AKC Purebred Preservation Bank (PPB)

Jerold S Bell DVM, Cummings School of Veterinary Medicine at Tufts University

The AKC Purebred Preservation Bank (PPB) was created by the AKC Board of Directors in August 2021. To understand the basis and need for a breed semen repository, there must be a realistic understanding of dog breed gene pools, genetic diversity, and genetic health.

The sustainability of dog breeds and purebred breeding has been a matter of consideration for some time. Can a breed continue to propagate over time with a closed gene pool and 1) Maintain adequate genetic diversity, 2) Not deteriorate in its health and quality?

Genetic Diversity

Pure breeds have closed gene pools. This means that all matings must be between AKC registered dogs from the same breed for the offspring to be AKC registered. Members of the breed from other countries and registries can be AKC registered if they conform to Foreign Registration eligibility (https://www.akc.org/rules/special-registry-services/). The issue with closed gene pools is that the genes of dogs not used for breeding are lost to the next generation. If entire lines of dogs cease to reproduce then that portion of the breed gene pool is lost. As only a small portion of the breed members are ever used for breeding, this represents a genetic bottleneck with each generation. This is why it is important that breed-wide selection of mates encompasses the breadth of genetic background of the breed gene pool, and the gene pool narrowing issue of the popular sire syndrome is avoided.

Small population breeds have concerns with genetic diversity because of low numbers of breedable dogs. Twelve AKC breeds registered fewer than 10 litters in 2021. Owners may also be reluctant to breed for fear of producing dogs affected with certain conditions such as hip dysplasia or epilepsy. For a breed to reproduce and sustain itself, breeders of small population breeds must select the best matings for quality and health and grow their populations. If breeders are not breeding, then the breed population will decline in numbers, in genetic diversity, quality, and health. Breeds with large populations had small populations many generations back. While all members of a breed originated from the same small background, population expansion creates many different “lines” of dogs that represent the breed’s genetic diversity and provides greater choices for selection.

Genes come on paired chromosomes – one from the sire and one from the dam. If a gene pair has two copies of the same gene this is called homozygosity. If a gene pair has two different variations of a gene it is called heterozygosity. Within a breed, there can be several variations of a gene available in each gene pair. Unless a gene variant is either desirable or deleterious then its homozygosity or heterozygosity has no effect on the quality or health of the dog. Molecular geneticists can measure the total percentage of homozygosity of all gene pairs, and this is a more accurate measurement than the pedigree-determined inbreeding coefficient. The percentage of heterozygosity is the opposite of the percentage of homozygosity; ex. 35% homozygosity equals 65% heterozygosity.

Any selection causes a loss of genetic diversity in what is being selected against. A loss of genetic diversity is not always detrimental to a breed unless its loss causes a decrease in health or quality. If a breed standard has certain requirements, or if breeders want to select against certain detrimental traits or disorders then you need breed-wide homozygosity at that gene location to reproduce the desired phenotype (what you see in the dog). It is homozygosity that allows a breed to breed true. Molecular genetic data shows that purebred dogs on average have higher homozygosity (44.87%) versus mixed-

breed dogs (35.98%).[2] This indicates that it takes approximately 35.98% homozygosity to be a dog, but *on average* an additional 8.89% of homozygosity to be a purebred dog.

There is misunderstanding of the meaning of breed-wide genetic diversity, how it is measured, and how it can be maintained. Commercial genetic companies market "genetic diversity tests" for dogs based on the amount of heterozygosity or homozygosity. Homozygosity measurements do not reflect the genetic diversity of the breed, but only the average type of mating being performed. Linebreeding is mating two dogs together that are more related than the average in the breed and results in a higher homozygosity in the resultant litter. Outbreeding is mating two individuals together that are less related than the average of the breed, and results in higher heterozygosity in the resultant litter. If a handful of dogs are mated to the ones most related to each other, then that population of dogs will have higher homozygosity. If the same dogs are mated to the ones least related to each other then there will be lower homozygosity and higher heterozygosity. This has not changed the genetic diversity of the population – they are the same dogs and have the same gene frequencies within the breed. Breed-wide genetic diversity means maintaining dogs from different areas of the gene pool (different pedigree backgrounds) in the breeding population.

Some breeds have a higher average homozygosity but based on valid health surveys are relatively healthy. Some breeds have lower average homozygosity and have considerable issues with hereditary disease. Each breed has its own parameters. It is not the homozygosity or heterozygosity of a breed that determines health, it is the breed-wide accumulation of disease predisposing genes.

