

Strategies in modern dog breeding

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Introduction

Breeding is one of the various possibilities to solve problems in keeping and using dogs. For example health traits can sometimes be treated medically by supplementing deficiencies or by surgery. While this is only a temporary solution, breeding leads to long term reduction and can therefore be more efficient and preferable. Improving traits concerned with performance and talent makes it easier to educate and handle dogs.

Some traits in dogs are strongly determined by predictable genetic effects, but most of them are modified by different environmental conditions. Behavioural traits (hunting, trail work, etc.) have heritabilities of about 20 % which means that 20 % of observable variance between animals is caused by genetic differences. Breeding therefore can not solve all problems. It is necessary to treat the dogs properly through optimal nutrition, socialisation, education and usage.

Breeding clubs have to care for the dogs and owners alike. They also have to support the breeders to be successful. Since we invest, produce and sell on a market, breeding is like a business. But, unfortunately breeding is done in a very traditional way. The clubs should be more professional and open to strategies that make breeding more efficient which is in the interest of the dogs welfare. This statement should not be misunderstood. Professional does not mean commercial.

Business planning

The strategic planning of a business consists of three main fields in which different substructures are involved.

1. Planning level

The highest and most important section is the planning level. The development of a strategy starts with critical analysis of the actual situation. If there are any insufficient parts or if the political, social or economic frame conditions change, different alternative plans must be developed. These plans must consider the present weaknesses and foresee possible problems in the future. New ideas and innovative technologies must be involved (for which experts are so important) and the expected response has to be calculated thoroughly. These new concepts are debated and the most preferable is then presented to the decision level.

2. Decision level

Within animal breeding clubs, decisions are done democratically either directly by the members of the club or their delegates. Once the new concept is found to be good and acceptable it will be submitted to the *level of implementation*. If not, it will be redirected to the planning group with certain suggested improvements to be considered for modification and adaptation.

3. Implementation level

All details must be organised in order to implement and maintain the plan. Once accepted the plan is put into execution and its strengths and weaknesses are analysed. Additional suggestions are then made to the planning level.

Breeding plans

Returning to the topic of animal breeding and the necessity of clearly defined breeding plans.

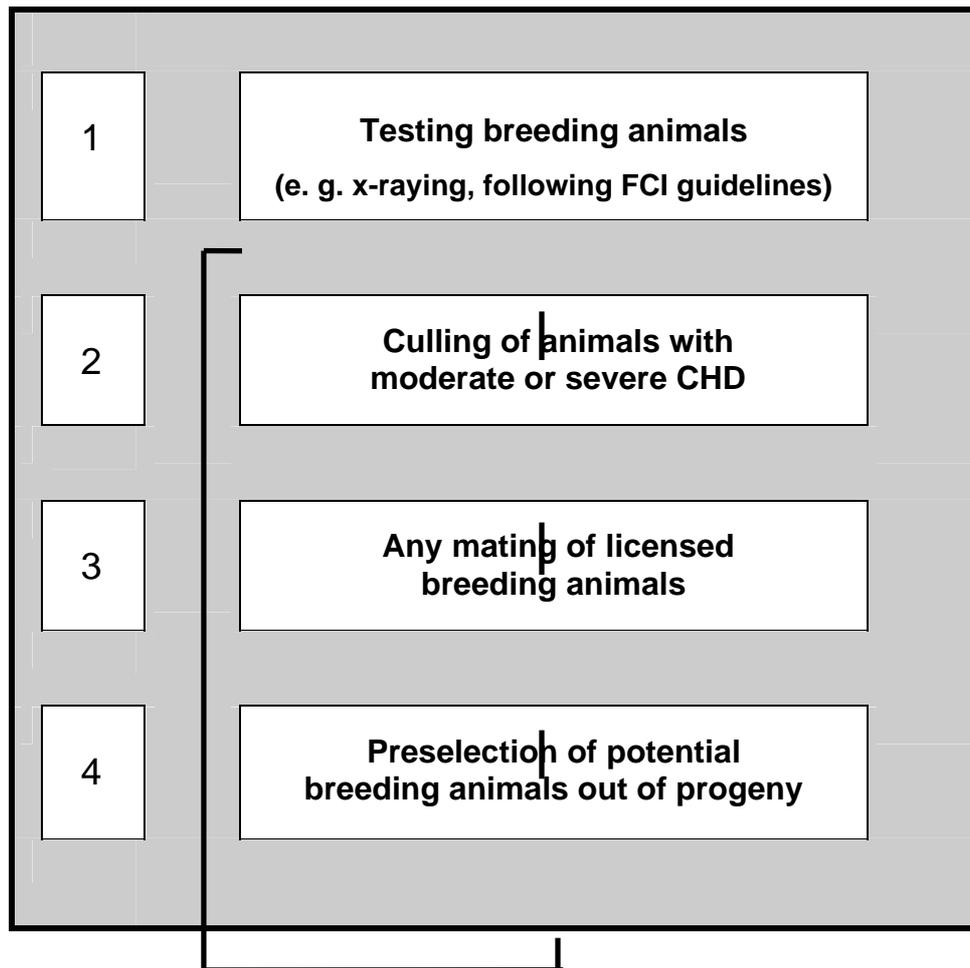
One example deals with canine hip dysplasia (CHD) in the German Rottweiler population. In order to evaluate the efficiency of the actual breeding program, it is necessary to have valid and actual planning parameters, shown in table 1. The selection trait is the hip grade (five classes, 0 to 4) following the conventions of the FCI. The heritability was found to be 0.22, about 33 % of the population is tested and the population mean in 1994 was 0.70 CHD-units.

