Demographics and management of dogs used to herd livestock in New Zealand

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

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Abstract

The aim of this research was to describe the demographics, and husbandry and management of Livestock Herding (LH) Dogs in the Manawatau-Wanganui region of New Zealand. To achieve this, a cross-sectional survey of farms was carried out between July 2008 and July 2009. This survey generated data for 119 farms, 198 LH Dog owners, 1,194 LH Dogs, and 768 pups.

Farms in the Manawatau-Wanganui region were randomly selected from AgriBase^{TM}. One researcher visited each farm to conduct face-to-face interviews with the LH Dog owners. The information gathered during the interview pertained to the farm, to the husbandry and management of LH Dogs, and to the demographics of the LH Dogs that were currently on the farm or that had been on the farm over the previous 12 months. In addition information about adverse health events experienced by the LH Dogs in the 12 months prior to the survey was collected, but the analysis is not presented in this thesis.

In total 119 farms were involved and 1,194 LH Dogs were enrolled in the study. Five hundred and seventy-two LH Dogs were New Zealand Huntaways and 415 were New Zealand Heading dogs. The median age of LH Dogs was four years (minimum = 0.50 years, maximum = 18.00 years). Of the 1,152 LH Dogs whose sex and neuter status was known 642 were entire males, 439 were entire females, 48 were neutered females, while 23 were neutered males. Of the 1,157 LH Dogs whose career stage was known 48 had not received any training, 87 had initiated training, 190 were partly trained, 698 were fully trained, 63 were semi-retired, and 71 were retired. Of the 1,173 LH Dogs whose life stage was known 918 were alive and on the farm at the time of the interview, 104 had been euthanised by the owner of the LH Dog, 42 had been sold, 38 had died, 37 had been given away, and 34 had been euthanised by a veterinarian. One hundred and seven litters had been bred over the previous 12 months on 45 of the 119 farms producing a total of 768 pups. Four hundred and sixty-four pups had died of which 356 had been euthanised.

The median age at which training was initiated was known for 881 LH Dogs. This age was six months but this ranged from two to 84 months. One hundred and forty-two LH Dog owners reported striking their LH Dogs while training them to undertake livestock herding activities. Of the 1,180 LH Dog shelters reported on, 970 had been built by the farmer while 170 had been commercially acquired. An additional 40 LH Dogs were sheltered in ad hoc shelters such as farm sheds or vehicles. Two hundred and sixty-five LH Dog shelters had bedding within and 46 of these beddings had been changed over the previous 12 months. Eight hundred and fourteen of the 1,180 LH Dogs whose shelter description was obtained had their food placed on the floor of the shelter or run, while 363 had their food placed in a container. Twenty-four LH Dogs did not have access to water from the confines of their shelter. One hundred and seventy-seven LH Dog owners had fed their LH Dogs commercial dry food over the previous 12 months, and eleven had fed raw sheep offal. Two hundred and nine LH Dogs were fed less than once per day, 994 had been given anthelmintic drugs, 211 had been vaccinated, and 109 had been given a flea control treatment over the previous 12 months.

This thesis provides baseline information about LH Dog demographics, and the husbandry and management of LH Dogs in the Manawatau-Wanganui region of New Zealand. Future research should

focus on genetic and behavioural problems specific to New Zealand Huntaways and New Zealand Heading dogs as this is likely to assist the most LH Dogs. The association between the LH Dog neuter status and behaviour, and neuter status and health is worthwhile investigating since this information would aid LH Dog owners to make decisions pertaining to the neutering of their LH Dogs. The relationship between method of LH Dog training and the LH Dog's herding proficiency is also a worthy research topic, as is the relationship between method of LH Dog training and LH Dog health. Such research would be pioneering given science-based research specific to New Zealand LH Dog training has yet to be undertaken, and the outcomes of this research would enable LH Dog owners to make informed training decisions. Finally, future research should aim to develop our understanding of how certain LH Dog management practises impact on the ability of a LH Dog to herd, and should investigate the relationship between LH Dog management practises and LH Dog health. The outcomes of these investigations would be invaluable for decisions pertaining to LH Dog management.

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Table of contents

List of Figures

List of Tables

List of Abbreviations

LH Dog(s)	Livestock Herding Dog(s)
∑	Sum
>	Greater than
<	Less than
95% CI	95% Confidence interval
NC	Not calculable
RR	Relative risk
GRTS	Generalized Random Tessellation Stratified design

Chapter 1: Introduction

Livestock Herding (LH) Dogs, also known as sheep-dogs, cattle-dogs, or working farm dogs, are an essential part of New Zealand's livestock farming industry. Such dogs are essential because they are able to be trained to induce herd fear-flocking and flight behaviours in animals (Coppinger and Schneider, 1995, p.29) which causes the animals to flock together and move as one in a given direction. The ability of LH Dogs to cause such behaviour in livestock is of assistance to LH Dog owners when they are carrying out every day livestock management activities such as herding farm animals from one location to another. Overall LH Dogs provide support to LH Dog owners by reducing the demanding nature and complexity of livestock farming in New Zealand and are therefore an important part of New Zealand's livestock farming industry (Lithgow, 1995; Cavanagh, 1990; Dalton, 2008; Coppinger and Coppinger, 2000; Redwood, 1980).

The topic of LH Dog health is important. Primarily this is because poor LH Dog health, perhaps caused by disease or injury, is likely to interfere with the ability of a LH Dog to herd and by extension the ability of a LH Dog owner to carry out livestock management tasks. Therefore factors which might cause poor LH Dog health are undesirable and steps should be taken to avoid them. Importantly, there has been limited investigation into risk factors for disease or injury in LH Dogs and into facets which reduce the overall health experience of a LH Dog. This lack of research is significant because without it we cannot identify if improvements can be made or where future research should focus. Collection of baseline demographic, and husbandry and management information for LH Dogs would contribute to a reduction in this knowledge gap.

This thesis presents the results of a cross-sectional survey that aimed to collect baseline demographic, and husbandry and management information for LH Dogs in the Manawatau-Wanganui region of New Zealand. Chapter 2 of this thesis reviews the following: what has been published about service working dogs in New Zealand; what has been published about the working dogs used on farms to manage animals; the history of LH Dogs in New Zealand; the current state of knowledge about the demographics, husbandry and management of LH Dogs in New Zealand; and what has been published about the epidemiology of health problems experienced by LH Dogs in New Zealand. Chapter 2 also discusses potential reasons for gaps in New Zealand LH Dog literature.

