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## An overview of breeding objectives for warmblood sport horses

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### Abstract

The aim of this paper is to review the current breeding objectives of organisations that run a selection programme for warmblood riding horses in the light of an increasing trend in trade of semen across countries. In a questionnaire, 19 horse breeding organisations provided information on breeding objective traits. Variation both in length and amount of details used to define individual breeding objectives was large, reflecting that many traits in sport horse breeding are not easy to measure, and therefore, have to be defined in a subjective way. The majority of the breeding objectives included conformation, gaits and performance in show jumping and dressage. Some breeding objectives also included behaviour, soundness, health and fertility. However, several organisations did not specify the sport discipline and the level of competition (amateur, national or international level) in the breeding objective. In general, relative weightings of the traits within the verbally presented breeding objectives were not given, but were assessed by the organisations in response to this study. The relevance of more information on expected future production circumstances and on the genetic parameters of the traits of interest are discussed. A further review of the consistency, completeness and the number of traits of the present breeding objectives for sport horses is recommended to optimise the efficiency of selection decisions.

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### 1. Introduction

Warmblood horses for the Olympic sports dressage, show jumping and eventing are used all over the world. Many breeding organisations, particularly in Europe, run selection programmes for such sport horses. An extensive international exchange of breed-

ing stock between breeding organisations has been going on for many years. Significant improvements in reproduction techniques (e.g. chilled and frozen semen) have further facilitated the simultaneous use of breeding stallions in multiple countries. Countries with large sport horse populations such as Germany and France often act as exporters, whilst countries with small populations often import breeding stock. This exchange in genetic material is illustrated in [Table 1](#), which shows the country of origin of actively used stallions in 2002 of five breeding organisations. The number of active warmblood stal-

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Table 1

Relative geographic origin of warmblood stallions (and their sires) used in different studbooks in 2002 (percentages)

	<i>n</i> <sup>a</sup>	Country of birth						
		NL	DK	S	F	IRL	D	Other
KWPN (NL)	195	<b>75 (32)</b>	– (–)	– (–)	5 (12)	– (–)	18 (49)	2 (7)
DWB (DK)	102	7 (6)	<b>42 (11)</b>	– (2)	1 (6)	– (–)	50 (75)	– (–)
SWB (S)	154	12 (9)	3 (2)	<b>54 (38)</b>	2 (6)	– (–)	27 (44)	2 (1)
SF (F)	765	2 (1)	– (–)	– (1)	<b>92 (87)</b>	– (–)	4 (4)	2 (8)
IHB (IRL)	200	4 (2)	1 (–)	1 (–)	5 (7)	<b>82 (81)</b>	6 (9)	2 (2)

<sup>a</sup> Number of active warmblood stallions.

lions ranged from 102 (Danish Warmblood) to 765 (Selle Français). All these organisations are dominated by stallions born in their own countries. In The Netherlands 75% were Dutch born, while in Denmark and Sweden about half (42% and 54%, respectively) of the active stallions were born in these countries. Most of the imported stallions were from Germany. In France and Ireland, the proportion of imported stallions was low (<20%). Within the breeding organisations in Denmark, Sweden and The Netherlands a large proportion (44–75%) of the sires of the active stallions originated from Germany. Again in France and Ireland the sires were mainly of their own origin (87% and 81%, respectively). The impact of foreign stallions on the genetic exchange between populations can be quantified by weighting the number of stallions by the number of mares covered. The percentages of mares covered by a foreign stallion for KWPN, DWB, SWB, SF and IHB are, respectively, 31%, 74%, 62%, 6% and 32% which are, except for France, higher than the proportions of foreign stallions given in Table 1.

Despite the large exchange of genetic material, similarities and variation of individual breeding programmes are not very well documented (Koenen and Aldridge, 2002). A better transparency of the individual breeding programmes, including breeding objectives, genetic evaluation procedures and selection practices, is likely to improve the efficiency of sport horse breeding in all countries. Therefore, the World Breeding Federation for Sport Horses (WBFSH) invited representatives from horse breeding organisations, EAAP and ICAR to review breeding programmes with respect to breeding objectives, data recording, testing procedures and genetic evaluations. This study describes and discusses the way breeding

organisations define current breeding objectives for warmblood sport horses.

