An investigation of selected diseases and aspects of husbandry of working dogs on sheep farms and sheep and beef farms in New Zealand in 2010.

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This study is dedicated to Bebop and Rocksteady. You rock my socks.

Abstract

A cross-sectional study of 202 working sheep dogs and 56 owners was undertaken in 2010 to investigate the dogs' age, gender, breed, body condition scores, aspects of their husbandry, prevalence of and risk factors for nematode and protozoan parasitism, and prevalence of and risk factors for chorioretinopathy in working sheep dogs. Owners were convenience sampled from the South-West Waikato and the Tux North Island Dog Trial Championship 2010. Two-way tables were used to explore the relationship between variables. Significance of association was assessed using a Chi-squared or Fisher exact test as appropriate with a p-value of < 0.05 considered significant. Faecal analysis found 68/170 dogs (40%) had a nematode and/or protozoan parasite infection. Nineteen per cent (33/170) were infected with parasites from the Nematode phylum: *Toxocara canis* (9/170, 5%), hookworms (*Uncinaria stenocephala* or *Ancylostoma caninum*) (20/170, 12%) or *Trichuris vulpis* (8/170, 5%). Prevalence of protozoan infections was: *Sarcocystis* spp. 35/170 (21%), *Isospora canis* or *Isospora ohioensis* 9/170 (5%), *Neospora caninum* and *Hammondia heydorni* 4/170 (2%) and *Giardia* spp. 13/170 (8%). Younger animals had a significantly higher prevalence of *Toxocara canis* (P< 0.0001) and *Giardia* spp. (P< 0.0001). Prevalence of chorioretinopathy in the working sheep dogs was 44/184 dogs (24%). Older animals and males had a significantly higher prevalence of chorioretinopathy than younger animals (P$= 0.0007$) and females (P< 0.0001) respectively. Body condition scores for 197 animals found that: 29 had a BCS less than or equal to 2/9, 78 had a BCS of 3/9, 77 had a BCS of 4/9 and 13 had a BCS equal to or greater than 5/9. The BCS varied significantly between breeds (P$= 0.002$) with Huntaways comprising 23/29 of the dogs who were BCS two or less. The mean age of the working sheep dogs was 4.8 years, 85/200 (43%) were Huntaways, 84/200 (42%) were Heading dogs and 173/191 (91%) of the working sheep dogs were entire. Seventy-eight per cent of owners fed their dogs a diet consisting of commercial food and home kill sheep meat once a day. This study concluded that gastrointestinal nematode and protozoan parasitism and chorioretinopathy are occurring in working sheep dogs. The aetiology of the chorioretinopathy is undetermined. Further farmer education on the use of anthelmintic and prevention of gastrointestinal nematode and protozoa parasites may be required.

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Definitions

Working sheep dog   In this thesis, the title 'working sheep dogs' will be used to refer to working dogs on sheep farms and sheep and beef farms.

Sheep farm   The definition of a sheep farm for the purpose of this study was a commercial sheep production facility where the sheep received a majority of their diet by grazing pasture and crops.

Cyst   In this thesis, 'cyst' will be used to refer to either a protozoan cyst or a protozoan oocyst,.

REF   When calculating relative risk, the REF (reference) is the value that was used for comparison with the other relevant values.

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List of abbreviations

>	Greater than
≥	Greater than or equal to
<	Less than
≤	Less than or equal to
=	Equals
95% CI	95% Confidence interval
Min.	Minimum
Max.	Maximum
GDV	Gastric Dilation-Volvulus
IQR	Interquartile range
NZVA	New Zealand Veterinary Association
MPS IIIA	Mucopolysaccharidosis IIIA
GME	Granulomatous Meningoencephalomyelitis
MCPA	4-chloro-2-methylphenoxy acetic acid
MDR1	Multidrug Resistance Protein 1
IFAT	Immunofluorescent Antibody Test
DCM	Dilated Cardiomyopathy
OLM	Ocular Larval Migrans
$ZnSO_4$	Zinc Sulphate
BCS	Body Condition Score
REF	Reference

Chapter 1. Introduction

1.1 An investigation of selected diseases and husbandry of working dogs on sheep farms in New Zealand in 2010.

In this study of gastrointestinal nematode and protozoan parasitism, age, gender, breed, body condition score, husbandry and chorioretinopathy of working sheep dogs in New Zealand, the history of agriculture and the working sheep dog in New Zealand will be examined. A literature review will then investigate what previous studies and literature have been published on working sheep dogs in New Zealand. Most of the studies published are case series and do not allow causality to be investigated. The literature review will provide a summary of studies investigating the overall health and welfare of New Zealand working sheep dogs; the literature review will then look at specific areas of disease, and overseas working sheep dogs. Following the literature review, the results of two cross-sectional studies will be presented, including study design, results and pertinent discussion. The first study will investigate the prevalence of nematode and protozoan parasitism, age, gender, breed, body condition scores and aspects of husbandry in working sheep dogs in New Zealand. The second study will investigate the prevalence of chorioretinopathy in working sheep dogs in New Zealand.

1.2 The development and importance of agriculture in New Zealand.

When early 19th century settlers arrived in New Zealand, they 'discovered' a mountainous and heavily forested landscape with an extensive, rugged coastline. The vegetation was dominated by kauri trees in the north and podocarp trees further south (Temple, 2008). The landscape and geographical isolation from any other landmass, especially the European market, meant New Zealand's farming potential was not fully appreciated initially. Instead, early settlers in New Zealand were heavily dependent on natural resources for the generation of economic wealth. Seals, whales, timber, gold, flax and kauri gum were important export commodities (King,

2003). The co-existence of two separate cultures (Maori and Pakeha), minimal physical or administrative infrastructure, challenging terrain and a lack of strong central governance were important factors in propagating what could be termed a 'cowboy economy', driven by esurient self-servitude. Despite these factors, New Zealand's agricultural industry, at least in certain provincial areas, developed swiftly. By the 1830's New Zealand agriculture was focused on cropping, with considerable amounts of grain being exported to Australia. This focus on cropping led to a remark in the *Sydney Gazette* on the 12th May 1836, that "New Zealand is becoming a perfect granary for New South Wales" (Rice, 1992).

Maori during the early to mid-19th century were not idle bystanders in New Zealand's agricultural development (King, 2003). They were fully involved in the production and exportation of barley, oats, peas, maize, wheat and potatoes (Rice, 1992). Early missionary influence had played an important role in the adoption of modern agricultural practices by Maori. The missionaries sought to garner influence amongst Maori by teaching skills and showcasing new technologies:

"Samuel Marsden, a missionary in the Bay of Islands, introduced horses and cattle in 1814; the first plough was used by a missionary at Kerikeri in 1820; in 1831 a demonstration farm was established at Waimate missionary station in Canterbury." (Rice, 1992).

As much of the early missionary activity was centred on the Bay of Islands, it was unsurprising that Northland Maori, including Chiefs Ruatara, Hongi and Taiwhangi, rapidly adopted new agricultural practices and their tribes were at the forefront of New Zealand agricultural production (Rice, 1992).

By the mid-19th century, lack of resource management practices had led to the over-exploitation and depletion of many natural resources, making the lifestyle and economics of the pioneer settler increasingly marginal. Agriculture at this time was still an isolated activity and limited to areas of the country with suitable cleared land and ready access to settlements and ports. Small numbers of livestock had existed in New Zealand since sealers and whalers had first built bases on New Zealand's shoreline in the late 18th century.

In the 1830's, livestock production in New Zealand became firmly established:

"In 1833 (or 1834) John Bell settled on Mana Island with 10 head of cattle and 102 sheep; a few years later there were 200 sheep on the island, 30 cattle and some horses… In November 1839 Captain W.B. Rhodes established at Akaroa the first cattle station in the South Island." (Rice, 1992; Wolfe, 2006)

Pastoralism developed in earnest in the 1850's and 60's, with large sheep runs on the east coasts of both islands, which had vast tracts of suitable open land. New Zealand traded in wool and tallow, products that could be shipped long distances. New Zealand's economic destiny seemed reliant on large-scale sheep farming, with wool being the primary export. Vast quantities of sheep, mainly Merino, crossed the Tasman. With them came sheep scab, *Psoroptes ovis,* which was to prove a scourge of the industry for many years. Despite sheep scab, New Zealand's sheep production flourished until the 1870's and 80's when a depressed British economy lowered prices of wool and tallow considerably (Rice, 1992; Wolfe, 2006). New Zealand had an economy strongly reliant on one export product, wool, being sold to one market, Britain. The effect of a depressed British economy highlighted the knife edge on which New Zealand's economy balanced.

In the late 1870's New Zealand entered a long period of depression and stagnation marked with rising unemployment (King, 2003; Rice, 1992). It was in the 1870's and 1880's that a new technology, refrigeration, was developed. This development opened up new opportunities for New Zealand farmers, enabling New Zealand to come out of its financial depression. The advent of refrigeration encouraged the development of freezing works and shipping of sheep meat and dairy products to international markets, mainly Britain (King, 2003; Rice, 1992; Wolfe, 2006). Refrigeration was a big step in the creation of a truly sustainable New Zealand economy as it allowed a diversification of exports.

Refrigeration changed agricultural production systems in New Zealand. Pastoralism, in the form of big stations and sheep runs, had taken advantage of large areas of open country on the East Coast, but much of New Zealand's forests remained untouched.

Refrigeration saw an explosion in development of family farms which resulted in the clearing of large areas of forest. In 1861 there were 158,000 acres of good pasture in New Zealand; by 1881 there were 3.5 million acres and by 1925, 16.5 million acres (Easton, 2009).

During the mid-1890's the British economy experienced rising commodity prices leading to New Zealand's first major economic boom as an independent colony (Rice, 1992). This economic boom led to a swift development in sheep farming in New Zealand, characterized by the uptake of technologies such as new and improved grasses and the importation of different sheep breeds. Dairy farming was slower to develop in New Zealand although there was a steady increase in dairy farms in the North Island in the 1870's. Much of dairying's early development was located in and around Taranaki. In 1891, Taranaki dairying co-operatives were producing more butter than the rest of New Zealand combined (Rice, 1992).

Refrigeration had allowed New Zealand to develop an economy dominated by meat, wool and dairy products. For the next 80 years, until the 1960's, these products made up approximately 90% of New Zealand's exports (Easton, 2009). New Zealand was truly an agricultural economy. Today's picture is little different. New Zealand export earnings are still dominated by agricultural products; dairy products are New Zealand's number one export commodity. Meat production is also an important sector of the economy, with lamb and beef being major export earners (Ministry of Agriculture and Forestry, 2011). However the international growth in demand for white meats, mainly chicken, pork and fish, has impacted on the demand for red meat and thus has affected beef and lamb production. Agriculture still remains the cornerstone of the New Zealand export earnings; tourism, however, has become as important as agriculture as a source of foreign exchange earnings to New Zealand (Ministry of Economic Development, 2012).

1.3 The development and role of the working sheep dog in New Zealand

The working sheep dog is an iconic part of New Zealand's heritage. Sheep and beef farm dogs were immortalised by the protagonist 'Dog' in the Murray Ball cartoon

strip *Footrot Flats*. The cartoon strip embodied the classically antipodean, stylised personification, held by New Zealanders and the rest of the world alike, of that motley collection of natives and immigrants who had come to consider themselves 'Kiwi' – a personification characterised by a black singlet and gumboot wearing, dry witted, emotionally straightforward, practical sheep and beef farmer and his best mate 'the dog'.

Dogs have been valuable 'workers' for and faithful companions of man for millennia, being one of the first animal species to be domesticated less than 16,300 years ago (Pang, Kluetsch, Zou, Zhang, Luo, Angleby, Ardalan, Ekstrom, Skollermo, Lundeberg, Matsumura, Leitner, Zhang, & Savolainen, 2009). Their use in farming, especially in livestock enterprises, dates from ancient times, with the guarding of livestock from predators being as important as aiding in the control of livestock. The first evidence of domesticated sheep dates to 9000BC in North-eastern Iraq (Wolfe, 2006). This evidence makes sheep one of the first species to be domesticated after the dog. The use of domesticated dogs to protect and control sheep may have existed for millennia. As sheep farming developed in New Zealand, breeds of dog that specialized in herding sheep were imported to help aid the industry. The Border collie, reputed to have been brought to New Zealand by pioneer Scottish shepherds in the 19th century, was the first breed of working dog in New Zealand (King, 2003; Redwood, 1980).

There are numerous types of working sheep dog in use in New Zealand but two breeds are dominant – the New Zealand Huntaway and the Heading dog:

"The Huntaway is a noisy dog, whose natural instinct is to hunt or chase sheep away. On account of their noise, they are used for forcing mobs, work in the sheep yards, and for clearing or hunting sheep off tracts of country. The Heading dog has a natural instinct to cast out (i.e., circle widely) round sheep and bring them back to its owner. These are silent working dogs. They are used for "heading" sheep and also for any quiet and careful work at close quarters at lambing time or for "shedding" (cutting out) sheep from a mob." (McLintock, 1966)

The origins of the New Zealand Huntaway are unclear. Its development started in the latter part of the 19th century. Farmers desired a hardy, robust dog that would drive sheep with its bark. The bark was desirable due to the large size of the sheep flocks, the high ratio of sheep to shepherd and long distances over which sheep were mustered and moved. The bark ensured sheep realised a dog was near, drove the sheep out of any scrub or hollows they might be hiding in and hurried up dawdling flocks (Gordon, 1998). British sheepdogs were selectively bred with numerous other breeds (exactly which is not known) to get a noisy dog with the desired attributes. The name 'Huntaway' originates from special events that were held at early sheep dog trials for these barking dogs that were called 'Huntaway events' (Redwood, 1980). The dog was required to gather the sheep and drive them with its bark.

The Heading dog is a result of farmers breeding Border Collies and other silent sheep dogs for performance and not to breed standards or for a pure-bred pedigree. The bulk of its genetic ancestry derives from Border Collies and other British sheepdogs; therefore the Heading dog usually resembles its classic British sheep dog parentage.

The New Zealand Huntaway and the Heading dog are not recognised breeds by any kennel club. The Huntaway and the Heading dog do not have to meet any conformation specifications because their performance is the key requirement for their use and for their development. The principal requirement of the Huntaway is that it barks on command, whereas the principal requirement of the Heading dog is that it casts out and around sheep. As a result of farmers breeding for performance more than one 'strain' of Huntaway and Heading dog exists, with some variation in their size and appearance.

Huntaways vary greatly in size but are, in general, large, strong dogs, with an average body weight in the mid-high 20kg range (Cave, Bridges, Cogger, & Farman, 2009). Their appearance varies: coat colours include black, tan and white; coat texture includes smooth or rough. The Huntaway has a loud, deep bark. In contrast the Heading dog is a much smaller, finer built animal that averages around 19kg body weight. The Heading dog is an agile, fast animal with quick reactions.

McLintock outlines the other types of working sheep dogs that have been bred over time in New Zealand, dependent on the work required in the different farming systems:

"Handy Dog; a dog which can do both heading and huntaway work. This is an 'all-round worker' making it a very useful sheep dog.

Leading Dog; some "heading" dogs have a natural aptitude for leading sheep. They are trained to work at the head of a mob of sheep and keep them in check. This is a most useful dog when droving sheep.

Backing and Yard Dog; usually this is a "huntaway" or "handy dog" trained to run over the backs of tightly packed sheep and to walk back through a mob in the yards to keep them moving ahead. It is a useful dog for loading and unloading sheep.

Stopping Dog; this is a heading dog which, once it has headed sheep, will hold them quietly until his master arrives. The ordinary heading dog will endeavour to "pull" the sheep. Stopping dogs were common in the early days for handling high-country Merino sheep which had become wild and difficult.

Cattle Dogs; most of the cattle in New Zealand are worked by sheep dogs. In Australia the "blue merle cattle heeler" is well known as a severe "heeler", and dogs with this ability are sometimes used for handling stubborn and refractory cattle in New Zealand". (McLintock, 1966)

The working sheep dog has been an essential component of the success of New Zealand's agricultural economy. The extensive, grass-fed sheep and beef operations that were the backbone of the developing New Zealand economy would not have been economically or physically viable without the aid of well-trained working sheep dogs. Today, sheep and beef farms are still an important facet of the modern New Zealand economy, and the role of the working sheep dog on these farms is still just as important as it was when they were first introduced by Scottish shepherds roughly 150 years ago.

Chapter 2. Literature review

2.1 The general state of health and welfare of working sheep dogs in New Zealand

While working sheep dogs are valuable contributors to the New Zealand economy, little research has been done to investigate their overall health and welfare. A survey of 2,214 examinations of working farm dogs by veterinarians in 30 practices in New Zealand over a 12 month period has been published recently (Cave, Bridges, Cogger, & Farman, 2009). Significant findings of this study are outlined below.

Of the 2,214 examinations, 51% were Huntaways and 39% were Heading dogs. Sixty-two per cent of all the visits were for non-traumatic disease. Gastrointestinal tract disease, skin disease, theriogenological disease, poisonings, cardio-respiratory disease and degenerative joint disease were all reported. Trauma was responsible for 38% of visits. Almost one-third of trauma cases were of an unknown aetiology. Causes of injury that were identified were: stock, automotives, fences, fighting with other dogs, falls (non-vehicle related) and gunshots. Eighty-nine per cent of dogs were either Huntaway or Heading dogs. The study found that Huntaways were over-represented for: constipation (43 out of 51 cases), GDV (33 out of 36 cases), theriogenological disease (108 out of 197 cases), laryngitis (17 out of 18 cases), hip dysplasia (16 out of 21 cases) and degenerative lumbosacral disease (27 out of 36 cases). Laryngitis and dsyphonia were almost exclusively Huntaway diseases (18 out of 18 cases and 8 out of 9 cases respectively), which may reflect their use as a barking dog. Heading dogs were over-represented for: multiple ligamentous injuries of the stifle (13 out of 18 cases), injury of the gastrocnemius or achilles tendon (16 out of 22 cases), tarsal injuries (23 out of 32 cases) and hip luxation (17 out of 27 cases). The authors postulated that "the propensity for serious musculoskeletal injuries in Heading dogs is a consequence of their faster working activities and their increased running requirements during heading activities". The survey looked at types of injury and disease that led to loss of working dogs from euthanasia, death or retirement of the animal due to the severity of the injury or disease. "Loss from work (death, euthanasia or retirement from work) was reported following 11.4% of all

visits. The most important non-traumatic causes of loss were GDV, degenerative joint disease, mammary neoplasia and diseases involving the female reproductive tract, cardiac disease and poisoning." Anticoagulant toxicity was responsible for the majority of the poisonings. It was noted that 'the overwhelming majority of working farm dogs in New Zealand were sexually intact' and that 'a dog might not be bred until later in its life once its performance was established'. This practice of delayed breeding until the animal is older may contribute to the high rate of theriogenological disease. The most common reproductive condition was mis-mating, which is malleable to improvement with further education of farmers and improved management. The authors identify that 'several important diseases were amenable to intervention through altered nutrition, neutering or behavioural modification. These conditions included constipation, GDV, theriogenological problems, dog-bite injuries and laryngitis'. The authors also suggested that 'altering transit across fence lines has the potential to reduce large numbers of serious orthopaedic injuries to working farm dogs'.