Chapters 3 and 4 of this thesis were written to be submitted as papers for publication. Chapter 3 reports the results of the cross-sectional survey with respect to LH Dog demographics. Specifically Chapter 3 presents demographic information pertaining to the following: the working environment of a LH Dog; the number of LH Dogs on farms; the breeds and types of LH Dogs; the age, sex, neuter status, career stage and life stage of LH Dogs; the number of dog litters born on farms; and the fate of pups born on farms.

Chapter 4 reports the results of the cross-sectional survey with respect to LH Dog husbandry and management. In particular Chapter 4 presents information about the ensuing: how LH Dogs were acquired; how LH Dogs were trained, sheltered and fed; and whether LH Dog owners had provided and LH Dogs had received anthelmintic drugs, vaccinations or flea control treatments over the previous 12 months.

This thesis ends with a general discussion of study results.

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Chapter 2: Literature review

2.1 Introduction

Livestock herding (LH) dogs, sometimes referred to as sheep-dogs, cattle-dogs, or working farm dogs, work on farms by herding livestock. They assist with everyday animal management activities on farms by causing livestock to either flock together and/or to take flight (Coppinger and Schneider, 1995, p.29) which enables a degree of control over their movement (Lithgow, 1995; Cavanagh, 1990; Dalton, 2008; Coppinger and Coppinger, 2000; Redwood, 1980).

The topic of LH Dog health is important for three reasons. Firstly a single adverse health event may permanently interfere with the herding ability of a LH Dog. For example, Worth and Bruce (2008, p.78) have suggested an association between experience of traumatic carpal injuries in dogs and subsequent experience of degenerative osteoarthritis and long-standing pain and lameness; long term health problems such as on-going pain are of concern because the LH Dog may need to be replaced which costs both time and money. In addition, the topic of LH Dog health is important because some mechanisms of diseases which affect livestock and by extension the income of the livestock producer can be linked to the health experience of LH Dogs on farms. For example, poor farm hygiene or dog feeding practises contribute to the sheep measles lifecycle. Specifically, poor farm hygiene or dog feeding practises provide opportunities for LH Dogs to consume sheep or goat meat infected with tapeworm cysts (*Cysticercus ovis*). The tapeworm cysts (*C. ovis)* mature into worms (*Taenia ovis)* within the dog's intestine and the worms shed eggs through the dog's faeces (Ovis Management Limited, 2012). If the faeces fall onto pastures sheep or goats may ingest the eggs. These eggs may later lead to cysticercosis in the sheep or goat's muscle tissue (Lawson, 1994; Blood and Studdert, 1988, p. 249) and sheep and goats infected with *C. ovis* may be rejected as carcasses which therefore reduces the income of the producer. By extension the notion that New Zealand sheep and goats may be infected with *cysticerci* could reduce their export market value (Sweatman, 1962; Ovis Management Limited; Lawson, 1994). Lastly, the topic of LH Dog health is important because the experience of good health is of inherent value to a LH Dog and the notion that New Zealand actively promotes the health of its LH Dogs may have positive implications for the way New Zealand is perceived, with respect to animal welfare, both nationally and internationally.

Given the health of LH Dogs is important access to population level information about the health of LH Dogs is valuable. Such information would facilitate prioritisation of research into varying LH Dog health problems, facilitate the design of veterinary services that would aim to minimise the incidence and impact of these adverse health events, and may provide insights that would guide the development of relevant organisations by government agencies. The first step in collection of this information is a detailed understanding of demographic features of the LH Dog population and an understanding of LH Dog husbandry and management.

The aim of the following review is as follows: to place New Zealand LH Dogs in the context of other New Zealand working dogs; to describe the history of LH Dogs in New Zealand; to describe the current state of knowledge about the demographics, and husbandry and management of New Zealand LH Dogs;

to describe what is known about the epidemiology of health problems experienced by LH Dogs in New Zealand; and to discuss potential reasons for gaps in New Zealand LH Dog knowledge.

2.2 Working dogs

New Zealand working dogs can be grouped in numerous ways depending on an individual's interpretation of the role of a working dog. For the purposes of this thesis, New Zealand working dogs are deemed to be divisible into those that are used for service and those used on farms. The five types of service working dogs in New Zealand are as follows: Police Dogs; Guide Dogs; Mobility Dogs; Hearing Dogs; and Detector Dogs which detect narcotics, explosives, substances of concern to quarantine, lost or trapped people, protected species, and predators of protected species. Working farm dogs assist New Zealand farmers with livestock and wild animal management. The two types of working farm dogs in New Zealand are Agricultural Animal-Pest Control dogs and LH Dogs. Service and farm working dogs are discussed in the following.

2.2.1 Service working dogs in New Zealand

2.2.1.1 Police Dogs

In New Zealand dogs are used by the Police for patrols or as detector dogs (New Zealand Police, 2013). Patrol Police Dogs are German Shepherds and typically used to track and search for people with a small number trained to carry out search and rescue. Detector Police Dogs are used to identify firearms, currency, narcotics and explosives. Detector Police Dogs are a variety of breeds including Labradors, German Shepherds and Springer Spaniels. All New Zealand Police Dogs are trained at the Royal New Zealand Police Dog Training Centre in Trentham, Upper Hutt. There are currently over 120 dog teams working within in New Zealand.

2.2.1.2 Guide Dogs

Guide dogs are used in New Zealand to guide blind, deaf-blind and vision-impaired people through hazards (such as traffic) and to everyday places (such as a supermarket or school) (Royal New Zealand Foundation for the Blind, 2013). Dog breeds used as Guide Dogs include purpose-bred crosses, German Australian Shepherds, Belgian Shepherds, Labradors, and Golden Retrievers. Guide Dogs in New Zealand are bred through the Douglas Pharmaceuticals Guide Dog Breeding Improvement Programme and are trained by the Royal New Zealand Foundation of the Blind Guide Dog Services.