Table 1: Data for planning strategies against CHD in the German Rottweiler Population

Trait for selection	5 CHD-classes (FCI) (scoring from 0 to 4)
Accuracy of phenotypic information to characterise the genotype (Heritability)	$h^2 = 0,22$
Mean within the Rottweiler population (1994)	$\bar{x} = 0,702$
Puppies per year (1994 / 1996)	N = 2958 / 3487
Rate of x-rayed animals	32.93 %
Age at x-raying	556 days, about 18.22 month

Breeding strategy in the German Rottweiler Club (ADRK) can be structured into four main points which are specified in Fig. 1. Dogs and bitches designated for breeding must be x-rayed at a minimum age of 15 month. Animals with middle (class 3) and severe (class 4) CHD are discarded from breeding. (Since 1996 also dogs with moderate (class 2) CHD are discarded which does not affect the data presented in this example.)

Fig. 1: Scheme of the breeding strategie against CHD in the German Rottweiler Club

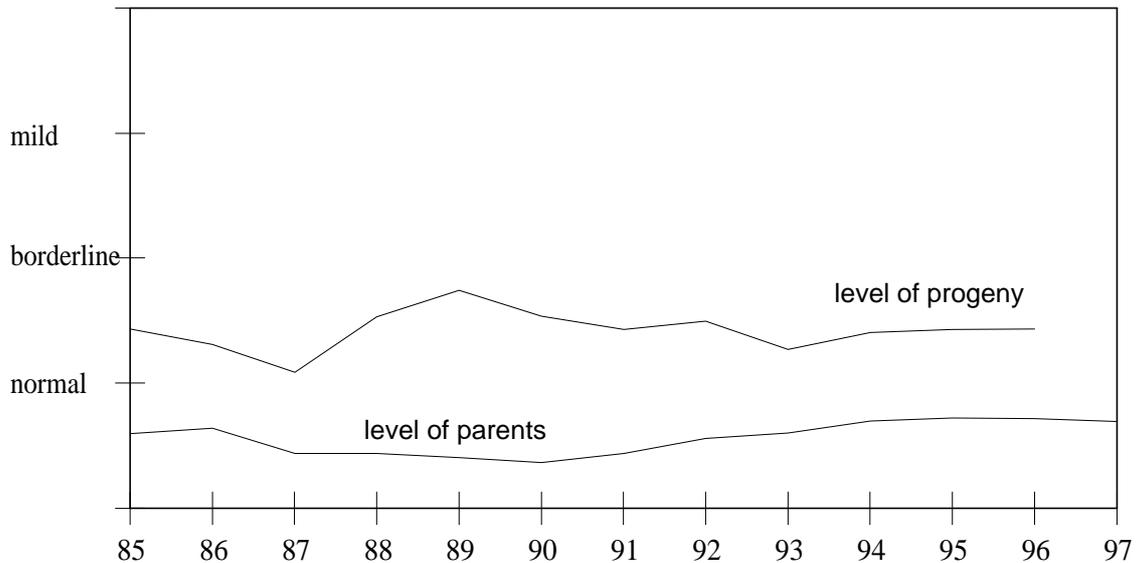


The dogs will get their licence for breeding after passing performance tests for other traits. Licensed dogs can be mated without any restrictions by the free decision of the owner of the brood bitch.

Finally, breeders select puppies and designate them as new members of their breeding stocks which means that the puppies will also have to be x-rayed later. By this the circle is closed.

The response of this breeding plan can be quantified by statistical analysis of the population in the course of time. The genetic gain is shown in graph 1. The CHD level, after changing the age at testing in 1987, decreases from 1989 to 1993 by about -0.06 CHD-units per year and is slightly increasing from 1993 on. The cost for x-raying 1000 animals is about \$100,000 per year which is not financed by the club but has to be paid by the owners. So since 1985 until today, the time-range shown in the graph, nearly 1.5 million dollars have been invested with no visible response.

Graph 1: CHD-means of parents and progeny from 1985 to 1997 in the German Rottweiler population



This identifies the breeding plan to be of little efficiency. It is understandable that critical comments appear and sometimes, without knowledge of the complexity of a breeding plan, the whole program against CHD is doubted.

Looking for alternatives

The search for alternatives can be done in any of the four sections of the breeding plan. This is why comments are given to each of the points.

1. Methods for genetic evaluation of animals

If decisions are made to accept or discard animals for breeding, this must be done in respect of the genes which the animal transfers by its gametes (sperms, ovar) to the progeny. More precisely, it is the effect of the genes on the trait of interest which is CHD in this example. The derived phenotypic grading from a single x-ray is very inaccurate information for the genetic disposition. Therefore two aspects have to be considered:

At this time, scoring is mainly done in order to predict the health risks of this special individual no matter if it is caused by genetic or environmental influences. It has to be proved, for the breeders point of view, whether or not the diagnosis can be focused to details which are mainly caused by the genetic makeup. On the other hand, standardisation and objectivation can give more valid breeding information.

The second aspect is to characterise the genotype by considering the information from related and tested animals. A part of the genome also exists in the relatives (parents, siblings, progeny), so that the characterisation of the genotype of one animal can be done more precisely by using appropriate statistical methods. These

procedures are called breeding value estimation which will be further explained in the following.

