

Breeding dogs in Sweden - SKK's tools and efforts to improve canine health

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The Swedish Kennel Club (SKK) owes its existence to the work of breeders and the results of their efforts. This is why breeding issues are given such prominence within the organization and why SKK dedicates substantial resources to helping breeders breed dogs in a way which benefits both the individual dog and the development of the various breeds.

The basic structure of SKK is that of a representative union of non-profit clubs with altogether about 300,000 individual members, of whom approximately 15,000 are breeders. Decision-making is done democratically by various committees. The SKK's Breeding Committee is responsible for all issues related to breeding within the organization. Its members are made up of breeders with a special interest in these issues, and a number of experts in veterinary medicine and genetics have been co-opted by the committee. In addition to regular meetings, the Breeding Committee organizes conferences for breeding officials from member clubs and initiates courses in specific subjects. The Breeding Committee is responsible for the genetic health programs as well as the project to develop a breed-specific breeding strategy for each breed, described below.

The breed clubs affiliated to SKK have delegated responsibility for one or more breeds, and the clubs therefore have their own breeding officials or someone responsible for breeding issues. Their tasks include keeping up-to-date with issues concerning the breed, at the individual as well as the breed level, both from a national and international perspective. The breeding officials provide breeders with information which helps them to set appropriate priorities and to make personal decisions regarding their breeding program. Sweden has a fortunate situation in the sense that each breed only has one official breed club, affiliated to SKK.

The SKK central office in Stockholm has a Department for Breeding and Health employing eight persons, including two full-time breeding consultants, a veterinarian and a geneticist. The department is responsible for assisting the Breeding Committee and breed clubs in various issues, e.g., managing health programs, breeding statistics, behavior assessments and genetic evaluations. The employees have access to a broad contact network made up of experts in the field of veterinary medicine, genetics, ethology and cynology. Moreover, the department plays an important role in SKK's education of breeding officials from the clubs. SKK organizes yearly courses for breeding officials, web-based educations as well as regular breeding conferences.

In addition, SKK carries out extensive supervision of its members, with the priority on breeders. Almost one hundred so called kennel consultants carry out approximately 2000 visits a year to kennels throughout the country. In many areas, the consultants work closely with the animal welfare officers employed by the municipalities.

Recording systems

There are approximately 780,000 dogs in Sweden, out of which about 70% are pedigree dogs and registered with SKK. The organization registers about 50,000 puppies yearly and all breeders who are members of SKK register their puppies with the organization. The registers are accessible to the public, and anyone can view them on the SKK website through a "Dog Data" internet service. The database contains pedigree information, results from various competitions, trials and tests, as well as the results of genetic health programs administered by SKK. This gives buyers the opportunity to obtain a lot of information before purchasing their puppy.

As an additional service to breeders and breed clubs, the SKK website also features a Breeding Records service, including breeding statistics for both individual dogs and for each breed as a whole. The statistics are based on results from health programs, behavior assessments, official competitions, and dog shows, as well as pedigree information. For each dog, individual records as well as statistics for littermates, full-sibs and offspring are available. Furthermore, the pedigree and coefficient of inbreeding is shown for each dog. More recently, predicted breeding values (EBVs) and genetic test results for some health traits are also included. The service includes an option to calculate the expected inbreeding coefficient for offspring resulting from a planned mating.

The population-wide information in the Breeding Records service provides a general picture of the development and status of a breed as a whole, including statistics on number of registrations, dogs used for breeding, health traits, behavior traits and average levels of inbreeding by birth year. The service is accessible to everyone and has become extremely popular. The transparency and opportunity to obtain information is relatively unusual from an international kennel club perspective.

The SKK database and the open registries constitutes a valuable source of information for breed clubs, breeders and dog owners. It also offers unique possibilities for epidemiological, behavioral and genetic studies in dogs. SKK frequently provides researchers with pedigree information and health or behavior records, enabling important studies for improved canine health.

Breed-Specific Breeding Strategies

There are more than 300 breeds registered within SKK and they all have different prerequisites and challenges with respect to e.g. population structure and health status. Moreover, various types of breeds have diverse breeding goals regarding function and behavior. In fact, also within the same breed, breeders may have diverging breeding goals and priorities when selecting their breeding stock. This structure, with a large number of dog breeds, many breeders involved and a vast number of traits to consider in the breeding strategy (e.g., health issues, behavior and appearance) creates a diverse and often subjective basis for genetic evaluation and selection of dogs.