## 2. Material and methods

A questionnaire was designed to study the breeding objectives currently practised by horse breeding organisations. The questionnaire included three questions on the breeding objectives. Firstly, the breeding organisations were asked to verbally define their

Table 2

Abbreviation, name, country and number of foals born in 2001 of the breeding organisations that were included in the questionnaire (*n* = 19)

Abbreviation	Name	Country	Foals
BAD	Baden-Württemberg	D	1211
BAVAR	Bavarian Warmblood	D	1426
BWP	Belgian Warmblood	B	3377
DWB	Danish Warmblood	DK	2228
FWB	Finnish Warmblood	F	220
HAN	Hanoverian	D	7784
HOLST	Holsteiner	D	3381
HUN	Hungarian Sporthorse	HUN	614
ISH	Irish Sport Horse	IRL	4413
KWPN	Dutch Warmblood	NL	11,785
NRPS	Dutch Riding Horse and Pony Studbook	NL	638
NWB	Norwegian Warmblood	N	100
OLD	Oldenburg	D	4384
SF	Selle Français	F	8300
SHBGB	Sport Horse Breeding of Great Britain	GB	592
SI	Italian Saddle Horse	I	3340
SWB	Swedish Warmblood	S	3000
TRAK	Trakehner	D	1563
WEST	Westphalia	D	3974

breeding objective as accurately as possible. Secondly, they were asked to assign a weighting from 1 to 10 to a list of nine traits (1 = not relevant, 10 = very relevant). Thirdly, they were asked if they practise different breeding policies within their breeding programme for special groups of horses.

The questionnaire was sent to the 44 breeding organisations that are member of the WBFSH and that produce in total approximately 90,000 foals per year. Finally, this study was based on the completed questionnaires for 19 organisations. All these breeding organisations happen to be European and produce in total approximately 62,000 foals per year (Table 2). Although many organisations did not respond, the majority of breeding horses were represented as the total number of horses registered by the non-responding organisations was small.

### 3. Results

The verbal definitions of breeding objectives vary largely and often include many subjectively defined traits as revealed in Appendix A. Table 3 summarises

these, whereas the relative weightings as given in the questionnaires are given in Table 4. One organisation (NRPS) was too unspecific in its verbal description to distinguish between different traits, and one (WEST) did not give any relative weightings.

Some discrepancies in describing the breeding objectives can be found when comparing the verbal and weighted definitions. For comparison a relative weight score of 8 is considered for traits given high emphasis in the breeding objective. All verbally expressed breeding objectives included performance ability but not all of them specified the sports discipline(s). The main sport disciplines of interest were show jumping (verbally mentioned by 16 organisations and 16 had a score of at least 8), dressage (14 vs. 12) and eventing (11 vs. 5). In addition to the performance traits, almost all breeding objectives included conformation (17 vs. 15) as well as gaits (14 vs. 16). Behaviour and health (including soundness, durability and robustness) were included in 11 versus 11 and 9 versus 14 breeding objectives, respectively. Driving was included in only four breeding objectives but none gave it a high score. Only three of the verbally expressed breeding objectives included fertility, but

Table 3  
Traits included in the individual verbal breeding objective definitions presented by 19 breeding organisations in Europe

	Conformation (n = 17)	Show jumping (n = 16)	Dressage (n = 14)	Gaits (n = 14)	Behaviour (n = 11)	Eventing (n = 11)	Health <sup>a</sup> (n = 9)	Driving (n = 4)	Fertility (n = 3)
BAD <sup>b</sup>	X	X	X		X				
BAVAR	X	X	X	X	X	X	X		X
BWP	X			X	X		X		
DWB	X	X	X	X	X		X		X
FWB	X	X	X	X	X	X	X		
HAN	X	X	X		X	X		X	
HOLST	X	X		X	X				
HUN	X	X	X			X		X	
ISH	X	X	X	X		X	X		
KWPN	X	X	X	X			X		
NRPS	Unspecific								
NWB	X	X	X	X	X	X	X		X
OLD	X	X	X	X		X		X	
SF	X	X	X	X	X	X			
SHBGB	X	X	X	X		X	X		
SI		X							
SWB	X	X	X	X	X	X	X		
TRAK	X			X	X				
WEST	X	X	X	X		X		X	

<sup>a</sup> Including durability and soundness.

