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# Recommendations on choice of scale and reference population for publication of breeding values in sport horse breeding


**Management summary**

*Breeding values (BVs) for performance and conformation traits of warmblood sport horses are currently published in different ways. This variation complicates the comparison of breeding values across countries. Different countries use different statistical methods to transform estimated BVs from the original recording scale to the publication scale. An Interstallion review followed by a number of analyses based on national data have resulted in a proposal on the publication of BVs. The application of this proposal is expected to increase the international transparency of the published breeding values.*


## 1. Why do breeding values of the same stallions differ between countries?

Nowadays, several countries routinely publish BLUP breeding values (BV) for performance and conformation traits of warmblood sport horses. Whereas BVs are published for stallions in all these countries it has become more common now to publish BVs also for broodmares. Whilst practical observations of traits for genetic evaluation and selection are usually recorded in units such as earnings, ranks and test scores, BVs of individual horses are commonly published on a relative scale. Breeders are used to that in almost all countries. They do also expect that when the same stallion has got progeny in several countries, and thus also a BV estimated in each country, that these should be the same. However, practical experience tells that the same stallion may have quite different BVs in e.g. Germany and the Netherlands. Why so?

- Most of the progeny in one country are imported, thus selected from the country of origin.
- The traits comprising the information for estimation of breeding values vary between countries, e.g. young horse data are used in one country and competition data in another.
- There are differences in genetic quality between the countries.
- The applied procedures to transform estimated BVs from the original scale to the publication scale differ between countries.

It is obvious that presently published BVs are not comparable between countries, which hampers the international comparison of breeding stallions. The desire to harmonise the ways breeding values are expressed has been articulated by countries realising the needs to regularly compare stallions across countries, and that are aware that their procedures should be more clearly defined. Also countries in the process of setting up new or modified systems for estimation and publication of breeding values would benefit from the guidance in applying the best practice in choice of base and scale for publication of BVs.

## 2. Working procedure

The procedure to transform BVs to the publication scale requires **a clearly defined reference population** and assumptions on the **level and variation of the publication scale**. This document addresses these issues by documenting the situation practised in a number of countries and evaluates possible solutions to harmonise the definitions of reference populations and means and scales for publication of BVs.

The first recommendations were based on what the studbooks have responded in a questionnaire and what has been published on methods practised (www.interstallion.org). This information, and possible recommendations, were subsequently discussed at several meetings. The first meeting was in September 2004 and was followed by e-mail circulation of recommendations and comments. At the meeting in connection with the EAAP conference in Uppsala (June 2005), scientists and genetic evaluation centres were asked to test the initial proposals as well as some alternatives (stallions only *vs* all tested horses) and different years

of birth. At the Interstallion workshop in Warendorf in September 2005, test results based on French, Dutch and Swedish national data were discussed with studbook representatives.

**3. Present status of publication scales**

The Interstallion questionnaire showed that international uniformity seems to be high as almost all countries apply a publication scale of 100 as a mean and a standard deviation of 20 (Appendix 1). At the same time, however, definitions of the reference population vary largely across countries and are in most cases not well defined. This means that 100 has different meanings in practically all countries. A well-defined reference population should at minimum tell which group of animals it includes and their birth year. This is essential as it affects level, variation and stability of published BVs. It is expected that improved and uniformed transformation procedures assists the interpretation, acceptability and use of the published BVs.

**4. Desired properties of the publication scale**

In order to support selection procedures within as well as across countries some properties of the publication scale are desired:

- *It should be applicable for the active population of stallions and mares and acceptable by the practical breeders.* This means that the mean BV of all active breeding horses should be close to 100 if relative BVs are used.
- *It should be stable and applicable for small as well as big populations.* This means in practice that the reference population should consist of as many representative horses as possible.
- *It should be as comparable as possible across countries.* This means that the same type of reference population, mean and standard deviation of BV should be chosen. Such a harmonisation would facilitate the transparency of published BVs although genetic differences between populations/countries cannot be adjusted for.

