



Guidelines for projects aiming at increased genetic variation in dog breeds



Hälleforshund is a numerically small Swedish breed that is primarily used for moose hunting. The breed originates from a litter of moose dogs that were born in the 1930s near Hällefors and were recognized as a separate breed as recently as in 2000. Within the breed, exemption registration of breed-typical individuals is applied to ensure long-term sustainable breeding, taking into account genetic variation. Photo: Ulrica Nykvist

Developed by the SKK Breeding Committee.

2022-10-27
(translated in July 2024)

Table of contents

Background.....	3
Mapping the current situation	3
Define the objective	4
Choice of approach.....	4
Exemption registration.....	5
From breed to variety of breed.....	5
Outcrossing.....	6
Open breed register	7
Planning of project	7
Outcrossing or open breed register?	7
Choice of donor breeds	7
Requirements for breeding animals.....	8
How many outcrosses should be made?.....	8
Evaluation of offspring	9
Planning and continuity for a successful project.....	9
Checklist for application.....	10



*Gotlandsstövaren (the Gotland Scent Hound) is the numerically smallest Swedish breed. Outcrosses with closely related breeds have been done to increase genetic variation.
Photo: Member photographer.*

Background

Within some breeds, where lack of genetic variation and/or widespread health problems make it difficult or impossible to achieve the breeding goals, addition of genetic variation may be necessary for a long-term sustainable breeding.

The great similarity in the genome of our dogs indicates that methods for increasing genetic variation within dog breeds is something we need prioritise and focus on, in order to achieve enough genetic variation for a sustainable breeding. Several breed clubs in Sweden have come to the same conclusion, and the Swedish Kennel Club, SKK, Breeding Committee receives an increasing number of requests for help and support with planning and implementation of outcrossing projects.

There are different approaches to increased genetic variation in a breed, in a controlled and well-planned manner, e.g., exemption registration, merging of closely related breeds, outcrossing and open breed register. What approach is preferable depends on the situation and circumstances in the breed concerned.

These guidelines give a brief description of different possibilities for increasing the genetic variation in a breed, and suggestions for planning and implementation.

SKK's Registration Rules (p. 13) state the following: *"Breeding is a creative and constructive activity aimed at maintaining or developing the characteristics of the dog. In both numerically small and large breeds, breeding can lead to the loss of important qualities for the breed or that undesirable characteristics are widely spread."*

Outcrossing is not a new invention and has been used to various extent as a breeding method during the history of our breeds. For example, SKK's "Hundboken" (the Dog Book) from 1957 reads as follows: *"The knowledgeable breeder, who is about to seek to improve an essential detail of their breed and find that appropriate material is lacking within the breed, should not shy away from retrieving what he/she needs outside the breed"*.

In Sweden, outcrosses have been carried out within, for example, our Swedish scent hound breeds and the Clumber Spaniel. Several other examples can be found in our Nordic neighbouring countries. Breed crosses with back-crossing to the breed of origin is applied regularly in many other domestic animals (such as pigs, cattle and horses) and is an accepted method of improving health and function.

Mapping the current situation

The first step is to make a survey of the current status of the breed with regard to genetic variation, general health status and possible signs of inbreeding depression.

Closed studbooks/breed registers imply breeding in a closed population, which over time inevitably leads to increased inbreeding and reduced genetic variation. The Breed Club is encouraged to, as far as possible, investigate whether there are health problems that are widespread in the breed and whether these could be linked to inbreeding/lack of genetic variation. For example, it can be immune-mediated/autoimmune diseases or impaired fertility and reproductive ability.

Inbreeding depression is a collective term for negative effects of inbreeding that mainly affects characteristics associated with reproduction and survival, so-called fitness characteristics. Inbreeding depression can manifest itself, for example, as impaired fertility in the parents and impaired viability and/or growth of offspring. A tangible and measurable effect can be reduced litter size.

Determine and document which problems need to be solved and which characteristics need to be improved.

As a basis for a survey, official pedigree and health records (in Sweden SKK Avelsdata, i.e., breeding statistics) can be used, as well as statistics from insurance companies (e.g., Agria Breed Profiles) and health questionnaires sent to owners of the breed.

Information from molecular genetic analyses carried out at different laboratories may also be of interest (e.g., genetic inbreeding coefficients for individual dogs and/or planned matings and molecular genetic analyses of genetic variation/kinship within the breed).

It is also appropriate to examine and evaluate whether existing breeding strategies in the breed may need to be revised, in order to maintain and make use of existing genetic variation in a more efficient way.

Sometimes there are opportunities for a more efficient use of genetic variation *within* the breed. Are there strict requirements and thresholds for breeding animals that lead to the exclusion of many dogs from breeding? For example, requirements for merits at dog shows, hip dysplasia results, etc. for registration and/or puppy referral from the Breed Club that lead to the exclusion of a large proportion of the breed from breeding. It is appropriate to evaluate whether all the requirements are justified and possible, taking into account the number and health status of the breed. What does the population of the breed look like internationally? Can the exchange of breeding animals between countries increase to obtain a larger effective population size?

