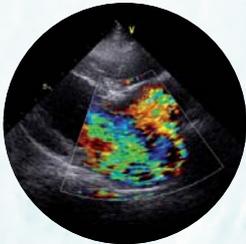
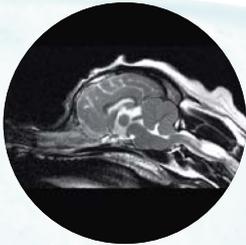


Pedigree dog breeding in the UK: a major welfare concern?

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[an independent scientific report commissioned by the RSPCA](#)



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Purpose and scope of the report

This independent report was commissioned by the RSPCA in order to help inform all those committed to protecting and improving the welfare of pedigree dogs.

It addresses the impact of traditional selective breeding practices on pedigree dog welfare. Specifically, it focuses on welfare issues associated with exaggerated anatomical features and inherited disease. Whilst conclusions are centred on the specific situation in the UK, the report reviews what is well-recognised to be an international problem.

As an independent report, its contents are the findings, views and conclusions of its authors and contributors, who are recognised experts in the fields of animal welfare science, genetics, epidemiology and veterinary science. It contains a review of the scientific literature and proposes, in brief, possible ways to improve the welfare of pedigree dogs.

This is a vast topic and one which could consume several years of work to thoroughly review. There are already several eloquent scientific descriptions of the current state of, and the perils associated with, pedigree dog breeding. Examples include published review papers by McGreevy and Nicholas (1999), Arman (2007) and reports by the Companion Animal Welfare Council (CAWC; 2006) and Advocates for Animals (2006). Therefore this report does not seek to repeat the efforts of past authors, nor does it aim to provide a comprehensive review of all scientific evidence on the subject. Rather, it aims to break the problem down into distinct components, providing a short summary of each (sections 3 and 4), using examples of scientific evidence to highlight the health and welfare issues and the complexities of the problem. It then uses examples to illustrate and discuss progress in both phenotype-based/clinical and DNA testing (section 4.7). Finally, based on discussions with experts and extensive literature review, many possible options are suggested for tackling the problem. These options have been prioritised into recommendations for possible ways forward via a process of questionnaire survey of numerous experts in the field (section 5).

This report refers only to domestic dog breeding. However many of the issues discussed within this report are relevant also to other species of animals bred by “fanciers”. The CAWC report (2006) describes the problems associated with the selective breeding of ornamental fish, reptiles, amphibians, birds, cats, horses, rabbits, hamsters, guinea pigs, rats and farmed animals as pets, as well as dogs. It also discusses the topic of biotechnological methods, which is beyond the scope of this report.

The RSPCA is firmly committed to helping protect the welfare of dogs and recognises that solving the welfare problems associated with exaggerated anatomical features and inherited disease presents a very complex challenge. It hopes that this report will be seen as a constructive contribution to the current debate on the welfare of pedigree dogs and that it will help stimulate and focus essential, wider discussion amongst all relevant stakeholders in order to identify and implement practical, evidence-based, effective solutions.

The problem and its cause

2.1. Overview of the problem

Many pedigree dogs which are registered in the UK and throughout the world remain healthy for much of their lives. However there can be no doubt that numerous pedigree dogs of many different breeds now experience compromised welfare due to the direct and indirect effects of selective breeding practices (sections 3 and 4). Many breeds have high rates of heritable disorders or disease, and some have physical conformations which can result in disability, behavioural problems or pain, and thereby unnecessary suffering.

Society and sections of the veterinary profession have become “desensitised to the welfare issues to such an extent that the production of anatomically deformed dogs is neither shocking, nor considered abnormal” (Arman 2007). Indeed pursuit of show standards and the desire to produce an unusual, exaggerated or spectacular conformation have often produced dogs which tend towards abnormality.

Dogs are regularly bred whose heads are too large to birth naturally (English Bulldog; Moon et al 2000), whose relative risk of inheriting a heart problem (often leading to fatal heart attack), is approximately 88 times that in the general population (Newfoundland; Kienle et al 1994), and whose faces are so flat that they will not be able to breath or exercise normally (brachycephalic (see glossary) breeds; e.g. English Bulldog, Pug and Boston Terrier; Riecks et al 2007). These examples are just three amongst many, and represent only the tip of the iceberg (section 3.3).

Dogs of many breeds have significantly lower life expectancy than cross breed dogs (e.g. Egenvall et al 2000). All objective studies which have compared average age at death have found that cross breeds, and in particular small cross breeds (Patronek et al 1997), live longer than individuals of most of the pure breeds. Partly, this reflects the inverse correlation between body size and life expectancy seen across all dogs, and of course reduced longevity is not synonymous with reduced quality of life. However, there is also considerable evidence that cross breed dogs have lower veterinary bills (Data from Churchill Insurance company cited in K9 Magazine 2007). This suggests that they are less often ill and less likely to suffer compromised welfare as a consequence. The phenomenon of heterosis (see glossary) means that pure breeds naturally

show less vigour (see glossary) than out-bred (see glossary) individuals. In some dog breeds, current breeding practices may have exaggerated this effect.

Limited record keeping, lack of transparency in the breeding and showing world, and the absence of sufficient research, means that the full extent of the problem is difficult to assess. For example, a popular veterinary text book lists 150 pages of breed predispositions to specific disorders with certain breeds being listed as predisposed to over ninety different diseases (Gough and Thomas 2004). A certain amount of inter-breed variation in disease prevalence (see glossary) is to be expected in closed populations due to genetic drift (see glossary), especially in small populations that have been closed for some time. But whatever the cause, when individual breeds show markedly high levels of a particular disorder, this is a cause for concern. However the collection of such data is currently unsystematic, and although there are specific case studies of individual breeds and particular disorders, relatively few have been conducted in the UK.

Individual breeds each suffer from their own array of problems, and although many of these are essentially symptoms of the same root causes (see sections 3 and 4), each breed's survival and improvement (in terms of health and welfare) is likely to rely on a different specific course of action. With 209 breeds currently registered in the UK (The Kennel Club 2008a), and more that are not yet recognised in this way, this makes the situation complex.

Breeding practices and efforts by breed societies and kennel clubs, to date, have been ineffective at protecting the welfare of many breeds of domestic dog. Therefore to safeguard the future of pedigree dogs, changes in breeding and selection practices are urgently required, and for some breeds more drastic measures will be needed. All members of society, and in particular all those who benefit from pedigree dogs, have a moral and ethical obligation to ensure that every action is taken to attempt to overcome the current problems and to increase the health and welfare of future generations of pedigree dogs.

2.2 Why this is an important welfare problem

“Welfare problems associated with genetic change” have been identified as being serious for four important reasons (CAWC 2006):

- a) they affect large numbers of dogs; there are approximately five million pure bred dogs in the UK, representing 75% of the overall dog population (PFMA; 2008), and the UK Kennel Club alone registers over 270,000 dogs per year (The Kennel Club 2008b),
- b) the effects perpetuate from generation to generation,
- c) animals' quality of life can be severely reduced, and
- d) the effects may be long lasting, potentially for a large proportion, or even the entirety, of an animal's life.

Additional reasons why welfare concerns regarding pedigree dogs are particularly important include:

- Much of the suffering which some pedigree dogs endure is unnecessary and a substantial part could be avoided with revised practices. Selective breeding of pedigree dogs by people has contributed to the problem (sections 3 and 4) and so we have a moral obligation to solve it.
 - Most dog breeding is a hobby, conducted by “dog lovers” rather than a truly utilitarian activity. As such, the moral obligation to maximise the dogs' quality of life, and address known and avoidable risks to their health and welfare, has to be of utmost priority.
- Dogs of specific breeds are born with a high likelihood that they will be denied at least one of the five freedoms, a generally accepted way of assessing animal welfare (FAWC 1992). Exaggerated anatomies (section 3) mean that dogs may suffer discomfort and be prevented from behaving normally without likely injury, whilst having a high likelihood of developing a disease (section 4) can lead to pain, fear and distress.
 - The English Bulldog is a regularly-cited example. This breed has been noted to have difficulties walking, breathing, mating (cradle devices are currently on the market to allow it to mate with the aid of only one person (Celtic Pride Bulldogs 2009)) and giving birth, as well as being predisposed to a range of heritable disorders. Many would question whether the breed's quality of life is so compromised that its breeding should be banned. This is just one example and there are a number of other breeds whose lives may be similarly compromised.
 - Greater understanding of the level of awareness in dogs and other animals has necessitated an ethical environment in which humans respect and live in harmony with other members of the animal kingdom. Deliberately breeding animals with a high propensity to suffer can in no way be regarded as either respectful or harmonious.

2.3 Selective breeding for physical appearance – the cause of the problem

Most breeds of dogs were originally selected for the performance of particular utilitarian purposes or functions. Consequently, when humans selected which dogs to breed from, they chose those which were best suited for the various roles required of them. Although different types of dog have long been selected for specific roles, fitness, ability and utility remained priorities (Mikloski 2007). Then in the relatively recent past, dog showing emerged as a popular hobby. Dogs began to be selected to emphasise their diverse physical conformations, specific breeds were recognised, and competitions commenced. The first official dog show was held in 1859 (The Kennel Club 1998), and the hobby has continued to grow until today. There are now over 400 dog breeds recognised worldwide (Wilcox and Walkowitz 1995), the UK Kennel Club recognises 209 breeds, and in excess of 30,000 people regularly show dogs in Britain (Cuddy B personal comm).

Pedigree dogs appearing in conventional breed shows are required to conform to written breed standards (or specifications) laid down by breed societies and kennel clubs (The Kennel Club 2006a). Although the vast majority of pedigree dogs will never appear in a show, many are bred by breeders who are aspiring to produce show-quality animals and whose surplus dogs are sold as pets (Willis 1995). Potential pet owners often choose to purchase a pedigree registered dog as they see this as an indication of the quality of the dog (27%), and many base their choice on the breed's physical appearance (37%; TNS survey 2008). Therefore trends in the show-dog breeding community have major implications for the domestic dog population at large, and decisions made by a minority of breeders have considerable repercussions for the pet-owning public.

Over the past 130 years, specific physical attributes have been selected for preferentially in many breeds, without sufficient attention to health, temperament, welfare and functionality (McGreevy and Nicholas 1999). Breeding programmes that concentrate primarily on physical conformation have been blamed extensively for this situation (e.g. Lindblad-Toh et al 2005) which has resulted in two distinct but inter-related issues:

- a) Morphological extremes – anatomical abnormalities that result directly in reduced quality of life (section 3);
- b) Increased prevalence of particular inherited disorders as a result of lack of genetic diversity (due to limited numbers of breed founders (see glossary) and small genetic pools (see glossary); strong selection causing “selective sweeps” (see glossary) of genes (see glossary) near to the gene under selection; inbreeding (see glossary) and line breeding (see glossary)), ill informed breeding choices, and over-attention to physical attributes rather than improved health, welfare and behaviour (section 4).

It is important to distinguish between these two issues when discussing the problems of pedigree dog breeding. Since the first is a direct effect, and the second an indirect effect of specific breeding practices, their remedy requires different approaches (but see also section 3.3 for an example of a condition where the distinction between the direct and indirect effects is a little blurred). When prioritising how best to improve the future health and welfare of a breed it is essential that both of these issues are taken into consideration. The following two sections deal with each of these in turn.

Welfare Issue 1 – exaggerated anatomical features that reduce quality of life

3.1 Background information

Trends in the breeding of specific breeds have often led to the accentuation of what are perceived, by some, to be desirable traits. In some cases physical features have been exaggerated to such an extent that they severely limit dogs' quality of life, and may cause pain and suffering. In some breeds, selection for the original function has led to a temperament unsuited to the current home environment, and this means that dogs may be predisposed to developing behavioural problems when kept as family pets. There is currently no widely applicable empirical basis on which to decide which breeds are most affected by a particular problem, nor to rule out other breeds as unaffected (section 3.5). Therefore within this section, most breeds are not named. However, where breeds are not named, there are many likely examples of every complaint mentioned.

3.2 Examples of exaggerated anatomical features

There are numerous extreme morphological features that may disadvantage a dog's health and welfare. Many of these were identified in the Multilateral Consultation of Parties to the European Convention for the Protection of Pet Animals, (Council of Europe 1995) which included reference to:

- overly large or heavy dogs that may suffer from joint problems;
- dogs with very short legs that may have limited locomotion, and be predisposed to disorders of the vertebrae column;
- short skulls and flat faces (brachycephalic breeds) that may lead to breathing disorders and blockage of the lachrymal (tear) duct;
- large flat skulls that may result in birth difficulties;
- abnormal positions of limbs, e.g. bowed or "too steep", that may result in difficulties of movement and joint degeneration;
- abnormal positioning of the teeth that may result in difficulties in feeding and caring for young;
- abnormal size and position of the eyes or eyelids that may lead to irritation, inflammation, degeneration and prolapse of the eyes;
- very long ears that can easily be injured;
- markedly folded or furrowed skins that may cause eczema or skin complaints, eye irritation or inflammation;
- hairlessness that may result in an inability to thermo-regulate.

In addition, McGreevy and Nicholas (1999) identified curved backs, long trunks and fine legs as likely to cause problems, whilst growth disorders are common in large breeds (Advocates for Animals 2006).

Specific breeds have been selected to show each of these anatomical features and they have each been described in particular breed standards. In moderation these features are unlikely to be problematic. However, when emphasised to extreme, as is now the case in some breeds, they are likely to severely compromise dogs' welfare.

3.3 Evidence that exaggerated anatomical features can cause suffering

There is remarkably little explicit recognition of the welfare issues that may be associated with the extreme morphologies selected for in some registered breeds, and few peer-reviewed papers documenting their effects. However, the veterinary literature describes palliative and surgical procedures to correct some of the worst effects and so what follows is a review of some of the recognised medical problems associated with extreme morphologies and an account of the likely suffering associated with the clinical signs of each.

Larger breeds of dogs suffer from problems associated with the overly rapid growth of bones and with loadings and distortion stress on bones that are too big for their biomechanical design. Osteochondrosis (see glossary) is caused by the death of bone tissue growing too rapidly for its blood supply to keep up, and may be accompanied by rupture of the cartilage, causing further damage to the joint. It is found around the shoulder, elbow, stifle and hock joints of large to giant breeds, resulting in painful swellings that affect the movement of the joint, and cause pain and can limit mobility from a very young age (Smith and Stowater 1975, Ekman and Carlson 1998). Other joint problems common in large size dogs are elbow and hip dysplasia (see glossary and section 4.7); Schnelle 1935, Corley and Carlson 1965, Fisher 1979, Leppänen and Saloniemi 1999, Demko and McLaughlin 2005). Here, there is malfitting of the bones of the joints, and the soft tissues surrounding these joints are too weak to hold the joint together, resulting in erosive change or partial or total dislocation. These are seriously painful conditions as the tissues are stretched and distorted beyond their functional capacity, leading in severe cases to lameness and painful arthritis of the joints. Many prevalence studies available for these conditions are reviewed by Coopman et al 2008. Although there is some variability between different countries and between different studies, it is clear that a substantial minority, and in some severely affected breeds a majority, of animals suffer one or more of these diseases.

Large breeds, and those with abnormally long backs, also suffer problems of vertebral degeneration when the physical stresses acting on the over-sized vertebrae and intervertebral discs exceed their biomechanical limits, resulting in tissue breakdown (Breit and Kunzel 2004). These dogs suffer pain and reduced mobility from an early age. In large to giant breeds, the cervical vertebrae are particularly affected and compression on the spinal cord leads to referred pain (perceived at a site adjacent or some distance from the site of compression) and weakness of the limbs (wobbler disease) (Burbridge et al 1994, Macias et al 2002, Poma et al 2002). In the long-backed breeds, compression on the spinal cord from prolapsed discs leads to referred pain and weakness of the hind limbs, and ultimately paralysis (Simpson 1992, Singh and Masuda 2005).

Large to giant breeds with deep chest cavities are also prone to gastric problems in which the stomach becomes overstretched by excessive build up of gas (bloat). Whilst this is likely to be uncomfortable and is associated with poor digestion and absorption, it may also lead to the stomach becoming twisted, preventing the gas escaping (Monnet 2003). This can be an extremely painful condition and causes up to 60% mortality in affected animals (Aronson et al 2000) and substantial mortality even in animals which are treated surgically (Beck et al 2006).

At the other extreme from the very large breeds are the skeletal problems associated with short limbs in the dwarf breeds (see glossary) and fine limbs in the toy breeds. The dwarf breeds have very short legs in which the bones can be deformed causing the legs to curve. In more extreme cases, dogs may have difficulty moving and abnormal stresses on the joints and spine can lead to lameness and painful degeneration of the joints from an early age (Demko and McLaughlin 2005). In the toy breeds, bred for their unusually small size, the fine radius and ulna of the front limbs are very vulnerable to stress fractures (Muir 1997, Brianza et al 2006). These dogs are at risk of painful fractures from minimal trauma such as jumping. Dislocation of the patella (knee cap) is also common in toy breeds, leading to pain and lameness (Roush 1993).

The small size of the toy breeds is also associated with incomplete formation of the cartilage rings in the trachea. This may lead to collapse of the cervical trachea (in the neck) during inspiration and of the thoracic trachea (in the chest) during expiration (Johnson 2000, Fossum 2002). Affected dogs have a characteristic cough (“goose-honk” cough) and are vulnerable to respiratory distress that severely limits their capacity to run about and exercise (section 3.4).

Many toy breeds have been selected for neotenus (see glossary) facial features to retain the visual appeal of a puppy into adulthood (Goodwin et al 1997). To achieve this, physical development of the skull is arrested in an immature domed form, indicated by incomplete closure of the skull plates (molera) and in some cases underdevelopment of the occipital bone forming the rear of the skull. The presence of molera does not itself cause welfare problems, as tough membranes between the skull plates provide adequate protection for the brain, but overall lack of development of the skull is one pre-requisite for syringomyelia (see glossary; Rusbridge and Knowler 2003, 2004). Here, the underdeveloped skull interferes with the brain and disrupts the flow of cerebrospinal fluid leading to fluid accumulation and the formation of a cyst in the cervical spinal cord. This cyst can expand and elongate over time, eventually damaging the spinal cord. This damage results in headaches and pain in the neck, weakness and stiffness in the back and limbs, and in some cases paralysis (Rusbridge 2005). The pain in severely affected animals is often so severe that the animals must be euthanased. This condition represents one of the areas where the distinction between the direct (section 3) and indirect (section 4) effects of breeding for physical appearance is a little blurred, since it is in part a direct effect of selection for skull size and shape which predisposes the dogs to this condition. However there is also an indirect effect of increased prevalence due to selective breeding choices, and additional heritable factors not controlling skull shape may be involved. Syringomyelia is therefore mentioned both within the current section and in section 4.3.

A second pattern of distorted skull development is found in the brachycephalic breeds where the skull has been selected to be shortened from front to back, giving a flat-faced appearance. This results in the severe shortening of nasal (nose) and buccal (cheek or mouth) features, including stenotic nares (narrowing of the nostrils) that restricts the flow of air through the nose, and a comparatively elongated soft palate that interferes with passage of air into the trachea (windpipe) (Monnet 2004). In their efforts to breathe, these dogs continually make forced inspirations that cause secondary damage to the larynx (voicebox), and eventually laryngeal collapse. This may, in turn, interfere with expiration. Tissue damage associated with forced breathing causes swelling in the very small nasal cavities and pulmonary edema (fluid on the lungs). Associated pulmonary inefficiency (breathing difficulties) eventually leads to right-sided heart failure. Dogs with such breathing difficulties are unable to lead an active life without triggering respiratory distress. So great is the problem in some brachycephalic breeds that surgical opening of the nostrils is almost routine, and soft palate resection (surgical reduction) is common (Monnet 2004).

The reduced size of the nasal and buccal cavities in these breeds reduces the available surface area for evaporation during panting for thermoregulation, and brachycephalic breeds are therefore vulnerable to heat stroke (Bruchim et al 2006). Another common problem associated with brachycephalia is blocked lachrymal (tear) ducts that often result in eye infections (Gelatt 1999).

