Demographics and Health of New Zealand Working Farm Dogs: A survey of dogs on sheep and beef farms in New Zealand in 2009.

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I hereby certify that the thesis has not been submitted for a higher degree at any University or Institution and work embodied in this thesis is my work unless noted otherwise in the acknowledgements.

Helen Sheard

Dedicated to Belle, Jack and Hoon, Huntaways supreme; and to Shears and Bubbles – you know who you are.

Abstract

The aim of this study was to investigate the demographics, disease prevalence and risk factors for death in a population of working farm dogs in the lower North Island of New Zealand. To this end, a cross-sectional study of working farm dogs was undertaken in 2009. Owners were randomly selected from farms in the lower North Island of New Zealand using Agribase^{TM}, a farm database maintained by AsureQuality. All owners were interviewed by one researcher. Completed surveys were received from 118 farms, providing data for 1,115 dogs. Any dog that had been present on the farm in the 12 months preceding the survey was eligible for inclusion. By using this criteria data was able to be collected from dogs that were dead or had been sold, as well as those that were alive. Data from dogs less than 6 months old were excluded on the premise that they did not contribute to the working population. 79% (n=885) of enrolled dogs were alive and on the farm at the time of the survey, 15% (n=167) were dead and 6% (n=63) had been sold or given away.

The average age of working dogs in the study population was 5.2 years (median 5 years, range 7 months to 18 years). Of the dogs enrolled in the survey, 653 (58.6%) were males and 462 (41.4%) females. For those dogs whose neuter status was known, 3.6 % of males (n= 23/647) and 10.4% of females (n=48/461) were de-sexed. The majority of breeds were the NZ Huntaway (n=531/1115, 47.6%) and the NZ Heading dog (n=402/1115, 36%). The majority (73.4%) of dogs were fed once daily, in the evening, primarily on a diet of home-kill sheep meat (58.3%, n=427).

During the study period, 1,267 health events were recorded from 1,115 dogs. Of the recorded health events, 69.9% (n=886) were described as non-trauma events, 28.3% (n=358) were described as trauma events, and 1.8% (n=23) were described as congenital events.

The health event most commonly reported by the owner (n =210, prevalence 18%), was the dog being underweight. Arthritis was the next most common health event reported, with a prevalence of 10.22% (n=114 cases). Injury or excessive wear to the pads was the most commonly reported traumatic event (5.56%, n=62), however the musculoskeletal system and integumentary systems were equally involved in traumatic events. Forty-eight dogs suffered limb fractures (4.3%) and 30 were injured by stock (2.69%).

Variables that increased the risk of a dog being dead were suffering more than one non-trauma event ($p<0.0001$), and residing on farms that had larger numbers of dogs present. When compared with dogs ≤ 2 years of age, the risk of a dog being dead decreased in ages between two and seven years. Dogs that were considered to be underweight, or those that had suffered an axial/limb fracture, were less likely to be dead than those that had not. Analysis of the data in this survey found no significant risk associated with career stage, breed, sex, neuter status, working on a farm with steep terrain, arthritis with or without lameness, or musculoskeletal injury.

Future research could focus on the importance of nutrition in the prevention of disease and injury; for example, constipation and musculoskeletal injury. The ideal body condition score, optimum diet composition and frequency also require investigation. Further to this survey, risk factors associated with a dog being lost from the working population due to death or euthanasia need to be identified so preventative measures can be developed.

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And as always, to family and friends who are there keeping things real.

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List of Abbreviations

>	Greater than
≥	Greater than or equal to
<	Less than
≤	Less than or equal to
95% CI	95% Confidence interval
IQR	Inter-quartile range
REF	When calculating relative risk, the REF (reference) is the value used for comparison to other relevant values
NZ	New Zealand

1 Introduction

Working farm dogs are an important and often necessary part of the workforce for many forms of agricultural endeavour in New Zealand. There are two main breeds of working farm dogs in New Zealand, the Huntaway and the Heading dog. Because they are bred for performance rather than appearance, there is a wide range of phenotypes in both breeds. In essence, the Huntaway is a noisy breed, required to bark and move stock ahead of him. The Heading dog is quiet, nimble and fast, and is used to turn mobs of stock, quietly manoeuvre them and split off individuals from the flock. The work they are required to perform, and the environment in which they do it, is markedly different from other groups of working or performance dogs, such as greyhounds and military working dogs. The range of illness and injury they suffer from would as such also be expected to differ from other groups of working dogs. In order to reduce incidence of disease and injury in working farm dogs, it is important to first determine the most prevalent types of disease and injury, and to then identify potential risk factors.

This thesis presents the results of a cross-sectional survey of working farm dogs on sheep and beef farms in 2009, investigating their demographic data and disease incidence. Chapter 2 of the thesis is a review of the current literature relating to working dog disease and injury in New Zealand, with some comparison to pet dogs, and to working dog populations overseas.

Chapter 3 presents the results of the cross-sectional survey. Demographic data including age, sex, neuter status, career stage and diet are presented. The prevalence of disease and injury are then investigated. Risk factor analysis is then presented comparing various injuries and demographic data with the probability of a dog being dead.

The thesis concludes with a general discussion of the results. References cited in the text are listed at the end of the thesis. Where ‘working dog’ is mentioned in the text, it refers to the New Zealand working farm dog unless otherwise stated.

2 Literature review

2.1 Introduction

The history of New Zealand's working farm dogs is inextricably entwined with the development of agriculture (Hughes, 2013). The first sheep to land in New Zealand were two Merinos brought to Marlborough by James Cook in 1773. Both failed to thrive and died before producing any offspring. The next major influx of sheep occurred in 1834, when Merinos from Australia were landed on Mana Island, before being moved to the Wairarapa. From 1840 on, more sheep were imported from Australia to graze the rapidly expanding arable land as bush and scrub was cleared (Dalton & Orr, 2004). It is thought that the original working farm dogs were British Border Collies brought to New Zealand by shepherds in the mid 1800's, when sheep numbers were increasing (Hughes, 2013).

Today working dogs are still an integral part of New Zealand's farming enterprise; indeed many sheep and beef farms could not operate without the effort of their dogs. It is estimated that New Zealand has as many as 200,000 working farm dogs (Cave *et al.*, 2009) in the agricultural sector, more than any other country except Russia (Farman *et al.* 2009). An Australian survey has found that over their lifetime, herding dogs contribute $40,000 worth of work, while costing their owners only $7,700, equating to a five-fold return on an investment (Arnott, 2013). It has been estimated that New Zealand's working farm dogs travel an average of 20 $\pm$ 1.3km per day during peak periods (Singh 2013), and Australian herding dogs covered approximately 21 km per muster and reached speeds of up to 44km/hr (Hampson & McGowan, 2007).

Both Huntaways and Heading dogs are thought to have developed from the British Border collie. The Huntaway was selectively bred to produce a black and tan barking dog that can move stock away from them. Huntaways are more solid than the Border collie, ranging from 25 to 30kg, and usually have a short coat and black and tan colouring. The Heading dog has retained the quiet manner of the Border collie, used to work silently, round up mobs of stock and bring them back to the shepherd. Heading dogs are lighter and quicker than Huntaways, ranging from 15 to 20kg and usually black and white, or black, tan and white, although there is great variety in the phenotype of both types of dog. The first sheep dog trials in New Zealand were recorded in Wanaka in 1867, Waitangi and Te Aka in 1868, and at Haldon Station in the MacKenzie Country in 1870 - all before the 1873 trial at Bala in New South Wales, which is claimed to be the first. The first Huntaway trials were recorded at Black Forest Station near Lake Benmore in 1870, so it could be assumed that by this time the Huntaway had been developed as a unique entity (Dalton, 2012).

Although there are many studies investigating the health and welfare of military service dogs (Evans, 2007; Moore, 2001), sled dogs (Bajer, 2011) and greyhounds (Davis, 1973; Ferguson, 2010) there are relatively few papers on the prevalence of disease in working farm dogs; dogs that require both speed and endurance ability. Several papers have been published on individual diseases in the New Zealand working farm dog; for example hip dysplasia (Hughes, 2001) and chorioretinitis (Hughes & Joyce, 1981) which are important because the authors have felt that the prevalence of the disease in question was increasing. Other literature published in New Zealand appears to be case reports biased towards the unusual rather than the common, for example photosensitivity in collies (Fairley, 1982).

Surveys of working dog health and demographics undertaken by Cave *et al.* (2009), and Jerram *et al.* (2009a) have investigated different populations of working dogs, concentrating on the whole population rather than a specific disease focus. Cave *et al.* (2009) collected data from veterinary clinics while Jerram *et al.* (2009a) surveyed farmers selected at random from the Agribase database in the lower North Island of New Zealand. A survey of demographic data obtained through interviewing owners of dogs participating at events organized by the New Zealand Trial Dog Association has also been published (Singh *et al.* 2011).

New Zealand farm dogs are likely to share many of the problems of their companion animal counterparts, but because they are exposed to different environmental factors they could be expected to show higher rates of disease and injury. However there are few papers (Antony, 2003; McKenna, 1980) that compare rural and urban dogs in regards to specific diseases.

This review will cover demographic data, sources of loss and nutritional issues and will examine what is currently known about adverse health events in New Zealand's working farm dogs.

2.2 Demographics

To date there have been two published studies that investigated the demographics of different subsets of the working dog population in New Zealand (Cave, 2009; Singh, 2011). Cave *et al.* collected data on working dogs presenting to veterinary clinics and Singh *et al*. surveyed working dogs belonging to members of the New Zealand Dog Trial Association. Preliminary results from a third study have also been presented, in which owners of working dogs on farms were interviewed regarding the health and demographics of their dogs (Jerram *et al.*2009a).

Cave *et al.* (2009) collected data from 30 veterinary clinics located in the major rural farming regions of New Zealand. Any visits to the clinic involving working farm dogs were included in the survey. Of the 2,372 original visits, the majority (n=2,128) involved dogs from sheep and beef farms, with the remainder of dogs from dairy farms (n=111), sheep-only farms (n=55), beef-only farms (n=5), and from unclassified or ‘other’ farming enterprises (n=73). Unique identifiers for properties were not collected, and consequently several dogs from the same property may have been included. Where the breed of the dog was recorded, 51% were Huntaways, 39% Heading dogs, 4% Beardies, 3% crossbreeds, <1% were Blue Heelers and <1% were Smithfields (bobtail collie). This is in contrast to Singh *et al.* (2011) who found that Heading dogs constituted the majority of their study population (53%), followed by Huntaways (41%). The higher percentage of heading dogs in Singh *et al.* compared to dogs presenting at clinics could be due to sampling difference or may represent true differences in dogs owned by people who trial working dogs. Singh *et al.*’s (2011) inclusion criteria required that all dogs enrolled in the survey were also involved in regular farm work; however trial dogs may represent a different working subset from the general working dog population.

Both Singh *et al.* (2011) and Cave *et al.* (2009) found that there were more males in the working population (57% and 54% respectively) than females; however Singh noted that in dogs 10 years of age and older the percentage of males and females was almost equal, perhaps suggesting an increased lifespan in females. Cave *et al.* (2009) also found that the percentage of de-sexed working dogs presenting to clinics was low; only two percent of visits were for castrated males, and three percent for speyed females. Comparison to Singh *et al.* is not possible as neutering rates were not reported in that survey.

Singh *et al.* (2011) found that there were significantly more dogs located on farms with steep hill country than on farms with rolling or flat terrain. However, there was no apparent correlation between the farm size and the number of dogs on a farm. The study population in Singh *et al.*’s survey was relatively young dogs, with a median age of 3.0 years (IQR 2-6).

2.3 Causes of loss

When investigating the health of working farm dogs it is necessary to ascertain the reasons dogs are lost from the working population, due to retirement and death. Evans *et al.* (2007) found that in military working dogs the major reason for discharge from service in dogs over five years of age was spinal cord disease (30%). Other reasons included degenerative joint disease alone (14%), degenerative joint disease with spinal cord involvement (13%), cardiac disease (<2%) and gastrohepatic disease (<2%). The majority of dogs in this study were German shepherd and Belgian shepherd dogs. The work these dogs are required to do differs to farm work, so in regards to disease and injury there are likely to be differences between these breeds and New Zealand's working farm dogs. A similar study by Moore *et al.* (2001) found that of 927 military working dogs that died between 1993 and 1996, appendicular degenerative joint disease, neoplasia, spinal cord disease, non-specific geriatric decline and gastric-dilatation volvulus were the most common causes of loss from work. In New Zealand, Singh *et al.* (2011) reported that on 19% of farms in their study at least one dog was euthanased during the previous year, and the main cause was degenerative joint disease associated with old age. Cave *et al.* (2009) reported that eight percent of working dogs visiting veterinary clinics died or were euthanased. This figure is likely to be an underestimation of losses as it only focusing on those dogs presented to veterinary clinics and there was no follow-up after dogs had returned to the farm. Preliminary data from Jerram *et al*. (2009) reported behavioural problems as the most common reasons for death or euthanasia, particularly in young dogs.

2.4 Nutrition

2.4.1 Macronutrients

There is little data depicting the energy requirements of New Zealand working farm dogs. It has been estimated that working dogs need 1.5 – 3 times the maintenance requirements of pet dogs (Cave, 2009;Guilford, 1997; Singh *et al.*, 2011), and that work undertaken in cold weather could increase energy needs by 50% (Singh *et al.*, 2011). Due to increased muscle catabolism when a dog is exercising, working dogs would be expected to have a higher requirement for dietary protein than sedentary non-working dogs. However, an exact minimum requirement for an optimum protein content has not been set (Hill *et al.*, 2009). High protein diets have also been proposed to help reduce the occurrence of both stress fractures and tendon and ligament injury (Cave, 2009; Singh *et al.*, 2011). Other proposed benefits of feeding a high protein diet include higher nutrient digestibility, a slower release of glucose into the blood, and a reduction in large intestinal fermentation of carbohydrate. These benefits were suggested by Hill *et al.* (2009), who compared two diets with different levels of protein, fed to a group of adult Harrier hounds. These dogs were chosen as they were genetically similar and were used for work similar to that of working farm dogs. One diet was comprised of a high protein (49.4%) and low carbohydrate (13.3%) dry baked biscuit formulated specifically for the trial; the other diet was comprised of a low protein (21.6%), high carbohydrate (45.3%), baked biscuit commercially available in New Zealand. It is believed that a source of carbohydrate is not necessary in the diet of adult dogs, as long as there is adequate protein and fat to provide glucose precursors (Hill *et al.*, 2009). Nevertheless, most commercial diets include significant quantities of carbohydrate as it is a relatively cheap ingredient (Hill *et al.*, 2009).