In order to facilitate appropriate priorities and agreement on the breeding goals within each breed, SKK decided in 2001 that every breed in Sweden should have a breed-specific breeding strategy. This strategy should include all aspects relevant in the breeding goal of each breed, i.e., physical and mental health as well as population structure and genetic variation. Hence, the strategy should constitute an overall plan for the breed and act as a guideline to breeders.

The breed-specific breeding strategies (RAS in Swedish) are developed by the breed clubs and approved by the SKK Breeding Committee. Each document contains the history of the breed, a description of the current situation, as well as goals and strategies for the future. At present, almost all breed clubs have developed and submitted a breeding strategy to the SKK.

The breeding strategies are published on the SKK website as well as on the breed clubs' websites, and thus easy to find for breeders and puppy buyers. The RAS documents are to be evaluated yearly and updated every 5 years.

The breed-specific breeding strategies should be seen as a continuous work and is an important tool to maintain a healthy and sustainable development of breeds. It is a way of working that puts focus on priorities at breed club level, and contains guidelines rather than rules and regulations.

Breeding for improved health

Health and longevity is a common breeding goal for all breeders, irrespective of breed, and health issues constitute an important part of the breeding strategy. To enable genetic evaluation and selection for improved health, accurate phenotype and/or genotype information is needed.

In addition to the information available through the SKK database, the large proportion of insured dogs in Sweden (about two thirds of all dogs) generates valuable complementary information about various health issues prevalent in each breed. The largest pet insurance company in Sweden (Agria Pet Insurance) provides breed specific statistics, so called Breed Profiles, for over 100 breeds comprising incidence rates and risk calculations based on veterinary care events and mortality. In the statistics the rate/risk of each breed is compared with all breeds combined.

Furthermore, health questionnaires and breed club registries can provide useful information. Ideally, information from several sources can be used to give an accurate description of the current health status of the breed, and serve as basis for appropriate priorities in the breeding strategy.

There are several tools to make efficient use of the available information, in order to enhance canine health. In my talk I will describe how some of these tools have been implemented by SKK.

Genetic health programs

Genetic health programs are one of the tools used by SKK to manage hereditary disease in dogs. SKK implemented the use of screening programs to improve health in Swedish dogs more than 30 years ago. The first program concerned hip dysplasia (HD), involving centralized evaluation and recording of hip status assessed by radiographic examination in young adult dogs. Currently, numerous breeds are also included in screening programs for other heritable conditions, such as elbow dysplasia (ED), patellar luxation, heart diseases and eye diseases. Health programs are based on breed-specific needs and have been introduced on request from and in consultation with the breed clubs. All results are submitted from the veterinary clinics to the SKK for recording in the database. In some cases testing is voluntary, in others testing of breeding animals prior to mating is mandatory. Regardless of the level of the health program, SKK put emphasis on including all test results in the database, positive as well as negative. For example, radiographs from hip and elbow screening are centrally evaluated at the SKK head office by one of three veterinary radiology experts, so called panelists, contracted by SKK. This procedure should minimize bias due to pre-selection of results to be recorded in the database. Unbiased and representative data are of great importance for accurate genetic evaluation, e.g., as basis for prediction of breeding values (see below).

All results submitted through the various health programs are registered with SKK and accessible to the public through the SKK webpage. About 15,000 records for HD, 11,000 records for ED and 18,000 records from eye examinations are registered yearly. In 2014, 48,000 health records altogether were recorded in the database.

So far, genetic health programs for physical health have been developed only for hereditary diseases with well-defined and validated methods for examination and diagnosis.

Molecular genetic tests

The sequencing of the dog genome in 2005 marked the start of a rapid development of genetic tests for various conditions in dogs. Today, laboratories worldwide provide DNA testing for numerous diseases as well as colors and some other traits. The availability of genetic tests makes it possible to accurately determine the genotype of an individual dog with respect to a specific disease, enabling a more subtle management of breeding programs to decrease the frequency of a particular disease gene without unnecessary reduction of genetic variation.

