Canine Hip Dysplasia as influenced by genetic and environmental factors

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INTRODUCTION

For more than 50 years, screening for hip conformity and breeding for sound hips have been on the agenda of the veterinary profession and dog breeders not only in Europe but all around the world.

When it became evident that one of the more common causes of lameness and pain in the hind limbs of dogs was a malformation of the hips, the condition was named canine hip dysplasia after a similar condition in man. It has, however, dissimilarities as well as similarities with its human counterpart [Schnelle *et al* 1959].

We all agree nowadays that hip dysplasia in dogs is a developmental disorder under the influence of several genes as well as various environmental influences. Over the years we have learned more about its heritability but also how environmental factor may influence its occurrence and severity. However, despite great efforts it is still a major cause of disabilities and even euthanasia in many of the larger sized breeds.

Much effort has been focused in the past on the phenotypical appearance of hip dysplasia and sophisticated methods have been developed to measure and grade various components of the dysplasia. These includes shallowness, laxity and secondary changes in structures of the hip joint. Unfortunately less has been done to influence the extent to which these measures are taken into account in the selection of breeding stock.

Whatever method is used to measure, grade and define hip dysplasia it is well proven that dysplastic parents are more likely to produce affected progeny and more severely affected progeny [Hedhammar *et al* 1979]. Consistent breeding from phenotypically unaffected breeding stock does decrease the prevalence of hip dysplasia in closed breeding colonies as well as in various breed populations in several countries [Swenson *et al* 1997, Reed at al 2000].

Our current efforts are based on extensive screening programmes in many countries but there are too few well functioning breeding programmes. The scientific commission of FCI have made efforts to harmonise the screening procedure and to introduce a quality control programme for the technical screening procedure as well as the evaluation of radiographs by 'validated' panellists. An advisory group of experts, including all the speakers at this symposium, was appointed at a meeting in Copenhagen to propose clarifications and changes to the current FCI Hip Dysplasia protocol. To optimise proper usage of hip dysplasia screening procedures it is equally important to develop and exchange experiences of successful breeding programmes.

Let us critically review what is currently known about the genetics and environmental influences of hip dysplasia and, based on that, reconsider our strategy to screen, breed, feed and treat dogs with reference to canine hip dysplasia.

Genetics

It has repeatedly been shown that Hip Dysplasia, regardless how it is defined, has a polygenic inheritance in all populations studied so far [Hedhammar *et al* 1979]. Even if the number of genes involved and their magnitude of importance is unknown, it is logical to assume that they affect various structures and function in the developing hip. These include conformity as shallowness of the acetabulum and the form of the femoral head. They also includes laxity and resulting poor fiting of the femoral head into the acetabulum and also the liability to secondary changes such as arthrosis.

Genes are also involved in rate of growth and maturity of various structures and supposedly act by hormonal activity. The so called Quantitative Trait Loci (QTLS) involved in hip laxity

have been identified and a couple of major loci have even been identified [Todhunter *et al* 2005, Janutta *et al* 2006, Tsai and Murphy 2006].

We are not yet at a stage where molecular genetic testing may indicate superior or inferior breeding stock. We still have to rely on phenotypic classifications. However, in addition to selection based on individual results, computerised breeding indexes have been shown to serve as good indicators of the genotype of tentative Sires and Dams [Lepanen at al 2000].

Environmental factors

Environmental factors proven to influence the phenotypic appearance of Hip Dysplasia can be divided in those acting during the development of the hip and those that act at the time of the screening process. The latter can more or less be considered as effects that should be minimised by standardisation of the procedure.

During the growth period *feeding intensity* [Kasström 1975] as well as *type of exercise* [Sallander *et al* 2006] has been shown to affect the resulting hip status.

Screening

Age at screening is a factor which repeatedly has been shown to influence all grades of Hip Dysplasia [Swensson *et al* 1997, Wood *et al* 2003a]. A standard time of screening has been proposed at an age when primary changes are satisfactorily apparent but not to many secondary changes have occurred.

The Season of birth has also shown to influence hip status [Hanssen *et al* 1991, Wood *et al* 2003b] but is obviously more difficult to standardise this. It is however possible to take it into consideration as a factor in the calculation of breeding indexes for hip dysplasia .

Positioning at screening is a factor that can be controlled by strict guidelines for the procedure.