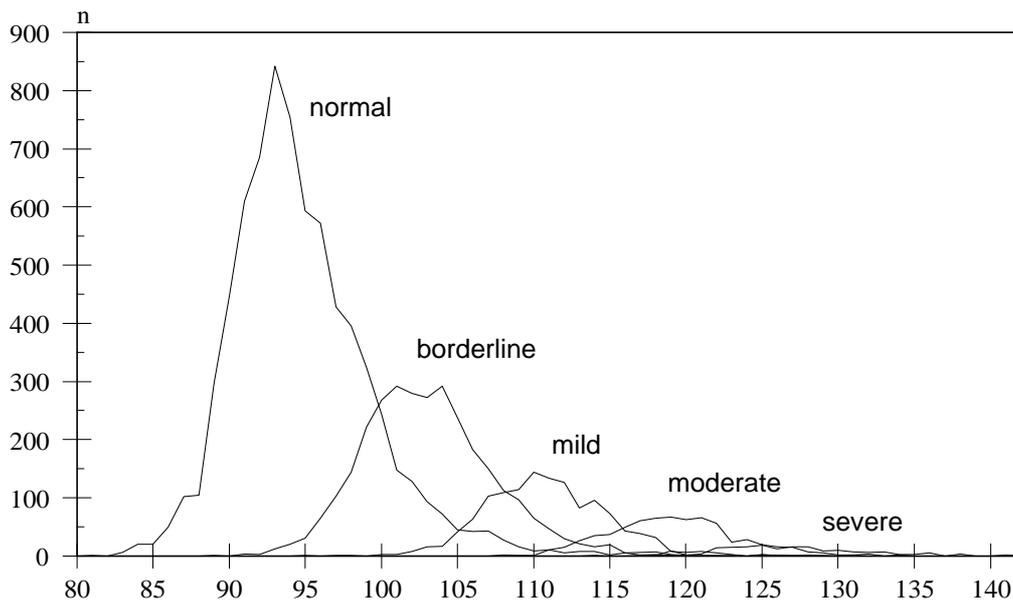
2. Selection

The genetic gain is directly proportional to the selection intensity done and because of this a stronger selection is demanded. Even a selection of only CHD-free dogs is often postulated. While planning strategies strong selection must be proved. At this point further principles come clear and the side effects of any activity must be included.

A stronger selection can cause a kennel to become blocked because the bitch does not fulfil the requirements in this particular trait. The selection basis is then reduced for other important traits. Genetic drift can more likely occur in uncontrolled traits (e. g. epilepsy). If the correlated negative effects are lower than the positive effects of the more intensive selection, the plan is preferable.

The result of a more intensive selection can be demonstrated in the example of the Rottweiler population. Graph 2 shows the level in which the animals breed, where 100 represents the population mean. Lower values indicate reduction of CHD whereas higher values indicate an amplification. The graph shows the breeding values for animals in different CHD classes and clarifies that CHD unaffected animals breed on a lower (better) level, but some animals with moderate CHD can breed much better than some unaffected animals.

Graph 2: Breeding values in the German Rottweilers with different CHD-classes



Statistical analysis show that discarding all animals with moderate CHD from breeding would not affect the average level of the paternal CHD because in practise no such sire was used. On the maternal side, this would reduce the average hip class from 0.458 to 0.257. Theoretically, an improvement of 0.02 units can be expected by assuming a heritability of 0.22. Currently, bitches with moderate CHD are in use in

some kennels. The introduction of this restriction would either block the kennel (since most kennels have only one bitch) or the restrictions would only become valid for new licensed bitches. Then the full effect will appear earliest after five to seven years. Instead of that theoretical foresee, it is also possible to check what CHD-level would have been realised in the year 1994, if the bitches with moderate CHD would not have been used for breeding. The average of the whole progeny (934 x-rayed animals) is 0.713. Without the offsprings from bitches with moderate CHD ($n = 857$) the level is 0.711. The realised advantage by this would be 0.002 CHD-units. The descendants of CHD unaffected parents ($n = 469$) is about 0.08 units better (0.635).

This shows that increasing selection intensity does not lead to much better results. It can even be irresponsible if considering the correlated effects on the size of the breeding stock. On the other side it can be irresponsible using unaffected animals which have shown by their relatives (siblings and progeny) that they breed worse. It makes no sense to select more strictly on the base of the phenotype which has a heritability of only about 20 %.

3. Mating control

The actual breeding plan in the Rottweiler breed is aiming to offer a wide range of quality animals (free and moderate CHD). The breeders association itself trusts in the breeders responsibility and competence to make the right decision by knowing the CHD-score and all other performances of the sire and dam. In fact, the free market with supply and demand leads to an additional selection. It can be observed that sires with moderate hips are practically not requested, but the effect on the population mean is only marginal. At that point, it is possible to introduce new requirements, e. g. mating restrictions. These can be applied on the base of phenotype or on the base of actual figures in respect to breeding expectations (breeding values).

