BREEDING DOGS FOR THE NEXT MILLENNIUM

The evil might of hazard - nobody knows when it will strike - Of coins and breeds What has pure chance to do with the fate of dog breeds? Quite a lot. An everyday example may illustrate this:

If you throw a coin, you have two options for the outcome, but only one can turn up. One alternative necessarily fails. If you throw six times, chances are that you get both options, but in different numbers for each. Hardly you will get both faces up six times, so one face will "win" over the other, or with other words, some options of one face will be "lost". Throw a hundred times, and there probably will be both options in about equal numbers. The higher the number of throws, the closer you get to a fifty-fifty ratio, provided the result is not biased by a defective coin that makes it fall more frequently to one side. In a million casts, the deviation from a half-half distribution will be insignificant. That means, the more throws, the lesser the power of hazard to produce an unequal, biased result of the two options.

The same happens genetically to a breed. If the breed is very small, the 100.000 gene pairs with 200.000 single genes (alleles) of each dog are "cast" with every new generation, that means freshly distributed. Chances are, that comparably to the coin example, some alleles of gene pairs in the populations get lost, others increase correspondingly in number, and finally one allele might completely vanish from the breed while the other holds the field, it is "fixed" in the population. Ok, there are still 200.000 alleles in the cells of all these dogs, but now many more allele pairs consist of identical alleles, and if some of these are defective, the dog will suffer from some disorder, sometimes even a deadly one. Besides, many genes yield more stamina and viability if there are two different alleles per pair.

Every breed is a" rare breed"

The greater the effective breed population size, the smaller the number of allele types lost or fixed in that way, the less the risk of a substantial deleterious change of the genetic situation. Effective population size means that a breed population may consist of many thousand dogs but if the breed was founded by a handful dogs and/or has been heavily inbred, it contains relatively few different alleles, so in effect a breed of several million dogs like the German Shepherd Dog may have an effective genetic population of just 500. In such a breed, the inbreeding advance because of breed size is minimal, but the inbreeding level resulting of the few founders and subsequent inbreeding or stud over-use will be relatively high. Thus, genetically seen, even the world's most popular breed is a "rare breed", and so are all the rest. Natural animal populations, by contrast, mostly have effective sizes of many thousands or even millions.

In the last decades genetic science has undergone a revolution that has given us a better understanding of how nature is governing the fate and evolution of animal populations. The secret to health and viability of wild animals is permanent severe selection plus high genetic diversity. Therefore, by contrast to what is commonly believed, most animals use diverse strategies to avoid inbreeding. Wolves, for instance, partly leave the pack as young adults being expelled or voluntary, and roam long distances (hundreds, even thousand miles and more) in order to find a non-related partner to found a new pack and a new territory or a pack that is willing to admit them. Inbred wild animals would be handicapped in the struggle for survival and mating partners so nature favors outbreeding behavior, even in species where few males reproduce (harem pashas). In these cases, the male turnover is rapid due to exhaustion, and often they are not able to effectively watch over their females. So short active periods before being replaced by a rival prevent mating with daughters. There are few mating males at any moment, but still rapid replacements provide for many mating males per time period. The creation and breeding of purebred dog breeds is based on an entirely different system with detrimental consequences: in creating today's breeds, a few animals of a characteristic strain, a "landrace", were selected that were highly typical. While showing some basic traits in common, these landraces were rather heterogeneous. The few selected animals were inbred in order to fix the desired characteristics. Sometimes, different looking strains were crossed in order to create an entirely new type.

