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Calcification of Intervertebral Discs in the Dachshund: An Estimation of Heritability

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Stigen, Ø. and K. Christensen: Calcification of intervertebral discs in the dachshund. An estimation of heritability. Acta vet. scand. 1993, 34, 357-361. – The heritability of calcified intervertebral discs in the dachshund was estimated using data gathered from a radiographic study. Radiographs of the vertebral columns of 274 clinically normal, 12 to 18 months old dachshunds, were examined. The dogs were offspring from 75 different sires, representing the same number of half sib groups. There were 2 to 14 offspring in each half-sib group. The number of full sib groups was 81.

Calcified intervertebral discs were identified in 20.4 % of the dogs. An analysis of variance that used the data as a continuous and as an either/or-variable estimated the heritability of calcified discs to be 0.22 and 0.15 respectively.

A genetic factor was found to be essential for the occurrence of calcified discs in a dog while a common environmental factor presumably resulting from non-genetic causes was significant in determining the number of discs to undergo calcification in affected dogs.

vertebral column; degeneration; inheritance; dog.

Introduction

Intervertebral disc disease (IDD) is frequently seen in dogs classified as chondrodystrophoid dwarfs (*Oliver et al.* 1987). The disease is most often diagnosed in dachshunds and different studies have shown that 45-70% of all canine cases occur in this breed (*Brown et al.* 1977, *Gage* 1975).

A dystrophic calcification of the nucleus pulposus predisposes the disc to protrusion and subsequently the dog to clinically significant IDD (*Hansen* 1952). *Havranek-Balzaretti* (1980) found that 79% of adult dachshunds that had calcified discs developed IDD whereas those dogs without calcified discs did not develop the disease.

The occurrence of calcified discs vary significantly between dachshunds of different coat and size varieties (*Stigen* 1991). As coat and size are genetically determined (*Wallerstedt* 1988), a genetic basis for development of calcified discs could be anticipated. A hereditary predisposition has been shown to be significant in the etiology of IDD in dachshunds (*Ball et al.* 1982, *Funkquist & Henricson* 1969). However, heritability or an exact pattern of hereditary transmission is not known.

This paper presents the results of the estimation of heritability for calcified intervertebral discs in the dachshund. The calculations are based on data from a previously reported radiographic survey (*Stigen* 1991).

Material and methods

The material comprises radiographs of the

vertebral columns of dachshunds aged between 12 and 18 months. The dogs were registered with the Norwegian Kennel Club (NKC) and subjected a physical and radiographic examination at the Department of Small Animal Clinical Sciences, Norwegian College of Veterinary Medicine in the period 1987-1989. All dogs were found to be clinically normal. The radiographs were taken and read according to earlier described methods (*Burk & Ackerman* 1986, *Morgan & Silverman* 1982). The occurrence of calcified intervertebral discs and the distribution of these lesions within the vertebral column of affected dogs are published in a previous paper (*Stigen* 1991).

For the present paper, radiographs of dogs that were the sole x-rayed offspring of a sire were excluded. In addition, miniature dogs (i.e. dwarfs plus kaninchens) with the exception of longhaired dwarfs were omitted. Thus, the original material was reduced to radiographs of 274 dogs representing the offspring from 75 different sires and 148 dams. The distribution of offspring between the remaining sires is presented in Table 1. In the material were 81 full sib groups with an average of 2.56 sibs per group.

Table 1. The distribution of 274 offspring between 75 different sires.

Number of x-rayed offspring per sire (a)	Number of sires (b)	Number of offspring (a*b)
2	28	56
3	15	45
4	21	84
5	3	15
6	2	12
7	1	7
8	1	8
9	1	9
10	1	10
14	2	28
Total	75	274

The disease data were submitted to a nested analysis of variance with the classification:

Coat-size-varieties
Sires, within coat-size-varieties
Dams, within sires

using the procedure NESTED in the statistical analyses programme from SAS (*SAS Institute Inc.* 1986). The test of statistical significance is based on an assumed normal distribution of the disease data. The disease was analyzed using the actual disease score given by the number of calcified discs in each dog. The disease was also analysed using the classical either/or scale where an observation with normal discs is set to 0 and an observation with one or more calcified discs is set to the value 1 (*Falconer* 1989).

The additive genetic variance was estimated by the variance components caused by differences between sires multiplied by 4. The common environmental variance was estimated by the difference between the dam and sire variance component, this difference also contains a quarter of the dominance variance, but it can be set to zero. The heritability was estimated as the additive genetic variance divided by the total variance, and the common factor was estimated as the common environmental variance divided by the total variance (*Falconer* 1989).

Results

The mean value on the either/or scale was 0.204, corresponding to a sample incidence of 20.4%. In Table 2 the result of the analyses of variance is shown both as the absolute score and as an either/or score. The variance components between coat-size-varieties are 3.9 and 7.4% in the 2 analyses. The variance components between sires are similar in the 2 analyses, 5.6 and 3.7%, corresponding to a he-

Table 2. Nested analyses of variance for absolute disease score and either/or disease score, with the degrees of freedom (DF), mean squares (M.S.) and components of variance in percentage (V %). The statistical significance is given by * $p<0.05$ and ** $p<0.01$.