Define the objective

The next step is to define the objectives of the project.

In addition to increased genetic variation, there may be additional goals, e.g., improved fertility, reduced incidence of specific diseases, improvement of certain characteristics or re-introduction of characteristics lost in the breed.

Also, define which existing characteristics are important to preserve. For a broad support for the project, it is recommended to try to get a large proportion of the breeders and members involved in already in this step, so that as many people as possible can submit their views on important characteristics for the breed.

Choice of approach

In what way can and should the project best be conducted?

There are different approaches to introducing genetic variation into a breed, such as exemption registration, merging of closely related breeds, outcrossing and open breed register. These are briefly outlined below. What approach is best suited may vary between breeds depending on situation and conditions in the breed concerned.

Exemption registration

In some cases, there are unregistered individuals of a breed that can contribute with valuable genetic variation. It can, for example, be dogs with an incomplete pedigree that do not meet SKK's and FCI's requirements for registration in the studbook. These individuals may be added to the studbook through exemption registration if they are considered to represent a valuable addition to the breed. Dogs added to the studbook through exemption registration will be added to SKK's appendix to the original studbook, the so-called X register. In accordance with guidelines from the FCI.

The purpose of exemption registration is primarily to provide the breed with presumably valuable breeding animals. In order for a dog to be considered for exemption registration, it must: according to SKK's registration rules, "*meet the usual requirements for breeding such as being healthy with good behaviour as well as appearance, and genetically conceivable to add the qualities that the breed needs*".

An application for exemption registration of a dog is submitted to the SKK Breeding Committee, which asks the club concerned for their opinion. Decisions on exemption registration are made by SKK. The information that needs to be included in the application can vary depending on the purpose of the exemption registration. Exemptions may be given, for example, to enable the construction of breeds, in breeds where the gene pool has become too narrow or where important characteristics needs to be improved.

In some breeds, exemption registration has been used more frequently to reduce the risk of lack of genetic variation. One example is our Swedish Hälleforshund where exemption registration of breed typical individuals is applied routinely to ensure long-term sustainable breeding, taking genetic variation into account. The Swedish white elkhound has also applied exemption registration of breed-typical white elkhounds on a routine basis.

From breed to variety of breed

Another option for broadening the gene pool may be to open up for mating between closely related breeds, by redefining the breeds as varieties of the same breed instead of separate breeds. There are several examples where different size and furnishing are defined as varieties of the same breed rather than separate breeds, for example, the Dachshund, Poodle and Belgian Shepherd.

By defining closely related populations as varieties of a breed, instead of strictly separated breeds, it becomes possible for breeders who wishes to use genetically valuable individuals from a closely related population in breeding.

This type of measure is easier to implement for nationally recognized breeds than for FCI-recognized breeds, where an international consensus is needed. For Swedish breeds, which often consist of numerically small populations, SKK and the Swedish Breeds Clubs themselves have the opportunity to decide how strict we want to be with respect to the concept of breed.

Even for a variety of a breed, there is often a possibility to maintain a separate breed standard and for varieties to compete for separate CCs at shows. How CACIB at international dog shows are awarded may differ between breeds with several varieties and is governed by the FCI's regulations. Distribution of national certificates to different varieties of a breeds are governed by the national Kennel Clubs. Here, too, different routines in different breeds are used.

It is clearly visible in the studbook of an individual, and in the case of a mating, to which variety they current individuals belongs. In this way, matings between the different varieties become transparent

and well documented. Of course, using individuals from different varieties of a breed is completely voluntary.

Outcrossing

Outcrossing, or cross breeding, means the introduction of genetic variation and/or improvement of characteristics by mating with another breed. The offspring of the first generation (F1) will receive half of its genome from the original breed and half from the other breed, i.e., the donor breed. In future generations, F1s are back crossed to the original breed (F2, F3, etc.). For each generation, the genetic contribution of the donor breed is halved. Dogs of generation four, i.e., F4, will have 6.25% of their genome from the donor breed.

To achieve a long-term effect of outcrossing to another breed, it is not enough to carry out a one or a few outcross matings. The genetic contribution will, as described above, relatively quickly decrease over time with each generation. For a long-term effect on the population as a whole repeated outcrossing is necessary.

The application to carry out an outcrossing project should be submitted to the SKK Breeding Committee and must be submitted well in advance, preferably no later than six months before the first intended mating. Permission for an outcross project is given after requesting the opinion of the breed club. Approval is not given retrospectively to outcrosses made without permission. For a long-term and successful outcrossing project, it is highly desirable that the breed club supports and develops a plan for the project, rather than single outcross matings initiated by individual breeders.