Again, the few resulting animals showing the right type the breeder wished to materialize were inbred to stabilize the result. So, new breeds were born. This happened about hundred years ago with most breeds. Since then, they became "pedigree dogs" and no crossbred or unregistered dog was anymore accepted to the stud books. Thus breeds were kept in a "golden cage" losing genetic variety ever since for the reasons described above (stronger hazard effect plus actual inbreeding and over-use of far too few studs). The results is seen in better health and longevity of mongrels, but appropriate state of the art breeding and selection would produce dogs that are even healthier and live longer than mutts, a goal sound breeding ethics prescribes. Incest - not only an abomination in humans It was soon detected that incestuous inbreeding could create a hoard of problems. Highly inbred animals became delicate, easily sick, sterile or showed other defects. So breeders learned to be careful with matings between close relatives, and sometimes it became even necessary to outcross. This immediately remedied all problems, but often hampered the breeding progress. If during the inbreeding period, animals showing defects or diseases were carefully culled, the breeding lines were actually "cleansed" of the most deleterious genes. So, the general conception of inbreeding was to be a very effective and essential tool for achieving any breeding goal, being harmless, even useful for the health of the breed if appearing defects were severely eliminated. Often just one dog showed all the desired breed characteristics to such a high degree, that this one, having won high awards and championship, was wanted as a sire by many breeders, sometimes most or all of the bitch owners of that particular breed. Often this stud turned out to be a prepotent sire, improving the conformation or performance of part of or the whole breed. But this prepotency was mostly the effect of the genetic depletion of this sire. As he had little more to transmit than his own good looks and other traits, he could not transmit any undesirable traits to his offspring. In biological terms, however, he is not "prepotent" but biologically inferior. Sometimes it happened that the dog world did not like the current look of this breed any more. So the standard was modified or just otherwise interpreted by judges, clubs and breeders. As standards are just descriptions, there was room enough for everybody reading it to get a different notion of what this breed should look like. In fact, just by reading a standard it is difficult or impossible to get a realistic idea what the breeds looks like, if you have never before seen a dog of this breed. These changes of breeds can be seen if we look at old pictures and new ones of the same breed. Sometimes one should think the dogs belong to different breeds. A change of

characteristics required a special selection for the new traits ensued by increased inbreeding to fix them in the breed. As very few dogs showed the characteristics of the new type, only these were now suitable for further breeding, especially of course those males that were the best representatives of the new type.These were again heavily used as studs. Quite often it happened that a breed lost its specific working task and became nearly extinct, e.g. the Irish Wolfhound, or the Saint Bernard. Or, in wartime, people could no longer afford dogs, especially of big breeds, so again these were threatened of extinction. When renewed interest or improved economic conditions allowed to produce dogs of these breeds again, just a few were left to start anew building up a population. Now let us see what happened genetically in our pedigree breeds. They were and are continuously subject to close breeding. While "close breeding" is often used to designate "incestuous" matings (brother-sister, parent- child) I mean to characterize all those breeding practices that decrease genetic diversity, i.e. (i) close inbreeding (incest) (ii) mild inbreeding (line breeding - uncle - niece, aunt - nephew, cousins, etc) (iii) too small numbers of studs in breeding populations and their highly disproportional use (iv) shrinking gene pools due to changes of breed characteristics (revising or reinterpreting the standard) (v) the case of rare breeds (vi) "overstandardizing" breeds, as this too eliminates the necessary genetic diversity (polymorphism)

All this adds up in permanent accumulation of the inbreeding and homozygosity level of breeds, both real inbreeding as well as all the other practices listed above, so some of them produce inbreeding effects even if the breeder does not use "real" inbreeding! So all the cited events and practices used in a breed's history tended to give rise to genetic depletion. The average inbreeding level (inbreeding coefficient) of dog breeds is therefore estimated to have reached 14%. That is about the inbreeding level of progeny from a halfsib mating, but many will be much higher. In fact, many breeds constitute family clans, outcrossing becomes impossible. Any increase of the inbreeding level is a proportionate rise of identical genes (alleles) in a gene pair resulting in corresponding higher risks for hereditary defects and diseases. In progeny of sib matings (inbreeding factor 25%) probability to be affected by a hereditary defect is about six times higher than in that of non-related matings, if five percent of the population carry the defect gene! A friend that tries to keep inbreeding levels low was happy to get down to an inbreeding coefficient of 6% but was aghast when he was told that after computer calculation of the