Keeping the breeding goal in mind, in order to improve the next generation, mating restriction should be applied on the base of the genotype. This principle its named Strategic Mating. The mating strategy is to produce only puppies with a below average dysplasia risk. The breeding values describe the effect of the genes and by this the breeding values describe the expectations under normal environmental conditions. Since half of the genes come from the sire and half of the genes from the dam, the expectation for the puppy is half of the breeding value of the sire plus half the one of the dam. Therefore, the average breeding value from sire and dam can be used for restrictions in mating. The brood bitches in the kennel must be accepted as the given base. As a result, the mate must be chosen in such a way that his genes will compensate the deficiencies of the dam. Strategic Mating does not require any preselection of the parents. Kennels are not in danger of losing continuity. Strategic Mating avoids mating "poor with poor", but definitely allows for mating "best with best" which encourages the breeders to breed at their optimum ability.

4. Sorting the best young dogs to the kennels

Preserving an adequate number of animals in the breeding population is often taken as a limiting factor in animal breeding. It is mostly overemphasised, but it must still be taken as a serious argument with dependence on the population size. Especially if personal commercial interests are involved unproved fears are unfortunately taken as points against efficient breeding programs.

There is no doubt that the population size needs to be stabilised by improving the image of the breed and by having enough qualified kennels. Sorting puppies from the leading lines into the breeding stocks can especially avoid too many good genes from becoming lost by being sold as toy pets. In addition, it is necessary to break down some barriers which will make it easier for dog owners to allow their dogs to be available for breeding. As a result, additional good males can be used for breeding even though the owner is not a breeder in a narrow sense. The owner might be willing to x-ray his dog or bring him to an inspection, but he might not want to take part in show competitions. An optimal breeding plan must look for a compromise between the necessity of tests and the preservation of the genepool.

Conclusions

Under critical review the following points can be modified depending on the trait of interest, the breed and the frame conditions.

The testing methods can be modified to reach higher heritabilities.

The genetic evaluation can be modified from simple performance testing to complex breeding value estimation.

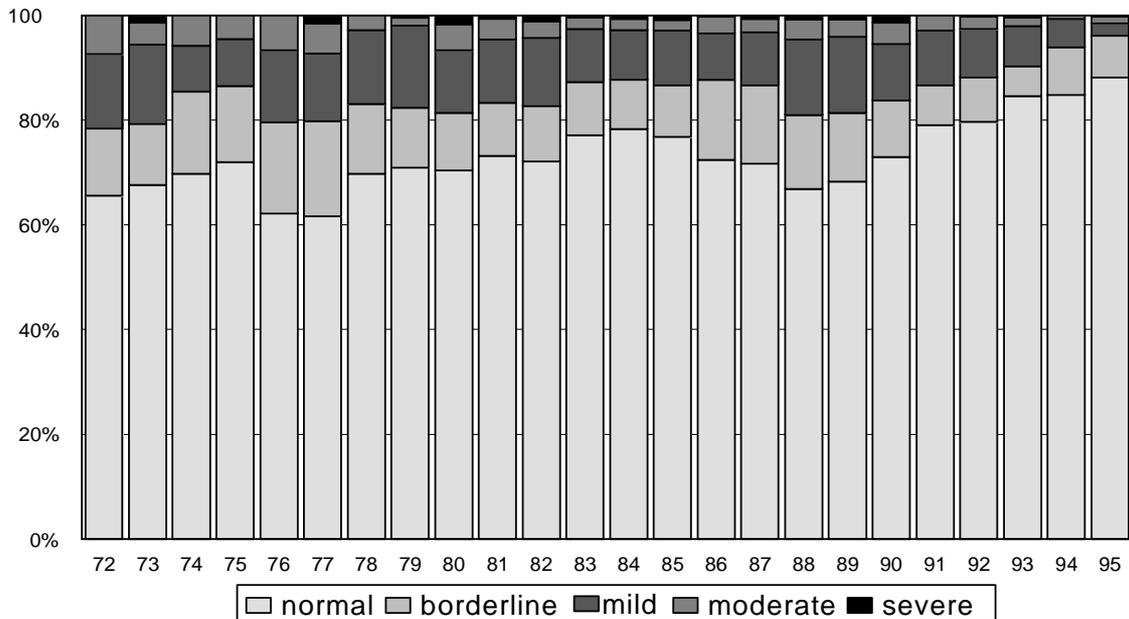
The mating restrictions can be changed from demands on the performance of the parents to demands on the mating.