The dietary proportions of fat, protein and carbohydrate can be altered to influence the energy source selected during exercise. At rest muscles preferentially use fat as their fuel source. The most efficient of these lipids are non-esterified fatty acids (NEFA) which are metabolized to release energy relatively slowly. As the dog’s exercise intensity increases, glucose becomes the predominant source of energy (Cave, 2009). For example, greyhounds are reliant on carbohydrate, which is stored in the muscle as glycogen and can be quickly metabolised for sprints. Dogs used for endurance preferentially use free fatty acids for muscular work. A study by Hammel *et al.* (1977) concluded that as far as glucose homeostasis was concerned, sled dogs had no need for carbohydrate in their diet. High fat (>46%) low (26-28%) carbohydrate diets increase the storage of fat within muscle, and also the rate of fat usage, thereby increasing endurance through preserving muscle glycogen stores. Feeding high carbohydrate diets can also increase glycogen storage in muscle; however high carbohydrate intake also increases the rate at which it is metabolised, thus negating its effect. Therefore muscle glycogen is preserved more effectively by feeding high fat diets (Cave, 2009), and as such it would appear that the ideal working dog diet would include high fat and low carbohydrate levels.

Dogs fed diets that are low in protein have been found to have a higher incidence of both orthopaedic and soft tissue injuries. A study by Reynolds *et al.* (1999) found that even with a difference of 19% metabolisable energy as protein versus 24% metabolisable energy as protein, sled dogs in the lower protein group experienced eight times more musculoskeletal injuries. The timing of feeding may also affect the incidence of musculoskeletal injuries. Feeding a readily digestible protein source within two hours of exercise has been shown to promote recovery from muscle fatigue, and digestible carbohydrate sources given during or immediately after exercise improves endurance and promotes greater muscle glycogen repletion (Cave, 2009).

Poor immunity and susceptibility to infection and poor skin healing have also been said to be associated with suboptimal diets in New Zealand working dogs (Guilford, 1997). However, other than musculoskeletal injuries, no specific studies have investigated a relationship between diets and poor health.

2.4.2 Micronutrients

Singh *et al.* (2011) found that the vast majority of working dogs (97%) were fed once daily, with a combination of home-kill meat and commercial biscuits. The amount of each component fed increased with increasing workload but the composition remained largely unchanged. A small percentage of dogs were fed rolls, jellimeat and table scraps, but these components were to supplement the diet rather than form a large component. Similarly, Guilford (1997) found that working dogs were most commonly fed 60% home-kill meat, and 40% commercial biscuits. Feeding farm-kill mutton is likely to be deficient in or have marginal concentrations of a number of vitamins and minerals such as iodine, copper, and vitamins A, E and B12 (Cave, 2009). Iodine deficiency has been observed in abattoir dogs fed long-term on a mutton only diet (Nuttall, 1986). Good quality commercial dry diets are likely to compensate for the vitamin and mineral inadequacies of meat, as long as meat comprises no more than 30% of the diet (Guilford, 1997). Without bones a meat-only diet (whether beef or mutton) is also likely to be deficient in calcium and phosphorus; however feeding bones has all the potential risks of perforation or obstruction of the bowel, and constipation (Singh *et al.*, 2011). It would appear that feeding commercial biscuits and farm-kill meat together still presents nutritional problems. While farm-kill meat can be deficient in a number of micronutrients, commercial dog biscuits contain high carbohydrate concentrations and so large quantities of both of these feeds need to be consumed for the dog to meet its minimum nutrient requirements (Hill, 2010b). As the majority of working dogs are fed only once per day (Singh *at al.* 2011), it may not be physically possible for the dog to consume enough food to meet its nutrient requirements.

Following legislation banning the feeding of raw offal to working dogs, and recommending freezing or cooking of meat before feeding, a neurological syndrome associated with suspected thiamine deficiency has been recognized. This syndrome has been associated with feeding boiled mutton, rendered scraps or improperly rendered dog rolls (Mayhew & Stewart, 1969). Selenium deficiency may also occur, as a condition similar to 'white muscle disease' in lambs was found in an adult working collie and a litter of pups fed a farm-kill meat only diet, on a farm that had a history of selenium deficiency in its sheep flock (Jolly *et al.*, 2002a).

It is evident from these papers that more work is required to determine the optimum levels of nutrients in the diet of working farm dogs. It would also be necessary to determine the ideal feeding schedule, to take into account energy supply for exercise, balanced against the risk of feeding related diseases such as gastric dilatation volvulus. It would also be interesting to determine how farmers estimate the amount to feed each dog; whether it is based on body condition scoring, and what they consider the ideal body condition score for a working dog.

2.5 Adverse health events

Although there are many studies investigating the health and welfare of military service dogs (Evans, 2007; Moore, 2001), sled dogs (Bajer, 2011) and greyhounds (Davis, 1973; Ferguson, 2010) there are relatively few papers on the prevalence of disease in New Zealand's working farm dogs. There are several papers on individual diseases, for example hip dysplasia and chorioretinitis that have been published because the authors have felt that the prevalence of the disease in question was increasing. Other information published in New Zealand appears to be biased towards the unusual, rather than the common (Cave *et al.*, 2009). The surveys of working dog health and demographics undertaken by Cave *et al*. (2009) and Jerram *et al.* (2009a) have investigated different populations of working dogs, concentrating on the whole population rather than a specific disease focus.

Jerram *et al.*(2009a) presented preliminary data from a large cross-sectional survey of working dogs on sheep and beef farms in the lower North Island of New Zealand. The farms were randomly selected through Agribase, a database of rural properties maintained by AsureQuality, and at the time of publication 44 farms had been visited and data collected on 479 dogs. Of 479 dogs surveyed 230 (48%) had suffered at least one adverse health event in the 12 months preceding the survey. Excluding behavioural problems, joint, limb and skin injuries or disease were most common. Cave *et al.*'s (2009) survey of veterinary practices collected data on 2,214 presentations, excluding revisits, involving working dogs. Trauma was identified as a cause of injury in 38% (n=848/2,214) of visits, while the remainder of visits were for non-traumatic disease (n=1,024/2,214), for visits where cause was unknown, or for vaccinations. Loss was reported to have occurred following 10 - 11% of visits (the percentage of loss had been calculated using both the number of visits excluding and including revisits). This is likely to have been an underestimate of the true population as there was no long-term follow-up after visits, and the data did not include dogs that had died on farm without visiting a veterinary clinic.

The following five sections will discuss individual conditions that could be considered as adverse health events in the working dog population.

2.6 Toxicity/Poisoning in working farm dogs

Farm environments have a number of chemicals that working dogs can potentially gain access to including herbicides, pesticides, stock feed additives and animal remedies (Parton, 2002). However as there are strict regulations concerning the storage of these chemicals it may be that poisonings in farm dogs are less common than in companion animals in urban or semi-rural areas. Unfortunately there is no data available to compare the incidence in these two populations. Cave *et al.* (2009) found that anticoagulant poisonings were the most common toxicity reported in working dogs, (n = 36/1,024 non trauma visits) followed by metaldehyde (n=3) and ivermectin (n=1), organophosphate (n=1), rumensin (n =1) and paraquat (n=1). Both ivermectin and rumensin (ionophore) toxicities can occur through chewing on regurgitated capsules, or capsules scavenged from carcasses (Agnew, 1996). Other reported poisonings include arsenic from pelt treatments (Bruere, 1980), and secondary phosphorus poisoning when phosphorus baits were used for possum control and dogs subsequently ate the carcasses (Gumbrell & Bentley, 1995).

2.6.1 MCPA toxicity

Hasselman (2001) reported a case of poisoning involving MCPA (4-chloro-2-methylphenoxy acetic acid) which is one of the phenoxyacid herbicide group of chemicals, widely used in New Zealand. MCPA had been mixed with a fish based fertilizer in order to spray paddocks. The solution was unable to be used, so was discarded and partially buried. Eight dogs in total were affected, four of which died. Two of the affected dogs had been seen eating a white substance off the ground where the solution had been buried. Clinical signs included ataxia and stupor which quickly progressed to coma and death. Other clinical signs in the surviving dogs included vomiting, diarrhoea and dysphagia.

2.6.2 Macrocyclic lactone toxicity

Macrocyclic lactone toxicity can occur in any breed of dog, however those dogs carrying the ABCB1 mutant allele are more sensitive to macrocyclic lactones as the drug more readily crosses the blood-brain barrier into the central nervous system. The toxic dose is 0.12 mg/kg for homozygous mutants, compared to 2mg/kg for homozygous normal dogs. It is thought that for heterozygotes the toxic concentration is between 0.12 – 2 mg/kg (Gieseg & Parton, 2012).

As there are a large number of sheep and cattle drenches containing abamectin, ivermectin and moxidectin, farm dogs are likely to have a higher risk of exposure to macrocyclic lactones than urban dogs. Toxicity can occur through direct ingestion, through skin absorption, and also through ingestion of faeces from livestock and horses treated with macrocyclic lactones. Horse drenches in particular may provide a greater risk of ingestion by dogs as many have a flavour additive that may be attractive. Some dogs will be intentionally treated with macrocyclic lactone-containing drenches by owners, believing them to be safe products for this purpose (Parton *et al.*, 2012).

2.7 Non-traumatic diseases

2.7.1 Disease of the gastrointestinal system

In the study by Cave *et al.* (2009), nine percent of all original veterinary visits were related to conditions of the gastrointestinal tract. The preliminary results published by Jerram *et al.* (2009a) investigating different groups of working dogs (working, semi-retired, retired and dead/destroyed) also found that between three and 10% of dogs had some kind of gastrointestinal disease in the 12 months preceding the survey.

Constipation

Constipation can be a debilitating and costly disease, and was found to be the single most common diagnosis in Cave *et al.*'s (2009) survey. Entire males were overrepresented (n=31/51), as were Huntaways (n=43/51). Contributing factors to constipation include ingestion of wool, hair and bone, dehydration, infrequent opportunities to defaecate, and suboptimal feeding practices. However, these factors are not likely to vary significantly between different breeds of dog on the same farm, leading Cave *et al.* to suggest a difference in colonic function in the Huntaway that may predispose the breed to constipation. Prostatic enlargement in ageing entire males is also likely to contribute to the risk of constipation. Cave *et al.* (2009) found that enlarged prostates were implicated in cases of constipation in six dogs.

Further investigation is required into the predisposing factors for constipation in working dogs, and why Huntaways are overrepresented. Possible factors may be differences in prostatic enlargement between Huntaways and Heading dogs. Huntaways are also overrepresented in cases of lumbosacral disease, as Cave *et al.*'s (2009) survey has shown. It may be that neurological disease as a result of lumbosacral stenosis affects the ability to defaecate, thereby predisposing to constipation.

Gastric dilatation volvulus

In Cave *et al*. (2009) gastric dilatation volvulus (GDV) was the second most common diagnosis after constipation recorded in working dogs, and was the fourth most common reason for loss. Cave *et al.* reported that 33 out of 36 cases of GDV involved Huntaways. Further analysis of this data by Hendriks *et al.* (2012) using a case-control study design found that after adjusting for other potential confounders, Huntaways were 17 times more likely than heading dogs to experience a GDV. Anatomy and genetics, feeding practices, exercise demands and housing are all likely to play a role.

With regards to anatomy, chest conformation as well as breed size is important: those dogs within a breed which have an increased thoracic depth to thoracic width ratio are at greater risk of GDV (Glickman, 1996). It is postulated that this conformation results in stretching of the gastric ligaments over time as the stomach is filled with digesta, making it more prone to rotate about its axis. When compared to German shepherds, Collie-type breeds (such as the Heading dog) are at lower risk of developing GDV due to their lower thoracic depth to thoracic width ratio (Glickman *et al.*, 1996).

Although Hendriks *et al.* (2012) reported no significant association between sex, body weight and risk of GDV, Glickman *et al.*'s (2000) study of military working dogs, the majority of which were German or Belgian shepherds, found the risk of GDV increased with increasing bodyweight and was greater in males. However, an earlier study by the same author found no gender associated risk (Glickman *et al.*, 1996). Other predisposing factors found by Glickman *et al.* (1996) included a thin body condition, being fed only one meal per day, eating rapidly, being fed a diet with a high proportion of fat, and having a fearful or anxious temperament.

Raghavan *et al.* (2006) investigated the effect of different ingredients in dry food rations. It was found that dry foods containing an oil or fat amongst the four main ingredients were associated with a significant 2.4-fold increased risk of GDV. In an earlier study by the same author (Raghavan *et al.* 2004), 1,634 dogs were recruited and followed for five years. Six percent (n=106/1,634) of the study population developed GDV. It was found that larger volumes of food per meal increased the risk of GDV regardless of the number of feeds per day. For both large and giant breeds of dog, the risk of GDV was highest if fed a large volume of food once daily.

Studies in military working dogs overseas has shown that meteorological changes may play a role, as Moore *et al.* (2008) found that 47% of GDV cases occurred in winter and often after large hourly drops in temperature, although this was found to be a weak association. Moore *et al.* (2008) also suggested an increased risk of GDV with higher minimum barometric pressure the day of, and the day prior to, a GDV case. Although there was an association between barometric pressures and incidence of GDV, Moore *et al.* found that barometric pressures were not reliable predictors of GDV occurrence.

A retrospective study by Jennings & Butzin (1992) of 914 military dogs that died between 1987 and 1989, found that 31 (3%) deaths were attributed to GDV or its complications. The majority were entire male German shepherds between six and 10 years of age. As German shepherds have a similar body type to Huntaways, this percentage of loss may be similar in New Zealand Huntaways. However as the diet and type of work performed is likely to be different from military working dogs, this percentage loss should not be extrapolated directly to working farm dogs.