breed population the actual inbreeding coefficient of his dogs is around 30 %, i.e. higher than that of a sib mating offspring! Breeding pet animals genetically highly depleted by inbreeding or any of those other practices listed above has began to cause serious concern in many advanced countries. Holland has enacted a bill for animal protection stipulating possible bans both on breeding with animals with a high incidence of severe defects and methods of breeding that could result in sick or otherwise suffering animals. According to a Dutch expert, upcoming provisions to this law could ban breeding dog breeds that show increasing severe affliction by hereditary diseases, and line breeding, being a method that is liable to result in higher risk of hereditary defects. In Sweden it was proposed to limit the lifetime litters from one stud between 1 (!) to 100, according to the population size of each breed. While this proposal was rejected by a majority of breed clubs, working breed clubs were more positive about it than clubs for show breeds. The Swedish Clumber Club already fixed this figure to 4 litters per stud. Moreover, the Swedish Kennel Club is sponsoring an Interscandinavian Research Project to investigate the homozygosity level of thirty important breeds by molecular methods like DNA finger- printing. The results will be most interesting, as they will be informative on the background inbreeding level of domestic dog breeds since inbreeding factors calculated from pedigrees are always too low and misleading. They refer only to a few ancestor generations, the preexisting background inbreeding level is not shown. In Germany, a draft expertise on the interpretation of the animal protection law's paragraph prohibiting matings of pet animals liable to produce disease-affected offspring has stigmatized incest mating as an infraction.

Inbreeding has a very strong effect on outbreaks of inherited diseases. If e.g. 5% of dogs in a breed carry a defect gene without being sick, a dog that has been bred from a brother- sister mating has an inbreeding coefficient of 25%. That means it has lost a fourth of the original genetic diversity and its risk to suffer from the hereditary diseases are 8,6 times higher than those of a non-inbred dog! So close breeding, while not actually producing inherited disorders, largely boosts the chances of an inherited disease to be manifested. As practically every dog and every human carries several defect genes, this risk is nearly always present. So many decades of close breeding have brought about high percentages of defect genes in nearly every breed producing the so-called "breed-specific diseases". While natural animal and human populations may carry hundreds or thousands of different defect genes, in individual dog

breeds there are only a few but since a big proportion of the breed carries defects of the same type, so many dogs of pedigree breeds get sick. By contrast, in wild animals of natural populations sick individuals suffering from genetic diseases are extremely rare, as parent animals while mostly carrying several defect alleles each, rarely the same ones are incidentally present both in a mating male and female, so sick offspring is an exception in nature.

Small population size, but also all the other breeding practices increase the deleterious power of hazard to make genetic diversity get lost. But as in the comparison with the defect coin that falls irregularly, the right kind of selection can, if partly, counteract this effect. In fact, the calculated inbreeding coefficient is never precisely equal to the actual loss of genetic variance, for it is subject to incidental variation as explained before. The meansto keep variance high is selection for health and fitness, because it favors those individuals that by chance have maintained a higher level of genetic diversity (there are always some of these in a larger population). Thus, in those former days of dog breeding dogs were still heavily exposed to forces of natural selection: low standards of general and veterinary care or its absence (no vaccination, poor feeding and care, more use as working dogs, poor housing etc.) helped to maintain genetic variability for some time in spite of inbreeding. In the meantime, this has materially changed, dogs with poor viability may today be raised and successfuly bred on account of high standards of general and veterinary care. So inbreeding damage is much more pronounced as biologically inferior subjects enter the breeding stock (actual genetic loss may thus be higher than the calculated inbreeding coefficient!)

As a result of these developments, and most inexpectedly, in 1996 the time-honored mother of modern pedigree breeding herself, the English Kennel Club, has changed her basic and principal centennial rule: dogs of unknown or "impure" origin are no more absolutely excluded from being registrable if officially admitted! The idea behind is probably the risk that advancing DNA-testing would disclose that a majority or even all dogs of some breeds already carry some deleterious defect what obviously could badly impair a breed's market appeal. Now the only way to decrease defect gene levels in so highly affected breeds without any reserve of non-carriers is crossing with a less affected but closely related breed. In fact this would not destroy a breed's characteristics if well planned and followedby back-breeding and appropriate selection. On the contrary, as few as just one strange animal per hundred

breeding dogs and generation in a population would very effectively prevent genetic losses and thus counteract the advance of inherited diseases and improve viability, health and general fitness of the breed!