In general, eye radius in dogs partly correlates with skull dimensions (McGreevy et al 2004), but selection for large eyes is a common feature of both toy and brachycephalic breeds. This leaves the eye poorly protected and proptosis (eye dislocation from the socket) following head trauma is common in these breeds (Cho 2008). Other breeds also suffer eye problems related to their selected appearance including ectropion (drooping) eyelids that fail to clean and protect the eye, leading to eye infections; entropion (inward folding) eyelids so that the eyelashes (upper) or coat fur (lower) rub against the cornea causing pain, infection and corneal ulcers; and hair from the eyelid growing in the wrong direction also rubbing on the cornea (Gelatt 1999). Surgery is needed to correct these conditions and relieve the animal of the discomfort.

Some breeds of dog have been selected to have large pendulous ears that dangle into things the dog investigates and are prone to damage and infection (Rosser 2004). In others, excessively loose skin and extensive skin folds commonly lead to skin infections in the folds, causing itching and irritation (Muller 1990). Surgical removal of the excess skin may be required.

In some breeds, selection for very short or screw tails associated with misshapen tail vertebrae may lead to the tail lying tightly against itself or the body and being prone to infection. Amputation is needed in the worst cases (Bulldog Rescue and Rehoming 2008). The vertebral malformation needed for the screw tail may occasionally also affect other parts of the spine, causing kyphosis or scoliosis (abnormal curvature of the spine) and narrowing of the spinal cord. These in turn may lead to hind limb weakness or paralysis, urinary or faecal incontinence, and/or spinal pain (Braund 2003).

Whilst breeds with excessive coat volume have problems keeping their coats clean and are vulnerable to overheating, hairless dog breeds are vulnerable to weather exposure. Many hairless dogs have acne indicating poor skin health, with the skin on the ears particularly vulnerable to becoming cracked and infected (Kimura and Doi 1996). Sun protection is necessary, as dog, unlike human skin, does not darken to protect itself; and clothing is often needed for protection from the cold, particularly in the smaller breeds. Hairlessness is also associated genetically with missing molars and premolars that may interfere with the dog's ability to eat (Goto et al 1987).

In at least two breeds, a dorsal ridge has been selected for as a cosmetic trait. This ridge is caused by a dominant mutation (see glossary) that also predisposes a dog to the congenital (see glossary) developmental disorder dermoid sinus (Salmon Hillbertz et al 2007). Dermoid sinuses are narrow tube-like structures, which are derived from a skin defect. They penetrate from the skin surface to varying depths downward into the muscles and towards the spinal cord. This condition closely resembles a neural-tube defect in humans that is usually termed dermal sinus and is often associated with spina bifida occulta, but it may also occur independently (Salmon Hillbertz et al 2007). There are no peer reviewed reports of ridgeless dogs with dermoid sinus, whilst approximately 5–6% of Rhodesian Ridgebacks

born in Sweden are ridgeless, and around 8–10% of ridged offspring have dermoid sinus (Hillbertz, 2005). Neither ridgeless dogs nor those with dermoid sinus are allowed to breed, according to Rhodesian Ridgeback club rules. Because dermoid sinus is found largely in those dogs with two copies of the ridged genes, whilst the ridge phenotype shows overdominance (see glossary), "The problem of dermoid sinus could be virtually eliminated by allowing unridged dogs in breeding and by avoiding matings between ridged dogs" (Salmon Hillbertz 2007 p1320). Breed clubs refuse to do this, and even after revision of their code of ethics in the last year, the UK breed club still excludes unridged dogs from the breed standard (Rhodesian Ridgeback Club of Great Britain 2008). Until relatively recently they also recommended that ridgeless puppies be culled.

In merle (see glossary) coloured animals and breeds with predominately white coats, deafness is common (up to 30% of the breed affected; Strain 2004) and eye defects are sometimes present (European Convention for the Protection of Pet Animals, Council of Europe 1987). Dogs that are deaf in one ear are able to compensate, but fully deaf dogs cannot and as a result are sometimes euthanased. In these animals, it is deliberate selection for the abnormal function of melanocytes (see glossary) that causes the disease problems.

Finally, some breeds have been selected to extremes of head size and narrowing of the pelvic girdle, such that they are unable to birth naturally and require caesarean section to deliver the pups. In a retrospective study of Swedish dog insurance claims, Bergstrom et al (2006) reported that three breeds cannot be insured against this risk in Sweden. Amongst insurable breeds, the most vulnerable breed had an incidence (see glossary) of roughly seven times that in the general population. Amongst uninsurable breeds in Sweden, a 2003 study suggests the incidence of dystocia (difficulties in birthing) may be 50 – 100% (Linde-Fosberg 2003). Without veterinary intervention, these bitches and pups would die

Overall, the list of disorders likely to cause suffering due to extremes of morphology and cosmetic characteristics in modern dog breeds is alarming. That treatments and procedures have been developed explicitly to counteract these exaggerated features is in itself evidence that the

problems are of sufficient welfare concern to need veterinary and/or surgical intervention. This situation calls for urgent ethical review and attention to breed standards and showing, breeding and veterinary practices (see section 5).

3.4 Effects of exaggerated anatomical features on behaviour

Whilst some extreme anatomical traits may result in obvious pain and suffering, others may cause more subtle problems such as preventing the dog from behaving “normally”, or how it would choose to, were it not constrained by that trait. For example, according to the breed standard, the Hungarian Puli should have “long hair that over-shadows the eyes like an umbrella” (The Kennel Club 1998). This feature obstructs the dog’s vision and is likely to reduce its awareness of its surroundings, increasing the risk that the dog will be startled, and react fearfully or aggressively because it cannot adequately assess the context (Haupt 1991). Further examples include breeds with severely reduced limb lengths (dwarf breeds, section 3.3) whose abnormal legs may restrict their ability to run freely; and breeds with respiratory deformities (e.g. the brachycephalic breeds, section 3.3) whose difficulties in breathing prevent them from running without shortness of breath. For these dogs, their ability to explore, and exercise are compromised, thereby limiting their opportunity for natural behaviour and normal social interactions with other dogs. This likely diminishes their quality of life. In addition, some breeds are so small that they are likely to suffer frequent fear and show correspondingly high levels of fearful and defensive behaviours (Duffy et al 2008).

Numerous breeds are anatomically modified in such a way that their capacity to signal is drastically decreased in comparison to their ancestor, the wolf (Goodwin et al 1997). For example, the stiff legs of French bulldogs prevent them from signalling by subtle adjustments of their height, commonly used by dogs of many other breeds (Netto et al 1992). Those breeds with short legs and long bodies are less able to play-bow to invite playful interactions with other dogs. Play behaviour is rewarding to animals (Boissy et al 2007), it is important for their normal social development (e.g. Suomi 1982), and high play levels are often used as an indicator of positive welfare (e.g. Jensen et al 1998). Since play signalling is critical to the initiation and continuation of dog play (Bekoff 1995, Rooney et al 2001) an inability to perform these signals may have important welfare consequences.

Dogs with flat faces (brachycephalic breeds) are less able to utilise facial expressions; whilst breeds with very short or tightly curled tails (e.g. Leaver and Riemchen 2008), or with immobile drooping or permanently erect ears are less able to signal their intentions. Breeds with very short coats or permanently erected fur are unable to raise their hackles; and for breeds with very long or dense fur, nearly all body language communication is obscured. Such extreme anatomical breed traits are likely to affect a dog's ability to interact with other dogs and engage in normal social interactions (see Bradshaw and Nott 1995).

Recent pilot research at the University of Bristol has indicated that on a walk, breeds with the least ability to signal, for example Boxers with immobile ears, docked tails and folded skin on their faces, are less likely to be approached and more likely to be ignored by other dogs, than other less modified breeds. And in a study using robotic dogs to control for all other interaction variables, Leaver and Reimchen (2008) found dogs were less likely to approach the model with a short tail than a longer one, and were more cautious in approaching a long, still tail than one that was wagging, indicating the importance of visible tail signalling in affecting interactions with other dogs.

As most modern dog breeds were initially bred for function, different aspects of ancestral wolf behaviour have been accentuated in different breeds (via artificial selection) to match their original function. For example, herding dogs emphasise the chase aspects of hunting, whilst guard dogs emphasise territorial behaviours (Clutton Brock 1988). In some breeds these behavioural tendencies have been selected to the extreme and may be a welfare concern for the affected animals. For example, Border Collies have been selected to 'show eye' (stare) and some dogs now demonstrate stereotypical staring at blank walls (McGreevy and Nicholas 1999). Other breeds selected to retain juvenile anatomical features also retain juvenile behaviour patterns (Goodwin et al 1997) making them particularly dependent upon their human carers and vulnerable to distress when left alone (McGreevy and Nicholas 1999).

The impact of these behavioural deficits on the welfare of the dogs is even less well documented than the impact of anatomical extremes, but is equally an important and a valuable area for future research and attention.

3.5 Unresolved issues

Numerous breeds show anatomical extremes of form in one or more features. The presence and danger of breeding for extreme morphology has been acknowledged by the Kennel Club (2008c), and breed standards are being modified, judges trained, and other programmes initiated to try to address these issues (The Kennel Club 2008a). This is greatly to be welcomed. However, the problem is widespread, affecting the majority of breeds, and is unlikely to be solved by the modification of appearance-driven breed standards (CAWC 2006). Changes must be directed specifically at ensuring breed health and welfare even to the exclusion of such distinctive features of the breed. The question that must be addressed is what level of exaggeration in each morphological trait warrants concern.

As shown in section 2.2, there is little doubt that the anatomy of the English Bulldog has considerable capacity to cause suffering. The breed is noted to have locomotion difficulties, breathing problems, an inability to mate or give birth without assistance and physical and surgical interventions, respectively (Advocates for Animals 2006). Most people would have little hesitation in questioning the ethics behind breeding an animal with such a suite of potential problems and capacity to suffer.

However, this represents an extreme, and there are many other, less visually obvious anatomical deformities that also lower the quality of a dog's life. The problem is that little empirical data currently exists to allow objective comparison of their relative severity or decide what level of modification is acceptable and what is unacceptable. For example, it is difficult to assess whether a dog that has increased potential to fracture a limb due to fine bone structure or a dog that suffers from continual skin irritation due to skin folds has the greater compromised welfare.

Recent research has started to quantify relative quality of life for dogs (Hewson et al 2007; Budke et al 2008). Physiological (Hiby et al 2006, Rooney et al 2007) behavioural (Rooney et al 2008), and cognitive techniques (Brooks et al 2008) continue to be validated, and show great promise. Such development of robust indicators will prove an invaluable way of measuring the relative impact of different morphological features, as well as the impact of specific diseases (section 4) on dog welfare. In the long term, they will provide an empirical basis by which to prioritise selection efforts towards the factors with the biggest welfare potential. This research needs to be supported, but the results will not be instantaneous. Given the evidence of current suffering (section 3.3) radical decisions cannot wait and so subjective assessments of relative welfare impact must be employed in the interim. Ethical review and appropriate breed management strategies must take the relative welfare costs of exaggerated anatomical features into account (see section 5). A breed-by-breed assessment of the most severe problems from a welfare perspective is urgently needed. We suggest it would be safest to recommend that any features which have the potential to cause suffering should be actively selected against (and not simply avoided). The decision on which have the potential to cause suffering requires considered debate, involving a range of specialists from various disciplines including veterinary, behaviour and welfare experts, and must be made by individuals independent of vested interest in the breeds involved. A reasonable starting point may be, if the animal's morphology results in health problems, and if those types of health problems cause pain or suffering in humans, then we are ethically obliged to assume that they cause comparable pain and suffering in dogs, unless we have clear evidence to the contrary.

Welfare Issue 2 – increased prevalence of inherited disorders

4.1 Background information

Breed related diseases are often considered to be genetically driven, as a breed is by definition a genetically restricted subset of the gene pool (see glossary) of a species. The indirect effects of selective breeding for appearance include very significantly reduced genetic diversity unevenly spread across the genome (see glossary), resulting in elevated prevalence of specific diseases within particular breeds (section 4.3). Coupled with ill-advised breeding practices and insufficient selection pressure on health and welfare (section 4.5), this has led to certain breeds becoming especially susceptible to a whole suite of disorders, many of which are acutely painful or chronically debilitating.

Typically, modern dog breeds originated from a relatively small number of founder animals. Dogs showing desirable conformations (defined by “fanciers” and later laid down in breed standards) were mated together within this small group to accentuate what were perceived to be desirable traits, and popular, winning sires were used intensively for stud. For the last 50 years, dog registration rules in the UK have stipulated that out-crossing (breeding with another breed) is not normally permitted. A dog can only be registered with the Kennel Club if the sire and dam are registered members of that breed’s studbooks (in which all pedigree animals are registered) hence dog breeds each represent a closed gene pool. One of the outcomes of this approach, referred to as “directed selection” by André et al. (2008), is that purebred dogs are genetic isolates (Parker et al 2004). In this way, the Kennel Club, breed societies, and the pedigree dog showing community have formally endorsed the inbreeding of dogs.

Although the intention of these rules was to preserve and improve breeds, in terms of the distinctiveness of their physical and functional attributes, this has resulted in dog breed populations in which the amount of genetic diversity is rather low (Lindblad-Toh et al 2005). Parts of the genome are impoverished of genetic variants (see glossary; Jones et al 2008) and there is a very high chance that any two individuals in the breed are related at the genetic level, and hence an increased chance of rare inherited disorders being manifest in their offspring (Cruz et al 2008). In addition, genetic diversity within the individual also causes hybrid

vigour or heterosis (see glossary), a contribution to fitness which is absent in inbred (see glossary) individuals.

Genes are paired in animals, with one copy or allele (see glossary) coming from each parent. In the case of simple or monogenic genetic diseases (see glossary) it is one pair of genes that controls a disease. There are only three combinations of a pair: two genes for the disease, one normal gene and one disease gene, or two normal genes. In recessive (see glossary) inherited diseases, animals may either be abnormal and have two genes for the disease, or be normal but have one normal gene and “carry” a hidden disease gene, or be normal and have two normal genes. The abnormal animals are identified by their disease, and the apparently normal animals can be divided into genetically normal and carrier (see glossary) animals by gathering data from a few generations and applying simple genetic principles to investigate patterns of inheritance.

Since many diseases are the consequence of homozygosity for recessive alleles, breeding of close relatives is accompanied by a corresponding increase in the occurrence of these disorders (McGreevy and Nicholas 1999) because an animal must inherit one defective gene from each parent in order to develop the condition. When parents are closely related, the likelihood of them both carrying a copy of the same deleterious gene is significantly elevated. The low genetic diversity in some parts of the genome in the majority of dog breeds (Jones et al 2008) also means that in these regions there are few unrelated possible mate choices. Therefore it is difficult to eliminate any problems or diseases stemming from these regions of the genome without breeding to members of another breed, which is currently prohibited (see also recommendation 3, section 5).

Today the problems continue. Many breeders now understand the need to avoid inbreeding of very close relatives, but often do not look far enough up the pedigree for common ancestry. Unfortunately some breeders still do inbreed as they strive for specific features as laid down in the breed standards. In addition, “line breeding” (aimed at accentuating features expressed in that family) means that breeding partners are often selected from a sub-population of the entire breed. Furthermore, the over-use of very popular champion sires means that any deleterious alleles which they carry can very rapidly become widely distributed

in the breed. These practices exasperate the problem of elevated disease incidence within specific breeds, and there are currently no regulations nor legislation specifically aimed at controlling these practices in the UK¹. This situation needs to be addressed (see section 5).

4.2 The link between inbreeding and disease

It has long been known that crosses between different breeds or strains of animal or plant display extra vigour (hybrid vigour or heterosis), and indeed one standard early indicator suggesting that a disease may have a genetic origin is the fact that a disease affected group is more inbred (i.e. has a higher coefficient of inbreeding; see glossary) than an equivalent control group of the same breed. While there is abundant evidence of inbreeding depression in humans and agricultural species, there is rather less available in dogs where fewer studies have been conducted. Nonetheless in single breeds of dogs, the inbreeding coefficient of the parents is known to have a direct relationship to the litter size and number of stillborn pups per litter (e.g. Gresky et al 2005) and on pre-weaning mortality (van der Beek et al 1999). Cross breed and mixed breed dogs typically have longer life expectancy than pedigree dogs (Michell 1999) although care must be taken to allow for the confounding effects of weight and environment in this analysis and some smaller breeds of pedigree dogs are long lived (Michell 1999, Greer et al 2005, Jones et al 2008).

The link between inbreeding and increased disease risks in purebred dogs has been noted by many authors and comprehensively reviewed by Brooks and Sargan (2001). There are many known cases where inherited diseases are found in more inbred representatives of their breeds and in particular where specific common ancestors can be found amongst all animals segregating for the disease. There are many documented cases in clearly monogenic disorders, but also examples from more complex diseases. To take a few examples at random:

- Cardigan Welsh Corgis suffering from a blinding eye disease, progressive retinal atrophy (see glossary), that is caused by a known recessive mutation can all be traced to a single ancestor (Petersen-Jones et al 1999);
- epilepsy, either as a possibly monogenic disease in the Keeshond (Hall and Wallace 1996) or in a probably more genetically complex form in the Labrador Retriever, is found in relatively inbred sub-populations within the breed (Jaggy et al 1998);

¹ Note: as this report was going to press, the UK Kennel Club announced that it will not register puppies that are born from any mother/son, father/daughter or brother/sister mating, taking place on or after 1st March 2009.

- similarly, a clearly polygenic disease (see glossary) such as hip dysplasia in Labrador Retrievers (see also section 4.7i; Engler et al 2008) is associated with high inbreeding coefficients in affected animals.

This causal relationship is also supported by studies such as that of the Bouvier Belge des Flandres in France (Ubbink et al 1992). Dogs being treated for numerous ailments (osteochondrosis, food allergy, autoimmune disease, neoplasm, or hypoplastic trachea: see glossary) were seen on average to have higher coefficients of inbreeding than a control population of healthy dogs. Syringomyelia (sections 3.3 and 4.3) was first reported in Cavalier King Charles Spaniels in 1997 (Rusbridge et al 2000). A genetic analysis showed that six of eight grandparents of all affected dogs in a study could be traced back to two female ancestors and the condition showed increased severity and an earlier age of onset with increased levels of inbreeding (Rusbridge and Knowler 2004). There are many other examples in the canine literature that highlight the risks of small founder numbers and high levels of inbreeding.

There is direct evidence that many pedigree breeds have undergone a good deal of inbreeding. In a study of 11,384 Portuguese Water Dogs in the USA, all of them were found to originate from only 31 founders, and ten animals were responsible for 90% of the current gene pool (Chase et al 1999). Similarly, the Cavalier King Charles Spaniel breed, which is mentioned in this report in connection with both mitral valve disease (see glossary) and syringomyelia (section 4.3), was established in 1928 and is believed to be descended from just six dogs (Rusbridge and Knowler 2003).

Line breeding for desired characteristics, in which descendents of a common ancestor are repeatedly bred together over many generations with few external additions, is well known to be commonplace in the canine community. Popular sires such as show champions, may have many tens of matings, producing hundreds of progeny, and having a disproportionate influence on the gene pool subsequently. The influence of these trends in reducing genetic diversity and the potential for hybrid vigour is shown in a recent comparison of common UK breeds registered by the Kennel Club. In this study, Calboli et al 2008 identified effective population sizes

(see glossary) of less than 100 individuals in nine of the ten breeds they studied (Boxer, English Bulldog, Chow Chow, Rough Collie, Golden Retriever, Greyhound, German Shepherd Dog, English Springer Spaniel, Akita Inu), in spite of actual populations ranging from 1060 to 703,566. That is to say the level of inbreeding in these breeds was so high that it was the same as one would expect in much smaller populations. This situation was particularly pronounced in the Boxer, where almost 45,000 individuals were studied, but the effective population size was only 45. These authors also saw a very large loss of ancestral genetic combinations over six to seven generations, (over the period 1970 to 2006) for seven of the ten breeds, so that loss of different combinations of genetic variants was much greater than loss of variation in individual genes. This alarming level of loss of genetic variability, in relatively common breeds, is considerably higher than that which is aimed for in sustainable captive breeding programmes in zoos (WAZA 2005).