However, even though genetic tests offer new opportunities as a tool for breeding, they also imply new questions and challenges. Not all tests offered can be considered reliable and/or suitable to be implemented in a breeding program. For example, the genetic background of the disease may be more complex than is considered or detected by the test, which can result in discrepancy between the genotype (test result) and phenotype (the clinical status). In addition, the test may be validated for one or a few breeds, but not for others. The test may also be irrelevant in the sense that the disease does not occur, or is very rare, in the breed concerned. Applying a test that is irrelevant or inaccurate may result in focus being taken away from more important issues with respect to health and wellbeing.

SKK records results from genetic tests for several gene mutations. Currently 14 different diseases, all with an autosomal recessive inheritance, are included in the health program for one or several breeds. The health program based on a DNA test could be either voluntary or mandatory. The latter implying that all breeding animals must be tested and have their results published in the database before breeding. Dogs with tested relatives, i.e. both parents tested clear, are "hereditary clear" and do not have to be tested themselves. Regardless of level, dogs with the test result "carrier" can only be mated to clear/normal dogs. Genetically affected dogs are not allowed for breeding.

For recording in the SKK database the DNA test should be considered relevant and accurate. Hence, before a new test is approved for registration the test is validated by a working group appointed by the SKK Breeding Committee. This "DNA group" includes staff at SKK, members of the Breeding Committee and researchers in molecular genetics. Only tests based on a scientific publication are considered. If the scientific study is based on a foreign population of the breed, a validation of the test for the Swedish population might be necessary, depending on the genetic links between the Swedish population and the study population. For example, if the study is based on Golden Retrievers in the US, a validation is probably needed to ensure that the mutation is relevant also for the Swedish subpopulation of the breed.

Another important issue before recording of a new DNA test is to certify that the disease tested for is of clinical relevance in the breed. If there are, for example, no known cases of clinically affected dogs in the Swedish population it might be wise to rather focus on other issues in the breeding strategy. When applying for a health program, the breed club is asked to present prevalence figures and describe the severity of the disease, in relation to other health issues/traits of importance in the breeding program. It is of utmost importance that the genetic test is implemented in the overall breeding strategy for the breed. Hence, breeders and dog owners should carefully evaluate the benefits and consequences of a genetic test before it is applied. A one-sided or exaggerated focus on DNA test results may result in an increased risk that other important conditions or characteristics are overlooked.

When a genetic test is approved for registration, SKK have several requirements related to the testing procedure, in order to ensure the accuracy of the test result. The sample should always be taken by a veterinarian, checking the ID of the dog. Both blood samples and cheek swabs are accepted. The SKK form (specific for each test) should be filled in by the owner and the veterinarian. By filling in the form the owner approves that the test result is recorded and published by SKK (regardless of what the result is) and the veterinarian certifies that he/she has verified the ID of the dog. The SKK form is submitted to SKK together with a copy of the test result from the laboratory.

Prediction of breeding values

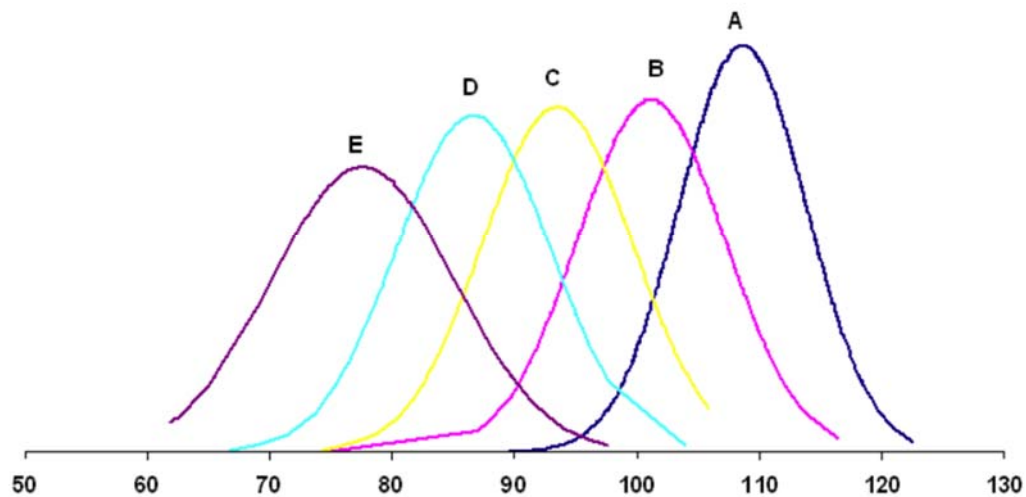
Many hundreds of heritable diseases have been reported in dogs, with varying prevalence depending on breed and disease. Some diseases are known to be caused by a single mutation, but many of the common diseases, e.g., cancers, allergies, heart diseases and degenerative joint diseases, are of a

