MONITORING HERITABLE DISEASES IN CANINE PEDIGREE BREEDS FOR GENETIC IMPROVEMENT USING EVIDENCE-BASED BREEDING SELECTION

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All living things are liable to diseases that may be acquired (exposure/infection) or inherited (from ancestors). Because of high inbreeding, pedigree dogs are prone to heritable diseases. Although many have no cure, epidemiological research can help to direct optimal preventive schemes based on phenotype, particularly for diseases with no genotypic marker. This paper covers research results for controlling deafness in Dalmatians (n = 1234)[1,2], hip dysplasia in Flat Coated Retrievers (FCR: n = 1258)[3], Newfoundlands (NF: n = 1566)[3] and Gordon Setters (GS: n = 1152)[4] and glaucoma in FCR (n = 437)[5] and Great Danes (GD: n = 180)[6].

Materials & Methods

If the condition or an associated phenotypic attribute is heritable, then selective breeding can produce offspring with a satisfactory phenotypic attribute and a low probability of disease. The deafness status of tested Dalmatians was categorised as normal (no deafness), unilaterally deaf (in right or left ear) or bilaterally deaf (in both ears) using brainstem auditory evoked response (BAER) testing.[1,2,7] The degree of hip dysplasia (hip-score) was estimated on a numerical scale by a panel of veterinarians as the sum of scores for nine specific radiographic features on the radiographs of both coxofemoral joints.[3,4] Lower scores represented better joints. The GS data included also the scores for individual components. In our glaucoma studies, the observed number of cases was low but the data also included the degree of goniodysgenesis for both FCR and GD and ultrasound measurements of the depth of the anterior chamber of the eye, vitreal body length and the total depth of the globe for 30 GD.[5,6] For each condition, clinical data were merged with the Kennel Club pedigree data so that the research data contained the monitored animal's identity, date of birth, gender, other attributes and the clinical status, as well as similar data for its parents. Multiple regression, logistic or generalised logistic models were developed to predict the value of the offspring attribute from variables including its parent's attributes. Heritability of hip-score was estimated from regression of offspring litter mean score on mean parental score.

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Results

For 1234 Dalmatians, the prevalence of overall deafness was 18.4% (510 females: 21.1%; 497 males: 15.5%), of which 13.1% were unilaterally deaf (females: 15.2%, males: 10.9%) and 5.3% were bilaterally deaf. The deafness was significantly higher in females.[2] Ordinary logistic as well as generalised logistic-binomial regression (with random litter effects) showed that the probability of deafness in a Dalmatian depended significantly on the hearing status of its dam and its gender.[1, 2]

For hip-scores, the 25, 50 and 75 percentiles in FCR were 6, 8 and 11 in 330 males and 7, 9 and 12 in 928 females. These figures were 10, 19 and 43 for 557 NF males and 12, 22 and 47 for 1009 females; and 12, 21 and 37 for 420 male GS and 11, 18 and 33 for 732 female GS. Regression modelling showed that for predicting the FCR's hip-score, its dam's hip-score was a significant variable ($P<0.001$), but its sire's hip-score was not. In contrast, both parental hip-scores were significant for NF (both alone and in combination: $P < 0.001$ throughout).[3] For GS, each parental variable was significant in separate (one parent) regression models ($P<0.001$). For GS the results for different components of the hip-score were similar. Thus, the hip score and each significant individual component score of the male GS depended significantly upon the corresponding score in its sire, but for the female GS, the dependence was upon the corresponding score in the dam. The heritability ± s.e. of hip-score in FCR was high (0.74 ± 0.25) and significant ($t=2.98$, $p=0.004$). For NF these figures were 0.49 ± 0.08 ($t=5.78$, $p<0.001$).[3] In GS, heritability of hip-score from both parents was 0.20 ($p=0.05$) but it was higher from dam (heritability = 0.36, $p = 0.01$). Also in GS, significant heritability was found for five of the nine components of hip-score (cranial effective acetabular rim, femoral head and neck exostosis, femoral head recontouring, Norberg angle and subluxation), again with greater heritability from the dam.[4]

In FCR, glaucoma is a condition with onset well past the age of peak reproductive capability. However, there was a significant positive association between goniodysgenesis (a congenital ocular abnormality affecting the iridocorneal angle, the degree of which was estimated gonioscopically as the affected proportion of the total circumference) and the probability of glaucoma. This probability of glaucoma was modelled as a logistic function of the degree of goniodysgenesis. There was a significant offspring/parent regression relationship for the degree of goniodysgenesis and the heritability of goniodysgenesis was high (0.71 ± 0.12) and significant ($t=6.0$, $P<0.0001$). These results indicated that glaucoma was likely to be heritable, and could be controlled by breeding from those parents with goniodysgenesis scores less than 60%. Similar results for Great Danes showed that in GD glaucoma could be controlled by breeding from only those potential parents that had goniodysgenesis <70% or alternatively had the depth of the anterior chamber of the eye >3.7 mm.

Discussion

A general observation from these studies was that dog breeders tended to be more selective of sires than dams in terms of their health status. The results demonstrated that substantial reductions in the frequencies of these diseases could be achieved by only breeding from dogs and bitches shown to be free from the relevant phenotypic attribute. If recommendations from AHT and similar research are followed[1-7], (i) the prevalence of bilateral deafness should be reduced from 5.3% to <4%, (ii) the prevailing degree of hip dysplasia in FCR, NF and GS should be substantially reduced and (iii) the prevalence of glaucoma in FCR and GD should be reduced to <0.1%.

References

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