2.2.1.3 Mobility Dogs

Mobility Dogs facilitate the everyday activities of physically disabled people (Mobility Dogs, 2012). There are three categories of Mobility Dog: 1) Service Dog; 2) Assist Dog, and 3) Skilled Companion Dog. The Service Mobility Dog supports a disabled person with everyday tasks such as retrieving the telephone or opening a door. Service Mobility Dogs have full public access rights. The Assist Mobility Dog also provides support to a disabled person in the home environment, but their public access is directed by a facilitator. The Skilled Companion Mobility Dog is considered a very well trained pet and is able to support three aspects of a disability. Given the nature of their job, medium to large breeds such

as Labradors and Golden retrievers are preferred in Mobility Dog roles. In 2012 over 35 Mobility Dogs were working with disabled people.

2.2.1.4 Hearing Dogs

The primary objective of a Hearing Dog is to identify important sounds, such as a smoke alarm or the telephone, for people who are hearing impaired (Hearing Dogs, 2012). No specific breed is used for hearing dogs; rather the majority of Hearing Dogs are sourced from animal shelters. Hearing Dogs for Deaf People, New Zealand currently has a national training centre based in New Plymouth.

2.2.1.5 Detection Dogs

In New Zealand the Ministry for Primary Industries, the Department of Corrections, the Royal New Zealand Air Force, New Zealand Land Search and Rescue, the Department of Conservation, and private organisations all use dogs of detection. The Ministry for Primary Industries uses dogs to detect illegal substances such as narcotics and explosives or substances of quarantine concern from flights, cargo and cruise ships, and mail services (Ministry for Primary Industries, 2010). The New Zealand Department of Corrections uses dogs to detect illicit drugs (Department of Corrections, 2013). Such dogs may search prison cells, and incoming property, parcels, or mail. Department of Corrections Dogs may also search visitors to a prison and their vehicles, may undertake property searches, or may patrol the periphery of a prison fence. The Royal New Zealand Air Force uses dogs to protect the air base and aircrafts, and to secure the Air Force when units are deployed (Air Force, 2013; New Zealand Defence Force, 2012). Such Military Working Dogs protect and secure by patrolling areas, and tracking and detecting explosives. New Zealand Land Search and Rescue uses Avalanche and Wilderness detection dogs (Search and Rescue Search Dogs, 2013). Avalanche Land Search and Rescue Dogs use airborne scent to detect people trapped beneath snow, while Wilderness Land Search and Rescue Dogs detect lost persons by tracking airborne or ground scent. The Department of Conservation also uses Protected Species Detection Dogs and Predator Detection Dogs (Cheyne, 2008). Protected Species Detection Dogs assist with the location of rare birds and lizards such as kiwi, pateke taiko, takahe, kakapo, skinks and geckos. Location of such species is important for translocation and monitoring reasons. Predator Detection Dogs support threatened species recovery programmes by detecting the predators of a recovering species. Typically these predators are rodents, mustelids, cat, or hedgehog. The purpose of such detection is to confirm a need for further predator trapping at a recovery site. Additionally, Predator Detection Dogs are used to prevent reinvasion or the accidental introduction of a predator to an area. Finally, New Zealand has organisations that provide specialist dogs and handlers to the private sector for the purposes of detecting drugs and explosives or other unwanted substances. For example New Zealand Detector Dogs provides drug or explosives detector dog services to educational, business, government and private enterprise sectors (NZ Detector Dogs, 2013). New Zealand Detector Dogs drug detection teams support private company or organisation goals to have a drug-free workplace, while their explosive detector dog teams assist the New Zealand cruise ship and security industry to provide an explosive-free operation.

2.2.2 Farm working dogs

Internationally, three kinds of working dogs can be used on farms to manage animals. One kind is used to guard livestock from predation by wild animals and is termed a 'Livestock Guarding Dog'. In New Zealand the lack of wild animals that prey on livestock means that 'Livestock Guarding Dogs' are not used and as such they are not discussed further in this thesis. A second kind of working dog used on farms detects and/or eliminates agricultural animal pests on New Zealand farms and for the remainder of this thesis is termed an 'Agricultural Animal-Pest Control Dog'. A third kind – the focus of this thesis – assists New Zealand farmers with livestock herding tasks and is termed a 'Livestock Herding Dog'. The term 'Livestock Herding Dog' encompasses dogs otherwise referred to as 'sheep dogs', 'cattle dogs' and 'working farm dogs'. The 'Livestock Herding Dog' term was used in preference to the former three phrases to make it clear that the dog works with livestock but in a herding capacity rather than a guarding roll.

2.2.2.1 Agricultural Animal-Pest Control Dogs

Agricultural Animal-Pest Control Dogs are used on New Zealand farms for their ability to hunt wild animals. Such hunting may involve detection, tracking, and killing. Importantly, Agricultural Animal-Pest Control Dogs do not hunt for the purposes of human entertainment. Nor do Agricultural Animal-Pest Control Dogs exist to hunt food for humans, such as the dogs used to hunt wild pigs to supplement the otherwise fish and shell-fish diet of the Onges community, Andaman Islands (Serpell, 1995, p. 247). Rather, Agricultural Animal-Pest Control Dogs are used on farms to hunt wild animals which might otherwise harm or spread diseases to livestock, eat the food of livestock, or threaten the farming environment. Since Agricultural Animal-Pest Control Dogs hunt wild animals in order to maintain status quo, Agricultural Animal-Pest Control Dogs could be classified alongside other working dogs used in detection roles such the Department of Conservation's Predator Detection Dogs or the Royal New Zealand Air Force Military Working Dogs.

The terms used to describe how an Agricultural Animal-Pest Control Dog detects vary greatly in the literature. Still the underlying principles are the same. The most common terms used are 'finding', 'bailing', 'holding', 'flushing', and 'killing' (Holden, 1982; Cuthbertson, 1968). 'Finding' refers to the detection of a wild animal by following air scents or ground trails. 'Bailing' refers to keeping an animal within a confined area while simultaneously alerting the dog's owner, usually by barking. 'Holding' refers to the use of the dog's body-weight or teeth to immobilise an animal until required to release it. 'Flushing' refers to moving an animal out of its hiding place in order that it is accessible for killing. 'Killing' is typically achieved with a dog's teeth and/or body-weight. The relevance of these techniques to each Agricultural Animal-Pest Control Dog appears to be dependent on the wild animal whose presence is being managed and the expectations of the Agricultural Animal-Pest Control Dog's handler.