In addition to intensive line breeding, Calboli et al (2008) note popular sire effects and some inbreeding, resulting in loss of genetic variability and increased prevalence of recessive heritable disorders, which raise serious concerns about canine welfare. Similarly Chase et al (2006) note, “the high frequency of disease in domestic dog breeds likely reflects the small number of founders associated with many breeds, subsequent inbreeding, and the frequent use of popular sires”. Hence changes in breeding practice are suggested in section 5 of this report.

When combined with the selection for specific conformations through the operation of breed standards and the influence of show judges, these breeding choices can lead to parts of the genome which are under heavy selection becoming virtually homozygous (see glossary) within breeds (Lindblad-Toh et al 2005). Although the data is limited, most pedigree breeds appear to have these homozygous areas, probably created by a so-called selective sweep around the genes which contribute to successful show ring performance, or some other selected characteristic in that particular breed (Pollinger et al 2005, Wayne and Ostrander 2007). They may amount to 15-30% of the genome, or many thousands of genes. These genes will likely be somewhat different for each breed. For these loci the loss of vigour and especially the loss of ability to

select away from diseases will be most pronounced. More understanding of these phenomena would be valuable (see section 5).

As a result of these selective sweeps there is sometimes “co-selection” of a deleterious gene found close to one that is under selection. For example, in the Dalmatian it appears that selection for the spotting pattern inadvertently selected for a linked gene that results in high uric acid levels and may cause urinary stone and dermatological problems (Dalmatian Club of America 2007). These problems are now thought to potentially affect all pure bred Dalmatian dogs. A trial, in which a Dalmatian was outcrossed to a Pointer, followed by selection against the defect during backcrossing to Dalmatians, took place and although its results are claimed to be successful in ridding offspring of the disorder, (as explained in recommendation 3) only after the fifth generation would the Kennel Club allow registration of offspring. This provides a financial disincentive for breeders to outcross.

4.3 Examples of diseases

An online database (Online Mendelian Inheritance in Animals) lists over 480 identified heritable traits (mostly diseases or disorders) in the domestic dog, over 130 of which are known to be single-locus disorders/traits (and hence inherited via simple rules of genetics; Nicholas 2003). It is likely that the incidence of many of these disorders increases as the extent of inbreeding increases. However, modes of inheritance vary and some are complex and so in-depth genetic research of each is required. Many of these conditions have already been noted and documented to be more common in certain breeds than other breeds. Those frequently quoted include: cancer, blindness, heart disease, cataracts, epilepsy, hip dysplasia, brachial airway syndrome, skin disease and deafness (Lindblad-Toh et al 2005). A second database lists 519 inherited disorders, all of which are associated with one or more dog breeds through calculation of relative risk or demonstration of a mutant gene, such that 1321 combinations of breed and disease are listed (Inherited Diseases in Dogs IDID; Sargan 2004).

It has been estimated that on average, each breed has had reported an elevated prevalence for between four and eight disorders (Brooks and Sargan 2001), although some authors quote much higher figures, with Labrador Retrievers being listed as prone to 88 different disorders (Gough and Thomas 2004). Breeds that are numerous and with higher levels of veterinary surveillance tend to have higher numbers of reported inherited diseases, suggesting that lower figures are often underestimates. In fact, there is a significant correlation between the number of Kennel Club registrations in 2007 and the number of entries for the breed in the IDID Database (Sargan 2004; and IDID web pages) (Spearman's Rank correlation; $Rho = 0.716$, $p < 0.001$), strongly suggesting that current knowledge of genetic diseases in dog breeds is a function of the level of veterinary surveillance.

There are a large number of reports of breed predispositions to disease, and reliable research has been conducted for some of the conditions within specific countries (few in the UK). The results of many of these are shocking, indicating that certain breeds experience very high rates of heritable disorders/diseases. Some examples

are given here, but these should not be taken as being either isolated or even the most extreme examples:

- Abnormalities in skull bone formation are considered major contributors to the development of syringomyelia. The prevalence of craniocervical junction (see glossary) abnormalities and Chiari malformation (see glossary) is high in Cavalier King Charles Spaniels and although several factors are associated with neurological signs, occipital underdevelopment (making the skull small) appears to be the most important factor (Cerda-Gonzalez et al 2006). In this study of 64 dogs, 49 were free of clinical signs of disease, but 26.5% of the asymptomatic dogs were found to be affected with syringomyelia (actually having cysts in the spinal cord); this figure rises to 42% if symptomatic dogs were included.
- Cardiac problems are also common in Cavalier King Charles Spaniels; highlighted in a recent Kennel Club survey (The Kennel Club 2006b; but see also section 4.4 for limitations of this data) to be the commonest disease condition reported in the breed (25% of all conditions or a prevalence of 17%). Other reports suggest much greater numbers of Cavalier King Charles Spaniels have subclinical disease (section 4.7.3).
- A recessive eye disease called Collie Eye Anomaly (see glossary), which when severe can cause blindness, affected some 13.7% of the whole Lancashire Heeler breed (Bedford 1998) (suggesting that 60% of all dogs in the breed carry one or more copies of the mutation).
- Diabetes is very common in certain breeds. Occurrence in breeds is elevated by three to more than ten fold in Australian, Cairn and Tibetan Terriers, Samoyeds, Swedish Elkhounds, and Swedish Lapphunds (Kennedy et al 2006; Fall et al 2007). For the Australian terrier, the level reached in a large Swedish survey was 183 new cases per 10,000 dog years at risk (Dog Years at Risk: DYAR (see glossary); or a rough 10-20% incidence in a lifetime; Fall et al 2007). For many of these breeds, diabetes susceptibility is known to be because of the presence of a particular reduced set of genetic variants in the immune system.
- A survey of over 11,000 Portuguese Water Dogs showed a breed-specific incidence of late-onset Addison's disease (see glossary) of 1.5% in the USA (Chase et al 2006). Nine percent has been reported previously for Bearded Collies (Oberbauer et al 2002). There is evidence that Addison's disease in both the Portuguese Water Dog and Standard Poodle is inherited under the control of an autosomal recessive locus (see glossary; Famula et al 2003, Oberbauer et al 2006) which may be associated with red coat colour in poodles.
- Comparisons of the prevalence of breed-specific glaucoma (see glossary) in North America revealed figures of 5.52% and 5.44% in American Cocker Spaniels and Bassett Hounds respectively. This is considerably higher than the prevalence of 0.89% in the general dog population (Gelatt and MacKay 2004). Most worryingly, the prevalence in each breed was also seen to increase over the study period (1964-2002). This may be due to increasing incidence in these dogs, or alternatively concurrent changes in practice of referral and diagnosis, meaning that more cases are correctly diagnosed and reported.
- Atopic dermatitis (see glossary) in dogs is characterised by chronic allergies to environmental antigens and is genetically programmed. A survey of Swedish dogs determined that Bull Terriers had the highest risk (21 cases per 1,000 DYAR), compared to the general population incidence (1.7 cases per 1,000 DYAR). Boxers, West Highland White Terriers and Staffordshire Bull Terriers also had considerably above average risks (Nodtvedt et al 2006).
- Several different types of cancers have been shown to be more likely to be found in particular breeds (Richards et al 2000, Dobson et al 2002, reviewed

in Giger et al 2005). Analysis of a canine biopsies database suggested that Boxers were at 1.3 times greater risk of a neoplastic (see glossary) diagnosis (abnormal mass of tissue growth) compared to Labrador Retrievers (Richards et al 2000). Other authors have also suggested that the Boxer breed has an increased risk of neoplasia (Priester and Mantel 1971, Howard and Nielson 1965, Nordstoga et al 1997), and in the Kennel Club Health Survey (see also sections 4.4 and 4.7.3) 39% of Boxers died of cancer, an unusually high percentage compared to 27% across all breeds.

- Other conditions with very high breed specific risks include malignant histiocytic tumours (see glossary) in Bernese Mountain Dogs and Flat Coated Retrievers; osteosarcomas (see glossary) in Irish Wolfhounds and other giant breed dogs; haemangiosarcomas (see glossary) in German Shepherd Dogs in the UK; and the same tumour in Golden Retrievers in the USA. A host of other conditions with smaller but still significant breed predispositions have also been identified (all reviewed by Giger et al 2005).

4.4 Limitations of current prevalence data

When studying disease epidemiology, it is better to analyse incidence rather than prevalence. Prevalence is a measure of the total number of cases of disease in a population and is therefore affected by the duration of the condition. Incidence measures the rate of occurrence of new cases, and thus conveys information about the risk of contracting the disease. But many studies can only report prevalence because they are a cross-sectional studies of populations at single points in time.

Although the examples provided above (section 4.3.) are of relatively robust studies, they are still somewhat ad-hoc, as the breeds, disorders, and populations to study have not been selected systematically. To date, few large and rigorous population-based epidemiological studies documenting the incidence and prevalence of canine diseases in dog breeds have been performed. Even if a specific disease is studied, it is often hard to gain any reliable results about differences between breeds because by the time the data has been subdivided into breeds the numbers in each group are too small for statistically meaningful comparisons. Reports of breed-associated specific disease risk are often anecdotal, or are cross-sectional studies based on data from specialised referral practices (practices that offer only specialist consultation in a particular disease or area e.g. Richards et al 2000, LaFond et al 2002, Gelatt and Mackay 2004) or are derived by analysing large databases collected for other reasons such as insurance data or open test registries (see glossary; e.g. Dobson et al 2002, Egenvall et al 2005, Fall et al 2007). Many conditions will only be seen by the primary veterinary care service, and thus not be included in estimates gained from reports from referral services.

Insurance databases usually lack detail and they show a bias to pedigree animals and to younger animals (the former are often owned by more wealthy households, whilst premiums increase with age and older animals are uninsurable) (Fall et al 2007). Thus prevalence estimates are subject to biases due to non-random or non-representative samples, and caution must be exercised in their interpretation. Inherent biases in the way the population is sampled (selection bias) and the accuracy of the information collected (information bias) as well as random sampling

biases can affect the validity of any results gained (Dohoo et al 2003a). In the UK, only just over a quarter (26%) of dogs are insured, although this proportion is increasing (Datamonitor 2008), and a much higher proportion are insured in some other countries such as Sweden. Despite these reservations, the use of insurance databases could be a first step towards gaining some knowledge in this area, and likely less costly and time-consuming than setting up entire new data collection systems.

We must also be wary of generalising results from a study in one country and applying them to dogs in a different country. Genetic data has already revealed differences between the same breeds in different countries (Quignon et al 2007). Due to geographically separated populations and genetic drift, it is likely that these populations are distinct and live under different selection pressures, although the full extent of this phenomenon is unknown.

Another approach has been taken by the UK Kennel Club, who in partnership with epidemiologists from the Animal Health Trust, conducted a breed health survey in the UK, by contacting the largest breed clubs for each breed and sending out questionnaires to owners/breeders (the Kennel Club 2006b). The results of this have largely supported known breed predispositions, but in some cases have suggested lower prevalences of certain conditions compared to other studies. Although this dataset represents 52,000 dogs in total, for individual breeds numbers are small, and the study had low response rates from owners (average 24%), who were self-selecting and hence may present a biased sample. Thus, these results should be interpreted with caution. Perhaps for this reason, the Kennel Club did not publish breed specific disease prevalences from this work.

In cross-sectional prevalence studies, identifying true cause and effect is difficult (Dohoo et al 2003b), especially when considering environmental and lifestyle factors. Effective study design is crucial as confounding variables that are unaccounted for can lead to spurious apparent associations. Longitudinal data collection would greatly benefit the elucidation of the causes of breed predispositions to particular diseases in dogs.

In conclusion, the true prevalence and incidence of many disorders in pedigree dogs remains unknown.

However, there is convincing evidence that some breeds have unacceptably high prevalences of specific diseases that should be addressed. Increased effort and funding to facilitate larger, purposefully designed studies would considerably improve the quality of the data and conclusions that can be drawn from them. To fully monitor progress, accurate and reliable recording methods and systems need to be developed in collaboration with epidemiologists (see section 5). Only when these are in place will we be able to fully ascertain which breed predispositions are due to heritable factors that can be influenced by breeding, and which are affected by common environmental factors associated with the breed (such as the way individuals are likely to be kept and managed, and the type of person who owns them).

4.5 Lack of attention to health, welfare and behaviour

A further indirect effect of breeding primarily for physical appearance is that there is very little selective power left, by which to drive positive changes in health and temperament. In a recent Dutch trial, van Hagen et al. (2004) offered genetic counselling to dog breeders for hereditary health problems in Boxers. This study found that breeders placed almost twice as much weighting on the physical characteristics of the dog as the advice from the geneticists when it came to selecting a stud dog. Glazewska (2008) also noted that despite the high level of inbreeding and inherited disease in the Polish Hound, breeders did not appear to be highly motivated to alter this state of affairs. This author stated that the breeding of Polish hounds is primarily governed by human ambition and financial reward.

Maki et al (2005) investigated how best to reduce the incidence of hip and elbow dysplasia by means of a computer simulation. They predicted the possible genetic improvement in these conditions, and in behavioural traits which could be achieved in the Finnish Rottweiler dog population if different priorities were to be given to each trait during selection. They concluded that selection must be based entirely on hip scores, elbow scores and behaviour and not on the physical appearance of a dog if useful improvement were to be seen in the incidence of these disorders. Unfortunately this appears an unrealistic goal, as breeders will concentrate on other imperatives both in terms of health and in pursuit of breed standards. This points to the need for ethical review, positive incentives, potential control of breeder's practices and revised breed standards and practices (see section 5).

Similarly when breeding choices are based mainly on physical appearance, many breeders have likely paid insufficient attention to temperament or capacity to cope in a domestic environment. This may account, at least in part, for the large numbers of behavioural problems that are encountered in dogs today. Pet behavioural counsellors regularly encounter specific behaviour problems that seem to be over-represented in specific breeds, and some of these have been investigated.

In a Danish Kennel Club survey of dog owners, Belgian Sheepdogs, Dachshunds, Dalmatians, German

Shepherd Dogs, Hovawarts, Pinschers, Rottweilers, Scent dogs and Spitz dogs were reported to have significantly higher inter-dog dominance aggression problems than Labrador Retrievers (the most numerous breed and used as a reference category). Other breeds such as Poodles, Sheepdogs and Terriers were more likely to have a sudden noise phobia (Rugbjerg et al 2003). Analysis of problem behaviour consultations in Denmark (where there is a system of free advice) identified some breeds as having higher risks of certain behaviours when compared to Labrador Retrievers, for example German Shepherd Dogs scored higher for aggression towards dogs, strangers and general anxiety; Cocker Spaniels were noted for aggression towards owners and strangers, and for indoor toileting; and Collies were likely to show aggression towards strangers, indoor toileting, and general anxiety. Terriers generally tended to have a lower risk of reported behaviour problems (Lund et al 1996). A recent study in the USA also saw highly significant differences in owner-directed, stranger-directed and dog-directed aggression between a variety of breeds (Duffy et al 2008). Hence there are obvious differences between breeds in behavioural tendencies that need investigating.

There is also evidence for a genetic predisposition towards aggression in Golden Retrievers (Knol et al 1997, Liinamo et al 2007) as this behaviour tends to occur more in some family groups than others (Knol et al 1997). When comparing different coloured Cocker Spaniels, Podberscek and Serpell (1996) and Perez-Guisado et al (2006) saw that "dominant-aggressive" behaviour varied greatly between different coloured dogs, so breeders who choose specific colour types to breed may have inadvertently selected for an aggressive temperament. When exploring the effect of selection practices, Duffy et al (2008) found that conformation-bred English Springer Spaniels were more aggressive to humans and other dogs than were field-bred individuals, which is likely a result of the extensive use of popular sires of this temperament type. Similarly, in a review of breed-typical responses of 13,097 Swedish dogs of 31 breeds to standardised behaviour tests, Svartberg (2005) found that dogs bred for showing were more likely to display social and non-social fearfulness, and were less playful and curious than dogs from working lines. Since most pedigree dogs live most of their lives as household pets, and require

higher sociability, this situation needs further investigation. Breeding to show standards may have adverse effects on behavioural traits in some instances. In any case, initiatives that increase the attention paid to temperament during breeding selections would be valuable (see section 5).

4.6 Access to knowledge of inherited diseases for breeders and owners

Many documents and literature sources produce lists of diseases and disorders to which certain breeds are predisposed. For example, Gough and Thomas (2004) list predispositions for over 500 diseases, Gelatt (2000) lists breeds known to show specific hereditary eye diseases, and Martin and Cocoran (1997) concentrate on breed-related heart and respiratory problems. In addition, Dogs Today (2007) amalgamated all these resources, to produce a chart showing all the hereditary problems for which tests are currently available. The UK Kennel Club has also published a chart on their website (The Kennel Club 2008d), for those breeders that are part of their Accredited Breeder Scheme (section 4.7.3), showing which tests they recommend for which breeds.

A problem with these lists is that they are not fully comparable for the following reasons:

- Many published lists of breed-specific predispositions do not state what objective criteria of increased prevalence they use for categorising a cut-off point for a breed-specific predisposition and this makes consistency and comparison difficult.
- They are often based primarily on veterinary surgeons' reports and textbooks and not on systematically collected data. In fact, many lists appear to be compiled from case reports, so that where a disease is rare but general in the dog population it becomes attributed to the breed in which it was first noticed.
- Often there is no proof that the disease is inherited, so it may be that environmental conditions or infections to which a breed is exposed through owner behaviour or work cause the high prevalence, rather than any genetic predisposition. One of the old established examples of this is Coonhound paralysis which causes motor nerve inflammatory disease in the breed. This has been shown to be a response to raccoon bites rather than an inherited breed predisposition, and may well be an infectious or allergic response (Cummings and Haas 1966, Holmes et al 1979)

- The Inherited Diseases in Dogs web site (IDID; section 4.3) attempts to list cases of genuine inheritance or predisposition, but even here the quality of data available is variable. It lists breed predispositions to diseases in 240 breeds. Conditions are limited to those that have appeared in peer-reviewed publications, but it is an international compilation so figures compiled overseas are not necessarily equally valid in the UK.

Supporting, developing and publicising such an up to date listing of known breed predispositions has been suggested to be a good way to inform potential buyers and breeders (see section 5). However, such lists raise a number of important issues:

a) These lists can be misleading when used for inter-breed comparisons because the data on which they are based is incomplete. In the UK, there is no obligation to record disease occurrence or cause of death of a dog.

In the absence of accurate, thorough record keeping, inter-breed tables will disadvantage breeds about which much is known and in which responsible research and screening (see glossary) tests have been established. Conversely, rarer, less researched breeds may appear healthier simply because less is known about their susceptibility to specific disorders. The correlation between the popularity of a breed and the number of diseases ascribed to it in IDID has already been noted (section 4.3). Hence, it is important to question whether other breeds are equally or more affected yet less is known about their fate.