Another study investigated the age, breed, gender and nutrition of a population of working sheep dogs in New Zealand, by surveying members of the New Zealand Sheep Dog Trial Association (Singh, Tucker, Gendall, Rutherfurd-Markwick, Cline, & Thomas, 2011). Five hundred and forty members with 2,861 dogs completed the survey. The median farm size was 440 hectares (IQR 132-1,200) and 82% of farms were either hill country or a mix of hill and flat country farms. Singh *et al.* (2011) found that the median age of working sheep dogs was three (IQR two to six), the median number of working sheep dogs per farm was six (IQR five to eight), Heading dogs were the most common type of working dog (52.8%), followed by Huntaways (40.6%) and that 57% of dogs were male though the gender imbalance decreased with age. Singh *et al.* (2011) found that 97% of owners fed their dogs once a day, with 58-61% of farmers feeding a combination of commercial dry food and home kill sheep meat depending on the amount of work being done by the dogs and that the most common combination of commercial dry food and home kill sheep meat fed was less than 50% dry diet and greater than 50% home kill sheep meat (25.6% of owners). Twenty-one to twenty-four per cent of dogs received other food, including scraps and wet commercial food, depending on the amount of work they were doing. Thirty-eight per cent of farms had sick or injured dogs in the previous year, with

73% of injuries due to trauma, mainly by livestock, fences or farm vehicles. Gastrointestinal disease and skin disease were the most common illnesses. Nineteen per cent of farms euthanased 149 dogs with the most common reason being degenerative joint disease. The authors concluded that optimal nutrition in working sheep dogs may not be achieved currently in New Zealand leading to sub-optimal working lifetime performance.

An epidemiological study, currently in progress, is looking to identify health problems of working sheep and beef dogs in New Zealand through a survey of farmers in the lower North Island (Jerram, Cogger, & Stevenson, 2009). Preliminary results from 44 farms with 60 farm dog owners and 479 dogs has been reported. Jerram *et al.* (2009) found that 320 of the 479 dogs suffered at least one adverse health event in a 12 month period. One hundred and sixty seven dogs either died or were destroyed. Adverse health events included behavioural issues and disease due to illness or trauma. Behavioural issues were the most common adverse health event in working farm dogs and in dogs that had died or were destroyed. Joint problems were the most common adverse health event in retired or semi-retired working sheep dogs.

Three conference presentations were published in the Society of Sheep and Beef Cattle Veterinarians and Companion Animal Society NZVA proceedings 1997, discussing dermatoses (Bell, 1997) and orthopaedic injuries (Walker, 1997a, 1997b) in New Zealand working dogs. Bell (1997) suggested that flea control is lax, atopy is uncommon and that predominately deep chested Huntaways suffer from sternal calluses. Walker (1997a) discussed an unpublished, undated, retrospective study by Preston Stubbs that identified 69 dogs with 77 orthopaedic injuries presented to Massey University over a two year period. Fractures (47%) and joint luxations/ligamentous instability (45%) were the most common causes of presentation. The type of orthopaedic injuries seen at Massey University Veterinary Hospital may be different to general veterinary practice as it is a referral hospital so may not be a good indication of what is happening to working sheep dogs on farm.

Considering the annual cost, in terms of reduced sheep farm and sheep and beef farm productivity and the cost of veterinary care, to the New Zealand economy due to

working sheep dog diseases, there is a significantly disproportionate amount of research published on the general state of health and welfare of working sheep dogs in New Zealand and this paucity is a clear indication that further research into general working sheep dog health and welfare is warranted.

2.2 Specific health and welfare diseases of New Zealand working sheep dogs

Specific diseases and conditions that have been identified in working sheep dogs in New Zealand include:

2.2.1 Orthopaedic Diseases

There has been little published on orthopaedic conditions affecting working sheep dogs in New Zealand. This is somewhat surprising considering the large degree of physical activity they undertake in what may be considered a high risk environment for physical injury. The studies that have been published are case-series and as such do not allow causality to be investigated.

A technique for open reduction of chronic coxofemoral luxation in the dog and case examples of six dogs who underwent the procedure, including four working Border Collies, was published in 1965 (Twaddle, 1965). Three of the Border Collies were working normally again one month after removal of the screw. Two case reports in scientific literature involve musculoskeletal injuries sustained while working: a patella ligament injury in an acutely lame dog (Owen & Worth, 2005) and infraspinatus muscle contracture in a chronically lame dog (Dillon, Anderson, & Jones, 1989). Two case studies have been published on pancarpal arthrodesis for carpal injuries (Jerram, Walker, Worth, & von Lande, 2009; Worth & Bruce, 2008). These studies outlined possible techniques for surgical treatment and investigated owner satisfaction in regards to the degree of lameness and ability to work following treatment. Owners were satisfied or very satisfied with the resultant mobility and work performance of the dogs in ten out of the twelve cases in the Worth *et al.* (2008) study. In the Jerram *et al.* (2009) study, eleven out of twelve owners said that the result of the surgery met their expectations. A case study focusing on surgical

repair of common calcanean injuries (Worth, Danielsson, Bray, Burbidge, & Bruce, 2004) has been published; this study also investigated the ability of dogs to work and owner satisfaction following surgery. Seven out of ten dogs returned to full or substantial degrees of work and seven out of ten owners felt the financial investment in surgical repair was worthwhile. A clinical communication discussing the surgical repair of a fracture of the medial condyle of the distal femur in a Heading dog and a Huntaway with subsequent successful return to work has also been published (Davis & Worth, 2009). There is also anecdotal evidence of good outcomes in two Heading dogs that underwent bilateral carpal arthrodesis (Verhoek, 1994).

A survey on the developmental orthopaedic condition, hip dysplasia, was conducted on working dogs in the Taihape region of New Zealand (Hughes, 2001). This preliminary study indicated that hip dysplasia may be a problem in the Huntaway breed. Radiographic evaluation of 93 Huntaway and 48 Heading dogs using the NZVA Hip Dysplasia Scheme was undertaken. The prevalence of hip dysplasia in Huntaways and Heading dogs (defined as a combined score from both hips of ≥ 10) was 23.6% and 6.3% respectively. Another developmental orthopaedic condition, varus deformation, has also been described in a New Zealand working dog (Fox & Bray, 1993).

2.2.2 Neurological Disease

Inherited conditions of the central nervous systems (CNS) and peripheral nervous system (PNS) have been described in New Zealand working sheep dogs: cerebellar neuroaxonal dystrophy causing hypermetria, wide based stance, difficulty maintaining balance, intention tremour and ataxia in Collies (Clark, Hartley, Burgess, Cameron, & Mitchell, 1982), cerebellar degeneration in Border Collies, with clinical signs of progressive ataxia and a slight tremor (Gill & Hewland, 1980) and mucopolysaccharidosis IIIA in Huntaways (Jolly, Allan, Collett, Rozaklis, Muller, & Hopwood, 2000). Yogalingam *et al.* (2002) described MPS IIIA as "an autosomal recessive disease that occurs due to a deficiency of heparin sulphate sulfamidase. The deficiency of heparin sulphate sulfamidase results in lysosomal accumulation of the glycosaminoglycan heparin sulphate resulting in severe central nervous system degeneration. The affected dogs display progressive ataxia."

(Yogalingam, Pollard, Gliddon, Jolly, & Hopwood, 2002). In this survey of 203 New Zealand Huntaway dogs, 15 were identified as heterozygous carriers of the recessive allele (Yogalingam, Pollard, Gliddon, Jolly, & Hopwood, 2002).

Acquired neurological diseases of New Zealand farm dogs have also been described: protozoan encephalomyelitis involving *Neospora caninum* and *Toxoplasma gondii* which cause ascending hind limb ataxia and paralysis (Patitucci, Alley, Jones, & Charleston, 1997)*,* dieldrin poisoning (a pesticide banned for use in New Zealand agriculture in 1968) (Harrison & Manktelow, 1960; Harrison, Maskell, & Money, 1963) and neurological syndromes in five dogs including: champing jaws, excessive salivation, muscle twitching, convulsions and no response to sight and sound, that may have been due to thiamine deficiency (Mayhew & Stewart, 1969). A subsequent study confirmed thiamine deficiency was causing acquired neurological disease in working dogs fed cooked or frozen mutton and offal (Read, Jolly, & Alley, 1977).

The cause of some neurological diseases in New Zealand working sheep dogs that have been described in literature have yet to be established: progressive myelopathy and neuropathy in Huntaways (Jolly, Burbidge, Alley, Pack, & Wilson, 2000), granulomatous meningoencephalomyelitis (GME) in working dogs (Alley, Jones, & Johnstone, 1983) and lower motor neurone disease in dogs in the Canterbury region (Hutton, 1997). Clinical signs for GME include: cervical pain, seizures, behavioural changes, ataxia, head tilt, muscle tremor and paresis. Clinical signs of GME are often acute in onset (Alley, Jones, & Johnstone, 1983). Clinical signs of progressive myelopathy and neuropathy in Huntaways may resemble those of MPS IIIA; however the myelopathy is characterized by ataxia mainly of the hind limbs and not the generalized ataxia as seen with MPS IIIA (Jolly, Burbidge, Alley, Pack, & Wilson, 2000). Lower motor neurone disease is characterized by sudden hind limb ataxia in healthy young dogs, developing to quadriplegia over a two to four week period. In the Canterbury region, rural working Collie breeds are most often affected (Hutton, 1997). There is no indication that lower motor neurone disease has been investigated in dogs from outside of the Canterbury region, therefore it is unknown if the prevalence of lower motor neurone disease is higher in dogs from the Canterbury region than the rest of New Zealand.

2.2.3 Toxicities

The farm environment often contains a vast assortment of chemicals from petroleum products for machinery to pesticides to which a working sheep dog could potentially be exposed. As well as the dieldrin toxicity which was mentioned in the neurological disease section (Harrison & Manktelow, 1960; Harrison, Maskell, & Money, 1963), case reports on: arsenic poisoning (Bruere, 1980), secondary phosphorus poisoning (Gumbrell & Bentley, 1995), brodifacoum poisoning (McSporran & Phillips, 1983), MCPA, a phenoxyacid herbicide, (Hasselman, Sharp, Sharp, & Gill, 2001) and anecdotal evidence of copper poisoning from dogs that have drunk from copper sulphate footrot baths (Hogan, 1973) have also been published. Parton (2009) has stated that New Zealand farm dogs are at risk of lethal poisoning if exposed to sufficiently high doses of macrocyclic lactone parasiticides with case reports supporting this statement (Parton, Wiffen, Haglund, & Cave, 2012; Parton, 2009). Collie and Collie crossbreds and other breeds of dog descended from British working sheepdogs with an MDR1 gene mutation are particularly sensitive to these compounds (Neff, Robertson, Wong, Safra, Broman, Slatkin, Mealey, & Pedersen, 2004) though the frequency of the mutant MDR1 allele varies between different collie-type breeds(Mealey, Munyard, & Bentjen, 2005; Tappin, Goodfellow, Peters, Day, Hall, & Mealey, 2012). There have been no toxicity case reports published in literature since the mid-1990's; this may reflect a lack of interest in toxicity case reports or improvements by farmers in the secure storage of chemicals and in limiting the ability of dogs to roam and access toxins when unobserved.

2.2.4 Nutrition

Many working sheep dogs were traditionally fed all-meat/offal home kill sheep meat diets. The campaign to eradicate the significant public health risk from the disease hydatids, caused by the cestode *Echinococcus granulosus,* discouraged the feeding of raw sheep offal to dogs in 1940 (Kasper, 1990). The definitive host for *E. granulosus* is the dog, while many mammals can act as an intermediate host. The ban on feeding raw ruminant and porcine offal to dogs was established by the Hydatid Control Act (1959) which educated farmers about hydatid control and established programs focused on regular anthelmentic dosing and canine inspection.

This programme helped New Zealand to become provisionally free of hydatids in 2002 and lead to a significant reduction in *Taenia hydatigena*, another cestode that is transmitted between sheep (the intermediate host) and the dog (the definitive host) in raw sheep offal (Forbes, 1961; Gemmell, 1958; Kasper, 1990; Laing, 1957; Pharo, 2002; Sweatman, Henshall, & Manktelow, 1962). Sheep measles, caused by the cestode *Taenia ovis*, remains a potential industry problem (Jolly, Charleston, & Hughes, 2002; Sweatman, 1962). *Cysticercus ovis*, the larval stage of *T. ovis*, is usually found in the heart and diaphragm of sheep but can be found in any of its intramuscular connective tissue. It is transmitted to its definitive host, the dog, via feeding of raw or inadequately cooked ovine muscle.

The campaign to eradicate hydatids, and the legal requirement to feed dogs only sheep meat treated by freezing at -10°C for at least seven days (Whitten, 1970) or cooking, to prevent infection with *T. ovis*, led to an increase in the feeding of boiled sheep meat and alternate diets such as rendered scraps and commercially prepared dog rolls (Jolly, Charleston, & Hughes, 2002). Cooked, frozen and improperly formulated dog foods resulted in case reports of thiamine deficiency in working sheep dogs (Mayhew & Stewart, 1969; Read, Jolly, & Alley, 1977). Deficiencies, other than thiamine, have also been reported as a result of feeding the traditional all meat diet: iodine deficiency has been identified in abattoir working dogs (Nuttall, 1986; Thompson, 1979) and possible selenium deficiency which resulted in a myopathy resembling white muscle disease (Manktelow, 1963). The possible selenium deficiency was reported in an adult Collie sheep dog that lost the use of its hind legs, and on a separate property, in a litter of puppies that were congenitally affected. Both of these properties were in areas of Otago that were known for selenium responsive diseases in sheep and the dogs were fed almost exclusively mutton.

Singh *et al.* (2011) investigated epidemiological characteristics related to nutrition in working sheep dogs and this was discussed in the previous section on the general health and welfare of New Zealand sheep dogs. Two separate proceedings of the Sheep and Beef Cattle Veterinarians Society of the NZVA have outlined recommendations and nutritional requirements for feeding working dogs (Cave, 2009; Guilford, 1997). Many farmers now incorporate foods into the diet of their

working sheep farm dogs that have been scientifically formulated to meet working dogs nutritional needs, the most common feed combination being home kill sheep meat and commercial biscuits (Cave, 2009; Singh, Tucker, Gendall, Rutherfurd-Markwick, Cline, & Thomas, 2011). The education of farmers about, and research into, working dog nutrition is an on-going process however. A survey in 1986 (Meadows, 1986) looked at the opinions of veterinarians on the use of and recommendations for dog foods. The survey identified that 13.5% of respondents considered underfeeding of farm dogs to be a problem, although this number increased to 24% for those respondents in mixed practice and 36% of respondents in rural practice. Hill *et al.* (2009) identified that low-carbohydrate, high-protein diets appeared to offer certain advantages to working dogs including: higher apparent nutrient digestibility, slower release of glucose into the bloodstream and reduced large intestinal fermentation of carbohydrate.

2.2.5 Parasitic Disease

Working sheep dogs are susceptible to a variety of parasitic diseases. The close association with different species and other dogs, opportunities for eating raw meat (fed or scavenged), poor faecal disposal and unsanitary and closely confined housing may result in New Zealand working sheep dogs encountering areas of high parasitic challenge.

The nutrition section of this review discussed the level of infection with cestodes: *Taenia hydatigena*, *Taenia ovis* and *Echinococcus granulosus*. To date there have been no other investigations of nematode parasitic infections in working sheep dogs. Collins *et al.* (1981) published a survey identifying, using post-mortem examination of the gastrointestinal tract, gastro-intestinal helminth infections in 38 of 55 dogs surveyed (69.1%). *Dipylidium caninum*, *Taenia* spp., *Toxascaris leonina*, *Toxocara canis*, *Trichuris vulpis* and *Uncinaria stenocephala* were all isolated. The pulmonary nematode *Filaroides osleri* was not found in any of those dogs. The survey specified that 10 of the 55 dogs were working dogs, though did not identify what type of working dog. A case report identified canine pedal dermatitis due to percutaneous *Uncinaria stenocephala* infection in a group of dogs kept in unsanitary kennelling conditions on one farm (Smith & Elliott, 1969).

Dogs are a definitive host of several protozoan parasites that have been identified in New Zealand literature including: *Sarcocystis* spp., *Neospora caninum* and *Isospora* spp. (McAllister, Dubey, Lindsay, Jolley, Wills, & McGuire, 1998; McKenna & Charleston, 1980). Dogs are definitive host of some of the *Sarcocystis* spp. identified in New Zealand sheep (Pomroy & Charleston, 1987), goats (Collins & Charleston, 1979; Collins & Crawford, 1978) and cattle (Bottner, Charleston, Pomroy, & Rommel, 1987). McKenna *et al.* (1980) reported that 283 (58.8%) of 481 dogs' faecal samples contained *Sarcocystis* spp. sporocysts. The 481 dogs were from the North Island of New Zealand, of mixed age, from town and country environments and no breed was specified. *Sarcocystis* spp. can cause myositis in the definitive host (Sykes, Dubey, Lindsay, Prato, Lappin, Guo, Mizisin, & Shelton, 2011) though disease has not been reported in New Zealand. In the intermediate host aesthetically unacceptable *Sarcocystis* spp. macrocysts can develop in skeletal and cardiac muscle and schizogony of *Sarcocystis* spp. can cause myositis, fever, anaemia, haemorrhage, abortion and death, although disease in the intermediate host is rare.

Dogs can act as an intermediate host, as well as a definitive host, for *Neospora caninum.* In dogs the disease, neosporosis, can cause meningoencephalomyelitis as well as neuromuscular abnormalities in the hind limbs. Neosporosis can resemble the protozoan disease, toxoplasmosis, caused by *Toxoplasma gondii*, and GME, both of which have been identified in New Zealand dogs (Patitucci, Alley, Jones, & Charleston, 1997). *Neospora caninum* is an important parasite because it can cause multiple abortions in cattle and, at least experimentally, sheep (Antony & Williamson, 2001; Pomroy, 2005; Reichel, 2000; Thornton, Thompson, & Dubey, 1991; West, Pomroy, Collett, Hill, Ridler, Kenyon, Morris, & Pattison, 2006; Weston, Howe, Collett, Pattison, Williamson, West, Pomroy, Syed-Hussain, Morris, & Kenyon, 2009). The prevalence of *Neospora caninum* is high in working sheep dogs: 149 out of 154 sheep and beef farm dogs in the central North Island were infected at a cut off titre of 1:200 (96.8%) using an immunofluorescent antibody test (IFAT) (Antony & Williamson, 2003). However another study which also used a IFAT test with a cut off titre of 1:200 to identify the prevalence of Neospora caninum in 200 New Zealand dogs of unspecified origin found a prevalence of 9% which is lower than the prevalence for any population of dogs tested in the Antony and Williamson (2003) study (Reichel, 1998). The difference in prevalence of

Neospora caninum between the two studies may be because the canine population tested by Reichel (1998) may have been more urban in origin with less access to bovine tissue than the canine populations tested by Antony and Williamson (2003). The prevalence of *Neospora caninum* was lower in cattle and sheep: 14 out of 499 beef cattle (2.8%) had antibodies at slaughter in one survey (Tennent-Brown, Pomroy, Reichel, Gray, Marshall, Moffat, Rogers, Driscoll, Reeve, Ridler, & Ritvanen, 2000), 4 out of 640 rams (0.625%) had antibodies in another survey (Reichel, Ross, & McAllister, 2008). Dogs are infected with *Neospora caninum* by eating infective bradyzoite cysts found in the central nervous system, placenta and muscle tissue of intermediate hosts. Dogs produce *Neospora caninum* oocysts in their faeces that cattle and sheep can ingest (McAllister, Dubey, Lindsay, Jolley, Wills, & McGuire, 1998). Therefore to aid in control of neosporosis it is advocated that dogs are prevented from accessing expelled placentas, foetuses and raw beef and that they are not exposed to stock feed storage areas such as hay and silage stacks (Antony & Williamson, 2001, 2003; Reichel, 2000).