In New Zealand working farm dogs most cases of GDV occurred in summer and risk increased with age, and where recorded, most had food, bones or other indigestible contents in the stomach. This is in contrast to other breeds and overseas studies where gas was the predominant stomach content (Hill, 2010a). Therefore gastrotomies may be required more often in NZ's working farm dogs causing Hendriks *et al*. (2012) to raise the question: Does performing a gastrotomy affect the prognosis? Certainly decompression alone, without performing a gastropexy, has a poor prognosis. Jennings & Butzin (1992) found that dogs which had a prior history of acute gastric dilatation or GDV that were decompressed by non-surgical means (i.e. no gastropexy performed) eventually died as a result of GDV. Hendriks' (2012) study found that 50% of farm dogs with GDV were found by their owners in the morning. Due to farm feeding practices (one meal per day, fed in the evening) GDV is more likely to develop during the night, and so when first found the dog may have been suffering from GDV for several hours. This may well contribute to the mortality rate of 35% that was seen in Hendriks *et al.*'s study.

The conditions observed as risk factors for GDV in other populations of dogs overseas are likely to differ in regards to New Zealand farm dogs; therefore further work is required to identify the risk factors specific to working farm dogs in New Zealand.

Gastrointestinal parasitism

In Cave *et al* (2009) only two of 1,024 non-trauma related visits were attributed to intestinal parasitism. This may be an under estimation of the prevalence of intestinal parasitism as owners of farm dogs may be less likely to seek veterinary assistance for this problem. However, while interviewing farmers, Jerram (2009a) found that many farmers raised questions regarding the appropriate anthelmintic product and a suitable protocol for "worming" their dogs.

Like other hosts, dogs are susceptible to a wide range of helminth and protozoan parasites, some of which are of zoonotic importance. Those that feed on blood or tissue (e.g. the whipworm *Trichuris vulpis* and the hookworms *Ancylostoma caninum* and *Uncinaria stenocephala*) have the potential to severely affect the working ability of infected dogs. A Polish study by Bajer *et al.* (2011) investigating parasitism in racing sled dogs found that the number of dogs housed together and age of the dog were the most important risk factors for intestinal parasitism. Interestingly, Bajer *et al.* found that the prevalence of intestinal protozoa was significantly higher in dogs that were free of nematodes, than in dogs that had nematode infection. The highest prevalence of parasites affected dogs in kennels housing more than three dogs, in dogs less than two years of age, and in kennels where prophylactic treatment was carried out between one and four times per year. A New Zealand study using working farm dogs (O'Connell, 2013) found that dogs less than two years of age had higher prevalence of both Toxocara canis and Giardia spp than older dogs. O'Connell also found that the prevalence of parasitism was higher in females than in males, and that the frequency of worming had no significant effect on the likelihood of dogs having a positive faecal egg count. This suggests that there are other factors in New Zealand that increase the risk of gastrointestinal parasitism, such as being housed on the ground, being fed in the same area in which they defaecate and faeces being allowed to build up in the kennelling area (Guilford, 1997). Helminth parasites of farm dogs are also important because of their life cycle relationship with other species, such as *Taenia ovis*, *Echinococcus granulosus* and *Taenia hydatigena*. Although *Echinococcus* has been virtually eradicated *T. ovis* still remains an industry concern (Jolly *et al.*, 2002a).

Studies into coccidia in rural dogs in New Zealand found that 63% of faecal samples contained coccidia. Mixed ‘infections’ with different species of coccidian were found in 24% of samples from rural dogs, significantly higher than in urban dogs (four percent ‘infected’). At the time of this study ten species of sarcocysts were identified as being transmitted by dogs. Intermediate hosts for at least five of these have been found to infect stock animals such as pigs, sheep, cattle, goats and horses, however it has not been identified conclusively that the infections they were harbouring were in fact transmitted by dogs (McKenna & Charleston, 1980).

No studies were found investigating whether current worming protocols in working dogs are effective in reducing gastrointestinal parasitism. Given that many farmers use a tape wormer monthly to reduce incidence of sheep measles cysts, there would be merit in investigating whether there is any indication of helminth resistance developing.

2.7.2 Disease of the Integumentary system

There is little information concerning the incidence of skin disease in working farm dogs, and whether there is any difference when compared to companion or pet dogs. A paper presented by Bell (1997) is based on the personal experience of a handful of clinicians. The author suggests that skin disease may be underreported, as unless it is severe enough to interfere with the dog's ability to work, it is less likely that veterinary treatment will be sought. Trauma to the integument is likely to predispose to bacterial infection. Bell (1997) found that bacterial pyoderma, particularly pododermatitis and cellulitis from nail-bed trauma, is likely to be the most concerning as far as affecting work ability.

Cave *et al.* (2009) postulated that working dogs would be predisposed to atopic skin disease, as both Border collies and German shepherds are thought to be included in the ancestry of working dogs, and both breeds are genetically predisposed to atopic skin disease. However Cave *et al.*'s survey found that veterinary visits related to allergic skin disease were uncommon. Of 1,024 visits not associated with trauma, 15% (n=149) were for skin disease and the majority (n=96/149) were for infection, abscess or cellulitis. External parasites were found in 23 visits (n=11 *demodex spp*, n=6 fleas, n=4 *otodectes* and n=2 *sarcoptes*). Non-parasitic pruritus was seen in 54 visits, with causes including otitis externa, pododermatitis and suspected atopy (Cave *et al.*, 2009). Generalised demodecosis seems to be rare in the working dog population. Other skin diseases seen occasionally are sternal and pressure point callus, flea allergy dermatitis (often with marked seasonality due to outdoor housing), hookworm pododermatitis and photosensitivity reactions (Bell, 1997). Photosensitivity reactions have been described by Fairley (1982) in two collies that were anorectic and depressed, and had areas of acute exudative dermatitis confined to areas of non-pigmented skin. In several areas the skin became necrotic and sloughed, and the condition was intensely pruritic. No underlying cause was found. One affected bitch continued to be photosensitive for several months after the initial skin lesions had clinically resolved. The condition would appear to be rare, and limited to collie-type dogs due to their non-pigmented skin in areas of white hair coat.

Further investigation is required into the degree of allergic skin disease in working dogs. It may in fact be uncommon; or it may be that the dogs are rarely observed when not at work, when they are more likely to show signs of scratching. It may also be that unless pruritus or hair-loss is severe, treatment is not sought as it is unlikely to affect their ability to work. Another area of importance is nail-bed infection, due to its potential to cause osteomyelitis and require possible amputation of the third phalanx. Methods for early and aggressive treatment in these cases warrant further investigation.

2.7.3 Disease of the Respiratory system

Cave *et al.* (2009) found that respiratory disease was a relatively uncommon reason for working dogs to be presented to a veterinary clinic. The authors found this result somewhat surprising given the environment dogs are expected to work in; athletic demands, exposure to inhaled aero-allergens and the likelihood of stress and suboptimal nutrition would be expected to predispose to lower airway disease. Of the dogs presented with respiratory diseases upper respiratory tract disease was most common; primarily laryngitis, resulting in dysphonia in half of those cases. Laryngeal paralysis was noted in two out of 18 cases of laryngeal disease. All dogs that presented with laryngeal disease were Huntaways and Bearded collies, i.e. those breeds required to bark. Although dysphonia can occur with viral and bacterial infection, gastro-oesophageal reflux or laryngeal hemiplegia, it can also result from excessive barking (Cave *et al.*, 2009), which may occur with extended periods of work or may be a behavioural issue. The results from Cave *et al.*'s survey are likely to be an underestimate of the prevalence of respiratory disease in the population, as it is likely mild cases of respiratory disease are treated conservatively on farm with rest, and only severe or chronic cases are presented to a veterinary clinic.

Kennel cough

Meyer *et al.* (2010) describe an outbreak of kennel cough in a group of East Coast working dogs on a large station, involving 15 resident dog teams of between 10 and 12 dogs, plus additional casual mustering teams during busy seasons. Three dogs died during the outbreak with histological signs of severe sub-acute necrotizing bacterial bronchopneumonia. Culture from lung samples recovered heavy growths of beta-haemolytic Streptococci. Nasal swabs cultured heavy growths of beta-haemolytic Streptococci, *Staphylococcus intermedius* and *Klebsiella spp*., which were found to be resistant to clindamycin and doxycycline. The outbreak seems to have originated from a casual mustering team that had two dogs die suddenly soon after arrival on the station. A positive influenza ELISA result was found in one surviving resident dog that had been coughing for three days. However acute and convalescing samples found no evidence of seroconversion to Influenza A so the involvement of this virus in the outbreak was ruled out.

Pyogranulomatous disease

Due to the environment in which they work and the possibility of chest wall trauma from vehicles or stock, farm dogs are thought to be more at risk for intra-thoracic pyogranulomatous disease than companion animals. Doyle *et al.* (2009) described four cases seen at Massey University Teaching Hospital. All were large breed male dogs between four and seven years of age, and actively involved in farm work. Clinical signs included anorexia, weight loss (usually acute and severe), dyspnoea and pyrexia. A grass awn foreign body was discovered in one case. The larger airways and increased contact with seeding grasses are thought to increase the risk of inhaled grass awn foreign bodies in large breed working dogs. The authors considered it reasonable that both inhaled foreign material or licking of thoracic wounds could result in intrathoracic pyogranulomatous disease. Previous studies have indicated that the source of bacteria in canine pyothorax cases could be the oral cavity (Walker *et al.*, 2000). *Streptococcus* and *Actinomyces* species are those most commonly isolated from known grass-awn related infections, and are also found in the canine oral cavity (Doyle *et al.*, 2009). *Nocardia* is a ubiquitous soil bacterium that gains entry to the body through inhalation or inoculation via puncture wounds, and has also been associated with grass awn foreign bodies (Ribeiro, 2008; Kirpensteijn, 1992).

Mycobacterium bovis

Gay *et al.* (2000) reported a German shepherd dog that became infected with pulmonary *Mycobacterium bovis* after eating a possum. The authors postulated that the German shepherd breed may have an immunity defect that allowed this infection to develop, a theory that has been investigated previously in regards to various diseases in which German shepherds seem overrepresented (Day, 1985; German, 2000). It is feasible that farm dogs may also be at risk due to the presence of bush and possum habitat, and the possibility of infected cattle or deer herds. No reports were found of working farm dogs affected by pulmonary *Mycobacterium bovis*, and Cave *et al.* (2009) found that respiratory disease in general was an uncommon cause for presentation of working farm dogs to veterinary clinics. This may indicate that *Mycobacterium bovis* infection is rare in dogs; or it may represent successful control of the possum population in *Mycobacterium bovis* endemic areas. More research would be needed to determine the risk of *Mycobacterium bovis* infection in working farm dogs.

Oestrus ovis

Oestrus ovis is a common parasitic infection in New Zealand sheep. The *Oestrus ovis* fly deposits its larvae in the nasal cavity, which then develop through three larval (instar) stages in the nasal fossae and cranial sinuses. There are occasional reports from overseas of ocular myiasis and more rarely nasal myiasis in people, and nasal myiasis has been reported rarely in dogs overseas (Heath, 2001). In atypical hosts the larvae do not often develop past the first instar, however in dogs they may develop to the third instar stage. In dogs sneezing is the most common clinical sign, which resolves once the larvae are expelled. In New Zealand there has been one report of *Oestrus ovis* nasal myiasis in dogs. The infected animal was a sheepdog with persistent sneezing over six months, with no nasal discharge or other clinical signs of illness. The affected dog in this case was diagnosed by flushing a first-instar larvae from the nasal cavity, and no other treatment was given. Treatment with ivermectin may be successful but requires high doses (200µg/kg) (Heath & Johnston, 2001).

2.7.4 Disease of the Reproductive system

Cave *et al.* (2009) found that 19% (n=197/1,024) of veterinary visits unrelated to trauma were for diseases of the reproductive system. Huntaways appeared to be overrepresented for mammary neoplasia, pyometra/endometritis, vaginal prolapse and vaginal hyperplasia. Mismating was also common. Methods of treatment following mismating included medical in 28 dogs, surgical in eight dogs (speying) and were unrecorded for the remaining five. Benign prostatic hyperplasia was diagnosed in 15 dogs. It was not noted whether benign prostatic hyperplasia was more commonly seen in a particular breed.

Malignant mammary tumours are the most commonly diagnosed neoplasm of female dogs, and they are significantly more common in intact females, which make up the majority of the female working dog population (Worth, 2005). The majority of these reproductive diseases can be prevented with de-sexing, however since breeding is often delayed until work performance is proven, dogs remain intact well into adulthood. In Cave *et al.'s* (2009) survey only two percent of males and three percent of females were de-sexed, indicating the potential for reducing the prevalence of reproductive disease by encouraging de-sexing as soon as breeding replacements is accomplished.

2.7.5 Ocular disease

Hughes and Joyce (1981) observed that retinal disease was an increasing problem in New Zealand's working dogs in the late 1970s. The pair surveyed adult working dogs at national dog trials and found retinal lesions in 48% of 371 dogs examined with an ophthalmoscope. Both Huntaways and Heading dogs were affected and the authors concluded that it was not analogous to the central Progressive Retinal Atrophy seen in the British Border collie. A later study by Hughes *et al.* (1987) carried out detailed histopathological examination on 47 eyes with inflammatory retinal disease. The lesions could be divided into three broad groups based on the histopathological changes seen:

1. Dogs less than or equal to three years of age, with active inflammatory disease of the retina, uvea and vitreous. Four dogs in this group had migrating nematode larvae identified morphologically as Toxocara (most likely *Toxocara canis*).
2. Diffuse retinitis and retinal atrophy with localized retinal necrosis and fibrosis of the choroid. Dogs in this category had severe clinical signs e.g. blindness.
3. Chronic low-grade retinitis with variable retinal atrophy. Most dogs in this category were greater than three years of age and were displaying no obvious signs of visual impairment.

The above spectrum of inflammatory changes and the presence of *Toxocara spp* larvae in some samples strongly suggested that ocular larval migrans was the cause of the lesions. Irving (1997) reported that less working farm dogs were presenting with these types of problems and suggested that the reduction was due to regular anthelmintic administration. O'Connell (2013) found that the majority of dogs (n=131/164) were treated with an anthelmintic every one to three months.