quantitative nature and influenced by several genes and environmental factors. For example, canine hip dysplasia (HD) is known to have a complex genetic background. Despite extensive radiographic hip screening and subsequent selection based on the individual's own screening record, i.e., phenotypic selection, the magnitude of improvement has been disappointing in some populations. The quantitative and categorical nature of HD implies that the phenotype is not the most accurate indicator of the genotype. This makes the genetic evaluation based on radiographic hip status imprecise, limiting the genetic progress.

However, by the use of more appropriate methods for genetic evaluation a more effective selection is possible. Mixed linear models for prediction of breeding values (EBVs) have been used extensively in breeding of livestock for several years. These methods makes it possible to include all available phenotypic information for relatives, and simultaneously adjust for systematic environmental effects. In dog breeding, this methodology has so far been applied only to a limited extent. Selection of dogs has traditionally been based mainly on the individual's own record.

Since 2012, SKK predicts EBVs for canine hip and elbow dysplasia (HD and ED) in a number of breeds, using the so called BLUP method. The EBVs are published on the SKK website and updated once a week (as new information is added to the database, the EBVs may change).

EBVs for HD and ED enables a more accurate comparison of the genetic merit of dogs. Because the statistical model makes use of all available information about relatives, not only the dog's own hip status, and simultaneously adjusts for environmental effects, dogs with the same HD grade can be differentiated based on their EBVs. The non-genetic factors included in the Swedish model for prediction of HD breeding values are sex of the dog, birth month, year of examination, chemical restraint used for sedation, veterinary clinic and age at screening.



Distribution of predicted breeding values (EBVs) for canine hip dysplasia, by HD grade (A-E, according to the FCI protocol). Higher EBVs correspond to better hip quality. The figure illustrates that dogs with the same phenotype will get different EBVs. In general, dogs with grade A will get higher (better) EBVs than dogs with B, etc. However, the overlapping of the curves demonstrates that a dog with a worse phenotype in some cases may get a higher EBV than a dog with a better hip grade. This comes from the fact that more information than only the individual's own phenotype is considered in the model for prediction of breeding values.

In addition to EBVs for hip and elbow dysplasia, prediction of breeding values has also been introduced for some behavioral traits, so called personality traits, in the Rough Collie breed. The

predictions are based on data from a standardized and validated behavior assessment known as the Dog Mentality Assessment (DMA) and currently managed by researchers at the Swedish University of Agricultural Sciences (SLU). In the near future, more breeds are planned to get access to EBVs for behavior traits in order to facilitate breeding for desired behaviors.

Breed-Specific Instructions for show judges

Soundness and health in dogs must not be compromised due to morphological exaggerations. In 2009, SKK developed the first edition of the Breed-Specific Instructions (BSI) for show judges which address exaggerations in pedigree dogs. The BSI aims to identify characteristics at risk for exaggerations and implies recommendations to the show judge to observe the breed specific areas of risk and note issues as well as soundness in these areas. The BSI document also contains basic requirements for all dogs e.g., with respect to breathing, eyes and movement.

In 2014, the various BSI documents in the Nordic countries were harmonized and merged into a common Nordic BSI booklet, through the work of the Nordic Kennel Union (NKU). The NKU BSI document is founded on the experiences in the Nordic countries regarding identification of areas of risk in a selected number of high profile breeds during the last decade. The instructions are the result of inventories made possible through extensive collaboration between dog show judges, breed clubs, veterinary surgeons and supported by veterinary health insurance statistics.