2.2.6 Bacterial Diseases

Leptospirosis is an important disease of all dogs in New Zealand. Serovars that have been identified in this country include: *tarassovi*, *pomona*, *copenhageni*, *ballum* and *canicola* (Ellison & Hilbink, 1990; Hilbink, Penrose, & McSporran, 1992; Mackintosh, Blackmore, & Marshall, 1980). A serosurvey for antibodies to *Leptospira* serovars in dogs in the lower North Island and South Island of New Zealand in 2005 concluded that working dog breeds more frequently had titres to *Leptospira borgpetersenii* serovar *hardjo* when compared to other breeds and are at greater risk of infection by this serovar (Harland, Cave, Jones, Benschop, Donald, Midwinter, Squires, & Collins-Emerson, 2012). *Leptospira interrogans* serovar *copenhageni* was the most common serovar in New Zealand, with more than 10% of dogs having positive MAT titres to it. A serosurvey for antibodies to *Leptospira* serovars in dogs in the lower North Island of New Zealand found no significant difference in the prevalence of any specific serovar between dogs grouped as dairy, sheep and beef, and urban. The study found 14.2% (41/433) of all the dogs were positive for leptospiral antibodies (O'Keefe, Jenner, Sandifer, Antony, & Williamson, 2002). Various studies indicate *Leptopira interrogans* serovar

copenhageni is the most common serovar that infects dogs although there are possibly regional and environmental differences with rural dogs significantly more likely to be seropositive for serovar *hardjo*, which has cattle as a maintenance host (Ellison & Hilbink, 1990; Hilbink, Penrose, & McSporran, 1992; Mackintosh, Blackmore, & Marshall, 1980; O'Keefe, Jenner, Sandifer, Antony, & Williamson, 2002).

A four year old male Huntaway dog in the Huntly district of the North Island was presented with a history of acute progressive paresis. Clinical signs and demonstration of botulinus toxin in serum allowed a diagnosis of botulism, caused by the organism *Clostridium botulinum,* to be made (Read & Kelly, 1990). The source of the botulinus toxin was not found but it is associated with rotting vegetation and dead animals which are often found around wetland areas. Such areas are common on sheep and beef farms.

Intra-thoracic pyogranulomatous disease has been identified in four large breed male working farm dogs (Doyle, von Lande, & Worth, 2009). Two dogs had *Actinomyces viscosus* infection, a third had suspected *Actinomyces* spp. or *Nocardia* spp. infection and the fourth had a streptococcal infection with a grass-seed foreign body being removed at surgery. Grass awns were suspected to have caused all four cases of intra-thoracic pyogranulomatous disease, either through inhalation of the grass awn or migration of the grass awn across the thoracic wall. The exposure of working sheep dogs to grass awns makes this an important differential for intra-thoracic pyogranulomatous disease.

A pulmonary *Mycobacterium bovis* infection was identified in a German Shepherd which caused a granulomatous pneumonia. The dog initially presented with a persistent soft cough, inappetance and weight loss (Gay, Burbidge, Bennett, Fenwick, Dupont, Murray, & Alley, 2002). The authors state that this is an important disease to consider in any dog presenting with pulmonary disease and pleural effusion, that is living in regions of New Zealand known to have a high prevalence of mycobacterial infection in wildlife and farm animals.

Salmonella spp. have been isolated in 13 out of 300 (4.3%) sheep and beef working dog rectal swab samples (Timbs, Davis, Carter, & Carman, 1975). In the same study

no *Salmonella* spp. were found in 150 healthy, disease free dogs from Napier and Hawkes Bay cities. The authors proposed a relationship between infected sheep and in-contact dogs.

2.2.7 Chorioretinal Disease

The retina and the choroid are two components of the fundus. The retina is the organ responsible for transducing light into neuronal signals that are eventually perceived as a visual image. The choroid is the organ responsible for the blood supply of the outer retina, including the photoreceptor layer. The close proximity and functional intimacy of the retina and choroid mean that inflammation of one of these tissues will normally lead to inflammation of the other resulting in chorioretinitis or retinochoroiditis (Maggs, Miller, & Ofri, 2007).

Chorioretinitis is a disease with multiple causes, including infectious agents, neoplasia, immune-mediated disease, toxicity, trauma, haematological pathologies and idiopathic disease (often postulated as having a genetic cause). Chorioretinal lesion(s) are typically not pathognomonic and other tests are required to diagnose a cause.

The prevalence of chorioretinitis depends on the prevalence of potential aetiologies in a geographic location. A New Zealand study found that 39% of 1,448 working sheep dogs were affected with varying degrees of multifocal retinal disease on ophthalmoscopic examination (Hughes, Dubielzig, & Kazacos, 1987). Forty-two per cent of Huntaways and 34% of Heading dogs were affected. The same study also looked at 125 dogs raised in an urban environment and 70 rural pet dogs and found six per cent of urban raised dogs and 43% of rural pet dogs were similarly affected, suggesting that environment is important in the pathogenesis of the disease in New Zealand working sheep dogs. Some genetic variation in susceptibility to the disease may also exist. The fundoscopic appearance was characterised by multifocal, well-delineated, irregularly shaped and sized areas of hyper-reflectivity in the tapetal fundus. Hyper-pigmented clumping was often centrally positioned in these areas. Depigmented patches were often seen in the non-tapetal fundus and mild vitreal clouding was often present. Retinal lesions varied from small discrete areas of hyper-

reflectiviy to widespread hyper-reflectivity involving most of the fundus with blood vessel attenuation. Approximately half the animals were affected bilaterally. Fifty per cent of 990 working males and 15% of 458 working females were affected. Re-examination of 182 of the dogs over three years found approximately eight per cent annually had fundoscopic changes. The majority of the dogs could see according to the owners.

Seventy of the working sheep dogs in the study by Hughes *et al.* (1987) had both eyes examined histologically. Based on histological findings the dogs with inflammatory disease could be divided into three categories: 1) Dogs three years of age or less with active inflammatory disease of the retina, uvea and vitreous, normal vision; 2) Diffuse retinitis and retinal atrophy in conjunction with localised retinal necrosis and choroidal fibrosis, vision severely affected; 3) Chronic, low-grade retinitis with variable retinal atrophy, normally visually functional and mainly older than three years of age. Four dogs in category 1 had OLM due to migrating *Toxocara* spp. nematode larvae.

The authors postulated that the high prevalence of retinal lesions in rural dogs could be due to OLM because of a high *Toxocara canis* challenge (Hughes, Dubielzig, & Kazacos, 1987).When Hughes *et al.* (1987) conducted their study, New Zealand working sheep dogs were possibly exposed to a significant parasite challenge due to the number of dogs concentrated on farms, kennelling conditions and feed with potential parasite contamination.

2.2.8 Other Diseases

A possible predisposition to dilated cardiomyopathies has been identified in the Huntaway dog. Munday *et al.* (2006) examined 429 canine necropsy reports and identified 12 dogs in the Massey University necropsy database that were diagnosed either via gross necropsy examination, echocardiography or histology with DCM between 1999 and 2006. Thirty two of the necropsy reports examined were for Huntaways. Four of the 12 animals diagnosed with DCM were Huntaways. The prevalence in Huntaways was significantly higher than the prevalence in all other breeds (p= 0.008) and the prevalence in all large breeds of dogs (p= 0.025). All four

Huntaways diagnosed were male and were between two and six years old, with an average age of four years.

Black-hair follicular dysplasia, a heritable disease, was identified in a New Zealand Huntaway dog. This is a slowly progressive alopecia of black-haired skin that predisposes the skin to follicular plugging and secondary bacterial skin infections (Munday, French, & McKerchar, 2009). Photosensitive dermatitis in Collies is a rare disease characterized by moist, pruritic exudative dermatitis of non-pigmented areas of skin. It was identified in two Collie working dogs from the same property (Fairley, 1982). A neutropenia associated with myelokathexis with a possible autosomal mode of inheritance was identified in two Collie pups from the same litter. The disease was characterized by a persistent neutropenia and myeloid hyperplasia (Allan, Thompson, Jones, Burbidge, & McKinley, 1996). Lipoleiomyoma of the reproductive tract was described in a four year old nulliparous Huntaway bitch (Sycamore & Julian, 2011).

2.3 Overseas working sheep dog health and welfare

There has been little data published overseas on the overall health status of working sheep dogs. Instead studies involving working sheep dogs in other countries have tended to focus on specific diseases such as leptospirosis in dogs (Ward, Glickman, & Guptill, 2002) or the frequency of the mutant MDR1 allele in herding breed dogs in Australia (Mealey, Munyard, & Bentjen, 2005). While these studies are often not always relevant to dogs in New Zealand there are still inferences that are applicable and these studies can lead to useful insights; for instance, studies looking at local dog populations in Spain, Algeria, Hungary and New Zealand have all concluded that working sheep dogs have a higher prevalence of neosporosis than urban companion animals (Antony & Williamson, 2003; Collantes-Fernandez, Gomez-Bautista, Miro, Alvarez-Garcia, Pereira-Bueno, Frisuelos, & Ortega-Mora, 2008; Ghalmi, China, Kaidi, & Losson, 2009; Hornok, Edelhofer, Fok, Berta, Fejes, Repasi, & Farkas, 2006). This higher prevalence in working sheep dogs suggests the farming

environment may expose these different populations to similar risk factors for the disease.

Lorenz *et al.* (1986) released a study into the cause and economic effects of mortality in livestock guarding dogs (Lorenz, Coppinger, & Sutherland, 1986). These are dogs that are kept with the livestock (often sheep) on extensive farms and rangelands in the United States. They are not used to herd the animals, instead they guard them against potential predator threats. The environment they work in may place them at risk of some similar diseases to those of the New Zealand working sheep dogs. A major finding of the study was that accidents accounted for 57% of all deaths (including 31% of these being hit by vehicles and nine per cent poisoned), while disease only accounted for nine per cent of the total deaths. Five cases of disease diagnosed were due to organisms not found in New Zealand (*Dirofilaria immitis* and *Coccidioides immitis*). While these are a separate and unique population of animals the study highlighted the need for producers to be more aware of potential causes of injury to their animal as injuries were a significant and preventable cause of loss and expense. The idea of producers being more aware of potential causes of injury also applies to New Zealand working dogs.

2.4 Conclusion

Fundic disease, characterised as multifocal retinitis, was identified as a problem in working sheep dogs in New Zealand in a study published in 1987 and the authors postulated that OLM due to *Toxocara canis* may be the cause of the high prevalence of ocular lesions. Anecdotal evidence suggested that parasite management on-farm was lax and that the working sheep dogs were exposed to large parasite challenges (Hughes, Dubielzig, & Kazacos, 1987). No further studies have been conducted to follow up on the Hughes *et al.* (1987) study of fundic disease in working sheep dogs.

After reviewing the literature it is clear that there is a lack of data on fundic disease and parasitism in working sheep dogs in New Zealand. No data looking specifically at the prevalence of, or risk factors for, gastrointestinal nematodes and protozoa in New Zealand working sheep dogs has been published. There is also very little data

published on the age, gender, breed, body condition scores or husbandry of the New Zealand working sheep dog population from which to identify potential risk factors (Singh, Tucker, Gendall, Rutherfurd-Markwick, Cline, & Thomas, 2011). Studies of the age, gender, breed, body condition scores and husbandry of New Zealand working sheep dogs are important for a better understanding of not only fundic disease and parasitism in working sheep dogs in New Zealand, but all aspects of their health and welfare, assisting in the development of strategies to minimise diseases and improve their health and welfare.

The aim of this study was to investigate age, gender, breed, body condition scores, some aspects of husbandry, gastrointestinal nematode and protozoan parasitism and chorioretinopathy in a population of working sheep dogs from the Waikato region and Tux North Island Dog Trial Championship 2010 of New Zealand.

Chapter 3. Study design, analysis and discussion of the age, gender, breed, body condition scores, husbandry and nematode and protozoan parasitism of working sheep dogs in New Zealand in 2010.

3.1 Introduction

Much of the research undertaken on working sheep farm dogs has focused on specific diseases and tends to be case-series, e.g. arsenical poisoning (Bruere, 1980), photosensitive dermatitis in Heading dogs (Fairley, 1982), mucopolysaccharidosis IIIA in Huntaways (Jolly, Allan, Collett, Rozaklis, Muller, & Hopwood, 2000), dilated cardiomyopathy in Huntaways (Munday, Dyer, Hartman, & Orbell, 2006) and polioencephalomalacia (Read, Jolly, & Alley, 1977). There is a dearth of information on population aspects of working sheep dog health and welfare. There has been a move to rectify this lack of knowledge of the working sheep dog population with studies recently published including: a survey of working dog presentations to New Zealand veterinary clinics (Cave, Bridges, Cogger, & Farman, 2009) and a survey of the age, breed, gender and nutrition of working dogs in New Zealand (Singh, Tucker, Gendall, Rutherfurd-Markwick, Cline, & Thomas, 2011).

The aims of this cross-sectional study of New Zealand working sheep dogs and their owners were to improve knowledge of the basic health and welfare management of the working sheep dogs and investigate gastrointestinal parasitism in the working sheep dogs. More specifically, the first aim of this study was to describe the age, gender, breed and body condition score of the population of working sheep dogs in this study. The second aim of this study was to describe key aspects of the husbandry of working sheep dogs, specifically: the type of kennels, frequency of the movement and cleaning of the kennels, nutrition of the dogs and treatment of home kill sheep meat, vaccination and anthelmintic use and frequency of veterinary attention. The third aim of this study was to identify the prevalence of nematode and protozoan

parasites in the working sheep dogs and to correlate the prevalence of parasitism with age, gender, breed, body condition scores and aspects of the health and welfare management of the dogs, specifically kennel management and the frequency of administration of anthelmintics.

3.2 Study design

3.2.1 Funding

Funding and expertise were obtained from the Massey University Centre for Service and Working Dog Health, The New Zealand Companion Animal Health Foundation, The Veterinary Centre Te Awamutu, New Zealand Veterinary Pathology and The Massey University Veterinary Parasitology Laboratory.

3.2.2 Sampling method

Owners were initially approached based on the perception by either practice veterinarians, rural servicing staff or farmers that the owner may be willing to participate. The owners and their dog(s) were then convenience sampled based on their proximity to the veterinary clinic and proximity to other farms being sampled, the number of dogs available at the farm location, the ease of establishing contact with the owner of the working sheep dog, willingness of the owner to participate and the ability to arrange a time for sampling that suited both the owner and the investigator.

Forty-four working sheep dog owners and 183 working sheep dogs sampled were from farms in the South, South-west and West Waikato regions. Nineteen working sheep dogs belonging to 12 working sheep dog owners were sampled at the Tux North Island Dog Trial Championship 2010, which was held in Gisborne. All working sheep dogs available at a location that met the criteria for entry into the study were included. Data collection was performed between April 11th - July 7th 2010.

3.2.3 Criteria for inclusion into the study

The criteria for initial inclusion into the study were that the owner and their working sheep dog(s) worked on a sheep farm or a sheep and beef farm and that the working sheep dog(s) were greater than six months of age.

3.2.4 Collection of data

The owner was asked to complete a pro-forma that asked for both owner and dog information (see Appendix A). The owner data included the name, address and contact details of the owner. For each working sheep dog the following data was collected: name, breed, colour, age, sex, reproductive status of the dog, and New Zealand Sheep Dog Trial Association pedigree if applicable and known. Each dog was allocated a three digit number to be used as identification on the record, questionnaire and samples associated with that dog. Pertinent clinical history and physical and ophthalmalogical findings were also recorded by the investigator (see Appendix B). Owners also completed a separate questionnaire for each of their dogs in the study (See Appendix C). This questionnaire was designed to complement clinical and laboratory findings by indicating the general health and welfare management of the owner's working sheep dog(s). Questions focused on the animal's vaccination history (without the type of vaccine being specified), frequency of the use of anthelmintic agents against intestinal parasites, the type of insecticide used for anti-flea treatment, kennel management, nutrition including treatment of home kill sheep meat and frequency of veterinary attention. If an owner contributed more than one dog they would complete multiple questionnaires.

New Zealand Sheep Dog Trial Association pedigree refers to any animal that is registered with the New Zealand Sheep Dog Trial Association Stud Register and whose parentage is verifiable through the register.

3.2.5 Body Condition Score procedure

The body condition score (BCS) validated by Laflamme *et al.* (1997) was used. This scale system uses visual assessment and palpation to allocate a score between one

and nine. To determine body condition score for each dog in the study, the chart (see Appendix D) was referenced frequently and a distance (visual) and palpation examination was performed. A dog that had an ideal body condition score of five would have ribs palpable without excess fat coverage, waist observed behind the ribs when viewed from above and the abdomen tucked up when viewed from the side.

3.2.6 Faecal sampling procedure

All faecal samples were collected by the same field investigator (AO). Faecal samples were collected from each dog by either digital rectal examination or by collecting voided faeces that were observed being voided by the dog. A new pair of latex gloves was used when obtaining or handling the faecal sample obtained from each dog in the field.

3.2.7 Faecal Sample Processing

Individual faecal samples were collected contained in either a 50mL plastic specimen container or a 20mL milk sample plastic container. Faecal samples were immediately placed in an insulated chiller bag containing ice packs then placed in a refrigerator at four degrees Celsius at the end of the day. Faecal samples were couriered from Te Awamutu to Massey University, Palmerston North within 10 days of collection. A same-day courier was used and the samples were chilled using frozen ice-packs during transport. The faecal samples were stored at Massey University's Parasitology Laboratory at four degrees Celsius for a duration of one to thirty days until parasitologists were able to perform a faecal parasitological examination.

3.2.8 Faecal analysis

All faecal examinations were performed at Massey University Veterinary Parasitology Laboratory by two trained veterinary parasitologists to identify parasites with *Toxocara canis*, the hookworms *Uncinaria stenocephala* and *Ancylostoma caninum* (the examination did not distinguish which species were

present), *Trichuris vulpis*, *Sarcocystis* spp., *Isospora canis* and *Isospora ohioensis* (the examination did not distinguish which species were present), *Neospora caninum* and *Hammondia heydorni* (morphologically the oocysts are indistinguishable) and *Giardia* spp. Tapeworms were not investigated as testing was not technically feasible.

The procedure used for the faecal examination was based on the flotation method described by Zajac, Johnson and King (2002) with one exception: samples were centrifuged at 200G and not 400G. One gram of faeces was weighed out into a sieve inside a 100mL bowl. Approximately 20mL of 33% $ZnSO_4$ was poured onto the sample. The faeces were disrupted and coarse material retained by the sieve was discarded. The faeces/$ZnSO_4$ mixture was poured back into the test tube. Additional $ZnSO_4$ was added, drop by drop, until the test tube was full and a positive (bulging over the top) meniscus had formed. A coverslip was placed onto the fluid meniscus. The tube was centrifuged at 200G for five minutes. The coverslip was then transferred onto a microscope slide and examined.

3.2.9 Data management

When the data was received it was manually entered into a Microsoft Excel spread sheet. All paper records were kept and filed as appropriate and duplicate copies made. All parasitological laboratory data was provided in Microsoft Excel file format. When data collection concluded all data was checked for outliers and inconsistencies and any suspect value checked against the original written records.

3.2.10 Statistical Analysis

Initially data were examined for completeness and validity. If an unusual or missing value was found, the observation was checked against original written records and corrected if necessary. The distribution for the number of dogs per owner and the age of dogs were described using a histogram and the variables summarised using mean, median, minimum, maximum and 95% confidence intervals. Age, breed and gender data was also described using the number and percentage of dogs in each category.