2.7.6 Neosporosis

The presence of the protozoan parasite *Neospora caninum* has been confirmed in dogs in New Zealand. The parasite is an important cause of bovine abortion and may also cause an encephalomyelitis with hind-limb paresis in (mostly young) dogs (Jolly *et al.*, 2002a; Reichel, 1998). Antony *et al.* (2003) sampled dogs in central New Zealand and found a seroprevalence of 31% in urban dogs, 75% in dogs on dairy farms, and 97% in dogs on sheep and beef-farm. Another study by Reichel (1998) found 22% of dogs tested by immunofluorescent antibody testing (IFAT) were positive for Neospora antibodies at a dilution of 1:40. Of these, nine percent were still positive at a dilution of 1:200. It would have been expected that dogs positive at the higher titres would have been showing clinical signs, however none of the 200 randomly selected dogs were showing any sign of illness. Although it does not state specifically, it is presumed that these dogs are from dairy farms.

Further work would be required to determine what circumstances result in clinical signs of disease in dogs, what antibody titres are protective, and whether one-time exposure results in lifelong protection. Considering the above data it would seem that many dogs seroconvert without showing clinical signs of disease.

2.7.7 Leptospirosis

Where leptospires are present in livestock, working farm dogs are at risk of being exposed. The six leptospiral serovars known to be present in New Zealand are *L. interrogans* serovars Pomona and Copenhageni, and *L. borpetersenii* serovars Balcanica, Hardjo, Ballum and Tarassovi. Of these serovars Copenhageni, Hardjo, Pomona and Ballum are the most likely to affect dogs (Cave *et al.*, 2014).

Previously clinicians have believed that vaccinating dogs against leptospirosis was only necessary in the northern part of the North Island of New Zealand, where the serovar Copenhageni is endemic in the rat population. The only licensed canine vaccine in New Zealand is monovalent, containing *L. icterohaemorrhagiae*, which provides cross protection against Copenhageni (Cave *et al.*, 2014).

In 2011-12 leptospirosis was diagnosed based on serological tests in ill dogs in the southern part of the North Island of New Zealand (Thompson, 2012). The infected dogs were mostly from rural environments and may have been exposed to infected livestock or rats. One of the dogs had possibly eaten a possum carcass, which can act as maintenance hosts for the serovar Balcanica (Thompson, 2012). An earlier study by O'Keefe (2002) found that in the lower North Island of New Zealand 14% of 466 dogs tested were seropositive to leptospires, and rural dogs were significantly more likely to be seropositive to serovars Pomona and Hardjo than urban dogs. Cave *et al.* (2014) also found that farm working dogs were more likely to be seropositive for serovar Hardjo that urban dogs, however serovar Copenhageni was the most common leptospiral serovar isolated. The population of dogs in this survey was convenience sampled from sera submitted to New Zealand Veterinary Pathology laboratories. Both Cave *et al.* (2014) and O'Keefe (2002) found that the prevalence for the serovar Copenhageni was 10% in dogs in the North Island of New Zealand. Worldwide, Canicola has traditionally been the serovar associated with disease in dogs. Recent reports suggest that these serovars are being replaced in frequency by Pomona and Grippotyphosa, possibly due to widespread vaccination against the former (O'Keefe *et al.*, 2002).

Cave *et al.* (2009) note that the nature of leptospirosis in dogs has not been well-described. As clinical signs are non-pathognomic, and those of a multi-systemic, febrile illness (Cave *et al.*, 2014) it may be that cases treated empirically as parvovirus may in fact have been leptospirosis. Cave *et al.* (2009) found renal disease and acute hepatopathies were both uncommon in working farm dogs. Dogs presenting with acute renal or liver disease may in fact have been suffering from leptospirosis that went undiagnosed; however, it may be that the actual prevalence of clinical disease due to leptospirosis is low in the working dog population.

To date dog to human transfer of leptospires has not been reported in New Zealand. However, dog to human transfer has occurred overseas and should be considered as a possible source of human infection (O'Keefe, 2002).

2.7.8 Campylobacteriosis

Campylobacter spp are present in the gastrointestinal tract of dogs and may be a commensal bacterium in this species; however *Campylobacter* can also act as a primary pathogen in dogs and the farm environment is likely to be a source for disease (Bojanic *et al.*, 2013). *Campylobacter spp* have been found in commercial raw diets fed to dogs, and as such may also be found in home-kill meat fed to working dogs (Bojanic *et al.*, 2013). *Campylobacter spp* can cause gastroenteritis in humans and it is feasible that dogs may act as a potential source for this zoonosis. However it would be difficult to prove that infections in humans had been transferred from infected dogs, and not from exposure to the same environmental contamination.

2.7.9 Salmonellosis

Clark *et al.* (2004) investigated an outbreak of *Salmonella brandenberg* in sheep flocks in which dogs were also affected. The bacterium was isolated from seven dogs of which four that had diarrhoea or dysentery, two that had dead puppies (metritis and abortion) and one that showed no clinical signs. Six of the seven dogs were farm dogs within the outbreak area. The seventh dog, which developed diarrhoea, had not visited affected farms but had been fed fresh farm-kill meat that may have been contaminated with *S. brandenberg*.

2.7.10 Tyzzer's disease

Tyzzer's disease is thought to be rare in New Zealand dogs. Only one report was found in the literature, of a six week old working dog puppy showing lethargy, vomiting and diarrhoea, which tested negative for parvovirus (Vaatstra, 2012). Tyzzer's disease was diagnosed on post-mortem. Clinical signs are caused by *Clostridium piliforme*, which invades the gastrointestinal tract resulting in hepatic necrosis and necrotising enteritis. Spores may be carried by rabbits or rodents and disease onset is often associated with the stress of weaning or concurrent disease.

2.8 Breed predispositions for disease

Both Heading dogs and Huntaways have been selected for performance rather than appearance, and as such there is a wide range of phenotypes in both Huntaways (Figure 2-1) and Heading dogs (Figure 2-2). Breeding for performance traits results in potential for line breeding that may concentrate certain genetic defects; at the same time, breeding for performance also allows out-crossing to obtain the desired characteristics, essentially widening the gene pool.

Most of the New Zealand Heading dog's heritage is the British Border collie. While the exact origins of the Huntaway breed are uncertain, there is some robust speculation that the original breeds that may have played a role in producing the classic black and tan barking dog included Border collie, with Gordon setter added for barking ability. Bearded collies, German shepherds, black Labradors, Smithfield (bobtail) collies and Foxhounds may also contribute to the genetic makeup (Hughes, 2013). Although the breed character of the Huntaway seemed to stabilize around 1948 (Hughes, 2013) it is possible that congenital defects peculiar to the origin breeds may also occur in the Huntaway (see Table 2-1).

Figure 2-1: Examples of phenotypic differences within the New Zealand Huntaway breed.

Figure 2-2: Examples of phenotypic differences within the New Zealand Heading dog group.

Table 2-1: Canine inherited diseases in breeds with a common ancestry with the New Zealand Huntaway and Heading dog breed. Disease data from Canine Inherited Disorders Database (Crook *et al.*, 1998).

Breed	**Inherited disorder**
Border Collie	Collie eye anomaly* Neuronal ceroid lipofuscinosis* Cobalamin malabsorption disorder*
Gordon Setter	Hip dysplasia Black hair follicular dysplasia Gastric dilatation volvulus Progressive retinal atrophy Retinal dysplasia
Bearded Collie	Cataracts Corneal dystrophy Hip dysplasia Pemphigus foliaceous
Labrador Retriever	Elbow dysplasia Hip dysplasia Atopy Progressive retinal atrophy* Tricuspid valve dysplasia Labrador retriever myopathy*
English Foxhound	Hound ataxia
Smithfield	No information found
German Shepherd	Degenerative myelopathy Exocrine pancreatic insufficiency Hemophilia* Hip dysplasia Nodular dermatofibrosis* Pannus Panosteitis Perianal fistula Acral lick dermatitis Aortic stenosis Cervical vertebral instability (Wobbler syndrome) Elbow dysplasia Triscuspid dysplasia Masticatory myositis Myasthenia gravis Patent ductus arteriosus Progressive retinal atrophy* Small intestinal bacterial overgrowth Lumbosacral vertebral stenosis Gastric dilatation volvulus Pulmonic stenosis

* Testing available in New Zealand through Gribbles Veterinary Pathology.

2.8.1 *Hip dysplasia*

Hip dysplasia is a disease of complex aetiology, involving genetic conformation of the coxofemoral joint, rate of growth and the mineral composition of the diet fed during puppyhood. Hip joint laxity is also a feature of the disease (Hughes, 2001; Read, 2000).

Hughes (2001) surveyed 93 Huntaways and 48 Heading dogs that presented to his clinic for routine examination for problems other than lameness. The dogs were anesthetized for ventrodorsal extended-hip x-rays of the coxofemoral joints and subsequent hip scoring in accordance with the New Zealand Veterinary Association (NZVA) guidelines. Hip scores greater than or equal to 10 were considered to be dysplastic. The prevalence of hip dysplasia was 24% in Huntaways and 6% in Heading dogs. Hughes calculated that Huntaways were nearly five times more likely to have evidence of hip dysplasia than Heading dogs. Cave *et al*. (2009) also found that more Huntaways were presenting with hip dysplasia than Heading dogs (n=16 Huntaways, n =5 Heading dogs). At the time of Hughes' survey the average hip score of the Huntaways (10.8) ranked it the 5th worst of the breeds assessed by the NZVA scheme in New Zealand behind Bull mastiffs, German shepherds, Bernese Mountain dogs and Golden retrievers. Heading dogs fared much better at an average score of 5.9 (

Table 2-2).

Interestingly, few of the owners of dysplastic dogs noted any signs of lameness in their animals. Hughes (2001) postulated that radiological and physical signs may not correlate well in working dogs because they are typically lean, fit and highly motivated to work. Read (2003) also noted that dogs with greater hind-limb muscle mass to support the dysplastic joint, functioned better and with fewer signs of lameness, than less muscled dogs. If the surmises of Hughes and Read are accurate then it is likely that there may be many cases of hip dysplasia undiagnosed in the working dog population, with only the most severe cases diagnosed early. Without radiographing every dog prior to breeding, the trait can persist in the population, and will only be noticed in individual dogs when advanced joint degeneration occurs.

Table 2-2: Average hip dysplasia scores by breed in 2001, using the New Zealand Veterinary Association hip scoring scheme (from Hughes 2001)

Breed	Number of Dogs Scored	Average Score
English Bull Mastiff	51	19.8
German Shepherd	235	13.6
Bernese Mountain dog	42	11.6
Golden Retriever	233	11.5
Huntaway	93	10.8
Rottweiler	105	9.8
Alaskan Malamute	56	8.9
Labrador Retriever	410	8.5
Border Collie	66	6.7
Heading Dog	48	5.9
Siberian Husky	36	4.0

2.8.2 Heart disease

Most cases of Dilated Cardiomyopathy (DCM) are idiopathic; however certain breeds have higher prevalence (e.g. boxers and Dobermans) which suggests that genetics play a role in the pathogenesis of this disease. Munday *et al.*'s (2006) investigation determined the prevalence of DCM in Huntaways was significantly higher than other large breed dogs, and also other non-large breed dogs. Munday *et al.* examined necropsy reports from 429 dogs. Two hundred and eighty-five dogs were classed as large breed and 144 as non-large breed. German shepherds, Labradors, Huntaways, Rottweilers, Golden retrievers, Bull mastiffs, Rough collies, Boxers, Dobermans, Dalmations, Great danes, St Bernards, German shorthair pointers, Rhodesian ridgebacks, Samoyeds, Weimaraners, Newfoundlands, Old English sheepdogs, Irish setters and Huskies were included in the large breed group. The prevalence of DCM in Huntaways was 12.5%. When Huntaways were excluded, the prevalence in the large breed group of dogs was 2.8%. Only one Heading dog was found to have signs of DCM on necropsy. The average age of onset in the affected Huntaways was four years old, and all cases were male. These demographics correspond with DCM in the general canine population where age of onset is four to eight years, with a sex predilection for males. The gross anatomical and histological findings of DCM in Huntaways were the same as in other breeds with DCM. While this study provides evidence that Huntaways could be added to the list of breeds predisposed to DCM it is important to note that the number of Huntaways examined was small and further studies are required to support this preliminary finding.

2.8.3 ABCB1 gene mutation

The ABCB1 gene mutation has been discussed briefly in regards to its effect in macrocyclic lactone toxicity. Currently no investigations have been carried out to determine the prevalence of the ABCB1 mutant allele in the New Zealand working dog population. Geyer (2005) found that of 1500 dogs tested in Australia, 33% of Border collies, 6.9% of Australian shepherds and 5.7% of Shetland sheepdogs were homozygous for the mutant allele. The gene has also been found at a low frequency in the Old English sheepdog and the German shepherd, which are other breeds reported to make up the Huntaway gene pool (Parton *et al.*, 2012). Rough-coated collies, English shepherds and Australian shepherds are also known to be carriers (Gieseg & Parton, 2012).

2.8.4 Other genetic disease

A single case of Mucopolysaccharidosis IIIA, a lysosomal storage disease, was reported in an 18 month old male huntaway with progressive weakness and ataxia. It has been estimated that 8% of working dogs in the central North Island of New Zealand are heterozygotes for this disease (Jolly *et al.*, 2002b).

Black hair follicular dysplasia was diagnosed in a Huntaway that had developed progressive alopecia of the black hair coat at 12 weeks of age (Munday *et al.*, 2009).

Myasthenia gravis may be a congenital or acquired disease. Between 2007 and 2009 clinicians at Massey University Veterinary Teaching Hospital diagnosed suspected myasthenia gravis in two working farm dogs with exercise induced weakness (Hill, 2009).

The congenital diseases of concern, from the literature, would appear to be hip dysplasia and dilated cardiomyopathy in Huntaways, and ABCB1 gene mutation in Heading dogs. Without undertaking exhaustive genetic testing, it is likely that more congenital diseases will be uncovered with time, as clinicians notice increasing prevalence of certain diseases in the working dog population.