The presence of a disease says nothing about its prevalence or severity. For example, Gough and Thomas (2004) identify 49 diseases for the English Bulldog, and 88 for the Labrador Retriever; yet the median life expectancy of the Labrador is nearly thirteen years as compared to less than seven years for the Bulldog (Kennel Club Health Survey; section 4.4), and the annual veterinary bill for a Labrador Retriever is less than half the Bulldog's (K9 Magazine 2007). Simple lists can have limited value if they are unable to reflect severity and prevalence. Therefore systematic data collection must be a priority (see section 5).

b) What increase in the cumulative incidence (the number of new cases within a specified time period divided by the size of the population initially at risk), should be taken as a predisposition or an issue of concern? This question has no easy scientific answer – a study may be able to show that a particular breed had significantly higher rates of disease than a different breed, or than the general population, but these types of studies are rare due to the large sample sizes needed to have the statistical power required to identify such differences. It is not appropriate to compare incidences of different diseases directly without reference to the general population. For example, if a disease is very rare in the general population (say 0.1%), a 1% incidence in a breed might be highly significant. But if the disease is a common one (say 50% incidence), then a 5% increase in incidence for a certain breed is likely insignificant. These issues make consistency and comparison difficult. An arbitrary cut-off point could be suggested. A suggested baseline would be an average of the whole dog population, or the disease prevalence in mixed breeds, but this information is not currently available for many diseases. Alternatively, an independent panel (see section 5) could have power to discuss and decide which breeds are predisposed to what diseases, based on all available evidence and including severity of the disease and its impact on an affected dog's welfare.

c) Simple lists of hereditary disorders leave the buyer or breeder with no objective way of determining actual risks. Even odds ratios as suggested above can be misleading. Thus, LaFond et al (2002) reported varying increased risks of hip dysplasia across different breeds to a maximum of approximately ten times that found in mixed-breed dogs (section 4.71). This might appear as a low increased risk compared to that for osteochondrosis of the stifle in the Bull Mastiff, estimated at 1000 times more than in mixed-breeds (LaFond et al 2002), but this is because hip dysplasia is much more common in mixed breed dogs than osteochondrosis of the stifle, and may be considered a much more significant disease. This information is not apparent when just looking at a table of breeds and their conditions.

d) Similarly these lists do not help a buyer or breeder to assess the extent to which each complaint compromises a dog's quality of life, and hence its relative importance to breed or select against. For example, in the past much attention has been paid to hip and elbow dysplasia, which undoubtedly lead to very painful disabling, arthritic conditions that adversely affect a dog's quality of life, but mostly later in life. There may be other distressing conditions which also have a great effect on a sufferer's overall welfare and which may respond quicker to screening and selection efforts. If animals are to be removed from breeding at only a low rate compatible with maintenance of genetic diversity then these test results must be prioritised. This highlights the need for future research into ways of assessing welfare and quality of life (see also section 3.5) and also the need for a range of experts (e.g. welfare scientists, clinical specialists and geneticists) to be instrumental in deriving future breeding strategies, specifically for each breed (see section 5).

4.7 Progress in health and disease screening

The Kennel Club, together with the American Kennel Club and many veterinary scientists have long been aware of the heritable disease problems addressed above, and so have tried to bring forward adequate screening programmes to assist breeders in identifying dogs at risk, and reducing the incidence of inherited diseases. Testing programmes in the UK can be divided into older, clinically based health surveillance schemes (based on the detection of phenotype; section 4.7.1) for a large number of eye diseases, for hip and elbow dysplasia, and more recently introduced DNA based tests (section 4.7.2). Currently there are DNA tests available for well over 50 inherited diseases in well over 140 breed/disease combinations (see Appendix 1).

4.7.1 Tests based on detection of phenotype (using the current BVA/KC canine hip dysplasia scheme as an example)

Due to the significant impact of hip and elbow dysplasia on a large proportion of the dog population, for the past thirty years concerted efforts have been made towards countering these problems. Nevertheless, progress in selecting against these traits has been slow. Hence although there are several other similar screening schemes available for a range of diseases, we present a review of the background and progress of the hip dysplasia scheme as an example of progress using a phenotype based test.

Introduction

Hip and elbow dysplasia are problems that affect a range of dog breeds in the UK. They both feature a primary mal-development of the juvenile joint and its ligaments that causes a secondary osteoarthritis (see glossary). Clinically affected animals experience pain, loss of range of movement, and a reduction in ability to exercise in relation to the affected joint or joints. These diseases are mostly seen in specific breeds; there are other breeds that do not suffer

from them, and there is no substantive evidence to show that these diseases occur in wild canids. The existence of a genetic component has been proven (reviewed by Janutta and Distl 2006), and screening schemes have been devised in the UK and elsewhere in an attempt to control them. The hip and elbow schemes have many similarities, and so the hip scheme, on which more data is available, is considered here; but our conclusions are valid for both schemes.

The aim of a screening scheme is to enable breeders to select mating pairs in such a way as to minimise the chances of the offspring being affected by the disease, and to reduce the prevalence (section 4.4) of the disease. The question is how effective have these schemes been, and could they be improved? Only by answering these questions can we be confident that we are reasonably discharging our duty to ensure the welfare of pedigree dogs.

Background

It is impossible to understand the canine hip dysplasia screening scheme without understanding the nature of canine hip dysplasia (CHD) and some of the issues that surround it.

Unfortunately CHD, like most breed related disorders, is a polygenic disease involving the expression of a number of genes. There are many combinations of a number of genes, so there is no clear division between affected, carrier and normal animals. A simple way of thinking of the relationship between an animal's genes and its disease state, is to think that the more mutant genes for the disease an animal has, the greater its risk of the disease. What this implies is that there will be a proportion of the population who carry quite a lot of genes for the disease but do not suffer from it clinically. This is the state of subclinical disease (see glossary).

A dog that has clinical CHD will suffer signs directly related to mal-development of the hip and the ensuing secondary osteoarthritis that is caused by that mal-development. These include pain, discomfort, loss of range of motion, lameness and reluctance to exercise. Such animals require veterinary treatment and clearly should not be bred from, but they are only a small proportion of the disease problem. A much larger group are those with subclinical CHD. These animals do not have clinical signs and may have never been lame, but characteristic changes

related to the disease can be seen when these animals are radiographed or their hips are manipulated under anaesthesia. These animals are to a greater or lesser degree "carrying" the genes for the disease, and in order to reduce the prevalence of these genes and therefore the prevalence of the disease in the population these animals must be identified and removed from the breeding pool.

Screening schemes and the current BVA/KC scheme

The purpose of a screening scheme for a polygenic disease is to identify the subclinical population and stop or control their use in breeding programmes. The perfect screening system would be a test that identified animals precisely with the problem genes by a direct DNA analysis. Such a test for CHD remains unavailable today. Therefore CHD screening depends on the indirect method of quantifying pathological changes that relate to CHD, and making the assumption that the degree of severity of these changes is proportional to the degree that the individuals' genetic makeup is contaminated by genes for CHD. There are a number of methods for this, the most common being the use of a radiographic evaluation. In the UK the owners' local veterinary surgeon will take a radiograph of the dog's hips, and that image should then be sent to an expert panel at the British Veterinary Association (BVA). The reality is that owners will often ask the veterinary surgeon to pre-check the radiographs, and those that are obviously dysplastic are often not sent (Paster et al 2005). Once with the expert panel, the changes in the hip joints that are related to hip dysplasia are scored out of a total of 53 points for each hip. The score for an individual is given as the total of the two hips. The scheme calculates a five year rolling mean for each breed every year (the breed mean score, BMS). The advice to breeders is to select animals for breeding who have scores well below this breed mean. Participation in the scheme is voluntary and as a result only a small proportion of the dogs registered in the major breeds are scored. In 2006 the BVA screened less than 13,000 hip radiographs (BVA personal comm.) while the KC registered over 75,000 dogs in the screened breeds (The Kennel Club 2008b). This means that less than 20% of animals from breeds vulnerable to CHD were screened in 2006.

Table 1 – Five Year Rolling Breed Mean Score for the 4 most Commonly Scored Dog Breeds from 1996- 2006 (Data from BVA/Kennel Club)

Breed	Rolling Mean for Each Year										
	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006
1	16.5	16.1	15.8	15.4	15	14.5	14.2	13.8	13.6	13.4	13.1
2	19.5	19.2	18.7	18.1	17.6	17.3	17.1	16.8	16.7	16.6	16.2
3	19.3	19.4	19	18.9	18.7	18.3	17.7	17.5	17.5	17.5	17.2
4	12.2	12	11.7	11.6	11.5	11.3	11.2	11.2	11.2	11.2	11.1

Effectiveness of the current BVA/KC scheme

The Kennel Club publishes the results of the scheme for each breed, their headline figure being the breed mean score (BMS), a sample of which is given above for some of the breeds with the largest number of registrations (Table 1). Their interpretation of this data is that the scheme is effective, as the breed mean score (BMS) in most breeds is steadily decreasing over time, indicating that the hip dysplasia status of the breed is improving.

However there is other data to be considered before making such a straightforward conclusion. A key feature of any breeding scheme is that it is applied across the breed, or at least a large segment of the breed in order to eliminate as much “bad” genetic material as possible.

The questions that must be answered about the effectiveness of a screening scheme are:

- Is the scheme reducing the prevalence of CHD across a given breed?
- Is the scheme helping individual breeders to reduce the risk of CHD in their puppies?

The BVA/KC rolling mean figures answer neither of these questions. They show that the average grade of the hip radiographs submitted to the scheme is gradually decreasing, but this is only calculated on a small percentage of the registered dogs in the breeds above. Whilst the scheme should gradually reduce the hip scores of the whole population, it is of course impossible to calculate the reduction in risk of CHD puppies in an individual mating. The scheme will only work if the sample of dogs submitted to the scheme are representative of the whole population, and if breeders ensure that only dogs that have been scored, and

have hips with lower than the mean score for the breed, are the only ones used in matings. The inescapable conclusion is that the current scheme does not provide representative data for many UK dog breeds, so at the moment we simply do not know the true prevalence of the disease in many UK dog breeds, or whether there is any progress in reducing it.

Could the BVA/KC Scheme be more effective?

There are a number of different CHD screening schemes worldwide. Most of these are variants on the methods of scoring a standard radiograph, a few are dependent on scoring the hip laxity involved in the early stages of dysplasia. As well as variations in the scoring system and the age of the animal at scoring, a host of other procedural details, including compulsion to join the scheme, vary between countries, making inter-country comparisons difficult. There is considerable evidence to show that there are differences in the sensitivity and accuracy between scoring systems (Ohlerth et al 2003, Kapatkin et al 2004) but it seems that currently there would be little benefit in changing to a new scoring system in the UK.

Similar systems are used in other countries and there is a range of evidence from these schemes. A study in Finnish breeds concluded that there was slow and inadequate progression in improvement of CHD prevalence with a scheme involving compulsory screening (Leppänen and Saloniemi 1999), but in Swedish dogs, Morgan and Audell (1999) showed a reduction in prevalence of CHD from 55% to 35% between 1966 and 1996 coinciding with a gradual increase of the percentage of registered dogs scored to approximately 60%. If a higher percentage of registered dogs are scored, and particularly the breeding dogs, then techniques such as estimated breeding values (EBVs;

see recommendation 14, section 5) can be used for better selection of parents for the next generations (Leighton 1997). Such techniques have been shown to decrease the prevalence of CHD in a limited population from 55% to 24% in five generations. They also benefit from concentrating on CHD in the breeding program which has been shown to be important in effective programs (Maki et al 2004).

Future recommendations

The true prevalence of CHD in the UK dog population is unknown, because the proportion of dogs in most registered breeds taking up the scheme is very small. The prevalence may be high, possibly as much as 50% (similar to those countries described above), given the results of recent studies in similar populations in Europe. The current BVA/KC screening structure is a suitable system to detect CHD within the UK population, but improvements to the way it is used and reported could enhance its impact on CHD. Recommendations would be:

- improved participation
 - preferably 100% of registered dogs (see section 5);
 - or at worst 100% of sires and dams of registered dogs;
- an international standard for scoring an animal as having no disease, thereby allowing international comparison of the percentage of normal animals in any breed (see section 5);
- concentrate the efforts of breeders into breeding out these undesirable diseases;
- improved reporting based on prevalence;
- the provision of a centralised service to analyse screening data, hereditary patterns and calculate information such as estimated breeding values as an aid to better breeding;
- the use of current screening data to research the development of DNA based screening “fingerprinting” the disease (Mateescu et al 2008).

The cost involved to the owner/breeder and the voluntary nature of the current scheme are significant obstacles to these recommendations, and a way needs to be found to work with dog breeders in order to make progress quickly. However, increased participation can enhance the impact of the scheme on pedigree dog welfare exponentially.

4.7.2 DNA based tests

DNA based testing (see glossary) has many strengths, including the ability to detect a mutation before it is expressed as a disease, or in carrier animals; low error rates (for many but not all tests these are effectively zero); absolute specificity; and the ability to sample the dog under test cheaply and without specialist veterinary intervention through the use of buccal swabs (see glossary). In cases where a mutation is very common but recessive, the test can also be used to maintain the genetic diversity of a breed whilst gradually reducing the mutant gene frequency and preventing the birth or reproduction of affected animals. However sampling without veterinary intervention does leave the system open to abuse by dishonest owners (substituting samples from one dog for another), and where the owner is testing because they already suspect the presence of a particular inherited condition, a veterinary inspection will actually be an important complement to the DNA test because it may detect conditions other than those tested for.

As yet in the UK, registration of animals has been made dependent on clear DNA tests in only two breeds (Irish Red Setters and Irish Red and White setters) and for only one disease (Canine Leucocyte Adhesion Deficiency (CLAD); see glossary) (The Kennel Club 2008e). Given the large number of breeds in existence and the multiplicity of recognised breed predispositions, this is unsatisfactory. On the other hand, in many breeds for which testing is available, untested animals are regarded as much less valuable for breeding than tested ones, and the Kennel Club maintains publicly accessible registries of tested clear animals for several of the tests. Hence, although there are few if any published studies, DNA based testing has already gained a reputation for radically reducing or eliminating mutation frequencies for known inherited diseases. For instance, copper toxicosis had reached very high prevalence in Bedlington Terriers prior to the availability of DNA testing. There was a prevalence of 46% in the Dutch Bedlington population in the late 1970's and early 1980's. This had dropped to 11% by 1990-1997 without loss of genetic diversity through breeding away from affected animals (Ubbink et al 2000). These figures look modestly impressive, but imply only that the mutant gene frequency was halved, from roughly 68% to just over

33%. Subsequently, a much more rapid decline has been achieved through DNA testing so that very few affected Bedlingtons are now being born (these recent changes are unpublished, but a similar Danish programme is described by Proschowsky et al 2003). A randomised survey of an entire breeding stock of English Springer Spaniels in the USA for the mutation causing phosphofructokinase deficiency (the cause of one type of haemolytic anaemia; see glossary) showed that after several years of genetic testing, carrier rates had already been reduced from 16% to 3% (Giger et al 2000). Similarly, all UK breed lines of Irish Setter, and nearly all Cardigan Welsh Corgi lines, have been tested for progressive retina atrophy (PRA; see glossary) and these forms of PRA have been effectively eliminated, as has CLAD in both forms of Irish Setter. It is important that the trend for tested and clear animals to be of greater value continues to grow, and breeders continue to utilise the tests that are available.

DNA based tests are of course limited by the available knowledge of mutations causing or associated with diseases. Research funding for canine genetics has been rather limited, and is certainly tiny when compared with that available for human or even agricultural genetics. Most direct funding comes from canine charities, all of which have rather small resources, with the Kennel Club much the biggest funder in the UK in recent years. Development of tests is expensive, and because of the lack of funders with adequate resources, researchers have tended to concentrate on monogenic disorders (“the low hanging fruit”) rather than attempting to develop tests capable of giving information on more genetically complex disorders. Unfortunately, it is these latter that are most common in most dog populations. They include a wide variety of disorders such as skeletal malformations and degenerations (like hip dysplasia; section 4.7.1), many developmental and conformational problems, such as portosystemic shunt (see glossary) or Chiari malformation, cardiac and circulatory disorders such as mitral valve disease and probably a proportion of cancer predisposition syndromes, as well as many others. These are often hard to study not only because of their complexity, but also because some of the alleles involved may be the sole allele surviving in an affected breed, and therefore not be available for genome mapping (see glossary) as this process cannot be performed without at least some genetic

variation. In other cases, the complexity may mean that very large affected samples and control groups are required.

The collection of suitable DNA samples for test development is not simple. Each animal to be used in a study must be of the same breed and must have full veterinary, and, if needed, pathological work up, and sufficient DNA for the study must be collected. For whole genome screens, using high density array-based techniques, this often means the collection of blood samples. Such a collection will come under the Home Office Scientific Procedures Act unless clinical residues are available, which puts a number of practical barriers in the way. Veterinarians are often unwilling or have too little time to arrange these collections. Hence dedicated staff will be needed specifically for this purpose.

The standard mapping tests performed by geneticists are very powerful, but also very expensive. The finding of a genetic location or locations of mutation(s) associated with a given disease is not the same as having a test for the disease or even a test for the mutation causing the disease. Test development has sometimes proved difficult, although many breed societies have proved hugely helpful in test development and should continue to be involved (see section 5).

Given the clinical expenses involved in patient assessment and sample collection on top of the laboratory costs for mutation discovery, it would be unrealistic to expect new genetic tests for complex traits to be developed for less than one hundred thousand pounds per test. For the most part this money is not available from current funders. In nearly all cases (except for the most numerous breeds), tests are unlikely to be commercially viable in the sense of recouping their development costs through sales to breeders. Hence funding models must see research and development as a non-recoverable cost and the pet industry must be shown that the intangible benefits of greater popularity of dogs and greater certainties for insurers are worthwhile.

Fundamentally, understanding the genetic component(s) of disease is a requirement for the development of tests to identify carriers of the allele(s) contributing to the disease. This is demonstrated, for example, by considering the condition, degenerative myelopathy (see glossary). It is well known to be found predominately in German

Shepherd Dogs and is a progressive neurodegenerative disease (similar to multiple sclerosis in humans) resulting in complete paralysis of the hind end (Averill 1973, Clemmons 1992). A genetic test was developed based on a very small sample set without strong statistical support (Clemmons et al 2006) but the involvement of the gene it tests in the disease has since been disputed and the mode of inheritance of the disease is currently unknown (Clark et al 2008). Unlike DNA tests for monogenic diseases, the interpretation of DNA tests for polygenic diseases will be complex, and may well require a lot of input to breeders from the tester or a veterinarian or indeed specific genetics expertise.

However, André et al. (2008) recently noted that the increasing prevalence of genetic tests for these diseases is complex for both veterinarians and breeders requiring co-operation of veterinarians with researchers, and also of the dog breeder (or owner) with the veterinarian. Although the development of genetic markers is undoubtedly valuable, the time delay and costs means that they cannot be viewed as the sole answer to the current problems. Immediate action must be taken to decrease suffering, hence independent ethical review and detailed breed management plans should incorporate these tests, only as a component part of their strategy (see section 5).

4.7.3 Kennel Club Accredited Breeder Scheme (as an example of the difficulties of designing health and disease screening programmes)

In 2004, The Kennel Club introduced an accreditation system for breeders which lists “required” and “recommended” tests for specific breeds. So far, requirements for testing under this scheme have been brought forward for only about half of all Kennel Club breeds, although between them these breeds encompass the majority of pedigree dog registrations. Membership of this scheme is voluntary and relies entirely on breeder compliance, but the scheme has proved very popular and puppies from it have added value. Outside this scheme, and apart from the previously mentioned CLAD DNA test, no proof of screening/testing, nor of a negative result, is required prior to puppies being registered by the Kennel Club, although where such proof exists it is noted at registration. The difficulty of the decisions about what to test and whether these tests are requirements or recommendations is easily seen in this scheme.

Data from the health survey (section 4.4) also conducted by the UK Kennel Club reported the most common disease conditions in Labrador Retrievers to be musculoskeletal (27% of all disease conditions reported, or 14% of dogs, compared to 13% and 8% respectively across all breeds). Arthritis was the most common musculoskeletal condition reported in the Labrador, followed by cruciate ligament rupture (see glossary), hip dysplasia and osteochondrosis dissecans (OCD). The elbow was the most commonly reported area for both OCD and arthritis. OCD is a condition that can affect a number of joints, and is one of the types of primary disease in the elbow dysplasia syndrome. In elbow dysplasia, OCD and other primary diseases cause a secondary osteoarthritis, so that some of the owners' reports of arthritis in the elbow probably relate to otherwise unrecorded elbow dysplasia. Despite evidence from their own study and others (LaFond et al 2002) that elbow dysplasia is a common problem in the breed, the UK Kennel Club only *recommend* and *do not require* that dogs have their elbows graded. Difficulty in the accuracy of diagnosis is cited as one reason for not bringing in a

requirement for elbow grading. However, the Kennel Club do *require* eye and hip testing and *recommend* DNA based PRA testing even though ocular problems were the fourth most common conditions (7% of conditions or 4% of dogs), much less common than hip and elbow problems.