Two-way tables were used to explore the relationship between BCS ($\leq$ 2, 3, 4, $\geq$ 5) and age, breed and gender. Significance of the association was assessed using a Chi-squared or Fisher exact test as appropriate. For different husbandry practices the number and percentage of owners and dogs in each category was determined. For dogs with complete feed data the proportion of their diet that was home kill sheep meat, commercial food, household scraps or other was determined and results displayed as box plots.

Two-way tables were constructed to explore the relationship between infection with nematode or protozoan parasites and the explanatory variables: age, gender, breed, body condition score, kennel movement frequency, type of kennel, kennel cleaning frequency and frequency of anthelmintic treatment. The relative risk for the association was assessed with a 95% confidence interval and significance of the association was assessed using a Chi-squared or Fisher exact test as appropriate. For each parasite, the proportion of animals affected in each age group was determined and results displayed as bar charts. Again significance of the association was assessed using a Chi-squared or Fisher exact test as appropriate.

Data analyses were performed using a commercial spreadsheet program, Microsoft Excel 2010, and the statistical software package R Version 2.13. A p-value of < 0.05 was considered statistically significant.

3.3 Results

3.3.1 Owner and dog numbers

Fifty-six owners participated in the study and contributed 202 dogs to the study. Fifty-four owners completed questionnaires, with 51 completing the full questionnaire. The mean and median number of dogs sampled per owner were, respectively, 3.6 (95% CI = 3.0-4.1) and three (Min = 1, Max = 9) (Figure 3.1).
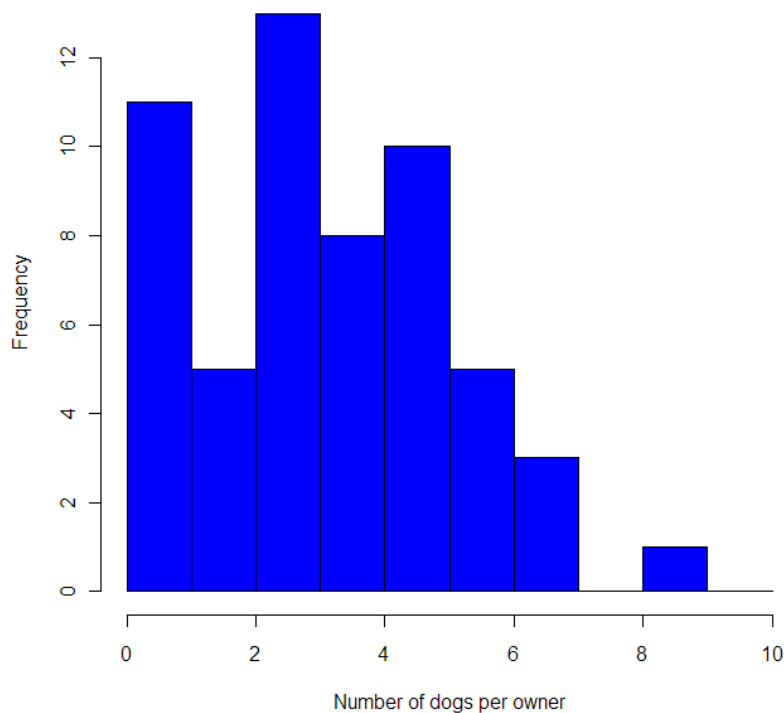
Figure 3.1: Histogram of the frequency of the number of dogs per owner in a study to determine the prevalence of parasitism in a population of working sheep dogs in New Zealand. Data from a cross-sectional survey involving 56 dog owners and 202 dogs from the central North Island and the Tux North Island Dog Trial Championship conducted in 2010.

3.3.2 Age, breed and gender and pedigree

The age of 198/202 (98%) dogs was known. The youngest animal was six months of age and the oldest animal was 15 years of age. The mean age was 4.8 years (95% CI = 4.3-5.3) and the median age was four years (Min = 0.45, Max = 15) (Figure 3.2).
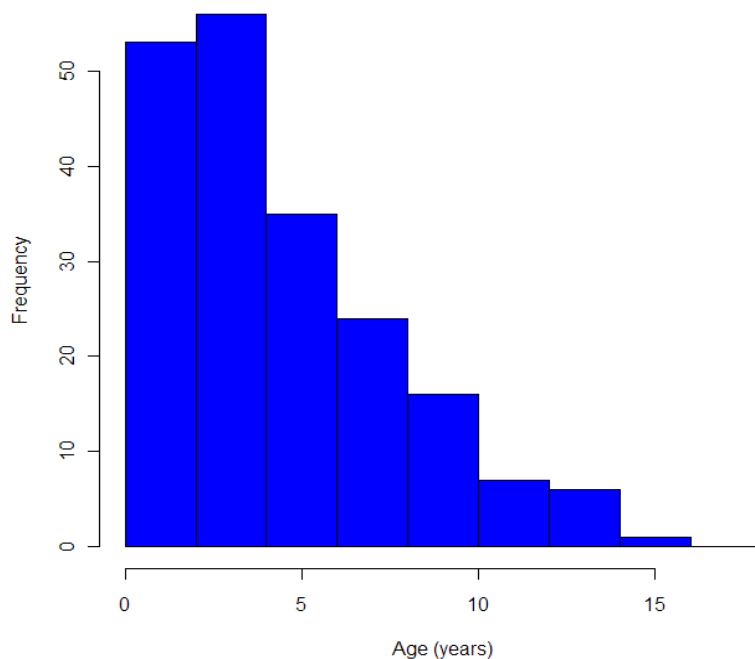
Figure 3.2: Histogram of the frequency of the age distribution of 198 dogs in a study to determine the prevalence of parasitism in a population of working sheep dogs in New Zealand. Data from a cross-sectional survey involving 56 dog owners and 202 dogs from the central North Island and the Tux North Island Dog Trial Championship conducted in 2010.

The breed of 200/202 (99%) of the dogs was known. Eighty-five of 200 (43%) of the dogs were Huntaways, 84/200 (42%) were Heading Dogs, 31/200 (16%) were other breeds. These other breeds were: Bearded Collies (n=6), Handy Dogs (n=3), Huntaway crossbreed and Heading crossbreed (n=21) and a Kelpie crossbreed (n=1).

The gender of 199/202 (98.5%) dogs was known: 118/199 (59%) dogs were males and 81/199 (41%) were females. For the male dogs the neutered status was not recorded for five dogs and in the 113 dogs with known status 105 (93%) were entire. Similarly, neutered status was unknown for three females and in 78 with known status 68 (87%) were entire.

The pedigree information section was poorly completed thus no analysis was possible with the limited results for this section.

3.3.3 Body condition score

One hundred and ninety-seven dogs were body condition scored. BCS was unable to be obtained for five of the dogs in this study because the farmer did not have time to assist in holding the dog; in the remaining 197 dogs: 29 had a BCS less than or equal to two, 78 had a BCS of three, 77 had a BCS of four and 13 had a BCS equal to or greater than five. The BCS varied significantly between breeds with Huntaways more likely to be under weight (Table 3.1).

Table 3.1: Number and percentage (in brackets) of dogs in each body condition score category stratified by age, breed and gender in a study to determine the prevalence of parasitism in a population of working sheep dogs in New Zealand. Data from a cross-sectional survey involving 56 dog owners and 202 dogs from the central North Island and the Tux North Island Dog Trial Championship conducted in 2010.

Variable	Categories in each variable	Body condition score (1-9)				P-Value
		≤2	3	4	≥5	
Age	<2	4(13)	11(34)	13(41)	4(13)	0.62
	2-3	10(20)	24(47)	15(29)	2(4)	
	4-7	12(17)	26(37)	29(41)	3(4)	
	≥8	3(8)	16(40)	17(42)	4(10)	
Breed	Heading	4(5)	32(40)	39(48)	6(7)	0.002
	Huntaway	23(28)	31(37)	24(29)	5(6)	
	Crossbreed	2(7)	15(48)	12(39)	2(7)	
Gender	Male	21(18)	46(39)	45(38)	5(4)	0.16
	Female	7(9)	32(41)	32(41)	8(10)	

* Number of dogs sampled for the BCS stratified by age, breed and gender was, respectively, 193, 195 and 196. Dogs were excluded if they did not have a BCS exam performed or the owner of the dog did not complete the relevant section of the questionnaire.
* There was insufficient numbers of desexed dogs to separate gender into entire and neutered groups

3.3.4 Husbandry

Table 3.2, Table 3.3 and Table 3.4 show the husbandry practices by owner and dog. Seventy-seven per cent of dogs owned by 78% of owners received a combination of commercial food and home kill sheep meat. Figure 3.3 describes the proportion of diet composed of commercial food, home kill sheep meat, household scraps and other items. For those dogs fed home killed food 39/41 owners reported freezing the home kill sheep meat for greater than seven days or boiling it for more than one hour prior to feeding the dogs.

Table 3.2: Number and percentage (in brackets) of owners and dogs in each category for stated kennel husbandry variables in a study to determine the prevalence of parasitism in a population of working sheep dogs in New Zealand. Data from a cross-sectional survey involving 56 dog owners and 202 dogs from the central North Island and the Tux North Island Dog Trial Championship conducted in 2010.

Variable	Categories in each variable	Number and percentage (in brackets) of owners	Number and percentage (in brackets) of dogs
Frequency of kennel moved to a new site	Less than once per year or never	49(92)	187(96)
	Greater than or once per year	4(8)	9(4)
Floor design of kennel run	Raised slats	42(79)	164(84)
	Solid or dirt	11(21)	32(16)
Frequency kennel cleaned	Less than once per year or never	6(11)	22(10)
	Greater than or once per year	47(89)	174(90)

* 2 owners with 5 dogs did not answer the questionnaire, 3 owners with 13 dogs partially completed the questionnaire.

Table 3.3: Number and percentage (in brackets) of owners and dogs in each category for stated diet husbandry variables in a study to determine the prevalence of parasitism in a population of working sheep dogs in New Zealand. Data from a cross-sectional survey involving 56 dog owners and 202 dogs from the central North Island and the Tux North Island Dog Trial Championship conducted in 2010.

Variable	Categories in each variable	Number and percentage (in brackets) of owners	Number and percentage (in brackets) of dogs
Frequency of feeding	Once per day	51(96)	187(98)
	After exercise	1(2)	2(1)
	Other	1(2)	2(1)
Diet°	Commercial	47(89)	174(91)
	Home kill sheep meat	45(85)	158(83)
	Household scraps	13(25)	39(20)
	Other	3(6)	9(5)
Frequency of home kill treatment[+]	Always	37(82)	147(93)
	Sometimes / never	8(18)	11(7)
Home kill sheep meat treatment method	Frozen for greater than 7 days or boiled longer than one hour	39(95)	139(95)
	Frozen for less than 7 days or boiled less than one hour	2(5)	7(5)

* 2 owners with 5 dogs did not answer the questionnaire, 3 owners with 13 dogs partially completed the questionnaire.

° Owners could give multiple answers to question 8 which provided information for this variable

[+] *Boiling / cooking the home kill sheep meat or freezing the home kill sheep meat*

Table 3.4: Number and percentage (in brackets) of owners and dogs in each category for stated animal health husbandry variables in a study to determine the prevalence of parasitism in a population of working sheep dogs in New Zealand. Data from a cross-sectional survey involving 56 dog owners and 202 dogs from the central North Island and the Tux North Island Dog Trial Championship conducted in 2010.

Variable	Categories in each variable	Number and percentage (in brackets) of owners	Number and percentage (in brackets) of dogs
Vaccination frequency	Unvaccinated	10(19)	42(20)
	Don't know if vaccinated	1(2)	1(1)
	Only when a pup	10(19)	24(13)
	Annually	18(34)	78(42)
	Every two years	6(11)	26(14)
	Sporadically	7(13)	18(10)
Frequency of gastrointestinal anthelmintic administration	Only when a pup	0(0)	0(0)
	More than once a month	2(4)	5(3)
	Every 1 to 2 months	20(38)	69(35)
	Every 3 months	22(42)	86(44)
	Every 4 to 6 months	7(13)	26(13)
	Annually	2(4)	10(5)
	Sporadically	0(0)	0(0)
	Never	0(0)	0(0)
Type of flea treatment	None	13(25)	49(25)
	Water / swim	6(11)	21(11)
	Commercial dog product	31(58)	115(58)
	Commercial non-dog product	3(6)	11(6)
	Non-medicated shampoo	0(0)	0(0)
Frequency of veterinary examination	Only when vaccinated	7(13)	32(17)
	Frequently	2(4)	8(4)
	Occasionally	36(68)	120(63)
	Never	8(15)	31(16)

* 2 owners with 5 dogs did not answer the questionnaire, 3 owners with 13 dogs partially completed the questionnaire.
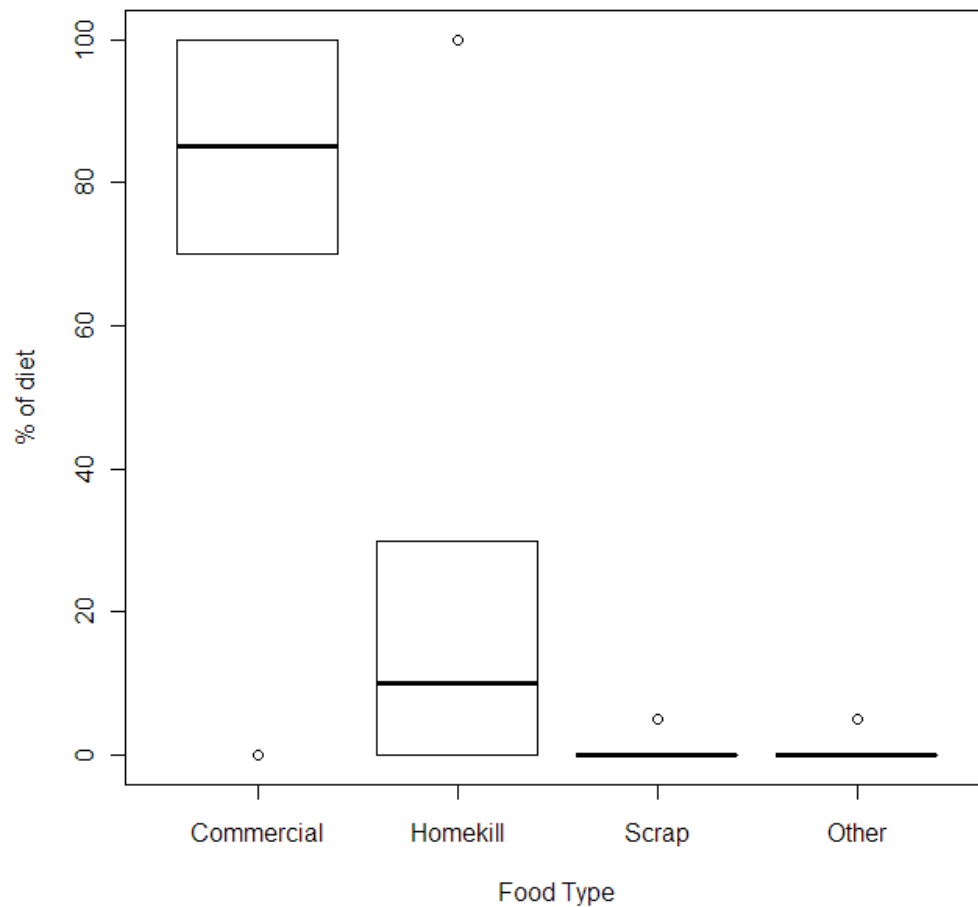
Figure 3.3: Box plot of the proportion of commercial, home kill sheep meat, household scraps and other foods in the diet of 169 dogs owned by 46 owners in a study to determine the prevalence of parasitism in a population of working sheep dogs in New Zealand. Boxes display interquartile range with a line at the median and outliers highlighted by circles. Data from a cross-sectional survey involving 56 dog owners and 202 dogs from the central North Island and the Tux North Island Dog Trial Championship conducted in 2010.

3.3.5 Prevalence of nematode and protozoan infection

One hundred and seventy working sheep dogs had faecal examinations performed. Sixty-eight dogs (40%) had evidence of nematode and/or protozoan parasite infection: 38 dogs had only one species of parasite, 25 dogs had two species and five dogs had three or more species of parasites. Nineteen per cent (33/170) of dogs were infected with parasites from the Nematode phylum: *Toxocara canis* (9/170, 5%),

hookworms (*Uncinaria stenocephala* or *Ancylostoma caninum*) (20/170, 12%), or *Trichuris vulpis* (8/170, 5%). *Sarcocystis* spp. sporocysts were present in the faeces of 35/170 (21%) dogs, *Isospora canis* or *Isospora ohioensis* were found in 9/170 (5%) dogs, *Neospora caninum* and *Hammondia heydorni* in 4/170 (2%) and *Giardia* spp. was found in 13/170 (8%) dogs.

3.3.6 Risk factors for nematode and protozoan infection

Table 3.5 and Table 3.6 describes the relationship between infection with a nematode and/or protozoan and the age, breed, gender, body condition score and kennelling variables. There was a statistically significant relationship between age and infection (P≤ 0.03). While parasitism was common in all age groups the prevalence did decrease with increasing age (Table 3.5 and Figure 3.4). Dogs less than two years old were 2.31 times more likely to be infected with parasites than dogs greater than or equal to eight years of age.

Dogs less than 2 years of age had a significantly higher prevalence of *Toxocara canis* (P< 0.0001) and *Giardia* spp. (P< 0.0001). In contrast the prevalence of hookworm and *Sarcocystis* spp. did not vary significantly with age (Figure 3.5).

Females had a higher prevalence of parasitism for all species except *Neospora caninum* and *Hammondia heydorni*. However there was no significant difference for any parasite species by gender. Parasitism with *Trichuris vulpis* and *Giardia* spp. was significantly different between breeds (P= 0.03 and P= 0.009 respectively*)*. The other parasite species showed no trend towards significance when stratified by breed. No significant differences were seen when individual parasite species were stratified by body condition score.

Table 3.5: Effect of age, breed, gender and body condition score on nematode and protozoan parasite infection in a study to determine the prevalence of parasitism in a population of working sheep dogs in New Zealand. Data from a cross-sectional survey involving 56 dog owners and 202 dogs from the central North Island and the Tux North Island Dog Trial Championship conducted in 2010.

Risk factors for parasite infection	Categories for each risk factor	Frequency of parasite positive dogs	Frequency of parasite negative dogs	Relative risk of parasite infection for each category (95% confidence interval in brackets)	P-value for each risk factor
Age	Less than 2 years old	17	11	2.31 (1.25-4.25)	0.03
	2-3 years old	18	22	1.71 (0.91-3.22)	
	4-7 years old	22	38	1.39 (0.74-2.61)	
	8 years old or greater	10	28	REF	
Gender	Male	33	64	REF	0.08
	Female	35	37	1.43 (0.99-2.06)	
Breed	Heading	32	43	REF	0.82
	Huntaway	27	42	0.92 (0.62-1.36)	
	Crossbreed	9	16	0.84 (0.47-1.51)	
Body condition score	≤2	10	10	REF	0.63
	3	24	42	0.73 (0.42-1.25)	
	4	26	41	0.78 (0.46-1.32)	
	≥5	6	6	1 (0.49-2.05)	

* Number of dogs sampled for parasite infection stratified by age, gender, breed and BCS was, respectively, 166, 169, 169 and 165. Dogs were excluded if they did not have a BCS exam performed or the owner of the dog did not complete the relevant section of the questionnaire.