Genetic resources can be made available and can be expanded by - for example - testing a higher percentage of the population and sorting the best to the breeders.

If these points are assembled into a total breeding plan, the expectation of the genetic progress must be calculated. The optimal combination of the factors leads to the best breeding plan which then must be accepted and brought to realisation. Under permanent control, the plan must be adapted or continued, if there is no alternative. The various factors will be illustrated through different examples.

The breeding club for Hovawart dogs successfully bred against CHD. The analysis showed that the amount of unaffected animals decreased beginning in the year of 1984. Since only unaffected animals have been used for breeding, there was no way for a stronger selection. By introducing breeding value estimation it became possible to differentiate between good and poor breeding animals. Graph 3 shows that the modified breeding plan, started in 1989, turned the genetic trend into a constant improvement.

Graph 3: CHD-development within the Hovawart population in former West-Germany



Breeding value estimation is a method for better characterisation of the breeding stock. Progress can only be made if this improved knowledge is put into use. Combined with the introduction of the breeding value estimation, Strategic Mating was established out of which the success finally came.

It can be shown through other examples that the progress stops or depreciates if breeding values are only offered without any mating rules.

Comments on the genetic evaluation of animals

As already mentioned, an important aspect in animal breeding is the genetic characterisation of the individual. The method for that will be further more explained since the total of the steps are strongly influenced by the method of choice.

The phenotypic grading is one of the easier part because it is a constant. Once graded, the individual will keep this result in the future. The parameters for a breeding license are the CHD-result, the behavioural test and other tests. They are like a parcour towards the final license for breeding.

Instead of looking how the animals are, it is much more effective to look how the animals breed. This depends on the quality of the genes which are transferred from the animals to their offsprings. Because of the continuity of the genes and the fact that no gene can be transferred from the sire to the offspring which has not passed from the grandparents to the sire, statistical analysis of the relatives give a good information which genes may be located in the animal and therefore may be transferred to the offspring. Paternal siblings indicate, which genes have been transferred from the father and this gives the probability that the individual itself has

genes likely to those. Sires performance is also caused by the genes and may indicate what quality of genes has been transferred from his parents to himself. Also fullsibs and maternal halfsibs give information about the geneflow from the parents to their offspring.

By meiosis, only half of the genome is transferred to the progeny. It is a random sample. Therefore it is necessary to prove which sample from the parent might be located in the particular animal. The own performance helps to find out how this animal is genetically different from its siblings. Once used for breeding, the experiences made by testing the progeny, taking into account which genes come from the mates, show more and more clearly the genetic makeup of the animal.

The fact mentioned above shows that the amount of information is growing in the course of time. At first only weak information from the pedigree exists, which will be expanded by a growing number of siblings, later the own performance test will be added and finally the genetic evaluation becomes more and more accurate as the progeny is growing.