Offspring after an approved outcrossing are registered in an appendix to the studbook, the SKK X register. X registered individuals may be used in breeding, provided that they meet the registration requirements of the project breed (i.e., the breed of origin) in question. Also, offspring after X registered dogs are recorded in the X register for three generations. After three generations of back-crossing to the project breed, the individuals will again be registered in the original studbook (in Sweden called the SE register), this in accordance with FCI's guidelines.

X registered dogs can participate and qualify in shows, tests and competitions on the same premises as the project breed. However, X registered dogs cannot be awarded any of the international certificates, and accordingly nor obtain any of the FCI international championship titles. Dogs in the appendix may also get official health results and results from behaviour assessments recorded in SKK's database, in the same way as other dogs in the breed. This possibility is important for the evaluation of outcross individuals as guidance for selection.



*The dog pictured, Spider's Crossline, is grandson of a Clumber Spaniel and a field type cocker spaniel. Outcrossing with Cocker Spaniel was made to add genetic variation to the numerically very limited breed Clumber spaniel.
Photo: Annika Åkerman*

Open breed register

Another way to add genetic variation through mating with another breed may be to, in a controlled way, open the breed register (studbook) to one, or more, breeds.

Examples of breeds with an open breed register are the Miniature Bull Terrier which has open studbook to Bull Terrier and the three griffon breeds (Griffon Belge, Griffon Bruxellois and Petit Brabancon). The exchange with open breed registers is often one-directed, i.e., breed A may be mated with breed B and the offspring registered as breed A but not as breed B. According to this principle, for example, offspring from a mating between Miniature Bull Terrier and Bull Terrier will always to be registered as Miniature Bull Terrier.

In the event that mating between two breeds is sanctioned by the FCI, i.e., the breeds are listed on the FCI's list over breeds that are allowed to mate with each other, the offspring will be recorded in the regular studbook (SE register). This is the case for matings between e.g., Bull Terrier/Miniature Bull Terrier, Griffon Belge/Griffon Bruxellois/Petit Brabancon and Greenland dog/Canadian Eskimo dog.

In other breeds with open breed register, e.g., some the Swedish Scent Hound breeds, offspring will be recorded in the Appendix, the SKK's X register. After three generations, the individuals are again to be registered in the regular studbook, in accordance with the FCI guidelines. Offspring recorded in the X register may be used in breeding, provided that they fulfil the registration requirements for the breed in question.

An open breed register can be an administratively simpler and more efficient way to add genetic variation to the breed, compared to an outcrossing project. Provided that both breeding animals meet the requirements for registration, no application needs to be made before each individual mating. Hence, the procedure gives more freedom and flexibility to the individual breeder to choose the appropriate mating combination.

Planning of project

If it is concluded that mating with another breed (outcrossing or open breed register) is the best method of adding genetic variation to the breed, there are several things to consider and decide on.

Outcrossing or open breed register?

As mentioned above, an open breed register to one or more breeds can be an administratively simpler and potentially more efficient way to add genetic variation, compared to an outcrossing project.

An open breed register is less complicated for everyone involved and gives greater freedom to both breeders and owners of stud dogs. However, some clubs find it more controlled and perhaps less controversial to initially perform a few outcrosses, and evaluate these, before considering to possibly open the breed register towards one, or more, breed(s). Discuss the pros and cons with the different alternatives within the breed club and with the breeders. Also, the SKK Department for Breeding and Health, as well as the SKK Breeding Committee can offer advice and support to breed clubs.

Choice of donor breeds

A central question in an outcrossing project is which breed(s) are appropriate with respect to health status, behaviour, appearance and kinship/genetic distance.

The objectives of the project can provide guidance on the choice of donor breed(s). For example, if the main goal is to add genetic variation, one should look for a breed that is not too closely related, with few health problems. The breed(s) chosen should not have the same hereditary health issues as the project breed, but preferably the same or similar background/function.

Note that appearance/morphology is generally easier to restore after outcrossing than, for example, behaviour and function, which has a lower heritability. Thus, in the choice of breed(s), the focus should be on health, behaviour and function rather than on morphological traits.

If the project breed and the donor breed(s) differ greatly in size, it is advised that the female is of the larger breed and the male of the smaller. Regardless of the breed of the female, offspring are registered in an appendix register (X register) under the breed code the project breed.

For a broad anchoring in this central issue, it is suggested to include breeders and stud dog owners in the discussions at an early stage. Also, the breed clubs and breeders of the donor breed(s) can contribute with valuable information.

If the main purpose of the outcrossing project is to increase genetic variation, it may be of value to evaluate the kinship/genetic distance between the project breed and the plausible donor breed(s).

Requirements for breeding animals

What requirements should be made on the breeding animals of the project breed and the donor breed, respectively? It can for example apply to health, behaviour, function, age and evaluation of previous offspring.