Last year, the International Ethological Conference at Vienna bore ample witness of how animals in nature (including man) make sure that their progeny is provided with that genetic fitness as is necessary to give it the means to withstand environmental challenges, e.g. the onset of parasites and infections of all kind. This constant "arms race" between animals and parasites is at the root of evolution of species. Animals use the costly sexual reproduction (two animals needed for one progeny) for being able to throw persistingly new genetic combinations into the battle for survival. In he majority of cases, inbreeding is of course avoided for an inbred offspring would be at disadvantage competing with outbred progeny of other parents.

This requires to dispose of a heterozygous MHC and possibly a well matching one, which is mostly achieved by skilful female mate choice: the MHC, the Major Histocompatibility Complex of genes, is not only responsible for an animal's immune capacity but at the same time also for its body odor, thus serving as an infallible indicator ("honest certificate") of a male's genetic quality as a sexual partner. So by sniffing a female can easily ascertain if a potential male partner is too near a relative and if not, if he would make an adequate match to produce good resistance and competitive strength in the offspring. So far, this phenomenon has been verified a.o. in mice - and at leat partly, in man, or women, for that matter. Less smell-oriented animals, like peahens and other birds see on their cocks' ornamental feathers, symmetry, and color brightness if they are genetically eligible or not. This has revealed the vast importance of female mate choice for the survival of animal species (including the human race, come to that). The loss of MHC variability not only decreases vital infection resistance, but poor MHC's even give rise to autoimmune disease and vaccination accident susceptibility, so the dog's MHC is currently an object of veterinary research. Unfortunately, we cannot allow our brood bitches to chose their females as they would lay little weight on standard and working traits. Besides, chances are they have lost the selection capacity during the domestication history, though examples of female choosiness are known to dog breeders, but hopefully vets will be soon able to substitute females in this job tofind the right mating matches.

In conclusion, hopefully rigid "racism" may finally give way to a more

competent, enlightened kind of breeding benefiting from the long-established rules of population genetics: while maintaining the breed concept, keeping breed populations genetically variable but allowing for a more natural, health-conserving approach that rejects inbreeding and over-use of studs as well as the other deleterious breeding practices. Genetically variable dogs are more adaptive and resistant to environmental changes and requirements, better performers, healthier, showing better intelligence and character. This is called heterosis while inbreeding causes the opposite, inbreeding depression. Symptoms are loss of fertility, less resistance, intelligence, performance etc. These symptoms may but must not occur, but long-time close breeding invariably must end up in disaster. Breeders may line-breed all their life and apparently enjoy best results, but sooner or later some successor will dearly pay the bill for it in form of progeny of poor health and viability. All those hecatombs of dogs sacrificed every year for some inherited defect bear witness.

Steps to better breeding for breed preservationbanning inbreeding (incestuous and line breeding) severely restricting use of individual studs according to numerical breed size, i.e.use of many sires no over-typing selection DNA breed studies investigating actual state of remaining genetic diversity per breed selecting dogs primarily for performance, health, longevity, temperament, not just for looks and soundness planning measures for boosting genetic diversity (use of genetically distant individuals, planned crossbreeding, combining color and coat variants etc.)

These postulations may appear revolutionary but they are based on long established scientific knowledge long applied in any other discipline of animal breeding (farm animals, wildlife conservation, rare zoo animals). Indefinite seclusion of breed populations from any genetic inflow as it has been practiced these last 100 or even 150 years is impossible and seriously jeopardizes a breeds' survival. The only option would be cloning champions like the Scottish lamb Dolly, a horror vision that we really would not wish for the dog our companion for over 100.000 years (if the recent astonishing molecular genetic research findings are right).

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