**5. Definition of the reference population**

It is important that random year-to-year fluctuations of the mean level of the reference population are minimal, as this mean greatly affects the level of all published breeding values. A reference population including a high number of horses with reliable breeding values is therefore preferred. This suggests that **either only breeding stallions** born in a given period of years, and having (many) tested progeny, **or alternatively all tested horses,** again born in a certain period, are to be included. In Germany and Sweden they currently use a reference population including stallions with a minimum number of tested offspring. An important difference between both procedures is that the Germans have a **moving base**, whereas the Swedish use a **fixed base** (years of birth 1972-1981). Although mean BVs of tested stallions are expected to decrease in time due to the positive genetic trend, a moving base may be preferred as it better reflects the genetic level of the active breeding population.

**6. Definition of the mean and standard deviation of the publication scale**

The majority of the organisations use a mean of 100 and a standard deviation of 20 to define the publication scale. The only exceptions are the French who use a mean of zero and the Dutch who use a standard deviation of 4 (conformation only).

When transforming BVs it is also important to consider how the standard deviation is standardised. Almost all organisations use the standard deviation of the estimated BVs of the reference population to standardise the BVs. The Germans, however, use the additive genetic standard deviation. Both methods are only identical if the reliability of the BVs of all horses in the reference population is 100%. However, when standardising against the genetic standard deviation, BVs on the publication scale are easier to interpret as its deviation does not relate to the reliability of the estimated BVs.

## 7. Initial proposal

The initial proposal to transform estimated BVs included the following elements:

- The reference population includes all stallions born a given period before the year of publication and that have at least 15 tested progeny.
- The BVs on the underlying scale are standardised against the genetic standard deviation of the tested population of horses and estimated within year of birth.
- The mean and standard deviation of the reference population horses on the publication scale is 100 and 20, respectively.
- The period of birth of the reference population stallions should be chosen so that the active horse population has a mean around or slightly above 100. It was suggested to investigate what the effects would be of choosing stallions born 11-15 years before the year of publication as reference population.

In mathematical terms, transformation can be represented by the following formula:

$EBV_p = 100 + ((EBV_u - mean_u) / \sigma_a) * 20,$

where:

$EBV_p$ = estimated BV on the publication scale;

$EBV_u$ = estimated BV on the original scale;

$mean_u$ = mean estimated BV on the original scale of reference population;

$\sigma_a$ = genetic standard deviation of evaluated trait.

## 8. Evaluation of alternatives

*France*

Anne Ricard found that with the initial proposal 85% of the horses in the active Selle Français and Anglo Arab populations had a BV smaller than 100. This would not be accepted by breeders as they are used to select stallions with positive values (i.e. greater than 0 or 100) and that the mare population has a BV around the mean.

The mean BV of the active breeding population increased when the reference population consisted of older horses. A mean of 100 for the actual breeding population was realised when the reference population included stallions born 16 to 20 years ago. The selection of the birth years of the reference stallions in order to have a mean of 100 for the active population may be population specific as it also depends on the realised genetic response.

*The Netherlands*

The current genetic evaluation of the KWPN uses a reference population including all horses with an estimated BV without any restrictions on birth year and reliability of their BV. Comparable reference populations are defined in Belgium and Ireland. Although approximately 50% of all evaluated horses have a BV above 100, the mean BV of the active breeding population is considerably higher than 100. This is mainly because the used reference population also includes many older horses that are no longer alive.

Hans van Tartwijk has compared alternatives that differed in reliability, the sex of the horses (all sexes *vs* stallions only). With restrictions on reliability and sex the number of horses in the reference population decreased considerably. Thus, the reference population should not be restricted to stallions and should be chosen so that the mean BV of active horses is around 100.

*Sweden*

Åsa Wikström and Jan Philipsson have tested two different reference populations for the Swedish population. The first reference population included horses tested in the riding Horse Quality Test (RHQT) with varying years of birth. The second reference population included sires having at least 15 RHQT-tested progeny.