Sedation at screening has been shown to significantly affect the result [Malm *et al* 2006, Genevois*et al* 2006] and should therefore be standardised

Screening programmes

Within Europe, the FCI screening protocol is most widely used. At the above mentioned meeting in Copenhagen which aimed to harmonise its usage, it was noted that a total of more than 90 000 dogs were screened yearly for hip status in Europe. Out of these 27 000 were screened in Germany and 20 000 in Sweden.

In UK a scoring system developed by BVA/ KC is used [Houlton 2005]. Outside Europe the FCI protocol and a slightly different version developed by the Orthopaedic Foundation of Animals (OFA) in USA , is most commonly used (Reed *et al* 2000). In the USA a method to evaluate hip laxity by a special procedure has also been developed [Smith *et al* 1990]

Breeding

Selection of breeding stock with reference to hip status by national screening procedures has been practiced in many countries since 1960 When consistently performed it has drastically decreased the prevalence of Hip Dysplasia in closed colonies as well as in the national populations of several breeds [Swensson *et al* 1997].

In populations where only a fraction of Sires and Dames are screened and are phenotypically unaffected by Hip Dysplasia, decreased prevalence is not to be expected. Most dogs in many countries – purebred as well as non-purebred are out of unscreened – and therefore also to great extent Hip Dysplasia affected – breeding stock.

In countries where most breeding stock in many breeds is already screened and shown to be unaffected, it is difficult to further decrease prevalence of Hip Dysplasia by using only of the phenotypic screening result of Sire and Dame. Therefore Breeding Indexes have been introduced in several countries [Mäki *et al* 2004] to make use of additional information also on relatives including already produced progeny.

Feeding

Studies on feeding intensity – that is amount of food/ calories consumed during the growth period - do show that this affects rate of growth as well as prevalence and severity of Hip Dysplasia [Kasström 1975, Kealy *et al* 1992] Restricted caloric intake reduces prevalence and severity of primary signs of HD as well as degree of resulting osteoarthrosis [Kealy *et al* 1997]
Neither vitamin C, nor any other vitamins or minerals have been shown to protect against Hip Dysplasia. It is still to be proven if any of the other new nutraceuticals favourably affect the risk of developing hip dysplasia. These new remedies may however beneficially affect the course, as a restricted food intake certainly does.

Handling and Exercising

How to exercise and handle a growing dog with reference to skeletal development and risk of skeletal diseases have been the focus of very few studies. A small pilot study on the effects of nutrition and exercise on Hip Dysplasia did show that exaggerated playing with other dogs and running after balls and sticks during the growth period may unfavourably affect the hip as well as the elbow status when screened at one year of age [Sallander *et al* 2006]

Conclusions

Screening - Further standardisation of the screening procedure is essential for exchange of information on hip status between countries and also for the use of these results to calculate breeding indexes. That standardisation includes age at screening, identification of dogs and radiographs, proper sedation to allow full relaxation and further harmonisation of the criteria for evaluation of radiographs.

Breeding - To decrease prevalence of Hip Dysplasia in many populations, less usage of unscreened / affected breeding animals must be encouraged. In populations where breeding stock already are screened and unaffected, further improvement can only be reached by using computerised breeding indexes for Hip Dysplasia or in the future, hopefully, also molecular genetic tests.

Feeding - To favourably influence the development of sound hips, puppies in breeds with predisposition to Hip Dysplasia should be fed a restricted amount of a balanced diet rather than ad lib or over feeding.

Exercising - To minimise the risk of developmental skeletal diseases such as Hip Dysplasia, exaggerated playing with other dogs and/ or running for balls and sticks should be avoided.

References

GENEVOIS (J.P.), CHANOIT (G.), CAROZZO (C.), REMY(D.), FAU(D.), VIGUIER(E.) - Influence of anaesthesia on canine hip dysplasia score. *J Vet Med A Physiol Pathol Clin Med.*, 2006 Oct; **53**(8): 415-7.

HANSSEN (I.) - Hip dysplasia in dogs in relation to their month of birth. *Vet Rec.* 1991 May 4; **128**(18): 425-6.

HEDHAMMAR (A.), OLSSON (S.E.), ANDERSSON (S.A.), PERSSON (L.), PETTERSSON (L.), OLAUSSON (A.), SUNDGREN (P.E.) - Canine hip dysplasia: study of heritability in 401 litters of German Shepherd dogs. *J Am Vet Med Assoc.* 1979 May 1; **174**(9): 1012-6.

HOULTON (J.E.) - BVA/KC hip and elbow dysplasia schemes. *Vet Rec.* 2005 Dec 24-31; **157**(26): 853

JANUTTA (V.), HAMANN (H.), DISTL (O.), Complex segregation analysis of canine hip dysplasia in German shepherd dogs. *J Hered.* 2006 Jan-Feb; **97**(1): 13-20..