In New Zealand, possums (*Trichosurus vulpecula*), rabbits (*Oryctolagus cuniculus)*, feral pigs (*Sus scrofa)*, and feral goats (*Capra aegagrus)* can negatively impact on livestock farming making the detection of these wild animals of relevance to Agricultural Animal-Pest Control Dogs. Possums are a concern to livestock farming because they are a maintenance host vector for bovine tuberculosis which threatens livestock health and by extension international export trading (Department of Conservation, 2011). Rabbits are a problem for livestock farming because they heavily graze pastures (Lough, 2009).

Not only does this reduce the amount of pasture available for livestock, but heavy grazing may modify land vegetation cover and constitution which leads to soil damage, erosion, and change of water values. The rabbit is also a problem because it is a food source of two recognised bovine tuberculosis vectors namely the ferret and the cat. Feral pigs are a concern to livestock farming because of their tendency to maim or kill livestock and farm workers. Feral pigs also damage land and crops by rooting up the soil and consuming soil microorganisms (Cuthbertson, 1968; Howard, 1964; Holden, 1982; Manawatau Standard, 1884; Ellesmere Guardian, 1930). Feral goats entering farm land are a problem to livestock farming because they compete with livestock for pasture and water, and damage fences (Parkes et al., 1996; Howard, 1964). Agricultural Animal-Pest Control Dogs are currently used on farms in the following ways: to 'find' possums in order that they be shot or 'killed'; to 'find', 'bail, and or 'hold' feral pigs and feral goats in order that they be shot, stabbed, or 'killed'; and to 'flush' rabbits in order that they be shot or 'killed'(see Albertland Gazette (1863), Batchelor and Bell (1974), Clutha Leader (1879), Feilding Star (1882), Lough (2009), McIlroy (2010), Parkes (1990), and Redwood (1980, pp.33 – 37) for examples).

2.2.2.2 Livestock Herding Dogs

Livestock Herding Dogs assist LH Dog owners during livestock management activities such as moving livestock between locations, or controlling livestock in wide open spaces. Of specific assistance to LH Dog owners is the ability of a LH Dog to cause livestock to flock together and/or to take flight (Coppinger and Schneider, 1995, p.29). The ability of a LH Dog to group a herd or flock of livestock together and to move them in a given direction is advantageous to LH Dog owners since this reduces the complexities of moving farm animals from one location to another.

Coppinger and Schneider (1995) divide the general LH Dog population of the world into three groups: 'heading', 'heeling' and 'catching' dogs. Livestock Herding Dogs within the 'heading' group exhibit the behaviour of circling livestock and bringing them back towards the LH Dog owner. Livestock Herding Dogs within the 'heeling' group display the behaviour of following behind livestock for the purposes of driving them away from the LH Dog owner. Livestock Herding Dogs within the 'catching' group exhibit behaviours that enable them to bring livestock to the ground, thereby stopping them. Coppinger and Schneider (1995) also note that certain dog breeds more readily display behaviours relevant to a 'heading', 'heeling' or 'catching' LH Dog group. Subsequently, some dog breeds are preferred for 'heading', 'heeling' and 'catching' over others. For example, the Blue Heeler dog breed readily displays the behaviour of biting the heels of livestock which facilitates the driving of livestock away from a stockman. Subsequently, the Blue Heeler dog breed is a popular 'heeling' LH Dog. Overall, 'heading', 'heeling' and 'catching' LH Dog groups are used to herd sheep, cattle, deer, llama and fish (Morris, 2001).

2.3 New Zealand Livestock Herding Dog groups

Despite international literature tending to stratify LH Dogs into 'heading' 'heeling' or 'catching' groups, review of New Zealand LH Dog literature divides LH Dogs into 'hunt-away', 'heading' or 'handy' groups.

2.3.1 The hunt-away group

A distinguishing behaviour of LH Dogs within the 'hunt-away' group is that they push livestock with noise. Dog breeds typically considered to belong in the 'hunt-away' group include the Bearded Collie and Smithfield. According to Dalton (2008, p.4), the Bearded Collie breed displays barking and gathering characteristics, while the Smithfield breed arose from the barking dogs utilised by Drovers at Smithfield market in London.

The 'hunt-away' group also includes the New Zealand Huntaway[1] Here it is important to note that the New Zealand Huntaway is not a dog breed, since the New Zealand Kennel Club does not consider the New Zealand Huntaway to have an 'official breed standard'. Rather, the New Zealand Huntaway is considered a 'type' of LH Dog, and LH Dogs classified as a New Zealand Huntaway are so on the premise that they herd livestock using similar styles. Dogs considered to be a New Zealand Huntaway bark continuously when working to the effect that they can drive livestock away from, or towards, the LH Dog owner (Dalton, 2008, p.4; Rennie, 1984, p.39; Redwood, 1980, p.40; Oliver et al., 2004, pp. 11 - 12). Some New Zealand Huntaways are also able to 'back' livestock which involves running over the backs of livestock (in particular sheep) in order that the livestock be pushed forward. In addition, some New Zealand Huntaways are also able to 'head' livestock by moving to the front of a flock/herd in order to turn or hold them, or to gain control

2.3.2 The heading group

A differentiating behaviour of LH Dogs within the 'heading' group is that they herd livestock silently. According to Oliver and Sheild (2004, p.9) header dogs handle livestock "...silently, relying on position and use of eye to control the animals". Dogs belonging to the heading group may also be able to 'heel' by biting below a livestock's hock, and 'cover' which involves collecting livestock together (Cavanagh, 1990, p.24; Dalton, 2008, p.4; Rennie, 1984, pp.14, 37; Redwood, 1980, p.40; Lithgow, 1995, p. 5). Dog breeds usually considered to belong in the 'heading' group include the Border Collie and the Australian Cattle dog.

The 'heading' group also includes the New Zealand Heading Dog[2] Pertinently, like the New Zealand Huntaway, the New Zealand Heading Dog is not a dog breed as the New Zealand Kennel Club does not consider the New Zealand Heading Dog to have an 'official breed standard'. Rather, the New Zealand Heading Dog is a 'type' of LH Dog and LH Dogs considered a New Zealand Heading Dog are so on the basis that they herd livestock similarly.