Cardiac problems in Cavalier King Charles Spaniels (CKCS) were mentioned in section 4.3. The Kennel Club health survey highlighted these as the number one disease condition reported (25% of all conditions or a prevalence of 17%), and of these the most common was heart murmurs, followed by mitral valve dysplasia (MVD). Although the disease is a frequent cause of death in the breed, the Kennel Club only *recommends*, but does not require, that CKCS dogs in the Accredited Breeder Scheme are tested for MVD. This may be because prevalence of heart murmur and MVD is often considered to be higher than reported in this survey (Gough and Thomas, 2004 quote 59%, whilst many veterinary cardiologists would suggest that a minor heart murmur is normal in all CKCS), but the clinical significance of a minor murmur is difficult to decide. Deaths from cardiac problems are usually at quite advanced ages, above the median age for death in all pedigree breeds, so it is possible that the Kennel Club has taken the view that they are relatively unimportant to breed welfare. However cardiac problems tend to progress and become debilitating as the dog ages, causing exercise intolerance, coughing, breathlessness, and sometimes a distended abdomen and weight loss, so the welfare problem is a real one. As mentioned earlier, the breed is also predisposed to the serious and painful condition, syringomyelia (sections 3.3 and 4.3), but currently there is no mention in the KC breeding scheme recommendations of not breeding from individuals diagnosed with the disease or from lines known to have had cases. Evidence for the disease can be found by MRI scans (Rusbridge et al 2000) but the cost of these scans may be a disincentive to breeders. It is encouraging that the KC is reconsidering this area, and after a meeting of cardiologists in Dec 2008, expects to issue a Health Plan for the breed early in 2009 (The Kennel Club 2008f), but progress needs to continue to be assessed regularly (see section 5).

Comparison of the accredited breeder requirements to the IDID database (section 4.3), further highlights the inconsistencies: 25 breeds identified in the IDID database

as having PRA of some form, are required to have eye tests (or DNA test if available); four are recommended only. However, there are five breeds that are in the IDID database as susceptible to PRA but no eye tests or DNA tests for PRA are listed by the Kennel Club within the rules of the Accredited Breeders Scheme. Note though that the list of conditions in the Kennel Club BVA Eye Scheme is compiled by working British veterinary ophthalmologists based on what has been found in the UK, whilst IDID includes records from elsewhere which may partly explain this discrepancy.

In conclusion, these inconsistencies point to a need for a consistent approach, in which individual breed societies do not operate autonomously. The issues described above illustrate that the review of the tests currently recommended by the Kennel Club which is now underway is very necessary. However, to be most valuable such a review must involve a range of experts from a variety of disciplines, composed predominantly of independent individuals with no vested interests and a coordinated approach must be adopted (section 5.7). The cross-over between genetic inheritance and canine disease presents a complex interplay between a number of fields, each of which contain a unique level of expertise and all must be involved in resolving current problems.

Possible ways forward

5.1 Where are we now?

In the UK, the dog breeding and showing industry is essentially self-regulating. Whilst there are a number of small dog registries in existence (e.g. The Dog Lovers Registration Club Ltd 2008), the Kennel Club effectively has the monopoly on registering pedigree dogs and keeping stud books. Breed standards have traditionally been the responsibility of the Kennel Club and several hundred different breed clubs/societies (The Kennel Club 2006a). Individual breed societies vary in the initiatives they have taken to try to preserve and improve the health and welfare of their breed, and some are certainly diligent. However, there still remain many breed societies that show a marked reluctance to acknowledge or publicly admit the common problems within their breed.

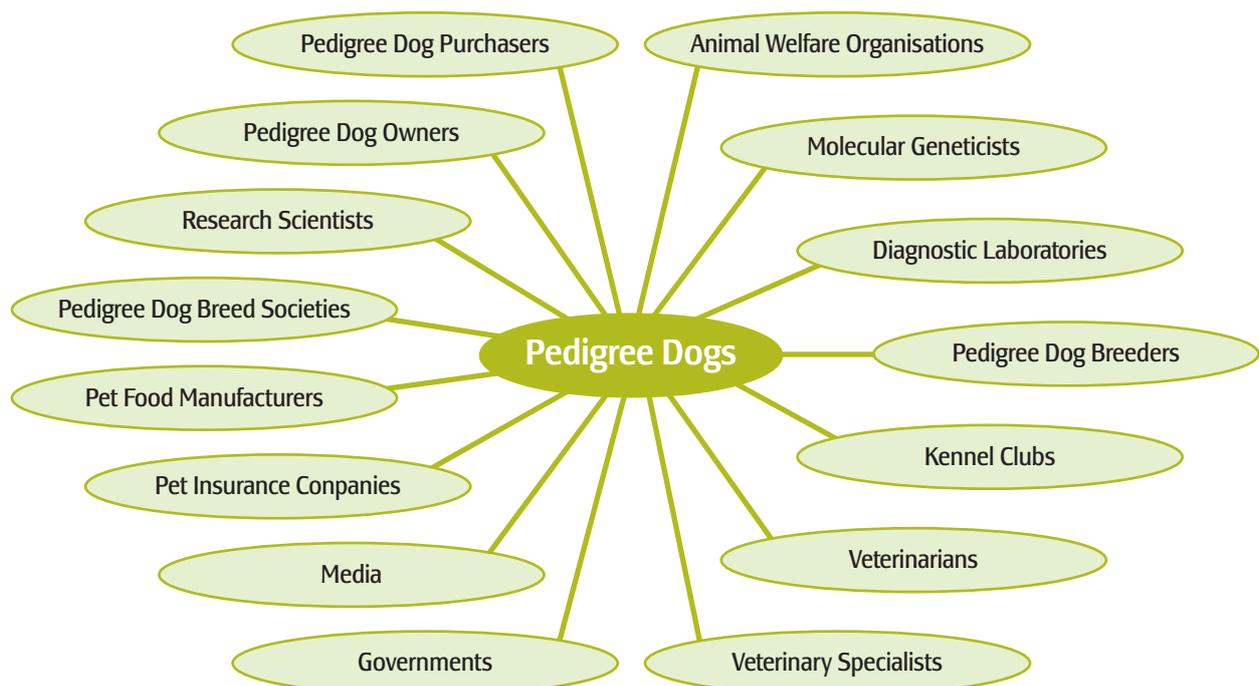
The issues described in sections 3 and 4 are definitely ongoing, as some genetic material continues to be lost with each generation (Calboli et al 2008), and new diseases continue to be identified. Recommended screening

programmes are in place, but these are nearly all non-compulsory and necessarily incomplete, as tests are only available for a portion of the inherited diseases identified.

The UK Kennel Club (2008c) has recently acknowledged the presence and danger of breeding for extreme morphology. It has a documented health and welfare strategy described in its annual report (The Kennel Club 2008g), and numerous new initiatives are intended to combat the problem (The Kennel Club 2008a). However, a strong case can be made that there are many breeds whose anatomies raise serious current welfare concerns, and while physical attributes continue to dominate the breed standards, with less mention of health, welfare or temperament, this is likely to continue. This situation needs to be addressed as a matter of urgency.

There are numerous stakeholders with an interest in pedigree dogs, and they all have a role to play in addressing this issue. The diagram below shows the complexity of the situation.

Figure 1 – Summary of the multiple stakeholders with a role to play in improving pedigree dog welfare



5.2. What could be done? – a vision for the future

The situation is complex, with many stakeholders and numerous plausible courses of action. Each breed has its own array of problems and so there is no single solution. However all future initiatives should have the following generic aims:

- only breed dogs whose anatomy, temperament and genetic predisposition for disease or disorder, make them likely to produce offspring which will experience a high quality of life, free from pain and suffering;
- only breed sufficient dogs to meet current demand so that each puppy can be successfully homed in a suitable and caring environment.

In order to achieve this vision, the following key objectives need to be met:

- a) the public is well educated about the issues surrounding the welfare of pedigree dogs and so is able to make informed choices;
- b) culture shifts such that dogs that are perceived as the most desirable are those which are fit, healthy, are well suited to the lifestyle they lead and have a high quality of life;
- c) all those who breed pedigree dogs prioritise the health and welfare of parents and offspring;
- d) breeders only breed dogs that are well suited to the lifestyle they will lead and refrain from breeding those that are likely to experience unnecessary suffering;
- e) effective regulation of pedigree dog breeding and supply chains to protect the welfare of dogs and the well being of pet owners;
- f) breed standards, breed management policies and breeding strategies are evidence-based;
- g) genetic diversity of most existing breeds is increased.

5.3 Prioritised actions – a survey of experts

To achieve the objectives above, a great many different actions could be taken. In light of the findings from this report, past literature and discussions with prominent experts in the field, we composed a list of 36 distinct actions which have been suggested as plausible routes forward (each with a description of its proposed merits). Many of the actions require input from numerous stakeholders, and several could be equally well tackled by any one of a number of different bodies. Hence, we simply list the potential actions and note suggestions of who could contribute to their execution, with the aim that many of the actions will be engaged by multiple stakeholders. We have made no explicit effort to assess the extent to which each action is already being tackled.

We presented these suggestions as a survey to a focus group of experts in order to prioritise the recommendations presented in this report. The group consisted of twenty prominent experts drawn from four disciplines. These were four dog welfare experts; five university-based veterinary experts; five geneticists and six practising veterinarians (who would have first hand experience of the problems encountered and the feasibility of specific recommendations). These individuals were selected to cover a range of disciplines all integral to pedigree dog welfare with the aim to balance attention to particular concerns. They all had current knowledge and interest in the problems surrounding pedigree dog breeding.

This group is opportunist and cannot be viewed as fully representative of all potential stakeholders. However, the survey respondents were all judged to be independent of conflicting affiliations, and the diversity of their views is evident from the results (see Appendix 2). We therefore believe that by utilising twenty people's opinions when selecting the best actions to recommend, these choices are considerably more valuable than if the list were based on the authors' subjective opinions alone. Each respondent rated the potential value of each of the suggested actions in improving pedigree dog welfare, and based upon their average ratings we have prioritised our recommendations.

Full details of the survey design, results and categorisation of recommendations are presented as Appendix 2. Here, we present descriptions of our top 14

recommendations (categorised as priority and primary recommendations sections 5.4.1 and 5.4.2; see Appendix 2 for description of categorisation). Based on the opinions of the expert group, we suggest that concentrating on the development of these recommendations is a good way to prioritise resources into those actions which are widely thought to be of most value. After this we also present summaries of lower ranked suggestions which were less strongly supported (undisputed 5.4.3 and further 5.4.4) recommendations and poorly supported actions (5.4.5). These could also be useful routes forward for stakeholders, especially those actions that can be carried out relatively rapidly and inexpensively. These are described in more detail in Appendix 3. (Inclusion of these actions in the report does not imply support for all of them from all authors).

5.4 Recommendations

The logic behind each of the key actions, as presented in the survey, is shown below. The italicised text indicates the main conditions/concerns raised by respondents. Since many such points were raised by a single person, it is impossible to list all of these, so we have summarised only the common themes described. Although actions here are presented in order of our panel's view of their relative value, in reality their execution would need to be carefully planned and coordinated in a strategic order (section 5.7).

5.4.1 Priority recommendations – supported by over 94% of respondents (all except one respondent); rated on average greater than 7.5 (out of 10) for value, and listed by multiple respondents in their top five.

1. **Systematic collection of morbidity and mortality data from all registered dogs** would allow us to amass reliable data on the prevalence of different disorders in each breed in the domestic dog population. With our present ad-hoc methods of data collection and inconsistent ways of reporting changes in prevalence, we are in danger of penalising popular and well researched breeds whilst overlooking potentially more serious problems in rarer breeds (section 4.3).

Although insurance databases provide some useful statistics, these samples are inevitably skewed and unrepresentative of the whole population. A standardised data collection system is an essential tool needed to establish current baselines and to monitor the effectiveness of any interventions or initiatives which are introduced. A suitable system has been developed, ready for trial and implementation in Australia (McGreevy 2007), and can easily be adapted for use in the UK, but funding is required and support is needed from veterinary surgeons. Similarly the University of Liverpool is in the initial stages of developing the Small Animal Veterinary Surveillance Network (SAVSNET; Radford A personal comm.) to extract surveillance data on vomiting and diarrhoea, but could be extended to collect prevalence data for any disease.

There is, however, the concern that not all UK veterinary surgeries are currently computerised, so this system may require gradual implementation and considerable cost. Respondents also raised concerns that this data collection should incorporate cross breed dogs, behavioural morbidity surveillance and should be regarded as only part of the solution, as freedom from disorder does not necessarily represent high welfare.

2. **Revision of registration rules to prevent the registration of the offspring of any mating between first-degree and second-degree relatives.** Any mating between parent and offspring, two siblings, grandparent and offspring or half siblings, should result in non-pedigree offspring. This would lead to a reduction in the rate of inbreeding (which is one way of rapidly depleting gene pools) and would make a statement about the importance of genetic diversity. However, it must also be accompanied by other efforts to increase genetic diversity.
3. **Open stud books to allow more frequent introduction of new genetic material into established breeds** in order to increase genetic pools. Breed societies and breeders often voice worries about substantially altering or “watering down the breed” from that described in the breed standard. However, these worries have been shown to be unfounded by a UK trial that successfully produced a “Bob-tailed Boxer” by crossing a Boxer to a Welsh Corgi, and then backcrossing to Boxer. A fourth-generation animal (3rd back-cross) was registered with the Kennel Club and won prizes (Cattanach 1996). Ironically, this introduction of non-pedigree genetic material into the line was permitted for purely aesthetic reasons.

Similar success has been obtained with a trial to overcome elevated uric acid levels in Dalmatians (described in section 4.2). However only by the fifth generation of back-crosses were a small number of the dogs considered adequately pure Dalmatian to be registered by the breed society.

Such reluctance by breed societies provides a financial disincentive for breeders to outcross, and this needs to be addressed. Registration should become available as a right to any dog that can be shown to be the product of a third (or later) back-cross with registered breed dogs from an original cross. Success at shows would remain reliant on adherence to a breed standard (albeit a revised one in some cases): but this would be based on phenotype and not “genetic purity”.

Survey respondents noted that although worries have been expressed by breeders and Kennel Clubs that cross breeding may potentially introduce new problems, there is no genetic reason to expect that problems in newly introduced genetic material will occur at higher rates than those in the material they replace. If some genetic diversity is maintained, heterosis will tend to reduce prevalence and severity both of introduced problems and previously present ones.

4. **Setting up systems to monitor the effectiveness of any interventions and changes in breeding strategies.** It is absolutely vital that methods are put in place to regularly review, assess, evaluate, and report upon the effect of any intervention and to monitor changes that occur over time. If change is either inadequate or negative, new initiatives must be adopted.

Regular updates are built into the data collection system proposed by McGreevy (2007), or they could become the responsibility of an independent panel – recommendation 13).

5.4.2 Primary recommendations – supported by 85% or more of respondents and rated an average of 7 (out of 10) or more for value.

5. **Conducting a full ethical review of current breeds.** This could potentially arrive at conclusions that inform decisions to enforce rapid out-crossing in some breeds or even to phase out specific breeds that an expert panel considers cannot be saved without unacceptable suffering.

Respondents were concerned that any such panel should be independent and broad-based in its expertise and should be chaired by one or more experienced ethicist (see also recommendation 13). Its purpose should be to identify the worst or most pressing problems based on the likely suffering endured by the animals, the probable distress experienced by the owners of those animals, and any subsidiary problems created for society at large.

6. **Development of detailed management plans for each breed,** constructed in conjunction with geneticists who can advise on available DNA markers for hereditary disorders and recognise the distinction between (a) eliminating or decreasing the incidence of inherited disorders (which is certainly possible), and (b) eliminating all mutant genes that cause disorders (which is not possible). Planning should also involve epidemiologists, welfare scientists, breeders and potentially conservationists (who are familiar with similar genetic problems), or the independent panel, (see recommendation 13). These plans should involve measures to decrease inbreeding and increase genetic diversity which, for less numerous breeds, may involve the development of international breeding pools, and out-crossing (recommendations 3 and 8). The plans should include methods for continually estimating the incidence of inherited disorders and for making this information available to breeders, veterinarians and potential pet-purchasers.

Supporters of this recommendation point out that “current state of the art in genetics theory actually allows multiple tests/conditions to be tackled at the same time. Breeding programmes could be established that incorporate all known health information, developing proper genetic evaluation for each trait, combining multiple traits and weighting them appropriately so that progress can be made towards the ultimate goal of a healthy breed. Diminution of the gene pool can be avoided by the use of optimisation techniques so that selection can be carried out and the rate of inbreeding/loss of genetic diversity restricted to a pre-defined level” (anonymous). However others warn that “because of false positive rates in gene chips [a shorthand for the methodologies that allow simultaneous multiple genetic assessments] and potential false negative rates in phenotypic assessments, all of this work should be peer-reviewed before decisions are made.” (K. Overall personal comm.)

7. **Refinement of diagnostic tests and DNA markers for inherited disorders** is critical, although their limitations must also be acknowledged. The development of DNA-based screening tools for complex heritable diseases has become more accessible with the availability of high throughput and array-based analysis techniques. However four critical hurdles remain, which require input from numerous stakeholders to overcome (here summarised in brief. The fuller information provided to respondents included the information on test development summarised in section 4.7.2).

- The collection of suitable DNA samples from affected and control populations is not simple. Dedicated staff will be needed specifically for this purpose.
- The high density techniques are rapid and accurate, but have high associated costs. Funding both for staff and for test development should be sought from all stakeholders.
- Even once a genome location has been found to be associated with a disease or disorder, test development and use has sometimes proved difficult. Breed societies have proved hugely helpful in test development and should continue to be involved.
- In nearly all cases, tests are unlikely to be commercially viable in the sense of recouping their development costs through sales to breeders. Hence the intangible benefits of tests must be made clear to stakeholders.

Respondents pointed out the necessity to view this as a long-term action and not the sole answer to the current problem.

- 8. Increase genetic diversity by encouraging importation and inter-country matings**, especially in numerically-small breeds. If this is to be employed, the use of frozen semen should be considered, to avoid the welfare impact of transporting live animals.
- 9. Make registration of pedigree dogs conditional upon both parents undergoing compulsory screening tests for prioritised disorders**, drawn from those known to be a problem in that particular breed. A holistic approach, which takes into account the method of inheritance of each disorder, and careful breed management planning, is required. For example, with autosomal-recessive disorders, the Kennel Club should not register the offspring from matings where both parents are known heterozygotes, whilst matings in which one parent was heterozygous (see glossary) would be acceptable in pre-agreed circumstances.

In 2004 The Kennel Club introduced a voluntary accreditation system for breeders (The Kennel Club 2008d). The inter-breed inconsistencies in required and recommended tests under the scheme have been highlighted in section 4.7.3.

Quicker progress would be possible if screening were mandatory for all registered dogs, and if the list of required tests for each breed were based on objective criteria. This would initially be based on our current state of knowledge but if data collection methods are standardised and improved (see recommendation 1) then, in time, the list would be standardised according to accurate prevalence data. This scheme could commence with mandatory hip screening (section 4.7.1).

It is important to realise that when many tests are available, breeders and breed societies must tackle one or only a few problems at a time in order to avoid further diminution of the gene pool. A phased introduction of the tests listed should therefore be decided with input from the individual breed societies and independent veterinary and genetic experts in discussion with the Kennel Club. Most breed societies do have health

committees that currently perform a recommending function, but these must incorporate a range of external experts. Infallible ID systems based on micro-chipping would be critical for this action to be achievable.

Respondents raised a concern that the schemes need to be proven to work, and their relative welfare benefit prioritised before significant funds are invested in their implementation. It was also suggested that such schemes should include cross breeds as well as pedigree dogs through the use of test registries (see also 5.5).