		Absolute score		Either/or score	
Cause of variance	DF	M.S	V %	M S.	V %
Between coat-size-varieties	3	4.94*	3.9	1.022**	7.4
Between sires, within coat	71	1.70	5.6	0.171	3.7
Between dams, within sires	73	1.22*	24.7	0.149	1.5
Within dams	126	0.79	65.8	0.145	87.4

ritability estimate of 0.22 and 0.15, respectively. None of the estimates deviate significantly from zero ($P>0.05$). The between dams component of variance did vary between the 2 analyses yielding a common environmental factor of 19% and zero, respectively.

Discussion

This study was based on radiographs of dachshunds of the following size and coat varieties: standard smoothcoated, standard wirecoated, standard longhaired and dwarf longhaired. Within the NKC these varieties constituted 98.9% of all dachshunds registered in the period 1987-1991. Thus, all common varieties were included.

Oliver et al. (1987) reported IDD in 3.6 % of dachshunds aged between 1 and 2 years. This frequency would represent less than 10 offspring in the present study. As IDD usually causes intermittent symptoms, it is not surprising all offspring examined were clinically normal.

The mean value on the either/or scale represents the fraction of dogs with 1 or more calcified discs in the material. The value of 20.4% corresponds well to the previous estimated occurrence of 23.5% in Norwegian dachshunds (*Stigen* 1991).

The estimated heritability in the present study varied from 0.15 to 0.22, depending on the method used. These estimates are similar to previous estimated heritabilities for other diseases with abnormal calcification of joints in dogs. The heritabilities have been estimated for hip dysplasia in 10 different breeds (*Lingaas & Heim* 1987, *Andersen et al.* 1988) and arthrosis of the elbow joint in rottweilers (*Grøndalen & Lingaas* 1991). In these diseases the heritabilities ranged from 0.10 to 0.50.

In the present study, the estimated heritabilities did not deviate significantly from zero, so a genetic basis for calcified discs in the dachshund has not been demonstrated conclusively. However, in this breed, the frequency of calcified discs varies significantly between coat-size-varieties (*Stigen* 1991) and these varieties have a genetic basis (*Palmer* 1985, *Wallerstedt* 1988). Thus the estimated heritabilities of moderate magnitude determined in this study, would be expected. The narrow statistical basis for the present study produces large sampling errors of the estimates. A larger sample population resulting from a continued investigation of calcified discs in Norwegian dachshunds would broaden this base and improve the estimates.

The 2 methods of analysis of the occurrence of calcified discs yielded widely different estimates for a common environmental factor. The difference between the estimate using an

either/or scale (zero) and the estimate using an absolute scale (19%) suggests that these scales are measuring different traits. The interpretation is that the either/or scale is not influenced by the environment while the absolute scale responds to a common environmental factor. This further suggests that a common environmental factor is active at an early age and affects the severity of the disease but does not influence the disease occurrence. Many different factors can act as a common environmental factor for a group of offspring before they are dispersed at about 8 weeks of age. In the present study, a common environmental factor has not yet been identified. It is known that feeding intensity can affect the development of bones and joints and thereby cause skeletal disorders in dogs (*Hedhammar et al.* 1974, *Lust et al.* 1978). Other non-genetic causes of abnormal bone and joint development could include disease, exercise and stress.

A study of heritability of osteochondrosis of the elbow in labrador retrievers (*Studdert et al.* 1991) found a significant 'maternal' effect resulting from presumably non-genetic causes. However, as in the present study a basis for this effect was not identified. Although the findings of both studies suggest that further investigation of non-genetic components of the common environmental factor is warranted.

In Norway and Denmark eradication programmes for hip dysplasia and elbow arthrosis in certain breeds, have been in existence for some years. The heritability of calcified discs estimated in the present study indicates that through careful selection of breeding animals it may be possible to decrease the frequency of disc disease in norwegian dachshunds. Based on this estimate of heritability, the recommendation would be that dachshunds from families with many members affected by calcified discs should not be used for breeding.

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Sammendrag

Forkalkede intervertebralskiver hos dachshund: En estimering av arvbarhet.

Arvbarheten for forkalkede intervertebralskiver hos dachshund ble estimert på grunnlag av data fra en røntgenologisk undersøkelse. Røntgenbilder av virvelsøylen til 274 klinisk normale dachshunder i alderen 12-18 måneder inngikk i materialet. Hundene var avkom etter 75 ulike fedre og utgjorde det samme antallet halvsøskengrupper. Det var fra 2 til 14 avkom i hver halvsøskengruppe. Antallet helsøskengrupper var 81.

Forkalkede intervertebralskiver ble påvist hos 20,4% av hundene. Ved variansanalyse som behandlet dataene som en kontinuerlig og en enten/eller variabel, ble arvbarheten for forkalkede skiver estimert til henholdsvis 0,22 og 0,15.

En genetisk faktor ble påvist å ha betydning for om en dachshund utvikler forkalkede skiver eller ei. En felles miljø faktor som trolig har en ikke-genetisk årsak, ble påvist å ha innvirkning på antallet forkalkede skiver som utvikles hos en affisert hund.

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