2.3.3 The handy group

[1] Also referred to as 'Huntaways'.
[2] Also referred to as 'Heading dogs'

Livestock Herding Dogs within the 'handy' group are reported to display the behaviours of both the 'hunt-away' and 'heading' group, though without any particular refinement. The Australian Kelpie breed is usually considered to belong to this group.

The 'handy' group also includes the New Zealand Handy dog[3] Like the New Zealand Huntaway and New Zealand Heading dog, the New Zealand Handy dog is not regarded as a breed by the New Zealand Kennel Club but is rather a 'type' of LH Dog characterised by its herding style. Dogs considered a New Zealand Handy dog are described as all-rounders that are able to bark, 'eye', 'heel' and 'back' (Dalton, 2008, p. 4; Rennie, 1984, p.13; Lithgow, 1995, p. 6).

2.4 History of Livestock Herding Dogs in New Zealand

Very little has been documented about the establishment of LH Dogs in New Zealand. Special interest books suggest that the first LH Dog breeds in New Zealand were Border Collies that arrived alongside Scottish settlers, and Bearded Collies that were bought out by English settlers (Dalton, 2008, p. 4; Redwood, 1980, p. 1; Rennie, 1984, p. 8; Oliver et al., 2004, p. 13). Other LH Dog breeds that are thought to have arrived in New Zealand during early European settlement, though in fewer numbers, include the Smithfield and Scottish 'hunter' dog (Rennie, 1984, p. 8).

Special interest literature describes four uses of LH Dogs while livestock farming was being established in New Zealand. Specifically, LH Dogs are reported to have been used in 'stopping,' 'gathering', 'boundary' and 'droving' roles, and Redwood (1980) describes how 'stopping', 'gathering', and 'boundary' LH Dogs were used by sheep farmers before all farm fences had been erected. 'Stopping' dogs blocked the front of the flock thus stopping sheep from moving further away from home. 'Gathering' dogs continually gathered sheep together and ensured sheep did not stray or break away. The breed of the 'stopping' and 'gathering' LH Dogs is thought to have been Border Collie. 'Boundary' dogs were important on farms where line riders[4] had not been employed. 'Boundary' dogs were tethered around the outskirts of the farm within barking distance of other another, and their isolation and a desire to communicate lead to the production of noise which kept sheep within the propertie's territory (Redwood, 1980, pp. 6 - 8; Star, 1901; Otago Witness, 1908). The fourth type of LH Dog used during early livestock farming was a 'droving' dog (Rennie, 1984, p. 12; Redwood, 1980, pp. 85 - 95). 'Droving' dogs are reported to have been vital for Drovers[5] prior to advancements in train and truck livestock transportation systems because they could push livestock through bush, over rivers, and along unfenced roads for extended periods of time. This enabled a Drover to relocate livestock from one place to another such as sale yard to farm over the period of a few days or a few months. The Bearded Collie is reported to have been the breed of choice for Drovers.

A variety of literature suggests that the New Zealand Huntaway was developed by New Zealand LH Dog owners in response to New Zealand farming environments. Specifically, after the advent of refrigerated

[3] Also referred to as 'Handy dogs'
[4] Line riders walked the boundary of farms to keep sheep within the farm's territory.
[5] Drovers drove livestock from one location to another.

shipping in 1882 the demand for mutton and lamb exports grew which meant many flighty Merinos (wool sheep-breed) were replaced with docile Leicester, Lincoln and Romney breeds (meat sheep-breeds) (Wolfe, 2006; Palmer, 2010b; Palmer, 2010a; Rennie, 1984, p. 11). These docile sheep could not be pushed with quiet LH Dogs as easily as Merino had been. Subsequently, selective breeding for LH Dogs that produced noise/barked became popular. Dalton (1996) and Rennie (1984) suggest the genetics of the New Zealand Huntaway type includes the Border Collie, Bearded Collie, Fox hound and Labrador.

2.5 Demographic characteristics of the New Zealand Livestock Herding Dog population

Two cross-sectional studies have been undertaken that provided some insight into demographics of the general LH Dog population of New Zealand. The first was a 12 month survey that collected demographic and health information about LH Dogs that attended veterinary clinics between April 2008 and April 2009 by Cave et al. (2009). After excluding re-visits, data were obtained for 2,214 LH Dogs. A detailed physical description was provided for 2,198 of these LH Dogs of which 51% were Huntaways and 39% were Heading dogs. The remainder were 4% Beardies, 3% Crossbreeds, <1% each of Blue Heelers and Smithfields, and 2% 'other'. More male LH Dogs (56%) were identified than female LH Dogs (44%). Though this survey provided some insight into New Zealand LH Dog demographics the results may not be representative of the general LH Dog population since the survey systematically excluded LH Dogs that did not attend one of the participating veterinary clinics during the study period.

The second study gathered demographic and nutrition data of LH Dogs whose owners were members of the New Zealand Sheep Dog Trial Association (NZSDTA) as of August 2007 by Singh et al. (2011). Of the 2,861 LH Dogs studied Heading and Huntaway dogs were the most common type of breed. Fifty-three percent of the study population were Heading dogs while 41% were Huntaway dogs. The study identified more male LH Dogs (57%) than female; the median age of LH Dogs was three years; and the median number of LH Dogs per owner was six. Care must be taken when extrapolating these results to the general population as the study population only included members of the NZSDTA. NZSDTA members have a special interest in herding competitions and by extension in LH Dog training and efficiency in comparison to non NZSDTA members and as such they may have their LH Dogs trained earlier, and may require more or less LH Dogs in comparison to the general LH Dog owner population.

2.6 Husbandry and management of the New Zealand Livestock Herding Dog population

Several special interest books have discussed the husbandry and management of New Zealand LH Dogs with respect to nutrition, sheltering and training (Rennie, 1984; Dalton, 2008; Oliver et al., 2004; Smith, 2005; Mills et al., 1964; Redwood, 1980). While special interest books provided some insight into the LH Dog husbandry and management practises of New Zealand LH Dog owners the information is typically based on tradition, anecdotes, and personal views, so cannot be considered scientifically accurate. To date there have been two published studies examining New Zealand LH Dogs by Singh et al.(2011) and Cave et al. (2009). In addition, a survey of Australian working dogs was recently undertaken by Branson et al. (2009). In this survey working dogs were defined as any dog not kept as a companion animal and as such their study population included farm working dogs and other dogs in private industry as well as assistance, government, and sport working dogs.