They showed that the proposed reference population (sires born 11-15 years before the publication year) yielded BLUP values around 90 for the present breeding population (tested

horses born 1986-2000). Another disadvantage of the initial proposal is the low number of horses included in the reference population (n = 20). Only if the reference population would include stallions born more than 20 years ago, the mean BV of the active population would be around 100.
They suggested including the present population of all possibly live horses in the reference population as an easy method to arrive at a stable mean of 100 for the present breeding population.

**9. Actual proposal**
Based on the reviews of the original proposal and the results from investigated alternatives evaluated against the desired properties of the publication scale (as of paragraph 4 above), it appeared that a reference population based on only sires born 11-15 years before the year of publication is not an optimal definition as it generally leads to average BVs of the active population of broodmares considerably below 100. This would not be accepted by the breeders. Furthermore, it easily yields fluctuations in mean BVs except in very large populations.

We therefore recommend the following definition of the reference population and scales for publication of BVs:

- The reference population should include **all tested horses born a given period before the year of publication**. This implies a **moving base**.
- The period of birth of the horses in the reference population should be chosen so that **the active horse population has a mean around or slightly above 100**. This implies that the horses constituting the reference population should be born e.g. 4-18 years before publication to be representative of the active breeding population (average age 11-12 years)
- The BVs on the underlying scale should be **standardised against the genetic standard deviation of the tested population of horses** and estimated within year of birth.
- The **mean and standard deviation** of the reference population horses on the publication scale **is 100 and 20**, respectively.
- This procedure **applies to performance as well as conformation traits**.

## Appendix 1.

**Table 1. Mean and standard deviation (σ) of the publication scale, definition of the reference population in Belgium, Germany, Denmark, France, Ireland, The Netherlands and Sweden for performance traits**

| country | trait[1] | mean | σ | definition reference population |
|---|---|---|---|---|
| B | J | 100 | 20 | horses having an estimated breeding value |
| D | D | 100 | 20 | stallions born 11-15 years before year of evaluation that have passed a stallion performance test or having ≥5 tested sons |
| | J | 100 | 20 | stallions born 11-15 years before year of evaluation that have passed a stallion performance test or having ≥5 tested sons |
| DK | D | 100 | 20 | |
| | J | 100 | 20 | |
| F | J | 0 | 11.2 | horses born 5 years before the year of evaluation |
| | D | 0 | 11.2 | horses born 5 years before the year of evaluation with a reliability ≥34% |
| | E | 0 | 11.2 | horses born 5 years before the year of evaluation with a reliability ≥14% |
| IRL | J | 100 | 20 | horses having an estimated breeding value |
| NL | D | 100 | 20 | horses having an estimated breeding value |
| | J | 100 | 20 | horses having an estimated breeding value |
| S | D | 100 | 20 | stallions born 1972-1981 having ≥15 tested progeny. |
| | J | 100 | 20 | stallions born 1972-1981 having ≥15 tested progeny. |

[1]D = dressage, J = show jumping and E = eventing.

**Table 2. Mean and standard deviation (σ) of the publication scale, definition of the reference population in Belgium, Germany, Denmark, France, Ireland, The Netherlands and Sweden for conformation and movement related traits**

| country | trait[1] | mean | σ | definition reference population |
|---|---|---|---|---|
| B | C (1) | 100 | 20 | horses having an estimated breeding value |
| D (HAN, MECK)[2] | C (8)<br>M (3)<br>R (1)<br>J (2) | 100 | 20 | horses born 9-10 years back |
| D (HOL)[3] | C (4)<br>M (2) | 100 | 20 | |
| DK | C (6)<br>M (3)<br>CM (1) | 100 | 20 | horses having an estimated breeding value |
| NL | C (22)<br>M (7) | 100 | 4 | horses having an estimated breeding value |
| S | C (3) | 100 | 20 | stallions born 1972-1981 having ≥15 tested progeny |

[1]C = conformation, M = movement, R = riding and J = jumping trait (within brackets number of traits).
[2]Hanovarian and Mecklenburg-Vorpommern studbooks (evaluated by VIT).
[3]Holstein studbook (evaluated by Landwirtschaftskammer Schleswig Holstein).