Looking for the effect of the genes on one particular trait, the statistic analysis shows whether the genes are reducing or increasing the level of the trait. This effect, called breeding value, is given in units of the trait, for example in cm for wither height, in CHD-units, in points for field trial tests, etc. For practical application, this statistical figures are transformed in that way, that animals which hold the population mean are characterised with a breeding value of 100 and a standard deviation of 10 points. Animals with lower values than 100 reduce the trait, animals with higher values than average will increase it. Breeding values are purely descriptive and have nothing to do with "good" or "bad". For CHD a low breeding value is good, because the genetic risk is reduced. For the trait "self-confidence" high values may be good and for "wither height" the optimum is around 100.

In practical application, not more than 6 traits should be given to the breeder to concentrate on. These traits should be the ones of most importance. For some a breeding plan should exist and some of them can be offered purely informative.

Breeding plans

Breeding strategies must be exactly written down with all details. That is necessary, if constraints from the breeding plan are mandatory. An example of a breeding plan for the Rottweiler population is given in the appendix. It is based on the parameters mentioned above, including breeding value estimation and Strategic Mating. It was a recommendation for that population and computersimulation showed that the breeding plan is more than double as effective than breeding only with CHD unaffected animals. Nearly all bitches can remain in the kennels and youngsters with good performances from leading lines can be used for breeding although CHD might be moderate or borderline. Meanwhile this breeding plan did pass in various breeding clubs (latest: Bordeaux Dog Club in Switzerland and the German Sheppard Club in Germany).

Furthermore, similar breeding plans exist for monogenious traits in which genotype probabilities are used instead of breeding values.

Summary

Principles in constructing breeding plans are outlined and comments are given to different points. It was shown that genetic evaluation, mating and selection affects mainly the response of the total breeding activity. It is necessary to formulate the procedure beginning with the recording of data and ending with the constraints.

Breeding plans always have to be controlled routinely by annual statistics in order to be sure that the plan is still working and to be open for modification and improvement, if necessary.

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Appendix

Breeding plan against the Canine Hip Dysplasia in the Rottweiler population

1. Preface

Rottweiler belong to that breeds in which individuals can be affected by middle or severe Hip Dysplasia. This can be caused by a genetic disposition. The following breeding plan deals with the genetic improvement, besides this it is necessary to care for an optimal nutrition, keeping and training of growing dogs.

2. Calculation of genetic risk

The German Rottweiler Club (ADRK) applies a scientifically accepted method for breeding value estimation to calculate the genetic risk. Currently, the method BLUP (Best Linear Unbiased Prediction), including information from all relatives is the best method momentarily available. The breeding values have to be transformed to relative breeding values with a mean of 100 (average of the breed) and a standard deviation of 10 points.

3. Information used

The data used for calculating breeding values are the CHD-grades, following the guidelines of the FCI. Knowledge from x-raying non-adults can to be used proportional to its information content. Whereas, the recommended age for x-raying of breeding animals is 15 month.

4. Calculation intervals / Duty towards Information

Breeding Value Estimation has to be done four times a year. The actual results must be available for breeders. Every three month, the club has to hand out lists with all licensed dogs to the breeding councillors. Further more, the breeding values are updated in the information-software "DOGBASE" which must be available for all breeders. These figures are base for all restrictions coming from the breeding plan.

5. Restrictions

Animals with moderate or severe CHD have to be discarded (following § 4, 1.3 VDH). Dogs licensed by the Club, in respect to other traits, are only allowed for mating with mates in that way, that the CHD risk of the puppies will be below a defined level. The risk for the puppies results from the average breeding value of both parents. Currently the border line is at 100, it is recommended to aim lower values.

It is the breeders responsibility to inform himself in an adequate way about the admissibility of a certain mating. Puppies with an not allowed high risk are marked in the pedigree as not to be useable for breeding.

6. Contravention

Contravention against restrictions in the breeding plan will be punished like contravention against the General Breeding Order.

7. Effective Date

The guidelines of this breeding plan become obligatory with the date of The management is authorised in cooperation with the breeding panel and involving scientific guidance to adapt the breeding plan to the given frame conditions including the actual experience.