2.6.1 Neuter status

Literature pertaining to the neuter status of LH Dogs in New Zealand is limited to the study by Cave et al. (2009). Of the 2,198 LH Dogs studied few had been neutered. Specifically, only 2% of the study population where castrated males while 3% were spay females. As mentioned earlier however, the results

of this study may not be representative of the general LH Dog population since the survey systematically excluded LH Dogs that did not attend one of the participating veterinary clinics during the study period.

There is no literature describing the reasons why LH Dog owners elect to neuter their LH Dogs. Cave et al. (2009) hypothesised that LH Dog owners delay neutering in order that a dog be given time to prove its ability to perform and so to prove its worth to breed from. Although not LH Dog specific, other reasons for deciding against the neutering of an individual dog have been recorded in a variety of studies. These reasons include considering the procedure unnecessary, having a desire to breed from the dog, being unable to pay for the procedure, considering the dog to be too old or too overweight to deal with the procedure, considering neutering to be a threat to the health of a dog, and considering neutering to be un-natural (Rohlf et al., 2010; Blackshaw and Day, 1994). A better understanding of rates of neutering in the general LH Dog population would provide valuable LH Dog demographic insight. Further, an understanding of when and why a LH Dog owner opts to neuter a LH Dog may aid the development of relevant LH Dog health awareness campaigns.

2.6.2 Diet

Literature pertaining to the diet of LH Dogs in New Zealand is limited to the study by Singh et al. (2011). Of the 542 NZSDTA members studied 97% fed their LH Dogs once at the end of the working day. During peak work periods 4% of NZSDTA members fed their LH Dogs a 100% dry diet, 7% fed a 100% home-kill diet, 50% fed a combination of dry diet and home-kill, while 21% fed a combination of wet diet (canned and dog roll) and/or table scraps and/or dry diet and/or home-kill. The diet fed to LH Dogs during peak work periods by 18% of NZSDTA members was unknown. During off-peak work periods 4% of NZSDTA members fed their LH Dogs a 100% dry diet, 5% fed a 100% home-kill diet, 48% fed a combination of dry diet and home-kill, while 24% fed a combination of wet diet (canned and dog roll) and/or table scraps and/or dry diet and/or home-kill. The diet fed to LH Dogs during off-peak work periods by 18% NZSDTA members was unknown. Problematically, this study by Singh et al. (2011) cannot be extrapolated to the general LH Dog population since the study population were members of the NZSDTA. These members represent a group of people who engage in competition and as such the diets they feed their LH Dogs may differ from LH Dog owners who use LH Dogs but who do not compete.

The diets of New Zealand LH Dogs are somewhat controlled owing to the existence of true hydatids and sheep measles within New Zealand. For the purposes limiting the spread of true hydatids (*Echinococcus granulosus*) the whole of New Zealand (bar Arapawa Island) has been declared a controlled area for *E. granulosus* pursuant to section 131(2) of the Biosecurity Act 1993 (Ministry for Primary Industries, 1996). Under this Controlled Area Notice no dog should be allowed access to raw sheep, goat, cattle, pig, deer, horse, llama, or alpaca internal organs (including liver and lungs). Further, internal organs should be boiled for a minimum of 30 minutes prior to be being fed to a dog. For the purposes of limiting the spread of sheep measles (*C. ovis*) in New Zealand, Ovis Management Ltd, a non-profit organisation owned by the Meat Industry Association of New Zealand, has recommended sheep and goat meat be frozen for at least seven days below -10 °prior to it being consumed by a dog (Ovis Management

Limited, 2012). Though the Declaration of a Controlled Area Notice stipulates, and Ovis Management Ltd recommends, how offal and sheep and goat meat should be prepared prior to its consumption by a dog, there is no literature that identifies the proportion of LH Dog owners in New Zealand that comply.

2.6.3 Shelter

Although not New Zealand based, the Australian Working Dog Survey Report 2009 by Branson et al. (2009) has provided insight into types of working dog shelters. The 4,195 Australian working dogs studied were stratified into four groups during analysis which were assistance (n = 1,336), private industry (n = 1,072), government (n = 960) and sport (n = 827) working dogs. The results of the private industry Australian working dog group were considered of relevance to this thesis as this group included hunting, security and detection dogs, *and* farm dogs. The study found that private industry Australian working dogs were individually sheltered outdoors overnight and during the day irrespective of whether they currently working. Three types of shelters for private industry Australian working dogs were identified. These were an outdoor individual shelter with chain, an outdoor individual shelter with yard, and a vehicle. Unfortunately the report does not identify what proportion of private industry working dogs were sheltered in each shelter type.(or what proportion of the private industry Australian working dogs studied were farm dogs) so it is difficult to make inferences about the sheltering of Australian private industry working dogs. Further, while this report identifies how some private industry working dogs are sheltered in Australia, the data was mainly acquired from Australian working dog owners that completed an electronic version of the survey. Therefore the study results may be bias towards working dog owners that had access to the internet. Most importantly though, the results of this study are specific to Australia so may not reflect the way private industry working dogs are sheltered in New Zealand.

Rennie (1984, Chapter 7) and Dalton (1996, p.23) have described how some LH Dogs have been sheltered in New Zealand. The shelters included single outside kennels, boxes inside larger buildings, combined kennel and cage run shelters, and multiple dog kennels and cage run units . Though a description of the benefits and problems associated with each shelter type is provided the text does not identify what proportion of the general LH Dog population of New Zealand is sheltered in these ways. Therefore we are unable to infer how LH Dogs in New Zealand are sheltered at a population level.