- 10. Introduction of Codes of Practice that encourage breeders to consider health, temperament and welfare.** The Animal Welfare Act 2006 allows the government to issue and, from time to time, revise specific codes of practice. The main purpose of these codes is to give practical advice to owners and others responsible for animals on how they can ensure that their animals' welfare needs are met. Welfare codes for farmed animals have been in existence for some years and the Act will allow these to be issued for companion animals too. Drafting of several codes are currently underway, including a "Dog Code" and an "Animal (dog & cat) Boarding Code" in also planned (DEFRA 2008). However there is no specific code for breeding and a code of practice specifically relating to the breeding of dogs, or relevant clauses within the species-specific codes, is required.²

Respondents voiced concerns about the opposition this action may face, suggesting the need for accompanying secondary legislation (recommendation 24) and penalties for non-compliance (recommendation 32).

- 11. Training and accreditation of judges to prioritise health, welfare and behaviour in the show ring,** ensuring that dogs are judged with these factors as paramount; of equal, if not greater weight than physical attributes. The Finnish Kennel Club has commenced a programme educating judges to avoid potentially detrimental traits (Maki et al 2005; although this is obviously limited to those traits which are visually evident), and the UK Kennel Club has recently initiated something similar (The Kennel Club 2008h). A system to ensure that health and welfare is adequately considered in the ring may involve two-tier judging, in which dogs are pre-screened by a veterinarian before being judged on conformation (as is common at cat shows). Measures to avoid diseased animals, or those showing fear or stress behaviours appearing in, or winning shows should be implemented and owners known to show such animals disqualified and discredited. Proof of passing designated screening tests should also be an entrance criterion at shows.

Respondents expressed the view that in order for this action to be useful, the training and judging should be monitored and reviewed by external experts, and penalties or disqualifications imposed upon non-conforming judges.

- 12. Creating and fostering the image of a happy and desirable dog being one that experiences high welfare.** Happy dogs are those that are bred for fulfilling lives, not beauty. A catchy appealing "brand" is required to challenge current cultural norms, similar to the successful "happy chicken" campaign (e.g. The Telegraph 2008). This would encourage the general public to choose dogs on the basis of their quality of life and not just appearance, and to consider a range of breeds and cross breeds. Their choice should be influenced by low prevalence for disease, low insurance premiums, sound temperament, and low requirement for surgical

² Please note that this recommendation has been drafted based on the situation in England. In Wales, a dog Code of Practice has already been passed by the National Assembly of Wales

intervention during birth. This image may be aided by charities, the media, and pet food companies picturing collective groups of pedigree and crossbred dogs, thereby illustrating how the issue of health, vigour and happiness, applies to all dogs regardless of the pure vs cross distinction.

Although this action was generally well supported, several people noted the difficulty of changing ingrained perceptions.

- 13. Formulation of an independent panel of experts from multiple disciplines.** Collaboration between interested parties to form a committee that will facilitate dialogue and result in positive action by all stakeholders. This panel could help with the execution of many of the actions listed below, but must remain independent of any specific organisation. It should continue to meet at regular intervals to assess, monitor and direct future progress. This will also help direct objective research to the missing knowledge gaps, such as effective data collection on disease and disorder prevalence, and methods for objectively assessing quality of life that may be critical for producing breeding strategies that maximise improvement in dog welfare.

Over half the respondents stressed the need for (and challenge of achieving), independence (from financial or other vested interest) and careful composition of this panel. The members should include credible experts from many fields, who should be approved by all stakeholders. If carefully composed, this panel could coordinate many of the recommendations mentioned previously.

- 14. Development of schemes for calculating Estimated Breeding Values (EBV)** for multi-factorial disorders. The EBV of an animal for any trait predicts the average performance of its progeny for that trait. This assessment should be performed by geneticists in collaboration with breed societies and initially would utilise phenotypic, heritability and pedigree data. However in the future, it is likely that DNA marker data could also be utilised. By developing a set of EBVs, a rational approach can be taken to mate choice.

Again respondents raised the point that this must be viewed as a long-term action and not a rapid solution.

5.4.3 Undisputed recommendations – supported by 100% of respondents but rated an average of less than 7 (out of 10) for value

Please note that from here onwards, the descriptions of each action are short summaries and for full details of the action as proposed in the survey please refer to Appendix 3.

15. **Provision of expert and accurate information to the public and potential buyers.** The general public own most of the pedigree dogs in the UK and so their buying power is a potentially strong force in influencing positive change. Educating potential owners about the likely problems for each breed will help them to make informed decisions.
16. **Review all and when appropriate, revise breed standards to prioritise health and welfare.** Many of the current breed standards make reference to health and welfare and indeed revisions are ongoing. However, health and welfare should be paramount and not just nominally included in each standard.
17. **Measurement of real current homozygosity levels in breeds.** Initial research has identified links between disease and heterozygosity in specific breeds of dog (e.g. Ubbnik et al 1992). Measurement of existing heterozygosity using SNP arrays (see glossary) can inform choices on attempts to change population structure, such as whether out-breeding will be needed to make any changes.

5.4.4 Further recommendations – supported by 80% or more of respondents (but not falling within any of the above categories)

18. **Development and support for shows that are judged on temperament, health and welfare,** rather than solely on conformation, is an action point for the public, veterinary surgeons, charities, sponsoring companies and breeders alike. A further suggestion may be the introduction of welfare classes, in which dogs compete based purely on their health, temperament and quality of life.
19. **Introduction of dog breeder warranties or contracts** which commit breeders to paying compensation for avoidable inherited disorders that develop in the dogs they sell.
20. **Placement of restrictions on the number of caesareans permitted per bitch** so subsequent litters can not be registered. This would decrease potential distress and suffering to both mother and offspring.
21. **Conducting pedigree analyses on all UK breeds.** Pedigree analyses have been conducted on several UK breeds (e.g. Calboli et al 2008) and they provide evidence that the extent of inbreeding and loss of genetic material varies considerably between breeds, but experts vary in their interpretation of the extent of the problem.

- 22. Revision of registration rules to limit the number of offspring that any one male can sire,** by restricting registration to a maximum number per parent. There is a limit of six on the number of litters from a given female that can be registered (The Kennel Club 2006d), but males are currently unlimited.
- 23. Development of methods for enhanced communication between geneticists and individual breeders** e.g. via websites, discussion forums or help-lines. Although some forums do exist (e.g. Canine Genetics Discussion Group; see Canine Diversity Project 2002) wider publicising their existence may be extremely useful, and breed societies should seek their own collaborations to help their members.
- 24. Development of secondary legislation (see glossary) to control dog breeding³**
The Kennel Club, and breed clubs are members' societies and have legitimate worries about losing membership if the conditions of registration and control which they exert are too strict. However, there is then an argument for external control of breeding practices via an independent panel or via secondary legislation.
- 25. Encouragement for breeders to make responsible breeding choices** and only breed when the offspring are likely to be homed and to experience a high quality of life.
- 26. Set a minimum number for founder stock for new breeds.** New breeds are regularly founded and so it is essential that their welfare is prioritised from the outset.
- 27. Development of methods to objectively measure quality of life.**
These will become tools with which to: assess whether a breeds' quality of life is so compromised that it should not be bred or maintained any longer; prioritise which morphological traits and disorders should be bred against; and investigate the extent to which different anatomical modifications lead to compromised quality to life.
- 28. Campaign for revision and then sign and ratify the European Convention for the Protection of Pet Animals.** Article 5 of the Council of Europe's 1987 Convention for the Protection of Pet Animals (section 3.2) states that "any person who selects a pet animal for breeding shall be responsible for having regard to the anatomical, physiological and behavioural characteristics which are likely to put at risk the health and welfare of either the offspring or the female parent".
- 29. Encouragement of future owners to fully research the breed that they are considering buying,** including health, welfare, temperament, and disorder prevalence.
- 30. Seek consistency and transparency in reporting of hip scores (and other test results).** These are currently reported differently in various countries, making it difficult to compare schemes and making relative progress impossible to ascertain.

³This would require separate secondary legislation by the respective governments in England and Wales.

31. Development of an accreditation scheme for breeders, breed societies, and veterinarians. Such a “kite mark” could provide a positive incentive to encourage progress, by providing a system of rewards that authenticates both breed societies and individual breeders who prioritise the health and welfare of their dogs, and similarly veterinary surgeries which show positive initiatives.

5.4.5 Poorly supported actions – supported by less than 80% of those respondents expressing an opinion

32. Exploration of methods by which to penalise unethical breeding.

Breeders known to contravene codes of ethics or to breed from animals diagnosed with heritable disorders should be barred from membership of their breed society and the Kennel Club, disqualified from showing, and the reasons publicised and the potential for prosecution should be explored.

33. Production of neutered F1 hybrids (see glossary) has been suggested as a healthy, yet equally lucrative alternative pet stock for pedigree dog breeders to consider (see McGreevy and Nicholas 1999).

34. Prioritisation of animal welfare over financial gain by veterinarians when making recommendations about potential purchases, matings and treatments.

35. Production of a safe, honest feedback mechanism to help empower potential pedigree dog buyers and breeders. When buying a car, information is freely available on likely pitfalls of each make and model, often provided by previous customers. It would seem ethical and responsible that similar information is collected for breeds of dog.

36. Utilisation of temperament assessments to select dogs that are best suited to the environment in which they will live. One suggested step towards achieving this has been to introduce temperament tests at, or ahead of, dog breed shows (McGreevy and Nicholas 1999) or alternatively, the collection of feedback from owners on the behaviour, including problematic behaviour, of their pedigree dogs.

5.5 Survey respondents' opinions

Respondents' comments were wide-ranging, from the opinion that current internal control has failed and thus external legislation is imperative, to strong beliefs that encouragement and rewards are the best routes forward. However, many respondents reiterated the importance of education, of both breeders and the public, throughout their responses. The respondents were very keen that any "independent panels" or review committees were carefully composed, via a transparent process, to incorporate experts from multiple disciplines. Several respondents noted that some of the proposed actions would be valuable to cross breed dogs as well, and hence they should be applied to all dogs, and not just pedigrees. A common concern addressed by many was that priority designated funding, and staff, are required to tackle the issue no matter which actions are employed, and this is something that must be addressed. Indeed, one problem for genetic understanding is lack of genetic knowledge (section 4.7.2), and many of the recommendations here will place demands on funding for research. Current funding is not adequate to these tasks, so we would urge that government agencies, as well as all stakeholders (see Figure 1) are involved in discussion of where responsibility for provision of these resources should lie.

5.6 In conclusion

In spite of the wide range of their opinions, there were actions that were universally valued (see Appendix 2) and hence it was possible to use the survey responses to help prioritise our recommendations. This sample of experts, on the whole, agreed with McGreevy (2007) that systematic data collection is the most important priority. The fourteen actions which they rated as most valuable included those designed to achieve each of the objectives outlined in section 5.2, hence further discussions and development of these actions would be very beneficial.

Our recommendations include many long-term, research initiatives aimed at increasing the evidence-base and thereby informing long-term strategies and increasing objectivity in planning and decision-making. However although improvements will, and must, depend upon science in the long-term, there are actions that can be taken now, that will have an immediate impact and improve welfare, (including many of the plausible actions). Hence the recommendations also include more immediate actions, which would could generate rapid effect (e.g. recommendations 2, 3, and 5).

5.7 The need for a coordinated approach

Some stakeholders have expressed concern that attempts to enforce higher standards on breeders by a voluntary registration agency such as the Kennel Club may be met by a move away from registration of animals with that agency. Such a trend appears to be taking place in the United States, where numerous small break-away Kennel Clubs have been founded following first the introduction of breed specific control legislation with American Kennel Club (AKC) support, and subsequently conditional registration based on DNA testing brought in by the AKC (American Kennel Club 2009).

Several of the recommendations would place extra duties on breeders wishing to register dogs. It will be important not to create an “underground” set of registries without rules, or to cause owners to relinquish their dogs. The time may have come to reconsider the idea of compulsory licensing of all dogs (regardless of pedigree status) by a body with legislative backing. In several countries that place such an obligation on owners, the national kennel clubs appear to have a higher level of registrations and much greater compliance with required testing, perhaps because owners are more used to the disciplines and responsibilities of canine ownership.

Traditionally, dog breeding has been almost exclusively the unregulated domain of the dog breeder. However, in recent years and, in particular, since the publication of the dog genome by Lindblad-Toh et al (2005) there has been a gradual merging of the fields of dog breeding, genetics and disease. Last year McGreevy (2008) stated that dog breeders are “... very good at what they do – the problem is that what they currently do is not very good”. This highlights the need for a coordinated approach. Welfare charities, veterinary associations, dog breeders and all other stakeholders must unite in using the latest advances in genetics and epidemiology to find a new model of dog-breeding practice. To say that there are numerous challenges facing the selection of healthy dogs in order to produce healthy offspring would not be an overstatement.

Hence, to maximise progress at improving the welfare of pedigree dogs, it is vital to engage all stakeholder groups and to consider both the direct (section 3) as well as the indirect (section 4) effects of breeding practices. Change will most quickly come about through a concerted approach that engages each, and in which the actions support one another. The most important element, however, is to ensure that all stakeholder groups buy into the process and fully support the action(s) they need to take. This is the challenge that lies ahead.

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Glossary of terminology

Addison's disease is also known as adrenal insufficiency, hypoadrenocorticism or hypocortisolism. It is an endocrine or hormonal disorder characterised by weight loss, muscle weakness, fatigue and low blood pressure. Addison's disease occurs when the adrenal glands do not produce enough of the hormone cortisol.

Allele is one member of the set of different forms of a gene. An individual's **genotype** for that gene is the set of alleles it happens to possess. In a diploid organism (such as a dog), an animal has two copies of each chromosome, and hence two alleles make up the individual's **genotype** at any gene.

Atopic dermatitis is a hypersensitivity mediated disease characterised by inflammation of the skin. There is an inherited predisposition to this disease, and it is non-contagious.

Autoimmune disease is any disease in which the body's immune system starts to attack the body itself. This can occur through a failure of recognition of self, often believed to be connected to a previous infection. The immune response is unable to discriminate between a structure in the previous disease organism and a similar structure in the body. This lack of discrimination may be connected to a reduced repertoire of the molecules (known as major histocompatibility complex or MHC) which present the immune system with components to trigger immune responses. Examples include common forms of diabetes, atopy, lupus, multiple sclerosis and many others.

Autosomal recessive is a mode of inheritance in which a character is expressed only when genes for it are inherited from both mother and father.

Brachycephalic is a term to describe an animal which has a short, broad head.

Buccal swab is a sample derived by brushing the gums and palate to obtain cells, which can then be used to derive DNA for a DNA based test. Buccal swabs can be prepared by dog owners, whilst most other DNA sources need veterinary assistance in taking a sample.

Canine Leucocyte Adhesion Deficiency (CLAD) is an inherited fatal immunodeficiency disease. Pups that inherit two recessive genes for CLAD usually die early in

life from multiple severe infections, even when treated with massive doses of antibiotics. It is usually apparent in very young puppies; they fail to thrive, constantly succumb to infection, have various growth problems and die as a result of their poor health state, often well before one year old.

Carrier is an animal which has a mutant gene but does not express the condition induced by the mutation. Normally this is a condition in **autosomal recessive** inherited disease in which an animal has inherited the mutant gene from just one parent, and so is **heterozygous** for the condition, or in the mother of male offspring suffering from sex-linked diseases such as the blood clotting disorder haemophilia.

Chiari malformation is also known as Arnold Chiari malformation (CM) and is a structural defect of the cerebellum and brain stem, the part of the brain that controls balance and co-ordination. Normally the cerebellum and parts of the brainstem sit in an indented space at the lower rear of the skull (the occipital fossa), above the foramen magnum (a funnel-like opening to the spinal canal). But with this condition, part of the cerebellum is pushed through the foramen magnum. CMs may develop when the bony space is smaller than normal, causing the cerebellum and brainstem to be pushed downward into the foramen magnum and into the upper spinal canal. The resulting pressure on the cerebellum and brainstem may affect functions controlled by these areas and disrupt the flow of cerebrospinal fluid (CSF) – the clear liquid that surrounds and cushions the brain and spinal cord – to and from the brain. It is this disruption that causes **syringomyelia**.

Clinical disease is a disease with clinical signs and symptoms that are recognisable, as opposed to a **subclinical disease** which has no clinical manifestations. Diabetes, for example, can be subclinical in an individual before emerging as a clinical disease.

Coefficient of inbreeding. In population genetics, Sewall Wright's coefficient of inbreeding is the probability that at any gene, the alleles are identical by descent. That is to say the probability that the two alleles of the gene, united in the individual under study, are both descended from a gene found in an ancestor common to both parents.

Collie eye anomaly (CEA) is an **autosomal recessive** condition that results in abnormalities of the structures underlying the retina of the eye, most frequently causing reduced growth of the layer containing blood vessels (the choroid). There is a wide range in severity, but in the more severely affected animals there is a possibility that the retina may become detached, or that there may be bleeding from the blood vessels in the eye, either of which can cause blindness in the affected eye.

Congenital disorder. A disorder which is observable in an offspring from before, or at birth. It may be the result of a chromosomal or other genetic abnormality, the intrauterine environment, or an error of morphogenesis. The outcome of the disorder will further depend on complex interactions with the post-natal environment.

Cranio cervical junction is where the spine meets the head of a dog.

Cruciate ligament is one of the four major ligaments of the knee. It connects from a postero-lateral part of the femur to an antero-medial part of the tibia.

Degenerative myelopathy is an adult-onset, progressive disease causing degeneration of the spinal cord, which then results in nerve and locomotive disorders, weakness in the hind limbs and eventually paraplegia.

DNA based testing searches directly for a mutation in DNA sequence, rather than looking for the clinical effects of the disease caused by the mutation.

Dog years at risk is a unit of **incidence** used to describe the occurrence of disorders. For example 183 new cases per 10,000 dog years at risk [DYAR] means that 183 cases would be expected in 10,000 dogs observed for one year.

Dominant mutation means that only one copy of the allele is needed for the condition to be expressed.

Dwarf breeds are dog breeds with limbs disproportionately short compared with their body size. In addition, atypically small dogs within a particular larger breed may be referred to as dwarfs, but if small size is typical of the breed it will be referred to as a toy breed.

Effective population size is the size of a population which, if it were interbreeding at random, would have the same average rate of **inbreeding** as the population under study. Hence if a large population has a very small effective population size, then that population has a very high rate of inbreeding.

Elbow dysplasia (ED) is abnormal development of the canine elbow with a hereditary basis. It originates from improper formation of parts of the cartilage surface of the joint, which may sometimes involve a process of **osteochondrosis**. These primary lesions lead to a series of secondary changes that include thickening of the joint capsule, change in shape of the joint and **secondary osteoarthritis**. The main clinical signs are pain, restriction of movement and lameness, but the disease may be **clinical** or **subclinical**.

Founder effect. A high frequency of particular **genetic variants** present within a population because one or more founders of that population carried those particular variants, which have subsequently been inherited by many members of the population.

Founders are those animals from which the breed was established.

Gene is the DNA coding for a single protein (or in some uses for a single trait). There are something over 20,000 genes in the complete genome.

Gene pool is all the genes or genetic variants within a population.

Genetic drift is the change in frequency of particular **genetic variants** over time because of random sampling of the genes during the formation of gametes. Over a period of generations genetic drift can cause large unpredictable changes in the proportion of particular variants, especially in small populations and those where only a small proportion of animals are used in breeding. Over time there is a tendency for this to lead to complete loss of particular variants.

Genetic variants are either differences in the sequence at particular positions along the DNA, also known as **polymorphisms**, or in some contexts, the animals carrying these differences.

Genome. The whole of the genetic material of the animal.

Genome mapping (or simply **mapping**) is the process of finding a mutation causing a disease, a disorder or a trait, through searching systematically for **polymorphisms** at different positions in the genome which are found in higher numbers in individuals showing the disease or trait **phenotype**. When such an association is found the polymorphic locus must be near to a mutation contributing to the disease or trait, allowing the position of the gene for the trait to be located in the genome.