<sup>b</sup> See Table 2 for abbreviations.

Table 4  
Individual relative weights (0 = not relevant, 10 = extremely relevant), means and ranges for breeding objective traits

	Show jumping	Gaits	Conformation	Health	Dressage	Behaviour	Fertility	Eventing	Driving
BAD <sup>a</sup>	6	8	8	5	7	9	4	3	1
BAVAR	8	9	8	8	9	9	8	6	5
BWP	10	2	10	10	10	8	8	8	2
DWB	10	9	8	7	10	7	7	5	1
FWB	9	10	10	10	9	9	10	5	1
HAN	10	10	8	8	10	10	8	6	6
HOLST	10	7	7	9	5	7	7	7	5
HUN	9	10	8	7	7	7	8	7	5
ISH	8	9	8	8	5	7	5	5	1
KWPN	10	8	8	9	10	9	9	1	1
NRPS	8	10	10	10	8	10	10	6	6
NWB	9	9	8	9	9	7	8	9	2
OLD	8	10	8	10	8	6	7	5	3
SF	10	9	9	9	7	8	8	8	1
SHBGB	8	9	10	9	8	8	10	9	0
SI	10	8	7	8	6	7	6	7	6
SWB	10	8	7	8	10	8	3	6	6
TRAK	5	10	9	6	10	8	3	10	1
Number $\geq 8$	16	16	15	14	12	11	10	5	0
Mean $\pm$ S.D.	8.8 $\pm$ 1.5	8.6 $\pm$ 1.9	8.4 $\pm$ 1.0	8.3 $\pm$ 1.4	8.2 $\pm$ 1.7	8.0 $\pm$ 1.1	7.2 $\pm$ 2.2	6.3 $\pm$ 2.2	2.9 $\pm$ 2.3
Min.–Max.	5–10	2–10	7–10	5–10	5–10	6–10	3–10	1–10	0–6

<sup>a</sup> See Table 2 for abbreviations.

10 organisations gave it a high weighting. Clearly the main emphasis in all breeding organisations is on performance but also conformation and gaits have high weightings. Only one studbook (BAD) assigned higher weightings to conformation and gaits than for performance traits. Within the performance traits many organisations put an equal weighting on show jumping and dressage. However, the Holstein and Irish Sport Horse studbooks clearly put more weighting on show jumping, whereas the Trakehner studbook puts significantly more weighting on dressage. The Selle Français studbook horses are known for their jumping quality, but not for ability in dressage, although the score for the latter trait indicates dressage to be of increasing importance.

Most breeding organisations stated that they did not have different breeding policies within their active breeding population. However, the Dutch Warmblood mentioned that they have different policies for the sport horse, the driving horse and the Gelders horse. The Holstein studbook stated that they have a specific breeding programme for show jumping horses, the Swedish Warmblood for the production of eventing horses by utilising thoroughbred stallions for crossing with warmblood mares, and the Belgian Warmblood

for both show jumping and dressage horses. Similarly, within the Hanoverian and Swedish Warmblood breeding programmes, which comprise both show jumping and dressage, specialisation is promoted in selection of stallions for either of the two disciplines.