The breeds listed in BSI constitute 39 of the approximately 300 FCI breeds represented in Nordic countries and are selected from 73 breeds deemed, by Scandinavian Kennel Clubs, as possibly challenged with a negative development due to exaggerated features.

A judge should familiarize himself/herself with the breed specific instructions (BSI) for the breeds he or she has been invited to judge. The observations regarding the areas of risk (BSI issues) specific for each listed breed should influence quality grading and competition assessment depending on the degree and severity of the deviation just like other faults. In written critiques, judges should comment on the BSI issues and how these observations influence the grading of each dog.

An essential value of the BSI concept is the judges' reports on observations regarding areas of risk on a special form for each breed. These reports are necessary for the follow-up of the listed breeds and for the continuous updating of the BSI document. These forms are also communicated to the breed clubs in order to create consensus between judges and breed expertise. It's up to the national kennel clubs to decide about the practical implementation of the reporting.

The latest version of the NKU BSI document can be found at the SKK webpage (<http://www.skk.se/Global/Dokument/Utstallning/special-breed-specific-instructions-A8.pdf>). As a complement to the BSI document, SKK has produced a short movie with the aim to educate show judges and breeders regarding the assessment of dogs' respiration. The film illustrates the causes and background to dogs' respiratory problems and the difficulties to adjust the body temperature. It also discusses the signs of affected breathing that a judge may observe. The movie is available on Youtube (https://www.youtube.com/watch?v=kQ_3f4bLkME&feature=youtu.be)

Breeding for behavior traits

In addition to health issues, behavior traits are of great importance in the breeding goal of dogs. Most of the dogs today are not used for their original purpose but are mainly used as companion dogs. Hence, the majority of potential dog owners are looking for a non-aggressive, non-fearful, social and easily trained dog that functions well in everyday life.

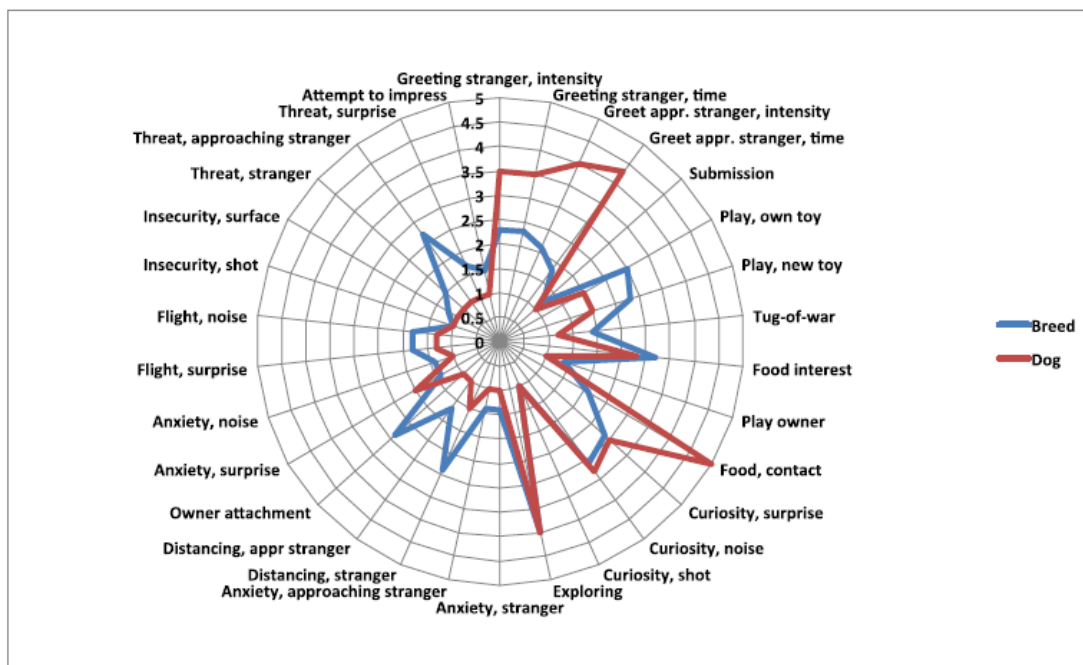
SKK record results from two different behavior assessments; the Dog Mentality Assessment (DMA) and a new Behavior and Personality Assessment (called BPH) launched by SKK in 2012. The DMA was