Genotype. The genotype is the actual sequence of the DNA constituting the genome of an individual. It can also be used in describing the sequence of particular genes.

Glaucoma is a leading cause of blindness in dogs. It is the result of increased fluid pressure within the eye. If the pressure cannot be reduced, permanent damage to the retina and optic nerve occurs, resulting in visual impairment.

Haemangiosarcomas are aggressive cancers that arise from cells that in normal tissue grow to make up the walls of blood vessels and can be found anywhere in the body.

Haemolytic anaemia is a disease in which the red blood cells of the blood suffer rupture leading to a reduced number in circulation and deposition of iron in the tissues and loss in urine.

Heterosis (also known as **hybrid vigour** or out-breeding enhancement) describes the increased strength of different characteristics in **hybrids**; the possibility to obtain a genetically superior individual by combining the virtues of its parents.

Heterozygous/heterozygosity. The opposite of homozygous/homozygosity. A term used to simplify the description of the **genotype** of a diploid organism at a single gene. At a given gene or position along a chromosome (a locus), the DNA sequence can vary among individuals in the population. The variable DNA segments are referred to as alleles, and diploid organisms generally

have two alleles at each locus, one allele for each of the two homologous chromosomes. Simply stated, heterozygous describes two different alleles or DNA sequences at one locus.

Hip dysplasia (Canine hip dysplasia: CHD). Abnormal development of the canine hip with a hereditary basis. It is started by excessive laxity of the ligaments around the joint. This leads to abnormal positioning of the femoral head (ball) with respect to the acetabulum (socket). The consequence is a series of secondary changes that include thickening of the joint capsule, change in shape of the joint and **secondary osteoarthritis**. The main clinical signs are pain, restriction of movement and lameness, but the disease may be **clinical** or **subclinical**.

Histiocytic tumours are tumours composed of a particular type of white blood cell, the macrophage.

Homozygous/homozygosity. The opposite of **heterozygous/heterozygosity**. A term used to simplify the description of the genotype (genetic make up) of a diploid organism at a single gene. At a given gene or position along a chromosome (a locus), the DNA sequence can vary among individuals in the population. The variable DNA segments are referred to as alleles, and diploid organisms generally have two alleles at each locus, one allele for each of the two homologous chromosomes. Simply stated, homozygous describes two identical alleles or DNA sequences at one locus.

Hybrid. The progeny of a cross between two different species or two different breeds or strains.

Hybrid vigour see **Heterosis**

Hypoplastic trachea is a small and narrowed windpipe, most often seen in brachycephalic dogs.

Inbreeding is the mating of related individuals. I.e. individuals that have one or more ancestors in common.

Incidence refers to the frequency of a disorder in a population in a certain period of time, normally one year. For example, if the incidence of a cancer has increased in past years, this means that more individuals have developed this condition year after year.

Line breeding is a form of **inbreeding** practised by some animal breeders with the aim of “fixing” desirable traits in an animal. It involves arranging matings so that favoured individuals occur more than once in a pedigree. One problem with line breeding is that it is also likely to “fix” undesirable traits.

Malignant histiocytic tumour is a well-recognised canine tumour, which is characterised by fever, jaundice, and enlargement of the liver, spleen, and lymph nodes. It can rapidly cause fatality.

Mapping. See **genome mapping**.

Melanocytes are pigment-producing cells in the skin, hair, eye and the cochlea of the ear. They produce melanin, and the level of their activity determines the colour of the eye, skin or hair. When they are absent from the ear, this organ cannot function and profound deafness results. Similarly absence from the eye is associated with reduced vision.

Merle is a colour combination in dogs' coats. It is a solid base colour (usually red/brown or black) with lighter blue/grey or reddish patches, which gives a mottled or uneven speckled effect. Although most breeds that can have merle coats also have white markings, this is a separate colour from the merle; some dogs do appear completely merled with no white or tan markings. In addition to base coat colour, merle also modifies eye colour and colouring on the nose and paw pads. The merle gene modifies the dark pigment in the eyes, occasionally changing dark eyes to blue, or part of the eye to be coloured blue. Merle is a distinguishing characteristic of several breeds, particularly the Australian Shepherd, and others, including the Koolie, Shetland Sheepdog, Spaniels, Collies, the Welsh Corgi (Cardigan), the Pyrenean Shepherd and the Old English Sheepdog.

Mitral valve disease/dysplasia (MVD) is a malformation of the valve dividing two chambers of the heart, the left atrium and left ventricle, such that when the ventricle contracts, providing the main impulse to circulate blood around the body, some blood flows back into the atrium. In mild cases this simply causes a heart murmur without very much clinical significance, but bad MVD is severe and life threatening.

Monogenic disorders are those in which the disorder/disease is specified by a single mutant gene. This is as opposed to **polygenic** or complex disorders which occur because of the cumulative effects of more than one gene.

Mutations are differences from the normal sequence of DNA, caused by damage by the environment or errors made by the cell during DNA replication.

Neoplasm. Any abnormal mass of tissue resulting from new growth, and includes both benign and malignant tumours.

Neotonous refers to the retention into adult life, of characteristics usually found in a juvenile, infant or foetus. Domestic dogs retain some anatomical and behavioural characteristics of juvenile and infant wolves.

Nucleotide. The four nucleotides adenine, cytosine, guanine and thymidine (A, C, G & T) are the chemical bases that are ordered along the DNA helix to encode the genetic information. **Single nucleotide polymorphisms (SNP)** are changes of nucleotide at a single position on the DNA.

Occipital hypoplasia is a term for the reduced size of the back of the skull. This leads in turn to the **Chiari malformation** and hence to **syringomyelia**.

Osteochondrosis is a juvenile developmental disease of joints that occurs when a portion of the joint surface is formed incorrectly. There are series of potential secondary changes that include areas devoid of normal cartilage, pieces of cartilage and supporting bone becoming loose in the joint and areas of abnormally thickened cartilage. Thickening of the joint capsule and **secondary osteoarthritis** can also occur. The main clinical signs are pain and lameness, but the disease may be **clinical** or **subclinical**.

Osteosarcomas are tumours of the cells that build bone and hence have their primary sites in bones.

Out-bred refers to offspring from parents who are not closely related.

Overdominance is a situation where the **phenotype** of the heterozygote at a particular locus is quantitatively greater than the **phenotype** of either homozygote. Positive effects of overdominance are a major explanation for **heterosis** or **hybrid vigour**.

Phenotype (phenotypic) is any observable characteristic of an organism, such as its morphology, development, biochemical or physiological properties, or behaviour. Some phenotypes are due solely to the action of one or more genes; others are due solely to non-genetic factors, and others are due to a combination of both.

Polygenic disease. An inherited disease caused by a group of genes rather than a single gene pair. Many breed related diseases or traits have a polygenic inheritance. Polygenic characteristics are more difficult to define, track and control.

Polymorphism. Although this can be used to mean any difference between two animals of the same type, in this document and in most modern sources it is used in the restricted sense of differences at the molecular level. When used in connection with DNA, it means any difference in genotype between two individuals or between the maternal and paternal chromosomes of a single individual. Such differences are often single changes to the **nucleotide** string on the DNA or changes to the numbers of repeats in simple repeated sequences within the **genome**. Although a proportion of polymorphisms cause all of the heritable differences of **phenotype** between individuals, many polymorphisms have no measurable consequence to the **phenotype**.

Portosystemic shunt. A defect in circulation of blood from the gut, bypassing the liver and passing directly into the circulation. This can cause toxic ammoniacal salts to reach the brain, causing an encephalopathy.

Prevalence refers to the current number of individuals suffering from an illness in the defined population. This number includes all those who may have been diagnosed in prior years, as well as in the current year.

Progressive retinal atrophy is a group of genetic diseases seen in many breeds of dog. It is characterised by the bilateral degeneration of the retina, causing progressive vision loss, culminating in blindness. The condition in nearly

all breeds is inherited as an **autosomal recessive trait**, with the exception of the Siberian Husky (inherited as an X chromosome linked trait) and the Bullmastiff (inherited as an autosomal dominant trait).

Recessive. A recessive allele is one whose effect on the **phenotype** is evident only when the animal is **homozygous** for that allele.

Screening. Testing a group of animals to identify individuals at risk of having or passing on a specific disorder.

Secondary osteoarthritis is a type of degenerative arthritis that results from trauma to the joint or from chronic injury.

Secondary legislation is sometimes known as regulations; subordinate or delegated legislation; or statutory instruments. It is often more detailed and specific than primary legislation and can usually be passed by Parliament in a simplified, quicker process.

Selective sweep. When a gene is under selection for a particular variant, the frequency of that variant will increase, and eventually this increase will cause the population to become **homozygous** for that gene. Genes do not exist as isolated fragments but are joined to their neighbours in a chromosome, like beads on a string. Selection then acts on these “strings of beads”, dragging not just one gene, but that gene with all its neighbours, to prominence. In fact, in nature there is a system for recombining these “beads”, such that the nearer a gene is to the gene under selection, the more often it will be selected with it. The phenomenon by which a whole region of a chromosome is selected for and loses **heterozygosity**, rather than a single gene, has been called a selective sweep.

Single Nucleotide Polymorphisms (SNP)

See **Nucleotides**.

Subclinical disease (as opposed to **clinical disease**). In a subclinical disease, signs of the disease, such as a change in the anatomy of an organ like the eye or a joint can be recognised, normally with the use of a specialised techniques such as radiography (x-rays or ophthalmic examination). However these changes may create no signs of an obvious problem to an observer.

Syringomyelia. The formation of cavities in the nervous tissue of the spinal cord. In dogs this is often but not always accompanied by “referred” pain (perceived at a site adjacent to or some distance from the site of the cavity) or irritation. The dog is clearly in discomfort and tries to scratch at or near the shoulder or face, in the position from which they perceive the pain to originate.

Test registries. For most clinical and DNA tests in most countries, results are compiled either by a statutory body or voluntarily into registries. These are said to be open if the data is accessible to others apart from the dog owner. Usually, even if not fully open, they can provide anonymised data, to allow statistical analysis.

Vigour is increased general health, resistance to disease, and other superior qualities. These are often manifested in **hybrids**. **Hybrid vigour** represents the opposite of inbreeding depression.

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Appendix 1 – DNA tests available for inherited diseases of pedigree dogs.

This list was compiled in November 2008 for laboratories operating in the UK, the EU, the USA or Australasia. Tests for 53 diseases are currently available in at least one of 108 breeds, giving a combined total of 139 breed and disease combinations. The table excludes DNA tests for traits

without large health implications such as coat colour and length, although such tests are readily available and popular. Although many test methods and sequences are proprietary, all but two tests appear likely to be based on published information about mutations.

DNA Test Trait

Diseases	Breed
Black hair follicular dysplasia	Large Munsterlander
Bully (myostatin deficiency)	Whippet
Canine multifocal retinopathy (CMR)	Bull Mastiff & Old English mastiff
	Coton de Tulear
	Dogue de Bordeaux (French mastiff)
	Great Pyrenees
Centronuclear myopathy	Labrador Retriever
Ceroid lipofuscinosis (CLN5)	Border Collie
Ceroid lipofuscinosis (Cathepsin D/CTSD)	American bulldog
	British bulldog
Ceroid lipofuscinosis (CLN8)	English setter
Ceroid lipofuscinosis (CLN2/TTP1)	Dachshund
	Irish Setter
Canine leukocyte adhesion deficiency	Red & White Setter
	Staffordshire terrier
Cerebellar ataxia	Spinone
	Giant Schnauzer
Cobalamin malabsorption (Vitamin B12 def)	Giant Schnauzer
Collie eye anomaly/ choroidal hyperplasia (CEA/CH)	Australian Shepherd
	Border Collie
	Boykin Spaniel
	Collie
	Lancashire Heeler

Diseases	Breed
	Longhaired Whippet
	Shetland Sheepdog (sheltie)
Cone degeneration	German Shorthaired Pointer
Congenital stationary night blindness	Briard
Copper Toxicosis	Bedlington Terrier
Cyclic Neutropenia (Gray collie syndrome)	Border Collie, Collie
Cystinuria	Landseer
	Newfoundland
	Labrador Retriever
Degenerative myelopathy	German Shepherd Dog
Factor VII deficiency (1)	Airedale
	Alaskan Klee Kai
	Beagle
	Giant Schnauzer
	Scottish Deerhound
Factor VII deficiency (2)	Kerry Blue Terrier
Fucosidosis	English Springer Spaniel
Globoid cell leukodystrophy (Krabbe disease)	Cairn Terrier
	West Highland White Terrier

Diseases	Breed
GMI Gangliosidosis	Siberian Husky
Haemophilia B (Factor IX Deficiency)	Bull Terrier
	German Wirehaired Pointer/ Deutch Drahthaar
	Lhasa Apso
	Labrador retriever
Hereditary cataract (HSF4)	Australian Shepherd
	Staffordshire Bull Terrier
Juvenile hereditary cataracts (HSF4)	French Bulldog
	Boston Terrier
Hypothyroidism with goiter (TPO deficiency)	Toy Fox Terrier
Ivermectin sensitivity (MDR1 mutation)	Australian Shepherd
	Border Collie
	Collie (all breeds)
	English Shepherd
	Longhaired Whippet
	McNab shepherd
	Old English Sheepdog
	Shetland Sheepdog (sheltie)
	Silken Windhound
L-2-hydroxyglutaric aciduria	Staffordshire Bull Terrier
Malignant hyperthermia	All susceptible breeds (Greyhounds and mixed breeds)
Mucopolysaccharidosis (MPS) IIIB	Schipperke
Mucopolysaccharidosis (MPS) VI	Miniature Pinscher
Mucopolysaccharidosis (MPS) VII	German Shepherd Dog
Myopathy (X-linked) (Muscular dystrophy)	Golden Retriever
Myotonia congenita (CLCN1)	Miniature Schnauzer

Diseases	Breed
Narcolepsy	Dachshund
	Doberman Pinscher
	Labrador Retriever
Neonatal encephalopathy with seizures (ATF2)	Standard Poodle
Nephropathy (familial)	Cocker Spaniel
Oculo skeletal dysplasia/retinal dysplasia	Labrador Retriever
	Samoyed
Phosphofruktokinase deficiency	American Cocker Spaniel
	English Cocker Spaniel
	English Springer Spaniel
Progressive retinal atrophy (rcd1/PDE6B)	Irish Setter
	Red & White Setter
Progressive retinal atrophy (rcd2)	Rough Collie Smooth Collie
Progressive retinal atrophy (PDE6B)	Sloughie
Progressive retinal atrophy (Cord1)	Miniature Long / Smooth Haired Dachshund
	English Springer Spaniel
Progressive retinal atrophy (Dominant)	Mastiff (Old English & Bull)
Progressive retinal atrophy (rcd3)	Cardigan Welsh Corgi
Progressive retinal atrophy (prcd)	American Cocker Spaniel
	Eskimo Dog
	Australian Cattle Dog & Australian Stumpy Tail Cattle Dog
	Australian Shepherd
	Chesapeake Bay Retriever
	Chinese Crested
	Cockapoo, Labradoodle & Goldoodle
	Entlebucher Mountain Dog
	Finnish Lapphund
	Golden Retriever

Diseases	Breed
	Karelian Bear Dog
	Kuvasz
	Labrador Retriever
	Lapponian Herder
	Miniature and toy poodles
	Nova Scotia Duck Tolling Retriever
	Poodle (toy and miniature)
	Portuguese Water Dog
	Silky Terrier
	Spanish Water Dog
	Swedish Lapphund
Progressive retinal atrophy type A	Miniature Schnauzer
Progressive retinal atrophy XL	Samoyed
	Siberian husky
Pyruvate dehydrogenase phosphate 1 deficiency (PDP1)	Clumber Spaniel
	Sussex Spaniel
Pyruvate Kinase Deficiency	Basenji
	Beagle
	Cairn Terrier
	Chihuahua
	Dachshund
	Eskimo Dog
	German Shepherd Dog
	Springer Spaniel
	West Highland White Terrier

Diseases	Breed
Severe combined immunodeficiency	Basset Hound
	Welsh Corgi
Trapped neutrophil syndrome	Border Collie
Von Willebrands Disease	Irish Red & White Setter
Von Willebrands type I	Bernese Mountain Dog
	Coton de Tulear
	Doberman Pinscher
	Drentsche Patrijshond
	German Pinscher
	Kerry Blue Terrier
	Manchester Terrier
	Papillion
	Pembroke Welsh Corgi
	Poodle
	Stabyhound
Von Willebrands type II	Deutsch Drahthaar
	German Shorthaired Pointer
	German Wirehaired Pointer
	Pointer (unspecified)
Von Willebrands type III	Scottish Terrier
	Shetland Sheepdog
	Kooikerhondje

Appendix 2 – Further details of the survey of experts, used to prioritise recommendations as described in section 5.3

Survey design

Each respondent was asked to consider the 36 potential actions in turn, and state whether they supported, conditionally supported, or disagreed with it (or whether they had no opinion). They were then asked to rate each suggestion on a scale of 1- 10 for its relative value to the pursuit of improving pedigree dog welfare. They were given the opportunity to comment on, and attach conditions to each action. Finally, the respondents ranked the five actions that they viewed to be most crucial to improving pedigree dog welfare.

Of those respondents who expressed an opinion, we calculated the percentage who supported each of the suggested actions and the mean value they attributed to the action. We also summed the number of people who ranked each action as one of their five most important recommendations.

Based upon these three values, we constructed five categories of action:

Priority recommendations: supported by over 94% of respondents (greater than the average value for all recommendations, and represents support by all except one respondent) and rated on average greater than 7.5 (out of 10) for value, and listed by multiple respondents in their top five.

Primary recommendations: supported by 85% or more of respondents and rated an average of 7 or more for value;
Undisputed recommendations: supported by 100% of respondents but rated less than 7 for value;

Further recommendations: supported by 80% or more of respondents (but not falling within the above categories);

Poorly supported actions: supported by less than 80% of those expressing an opinion.

Results

Respondents varied greatly in their opinions, and the importance they attached to each action. This highlights the difficulty in finding consensus between stakeholders regarding recommendations on this issue.

In spite of these disparate views, there were four actions which all respondents believed should be supported (although some with specific conditions attached), and a further 23 which 85% or more of respondents supported in principle. There were four actions categorised as *priority*, ten as *primary* recommendations, three as *undisputed*, (even though these were not always seen as giving the best value), fourteen as further recommendations and five were *poorly supported* (Table A2).

Of course, the selection of cut-off points used to define such categories involves some subjective judgement, and many of the *undisputed* and *further* recommendations may also be useful routes forward for stakeholders, especially those that can be carried out relatively rapidly and inexpensively. For this reason, although we restrict full presentation to the priority and primary recommendations, the additional categories are summarised in the main body of the report and described in more detail in Appendix 3. The value rating is a simple indication of subjective opinion, but could be used further by stakeholders or an independent panel during decision-making processes. For example, techniques such as Analytic Hierarchy Process (e.g. Liu et al 2008), through which it is possible to factor in feasibility and cost as well as potential value, could be employed. Although actions here are presented in order of relative value, in reality their execution would need to be carefully planned and coordinated in a strategic order (section 5.7).