In general, it is advised to make high demands on the individuals of the donor breed. There are usually many potential breeding animals to choose from and one can thus afford to be thorough.

Below some suggestions for choice of individuals of the donor breed:

- Choose individuals that are slightly older and have been used in breeding previously, i.e., that are accurately evaluated.
- Ensure that the dogs are clinically healthy and have had all the required and recommended tests within the breed concerned.
- Ensure that the dogs have appropriate behaviour and functional characteristics, suitable for the project breed.
- In addition to the above, a genetic health test covering known disease mutations is suggested, in order to reduce the risk of introducing any new mutations to the project breed.

The dogs of the project breed to be included in the project should not be too closely related to each other. Also, these individuals should of course meet the requirements and recommendations for the breed and be accurately evaluated (preferably with previous offspring).

How many outcrosses should be made?

As mentioned earlier, outcrossing is not a "quick fix". For a long-term effect on the population as a whole, repeated outcrosses are needed.

Planning, administration and information about the project and planned matings is time consuming for the breeding officials in the club. Hence, it may be wise to plan and implement one outcross at a time, and to ensure the long-term continuity of the project over time. This includes, in addition to

several outcrosses, ensuring that the offspring of these matings are evaluated and, in turn, used in breeding, provided that they fulfil the requirements. When the F1 generation has been evaluated and suitable individuals have been selected and bred from, it's time to evaluate the F2 generation, etc.

There is no exact answer to how many outcross matings that are needed, for the project to provide the desired effect. It depends on several factors such as the population size, the purpose of the project and to what extent crossbred animals produced in the respective generation are further used in breeding.

Evaluation of offspring

Evaluation of offspring from the outcross matings is an important part of the project. If individuals from F1, F2, F3, etc. are not evaluated and used in breeding, the project will not have any effect on the breed.

Thus, an important task for the breed club will be to develop guidelines regarding requirements and recommendations for the offspring to be selected for breeding. For example, there may be requirements for certain health examinations, functional tests and/or behaviour assessments.

It is advised not to make unreasonably high demands on F1-F3 individuals for breeding. Their main contribution to the population is the addition of genetic diversity to the breed. A common pitfall in outcrossing projects is that very few dogs from the F1-F3 generations are selected and used in breeding, which will result in a very small or no effect of the project on the population as a whole.

The morphology of the first generation of outcross individuals (F1) in particular will deviate from the desirable. However, this is usually easy to successfully select for in later generations, thanks to the high heritability of morphological traits. It is therefore advised to make no, or very limited, demands on morphological traits for dogs of the F1 generation, preferably also in the F2 generation. It is a good idea to develop guidelines for evaluation of offspring, already at the start of the project. Be clear to breeders and puppy buyers what is expected with respect to e.g., examinations, assessments, surveys and other follow-ups. Moreover, it is important that the offspring within the project are not neutered before they are evaluated and that they are made available for breeding if considered suitable for the project.

Planning and continuity for a successful project

A crossbreeding project is a long-term project that requires planning, collaboration, persistence, and last but not least committed breeders who are willing to carry out the outcrosses as well as puppy buyers who are prepared to care for and evaluate the offspring.

For a successful project, good collaboration between breeders, owners of stud dogs and breed clubs for the breeds in question is important. A common pitfall is that the genetic contribution to the breed as a whole becomes small in the end, as only one or very few outcrosses are made. Or that the offspring are not sufficiently evaluated and/or not used further in breeding.

In addition to the above, information and communication are important parts of the project. Preferably, a dialogue should be conducted not only nationally but also internationally, especially with the country of origin of the breed. Hence, key words should be collaboration, communication, evaluation and persistence!

Below are some guidelines for what to include in an application for an outcross project (based on the Swedish guidelines for application to the SKK Breeding Committee).

Checklist for application

An application of an outcross project or an open register/studbook should include the following parts:

- A survey of the current status of the breed (especially with respect to genetic variation/inbreeding, general health status and possible signs of inbreeding depression). The Breed-Specific Breeding Strategy for the breed can form the basis of this description.
- The objective of the project.
- A description of how the project will be conducted, e.g., an outcross project, exemption registration, open register/studbook or a combination of different measures.
- Selected donor breed(s) for the project and explanation to the choice.
- Description of requirements for breeding animals, both of the project breed and the donor breed(s).
- Description of how the offspring (F1-F3) should be evaluated, and of requirements for breeding.
- A brief description of how the project will be communicated and anchored with breeders, owners of stud dogs and other members.
- A general schedule for the project implementation and follow-up.



The Swedish Smålandsstövare (the Småland Scent Hound) is a numerically small population. The breed register is now open to other closely related scent hound breeds to increase genetic variation and improve the health and hunting characteristics of the breed. Photo: Member photographer.