Table 3.6: Effect of kennelling conditions and frequency of anthelmintic treatment on nematode and protozoan parasite infection in 164 dogs in a study to determine the prevalence of parasitism in a population of working sheep dogs in New Zealand. Data from a cross-sectional survey involving 56 dog owners and 202 dogs from the central North Island and the Tux North Island Dog Trial Championship conducted in 2010.

Risk factors for parasite infection	Categories for each risk factor	Frequency of parasite positive dogs	Frequency of parasite negative dogs	Relative risk of parasite infection for each category (95% Confidence interval in brackets)	P-value for each risk factor
Frequency of kennel movement	< once a year or never	62	95	REF	0.35
	Once a year or more	1	6	0.36 (0.06-2.24)	
Type of kennel	Slatted floor	54	81	REF	0.49
	Solid or dirt floor	9	20	0.78 (0.66-1.91)	
Frequency of kennel cleaning	< once a year or never	6	11	REF	0.99
	Once a year or more	57	90	1.1 (0.56-2.16)	
Frequency of anthelmintic treatment (Nematodes only)	> once a month	1	4	REF	0.75
	Every 1-2 months	13	49	1.05 (0.17-6.46)	
	Every 3 months	10	59	0.72 (0.11-4.58)	
	Every 4-6 months	4	18	0.90 (0.13-6.48)	
	Annually	2	4	1.66 (0.21-13.43)	

* Dogs were excluded if they did not have a faecal analysis performed or the owner of the dog did not complete the relevant section of the questionnaire.

* Anthelmentic treatment used not specified by the farmer.
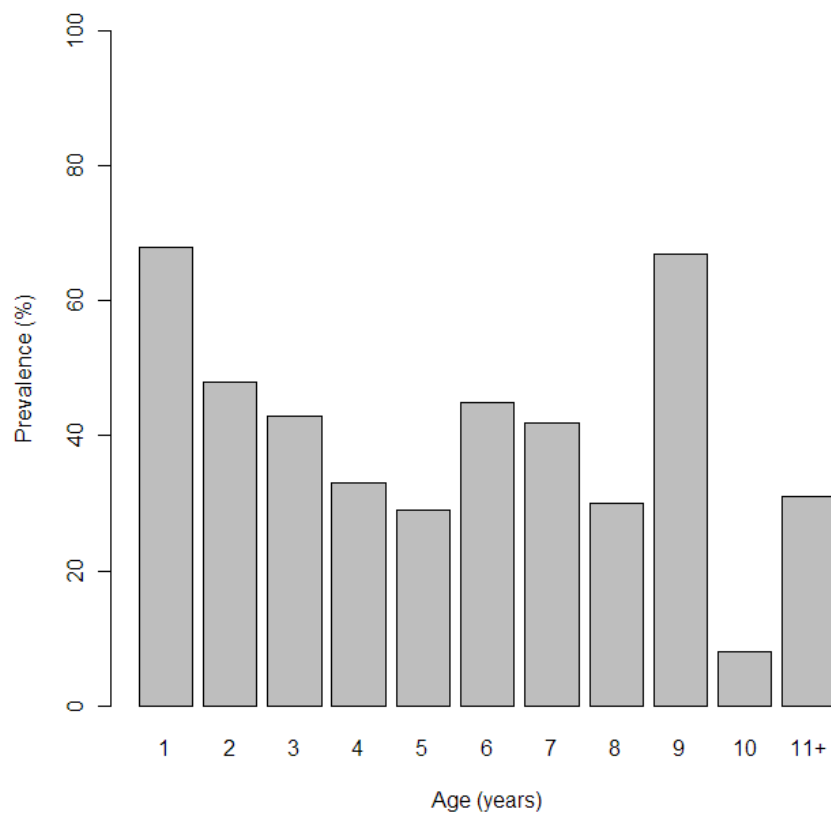
Figure 3.4: Prevalence of parasitism stratified by age for 166 working sheep dogs in a study to determine the prevalence of parasitism in a population of working sheep dogs in New Zealand. Data from a cross-sectional survey involving 56 dog owners and 202 dogs from the central North Island and the Tux North Island Dog Trial Championship conducted in 2010.

Figure 3.5: Prevalence of infection with the individual parasite species stratified by age for 166 working sheep dogs in a study to determine the prevalence of parasitism in a population of working sheep dogs in New Zealand. Data from a cross-sectional survey involving 56 dog owners and 202 dogs from the central North Island and the Tux North Island Dog Trial Championship conducted in 2010. Toxocara canis (P≤ 0.0001); 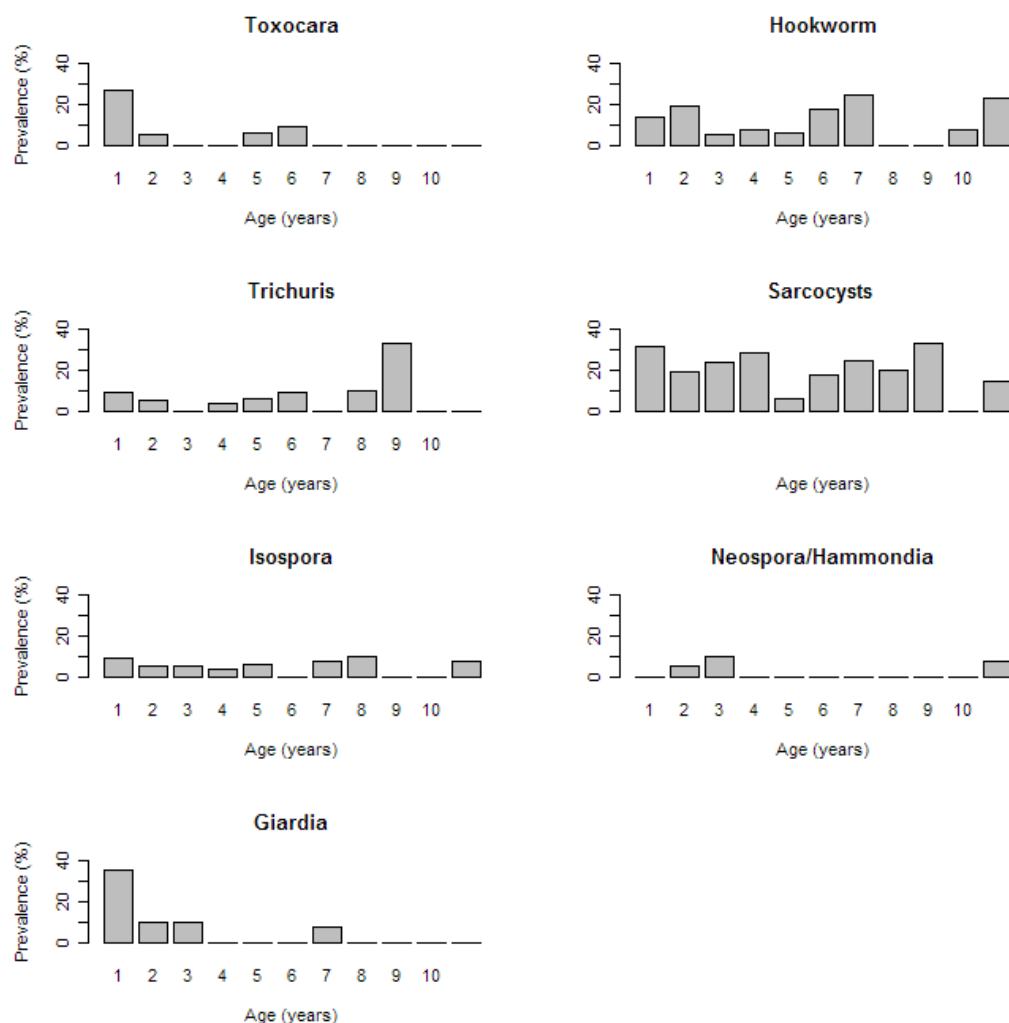hookworms Uncinaria stenocephala or Ancylostoma caninum (P= 0.92); Trichuris vulpis (P= 0.84); Sarcocystis spp. (P= 0.48); Isospora canis or Isospora ohioensis (P= 0.98); Neospora caninum and Hammondia heydorni (P= 0.08); Giardia spp. (P≤ 0.0001).

3.4 Discussion

This study found a high proportion of working sheep dogs were infected with gastrointestinal nematode and protozoan parasites, with a total prevalence of 40%. The prevalence of infection in working sheep dogs with *Neospora caninum* and *Hammondia heydorni* was the lowest of all the parasite species, while *Sarcocystis* spp. had the highest prevalence of infection in working sheep dogs. While *Ancylostoma caninum* has been recorded in New Zealand (McKenna, McPherson, & Falconer, 1975), it is likely that the hookworm eggs found in this study are *Uncinaria stenocephala* as the environmental temperature is too cool throughout most of New Zealand, including the Waikato, for the survival of *Ancylostoma caninum* (Hill & Roberson, 1985). It is possible that the prevalence of *Giardia* spp. is higher than reported in the sample population because *Giardia* spp. intermittently shed cysts requiring multiple faecal examinations over numerous days to detect the cysts (Rishniw, Liotta, Bellosa, Bowman, & Simpson, 2010). Centrifugation of the faecal sample increases the sensitivity of detection of *Trichuris vulpis* however very light *Trichuris vulpis* infections may not have been detected. Also the specific gravity of the faecal / ZnSO$_4$ solution used may have caused destruction of some cysts and ova of parasites before they could be detected decreasing the prevalence (Zajac, Johnson, & King, 2002). Results from this investigation cannot be compared to other studies of similar populations in New Zealand because no other research has looked at the prevalence of gastrointestinal parasites in New Zealand working sheep dogs. An as yet unpublished study of the same nematode and protozoan parasites in a mainly urban population of dogs, patients of the Massey University Veterinary Teaching Hospital found that the lowest prevalence of infection of working sheep dogs were for the species, *Neospora caninum* and *Hammondia heydorni* at 1.7% and the highest species prevalence, *Sarcocystis* spp., was 7.5% (Scott, 2011, pers. comm.). A 1981 study of helminth gastrointestinal parasites, *Toxocara canis, Trichuris vulpis, Uncinaria stenocephala, Toxascaris leonine, Dipylidium caninum* and *Taenia* sp., by post-mortem examination of the gastrointestinal tract of 55 dogs of unspecified origin found a total prevalence of 69.1% (Collins, 1981). The results of the current study compared to the unpublished Massey University study suggest the prevalence of gastrointestinal helminth and protozoan parasites in New Zealand

working sheep dogs may be higher than that for urban dogs. The difference in prevalence of gastrointestinal nematode and protozoan parasitism between the Collins (1981) study, the unpublished Massey University study and this study could also reflect changes in anthelmintics and the use of anthelmintics across time or it could reflect differences due to the different geographical locations of the study populations. The differences in prevalence could also be caused by selection bias, since Massey University is a referral hospital as well as a first call clinic and therefore dogs examined at the hospital, whose owners are prepared to seek referral opinion and treatment for their animals, may be better cared for than other dog populations. The differences in prevalence could also be due to the design of the study as the Collins (1981) study used post-mortem examination which would be a more sensitive technique for detection of parasitism of the gastrointestinal tract than faecal analysis and also examined for tapeworms, while this study and the unpublished Massey University study both used the same zinc sulphate ($ZnSO_4$) centrifugation flotation test to detect eggs and cysts in the faeces and did not look for tapeworms. The effect of prolonged cold storage at 4 degrees celsius upon the survival of the structure of the egg or cyst for canine parasites has not been adequately investigated so is an unknown factor. The limited studies available on the effects of cold storage on faeceal egg counts in any species suggest faecal egg counts can decrease significantly with time when held in cold storage so can effect quantitative measures (Gibbs & Gibbs, 1959; Seivwright, Redpath, Mougeot, Watt, & Hudson, 2004). The purpose of the faecal egg counts in this study was to identify the prevalence of parasite species present, for which a single egg or cyst would be considered a positive result, not to quantify levels of parasitism. Therefore for the purpose of this study we considered that the effect of cold storage on our ability to identify parasite species present during faceal analysis was negligible and that there would have been no effect on the prevalence identified.

Younger working sheep dogs had a significantly higher prevalence of infection when all parasite species were combined for statistical analysis. When parasites species were analysed by species, younger working sheep dogs had a significantly higher prevalence of infection for *Toxocara canis* and *Giardia* spp.; in contrast, the other parasites were found across a broader age range with no significant differences due to age. The differences in prevalence due to age could be due to statistical error

resulting from the low number of working sheep dogs in the study or it may reflect a difference in the epidemiology of the various parasites. *Toxocara canis* is able to be transmitted via the placenta and mammary glands and will eventually provoke a reasonably solid immune response in dogs, resulting in a reduced prevalence in older animals and explains the higher prevalence of infection in young animals (Burke & Roberson, 1985; Overgaauw, 1997; Scothorn, Koutz, & Groves, 1965). A lower prevalence of *Giardia spp.* in older dogs may be due to the development of protective immunity (Gates & Nolan, 2009). Alternatively, as Giardia is transmitted via the faecal-oral route (Thompson, Palmer, & O'Handley, 2008), the increased risk of infection could be due to puppies and young dogs having a higher degree of exposure than older dogs if they are housed in more highly contaminated areas than the older dogs. Once they are moved from the puppy raising facility to the kennelling area with the older animals the degree of exposure may be reduced. As this study only included working sheep dogs six months and older, no dogs in the study were likely to be separately housed in any puppy raising facility at the time of the study. Therefore a lower prevalence in older working sheep dogs in the study due to a decrease in the level of exposure to *Giardia* spp. in the area the older dogs were housed compared to where the younger dogs were housed is unlikely. Aside from age, no other statistically significant results were found for parasitism for any of the variables analysed. It is interesting that the frequency of anthelmintic treatment did not have a statistically significant effect on egg numbers. This finding may be due to a perceived weakness in the study. Question (2) of the questionnaire: "How often do you worm your dog(s)?", did not identify the anthelmintic product(s) used and therefore may not provide a true indication of the effectiveness of parasite control, as that depends on the products used and the spectrum of activity of their active ingredients as well as frequency of anthelmentic use and correct administration.

The body condition score technique of Laflamme *et al.* (1997) has been validated as an effective way for trained personnel to evaluate a dog's body composition giving repeatable, reproducible and predictable results as well as being easy to use in a field setting and correlating well with the per cent body fat of dogs (Laflamme, 1997; Mawby, Bartges, d'Avignon, Laflamme, Moyers, & Cottrell, 2004). When using this method only a small number of dogs were considered to have an ideal body condition score of five out of nine. The overwhelming majority (93%) of working

sheep dogs had body condition scores that indicated the dogs were either marginally underweight or very thin. If a large group of dogs undertake regular amounts of strenuous activity some will always be underweight but the majority should have ideal body condition to ensure peak performance. Having more than half (54%) of the working sheep dogs less than or equal to body condition score of three out of nine may indicate that inadequate nutrition is common, and improvements in nutrition may be an area of focus to improve performance. Alternatively, finding a large number of animals underweight may be due to experimenter error as a single investigator performed all body condition exams and no calibration or feedback circuit process was performed to ensure accuracy with the published body condition scores or to ensure consistency of body condition scoring by the investigator throughout the study. Having one or more colleagues to body condition score the dogs may have improved the analysis. However, Laflamme *et al.'s* (1997) nine point body condition score system was shown to have good repeatability (the variation between BCS when the same investigator repeatedly assesses an animal) and reproducibility (the variation between BCS for an animal when assessed by different investigators) with the component of variance for each of these being 0.93 and 0.86 respectively. Also the investigator was a veterinarian experienced in handling dogs, had been previously trained to body condition score animals and used the system daily at work, and therefore should be considered proficient at using the method. The large number of underweight animals may also be due to the effect of breed on body composition which has been demonstrated to exist (Jeusette, Greco, Aquino, Detilleux, Peterson, Romano, & Torre, 2010).

Body condition score by breed was significant with a higher proportion of Huntaways being very underweight compared to the other breeds; 28% of Huntaways had a body condition score of two or less compared to 5% and 7% of Heading dogs and the other breeds respectively. The reason for the increased number of Huntaways with low body condition scores is not clear but could be the result of effects of both genetics and environment. Typically Huntaways are a taller, heavier built dog than the Heading dog so would have different dietary requirements for growth and maintenance than Heading dogs and these requirements may not be being adequately met by some owners. Alternatively Huntaways may be more

subsceptible to diseases that result in low body condition than Heading dogs and other breeds.

This study found that the typical diet of the working sheep dog comprised both commercial food and home kill sheep meat; the proportion of the diet that was commercial food had a median of 80%, with the remainder being home kill sheep meat. Thirty-four per cent of owners fed household scraps or other food; however, the amount of household scraps and other food that dogs typically received was a very small proportion of their diet. These findings support previous work by Singh *et al.* (2011) that found that 58-61% of farmers fed a combination of commercial food and home kill sheep meat. The proportions fed in the previous study were different with farmers tending to feed a major proportion of home kill sheep meat to their dogs 'topped up' with commercial food (Singh, Tucker, Gendall, Rutherfurd-Markwick, Cline, & Thomas, 2011). These differences could reflect true differences in the study populations, as the Singh *et al.* (2011) study focused on members of the New Zealand Sheep Dog Trial Association while the current study had a majority of 44 commercial sheep and sheep and beef farmers with a small subset of 12 New Zealand Sheep Dog Trial Association members. Commercial sheep and sheep and beef farmers may use and manage their working sheep dogs differently to the way a dog trial competitor uses and manages their trial dogs. Another reason for the difference could be that many owners seem to find categorisation of their feeding regimes difficult, and the phrasing of the question asked of the farmers could influence the answers supplied and the therefore influence the results. Five dogs who were fed a 100% commercial diet were excreting Sarcocystis spp. cysts suggesting they recently ate non-commercial meat. While it is possible that they scavenged meat on farm, it is also possible that the farmers fed them home kill and that their answer to the questionnaire regarding what they fed their dog(s) was inaccurate.

The proportions of the diet that come from commercial food and home kill sheep meat has important implications for working sheep dog health. It is postulated that an ideal working sheep dog diet contains high concentrations of fat and protein and low concentrations of carbohydrate. A high energy intake is necessary for working sheep dogs and high fat diets provide a dense high energy source (Guilford, 1997). High fat/low carbohydrate diets prime muscles to efficiently use glycogen which is an important nutrient for endurance performance (Cave, 2009). High protein diets

may help reduce the occurrence of musculoskeletal injuries in dogs (Reynolds, Taylor, Hoppeler, Wiebel, Weyand, Roberts, & Reinhart, 1996). In addition, high protein/low carbohydrate diets improved apparent nutrient digestibility, delayed glucose release into the bloodstream and reduced carbohydrate fermentation (Hill, Rutherfurd-Markwick, Ravindran Ugarte, & Thomas, 2009). Home kill sheep meat based diets are potentially high in fat and protein and lower in carbohydrate so on a macro-nutrient basis appear adequate; however, the diet could be deficient in a range of micro-nutrients (minerals and vitamins) (Cave, 2009; Guilford, 1997). If the majority of working sheep dogs receive a large proportion of commercial dog food in their diet, as found in this study, working sheep dog diets are probably nutritionally balanced for macro-nutrients and micro-nutrients. The converse is true if the results of proportions of commercial food and home kill sheep meat fed found by Singh *et al.* (2011) are more widely applicable to the New Zealand working sheep dog population. However, not all commercial diets offer balanced nutrition, either due to their poor formulation or because they are not intended for feeding to dogs undertaking regular, prolonged, strenuous activity. Further study investigating the actual commercial diets fed to working sheep dogs is needed to validate the claim that working sheep dog diets that include a large proportion of commercial food are probably nutritionally balanced.