2.9 Disease of the Musculoskeletal system

2.9.1 Lumbosacral stenosis

Degenerative lumbosacral stenosis (DLSS) is a common condition of active large breed dogs, and as such may occur in working farm dogs, particularly Huntaways (Worth *et al*. 2009). Cave *et al.* (2009) found that lumbosacral disease accounted for four percent (n=38/1,024) of disease unrelated to trauma. Twenty-seven of these cases were in Huntaways, compared to nine cases in Heading dogs. Most of the literature concerned with DLSS refers to military and police working dogs, of which German shepherds appear to be particularly at risk. The definitive lesion in this disease is an acquired narrowing of the vertebral canal, intervertebral foramina, or both. This results in compression of the cauda equina and subsequently pain and dysfunction of the lumbosacral junction. Lumbar spinal pain and hind-limb lameness are the most common presenting signs, but muscle atrophy, urinary/faecal incontinence, flaccid tail and hind-limb ataxia may also occur (Worth *et al.*, 2009). Conservative treatment such as pain relief and lifestyle modification is only suitable for pet or retired dogs, and would not be appropriate for working dogs. Although half of dogs treated conservatively with rest and non-steroidal anti-inflammatory drugs had a satisfactory response, 25% of dogs relapsed during treatment (Ness, 1994). Therefore, if dogs are required to return to work, surgery to decompress the cauda equina and stabilize the lumbosacral junction is the only satisfactory option. The prognosis for dogs with DLSS worsens with increasing age and when neurological defects are present (Worth *et al.*, 2009).

Although it is known that active large breed dogs are at risk for DLSS, other risk factors need to be investigated to fully understand the pathogenesis of the disease.

2.9.2 Degenerative joint disease

Cave *et al.* (2009) found that degenerative joint disease was the most common non-traumatic musculoskeletal condition seen in working dogs, accounting for 13% of non-trauma related visits, and seven percent of reasons for euthanasia or retirement. Singh *et al.* (2011) also found that degenerative joint disease associated with old age was the most commonly reported reason for euthanasia in working farm dogs (n=60/149).

In Cave *et al.* (2009) the coxofemoral joint was found to be the most common site for degenerative joint disease (n=23), followed by the carpal joint (n=18), elbow joint (n=7) and hock joint (n=3). The data did not differentiate cases of DJD by breed. However, as Huntaways are over-represented in cases of hip dysplasia (Hughes 2001) and lumbosacral disease, and Heading dogs appear to be predisposed to multiple ligament injuries of the stifle and tarsal trauma (Cave *et al.* 2009), these conditions may also predispose to DJD in the affected joints.

Further investigation could be directed at the suspected risk factors for degenerative joint disease, such as known trauma events, nutrition, housing, farm terrain and distance covered per day while working.

2.10 Traumatic disease

Cave *et al.* (2009) found that traumatic injuries accounted for between 25 and 46% of veterinary visits, and 32% of visits that culminated in death or retirement. At the time of writing this thesis, only Cave *et al.*'s (2009) survey and Jerram *et al.*'s (2009) preliminary report have investigated the prevalence of different types of traumatic injuries suffered by working dogs in New Zealand. In an effort to assist both farmers and veterinarians in the decision whether to treat orthopaedic injuries surgically, more papers are being published focusing on the prognosis for return to work following musculoskeletal injury. To date papers have been published on medial condylar intra-articular fracture (Davis & Worth, 2009), fractures or sprains requiring pan-carpal arthrodesis (Worth & Bruce, 2008) or tarsal arthrodesis (Scrimgeour *et al.*, 2012; Worth, 2010) and calcanean tendon injuries (Worth *et al.*, 2004).

For visits in which the anatomical location was known, Cave *et al.* (2009) found that foot injuries were most common, accounting for 40% of visits relating to trauma (n=260/655). The majority of foot injuries were described as cutaneous damage with or without secondary infection. Foreign bodies were found in 43 cases, 19 of which were in the interdigital soft tissue. Other injuries to the foot included contusion of the skin or pad (n=41), metacarpal or metatarsal fracture (n=30), phalangeal fracture (n=15) and unspecified injury to the toe (n=18). Secondary osteomyelitis was diagnosed in 50 cases, resulting in amputation of the toe in 34 dogs. The stifle was the next most common site for injury, accounting for 15% (n=100/655) of trauma visits. Where the geographical location that the injury occurred was known, fences were involved in 45% of cases. Injuries in the paddock were next most common at 39%, with incidents in the yards, and on the road occurring less frequently.

2.10.1 Carpal trauma

Severe trauma to the carpus, such as luxations or fractures, can result in joint instability, and if not repaired, the development of osteoarthritis. Pan-carpal arthrodesis (PCA) is indicated when there is joint instability or luxation, and where primary repair is either unlikely to be achieved or has a low rate of success for a return to work. Carpal injuries that would benefit from PCA include hyperextension injuries, luxation and fracture, and also dogs that have severe osteoarthritis. Worth (2008) found the most common cause of carpal hyperextension injuries in working dogs was trapping a foot in the carrier of the bike or truck when jumping off, or being stood on by cattle when the dog's leg was planted on the ground. Worth & Bruce (2008) investigated the outcome of twelve dogs with severe carpal injury that were treated by surgical pan-carpal arthrodesis (PCA). Over a five year follow-up period it was found that six of the 12 of dogs could return to normal duties following surgery. A further four dogs could perform most, but not all, duties as before the surgery. This study, although small, does assist the owner's and veterinarian's decision as to whether to undertake surgery, or whether to spend resources on training a new dog. Worth & Bruce found that the majority of dog owners (n=11/12) felt that the surgical repair was worthwhile in a trained dog. These results are similar to those of a prospective study by Jerram *et al.* (2009b) in which ten out of twelve dogs could perform duties normally or with some allowance for reduced performance, following PCA. Eleven out of twelve owners reported that the results of the surgery met their expectations. Three dogs had complications requiring implant removal, but this did not appear to affect the dog's ability to return to work.

Although it is not entirely suitable to compare results in pet dogs with those in working dogs, similar studies involving pet dogs undergoing PCA reported full limb function in 74% of dogs (Denny & Barr, 1991; Maarschalkerweerd *et al.*, 1996). Force plate analyses conducted on another group of PCA dogs found that peak weight bearing was no different from normal dogs (Maarschalkerweerd *et al.*, 1996). From this data, Worth (2008) surmised that any gait abnormality following PCA was due to altered movement in limb with the fused carpus rather than due to pain. In some cases *partial* carpal arthodesis has a superior functional outcome, with less gait abnormality; however the extra stress this places on the antebrachiocarpal joint can lead to osteoarthritis (Worth, 2010).

2.10.2 Tarsal trauma

Cave *et al.* (2009) found that tarsal injuries, excluding gastrocnemius tendon damage, accounted for 5% of all trauma cases presented for treatment at veterinary clinics. As with carpal injuries, the cost of corrective surgery has to be weighed against the dog's level of ability, breeding value and the cost of replacement. Conservative treatment of second and third degree sprains to the ligaments of the tarsal joint usually has a poor outcome. The intertarsal and tarso-metarsal joints have little movement in the healthy animal, and so respond well to arthrodesis, resulting in a relief of pain and restoration of athletic ability (Scrimgeour *et al.*, 2012).

Scrimgeour *et al.* (2012) reported on a case series of 14 working dogs that had undergone partial tarsal arthodesis at Massey University Veterinary Teaching Hospital. Eleven of the 14 dogs returned to normal work, or could perform most of their prior duties, with some allowance made for lower performance. Three dogs had complications (infection) that were considered major as they required removal of the implants used for arthrodesis. However two of the three dogs returned to work once the implant was removed. The remaining dog was found to have malalignment from the axial plane, resulting in suboptimal compression and limited fusion. This dog remained lame and was no longer useful as a working dog. Thirteen of the fourteen owners were either satisfied or very satisfied with the outcome of the procedure. One owner was very disappointed, presumably the owner of the dog that was unable to return to work.

A British study of 13 sport dogs that underwent pantarsal arthrodesis using a customized medial or lateral bone plate reported excellent results in six dogs, good results in six dogs and a fair result in the remaining dog. These dogs were followed for 29 to 156 weeks after the surgery (McKee *et al.*, 2004).

These results suggest that both pantarsal and partial tarsal arthodesis may be feasible options for working farm dogs suffering severe trauma to the tarsal joint. Although the numbers of dogs in each study are relatively small, the preliminary results are encouraging. Further studies using larger numbers of dogs and longer term follow up are required.

2.10.3 Common calcanean tendon damage

The common calcanean tendon (CCT) is made up of the superficial digital flexor tendon, gastrocnemius muscle group tendon, and the combined tendons of the gracilis, semitendinosus and biceps femoris muscles. Injury to the CCT is potentially a career-ending injury for a working dog. Any attempt at repair of the tendon must be able to support the high level of athleticism required by working dogs. The potential for returning to strenuous work after CCT tenorrhaphy is unlikely (Johnson & Hulse, 2002), although most pet dogs can resume normal activities. Little information is available as to the long-term outcome of CCT tenorrhaphy in working dogs (Worth *et al.*, 2004).

CCT injuries can occur with blunt force trauma, laceration, or spontaneously with abnormal activity. Muscular or musculotendinous rupture of the CCT is common in mature working or racing breeds, whereas incomplete ruptures due to gastrocnemius tendon avulsion is more common in large breed, mature and overweight dogs (Bloomberg, 1993). Bloomberg (1993) states that traumatic rupture of the CCT is most often seen when the dog jumps from a height and lands on its hind-legs, causing sudden hyperflexion of the hock joint. In contrast, a study by Vaughan (1981) found lacerations to be the cause of rupture in nine out of 10 dogs.

Worth *et al.*'s retrospective study (2004) investigated 10 dogs that were treated for CCT rupture. Two had become lame while running; two were injured falling from a truck, one of which lacerated the tendon during the fall; three dogs received trauma from stock; two involved falls while jumping and one caught a hind-leg in a fence. Five of the dogs in this study were Heading dogs, and five were Huntaways. Seven of the ten dogs returned to full or substantial work. The steepness of the farm terrain did not seem to preclude dogs returning to work. A follow up survey showed that 71% of owners were satisfied with the degree of work the dogs could perform. The author proposed that post-surgical time off work, financial factors and individual owner expectations may have played a role in this result. Three of the 10 dogs experienced major complications after surgery. The surgical site of one dog became infected whilst the limb was cast, with subsequent breakdown of both the skin wound and the tendon repair. One dog developed contracture of the superficial digital flexor muscle, resulting in difficulty placing the paw in the proper plantar position. The third dog re-injured the tendon and was presented in a plantigrade stance with a fresh laceration over the surgical site. It was found that the tip of the calcaneus had fractured resulting in avulsion of the CCT.

Worth *et al.*'s study highlighted the importance of rigid stabilization of the hock joint following surgery. All (n=7/7) dogs treated with screw immobilization of the hock joint during CCT tenorrhaphy returned to work. None (n=3/7) of the dogs stabilized post-operatively with a cast-only fixation returned to work, due to failure of the CCT to adequately heal, or due to complications associated with the cast itself.

As with the investigations into the outcome of carpal and tarsal arthrodesis, the number of dogs involved in the studies of CCT injuries are relatively small; however they provide a base for further studies involving longer term follow up and larger numbers of dogs.

2.10.4 Stifle injury

The stifle is a complex condylar synovial joint. It is capable of movement in three planes, and normal motion is directly related to the structure and function of the ligaments, bones and menisci that form the joint. Failure or dysfunction in any one of the components results in dysfunction of the joint as a whole, and predisposes the other components to failure (Carpenter & Cooper, 2000).

In America the annual cost of cruciate ligament disease of dogs, both medical and surgical, amounts to US $1.32 billion, making cruciate injury both a costly and prevalent disease (Wilke *et al.*, 2005). In the pet dog population, multiple ligament injuries to the stifle are uncommon (Bruce, 1998). In fact the majority of cruciate disease is not associated with any known trauma. Labrador retrievers, Rottweilers and Newfoundlands have a breed predisposition to cranial cruciate rupture, with the Rottweiler in particular being significantly more likely to develop bilateral disease than other breeds, and at a younger age. In comparison, Greyhounds have consistently been reported to be a low risk breed for cruciate injury (Guthrie *et al.*, 2012).

Progressive degeneration of the cruciate ligament, eventually leading to rupture, has been attributed to a variety of genetic, conformational, environmental, immune mediated and inflammatory factors (Griffon, 2010).

Worth (2007) described three groups of dogs affected by cruciate disease:

1. Acute traumatic tears of the cruciate ligament, without pre-existing degenerative joint disease.
2. Chronic degeneration of the cruciate ligament in middle aged, often obese, mostly de-sexed, medium to large breed dogs.
3. Young giant breed dog with bilateral cruciate disease, with onset at less than three years old.

In contrast to pet dogs, the majority of cruciate injuries in working dogs will fall into the first category (Worth, 2007). This is important to note as the lack of pre-existing cruciate pathology allows studies into prevention in working farm dogs to concentrate on the types of trauma that are causing cruciate injury, as well as methods for prevention. In the survey conducted by Cave *et al.* (2009), 8% of visits (n=65/848) for trauma-related incidents were for injuries to the cruciate ligaments. Heading dogs were involved in more than half of these visits (n=35/65). Eighteen Heading dogs suffered multiple ligament damage (cranial cruciate plus one or both collateral ligaments). In comparison only three Huntaways were found to have multiple ligament damage. Cave *et al.* also found that 31% of injuries to the stifle occurred while jumping over or through fences, which suggests that alternative transition points through fences could reduce the incidence of cruciate disease in the working dog.

2.10.5 Dog bite injury

In Cave *et al.*'s (2009) survey, dog bite injuries in working dogs accounted for 12% of veterinary visits related to trauma. Although this is a relatively high percentage when compared with other causes of injury, for example, 20% of trauma cases involved stock, none of the visits for dog bites resulted in euthanasia or retirement from work.

There was no apparent breed bias to dog bites, but entire males were the recipients in the overwhelming majority (75%). As Cave *et al.* found that only two percent of males were castrated, the incidence of dog bites may be an area that could be improved by neutering. Entire females were involved in 18% of dog bite injuries, speyed females in four percent and neutered males in two percent.

Given the pack structure of dogs and the number of dogs together on farm, it is likely that dog bites will never be completely prevented. Cave *et al.* (2009) suggested that improved socialization and training might reduce the frequency of bite injuries. Although Jerram *et al.* (2009) found that behavioural problems were one of the main reasons for euthanasia, particularly in young dogs, there were no behavioural studies found in the literature relating specifically to the New Zealand working farm dog.

2.10.6 Infraspinatus trauma

Infraspinatus muscle contracture is an uncommon condition noted most often in active working and sport dogs. The condition presents with severe muscle atrophy of the infraspinatus muscle and limited motion of the shoulder joint. It is thought to occur as a result of trauma, as some muscle groups are more prone to contracture following injury, for example quadriceps, infraspinatus, supraspinatus and gracilis muscles (Dillon *et al.*, 1989). Although no reports involving infraspinatus contracture in working farm dogs were found in the literature, the risk of trauma from vehicles and stock make this condition a possibility.