## 4. Discussion

### 4.1. Definition and completeness of breeding objectives

A clear and well-accepted breeding objective is an important aspect when optimising selection strategies (Dekkers and Gibson, 1998). Therefore, breeding organisations ideally formulate a breeding objective that includes a complete and concise definition of all biological traits that are thought to be (economically) important under future production circumstances. One difficulty in using present breeding objectives for sport horses is that the traits are defined in a general manner only. This reflects the fact that, in contrast to other livestock species, many traits in horse breeding are not easy to measure. Furthermore, some general traits are

the composite of many underlying factors, for example soundness is the result of many conformation and health characteristics. With respect to performance traits, many breeding organisations wish to breed a ‘performance horse’ but do not specify the sport discipline (for example, show jumping) or the level of competition (amateur, national or international) in which the horse is eventually to compete.

This study also illustrates that the same desired characteristics can be described in various ways. This variation in the definitions used to describe the breeding objective must be taken into account when comparing breeding objectives. It is of practical relevance for breeding organisations to compare the breeding objectives carefully in order to detect whether these differences represent real differences in traits or if they are differences only due to wording. Even when the variation is not due to wording and traits seem to be identical, estimated genetic parameters across countries show the genetic similarities and variation of the traits that are recorded by different organisations. For example, the genetic background of observations for show jumping may differ across countries due to variation in training, organisation, recording etc. The presence of such possible genotype  $\times$  environment interactions has to be considered when comparing breeding objectives.

The results of the questionnaire showed that many breeding organisations also assigned high weightings to traits that they did not define in the breeding objective. Also opposite situations occurred. This suggests that the present verbal definitions are often incomplete and may not truly reflect the selection practised. Additional studies comparing the defined breeding objectives to the actual selection strategies will make these inconsistencies more transparent.

#### *4.2. Relative value of traits within the breeding objectives*

When a breeding objective includes multiple traits, ideally the relative value of each trait is provided. However, this study illustrates the importance of quantifying the traits to be included in the breeding objective. Although similarities with the verbal definitions are demonstrated in many cases, it was clearly shown that relative weightings of the traits in breeding objectives for sport horses is a necessity. Applying correct relative weightings of the traits can have an important

effect on the genetic response to selection. Therefore, new studies on the relative weightings of the traits are especially relevant for the breeding organisations as they decide on long-term selection policies.

In breeding objectives for other livestock species such as dairy cattle or pigs, traits are often weighted by their effect on genetic improvement, and therefore, on the economic efficiency of production (economic values). One of the few examples in horse breeding is the study of [Bruns et al. \(1978\)](#) where economic weights for dressage and show jumping ability were derived from auction data. However, in contrast to other livestock production systems, many horse breeders manage horse breeding rather as a hobby activity, with no or very low requirements on profit level ([SLU, 2001](#)). It may, therefore, be questioned if the economic efficiency of horse production is a good criterion, on which to base selection.

A more suitable method to derive weights may be the desired gain approach ([Brascamp, 1984](#)). When using this method, breeding organisations decide on the desired genetic levels of future generations. The relative weightings are then derived from these desired gains and the genetic parameters of the traits of interest. However, making decisions on the optimal future genetic levels is not easy. Firstly, it is essential to have clear ideas about the future production circumstances in horse production and equestrian sport as the produced offspring should ideally reflect the demands of the end-users. Secondly, decisions on the relative importance of traits may also depend on the market position of a breeding organisation compared to its competitors. With increased possibilities for individual breeders to use genetic material from other breeding organisations, differences in the genetic levels for individual traits may directly affect sales volume of individual breeding organisations. In this situation, improvement of a trait with a low performance compared to competitors is very important while improvement of a trait with an acceptable performance has a low priority ([De Vries, 1989](#)). For example, when the breeding stock of an organisation has a high breeding value for show jumping but not for conformation then this organisation may decide to assign a very high weighting to conformation and no weighting to show jumping as long as their breeding stock continue to be superior in show jumping.

### 4.3. Specialisation

Whatever the choice of strategy for weighting, economic values or desired gain, these should be based on future market expectations, and at least for what purpose various proportions of the horse populations are sold and how that affects future opportunities to produce horses at a good price. Extremely important factors to consider in the choice of breeding strategy, when applied to a multiple trait or multiple market situation, are the genetic parameters governing the similarities or differences in traits of horses chosen or sold for various purposes.