Genetic Disease

Disease predisposing genes that can cause impaired health or diminished ability to reproduce are a major concern in dog breeding. These are usually recessive genes or additive genes that may not be identifiable in the individual breeding dogs unless there is a valid genetic test available. Homozygosity increases the expression of all (desirable and deleterious) recessive genes through pairing them up in the offspring.

If breeds have issues with hereditary disease, then these must be actively selected against through genetic testing, or if valid genetic tests are not available, then selection against affected dogs and their close relatives. This is possible with genetic testing and screening databases such as the OFA – Canine Health Information Center (CHIC). The AKC *Bred with H.E.A.R.T. and AKC Breeder of Merit* program have adopted AKC Parent Club determined requirements for pre-breeding health screening.

It is selection against specific diseases and their associated liability genes that improves breed health, not an overall measurement of homozygosity. Commercial genetic testing companies that recommend lowering the average homozygosity of proposed matings through their genetic diversity tests are not differentiating the desirable homozygosity that creates and maintains breeds, from detrimental homozygosity of disease-associated genes. If breeders are not selecting for quality and health, then both will decline. Constant selection for quality AND health are required to obtain and maintain both in purebred breeds regardless of their population size or average homozygosity.

Is The Threat of Breed Extinction A Reality?

Genetic bottlenecks have been a significant factor in restricting breed diversity and possibly increasing the frequency of hereditary disease if liability genes are carried by the survivors of bottlenecks. Many breeds went through genetic bottlenecks during World War II and emerged with smaller and less diverse populations. Historically, some working breeds were abandoned by their breeders due losing the need

for their function as technology advanced. Some breeds were replaced by similar but more popular breeds. The original breed sometimes contributed its genes through breeding to create the "new" breed that replaced it. However, this is less likely to occur today with closed studbooks.

The best way to preserve breed integrity and health is to utilize the existing gene pool diversity of the breed. This includes breed populations in other countries, or different breed varieties selected on working (hunting, herding, etc.) abilities. While these breed populations may diverge from each other and be based on different standards, they all derived from the original breed ancestors. They can be utilized to maintain overall breed diversity.

Crossbreeding (mating a purebred dog to another dog that is not of the same breed) can bring in new genes when disease-causing genes are "fixed" (homozygous) or at extremely high frequency in a breed gene pool. There are historical examples where at the request of the AKC Parent Club, stud books have been reopened and/or controlled crossbreedings have occurred. However, crossbreeding to other breeds to bring in new genes and genetic diversity, may also bring in deleterious and undesirable genes from the "other" dogs that are not present in the original breed. Therefore, breeding from within the breed's gene pool is the most desirable method to select for health and quality.

All of these are population-based issues: Are there enough numbers of breeding dogs to sustain the population? Is there enough variation in the breed gene pool to allow continued selection for quality and health? Is there enough availability of healthy dogs (and health-related genes) to provide for a healthy breed?

The Idea Behind a Purebred Preservation Bank

An excellent source of breed genetic material is in frozen semen. This preserves the dog's genetic diversity and chromosomal history of the breed and can be maintained for an almost unlimited duration. What if frozen semen were available from before the genetic bottlenecks in breeds with restricted genetic diversity or breed-wide inherited disease?

What if it were possible to add the conformation quality or health traits of a member of your breed from 50 or more years ago to today's gene pool? Preserving genetic material in the form of frozen semen of former and current quality dogs can have great value in future decades for maintaining and improving purebred dogs and can mitigate the risk of extinction due to genetic depletion. Encouraging and facilitating such banking is in the best interest of purebred dogs. A semen preservation bank is a hedge against breed deterioration, loss of genetic diversity, and population contraction, now or in the future.

Establishment of the AKC Purebred Preservation Bank

In 2017 the AKC approved a process allowing an AKC Parent Club to create a BREED REPRODUCTIVE BANK to own semen for use in AKC litters as a way to preserve genetic diversity in the breed. Since then, the Otterhound Club of America is the only breed that has fully established such an entity. The Akita Club of America is the only other club to formally request permission from the AKC Board to move forward their own reproductive bank. Other breed parent clubs have looked into initiating a breed reproductive bank, but have had difficulty navigating legal, procedural, financial, and political barriers. Due to these difficulties, AKC CEO Dennis Sprung suggested developing an AKC All-Breed Preservation Bank to benefit all Parent Clubs. An AKC breed preservation work group was established to explore the issues involved with establishing such a program, consisting of; Dr. Charles Garvin, Dr. Joellen Gregory, Dr. Marty Greer, Dr. Jerry Klein, Mark Dunn, Mary Beth O'Neill, and Ted Phillips. They contacted and surveyed the breed clubs, veterinary reproductive specialists, canine semen storage facilities, and legal counsel.