Home kill sheep meat may contain bones and hair which could play an important role in the aetiology of gastrointestinal injury: inflammation, ulceration and perforation, obstruction and constipation though no studies have been performed to corroborate this point. Cave *et al.* (2009) found, in a survey of the diseases for which working sheep dogs were presented to veterinarians in New Zealand, that gastro-intestinal disease was the most common non-traumatic cause of presentation for a working sheep dog to a veterinarian and constipation was the most common non-traumatic disease diagnosis. Further study investigating the role and importance of home kill sheep meat and its association with gastrointestinal disease is required.

The majority of owners who fed home kill sheep meat stated that they "treated" their home kill sheep meat and that they treated it either by freezing the meat for at least seven days or boiling it for more than an hour. However, there were some owners (8/45) who either treated their home kill sheep meat sometimes or did not treat the home kill sheep meat at all and therefore could be exposing their dogs to *Taenia ovis*

by their dogs eating viable *Cysticercus ovis* cysts (Sheep Measles) in the home kill sheep meat. The financial importance of sheep measles to farmers and the sheep meat industry and the potential for dog food to be a source of infection with tapeworm parasites should be sufficient reason to adequately treat home kill sheep meat being fed to dogs. In regards to the treatment of sheep meat, parasites like *Sarcocystis* spp. may survive freezing at -10 degrees for at least seven days which is a common method for the treatment of home kill(Collins & Charleston, 1980) though some immunity may develop in the dog that limits the excretion of cysts in the faeces (Srivastava, Sinha, Juyal, & Saha, 1987). The eight owners who either do not treat their home kill sheep meat or only treat it sometimes may have failed to understand the question asked. However this research may indicate that on-going farmer education about feeding home kill sheep meat may be required, and more research should be conducted to investigate whether there is a sizeable group of farmers with a lax attitude to home kill sheep meat feeding. Research into the prevalence of parasitism with tapeworms in the working sheep dogs in this study, had it been possible, would have been useful in assessing if the owners answers to the question about the treatment of home kill sheep meat was the same as what was actually occurring on farm.

This study also confirmed the observations of Singh *et al.* (2011) that virtually all working sheep dogs are fed once a day. There is no evidence to suggest that more frequent feeding would be beneficial for working sheep dogs with no studies found that investigated the effects of timing of feeding or frequency of feeding on health or performance of any type of working or endurance sport dog. Recommendations for the frequency of feeding for human athletes by human nutritional researchers are for multiple meals a day as the different meals provide a nutrient source for activities undertaken that day and a nutrient source for recovery and musculoskeletal repair once those activities are completed (Hawley & Burke, 1997; La Bounty, Campbell, Wilson, Galvan, Berardi, Kleiner, Kreider, Stout, Ziegenfuss, Spano, Smith, & Antonio, 2011), a practice which appears to be customary for human athletes (Burke, Slater, Broad, Haukka, Modulon, & Hopkins, 2003; Kirsch & Vonameln, 1981; Lindeman, 1990). A specialist New Zealand veterinary nutritionist recommends feeding working sheep dogs once a day within two hours of the finish of exercise and to not work the dogs within eight hours of a small meal or 16 hours of a large

meal to ensure complete gastric emptying (Cave, 2009). The main reason for this recommendation is that feeding prior to exercise is likely to increase abdominal discomfort and vomiting during exercise and increase carbohydrate utilisation at the expense of fat utilisation (Cave, 2009). Feeding within two hours after exercise provides nutrition for recovery, especially replenishment of muscle glycogen and muscle proteins. Human athletes may consume a higher ratio of carbohydrate to fat and protein than that recommended for working sheep dogs (Burke, Kiens, & Ivy, 2004) which may indicate that human and canine athletes require different feeding strategies and as such, comparisons should not be made. In the author's opinion research in this area is likely to be of little value as it is unlikely that feeding working sheep dogs more than once a day and providing adequate rest time would be logistically possible on most sheep and sheep and beef farms.

The majority of working sheep dogs in the study were kennelled in the same raised, slat bottomed, type of kennel with the majority of owners not moving their kennels frequently. All the parasite species in this study are shed in the faeces therefore a potentially high burden of infectious cysts and eggs will be found around the kennel environment, via either the dog defecating in the kennel or waiting until it is released from the kennel and then defecating in the kennel vicinity. Therefore, the area around the kennel represents a major area for exposure of the working sheep dogs to the cysts and eggs of the gastrointestinal parasites on the farm. It would be prudent to take basic precautionary measures to limit exposure by moving the kennels frequently if that is practical, cleaning the kennels with, at a minimum, soap and water to decrease the burden of infectious agents and picking up faeces around the kennels and feeding the dogs in bowls off the ground if they are fed in or near the kennels. Little could be done to prevent working sheep dogs eating farm animal faeces or drinking contaminated water which could be a potential route of exposure to gastrointestinal parasites, especially for *Giardia* spp. (Jakubowski, Hoff, Laboratory, & Laboratory, 1979).

Forty-three out of 53 owners (81%) with 160/196 dogs (81.6%) administered anthelmintic every three months or more to control parasitism. The anthelmintic products used typically treat nematode and/or cestode infections but not protozoan parasite infections. The minimum pre-patent period is 28 days for *Toxocara canis,* 14 days for hookworms and 10 weeks for *Trichuris vulpis* (Epe, 2009; Overgaauw,

1997) thus treating every three months will not eliminate the potential for egg shedding. Twenty-four out of 136 dogs (18%) who had faecal egg counts performed and who were treated with an anthelmintic every three months or more had nematode infections. The fact that nematode infections were found indicates that farmers should not rely on anthelmintic administration as the sole method of gastro-intestinal parasite control in their working sheep dogs. Alternatively the owners may not be using an anthelmintic that targets nematodes as farmers can use a cestode-only wormer due to the importance of killing cestodes for hydatid and sheep measles control. Also, the design of the questionnaire may have resulted in owners reporting an ideal use of anthelmintic rather than what they really do. Further study is required to quantify gastro-intestinal parasite infection in working sheep dogs and to correlate gastro-intestinal parasitism with the type of anthelmintic used and the frequency of the administration of the anthelmintic.

Owners had a variable approach in their attitudes to vaccinating farm dogs. Surprisingly, nearly a fifth of the dogs (22%) had never been vaccinated and a further 13% were vaccinated as a pup only. These owners may consider their dogs to be a 'closed pack' and never coming into contact with other dogs. While these dogs may never contact off-farm dogs, owners, workers and vehicles can be vectors for infectious disease and the lack of hygiene around kennels means that an infectious agentcould spread rapidly through a group of farm dogs. Acute gastroenteritis with evidence of severe mucosal damage has been reported in New Zealand working sheep dogs, sometimes resulting in death (Cave, Bridges, Cogger, & Farman, 2009). Acute gastroenteritis can be caused by parvovirus, a disease which core canine vaccines provide protection against. However there are many other infectious organisms that are not routinely vaccinated against, including those potentially found in raw meat such as *Salmonella spp*., *Campylobacter spp*., and enterotoxigenic *Escherichia coli,* therefore vaccines should not be relied on as a sole method of disease prevention There are leptospiral serovars endemic in New Zealand (Ellison & Hilbink, 1990; Harland, Cave, Jones, Benschop, Donald, Midwinter, Squires, & Collins-Emerson, 2012; Hilbink, Penrose, & McSporran, 1992; Mackintosh, Blackmore, & Marshall, 1980; O'Keefe, Jenner, Sandifer, Antony, & Williamson, 2002) and they have been found in working sheep dogs with at least one study reporting a prevalence in sheep and beef dogs of 24/155 dogs or 15.5% (O'Keefe,

Jenner, Sandifer, Antony, & Williamson, 2002). Leptospiral vaccinations should be considered in working sheep dogs. The current leptospiral vaccine available in New Zealand is not efficacious against all serovars endemic to New Zealand, including *Leptospira borgpetersenii* serovar *hardjo*, a serovar which rural dogs had titres to in a study identifying the prevalence of leptospiral serovars in New Zealand (O'Keefe, Jenner, Sandifer, Antony, & Williamson, 2002). Therefore, while leptospiral vaccination is recommended, disease due to leptospirosis on farms would still be an issue. This study indicates that a reasonable percentage of working sheep dogs may be unvaccinated and therefore at risk of preventable disease. Further study to investigate frequency of vaccinations in working sheep dogs should be conducted and farmers should be advised of the importance of vaccination.

Approximately a fifth of owners (28%) with a third of the total number of dogs (33%) never sought veterinary treatment for their dogs or only sought it for vaccination. There has been some investigation into the prevalence of disease on sheep and beef farms, with traumatic conditions and gastrointestinal disease being the predominant problems (Cave, Bridges, Cogger, & Farman, 2009; Jerram, Cogger, & Stevenson, 2009; Singh, Tucker, Gendall, Rutherfurd-Markwick, Cline, & Thomas, 2011). There is potentially a difference between the prevalence of diseases in working sheep dogs on a farm and the prevalence of diseases in working sheep dogs that are presented to a veterinarian. Cave *et al.* (2009) reported in one study that trauma was responsible for 38% of all working sheep dog presentations to veterinarians, 9% of presentations were due to gastrointestinal disease and 11% of all working sheep dogs presenting to a veterinarian were lost (retired or killed) with 7% of dogs lost due to degenerative joint disease. Singh *et al.* (2011) found that 38% of farms had sick or injured dogs in the previous year, with 73% of all problems in the study due to trauma and 11% due to gastrointestinal disease. Nineteen percent of farms killed at least one dog and 40% of dogs were killed because of degenerative joint disease associated with old age and their inability to work. Jerram *et al.* (2009) found 67% of dogs on a farm suffered one adverse health event in a 12 month period including behavioural problems and 35% of all working dogs on a farm, including retired dogs, died or were destroyed due to trauma or disease. Behavioural problems were the most common issue in working sheep dogs and the main reason that dogs were destroyed, while the most common adverse health event in retired or semi-

retired dogs was joint problems. Further investigation into the type and prevalence of working sheep dog disease on-farm and how farmers are managing these diseases in their working sheep dogs is required so that farmers can be better aided in their management of working sheep dog health and welfare.

Twenty-five per cent of owners with 25% of the dogs did not apply flea preventative to their dogs. Six per cent of owners with 6% of dogs used a non-canine commercial parasiticide treatment for the treatment of fleas. The use of such products would have concerns in regards to both safety and efficacy. These concerns are increased in Heading dogs who historically contain a lot of British working sheepdog genetic material as some of the breeds derived from British working sheepdogs have an MDR1 gene mutation that makes them particularly sensitive to macrocyclic lactone parasiticides (Neff, Robertson, Wong, Safra, Broman, Slatkin, Mealey, & Pedersen, 2004; Parton, 2009).

Previous studies have described the age, breed and gender distribution of populations of working sheep dogs in New Zealand by either surveying members of the New Zealand Sheep Dog Trial Association (Singh, Tucker, Gendall, Rutherfurd-Markwick, Cline, & Thomas, 2011) or those dogs presented to veterinarians (Cave, Bridges, Cogger, & Farman, 2009). The median number of dogs on the farm in the study by Singh *et al.* (2011) was six (IQR five to eight), which was twice the median number of dogs in the current study. This may be because Singh *et al.* (2011) surveyed New Zealand Sheep Dog Trial association members while this study mainly surveyed commercial farm owners and workers in the South-west Waikato who may use and manage their working sheep dogs differently to the way a dog trial competitor uses and manages their trial dogs. Alternatively it may be because of random error in the sample mean calculated due to the small sample size in this study. The median age of the dogs, gender distributions, the high proportion of entire animals and breed distributions were similar in this study to those in Singh *et al.'s* (2011) study. Cave *et al.* (2009) found more Huntaways were presented to veterinarians than Heading dogs even though this study found that the number of Huntaways and Heading dogs on farm are approximately equal. Cave *et al.* (2009) does not give a reason why more Huntaways are presented than Heading dogs or other breeds of working dogs.

There are many weaknesses of the current study. There were few inclusion criteria for this study which could result in a liberal interpretation of what defines a commercial sheep and sheep and beef farmer and what may be considered a working sheep dog. The majority of participants were identified through a rural veterinary clinic client list and were considered by the management of the veterinary company to be bona-fide sheep farmers in the sense they worked full-time on and lived on a commercial sheep farm. When collecting information from sheep dog triallists at the Tux North Island Dog Trial Championship 2010, they were asked about their working situation and all claimed to be commercial sheep farmers and all claimed that their trial dogs were working sheep dogs. If they were not commercial sheep or sheep and beef farmers or their dog(s) were not working sheep dogs they were not included in the study.

The sampling method could have introduced selection bias and the results may not be representative of the working sheep dog population. The majority of participants were from the South and South-West Waikato and often included farmer neighbours and friends, with the second largest subset consisting of sheep dog triallists. The participants who were from the South and South-West Waikato potentially farmed similar farming systems and had a similar farming and dog management ethos. As a sheep dog triallists trains and competes his dog in a sport, potentially the management of their dogs may be different from non-triallist sheep and sheep and beef farmers who uses their animals for a commercial purpose. Observational bias may have arisen due to untrue answers when the questionnaire was being conducted as the questionnaire was not anonymous. To help ensure a good response level for the questionnaire and limit the workload for the investigator, the questionnaire was completed while the primary investigator was on farm. Therefore creating an anonymous questionnaire, while possible, was not practical. Measurement errors possibly occurred due to inherent measurement errors in the faecal analysis procedure and the unaudited body condition scoring. Substantial random error potentially occurred due to the small sample size. The 56 owners and 202 dogs sampled in this study are a very small representation of the total farmer and working sheep dog population. The sampling bias and error in this study arose from the need for a practical and functional study design to ensure data collection was possible with the time available on farm, funding and labour constraints. A stricter target

population definition and geographical stratification may have reduced non-observational bias but would have increased random error as the sample size would have been smaller. The method of sampling all working sheep dogs a farmer owned resulted in multiple dogs being selected from a single establishment. This may mean the variables are not independent which violates the assumption when using Chi-Square or Fisher Exact analysis that the variables are independent. As the number of each parasite species found was low, all association analysis performed, except age and frequency of anthelmintic use, combined all parasite species into one group. Combining all the parasite species into one group would help minimise the effect of any bias such as one establishment having a higher prevalence for a parasite species than the total prevalence found across all farms for that species or a farmer having a preference for a breed of dog or husbandry or management practice.

The questionnaire was designed to provide information about basic health and welfare management of the dogs. It was designed to be easy to follow and quickly completed. The owner's details were recorded on the questionnaire as well as the dog's, therefore it is possible that answers were modified to 'best practice' due to the lack of anonymity and because the owners were often veterinary clients of the investigator. On reflection the structure of some questions in the questionnaire were not well designed, which could result in answers that were not relevant to the subject. Modifications to the questionnaire could have provided better structured questionnaire and resulted in improvement in the quality of the information provided. Questions (1) "Is your dog(s) vaccinated?" and (1a) "If yes to (1); how often is your dog(s) vaccinated?", (4) "Can your dog(s) kennel be moved?" and (4a) "If yes to (4); how often do you move your dog(s) kennel?", (8) "What do you feed your dog(s)?" and (8a) "Please indicate the proportion of different feeds fed", and (9) "If you feed home kill meat, offal or birth tissue to your dog(s), do you treat it first?" and (9a) "If yes or sometimes to (9); how is the meat treated?" were all two part questions. The first part asked a very simple 'yes/no/don't know or sometimes' question, the second part asked for further information from those who answered 'yes' or 'sometimes'. These two-part questions arguably improved the accuracy of the information as there was little room for confusion in the first part due to the specific questions asked. Cleaning of the kennel was not defined on the questionnaire and was open to a wide range of interpretation. While the lack of

definition of what constituted 'cleaning the kennel' was done on purpose to make the questionnaire short and easily answered, in hindsight it may have been useful if the question had been designed to give some indication of what the owner considered 'cleaning the kennel' to involve. Questions (8) "What do you feed your dog(s)?" and (8a) "Please indicate the proportion of different feeds fed", gave an option for the type of food fed as 'scraps' and also another feed option as 'other'. Potentially, after seeing owners responses, these two categories could have been combined as 'other' as both had few responses. Home kill and scraps were not defined on the questionnaire; however the owners were told by the investigator that they meant home kill sheep meat and household scraps. Question (9a) "If yes or sometimes to (9); how is the meat treated?", which focused on the method used to 'treat' home kill sheep meat fed to the dogs, did not question if the owners had any indication of the temperature of their freezers if they froze their home kill sheep meat as treatment. If the home kill sheep meat was not kept for long enough at a low enough temperature then treatment was potentially inadequate. Question (10) "How often does your dog(s) receive veterinary attention?", did not define 'frequent' or 'occasional' on the questionnaire, leaving these options open to a personal interpretation. While the questionnaire was designed to be short and easily answered, in hindsight it may have been useful if the question had given some indication of what the owner considered 'frequent' or 'occasional' to be. Alternatively the question could have been re-designed to not include these options and instead had 'as required' as a selector.

Conclusion.

This study has identified that working sheep dogs in New Zealand have gastrointestinal nematode and protozoan parasites and has provided data on age, gender, breed, body condition scores, and some aspects of husbandry. It should be noted that many of the variables investigated in this study have not been investigated in other canine populations including the pet population. Therefore no data is available to indicate if working sheep dogs are any different from other canine populations for any of the variables investigated, specifically kennel management, the use of veterinary services, nutrition and the provision of preventative medicines including anthelmintic and vaccinations. Future study needs to be done to identify

the routes of exposure to parasites in working sheep dogs and to quantify the degree of parasitic burden in working sheep dogs. The research suggests that welfare improvements are possible via better husbandry. Key areas of improvement include nutrition, as the majority of dogs were underweight, and preventative medicine. For example the high prevalence of parasitism of the dogs in the study and significant proportion of owners not administering anthelmintic suggests a need for further farmer education on the use of anthelmintics and prevention of parasitism in working sheep dogs. Alternatively the recommendations for the control of gastrointestinal nematode and protozoan parasites may require revision.

Chapter 4. Study design, analysis and discussion of the prevalence of chorioretinal disease in New Zealand working sheep dogs in 2010.

4.1 Introduction

The fundus of the eye is essential for vision. Anatomically the fundus comprises the tapetum, optic disc, retina, and choroid (Maggs, Miller, & Ofri, 2007). Fundic disease will decrease vision and if severe enough will result in blindness. There are a range of recognised pathological conditions that affect the fundus, including breed specific diseases (Storey, Grahn, & Alcorn, 2005). Loss of vision can affect a dog's work performance and may increase the risk of injuries sustained whilst working. A previous study by Hughes *et al.* (1987) identified that multifocal retinitis was present in working sheep dogs and that it was more prevalent in working sheep dogs than in urban dogs. Furthermore, these authors identified that OLM due to migrating *Toxocara canis* larvae was one cause of the retinitis. Since that paper was published there has been no further investigation of fundic disease of any kind in New Zealand working sheep dogs. The first aim of this study was to investigate whether chorioretinal disease is still present in working sheep dogs in New Zealand and, if so, to estimate the prevalence of chorioretinal disease. The second aim of this study was to associate the prevalence of chorioretinal disease with age, gender, breed, body condition score and internal parasitism. Associating the presence of chorioretinal disease with these variables may help identify potential causative factors of retinitis in working sheep dogs and affirm whether anthelmintic treatment with effective anthelmintics over the intervening years has reduced the prevalence of fundic lesions in working dogs. In this chapter the terms chorioretinitis, chorioretinal disease and chorioretinopathy will be used in place of retinitis, retinal disease and retinopathy as "the close proximity and functional intimacy of the retina and choroid mean that inflammation of one of these tissues will normally lead to inflammation of the other resulting in chorioretinitis or retinochoroiditis" (Maggs, Miller, & Ofri, 2007).