This study illustrates that a large number of the breeding objectives for sport horses analysed include many traits. In general, the disadvantage of considering a multiple trait breeding objective is that the genetic improvement per trait in absolute biological units can be considerably lower when compared to single trait breeding goals. Heritabilities and genetic correlations can indicate in individual situations the extent to which the traits of interest can be improved simultaneously. However, in practice the optimal selection strategy should be defined in terms of maximised gain for the aggregate genotype including all relevant traits.

The main competition traits are show jumping, dressage and eventing. Show jumping and dressage have only a weak genetic correlation (e.g. Bruns et al., 1985; Huizinga and Van der Meij, 1989; Thorén et al., 2002). The genetic correlations with eventing are 0.45 and 0.58 for show jumping and dressage, respectively (Ricard and Chanu, 2001). These correlations indicate that genetic improvement of the one trait will yield on average only a limited response in the other trait. In these situations, the genetic response per trait in a specialised breeding objective is significantly higher in comparison to breeding objectives including multiple traits. As shown, some breeding organisations already explicitly specialise in show jumping or dressage. In addition, the definitions of the breeding objectives of some other breeding organisations such as BWP, DWB, HAN, KWPN and SWB implicitly allow for specialisation as they aim at a high ability for both dressage or show jumping in their breeding objective. These latter organisations may consider replacing the present breeding objective by two breeding objectives: one breeding objective for show jumping horses and one breeding objective for dressage horses.

However, the efficiency of such specialisation may be considerably reduced if the market asks for horses of both disciplines, and if the breeding population size is limited. If the optimal selection strategy is defined in terms of maximised gain for the aggregate genotype including all relevant traits the issue becomes what the total economic or genetic gain is from multiple trait objectives versus more specialised breeding.

Some breeding organisations want to produce horses for both pleasure and performance in sport competition. When breeding horses that are primarily intended for use as leisure horses, character and temperament may have a higher weighting than sport performance. Studies on the genetic parameters for these traits are needed to evaluate the similarities between a leisure and high-level sport horse. However, in general, “good” temperament (which needs a more clear definition), soundness and rideability are traits of common interest to different groups of riders.

Almost all breeding objectives for sport horses include conformation. However, the exact inclusion of conformation in the breeding objective differs between organisations. Many breeding organisations include aesthetic conformation (“noble”, “expressive”, “well-shaped”) as a breeding objective as it often affects the financial value of a horse. In addition, many breeding objectives also include functional conformation (or correctness) and movements (walk and trot) as an aid to improve traits such as sport performance. For example, longevity and health are mentioned as it is generally assumed that specific levels of functional conformation are needed for sport horses to stay sound. This means that information on conformation is used to select indirectly for performance traits. The importance of including functional conformation including movements in the breeding objective compared to direct selection using information available on a performance trait depends on the genetic correlation between conformation and the trait to be improved, and at which age the horse is evaluated. It also depends on the availability of reliable information on the performance trait in the breeding objective. When more direct information on the traits of interest becomes available, e.g. data on longevity (Ricard and Fournet-Hanocq, 1997) or on soundness at special tests as described by Wallin et al. (2001), the relative importance of conformation in the breeding objective may decrease. However, there is an

advantage of recording functional conformation, as it provides an opportunity in early life for indirect selection for increased longevity as shown on the phenotypic level by Wallin et al. (2001). It remains to be studied what the genetic advantages are.

## 5. Conclusions and implications

Based on this study it can be concluded that breeding objectives for sport horses have a low transparency due to many subjectively defined traits without adequate information on their relative weight. These findings imply that current selection responses are sub-optimal, especially when also across organisation selection is considered. To improve selection efficiency, breeding organisations are encouraged to increase the transparency by improving their definitions and by evaluating the optimal number of traits in the breeding objective, given the relative weight of each trait and their genetic relationships.