KASTROM (H.) - Nutrition, weight gain and development of hip dysplasia. An experimental investigation in growing dogs with special reference to the effect of feeding intensity. *Acta Radiol Suppl.* 1975; **344**: 135-79

KEALY (R.D.), OLSSON (S.E.), MONTI (K.L.), LAWLER (D.F.), BIERY (D.N.), HELMS (R.W.), LUST (G.), SMITH (G.K.) - Effects of limited food consumption on the incidence of hip dysplasia in growing dogs. *J Am Vet Med Assoc.* 1992 Sep 15; **201**(6): 857-63

KEALY (R.D.), LAWLER (D.F.), BALLAM (J.M.), LUST (G.), SMITH (G.K.), BIERY (D.N.), OLSSON (S.E.) - Five-year longitudinal study on limited food consumption and development of osteoarthritis in coxofemoral joints of dogs. *J Am Vet Med Assoc.* 1997 Jan **15**; 210(2): 222-5

LEPPANEN (M.), MAKI (K.), JUGA (J.), SALONIEMI (H.) - Factors affecting hip dysplasia in German shepherd dogs in Finland: efficacy of the current improvement programme. *J Small Anim Pract.* 2000 Jan; **41**(1): 19-23

MAKI (K.), JANSS (L.L.), GROEN (A.F.), LIINAMO (A.E.), OJALA (M.) - An indication of major genes affecting hip and elbow dysplasia in four Finnish dog populations. *Heredity.* 2004 May; **92**(5): 402-8.

MALM (S.), STRANDBERG (E.), DANELL (B.), AUDELL (L.), SWENSON (L.), HEDHAMMAR (A.) - Impact of sedation method on the diagnosis of hip and elbow dysplasia in Swedish dogs. *Prev Vet Med.* 2006 Nov 15;

REED (A.L.), KELLER (G.G.), VOGT (D.W.), ELLERSIECK (M.R.), CORLEY (E.A.) Effect of dam and sire qualitative hip conformation scores on progeny hip conformation. *J Am Vet Med Assoc.* 2000 Sep 1; **217**(5): 675-80.

SALLANDER (M.), HEDHAMMAR (Å.) & TROGEN (M.) (2006). - Diet, exercise and weight as risk factors in Hip Dysplasia and Elbow Arthrosis in Labrador Retrievers. *J Nutr,* **136**: 7S, 2050S-2052S

SCHNELLE (G.B.) - Congenital dysplasia of the hip in dogs. *J Am Vet Med Assoc.* 1959 Aug 15; **135** 15(4): 234-5

SMITH (G.K.), BIERY (D.N.), GREGOR (T.P.) - New concepts of coxofemoral joint stability and the development of a clinical stress-radiographic method for quantitating hip joint laxity in the dog. *J Am Vet Med Assoc.* 1990 Jan 1; **196**(1): 59-70.

SWENSON (L.), AUDELL (L.), HEDHAMMAR (A.) - Prevalence and inheritance of and selection for hip dysplasia in seven breeds of dogs in Sweden and benefit: cost analysis of a screening and control program. *J Am Vet Med Assoc.* 1997 Jan 15; **210**(2): 215-21.

TODHUNTER (R.J.), MATEESCU (R.), LUST (G.), BURTON-WURSTER (N.I.), DYKES (N.L.), BLISS (S.P.), WILLIAMS (A.J.), VERNIER-SINGER (M.), COREY (E.), HARJES (C.), QUAAS (R.L.), ZHANG (Z.), GILBERT (R.O.), VOLKMAN (D.), CASELLA (G.), WU (R.), ACLAND (G.M.) - Quantitative trait loci for hip dysplasia in a cross-breed canine pedigree. *Mamm Genome.* 2005 Sep; **16**(9): 720-30.

TSAI (K.L.), MURPHY (K.E.) - Clinical and genetic assessments of hip joint laxity in the Boykin spaniel. *Can J Vet Res.* 2006 Apr; **70**(2): 148-50.

WOOD (J.L.), LAKHANI (K.H.) - Hip dysplasia in labrador retrievers: the effects of age at scoring. *Vet Rec.* 2003 Jan 11; **152**(2): 37-40.

WOOD (J.L.), LAKHANI (K.H.) - Effect of month of birth on hip dysplasia in labrador retrievers and Gordon setters. *Vet Rec.* 2003 Jan 18; **152**(3): 69-72