4.2 Study design

4.2.1 Funding

Funding and expertise was obtained from the Massey University Centre for Service and Working Dog Health, The New Zealand Companion Animal Health Foundation, The Veterinary Centre, Te Awamutu, New Zealand Veterinary Pathology, The Massey University Veterinary Parasitology Laboratory and Craig Irving Veterinary Ophthalmology.

4.2.2 Sampling method, criteria for inclusion into the study, collection of data and body condition score procedure.

The design of the study is described in detail in Chapter 3. Briefly, 202 dogs belonging to 56 owners from the Waikato region or dogs competing in the Tux North Island Dog Trial Championship were enrolled in the study and convenience sampled. Data was collected between the April 11th 2010 and July 7th 2010. All dogs were greater than six months of age and both the owner and the dog currently worked on a sheep or a sheep and beef farm. Details of the owners and dogs and information about the husbandry of the dogs was collected by questionnaire. Body condition score was determined for 197 dogs using a nine integer scale system (Laflamme, 1997). Faecal samples were collected from 170 dogs. The samples were stored at four degrees Celsius for one to thirty days prior to parasitological exam. Trained veterinary parasitologists identified the parasite ova or cysts of *Toxocara canis*, the hookworms *Uncinaria stenocephala* and possibly *Ancylostoma caninum* (examination did not distinguish which of the two were present), *Trichuris vulpis*, *Sarcocystis* spp., *Isospora canis* and *Isospora ohioensis* (examination did not distinguish which of the two were present), *Neospora caninum* and *Hammondia heydorni* (morphologically the oocysts are indistinguishable) and *Giardia* spp.

4.2.4 Fundic Examination Procedure

All fundic examinations were performed by the same field investigator (AO). The field investigator was a veterinarian who received extensive training in ophthalmological examination and interpretation from a specialist veterinary ophthalmologist (Dr Craig Irving) prior to the study. A mydriatic containing the active ingredient tropicamide (Mydriacyl® 1%, Alcon Laboratories), was applied to the conjunctivae of all the working sheep dogs before any other sampling activity was undertaken. Menace, dazzle and palpebral eye reflexes were observed after the mydriatic was applied. The use of the mydriatic meant that pupillary light reflexes could not be tested. The orbit, adnexa, cornea, iris and lens were closely examined using natural and artificial light. An indirect ophthalmoscope with a 20 dioptre lens was used to examine the lens, vitreous and fundus in a convenient shaded or dark area. If the owner consented abnormal or atypical fundi were photographed using the Clearview Optibrand Fundic Camera. If the owner did not consent to an atypical fundus being photographed then the animal was excluded unless the field investigator was confident of the diagnosis. The fundic images where downloaded to a Dell Latitude laptop computer and stored using proprietary software for Clearview Optibrand fundic images.

Once all dogs were examined the field investigator met with a veterinary specialist ophthalmologist who had prior experience performing fundic examinations in working sheep dog's eyes[1] and Dr Paul Hughes who had published a study on fundic lesions in working sheep dogs' eyes previously (Hughes, Dubielzig, & Kazacos, 1987)[2]. The fundic images were then examined by all three veterinarians and diagnosis was based on the images and the notes made by AO[3] from the time of the fundic examination. Fundi were diagnosed as being either normal or diseased (chorioretinopathy). Due to the large variation of the appearance seen in a normal fundus, if a consensus could not be agreed for the diagnosis of a suspected abnormality in a particular fundus then it was considered normal.

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[1] Craig Irving, BVSc(Dist), MACVSc, Cert. Vet. Ophthalmology RCVS
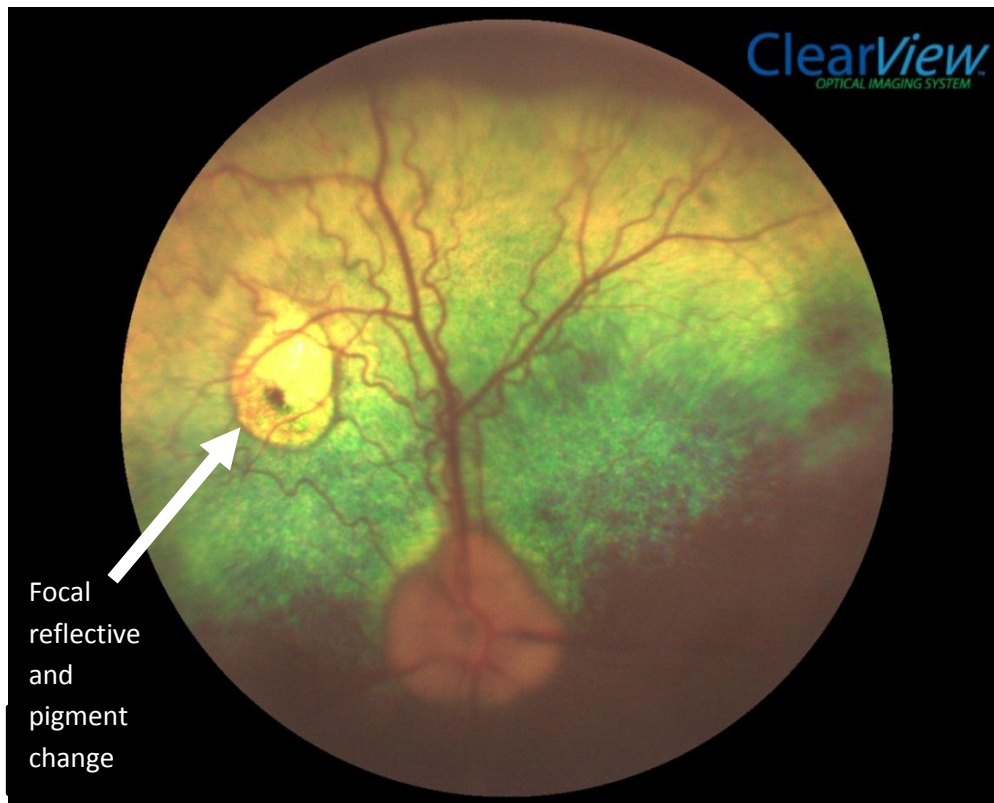[2] Paul Hughes, BVSc
[3] Adam O'Connell, BVSc

The lesions of chorioretinopathy were described by the presence of six possible clinical signs:

1. Diffuse reflective changes
2. Focal reflective areas
3. Diffuse pigment changes
4. Focal pigment deposition
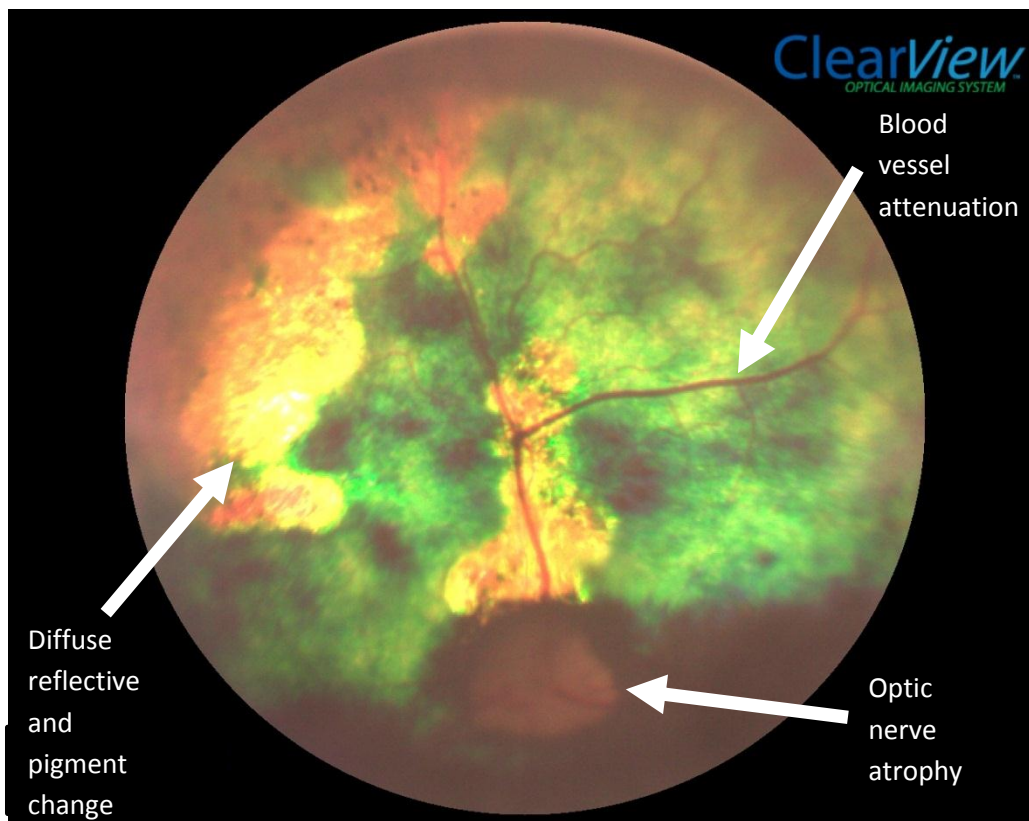5. Blood vessel attenuation
6. Optic nerve atrophy

A particular chorioretinopathy might be described as having 'focal reflective changes, focal pigment deposition, blood vessel attenuation'. Figure 4.1 shows an example of a typical normal fundus in a working sheep dog, Figures 4.2, 4.3, 4.4 and 4.5 give examples of the six clinical signs referred to above seen during the examination of the fundic images..

Figure 4.1: Example of a typical normal fundus for a working sheep dog in a study into the prevalence of chorioretinal disease in a population of working sheep dogs in New Zealand. Data from a cross-sectional survey involving 56 dog owners and 202 dogs from the central North Island and the Tux North Island Dog Trial Championship conducted in 2010.
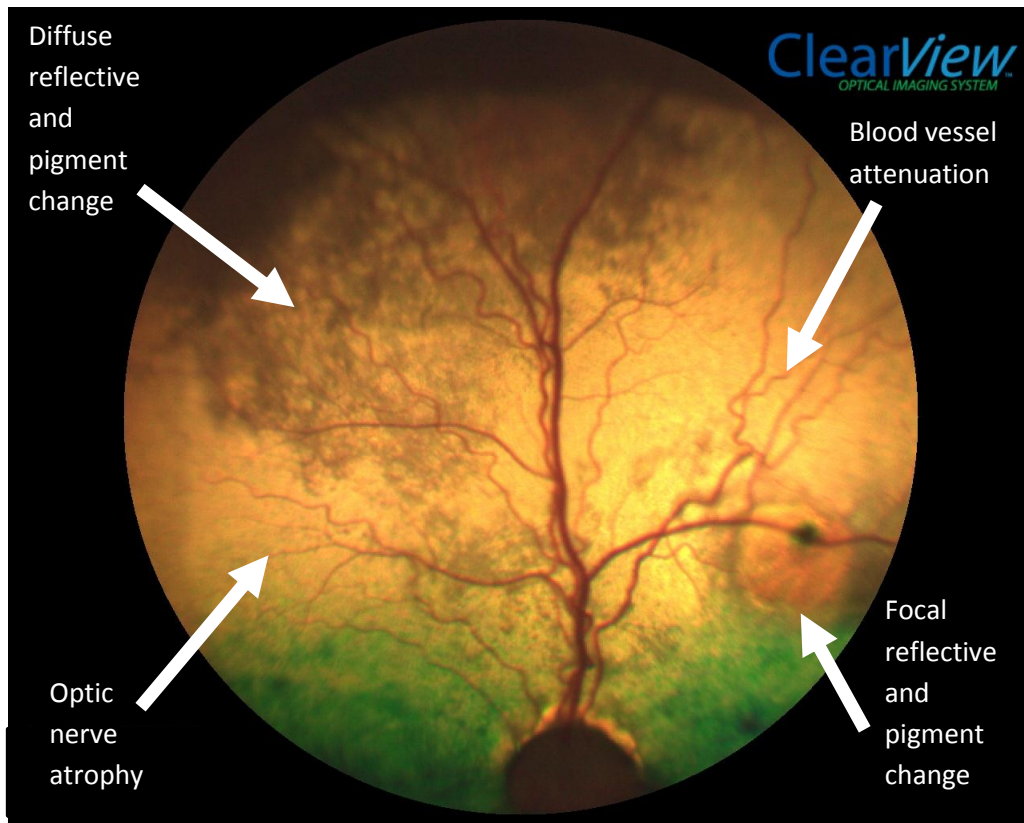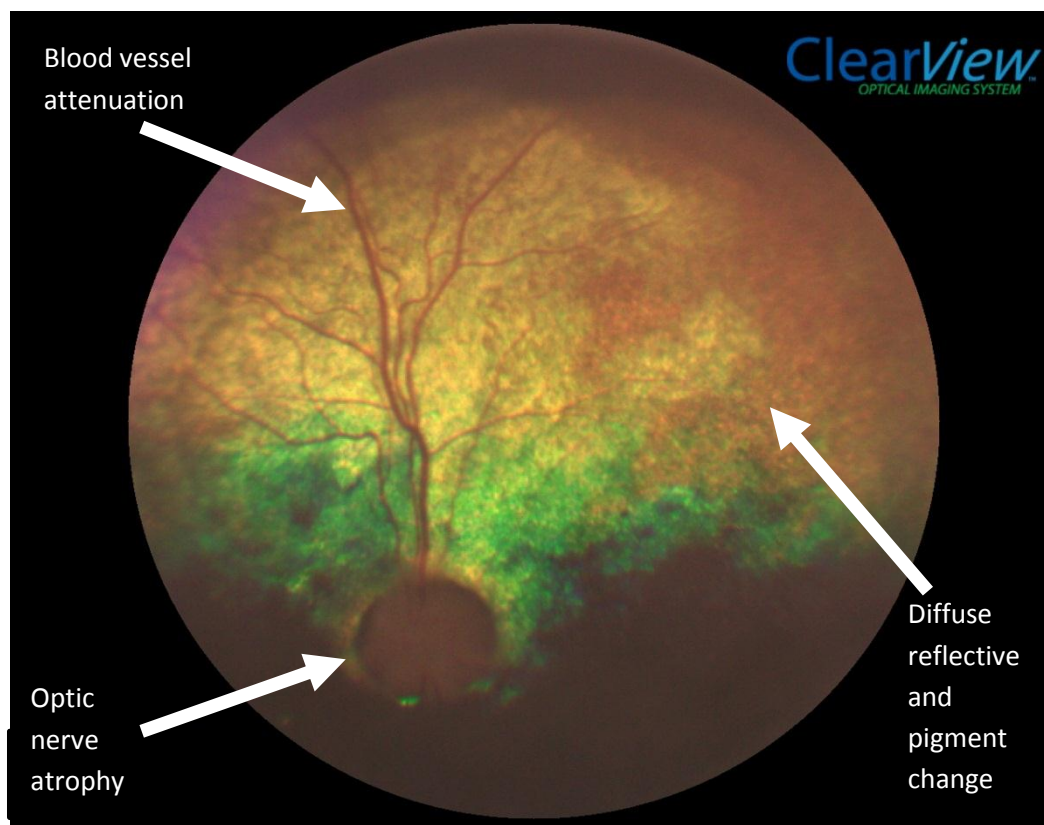
Figure 4.2: Example of a focal fundic lesion showing focal hyper-reflectivity and focal pigment deposition, in a working sheep dog in a study into the prevalence of chorioretinal disease in a population of working sheep dogs in New Zealand. Data from a cross-sectional survey involving 56 dog owners and 202 dogs from the central North Island and the Tux North Island Dog Trial Championship conducted in 2010.

Figure 4.3: Example of diffuse fundic lesions showing diffuse hyper-reflectivity and diffuse pigment deposition, blood vessel attenuation and optic nerve atrophy in a working sheep dog in a study into the prevalence of chorioretinal disease in a population of working sheep dogs in New Zealand. Data from a cross-sectional survey involving 56 dog owners and 202 dogs from the central North Island and the Tux North Island Dog Trial Championship conducted in 2010.

Diffuse reflective and pigment change

Blood vessel attenuation

Optic nerve atrophy

Focal reflective and pigment change

Figure 4.4: Example of focal pigment deposition, focal reflective change, diffuse hyper-reflectivity and diffuse pigment deposition, blood vessel attenuation and optic nerve atrophy in a working sheep dog in a study into the prevalence of chorioretinal disease in a population of working sheep dogs in New Zealand. Data from a cross-sectional survey involving 56 dog owners and 202 dogs from the central North Island and the Tux North Island Dog Trial Championship conducted in 2010.

Blood vessel
attenuation

Diffuse
reflective
and
pigment
change

Optic
nerve
atrophy

Figure 4.5: Example of optic nerve atrophy, blood vessel attenuation, diffuse hyper-reflectivity and diffuse pigment deposition in a working sheep dog in a study into the prevalence of chorioretinal disease in a population of working sheep dogs in New Zealand. Data from a cross-sectional survey involving 56 dog owners and 202 dogs from the central North Island and the Tux North Island Dog Trial Championship conducted in 2010.

4.2.7 Data Management and Statistical analysis

Data analyses were performed using a commercial spreadsheet program, Microsoft Excel 2010, and the statistical software package R Version 2.13. Initially datasets were examined for completeness and validity. If an unusual or missing value was found, the value was checked against primary sources and corrected if necessary.

The prevalence of chorioretinal disease was described using both a count of the number of normal and diseased dogs and as a proportion of total number of dogs who had their fundi examined. The distribution of chorioretinopathy between the left eye and the right eye was described using a count of the number of eyes affected. The six clinical signs of chorioretinal disease used in this study were described using a count of the number of dogs displaying the clinical sign of interest and as a proportion of the total number of dogs who had either a normal fundus or a diseased fundus which was imaged and reviewed. Two-way tables were constructed to explore the relationship between chorioretinal disease (lesion or no lesion) and age, gender, breed, body condition score, parasite infection and *Toxocara canis* infection. Significance of the association was assessed using a Chi-squared or Fisher exact test as appropriate and the relative risk for the association was assessed with a 95% confidence interval. A p-value of < 0.05 was considered statistically significant.

4.3 Results

4.3.1 General

184 dogs had both eyes examined. Prevalence of chorioretinal disease in the working sheep dogs was 44/184 dogs (24%). The number of left eyes with chorioretinopathy was 31 and the number of right eyes with chorioretinopathy was 36. Twenty three dogs had bilateral fundic lesions. All owners gave permission for atypical fundi to be photographed using the Clearview Optibrand Fundic Camera when requested.

The lesions of chorioretinopathy ranged from small focal and discrete lesions to diffuse and poorly delineated lesions involving the whole fundus. The tapetal fundic lesions were typically hyper-reflective with or without pigment deposition, while non-tapetal fundic lesions typically had a patchy loss of pigment deposition and were pale. Retinal blood vessels were often attenuated and optic nerve atrophy was commonly found in association with other evidence of chorioretinopathy.

Loss of vision assessed by menace and dazzle reflex was not found in any dog with chorioretinopathy. A small number of palpebral, orbital, adnexal, corneal, anterior chamber, iris and lens abnormalities were found but none appeared to have any relationship with the chorioretinal disease if they occurred with the fundic lesions. . No vitreal lesions were found.