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## Appendix A. Definitions of breeding objectives

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BAD <sup>a</sup>	The breeding objective includes two traits. The first is called “sport”. The aim is to meet the expectations of ambitious competition-riders. There is a specialisation either for dressage or for show jumping. The second trait is called “nice and easy”. The aim is to meet the requirements of the pleasure-rider. Selection criteria are beauty and easy handling.
BAVAR	Riding horse that performs well in the sport disciplines dressage, show jumping and eventing with an elegant conformation and willingness to work, a reliable temperament, a good health, a high durability and a good fertility.
BWP	A noble modern and correctly-built warmblood horse with a rectangular frame, big outlines and good basic paces. The horse should be pleasant to ride and have an unobjectionable character, so that it can be used by any rider, both as pleasure horse and as a performance horse. There has to be a balance between conformation, performance and health.

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## Appendix A (continued)

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DWB	A riding horse with a big performance ability in either dressage or show jumping, able to compete at international level. The horse is noble, sizeable and subtle with good health in use and high reproductive ability.
FWB	A horse that is suitable for use in dressage, show jumping and eventing at national and international level on basis of its type, conformation, gaits, character and soundness.
HAN	A rideable, noble, big framed and correct warmblood horse that, based on his qualities, temperament and character is especially suitable to be used as a performance and leisure horse. For this reason, the breeding of sport horses with a good ability for the disciplines dressage, jumping, eventing and driving is encouraged.
HOLST	An athletic long-shaped and expressive riding horse with the ability for sport performance at national and international level, especially in show jumping. Desired is a powerful elastic and good jumping, showing good control and intelligence. The movements have to show the typical knee action of the Holstein horse.
HUN	A noble, attractive, strong marketable horse for use under saddle and driving suitable for all the different branches of equestrian sports approved by the FEI, i.e. dressage, show jumping and eventing both at national and international competitions.
ISH	Sound and athletic horses that are capable of competing in show jumping, eventing and dressage at both national and international level.
KWPN	Sport horses performing at the highest level of international competition (dressage and/or jumping) with a good constitution and a functional and well-shaped conformation.
NRPS	Riding horses with (anglo) arabic blood that can contribute to the riding sport and that are able to perform in sport competitions.
NWB	A quality sport horse of good type which is correct, has a good frame and is sound. The horse should have a good temperament, a good attitude to discipline, be co-operative and have free forward movement, suitable for performance in dressage, show jumping and eventing. Conformation, performance capability, soundness, temperament and fertility are all characteristics to be improved. The desired height is between 1.60 and 1.70 m. The breeding goal weights the following traits as follows: conformation 40% and performance capability 60%. Performance includes soundness and temperament.
OLD	A noble, generously lined, high performing sport horse with active impulsion and space gaining, elastic movements which, because of its predisposition, is permanently suitable for any type of sport (dressage, show jumping, eventing, driving).

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(continued on next page)

**Appendix A** (*continued*)

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SF	Horses performing in competition with good conformation, gaits and temper. Priority is the jumping competition; but also eventing. Effort is made for dressage. There is also a highly performing branch of SF studbook specialised in steeple chase.
SHBGB	An athletic, good moving, sound rideable sports horse of correct conformation that can compete in a range of disciplines, including eventing, dressage and show jumping and meets the needs of both the British rider and the wider international market.
SI	High quality sport horses particularly suitable for jumping.
SWB	A noble, correct and durable sport horse which through its temperament, rideability, good movements, and/or jumping ability is expected to be internationally competitive in dressage, show jumping or eventing.
TRAK	Sound horse with Trakehner type, a big frame and correct and harmonious body proportions. Versatile riding and performance horses, easy to ride, with an energetic, elastic and ground-covering way of moving. Good and stable temperament, spirited but kind, intelligent, very willing to perform and with a tremendous stamina. All colours, usually standing between 1.60 and 1.70 m.
WEST	The Westphalian breeders should have the possibility to sell horses of every age-class (foal, mare, stallion, young riding horse, tested riding horse) for all disciplines. Important selection points include conformation, basic paces, riding ability and jumping potential.

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<sup>a</sup> See Table 2 for abbreviations.

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