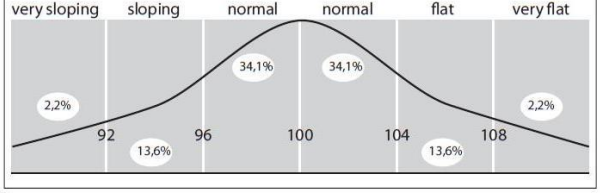
Just as wither height is expressed relative to the ground, a horse's genetic level (breeding value) must be expressed relative to something. That "something" is the average genetic level of all KWPN horses, or more precisely: all KWPN horses listed in the database. New information is added to this database each year. As a result, it grows and changes the average value of each trait every year. Breeding values slowly increase over time because horses added to the database every year are genetically better.
The most important principle in this regard, however, is realizing that an *individual* horse's breeding value (genetic level) is expressed relative to the genetic level of *all* KWPN horses. Every year, the genetic level (for each trait) of all horses in the database is equated to 100 points. This is the average with which we compare everything, making these 100 points the baseline.

High and Low Defined

The above information invites a couple of questions: first, if a stallion has a breeding value of 115 points for the trait dressage, is that value normal, high, or very high? And second, if the breeding value is above the 100-point average, does a stallion pass on normal, more than normal, or abundant dressage talent to his offspring? To answer these questions, we need to use standard deviation and normal distribution, both mathematical tools which are used in statistics. Each normal distribution has an average value and a standard deviation (also called a "spread") associated with it. For the various sport breeding values, the standard deviation is set at 20 points; for the other traits (conformation, OC health, height, and detail traits), it is set at 4 points.

Figure 1.

Example Interpretation of the Conformation Breeding Value for Shape of the Croup



With respect to breeding values, normal distribution is as follows: for the breeding value sport, 68.2% of horses (about 2/3 of the population) score 80 - 120 points. Therefore, breeding values ranging from 80 to 120 are roughly considered AVERAGE. A horse with a breeding value of 121 - 139 is considered a + PRODUCER, and a horse with a breeding value of 140 or more is deemed a ++ PRODUCER. However, it is important to note that a stallion which leads the list

with a jumping breeding value of 160 points is not substantially better than the second place stallion with 158 points. Both are genetically very strong. These examples show how to put breeding values into the proper perspective.
The remaining breeding values are based on a 100-point average plus/minus a 4-point spread, thus defining the average as 96 - 104 points. A stallion which passes on a croup angle value of 103 points falls within the average range. However, if he passes on a croup angle value greater than 104, that trait clearly deviates from the average and is termed a flat croup. If the breeding value is 108, the croup angle is twice the standard deviation. And if the croup angle is three times the standard deviation (112 points), the stallion passes on the trait to an extreme degree. These examples also apply to the converse situation: a breeding value of 96 points or less signifies a clearly sloped croup, and a breeding value of 88 points indicates an extremely sloped croup. Figure 1 is a graphic representation of how a trait, other than a sport trait, should be interpreted.

Reliability
We can never exactly measure a horse's genetic ability for a given trait. Fortunately, we can estimate the appearance of traits quite well (and breeding values are such estimates), but a reliability percentage should accompany every estimate. The greater a breeding value's reliability, the more the estimated genetic ability coincides with actual genetic ability. Reliability is really a measure of the amount of information available for calculating a breeding value. If a great deal of information is available, reliability is high; the converse is true as well.
Low reliability is readily subject to fluctuations in a breeding value as more information becomes available. However, as reliability increases, fluctuations in breeding value decrease and occur less often. Table 1 illustrates how reliability should be interpreted.
Reliability of approximately 60% is largely based on information about offspring. In such cases, lineage data and sport performance contribute little to the breeding value.

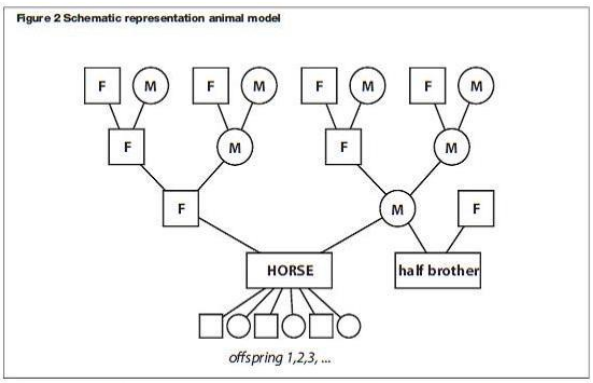
Table 1. Interpretation of a Breeding Value's Reliability

Reliability	**Interpretation**
Less than 30%	generally unreliable
30-55%	poor reliability
55-65%	sufficient reliability
65-75%	more than sufficient reliability
75-90%	good reliability
>90%	very reliable

Coincidence
If a sire of sires has a high breeding value for jumping, for example, that value indicates something about the AVERAGE of his offspring group but not about individual offspring. Let's use the example of Concorde x Nimmerdor x Lucky Boy xx. We expect horses with such bloodlines to jump well, which is often the case. However, not all stallions and mares breed "true". Coincidence determines which half of its parents' genes a foal inherits. A foal may inherit average genes from each parent, thus making it a kind of genetic reflection of its parents. However, the sperm or egg may also contain a better or worse set of genes. This principle of coincidence always applies in breeding, regardless the reliability of the breeding values. As stated, breeding values represent the AVERAGE genetic picture of a stallion or mare. Individual offspring may inherit traits above or below the average.