2.11 Conclusion

Farm working dogs are an important part of New Zealand agriculture and as such it is important that their health and longevity is maintained. After reviewing the literature it is clear that there have only been a small number of population based studies which report the relative frequency of a number of disorders. Other published data refers to single disease entities and often involve relatively small numbers of dogs only. Studies that collect data from veterinary clinics are more likely include serious health conditions that cannot be managed on farm. Therefore, these studies are likely to underestimate the prevalence of those diseases that cause sudden death, as well as ailments that can be managed by the owners without veterinary intervention. An example of this is illustrated by the study of Perkins *et al.* (2004) that found trainers of Thoroughbred race horses were less likely to seek veterinary assistance for conditions they were familiar with and that did not require detailed treatment. The authors found that of all the reported cases of shin soreness, veterinarians were only responsible for diagnosing eight percent. Therefore the prevalence or incidence for various types of injury obtained from veterinarians is likely to be an underestimate of the true value. Further research to determine the prevalence of disease should focus on collecting information directly from the farmer. A better understanding of the prevalence and impact of different health events in farm working dogs will enable prioritisation of research to those problems that cause the greatest loss.

The aim of this thesis was to investigate the demographics and health status of a population of New Zealand working dogs on farms. More specifically the thesis aimed to:

1. Describe the prevalence of non-trauma related health events;
2. Determine the prevalence of trauma related health events; and
3. Determine the relationship between disease status and risk of death.

3 Working farm dog demographics and health

Abstract

AIM: To describe the demographics and prevalence of disease and injury, and the putative risk factors associated with a dog being lost to the working population due to death.

METHODS: Dog owners from 192 farms in the Manawatu-Wanganui Territorial Land Area were randomly selected from AsureQuality's Agribase™ database of rural properties. Those owners that agreed to participate in the survey were visited on farm by one interviewer. Completed surveys were received from 118 owners, providing data on 1,115 dogs. Seventy-nine percent (n=885) of enrolled dogs were alive and on the farm at the time of the survey, 15% (n=167) were dead and six percent (n=63) had been sold or given away. Data was organised into demographic information (age, sex, neuter status, diet) and health data (congenital, traumatic and non-traumatic adverse health events). Demographic data is presented as a percentage of the study population, and adverse health events are presented as prevalence.

RESULTS: Of the study population 59% (n=653/1,115) of working dogs were males and 41% (n=462/1,115) were females. For those dogs whose neuter status was known, 2% of males (n= 23/1,114) and 4% of females (n=48/1,114) were de-sexed. The median age was five years and this ranged from seven months to 18 years. The majority of breeds were the NZ Huntaway (n=531/1115, 48%) and the NZ Heading dog (n=402/1115, 36%). The most common health problems were low body weight (n=210/1,115, 19%) and arthritis (n=114/1,115, 10%). Body systems most commonly affected by non-traumatic health events were the musculoskeletal system (n=153/1,115, 14%), integumentary system (n=135/1,115, 12%) and gastrointestinal system (n=58/1,115, 5%). For traumatic events, musculoskeletal and integumentary injury both had a prevalence of 12% (n= 136/1,115 and 130/1,115 respectively). Variables that increased the risk of a dog being dead included suffering more than one non-trauma event ($p<0.0001$) and residing on farms that had more dogs present ($p <0.05$). When compared with dogs less than two years of age, dogs between two and four years of age were less likely to be dead. Dogs between four and seven years of age were also less likely to be dead than dogs under two years of age, however the difference was not as marked. Dogs that were considered to be underweight ($p<0.05$), or those that had suffered an axial or limb fracture ($p<0.05$), were less likely to be dead than those that had not suffered these problems. From this data, there was no significant risk associated with career stage, breed, sex, or neuter status, or for dogs working on a farm with steep terrain, having arthritis with or without concurrent lameness, or suffering musculoskeletal injury.

CONCLUSIONS: Poor body condition and arthritis were the two individual health conditions most commonly reported by farmers. The musculoskeletal and integumentary body systems were those most commonly affected by trauma, of which pad wear and limb fracture were most prevalent. Further study into the risk factors for arthritis and injury, and the optimal diet frequency and composition should improve the health of working dogs. This survey has suggested some risk factors that may play a role in the risk of a working dog being dead. However prospective studies are required to better understand these associations before recommendations can be made to reduce loss from the working dog population.

3.1 Introduction

Today working dogs are still an integral part of New Zealand's farming enterprise; indeed many sheep and beef farms could not operate without the effort of their dogs. It is estimated that New Zealand has as many as 200,000 working farm dogs (Cave *et al.*, 2009) in the agricultural sector, more than any other country except Russia (Farman *et al.* 2009). In New Zealand there have been two published studies investigating demographic data in working dog populations (Cave *et al*., 2009; Singh, 2011). Cave *et al*.'s survey collected data from dogs presented to veterinary clinics, and as such excludes dogs that die on farm or have minor ailments that may not require veterinary attention, and yet may affect their working ability. Singh's survey collected data from dogs and owners involved in the New Zealand Dog Trial Association. Although the dogs included in Singh's survey also had to be involved in active farm work, it is possible that these dogs are treated differently as an 'elite' subset of the working dog population. With regards to causes of loss, there is little published data about the causes of death or retirement in the working dog population. Singh *et al.* (2011) found that the most common reason for euthanasia was degenerative joint disease associated with old age (60/149; 40%), followed by failing to perform satisfactorily (27/149; 18%) and trauma associated with working livestock (22/149; 15%). Cave *et al.* (2009) found that non-traumatic disease was a more common cause of loss than expected - only 32% of visits that resulted in loss were known to be due to trauma. Developing methods to reduce the incidence of loss in the working dog population relies on first identifying the most common causes of loss, and the risk factors associated with these causes. This thesis, as a continuation of Jerram *et al*'s (2009) survey, investigates the working dog population on farm, in an effort to collect data on those dogs that may not necessarily visit vet clinics or trial competitions.

The aims of this cross-sectional survey were to:

- Describe the demographics of a population of working farm dogs in New Zealand
- Describe the types and prevalence of disease and injury in working farm dogs;
- Determine risk factors for a dog being lost from the working population, due to death or euthanasia

This chapter presents the results of the survey, in regards to demographic data and the prevalence of injury and disease, followed by the analysis of risk factors for loss from work due to death, for selected health events, demographic groups and farm criteria.

3.2 Materials and methods

3.2.1 Study design and data collection

This cross-sectional study was described in detail in Jerram (2014). Briefly, farms were randomly selected from Agribase™, a database of rural properties maintained by AsureQuality. To be eligible for inclusion, properties had to be:

i) Located in the Manawatu Territorial Land Area, that is Stratford, Ruapehu, Wanganui, Rangitikei, Manawatu, Tararua and Horowhenua districts, and Palmerston North City;

ii) Classified as sheep and/or beef farms in Agribase™; and

iii) Carrying more than 20 stock units[1] and greater than 100 hectares.

Eligible farms were stratified by size into three groups, namely small (100-227 hectares), medium (228-440 hectares) and large (>440 hectares). A total of 192 farms were randomly selected; 63 small farms, 64 medium farms and 65 large farms. A letter was written to the primary decision maker listed in Agribase™ inviting them to participate in the study. One hundred and eighteen decision makers agreed to participate and were visited by a single researcher (i.e. Amy Jerram) who administered a four-part questionnaire in a face-to-face interview. The first section included questions about the farm on which the dogs worked. The second section gathered data pertaining to the owner/trainer of the working farm dogs. The third section collected data about dogs that were currently working on the farm, and the fourth section covered those dogs that had been retired or destroyed, or who had died on the farm in the last 12 months. The survey covered all dogs that had been on the farm in the 12 months prior to completing the survey, in order to include any dogs that may have died from acute disease and so not be present at the time of the survey. In order to be included in this study dogs had to be greater than six months of age.

3.2.2 Classification of adverse health events

Health events classified as non-trauma were those involving infectious and non-infectious disease, and those in which no specific traumatic incident was identified. For example pyoderma may have

[1] Stock units were calculated using sheep and beef numbers in Agribase™ and assumed that one cattle beast equated to 5.5 sheep.

initiated from traumatic damage to the skin, however if the owner of the dog was unaware of any inciting trauma it was classified as non-traumatic. Likewise, periods of lameness that were either a result of overuse or were not associated with a known traumatic event, were classified as non-traumatic. Problems described by the owners as underweight, overweight and fluctuating weight were classed together as metabolic, as the underlying cause of the problems were unknown. Where the problem described by the owner was specific, e.g. parvovirus, it was classified as such; if the owner described the problem as bloody diarrhea, it was classified as diarrhea, as it had not been confirmed that parvovirus was the causative agent. Likewise, problems described as twisted bowel were classified as such, rather than assuming the owner was referring to GDV. Health events were classified as traumatic if an injury were a direct result of trauma, for example, a laceration as a result of being injured by stock, or cruciate damage from trapping a hindlimb in a fence. Congenital diseases were classified as such if they had been present since birth, were known not to be the result of any trauma or disease, or were a recognised congenital disorder, such as umbilical hernia, undershot mandible or limb deformity. Health events were further classified by the body system affected, for example musculoskeletal, cardiovascular and gastrointestinal. Non-traumatic musculoskeletal events were those in which no specific trauma could be identified, or those in which an infectious cause was identified. The classification ‘other’ refers to either multi-systemic disease, or where the body system is not defined, for example the location of a cancer is not included in the description given by the owner.

3.2.3 Data analysis

The number and percentage of dogs was determined stratified by status (dead/alive/give away or sold), sex (male/female), neuter status (yes/no) and breed. The age of working dogs was determine stratified by career stage (no training or partially trained/fully trained/Retired) and the Kruskal-Wallis non-parametric ANOVA used to assess statistical significance. For health events the prevalence of congenital, trauma and non-trauma related health events was determined. For each of the groups the prevalence was determined stratified by body system and when appropriate the nature of the problem. To investigate reasons for loss each dog was classified as dead or alive. Dogs that had been sold or given away were classified as alive and no attempt was made to determine if the dog was actual still alive at the time of the survey. Two way tables were produced to explore the relationship between status of the dog (i.e. dead or alive) an a number of explanatory variables. The significance of the relationship was assessed using the Chi-squared test statistic or Fisher exact as appropriate.

3.3 Results

Completed surveys were received from 118 farms, providing information on 1,115 dogs: 885 (79%) of the enrolled dogs were alive and on the farm at the time of the survey, 167 (15%) were dead and 63 (6%) had been sold or given away. Sex was known for all dogs included in the survey; 653 (59%) were males and 462 (41%) females. For those dogs whose neuter status was known, 2% (n=23/1,108) were de-sexed males and 4% (n=48/1,108) were de-sexed females (Table 3-1)Table 3-1: . The two main breeds of dogs in the survey were the NZ Huntaway (Table 3-1; n=558/1,115, 50%) and the NZ Heading dog (Table 3-1; n=422/1,115, 38%). The median age for dogs that were fully trained and retired was five and ten years respectively (Figure 3.1; $p<0.0001$).

Twenty-three dogs were recorded as having a congenital problem (2%). None of these dogs had more than one congenital problem recorded. Hip dysplasia was diagnosed in 10 dogs (prevalence 0.9%). Six of the dogs with hip dysplasia were Huntaways, one was a Heading dog, one was a Border collie and two dogs of unknown breed. Although it is impossible to tell from the survey data why dogs listed as dead were euthanased or died, eight of the 10 dogs diagnosed with hip dysplasia were still alive at the time of the survey. Eight dogs (prevalence 0.7%) were described as having a limb or muscular disorder, defined as bowed or bent legs as perceived by the owner. This category also included muscular defects such as umbilical or inguinal hernias, with which two dogs were affected. Five dogs (0.5%), three Heading and two Huntaways, were described as having a noticeably undershot mandible that was severe enough to cause difficulty eating.

Eight hundred and eighty-six non-trauma events were recorded, affecting 576 dogs (52%): 366 dogs experience one non-trauma event; 192 experienced two non-trauma health events, and 18 experienced three or more non-trauma health events with one dog experiencing 11 events. Low bodyweight was the most commonly reported non-trauma health event affecting 19% (n=210/1115; Table 3-2) of the population. One hundred and fifty-three dogs suffered one or more non-traumatic musculoskeletal event making it the second most commonly affected body system for non-trauma health events. Arthritis was the most common non-traumatic musculoskeletal event reported (10.2%, n=114), followed by lameness of unknown cause (2.4%, n=27), weakness or ataxia of unknown cause (1.4%, n=16), flexor tendon laxity (0.5%, n=5) and infectious arthritis (0.4%, n=4). Weakness and ataxia may be a clinical sign of arthritis however the cause of weakness and ataxia was not differentiated in this study.

During the study period 358 health events associated with trauma were reported in 277 dogs (25%): 210 dogs had one trauma related event, 59 had two trauma related events and eight had three trauma related health events. One dog was affected by seven traumatic events during the study period. The body systems most commonly affected by trauma were the musculoskeletal (12%, n=136/1,115) and integumentary (12%, n= 130/1,115) body systems (Table 3-3). Other traumatic health events recorded included dogs that were knocked unconscious (0.9%, n=10), trauma causing blindness (0.5%, n=6), laceration to the genitourinary tract (0.4%, n=4), broken teeth (2.3% n=26) and tracheal injury (0.7%, n=8).

Table 3.4 describes the association between risk of death in the 12 months prior to the survey and a number of explanatory variables. Dogs that had experienced a non-trauma health event were 1.38 (95% CI: 1.04-1.82) times more likely to be dead than dogs that had not experienced a non-trauma related health event. Interestingly, dogs that were reported as being underweight by their owners were 0.30 (95% CI: 0.17-0.55) less likely to be dead when compared to those dogs that were not reported as being underweight.