2.6.4 Training

In the Australian Working Survey Report 2009 by Branson et al. (2009) some statistics regarding the training of private industry Australian working dogs were reported. For instance, the average length of time spent with a private industry working dog during a training session was 1.80 hours, the average number of training sessions per month was 14, and the average length of time it took to train a private industry working dog up to working standard was 16 months. The following is based on interpretation of bar graphs presented in the report. Approximately 75% of Australian primary industry working dogs were trained using ‘correction’, 38% using food, 28% using ‘other’, and 20% using play. During on-lead training approximately 45% of private industry working dogs were trained with a flat collar, 25% using a check chain, 12% using a body harness, 10% using a head harness, and 2% using a martingale (limited

slip) collar. During off-lead training approximately 50% of Australian private industry working dog were trained with whistles, 30% were trained using an electronic collar, 20% using a stick, 18% using a toy, and 5% using a clicker. Although this report identifies the variety of mechanisms used to train Australian private industry working dogs it did not stratify training results by type of private industry working dog and as such important differences in the way hunting, security and detection, or farm dogs are trained cannot be identified. In addition, as previously mentioned, the results of this study are specific to Australia so may not reflect the way private industry working dogs are trained in New Zealand.

Special interest books provide an array of training instruction for New Zealand LH Dog owners (Cavanagh, 1990, pp. 26 - 88; Dalton, 2008, pp. 8 - 14; Rennie, 1984, pp. 24 - 35; Oliver et al., 2004, pp. 20 - 47). These books tend to cover similar LH Dog training topics. Establishing dominance over a pup is considered important in many of these publications. For example, Rennie (1980) describes how a LH Dog owner can lay a pup on its side and hold it still in order to assert authority. Basic training is also widely described as a vital part of LH Dog development. In particular, teaching a LH Dog to 'sit', 'stay', 'heel', and 'stand still' are considered essential. For example, Dalton (1996) describes how a LH Dog can be taught to 'heel'[6] by putting the LH Dog on a lead and encouraging it to follow behind the LH Dog owner. Directional training[7] is another often discussed element of LH Dog training in these special interest books. Typically, directional training instruction incorporates the use of devices such as poles and ropes. For example, Smith (2005) describes how a LH Dog can be taught to walk out in front of a LH Dog owner by attaching the LH Dog to a pole and driving it forward. A last widely discussed training topic is the counteracting of herding problems such as the biting of livestock. Oliver and Sheild (2004) describe how a LH Dog can be deterred from biting by catching the LH Dog while it is biting, growling at it, and smacking it on the nose. While there are many special interest books that describe how to train a LH Dog none report the proportion of New Zealand LH Dog owners that use these particular training methods or training devices. Further, these training methods have no scientific bases so their impact on the health or overall performance of a LH Dog is unknown.

2.7 Incidence of health problems in the New Zealand Livestock Herding Dog population

A variety of veterinary case reports and case series which inform on topics such as LH Dog nutritional deficiencies (Thompson, 1979; Mayhew and Stewart, 1969), surgical repair (Worth and Bruce, 2008; Fox and Bray, 1993; Worth et al., 2004), poisoning (Gumbrell and Bentley, 1995; McSporran and Phillips, 1983; Bruere, 1980; Harrison and Manktelow, 1960), lameness (Dillon et al., 1989), skin disorders (Fairley, 1982; Munday et al., 2009), genetic disorders (Munday et al., 2006; Hughes, 2001; Jolly et al., 2002), and retinal diseases (Hughes et al., 1987; Hughes and Joyce, 1981) have been published. These veterinary case reports and case series do provide some insight into the types of health problems LH Dogs experience on farms. However, the usefulness of this information in understanding the epidemiology of LH Dog health problems is limited as it typically describes occurrence of diseases in a small number of animals.

[6] To 'heel' is to stay at a LH Dog owner's heel.
[7] Directional training teaches a LH Dog to move in a certain direction.

More recent study by Cave et al. (2009) provided some detailed information about the relative frequency of health events. Of the 2,214 LH Dogs involved in the study of Cave et al. (2009) 46% had experienced an adverse health event unrelated to trauma, while 38% had been subjected to an adverse health event caused by trauma. Of the 1,024 adverse health event cases that were unrelated to trauma 20% were associated with the gastrointestinal tract and reported as constipation (n = 51), dental or oral-cavity disease (n = 39), gastric dilatation-volvulus (n = 36), acute vomiting and diarrhoea (n = 32), and a foreign body in the gastrointestinal tract (n = 14). More Huntaways (n = 43) experienced constipation than Heading dogs (n = 4) and the average age of LH Dogs diagnosed with gastric dilatation-volvulus was six years. Fifteen percent of adverse health events that were unrelated to trauma were classified as skin diseases such as abscessation or cellulitis (n = 96), non-parasitic pruritic skin disease (n = 54), and cutaneous parasites (n = 23). Nineteen percent of adverse health events cases not associated with trauma were connected with the reproductive tract with the most common diagnoses being mismating (n = 41; median age at presentation = 5 years), mammary neoplasia (n = 27; median age at presentation = 9 years), vaginal prolapse (n = 18; median age at presentation = 2 years), pyometra/endometritis (n = 17; median age at presentation = 8 years), dystocia (n = 15, median age = 6 years), and vaginal hyperplasia (n = 7; median age = 2 years). Huntaways were reported to be over-represented for pyometra/endometritis, vaginal prolapse, and vaginal hyperplasia. Four percent of cases that were unrelated to trauma were classified as poisonings (or were assumed to be related to poisoning) with anticoagulants (n = 26), metaldehyde (n = 3), and one each of rumensin, organophosphate, paraquat, and ivermectin. Four cases of tetanus and five cases of leptospirosis were reported; the leptospirosis cases being located in the central lower North Island of New Zealand. Three percent of adverse health events not associated with trauma were related to the respiratory tract and included laryngeal disease (n = 18), congestive heart failure (n = 8), and dilated cardiomyopathy (n = 6). All cases of laryngeal disease were seen in Huntaways and one Beardie, and both cases of dilated cardiomyopathy were entire male Huntaways. Non-traumatic musculoskeletal conditions accounted for 20% of adverse health event cases and included degenerative arthritis (n = 129), lumbosacral disease (n =38), toe infections (n = 18), and hip dysplasia (n = 23). Degenerative arthritis was most commonly localised to the coxofemoral joint (n = 23), hip dysplasia was more common in Huntaways (n = 16) than Heading dogs (n = 5), and more cases of lumbosacral disease were reported for Huntaways (n = 27) than Heading dogs (n = 9). Of the 848 adverse health event cases that were the result of trauma 52% were Heading dogs while 43% were Huntaways. Where on the farm a trauma occurred was reported for 65% of traumatic injury cases and included a paddock (n = 289), a fence (n = 131), yards (n = 72), a road (n = 36), a race (n = 23), and a shed (n = 2). The anatomical location of 77% of traumatic injuries was recorded and included the foot (n = 260), stifle (n = 100), tarsus (n = 68), head (n = 58), abdomen (n = 54), hip (n = 31), thorax (n = 26), carpus (n = 22), elbow (n = 19), spine (n = 12), and shoulder (n = 5). The most common cause of foot trauma was a foreign body (n = 43) followed by contusion of the skin or pad (n = 41), metacarpal or metatarsal fracture (n = 30), and phalangeal fractures (n = 15). Of the 848 adverse health event cases that were associated with trauma 20% had been brought about by livestock, 19% resulted from interaction with an automotive vehicle, 17% were associated with a fence, 12% occurred via dog bite/fight, 2% were the result of a fall (not vehicle related), and 1% were associated with a gunshot. More entire males (n =