Model Breeding Value Estimate
Since 1993, the KWPN has used an animal model to estimate breeding values. The essence of this model is its use of all available data to calculate a horse's breeding value.
Figure 2 illustrates this concept. Figure 2 shows that three groups of information are used to calculate breeding values: information about a horse's parents (including their relatives, such as uncles, aunts, and grandparents); information about the horse in question; and information about the horse's offspring.
By including a horse's sire and dam in the model, information about all a horse's relatives is automatically included. For instance, if the horse in question has a half-brother who competes in international show jumping (see figure), this information is included in the breeding value of the dam, and in turn, included in the breeding value of the horse in the center of the diagram. Another advantage of the animal model is that each breeding value has optimum reliability as the model uses all available information.

Lineage Information
Using all sources of information (all relatives) means both knowing all a horse's relatives and considering each information source based on the degree of family relation. For example, a grandsire's breeding value influences his son's breeding value, which in turn, influences his son's breeding value. In this way, the grandsire's breeding value is included in the breeding value of his grandson. Of course, a grandsire's contribution is smaller than a sire's because of the generation between the grandsire and grandson. A sire contributes 50% to his son's breeding value, in contrast to a grandsire's contribution of 25%. The same principle applies to dams and granddams. The contribution of a half-brother or half-sister is 25%, while a full-brother or full-sister's contribution is 50%.
Taking all lineage information into account automatically brings dam-line information with it. It is also possible to calculate breeding values for young stallions and mares



with just lineage information, even if they lack a performance record. These breeding values are the expectation values and studbook indexes which are often printed in catalogs for stallion selections and mare inspections.

Information on the Horse Itself
A second source of information used in calculating breeding values is data gathered on the horse itself. This data includes competition records, performance test results, and linear score information. When such data becomes available, a horse begins to reveal whether or not it will live up to expectations (or the expected value) placed on it. If information on the horse itself is added to the lineage information, the reliability of the breeding estimate will increase. From that point forward, we can also estimate a true breeding value for the horse, which is still referred to as an expected breeding value because no offspring information has been included in the calculation thus far.

DNA Information
Since 2016, the KWPN has also calculated the so-called genomic breeding values (GFW). Thus far, these calculations are only done for the trait OC health and only for the dressage and jumping breeding directions. In a major study, the relationship between a horse's DNA composition and the final radiograph for osteochondrosis was closely compared. As a result, the DNA composition of a random horse is added as a source of information to the breeding value estimate for OC health, which can provide a good assessment of OC heritability without need for an offspring test.

Offspring Information
As soon as a horse's offspring are documented in the sport or on the linear score form, data from these sources are included in the breeding value estimate. As the number of offspring increases, so does the reliability percentage. As a result, the relative influence of lineage information and a horse's own performance on the breeding value decrease. At this point, we can truly speak of a breeding value because the calculation is now also based on offspring.

Data Types
Data from linear score forms are used to calculate breeding values for conformation and height. The OC health breeding values for the harness horse and Gelder horse breeding directions are based on the evaluation of offspring for osteochondrosis with respect to sires which are subject to the rules of the structural offspring inspection for osteochondrosis This policy applies to KWPN stallions which have been approved or recognized since 2007. For the dressage and jumping breeding directions, the breeding values for OC health are based on data from the offspring inspection for OC and the stallion's own DNA information. These are then referred to as genomic breeding values and apply only to sires subject to the rules of the structural offspring inspection for osteochondrosis.
Four different information sources are used to calculate breeding values for jumping and dressage. The first source is upper beam scores recorded at studbook inspections. Upper beam scores for movement are also used as an information source for dressage breeding values, while upper beam scores for free-jumping are used as an information source for jumping breeding values. The second source is the ability scores from the one-day IBOP test, and the third are the ability scores from the multiple-day tests for mares and stallions. The fourth source is the sport standings used in breeding value estimates. Sport standings are the most significant source of information, as they include data from the most important breeding goal trait. The other three sources are weighed based on their predictive power for the breeding goal. The KWPN obtains sport standings from the Dutch Equestrian Federation (KNHS) and the International Federation for Equestrian Sports (FEI).
Harness horses receive a driving breeding value, the underlying data for which is also obtained from the KNHS and various harness horse competitions held annually in the Netherlands. Competition data consists of horse placings in classes at specific shows and includes all a horse's results in its sport career. In the past, harness horse sport standings were expressed in prize money won. Although this data is still included in breeding values, it only applies to older horses, as young horses' results no longer include prize money earnings.