Table A2 Mean importance ratings, and percentage of respondents supporting, and ranking in the top five actions, listed in order of value rating

Potential action	Mean value rating	% of respondents of those expressing an opinion, who supported the action, with or without conditions	% of the supporters who detailed conditions	No of respondents ranking action within the most important five
Systematic collection of morbidity and mortality data from all registered dogs	8.72	100	38.9	8
Revision of registration rules to prevent the registration of offspring of matings between 1st-degree and 2nd-degree relatives	8.33	94.7	0	5
Open stud books to allow more frequent introduction of new genetic material into established breeds	8.33	94.7	5.9	3
Conducting a full ethical review of current breeds	7.88	85.0	31.3	4
Setting up systems to monitor the effectiveness of any interventions and changes	7.55	95.0	16.7	3
Development of detailed management plans for each breed	7.55	90.0	41.2	4
Refinement of diagnostic tests and DNA markers for inherited disorders	7.37	93.8	13.3	2
Increase genetic diversity by encouraging importation and inter-country matings	7.29	94.7	5.9	0
Exploration of methods by which to penalise unethical breeding	7.20	75.0	46.7	3
Make registration of pedigree dogs conditional upon both parents undergoing compulsory screening tests	7.17	94.4	25.0	4
Development and support for shows that are judged on temperament, health and welfare	7.1	80.0	31.3	0
Introduction of codes of practice that encourage breeders to consider health, temperament and welfare	7.06	94.1	25	4
Training and accreditation of judges to prioritise health, welfare and behaviour in the show ring	7.06	90.0	38.9	4
Creating and fostering the image of a happy and desirable dog being one that experiences high welfare	7.00	89.4	0	4
Formulation of an independent panel of experts from multiple disciplines	7.00	95.0	38.9	5
Development of schemes for calculating Estimated Breeding Values	7.00	86.7	15.4	1

Introduction of dog breeder warranties or contracts which commit breeders to paying compensation for avoidable inherited disorders	6.94	89.5	31.3	1
Placement of restrictions on the number of caesareans permitted per bitch	6.93	88.2	40	1
Provision of expert and accurate information to the public and potential buyers	6.89	100	31.6	4
Review all and when appropriate, revise breed standards to prioritise health and welfare	6.89	100	41.2	6
Conducting pedigree analyses on all UK breeds	6.88	94.1	5.9	2
Revision of registration rules to limit the number of offspring that any one male can sire ⁴	6.82	77.8	0	2
Development of methods for enhanced communication	6.82	94.7	23.5	1
Development of secondary legislation to control dog breeding	6.47	88.2	13.3	2
Encouragement for breeders to make responsible breeding choices	6.40	83.3	20	2
Production of neutered F1 hybrids	6.36	55.6	60	1
Set a minimum number for founder stock for new breeds	6.33	82.3	14.3	1
Development of methods to objectively measure quality of life	6.28	94.7	5.9	3
Campaign for revision and then sign and ratify the European Convention for the Protection of Pet Animals	6.00	87.5	21.4	0
Encouragement of future owners to fully research breeds	5.94	89.5	43.8	0
Measurement of real current homozygosity levels in breeds	5.93	100	13.3	1
Seek consistency and transparency in reporting of hip scores (and other test results)	5.88	94.4	17.6	0
Prioritisation of animal welfare over financial gain by veterinarians	5.86	77.8	14.3	1
Development of an accreditation scheme for breeders, breed societies, and veterinarians	5.67	94.7	47.1	1
Production of a safe, honest feedback mechanism to help empower potential pedigree dog buyers and breeders.	5.24	78.9	53.3	0
Utilisation of temperament assessments to select dogs which are best suited to the environment in which they will live	4.36	68.4	30.8	1

* Non-integers are a result of incomplete sample sizes for specific questions which respondents omitted to answer

Key	 Priority recommendations	 Primary recommendations	 Poorly-supported actions
	 Undisputed recommendations	 Further recommendations	

⁴ Although this action was supported by marginally less than 80%, its high average value rating, combined with the absence of attached conditions, have led us to categorise it as a *further recommendation* rather than a *poorly supported action*.

Appendix 3 – Details of undisputed recommendations, further recommendations and poorly supported actions – text as presented in survey (NB the conditions and concerns raised by respondents are not listed here)

Undisputed recommendations

15. Provision of expert and accurate information to the public and potential buyers. The general public own most of the pedigree dogs in the UK and so their buying power is a potentially strong force in influencing positive change. Educating potential owners about the likely problems for each breed will help them to make informed decisions. Honest, accurate information should be provided by breeders and veterinarians about health and potential disease and disorder predisposition.

There are many existing websites that claim to match a would-be owner to a suitable breed of dog (e.g. Pet Planet 2009, Purina 2009, Pedigree 2009). However, although these provide information on physical and temperamental traits of each breed, few sites inform the buyer of potential health problems that may be particularly prevalent in the breed.

Some UK sites that do include sections on common disorders or “ailments” include K9 Obedience 2007, Dogs.info 2009, and Puppyfinder.com 2008. Similarly, the Inherited Diseases in Dogs web site (Sargan 2009) contains peer reviewed information, but is not designed primarily for the general public. However, current lack of systematic data collection means that these lists are inevitably arbitrary in the disorders they do, and do not, mention. Hence organisations should join forces to create a thorough and independent resource that provides accurate and up-to-date information. This should initially be based on existing knowledge, then regularly updated as new data is accumulated.

16. Review all and when appropriate, revise breed standards to prioritise health and welfare. Many of the current breed standards make reference to health and welfare and indeed revisions are ongoing (e.g. The Kennel Club 2008i). However, health and welfare should be paramount and not just nominally included in each standard. One way to achieve this would be for breed societies to sign up to a mission statement which prioritises the health and welfare of their breed, and strives to eliminate suffering. The society would then need to revise its breed standards to meet this ultimate aim, eliminating any reference to anatomical traits which are known, or suspected to be, detrimental to a dog’s welfare. The Council of Europe’s (1995) list of traits (see action 28) may

be a good starting point, but for this process to be meaningful, it is essential that a “welfare panel”, including independent welfare scientists and the dog-owning public, is employed to derive a consensus on what level of each of these traits is likely to unacceptably compromise welfare. Initial subjective decisions should be superseded by objective data-based criteria in the future. Administration of the mission statement could be carried out by the Kennel Club, an independent body and/or could form part of a breed society accreditation scheme (action 3i).

17. Measurement of real current homozygosity levels in breeds. Initial research has identified links between disease and loss of heterosis in specific breeds of dog (e.g. Ubbink et al 1992). The availability of the high density oligonucleotide array (“SNP chip”) would allow a fuller understanding of the extent and distribution of homozygous tracts in real genomes for each breed. A group of dogs with different inbreeding coefficients for each popular breed would be selected and a homozygosity map derived by hybridisation to these chips. This will give information on the distribution of selective sweeps (areas rendered homozygous by selection for genes within them that confer particular traits or characters), and the degree of residual polymorphism in these areas. This can inform choices on attempts to change population structure, such as whether out-breeding will be needed to make any changes.

Further recommendations

18. Development and support for shows that are judged on temperament, health and welfare, rather than solely on conformation, is an action point for the public, veterinarians, charities, sponsoring companies and breeders alike. A further suggestion may be the introduction of welfare classes, in which dogs compete based purely on their health and quality of life. Although this may be quite subjective, it could be instrumental in achieving changes in public perception. Similarly, health prizes for older dogs (similar to “Best Veteran” classes used in horse shows e.g. The Show Ring 2006), or awards for dogs with the lowest Coefficients of Inbreeding may be valuable.

19. Introduction of dog breeder warranties or contracts

which commit breeders to paying compensation for avoidable inherited disorders that develop in the dogs they sell.

This action may seem likely to produce injustices because of the laws of probability, meaning that even the most conscientiously bred dog could still develop an inherited disorder. However this could potentially be overcome by insuring breeding stock against throwing offspring with particular disorders, especially those for which no DNA tests, nor Estimated Breeding Values, are available. This would provide increased financial security for vendors of breeding stock, reduce the likelihood of serious legal disputes between vendors and purchasers, and, very importantly, encourage the reporting of disorders.

In the 1970s, the Galloway Cattle breed society instigated a scheme for vendors at their annual young bull sale to insure against the bulls producing calves with an autosomal recessive disorder in the following twelve months. The purchaser could extend the insurance if he/she wished. This scheme was a great success: it provided financial security and encouraged reporting of the disorder. A similar scheme could also be valuable to pedigree dog breeding (see Nicholas 1987).

20. Placement of restrictions on the number of caesareans permitted per bitch

so subsequent litters can not be registered. This would decrease potential distress and suffering to both mother and offspring. Methods to enforce this would need careful design, but one suggestion would be for veterinarians to have to sign documentation certifying the method by which puppies, of specific breeds, were born, which needs to be produced prior to registration.

21. Conducting of pedigree analyses on all UK breeds.

Pedigree analyses have been conducted on several UK breeds (e.g. Calboli et al. 2008) and they provide evidence that the extent of inbreeding and loss of genetic material varies considerably between breeds, but experts vary in their interpretation of the extent of the problem. However, if all breeds were analysed similarly, this would allow the determination for each breed of:

- a) the effective population size;
- b) other population parameters such as the effective number of founders;
- c) the degree of variation of the inbreeding coefficient. This is essential because perceptions of high levels of inbreeding must be replaced with actual data on the extent of inbreeding.

22. Revision of registration rules to limit the number of offspring that any one male can sire,

by restricting registration to a maximum number per parent. There is a limit of six on the number of litters from a given female that can be registered (The Kennel Club 2006d), but males are currently unlimited. Limiting males may help to reduce the expression of harmful recessive conditions. Suitable limits would need to be determined for each breed based upon population size and existing genetic diversity, with initial simulations and modelling to help to ascertain this.

23. Development of methods for enhanced communication between geneticists and individual breeders

e.g. via websites, discussion forums or help-lines. Although some forums do exist (e.g. Canine Genetics Discussion Group; The Canine Diversity Project 2002), wider publicising their existence may be extremely useful, and breed societies should seek their own collaborations to help their members.

The involvement of specialists in advising individual kennels when planning their breeding strategy may be a way of avoiding problems in the future. They could advise how best to avoid breeding from any dogs diagnosed or suspected to have heritable disorders, whilst minimising the danger of removing more genetic diversity from already-impooverished gene pools. There may be dogs carrying valuable diversity which can be carefully bred to maximise this while minimising the disease potential.

24. Development of secondary legislation to control dog breeding⁵

The Kennel Club, and breed clubs are members' societies and have legitimate worries about losing membership if the conditions of registration and control which they exert are too strict. Loss of members may have severe consequences for dog welfare, as there will be less power with which to influence the majority of dog breeders via positive initiatives.

However, there is then an argument for external control of breeding practices via an independent panel or via secondary legislation. It is possible that some breeding practices are already illegal under the Animal Welfare Act, however there are limitations to the application of the Animal Welfare Act, for example it expressly does not apply to any animal while it is in its foetal or embryonic form.

The development of specific secondary legislation would make it more straightforward to prosecute those that knowingly cause animal suffering by the breeding choices they make. This possibility should be explored, and may

⁵ This would require separate secondary legislation by the respective governments in England and Wales.

be considered to be a plausible next step should initiatives implemented internally by the industry fail to make significant improvements (e.g. action 32).

25. Encouragement for breeders to make responsible breeding choices and only breed when the offspring are likely to be homed and to experience a high quality of life. Breeders should only breed when they believe there to be a demand and should only sell to people who can demonstrate they offer a good home where the dog is likely to experience high welfare for the rest of its life. Culling of healthy puppies contravenes the Kennel Club's Code of Ethics (The Kennel Club 2006c), however, it still occurs. Societies should explore ways of monitoring this and breeders should be discredited (action 32) if they are found to cull.

26. Set a minimum number for founder stock for new breeds. New breeds are regularly founded and so it is essential that their welfare is prioritised from the outset. Arman (2007) suggests that for agricultural practices such limits are set at 60 individuals. With a more open stud book (priority recommendation 3), this will be less problematic.

27. Development of methods to objectively measure quality of life.

Accurate assessment of welfare is notoriously difficult, and the search continues for the most reliable and robust welfare measures for farm, laboratory, zoo, and companion animals such as dogs. Recent work on dogs has started to validate indicators of welfare and quality of life, including physiological, behavioural and emotional measures, and it is important that work continues to produce universally applicable methods (section 3.5)

These will become tools with which to:

- assess whether a breeds' quality of life is so compromised, or its potential for suffering so great, that it should not be bred or maintained any longer.
- prioritise which morphological traits and disorders should be bred against in order to improve health and welfare.
- investigate the extent to which different anatomical modifications lead to compromised quality of life.

28. Campaign for revision and then sign and ratify the European Convention for the Protection of Pet Animals.

Article 5 of the Council of Europe's 1987 Convention for the Protection of Pet Animals states that "any person who selects a pet animal for breeding shall be responsible for having regard to the anatomical, physiological and behavioural characteristics

which are likely to put at risk the health and welfare of either the offspring or the female parent".

Arising out of the 1987 Convention, the Council of Europe's 1995 Resolution on Breeding of Pet Animals agreed to encourage breeding associations, in particular cat and dog breeding associations, to reconsider breeding standards to amend those which can cause potential welfare problems.

At present this resolution lists specific breeds, which is a mistake as there are insufficient objective data on which to base these lists (see priority recommendation 1). If the breeds were to be removed, several charities and organisations believe that the Convention should be signed and ratified.

However, it should be noted that the Council of Europe is not the same body as the European Union and has no legislative powers. It is an association of European states which seeks unity between European Countries on matters of ideals and principles. Even if signed and ratified by members, its conventions carry no force of law until introduced into domestic legislation. Its conventions carry moral if not legal force behind them. The UK has neither signed nor ratified the Convention for the Protection of Pet Animals. However, it could be argued that by not signing such a document when 19 other European countries have signed (some with ratifications), and when many signatories are generally considered less animal welfare conscious than the UK, this may be sending the wrong message regarding our commitment to resolving the issue.

29. Encouragement of future owners to fully research the breed that they are considering buying, including health, welfare, temperament, and disorder prevalence. They should also be educated to ask pertinent questions of breeders, to see both parents, to examine pedigrees for levels of inbreeding and ask to see any relevant certificates for screen-able disorders from both of the parents. Information sources are required to help direct the public in this task, and the Kennel Club could consider including Coefficients of Inbreeding (measured over a large number of generations), or estimates of homozygosity on pedigree certificates, along with an explanation to help empower buyers. Owners should also be educated to only buy dogs from reputable breeders, which are part of a certified scheme, and not from unmonitored sources.

30. Seek consistency and transparency in reporting of hip scores (and other test results). These are currently reported differently in various countries, making it difficult to compare schemes and making relative progress impossible to ascertain. What's more, in the UK, mean hip scores are rarely quoted in relation to the numbers of dogs scanned or registered each year, and are often presented as simply one overall breed

score (the average of all dogs ever scored) rather than the averages for each birth-year cohort. Consistent, transparent reporting would enable inter-country comparisons, and allow improvement to be measured over time.

31. Development of an accreditation scheme for breeders, breed societies, and veterinarians. Such a “kite mark” could provide a positive incentive to encourage progress in improving welfare. A system of rewards that authenticates both breed societies and individual breeders who prioritise the health and welfare of their dogs should be administered by a welfare charity, a specific welfare section of the Kennel Club (KC), or an independent overseeing body. Current KC accreditation of breeders is not ideal since “there are no formal checks on breeder compliance” for those health screening tests that are only recommended (section 4.7.3).

Accreditation of a breed society should be based upon the society’s ability to demonstrate that members and buyers are provided with ready access to current, accurate information and derivation of a management plan and breeding strategy to improve the health and welfare of the breed. Accreditation should be reviewed at regular intervals (e.g. 3 or 5 years), and if targets are met the society could be rewarded with enhanced accreditation status (e.g. bronze, silver and gold) and new targets set. Evidence, for example, of a reduction in the number of close matings could thus be rewarded.

Accreditation of breeders could similarly be based on evidence of efforts to take a responsible role in improving the breed, for example by prioritising health, functionality, temperament and quality of life, increasing genetic pools (e.g. when the average of the parental Estimated Breeding Values is on the favourable side of the kennel average and/or the breed average) avoiding close inbreeding and line breeding, educating customers and potential buyers. A similar system could be developed to accredit veterinary practices which show positive initiatives.

Poorly supported actions

32. Exploration of methods by which to penalise unethical breeding. Breeders known to contravene codes of ethics or to breed from animals diagnosed with heritable disorders should be barred from membership of their breed society and the Kennel Club, disqualified from showing, and the reasons publicised.

The potential for prosecution should be explored. However, there is the problem that in order to prove that a breeder knew that an animal had a heritable disorder, veterinary evidence would be required, which could involve breaking

client confidentiality. The duty of confidentiality is set out in the RCVS Guide to the Professional Code of Conduct (Rule 2A) and should not be breached in normal circumstances. The Guide suggests that a surgeon may report animal abuse to a responsible body such as the RSPCA, but that in normal circumstances the surgeon would be expected to discuss matters with the owner first, (Guide to the Professional Code of Conduct, Part 3 Annex c: Royal College of Veterinary Surgeons 2009)

There is also the issue that this course of action may lead owners/breeders to refrain from veterinary consultation, in order to avoid positive diagnosis. Thus, a more effective longer-term measure may be a system whereby breeding animals have to be confirmed free of disorder (see primary recommendation 9).

33. Production of neutered FI hybrids has been suggested as a healthy, yet equally lucrative alternative pet stock for breeders to consider (see McGreevy and Nicholas 1999). Owners often select specific breeds as they believe their physical and behavioural traits to be predictable. However, FI hybrids may also be as predictable as purebreds. It could be argued that this action would not improve the plight of pedigree dogs in general, as FI hybrids would not be part of the breeding pool. Hence potential breeding stock would not be increased and may even decrease in size. Breeding would also need to be closely monitored as recent trends for new hybrids e.g. Labradoodles and other “designer dogs” (The Independent, Saturday Magazine 2008), have resulted in irresponsible breeding and exaggerated and unproven claims of health benefits. However FI hybrids should be considered as a potential way to boost the health and welfare of pet dogs.

34. Prioritisation of animal welfare over financial gain by veterinarians when making recommendations about potential purchases, matings and treatments. They should advise owners not to breed from animals when the potential suffering to the offspring or parent is significant. Training for veterinarians on how best to determine this would be valuable, potentially as Continuing Professional Development (CPD), or as a specialist course (e.g. a diploma), and an accreditation system (action 31) may help provide positive incentives and recognition for responsible vets.

35. Production of a safe, honest feedback mechanism to help empower potential pedigree dog buyers and breeders. When buying a car, information is freely available on likely pitfalls of each make and model, often provided by previous customers. It would seem ethical and responsible that

similar information is collected for breeds of dog. This should be encouraged for individual breeders, and also in a more formalised way. An open forum for discussion of good and bad experiences of particular breeds or breeders could be initiated, or a satisfaction index could be generated on a website similar to EBay (2008), in which sellers are rated by their customers. Any such system would need to be carefully designed to be independent, and to minimise the risk of self-reporting and potential cheating.

This scheme could be linked to an accreditation scheme (action 31), or a breeder warranty scheme (action 19), such that breeders provide the contact and email address for each of their customers. A log-on is then generated linked to their registration number and sent to the individual customer. Owners would be requested to complete data entry when the dog reaches a number of specific ages, and positive incentives offered (e.g. prizes, rewards etc). The age at which this information is recorded is critical since many inherited disorders have specific ages of onset. If set up carefully, this could be an ideal way of collecting and disseminating information on many aspects of breeds' health and behaviour, including potential problematic behaviours and owner satisfaction.

36. Utilisation of temperament assessments to select dogs which are best suited to the environment in which they will live.

One suggested step towards achieving this has been to introduce temperament tests at, or ahead of, dog breed shows (McGreevy and Nicholas, 1999). However, the use of temperament tests is controversial since their predictive value is questionable, behaviour varies from context to context (e.g. Vas et al 2008), and it would be possible for owners to train dogs to pass a specific test. A more effective way of driving the breeding community to select for temperament may be to collect feedback from owners on the behaviour, including problematic behaviour of their pedigree dogs and use this to compare breeds and breeders (e.g. based on the validated resource CBARQ; developed and used extensively by Serpell (2009)). This could be done using a dedicated web site which could form part of an accreditation scheme (action 31). New owners purchasing dogs from an accredited breeder would be requested to report on their behaviour at specific ages. This data could ultimately be used to derive Estimated Breeding Values (priority recommendation 14), so future breeding choices could be based on temperamental suitability.

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⁶ Respondents only contributed to the average ratings presented and hence individuals do not necessarily endorse the views expressed in this report