Table 4.1 shows the number and relative frequency of the six clinical signs of chorioretinal disease classified in this study for each dog that was imaged for further assessment. There was no statistically significant difference in the frequency of clinical signs of chorioretinal disease between the right eye and left eye (P= 0.79).

Table 4.1: Frequency of six clinical signs of chorioretinal disease in 175 working sheep dogs in a study of chorioretinopathy in a population of working sheep dogs in New Zealand. Data from a cross-sectional survey involving 56 dog owners and 202 dogs from the central North Island and the Tux North Island Dog Trial Championship conducted in 2010.

Clinical Sign	Frequency of dogs with each clinical sign	Relative Frequency of dogs with each clinical Sign
Diffuse hyper-reflectivity	22	0.13
Focal hyper-reflectivity	20	0.11
Diffuse pigment deposition	25	0.14
Focal pigment deposition	17	0.10
Blood vessel attenuation	19	0.11
Optic nerve atrophy	13	0.07

4.3.3 Risk factors for chorioretinal disease in working sheep dogs in New Zealand

Table 4.2 describes the relationship between chorioretinal disease and age, breed and gender. Table 4.3 describes the relationship between chorioretinal disease and body condition score, parasitism with a nematode and/or protozoa parasite(s) and *Toxocara canis* infection. There was a statistically significant relationship between the presence of chorioretinal disease and age (P= 0.0007). While chorioretinal disease occurred in all age groups the prevalence did increase with increasing age. Dogs eight years old or older were 6.31 times more likely to have chorioretinopathy than dogs less than two years of age. There was also a statistically significant relationship between chorioretinal disease and gender with males having a higher prevalence of chorioretinal disease than females (P< 0.0001).

There was no statistically significant relationship found between chorioretinal disease and breed, body condition score, parasitism with a nematode and/or protozoan parasite(s) or *Toxocara canis* parasitism.

Table 4.2: Effect of age, breed and gender on the prevalence of chorioretinal disease in a study of chorioretinal disease in a population of working sheep dogs in New Zealand. Data from a cross-sectional survey involving 56 dog owners and 202 dogs from the central North Island and the Tux North Island Dog Trial Championship conducted in 2010.

Risk factors for chorio-retinal disease	Categories for each risk factor	Frequency of chorio-retinopathy positive dogs	Frequency of chorio-retinopathy negative dogs	Relative risk of chorioretinal disease for each category (95% confidence interval in brackets)	P-value for each risk factor
Age	< 2 years old	2	32	REF	0.0007
	2 – 3 years old	6	42	2.13[a](0.46-9.90)	
	4 – 7 years old	22	42	5.84 (1.46-23.38)	
	≥8 years old	13	22	6.31 (1.54-25.9)	
Gender	Male	38	70	REF	<0.0001
	Female	6	69	0.23 (0.10-0.51)	
Breed	Heading	18	56	REF	0.96
	Huntaway	20	59	1.04 (0.60-1.81)	
	Crossbreed	5	23	0.73 (0.30-1.79)	

* Number of dogs sampled for chorioretinal disease stratified by age, gender and breed was, respectively 181, 183 and 181. Dogs were excluded if they did not have a fundic exam performed or the owner of the dog did not complete the relevant section of the questionnaire.

[a] The relative risk of chorioretinal disease in working sheep dogs with an age of 2 – 3 years was 2.13 (95% CI 0.46-9.90) times more than those working sheep dogs with an age of less than two years.

Table 4.3: Effect of body condition score, nematode and/or protozoan parasite infection and Toxocara canis infection on the prevalence of chorioretinal disease in a study of chorioretinal disease in a population of working sheep dogs in New Zealand. Data from a cross-sectional survey involving 56 dog owners and 202 dogs from the central North Island and the Tux North Island Dog Trial Championship conducted in 2010.

Risk factors for chorioretinal disease	Categories for each risk factor	Frequency of chorio-retinopathy positive dogs	Frequency of chorio-retinopathy negative dogs	Relative risk for chorioretinal disease for each category (95% confidence interval in brackets)	P-value for each risk factor
Body Condition Score	≤2	7	20	REF	0.99
	3	16	54	0.88[a] (0.41-1.90)	
	4	17	53	0.94 (0.44 - 2.00)	
	≥5	3	9	0.96 (0.30-3.10)	
Parasite Infection	Infected	15	49	REF	0.65
	Uninfected	17	72	0.81 (0.44-1.51)	
Toxocara Canis	Infected	2	7	REF	0.74
	Uninfected	30	114	0.94 (0.27-3.2)	

* Number of dogs sampled for chorioretinal disease stratified by BCS, parasite infection and Toxocara canis infection was, respectively 179, 153 and 153. Dogs were excluded if they did not have a fundic exam or BCS exam or faecal exam performed.

[a] The relative risk of chorioretinal disease in working sheep dogs with a body condition score of 3 was 0.88 (95% CI 0.41-1.90) times less than those working sheep dogs with a body condition score of less than or equal to two.

4.4 Discussion

The current study found that on ophthalmoscopic examination, chorioretinal disease is still present in New Zealand sheep dogs and that the prevalence in the Waikato district was 24%. The prevalence in the current study is lower than that identified by Hughes *et al.* (1987) who found 39% of dogs in the Taihape region had multifocal retinal disease on ophthalmoscopic examination. No current urban dog prevalence data is available but the prevalence found in this study is considerably higher than the prevalence of 6% of urban dogs with retinitis found by Hughes *et al.* (1987). The lower rate in working sheep dogs found in this study could reflect a reduction in prevalence of chorioretinal disease over time due to improvements in the efficacy of anthelmintics and anthelmintic programmes or other unidentified causes. Alternatively the geographical and husbandry differences in the location of the working sheep dog populations in this study compared to the study of Hughes *et al.* (1987) may have resulted in the lower prevalence of chorioretinal disease found in this study. Both studies may be under-reporting prevalence due to environmental conditions associated with the on-site research, in particular sub-optimal lighting conditions for thorough eye examinations and inadequate restraint of the dogs by owners inexperienced in restraining animals for eye examinations.

Both the current study and the Hughes *et al.* (1987) study found a significantly higher prevalence of chorioretinal disease in older working sheep dogs. The most likely reason for the higher prevalence of chorioretinal disease in older animals is because older animals have had more opportunity for the development of or exposure to potential infectious agents or other known causes of chorioretinal disease.

Males had significantly higher prevalence of chorioretinal disease than females. Hughes *et al.* (1987) reported a similar finding and did not identify or postulate a reason for the gender difference. A veterinary ophthalmologist[4] (Acland, pers. comm., 2008), has identified a possible retinal disorder in dogs exposed to regular strenuous physical activity which characteristically affects males more than females (relative risk approximately six times greater) and the left eye more than the right

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[4] Professor Gregory M. Acland, BVSc, Cornell University.

eye (at least 75% of affected dogs). The postulated basic pathogenesis involves microvascular ruptures of the traversing capillaries of the choroid with micro-jets of blood passing into the vitreous. As focal lesions accumulate they eventually lead to generalised retinal degeneration which can be hard to differentiate from other forms of generalised retinal degeneration. Acland also postulated that ocular volume and pressure changes due to strenuous activity lead to these microvascular insults. No peer-reviewed literature has been published to support Acland's explanation, however there is literature demonstrating changes in ocular volume and pressure associated with cardiac cycles in humans (Lovasik, Kergoat, Riva, Petrig, & Geiser, 2003).

The gender/fundic disease prevalence correlates well with the proposed fundic disorder affecting dogs undertaking regular strenuous physical activity with both this study and the Hughes *et al.* (1987) study finding that males had a much greater risk of disease than females. However the prevalence in the left and/or right eye found in this study does not support the proposed fundic disorder affecting dogs undertaking regular strenuous physical activity as the prevalence of chorioretinal lesions in the left eye versus the right eye was not significantly different. The theory that regular strenuous physical activity may be causing a retinal lesion in dogs is an interesting possibility and could be responsible for causing chorioretinal disease in working sheep dogs if the hypothesis is true.

There was no predominance of any one of the clinical signs of chorioretinal disease which may indicate that all causes of chorioretinal disease can result in all clinical signs of chorioretinal disease detected in this study occurring, or that there is a similar prevalence of the different diseases that are causing the chorioretinopathy. However, twice as many dogs had the most common clinical sign, diffuse pigment deposition, as dogs with the least common clinical sign, optic nerve atrophy. This observation may reflect the possibility that optic nerve atrophy is a clinical sign seen in severely affected clinical cases or that causes of chorioretinopathy that result in optic nerve atrophy are occurring less often.

No significant association was found between chorioretinal disease and either 'parasitism with *Toxocara canis*' or 'parasitism with all species'. However, the approach of attempting to find a positive association between prevalence of

Toxocara canis infection or parasitism with other species and prevalence of chorioretinal disease has a substantial weakness: older animals are generally less permissive of patent *Toxocara canis* infection thus may be negative on the faecal egg count for *Toxocara canis* but are still susceptible to the effects of *Toxocara canis* larvae and may still have chorioretinal lesions that were caused by *Toxocara canis* larvae acquired recently or when they were younger. Alternatively, animals may have been treated with an intestinal parasite anthelmintic after developing chorioretinopathy due to OLM. This study did find that dogs aged three years of age and less had chorioretinal disease which, together with the finding reported in chapter 3 of this thesis that working sheep dogs are parasitized with *Toxocara canis*, indicates the hypothesis of Hughes *et al.* (1987), that OLM can cause fundic disease in working sheep dogs, is still supported.

None of the other variables investigated (see Table 4.2 and Table 4.3) were significantly associated with the prevalence of chorioretinal disease. The very small numbers of dogs found with other ophthalmic diseases meant that no correlation between non-fundic ophthalmic disease and chorioretinal disease was possible. It was interesting to find that no animal appeared to have loss of vision considering the severity of some of the chorioretinal lesions observed.

Applying mydriatic prior to assessing eye reflexes will have diminished the ability to assess retinal function as observation of the non-medicated eye and of the pupillary light reflexes were not available. Application of mydriatic at the beginning of the eye exam was a necessary compromise due to the limited time for farmer assistance when the on-farm survey and examination were being performed. The menace, dazzle and palpebral reflexes were still tested in all the dogs.

The weaknesses of the design of this study are discussed in more detail in chapter 3. Briefly, inclusion criteria were very broad and it is possible that some owners and their dogs were not bona-fide farmers or working sheep dogs therefore results obtained may not be representative of the general working sheep dog population. The study was convenience sampled, which could cause non-observational bias, with owners able to exclude dogs if they elected to. The majority of owners were from the same geographical area, with a sub-set of sheep dog triallists who may treat their working sheep dogs differently from farmers therefore results may not be

representative of the general working sheep dog population. Observational bias may have arisen due to false answers when the questionnaire was being conducted as it was not anonymous. Measurement errors possibly occurred due to inherent errors in the faecal analysis procedure. Substantial random error potentially occurred due to the small sample size. A single investigator, who was a veterinarian, performed all body condition examinations, however no calibration or feedback circuit process was performed to ensure investigator consistency of the body condition exams. However Laflamme *et al.'s* (1997) nine point body condition score system was shown to have a component of variance for repeatability of 0.93 and for reproducibility of 0.86 so investigator consistency when performing body condition examinations was expected to be good.

Conclusion

Clear vision is important for all working dogs especially when they are either in an unfamiliar environment or they are under pressure to perform as part of their normal work. Chorioretinal disease can result in the permanent destruction of cones and rods necessary for vision; therefore a chorioretinopathy can cause a decrease in visual acuity although it may be a negligible loss if lesions are mild and localised. This study found that approximately one quarter of its participants had chorioretinal disease. The limited information provided from other populations indicate that the prevalence of chorioretinal disease may have decreased in working sheep dogs since 1987 (Hughes, Dubielzig, & Kazacos, 1987). Working sheep dog males are significantly more susceptible to develop chorioretinal disease than females for unidentified reasons.

Further study to identify the specific causes of chorioretinopathy in working sheep dogs is required including why male dogs have a greater risk of disease. In particular, investigation into the importance of *Toxocara canis* OLM in causing fundic disease is warranted as OLM has previously been identified by Hughes *et al.* (1987) as a cause of fundic disease in working sheep dogs and this study has identified that chorioretinal disease and *Toxocara canis* infestation are still occurring in working sheep dogs. In this study, *Toxocara canis* infections were significantly more common in young animals while chorioretinitis were significantly more common in older animals. If ocular larval migrans due to *Toxocara canis* was a

significant cause of chorioretinitis in working sheep dogs then more chorioretinal lesions in young animals would be expected. Investigation into the prevalence of chorioretinal disease in other populations of dogs such as urban dogs, racing greyhounds and dairy farm working dogs would help identify if working sheep dogs are more at risk of chorioretinal disease than these other discrete populations. If the chorioretinitis is due to an exercise related increase in ocular pressure then it would be expected that the prevalence of chorioretinitis in working sheep dog breeds in New Zealand who have never worked or engaged in regular endurance exertion would be lower than New Zealand working sheep dogs. Further investigations may necessitate incidence studies to correlate the development of chorioretinopathy with potential aetiologies of chorioretinal disease.

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Appendices

Appendix A: Owner and Animal Details

Owners name…………………………………………………Dogs name………………………………………..

Section 1) Owner and Animal Details

*****Please complete as much of this section as you are able to*****

Owner……………………………………….....…………………………………………………………

Address…………………………….....…………………………………………………………

……

……

Contact Phone(s)…………………………………………………………………

Email…………………………………………………………………………………………………

Animal-Name……………………………………………………………………..

Breed………………………………….....…………………………………………………

Colour……………………………………………………………………………………

Age …..……………..   **Sex:** Male / Female   **Entire:** Yes☐   No☐

Pedigree

(If your dog has trial dog pedigree please record the details here. If your dog has no trial

dog pedigree, or it is unknown, please leave this blank)

Sire……………………………………………………………………………………………….

Dam……………………………………………………………………………………………….

Other Details

……

……

……

……

……

Record Number…………………….Date……………………….

Appendix B: Clinical Examination

Owners name……………………………………………………….Dogs name………………………………………..

Section 2) Physical Exam and Ophthalmic Exam

a) History / owners concerns

…………………………………………………………………………………………………

…………………………………………………………………………………………………

…………………………………………………………………………………………………

……………………………………………………………………………………................

a) Previous eye exam? No☐   Yes☐ *(If yes record details on the back of the sheet)*

b) Physical Exam Checklist

	Normal	Abnormal
Distance Exam	☐	☐
Cardiovascular	☐	☐
Respiratory	☐	☐
Gastrointestinal	☐	☐
Genitourinary	☐	☐
Integument	☐	☐
Musculoskeletal	☐	☐
Ears	☐	☐
Lymph Nodes	☐	☐
Nervous System	☐	☐

Right   **Left**
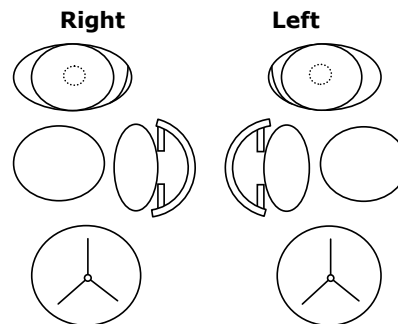
BCS _____

c) Eye Reflexes

	R.E.	L.E.
Menace	☐	☐
Dazzle	☐	☐
Palpebral	☐	☐

d) Parts of the eye

	Normal	Abnormal	L/R
Orbit	☐	☐	…..
Adnexa	☐	☐	…..
Cornea	☐	☐	…..
Iris	☐	☐	…..
Lens	☐	☐	…..
Vitreous	☐	☐	…..
Fundus	☐	☐	…..

c) Record details of abnormal findings below;

…………………………………………………………………………………………………

…………………………………………………………………………………………………

…………………………………………………………………………………………………

…………………………………………………………………………………………………

…………………………………………………………………………………………………

…………………………………………………………………………………………………

…………………………………………………………………………………………………

d) Samples

Record number on sample?

Faecal Sample	☐	☐
Blood Sample	☐	☐
Eye Exam	☐	☐

Record Number…………………..Date………………………

Appendix C: Owner Questionnaire

OWNERS NAME_____

DOGS NAME _____

SECTION 3) Owner Questionnaire

Please complete as much of this section as you are able to

IF THE ANSWER FOR A QUESTION DIFFERS BETWEEN YOUR DOGS LEAVE THE QUESTION BLANK AND I WILL WRITE DOWN THE DIFFERENCES BETWEEN THE DOGS WHEN I SEE YOU

1. **Is your dog(s) vaccinated?**

☐ Yes ☐ No ☐ Don't know

   If **Yes to (1); How often is your dog(s) vaccinated?**

☐ Only when a pup ☐ Annually ☐ Every 2 years
☐ Sporadically

2. **How often do you worm your dog(s)?**

☐ Only when a pup ☐ More than once a month ☐ Every 1 to 2 months ☐ Every 3 months

☐ Every 4-6 months ☐ Annually ☐ Sporadically ☐ Never

3. **What flea treatment do you use for your dog(s)?**

☐ We don't use flea treatment ☐ Wash with water / Swim
☐ Commercial dog product ☐ Commercial non-dog product (e.g. cattle or sheep etc)

☐ Non-medicated shampoo

4. **Can your dog(s) kennel be moved?**

☐ Yes ☐ No

   If **Yes to (4); How often do you move your dog(s) kennel?**

☐ Less than once a year ☐ More than once a year ☐ Never

5. **Is your dogs run* raised off the ground?**

☐ Yes with solid floor ☐ Yes with slatted floor ☐ No

> *** Run**; *The confined area attached to the front of the kennel* or *the area the dog(s) can reach when chained to the kennel*

6. **How often do you clean your dog(s) kennel?**

☐ Less than once a year ☐ More than once a year ☐ Never

Record Number……………………..Date……………………….

OWNERS NAME_____

DOGS NAME _____

---

1. How often do you feed your dog(s)?

☐ Once a day   ☐ More than once a day
☐ Only after exercise or work   ☐ Other (*Please specify below*)

....

....

………

2. What do you feed your dog(s)? (Tick as many as apply)

If possible can you please indicate the rough proportion of different feeds fed to your dog(s)
below the tick box (i.e. 50% or half Commercial, 30% or one third Home kill, 20% or one fifth Scraps).

☐ Commercial dog food   ☐ Home kill   ☐ Scraps   ☐ Other (*Please specify below*)

Proportion of Total;

....

………

3. *If* you feed Home kill meat, offal or birth tissue to your dog(s) do you treat it first (i.e. freeze or cook it)? (*If you don't feed Home kill go straight to Question 10.*)

☐ Yes   ☐ No   ☐ Sometimes

If Yes or Sometimes to (8); How is the meat treated? (Tick as many as apply)

☐ Frozen for greater than 7 days   ☐ Frozen for less than 7 days
☐ Boiled or cooked for greater than 1 hour   ☐ Boiled or cooked for less than 1 hour
☐ Other (*Please specify below*)

....

....

………

4. How often does your dog(s) receive veterinary attention?

☐ Only when vaccinated ☐ Frequently   ☐ Occasionally   ☐ Never

END OF SECTION 2

*** Please leave the following sections blank ***

Record Number…………………….Date……………………….
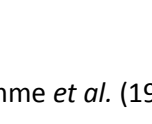
Appendix D: Body Condition Score Chart

The Body Condition Score Chart was developed by LaFlamme *et al.* (1997) in conjunction with Purina.