Foreign Stallions and Thoroughbred Stallions
The KWPN generally does not calculate breeding values for the parents of young foreign stallions or Thoroughbred stallions. If little or no information is available about a stallion's parents, he is initially assigned a breeding value close to the 100-point average. However, his KWPN counterparts of the same age generally have a breeding value higher than 100.
The Netherlands is not the only country to use breeding values. France, Germany, Belgium, Ireland, Sweden, and others use such data. Although their approach is broadly the same, each studbook has its own numbers and data. Breeding values are not mutually comparable because populations differ in their genetic composition. For example, if a Holsteiner stallion in Germany has a breeding value of 140, it does not automatically mean that the same stallion would also have a breeding value of 140 in the Netherlands.

The Presentation of Breeding Values and Statistics

Once a year, new breeding values are calculated for all horses in the KWPN Database. As per the conditions outlined below, breeding values for stallions are published annually online in the Stallion Database, by stallion. Breeding values for mares are listed individually in the KWPN Database under the heading Genetic Profile.

Sport breeding values for stallions are published in a rank table, which also includes the number of offspring for the various information sources in the calculation of the breeding value. These rankings are also available digitally through www.kwpn.org/breeding-values

Stallions are listed by breeding direction: dressage stallions, jumper stallions, Thoroughbred stallions, Gelder stallions and harness horse stallions. Recognized-, Thoroughbred- and Gelder- stallions are published in alphabetical order. Dressage- and jumper stallions are subdivided based on the number of offspring competing in the sport and the reliability of the breeding value, as follows:

1. stallions with 10 or more offspring in the sport and a reliability of 90% or higher (breeding values ranked from high to low);
2. stallions with 10 or more offspring in the sport and a reliability between 80% and 89% (breeding values ranked from high to low);
3. stallions with 10 or more offspring in the sport and a reliability lower than 80% (breeding values ranked from high to low);
4. stallions with offspring which have participated in the inspections/test and with fewer than 10 offspring in the sport (listed alphabetically); and
5. stallions with an expected breeding value based on lineage and their own performances (listed alphabetically).

Harness horse stallions are divided into three groups:

1. stallions with offspring in driving and a reliability of 80% or higher (breeding values ranked from high to low);
2. stallions with offspring in driving and a reliability of lower than 80% (breeding values ranked from high to low); and
3. stallions with an expected breeding value based on lineage and their own performances.

If a stallion's youngest offspring in the sport are older than age 10, that stallion is no longer published in the reference book.

For every breeding value, a reliability percentage is also calculated. Each breeding value must have a reliability value of 30% or more to be published. In addition, the genetic profile and detail traits (conformation, movement and jumping), depending on the breeding direction, are listed for current KWPN-approved stallions and KWPN-recognized stallions. The KWPN Inspection Department determines if a stallion is current. However, approved and recognized stallions are always listed in the digital KWPN Stallion Database.

Inbreeding and Relationship

In addition to the breeding values for sport, conformation and health traits, the KWPN also publishes relationship percentages for stallions in the harness horse-, Gelder horse- and dressage breeding directions, which are displayed with the current breeding population of the breeding direction in question. Over the past few years, these breeding directions have seen a relatively high increase, making it even more important to consider a stallion's bloodlines.

The relationship percentage indicates how unique a stallion's bloodlines are relative to the population in which he is active: the lower this percentage, the more unique the bloodlines. Through the years, the relationship percentage can change, as it is dependent on the bloodlines of horses in the breeding direction in question. Certain bloodlines which are initially rare may become common a year later if a particular stallion becomes very popular, as there will be more horses with these bloodlines. In this case, the relationship percentage will increase or become less favorable. A stallion with a low relationship percentage is very interesting for breeding, as he can contribute significantly to a lower level of inbreeding and therefore to the health and vitality of the horses in breeding direction in question.

The KWPN also offers a so-called inbreeding tool for the Gelder horse and harness horse breeding directions. This tool can be accessed through MY KWPN and used to create virtual pairings with the names of mares registered in these breeding directions by combining them with available stallions. This tool can assist you in arriving at a good partner choice and will provide you with the inbreeding percentage and virtual lineage of your prospective foal.

Legend rankings breeding values

	Dressage, jumping and driving	Other characteristics
VERY HIGH	> 160	> 112
HIGH	141-160	109-112
MEDIUM TO HIGH	121 - 140	105-108

Legend relationship percentage

	Relationship percentage Gelder horse	Relationship percentage driving horse	Relationship percentage dressage horse
VERY LOW	<2.0	<7.0	<0.8
LOW	2.0-3.5	7.0-9.0	0.8-1.5
LOW TO MEDIUM	3.6-5.0	9.1-11	1.6-2.2