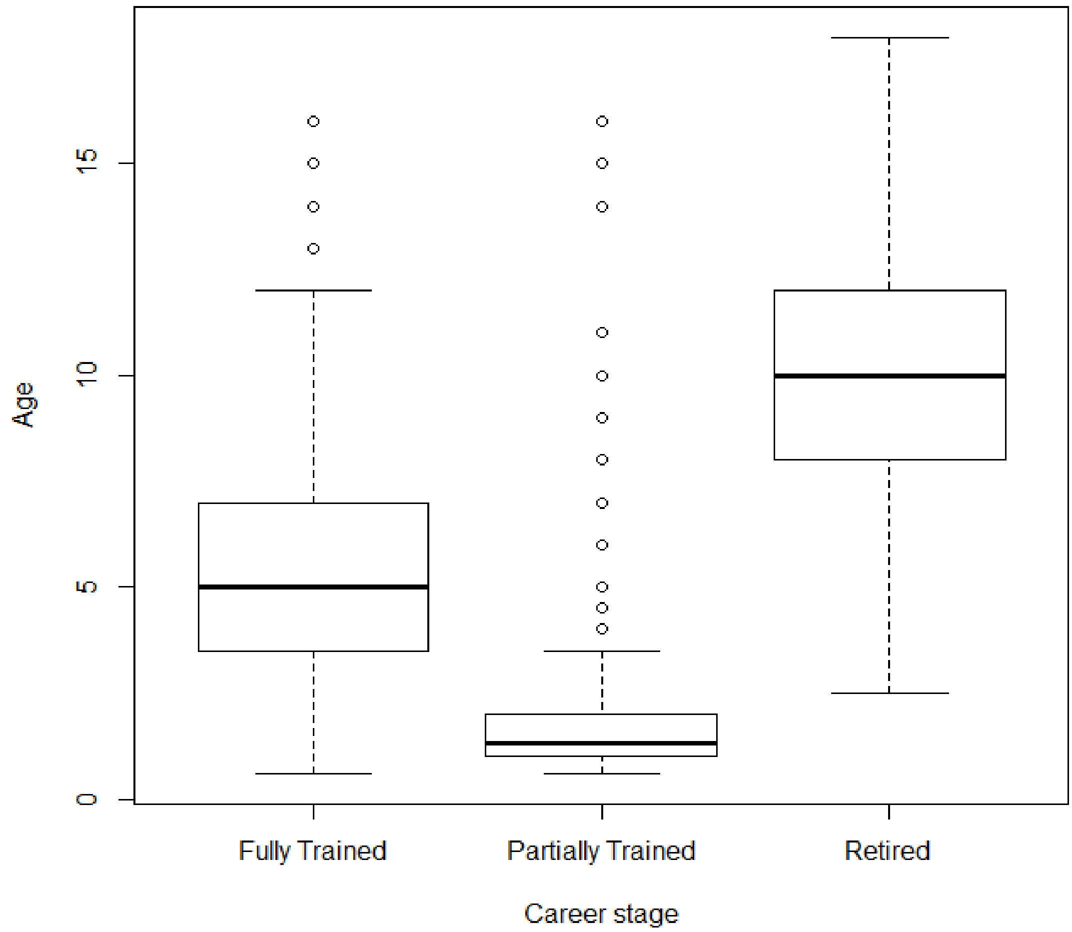

Figure 3-1: Box plot of age of dogs by career stage ($p<0.0001$). The box extends from the 25th to the 75th percentile, with a line at the median. Whiskers extend from the box a distance of 1.5 times the inter quartile range and the circle (○) symbol denotes outliers or extreme values that fall outside of the range of the whiskers. Data from a cross-sectional survey of 118 farms and 1,114 dogs in the lower North Island in 2009.

Table 3-1: Number and percentage of working farm dogs stratified by demographic variables. Data from a cross-sectional survey of 118 farms and 1,115 dogs in the lower North Island in 2009.

Variable	Number of dogs	% (n = 1,115)
Sex[a]		
De-sexed female	48	4.3
Entire female	413	37.3
De-sexed male	23	2.1
Entire male	624	56.3
Type of dog		
NZ Heading	422	37.8
NZ Huntaway	558	50
Bearded collie	36	3.2
Smithfield	4	0.4
Handy dog	43	3.9
Border Collie	19	1.7
Other[c]	33	3
Career Stage[b]		
Fully trained	693	62.2
Partial/no training	289	25.9
Retired	132	11.8
Age		
≤ 2 years old	302	27.1
2.1-4 years	230	20.6
4.1-7 years	298	26.7
>7 years old	285	25.6

[a] Sex was known for all dogs in the survey. Neuter status was unknown for seven 1,108/1,115 dogs.

[b]Career status was unknown for one dog

[c]Other refers to breeds not traditionally used for farm work, such as standard poodle and Labrador retriever

Table 3-2 Number and percentage of working farm dogs affected by a non-trauma event in the 12 months preceding the survey, classified by body system Data in bold represents total number of dogs affected, with dogs suffering multiple events counted only once. Data from a cross-sectional survey of 118 farms and 1,115 dogs in the lower North Island in 2009.

Body system affected	**Type of health event**	**Number of dogs**	**% (n = 1,115)**
Gastrointestinal (GI)	Ingested foreign body	4	0.4
	Constipation	15	1.4
	Diarrhea	9	0.8
	Other[b]	7	0.6
	Parvovirus	5	0.5
	Twisted bowel	14	1.3
	Intestinal parasites	5	0.5
	Number of dogs with one or more GI events	**58**	**5.2**
Integument	Abcess	10	0.9
	Allergy	6	0.5
	Alopecia	13	1.2
	Barley grass	12	1.0
	Neoplasia	7	0.6
	Flea infestation	7	0.6
	Matted haircoat	16	1.4
	Nailbed infection	13	1.2
	Otitis externa	11	1.0
	Pododermatitis	9	0.8
	Pressure callus	9	0.8
	Pruritus	14	1.3
	Pyoderma	17	1.5
	Sunburn	9	0.8
	Toe infection	7	0.6
	Number with one or more integumentary events	**135**	**12.1**
Metabolic	Fluctuating weight	11	1.0
	Heat stroke	9	0.8
	Overweight	21	1.9
	Underweight	210	18.8
	Number of dogs with one or more metabolic event	**249**	**22.3**
Musculoskeletal (MSI)	Arthritis	114	10.2
	Flexor tendon laxity	5	0.5
	Infectious arthritis	4	0.4
	Lameness	27	2.4
	Weak/ataxic	16	1.4
	Number of dogs with one or more MSI event	**153**	**13.7**

Body system affected	Type of health event	Number of dogs	% (n = 1,115)
Ocular	Blindness	33	3.0
	Conjunctivitis	22	2.0
	Other ocular problem	11	1.0
	Number of dogs with one or more ocular problem	**64**	**5.7**
Reproductive	Neoplasia	7	0.6
	Infertile	8	0.7
	Irregular cycle	5	0.5
	Misalliance	4	0.4
	Other	4	0.4
	Prostate disease	4	0.4
	Vaginal prolapse	6	0.5
	Number of dogs with one or more reproductive health event	**34**	**3.1**
Respiratory	Dyspnea	6	0.5
	Kennel cough	10	0.9
	Laryngitis/dysphonia	20	1.8
	Other	4	0.4
	Number of dogs with one or more respiratory health event	**39**	**3.5**
Other	Other	**23**	**2.1**
	Poisoning	**16**	**1.4**
	Polydipsiac	**13**	**1.2**
	Number of dogs with one or more health event classified as other	**51**	**4.6**

[b] Where details of health events are defined as other, this refers to health events where the exact cause is unknown – for example a testicle required removal, but it was unclear from the data why this was so.

[c] Polydipsia is defined as excess water intake where the cause is unknown.

Table 3-3: Number, and percentage, of working farm dogs affected by a trauma event in the 12 months preceding the survey, classified by body system, and presented as a prevalence. Data in bold represents total number of dogs affected, with dogs suffering multiple events counted only once. Data from a cross-sectional survey of 118 farms and 1,115 dogs in the lower North Island in 2009.

Body system affected	Type of health event	Number	% (n =1,115)
Integument	Broken nail	4	0.4
	Dogfight	17	1.5
	Fence/wire injury	25	2.2
	Laceration	28	2.5
	Pad wear/injury	62	5.6
	Skin graze	6	0.5
	Number of dogs with one or more integumentary trauma	**130**	**12**
Musculoskeletal	Axial fracture	10	0.9
	Cruciate injury	8	0.7
	Dislocation	9	0.8
	Fall	5	0.5
	Fence/wire injury	9	0.8
	Hit by vehicle	17	1.5
	Injury requiring amputation	5	0.5
	Lame	8	0.7
	Limb fracture	48	4.3
	Stock injury	30	2.7
	Tendon/ligament injury	8	0.7
	Number of dogs with one or more musculoskeletal trauma	**136**	**12**

Table 3-4: Unconditional association between explanatory variables and risk of death. Data from a cross-sectional survey of 118 farms and 1,115 dogs in the lower North Island in 2009.

Variable	Deceased		Alive		R (95% CI)	P-value [b]
	n	%	N	%		
Age						
≤ 2 years	68	23	234	77	REF	<0.0001
2.1 – 4	19	8	211	92	0.37 (0.23-0.59)	
4.1-7	29	10	269	90	0.43 (0.29 - 0.65)	
> 7 years	51	18	234	82	0.79 (0.57 - 1.1)	
Career stage						
Partially trained	71	25	218	75	REF	<0.0001
Fully trained	74	11	619	89	0.43 (0.32-0.58)	
Retired	22	17	110	83	0.68 (0.44-1.04)	
Heading						
No	90	13	583	87	REF	0.07
Yes	77	17	365	83	1.3 (0.99-1.72)	
Hunting						
No	84	17	425	83	REF	0.22
Yes	83	14	523	86	0.83 (0.63-1.1)	
Number of Herding Dogs on farm						
≤ 8	32	11	265	89	REF	0.01
9 to 15	35	13	235	87	1.2 (0.77-1.89)	
16 to 30	55	20	223	80	1.84 (1.23-2.75)	
>30	45	17	225	83	1.55 (1.01-2.36)	
Sex						
Female	71	15	391	85	REF	0.82
Male	96	15	557	85	0.96 (0.72-1.27)	
Neuter status						
Neutered	12	17	59	83	REF	0.73
Entire	152	15	885	85	0.87 (0.51-1.48)	
Steep and or high country contour						
Absent	28	15	154	85	REF	0.96
Present	139	15	794	85	0.97 (0.67-1.41)	
One or more non-trauma health event						
No	94	17	445	83	REF	<0.0001
Yes	73	13	503	87	1.38(1.04-1.82)	
Arthritis						
No	146	15	859	85	REF	0.26
Yes	21	19	89	81	0.76(0.5-1.15)	

Variable	Deceased		Alive		R (95% CI)	P-value [b]
	n	%	N	%		
Arthritis or lameness with no specified cause						
No	146	15	828	85	REF	0.92
Yes	21	15	120	85	1.01(0.66-1.53)	
Underweight						
No	156	17	749	83	REF	<0.0001
Yes	11	5	199	95	0.3(0.17-0.55)	
One or more trauma related health event						
No	129	15	709	85	REF	<0.56
Yes	38	14	239	86	1.12(0.8-1.57)	
Axial or limb fracture						
No	151	14	910	86	REF	0.004
Yes	16	30	38	70	0.48(0.31-0.74)	
Limb fracture						
No	157	15	912	85	REF	0.25
Yes	10	22	36	78	0.68(0.38-1.19)	
One or more musculoskeletal injury						
No	141	14	838	86	REF	0.19
Yes	26	19	110	81	0.75(0.52-1.1)	

3.4 Discussion

This thesis presents the results from a large cross-sectional study of a population of working farm dogs in the lower North Island of New Zealand, and shows that over 50% of dogs suffered from one or more non-traumatic health problems over the 12 month study period. The most commonly reported problems were low body weight and arthritis.

This is the first report of health events in working dogs collected from the dog owners' point of view rather than from a veterinary point of view (Cave *et al.,* 2009). By reporting health events from the owner the full spectrum of disease from mild to sudden death was included. However this method also increased the potential for misclassification bias as veterinarians were not always involved in the diagnosis of the health problems that were reported. As a result some error is inherent in interpreting the owner's comments and assigning disease classification, and in many cases the owner's observation may be a description rather than a diagnosis. For example the comment 'dent in head' is ambiguous as to whether it was a congenital disease or a result of trauma. Likewise a dog found dead in its kennel may automatically be attributed to GDV, when it fact it may be something else entirely. It is likely that some recall bias on the part of the owners will be present, and presumably some owners are more observant than others in regards to their dogs' wellbeing. There may also be some intentional misleading by owners regarding events that may not be perceived as ethical or appropriate. Classifications such as career stage also have inherent variability as it is reliant on what the owners' individual definition is of 'fully trained' or 'retired'. Some owners consider that dogs working only a few days a week are classed as retired, as they are no longer performing their full duties. Having relatively few exclusion criteria makes the sample population more representative of the population of working farm dogs. By including all dogs that had been present on the farm in the 12 months preceding the survey, whether alive or dead, the data includes diseases and conditions that may have run a very acute course, for example a dog dying overnight from gastric dilatation volvulus (GDV). However by excluding dogs less than six months of age, there is the potential to miss diseases that are more commonly associated with young dogs, such as parvovirus or debilitating congenital diseases that result in death or euthanasia at a young age.

In regards to the risk factor analysis, the data collected from the survey indicated only that the dog was recorded as dead, and did not include the cause of death. Therefore there are likely to be some confounding factors when interpreting relative risks using variables the dog was exposed to when alive, but not necessarily implicated in the cause of death. A prospective survey would be required to confirm associations suggested by this study. Despite these concerns, the main strengths of this survey are that it is a truly random sample rather than a convenience sample as in previous studies (Cave 2009, Singh 2011) and the survey design allowed data to be collected on conditions that may be very common, but are recognised and treated by the owner without referring to a veterinarian.

3.4.1 Demographics

The two main breeds of working farm dogs in this survey were NZ Huntaways (50%) and NZ Heading dogs (38%). The median age of fully trained working dogs in this study was older than that reported in Singh *et al.* (5 vs 3 Years). One possible reason for the difference is that Singh *et al.* (2011) focussed on owners involved in dog trialling. This subset of owners may be more likely to be involved in breeding and training of working dogs, and as such have a younger population of dogs than those involved strictly in farm work. It is unlikely that the difference in median age between the current study and Singh *et al.* was because dogs less than six months of age were excluded, as Singh only collected data on those dogs that were actively involved in farm work, effectively excluding dogs younger than 6 months also.

