

PRINCIPLES OF HIP SCREENING TO CONTROL A COMPLEX GENETIC TRAIT

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Genetic control of a complex disease requires: a) a knowledge of the principles of quantitative genetics, b) an accurate screening method keyed to a phenotype with optimal heritability, c) an organized screening program based on a proven screening phenotype, d) a centralized database containing essential phenotypic and pedigree information, and e) trust and cooperation among breeders and the veterinarians who perform the screening procedure.

Accurate hip screening is key to controlling a disease of complex inheritance, such as Canine Hip Dysplasia, (CHD). The objective of selective breeding is to maximize the pairing of good genes by breeding dogs that are not overtly affected with canine hip dysplasia (CHD). The relationship between phenotype and genotype is embodied in the concept of heritability represented by the symbol h^2 . Heritability denotes the reliability of the phenotype in predicting the genotype. The best phenotype for screening is one that is unaffected by environmental (non genetic) factors. Diet restriction (lean body condition) is an environmental factor shown to dramatically suppress the phenotypic expression of CHD including radiographic evidence of osteoarthritis (OA) and subjective hip score. This means that radiographic evidence of OA and subjective hip score are poor predictors of hip genotype and will therefore confuse the selection decision.

Worldwide, the predominant mode of choosing breeding stock is to make selections based on the hip phenotype of individual animals, so-called mass selection. However, this is not the most effective means to select breeding candidates. Rather, the calculation of estimated breeding value (EBV) is far more useful and will result in much faster genetic change. To successfully use such programs, it is important to know the magnitude of heritability.

For a quantitative trait such as CHD, the rate of expected genetic change in the next generation (ΔG) from mating a dog and a bitch is equal to the product of the heritability (h^2) times the selection pressure that is applied. Selection pressure is defined as the deviation of the parental mean of a specific trait from its population mean. The higher the heritability of a specific trait and the greater the selection pressure applied, the more rapid the expected genetic change per generation of breeding.

Estimates for the heritability of the PennHIP distraction index are roughly twice the estimates of heritability of subjective hip scoring for the breeds of dogs studied thus far. Breeders cannot influence the magnitude of a trait's heritability, but they can control the magnitude of applied selection pressure. Herein lies another important advantage of PennHIP over subjective scoring. The metric, DI, permits application of much greater selection pressure than that afforded by the ordinal subjective scoring system. By utilizing a quantitative phenotype with high heritability (such as PennHIP) and by successfully applying selection pressure, breeders can expect to make rapid and effective genetic improvement in hip quality. However, extreme selection pressure, for example by inbreeding and line breeding, may contribute to the loss of some desirable traits or the expression of some undesirable traits. To avoid this, a moderate approach has been suggested to go hand in hand with PennHIP testing. One can achieve slower, yet equally effective genetic improvement of hips by selecting breeding candidates from the tighter-hipped half of the breed for any given generation. Such a practice will result in all positive and no negative selection pressure and will gradually lower the propensity for hip OA and still maintain an acceptable level of genetic diversity within the overall population or breed.