In August 2021 the AKC Board approved the creation and funding of an AKC Purebred Preservation Bank as a separate 501c.3 organization. This is not a simple semen bank, and not designed to compete with current breeders. The PPB will not necessarily benefit todays breeds (with DNA from today's dogs), but for breeds 50 or 100 years in the future. It is to act as a safeguard against the depletion of breed genetic diversity and health, and for the long-term future of breeds.

The Mission of the AKC Purebred Preservation Bank is to ensure the long-term viability of purebred dogs. Through coordinating efforts with parent breed clubs, the AKCPPB will educate breeders, clubs, and the public about the importance of safeguarding frozen semen and protecting purebred dog breeds for future decades. This program is to assist parent breed clubs to preserve the genetic heritage of their breed.

In taking on this program, the AKCPPB will provide organization, infrastructure, funding and implementation of the program. This includes: legal, insurance, tax exempt administration, and initial funding. The breed Parent Club will provide crucial guidance on the use of semen for breed preservation, how it will be utilized, and selection criteria. The policies and procedures of the program are a work in progress, and basic and "ideal" guidelines are being worked out.

Practical Considerations for the PPB

Possible criteria for acceptance of semen into the PPB includes: definitive identification of the source of the semen sample – ideally through DNA analysis, details of the dog's conformation, behavior, health test results, reproductive history, and the quality of the semen.

Over time, new diseases are emerging or being discovered, new knowledge about the genetics of existing diseases is being developed, and new genetic tests are being deployed. If breed-specific DNA testing has changed at the time of consideration of use of the semen, then DNA tests should ideally be run to determine the health status of the donor dog. While all genetic tests can be run on semen, it is advantageous to also have DNA stored in a DNA repository – such as the OFA CHIC DNA repository - so that future tests can be run without wasting valuable semen. Even if a dog in a semen bank tests positive for a disease liability gene, it can be bred to a normal-testing bitch and the offspring can be tested for normal individuals. Costs for updating health testing have not been worked out, but could be covered by the PPB, the Parent Club looking to utilize the semen, or a combination of both.

Possible criteria for distribution of semen from the PPB will also be determined with input from the breed Parent Club. "Ideal" guidelines being developed could include; 1) scientifically validated detrimental loss of genetic diversity causing low fertility or high frequency of genetic disease, and 2) DNA validation showing that semen in the PPB expands the breadth of the gene pool (represents unique lines that no longer exist in the breed).

Some possible criteria for selection of dams being considered for insemination with PPB semen could "ideally" include; dam has produced at least one litter (proven fertility), dam is up to date on all breed-specific health screening tests, dam has no disqualifying faults, and dam represents the quality of the current breed population.

The importance of a non-political process to equitably distribute semen at this point cannot be overemphasized. This program is about breed gene pool rescue. While the identity and reputation of dogs stored in the PPB is known, the process must determine the best means of widening the breed's gene pool. Popular and prolific dogs from the past will not likely be good candidates if their contribution and

that of their close relatives already is represented in the breed gene pool. It is likely that by the time PPB semen is utilized the dog show reputation of specific dogs as well as their prior owners will be distant memories.

Semen Collection

How will the PPB semen be collected? A breeder can opt to donate the semen to the PPB. All owners must sign off ownership of the semen to the PPB. Semen can be bequeathed to the PPB. There can be a Parent Club semen collection event at a dog show or club event.

After lengthy discussions with commercial semen storage centers, a large problem is abandoned semen after all legal contacts with the owners have been exhausted. These include when the owner dies or becomes incapacitated, or because bills for storage are no longer being paid. Large amounts of canine semen are currently destroyed in this process or donated to research centers. These semen samples can represent a large source of diversity to populate the PPB, but again, criteria for acceptance and usage must be worked out.

PPB Semen Storage

Contracts will be made by the AKCPPB and semen storage centers to ensure experienced, reliable, responsible management with risk mitigation procedures and strategies. These include proper identification of the semen samples and strategies for storage viability in the event of power outages or disasters.

Final Remarks

Most dog breeds have within their gene pool sufficient genetic diversity. Efforts only have to be made to; 1) maintain selective pressure for health and quality, 2) utilize the breadth of pedigree background of the breed, and 3) continue to expand the breed population. Hopefully a breed's PPB will never have to be used. Its existence is a vital safety net if a breed finds itself in need of genetic rescue.

General References

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