The overwhelming majority were not desexed. The low proportion of de-sexed dogs in the current study (6%) correlates well with the results of Cave *et al.* (2009) who reported 2% of male and 3% of female working dogs that visited veterinary clinics were de-sexed. The percentage of desexed animals was not included in Singh *et al.* (2011) so a comparison is not possible. Increased incidence of reproductive disease has been attributed to entire sexual status, however despite 94% of the current study population being entire, less than 2% of dogs were affected by some form of non-traumatic reproductive disease (mammary and testicular neoplasia, misalliance, prostate disease and vaginal prolapse). In contrast, Cave *et al.* found that 9% of veterinary visits (n=197/2,214) were for disease of the reproductive tract. A proportion of dog fights may also be associated with entire sex status. In the current survey, dogfight injuries occurred in 2% of the population, and accounted for just fewer than 5% of traumatic events. In comparison, Cave *et al.* (2009) found that dogfight injuries accounted for 4% of all visits to veterinary clinics, and 12% of all visits relating to trauma. As Cave *et al.*'s data was collected by veterinarians, the higher prevalence of both dog-bite injuries and reproductive disease in their survey may be due to the owners not being able to treat these conditions themselves (unless the dog bite injuries are mild).

3.4.2 Adverse health events

Adverse health events in the current survey were common. Fifty-two percent of dogs suffered a health event that was not due to trauma, and 25% suffered a traumatic injury. In this study there was 2.4 non-trauma events for every trauma event. The ratio in the current study was higher than Cave *et al.* (2009) who found that the ratio of non-trauma events to than trauma events was 1.2:1 (1,024 non-trauma events, 848 traumatic events). This difference is likely to be due to the design of the current survey, which asked dog owners to list all health issues observed, not just those that required veterinary attention. As some of the non-traumatic events listed, for example matted haircoat, would not have warranted veterinary attention, the ratio of non-traumatic to traumatic disease was higher than in comparison to Cave *et al.* In contrast, Singh *et al.* (2011) found that of 205 farms that reported having sick or injured dogs in the 12 months prior to the survey, the most common adverse health event was trauma (73%). There is no obvious reason as to the difference found in Singh *et al.*, but may be due to a difference in questionnaire design, or may be a true representation of the working dog population at the time. It is possible that trial dogs (as used in Singh *et al.*) are viewed as being valuable and provided better nutrition and prophylactic health care (vaccinations, anthelmintics) that could improve general health. However there is no way of establishing this from the available data.

Low bodyweight was the single most common health event recorded in our survey, affecting nearly 20% of the population. Body condition scoring was not used in this study; therefore these are subjective measures from the owners as to whether the dogs are underweight. However this omission does not negate the importance of this result. As the majority of dogs in this study were fed once daily, on a diet consisting primarily of home-kill sheep meat, there would be definite scope for further studies into not only the ideal nutrition for working farm dogs, but also the ideal feeding frequency. There is nothing in the literature evaluating the nutritional values of the mix of farm-kill meat and commercial biscuits currently fed by most farmers. Although there is debate around carbohydrate levels (Cave, 2009), whether a carbohydrate source is required at all (Hammel *et al.* 1977), and what the ideal protein level is (Hill *et al.,* 2009), nothing has been published that sets forward the unique requirements of the farm working dog in New Zealand.

Arthritis was the second most common health event reported, with a prevalence of 10% (n=114/1,115). The specific anatomical location affected was not included in this data, however Cave *et al*. (2009)'s results found that the coxofemoral joint was most affected, followed by the carpus, elbow and hock joints. The location of affected joints is likely to depend not only on any injury sustained but also on the breed, as they are required to perform different types of work, placing stress on different joints. For example, as Heading dogs often 'crouch' when eyeing stock, the carpus and hock joints are likely to obtain more wear than in the Huntaway breed that stands and runs upright. The topography of the farm may also influence the prevalence of arthritis and the type of injuries.

The current survey found that when health events were compared by body system, the integument was most commonly involved in non-traumatic disease, affecting 14% of the survey population (n=160/1,115). Skin disease (6%), along with gastrointestinal disease at 11%, were the most commonly reported illnesses in Singh's (2011) survey also. In contrast, Cave *et al.* (2009) found that only 7% of all veterinary visits were for non-traumatic integumentary disease (n=149/2,214). This difference may be due to owners not seeking veterinary treatment for skin ailments that do not overly affect the dog's health or ability to work. Pet owners that have their dogs inside would be more likely to seek veterinary attention for greasy or malodourous skin conditions, whereas a farmer may not if the dog is otherwise healthy. An alternative reason may be that owners are less likely to involve a veterinarian in diagnosis of common conditions with which the owners themselves are familiar, and able to treat themselves. This theory is supported by a longitudinal study of racehorses which found that less than 10% of cases of shin soreness, the most commonly reported health problem, were seen by a veterinarian (Perkins *et al,* 2004). The distance between farms and veterinary clinics is also likely to affect the apparent prevalence of disease in Cave *et al.*'s survey. Some farms in New Zealand may be in excess of one hour from the closest veterinary clinic, and so it is likely that both mild disease and rapidly progressive, fatal disease are not always seen by veterinarians.

Diseases of the gastrointestinal tract accounted for 9% of all veterinary visits in Cave *et al.* (2009), with constipation and GDV the most common diagnoses. The prevalence of gastrointestinal disease was slightly lower in the current survey, affecting 5% of the population. Fifteen cases of constipation were recorded (prevalence 1%) and 14 cases of GDV (prevalence 1.3%). As mentioned previously, by excluding dogs less than six months of age, the prevalence of infectious gastroenteritis reported in this survey may be lower than in the working dog population as a whole.

In regards to respiratory system, it was mentioned by Cave *et al.*(2009) that the prevalence of respiratory disease in their survey was lower than expected (1% of visits). Because working dogs are exposed to dust, potential allergens, faecal contaminants, and dynamic dog populations as casual teams move on and off the farm, they would be expected to be predisposed to lower airway disease. The results from the current survey also found a relatively low prevalence of respiratory disease (4%), and the majority of cases were limited to the upper respiratory tract. Laryngitis with dysphonia was the most commonly reported respiratory disease (2%), followed by dyspnea of unknown cause (<1%) and Kennel Cough (<1%).

With regards to traumatic disease, the musculoskeletal and integumentary body systems were those most commonly affected, with pad wear and limb fracture the most prevalent injuries. Injury or excessive wear to the pads was the single most commonly reported traumatic event (6%, n=62/1,115), however when categorised by body system, the prevalence of trauma to the musculoskeletal system and the integumentary system were the same (12%). Cave *et al.* (2009) found that 40% (n=260/655) of traumatic injuries recorded involved the feet, however pad wear had a prevalence of only 2% (n=41/2,214). The lower prevalence of pad wear in Cave *et al.* is most likely due to the fact that it is not considered serious enough to involve a visit to a veterinarian. The current survey found that 48 dogs suffered limb fractures (4.3%) and 30 dogs had a musculoskeletal injury caused by stock (2.7%). There may be some overlap between these two categories as it was not always stated how the fracture occurred, or the type of injury that was inflicted by stock. The integument is the largest and most superficial organ so it is not surprising that it is one of the most common body systems affected by injury and disease. The musculoskeletal system too can be exposed to massive intrinsic and extrinsic forces and as such is also prone to injury. Although reducing the incidence of injuries caused by stock may prove to be difficult, reducing the incidence of vehicular injury could be achieved by methods such as: secure crates or cages on the back of vehicles rather than tying dogs up with ropes or chains; removing bars that may trap limbs; training dogs to remain behind the bike or ute if running; and being cautious when driving while dogs are loose. Likewise, reducing pad wear could be achieved by the use of protective boots, and not allowing dogs to run on roads or run long distances while they are not actually working stock.

Congenital problems were found to be uncommon in the current study population (2%), and included hip dysplasia (n=10/1,115), limb or muscular deformity (n=8/1,115) and undershot mandible (n=5/1,115). Hughes (2001) reported in his radiographical survey that hip dysplasia was more prevalent in Huntaways than in Heading dogs. As there were only small numbers of dogs described as having hip dysplasia in the current survey, it is impossible to comment on whether this data supports Hughes' results. Of the ten dogs that had suspected or confirmed hip dysplasia, six were Huntaways, one Heading dog, one Border collie and two of unknown breed. Eight out of these ten dogs were still alive at the time of the survey. Although this survey data does not allow analysis of why a dog died or was euthanased, it could be surmised that dogs diagnosed with hip dysplasia are not necessarily euthanased simply because of the diagnosis. This is supported by Hughes (2001) who suggested working farm dogs are well-muscled, fit and highly motivated to work, and as such may not show marked signs of lameness associated with hip dysplasia. It is likely that hip dysplasia contributes to degenerative joint disease later in life, which may result in euthanasia at this point, as Singh *et al.* (2011) found that the most common cause for euthanasia in working farm dogs was degenerative joint disease. It may also be that the dogs in this survey have only mildly dysplastic joints; and that as dogs less than six months of age were excluded from this survey, it may be that severe cases euthanased at a young age were missed.

Of the available literature involving New Zealand's working farm dogs, there is only the study by Cave *et al.* (2009) that has collected data regarding the prevalence of disease in the population, rather than concentrating on selected diseases. When comparing Cave *et al.* with the current study, there are similarities in demographics and disease prevalence which add support to the validity of both studies. For example, both studies found that Huntaways were the predominant breed, followed by heading dogs. Cave *et al.* found that respiratory disease was uncommon, as did the current study, and of all trauma cases, foot trauma was most common. Gastrointestinal disease had similar prevalence in both studies, and constipation followed by GDV were the most commonly reported gastrointestinal problems.

3.4.3 Risk of death

Fifteen percent of dogs included in the study population (n=167/1,115) were dead at the time of the survey. Although the data does not identify cause of death, it does provide variables that can be analysed to indicate potential factors that increase the risk of a dog dying. However it is likely that there will be confounding factors influencing some of these results, and as such need to be interpreted with caution. This data would benefit from being followed up with a study based on known cause of death in working dogs.

The risk of a dog being dead was higher in dogs that had experienced a non-trauma event and when the number of dogs on the farm increased. Dogs that were considered to be underweight by their owners, or those that had suffered an axial or limb fracture, were less likely to be dead than those that had not suffered these problems. There was no significant risk associated with career stage, breed, sex, or neuter status, or for dogs working on a farm with steep terrain, having arthritis with or without concurrent lameness, or suffering musculoskeletal injury.

The data suggests that being underweight is a protective factor, as dogs that were reported as being underweight were 70% less likely to be dead than dogs not considered to be underweight. This may indicate that these dogs are lean and fit or it may be that owners that recognise their dogs as underweight are more vigilant to other diseases. Without body condition score data it is unknown what owners consider underweight. It is also unknown what the ideal body condition score for a working farm dog may be. Cave (pers. comm. 2013)[2] suggests that it is likely to be lower than the 4-5/9 score recommended for pet dogs, and that 3/9 may be more realistic for a working farm dog.

Dogs that suffered a fracture of the axial skeleton and/or limb fracture were 52% less likely to be dead than dogs that had not. However, limb fractures alone did not significantly affect the risk of a dog being deceased. Intuitively it would be expected that dogs that suffered a fracture to the axial skeleton would be more likely to be dead, as this group included fracture to the ribs as well as to the spine. However there is no obvious reason why rib or spinal fractures would be a protective factor, so it is likely there are some confounding factors involved in this result.

Interestingly, arthritis conveyed no significant risk of a dog being recorded as dead. It may be that dogs with advanced arthritis are simply retired rather than destroyed, and those with early or moderate arthritis continue to work, with or without treatment.

Dogs that were less than or equal to two years of age carried the greatest risk of being recorded as dead. The least risk of death was associated with the 2.1 - 7 year age group. This pattern is likely to represent heavy culling of dogs in the earlier stages of training as they are found not to have the skills

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required for working stock, as well as the value of a highly trained dog in the prime of its working life. Behavioural issues were not included in this study. The increased risk of death in this age group may in fact also be due to younger dogs having less experience and so being more likely to be injured by vehicles or stock. This theory is supported by Singh *et al.* (2011) who found that vehicular and stock accidents were the two most common traumatic injuries.

The risk of an individual dog being dead was found to increase with the number of dogs residing on the farm. It may be that a larger population of dogs on a farm increases the risk of disease spread, as increased episodes of non-traumatic disease was also found to increase the risk of a dog being dead. However, the majority of non-traumatic health events recorded in this survey were not contagious diseases. Another possible factor may be that each dog receives less attention from the owner when they have more dogs to care for. It may also represent the notion that culling of dogs is more acceptable when there are more dogs to replace them.

Although there was no significant risk found associated with steep hill terrain, there may be risk associated with increased stock numbers, a variable that was not included in this analysis.

3.4.4 Topics for future research

Future research could focus on the importance of nutrition in the prevention of disease and injury; for example, dietary fibre component to reduce constipation and increased protein levels to reduce the incidence of musculoskeletal injury. The ideal body condition score, optimum diet composition and frequency also require investigation. Our results found that low bodyweight appeared to be a protective factor. It may be that dogs with a greater level of fitness are leaner than other dogs, and that training and conditioning constitute a protective factor rather than body condition per se. Further to this survey, risk factors associated with a dog being lost from the working population due to death or euthanasia need to be identified so preventative measures can be developed.

Although this survey did not differentiate disease events by breed, there are reports in the literature of Huntaways being predisposed to certain diseases, for example hip dysplasia, constipation, vaginal prolapse and dilated cardiomyopathy (Cave *et al.* 2009). Given that Huntaways and Heading dogs comprise the majority of working farm dogs in New Zealand (50% and 38% respectively) further investigation of diseases in each breed would appear necessary.

In regards to conditions more prevalent in intact dogs, incidence of these could be reduced by encouraging desexing as soon as replacements are bred.

3.5 Conclusion

This survey has identified that both disease and injury are common in the working dog population, with half of the enrolled dogs affected by one or more non-traumatic disease during the study period. As well as identifying the health problems most commonly reported by dog owners, our survey has also provided basic information on certain demographic aspects of this working dog population, and risk factors that may affect the likelihood of a dog being dead. The results provide a valuable baseline dataset for the working dog population, and in combination with Cave *et al*. create a platform from which to direct future study to improve the wellbeing and longevity of New Zealand's working farm dogs.

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