developed in the 1980s and -90s as a tool for working dogs, and has been used for many years by the Swedish Working Dog Association to assess behavior in dogs. SKK's new assessment, BPH, was created with the purpose to contribute to better knowledge about the behavior of all dogs, regardless of breed. The assessment aims to give an objective description of how the dog reacts to and cope with different situations in everyday life. It should be helpful for breed clubs, breeders and dog owners to have a tool which helps to describe the mentality of the dog, whether it is a potential breeding animal, pet or working dog. For a person considering to buy a dog, BPH can also give a description of the mentality of various breeds and of the parents of the litter of interest. Every BPH-evaluated dog contributes with a piece of information that increases our understanding and knowledge about the behavior of that specific breed and of dogs in general.

A BPH evaluation takes about 30 minutes. It consists of 7 parts and the aim is to give a summary of how the dog reacts in and handles various situations. This could be about meeting strangers, playing, searching for food and surprises. If desired, the dog's reaction to gunshot can also be evaluated. After finishing the track, the observer will give an oral summary of the dog's reactions to the owner and a subjective description of its personality.

The dog must be at least 1 year but there is no upper age limit. It must have known identity and be vaccinated. Unregistered dogs need to have a license to compete and the owner or handler must be a member of SKK or an associated breed club. No preparation or training is necessary and there is no minimum requirement for obedience level. The dog owner needs no preparation but will be guided by the observer at each step.

During the BPH the observer fills out a scoring form with several entries. The aim is to describe the behavior of the dog, not to rate it as being good or bad. The results for various behavior traits are summarized both in tabular and graphic form. The same behavior trait is measured in several situations and the presented results are a summarized result. In the graph, the individual dog's behavior is compared with the breed average. All results from dogs being evaluated in either of the two assessments (the DMA or BPH) are presented on SKK's website through the Breeding Records service.



Graph illustrating the BPH test result of an individual dog (red line), compared with the breed average (blue line). A low value on the scale means that the dog showed the behavior only to a small degree or for a short time, and vice versa.

The SKK database contains a large number of records from behavior assessments, more than 100,000 records for the DMA (from 1997 until today) and about 6000 for the BPH (from 2012 until today). So far, dogs of almost 200 breeds have participated in the new BPH assessment. The material constitutes a valuable source of information for breeders and dog owners as well as for researchers.

SKK recently produced a film about BPH. The film is currently only available in Swedish (<https://www.youtube.com/watch?v=Ip5LfESucME>).

International collaboration

Dog breeding is an international activity, apparent from an extensive exchange of breeding animals across the world. As a result, there are substantial genetic connections between populations of the same breed in different countries. Breeding animals typically have relatives in more than one country. Hence, international collaboration with respect to canine health and breeding is of uttermost importance for a long-term sustainable and successful breeding of dogs.

SKK is committed to promoting international collaboration to support dog health and wellbeing. In 2012, SKK arranged the 1st International Workshop on Enhancement of Genetic Health in Pedigree Dogs, the International Dog Health Workshop in short. The overall aim was to boost the collaborative actions needed for a healthy, long-term sustainable dog breeding. This initiative was carried on by the German Kennel Club (VDH) in February 2015, arranging the 2nd International Dog Health Workshop in Dortmund. Both workshops have attracted a wide range of stakeholders and provided valuable opportunities to exchange experiences and views on canine genetic health.

One important outcome of the 1st International Dog Health Workshop was the foundation of the International Partnership for Dogs (IPFD), a legally registered non-profit organization in Sweden. IPFD is a groundbreaking collaboration between cynological organizations (e.g., kennel clubs), health registries, research and veterinary organizations, non-profits, corporations and other stakeholders in dog health with the mission to enhance the health, well-being and welfare of dogs. IPFD represents an exciting step in the cooperation, collaboration and sharing of information and resources within the global dog community.

The internet platform of the IPFD, www.dogwellnet.com, functions not only as an information hub, providing links, documents and additional resources to breeders, breed clubs and others in the dog world, but also revolves around 'building community' – bringing people together.

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