74) than entire females (n = 18) experienced a traumatic injury because of a dog bite/fight. This study provides a substantial amount of information pertaining to the relative frequency of adverse health events related and un-related to trauma in New Zealand LH Dogs. However, the research lacked a control group and as such we are unable to infer risk factors for these adverse health events.

2.8 Risk factors for health problems in New Zealand Livestock Herding Dogs

2.8.1 Working environment

Review of literature indicates possible associations between a LH Dog's working environment and a LH Dog's experience of an adverse health event. To begin with, working in an environment with farm animals has been linked to traumatic injuries in LH Dogs; in the study of Cave et al. (2009) 20% of veterinary cases concerning trauma had been caused by livestock . Had the veterinary records used in this survey reported what, in particular, the LH Dog had been doing prior to it being injured useful information about risk factors for livestock associated trauma experiences in LH Dogs may have been gathered.

Working in an environment with livestock may also place a LH Dog at risk of poisoning. For example, cases of unintentional poisoning with anti-parasitic medications and growth-promoting drugs containing dieldrin (Harrison and Manktelow, 1960), arsenic (Bruere, 1980), and abamectin (Parton et al.) have been recorded. Further, the study by Cave et al (2009) identified possible cases of LH Dogs poisoning with ivermectin (n = 1), organophosphate (n = 1), and rumensin (n = 1). Livestock Herding Dog poisoning may also occur because of the presence of agricultural pests in the LH Dogs working environment. For example, instances of unintentional LH Dog poisoning with pest control poisons such as phosphorus (Gumbrell and Bentley, 1995) and brodifacoum (McSporran and Phillips, 1983) have been documented, and the study by Cave et al. (2009) reported 26 LH Dog poisoning events requiring veterinary attention that were attributable to anticoagulants. It is not possible to infer from the case reports what the prevalence of poisoning in the LH Dog population is nor is it possible to determine whether the prevalence of unintentional poisoning in LH Dogs is higher than in companion dogs.

Lastly, both livestock and agricultural pests within the working environment of LH Dogs may place LH Dogs at risk of infection with leptospirosis or dermatophytes since both diseases are transmissible between wild animals, livestock, and dogs (Carman et al., 1979; O'Keefe et al., 2002; Blood and Studdert, 1988, pp. 267, 528). While it is possible that LH Dogs in New Zealand are at greater risk of infection with leptospirosis or dermatophytes in comparison to dogs that do not work alongside livestock there is currently no research to support this hypothesis.

2.8.2 Breed

Case studies that hypothesise a relationship between disease and LH Dog breeds have been published. Specifically, a possible predisposition of Border Collie and Border Collie cross breeds for experience of cerebellar neuroaxonal dystrophy, cerebella degeneration, and persistent neutropenia and myeloid hyperplasia has been postulated (Hartley et al., 1978; Gill and Hewland, 1980; Allan et al., 1996). As these case studies lack a comparison group this information is unable to be used to identify whether LH Dog breed is a risk factor for certain diseases.

2.8.3 Type

Literature indicates five diseases which are more likely to occur in the New Zealand Huntaway. Firstly, a survey by Hughes (2001) identified a possible predisposition for hip dysplasia in New Zealand Huntaways. Dogs were recruited for this study by approaching and sending mailed requests to dog owners who were farmer clients of Taihape and Waimarino Veterinary Services. Those dogs that were enrolled were then radiographed. This study determined New Zealand Huntaways to be 4.60 times more likely to have a hip score of ≥ 10 in comparison to New Zealand Heading dogs. Care must be taken when extrapolating these results more widely as the dogs studied were a convenience sample and some of these dogs were lame prior to the study. Secondly, a case report by Jolly et al. (2000a) of a New Zealand Huntaway with Mucopolysaccharisdosis IIIA (Sanfilippo syndrome) suggests this disease may be of significance to the New Zealand Huntaway. Still, further research has been deemed necessary in order to support and/or better understand this hypothesis (Jolly et al., 2002). Thirdly, examination of dilated cardiomyopathy cases stored in the necropsy database at Massey University identified a significantly higher prevalence ($P = 0.025$) of dilated cardiomyopathy in New Zealand Huntaways in comparison to all other large breeds grouped. While four out of the 32 New Zealand Huntaways in the necropsy database had been diagnosed with dilated cardiomyopathy only seven of 253 other large breeds had been diagnosed with the same disease (Munday et al., 2006). That written, the results of Munday et al. (2006) should be interpreted with caution given only 12 dogs in total in the necropsy database had been diagnosed with dilated cardiomyopathy, meaning the number of dogs available for analysis was small. Fourthly, a case report by Jolly et al. (2000b) describes an unnamed progressive myleopathy and neuropathy and suggests this disease may be a possible inherited disease for the New Zealand Huntaway. Still, this case report also suggests that environmental biological agents, chemicals and drugs, or nutritional deficiencies may explain the observation of this degenerative disorder. Lastly, a retrospective study of a case series and a case control study has identified the odds of a case of gastric dilatation or gastric dilatation and volvulus being a New Zealand Huntaway, after adjusting for age and season, to be 19 times higher than the odds a control was a New Zealand Huntaway (Hendriks et al., 2012). Further work is required to determine if the risk factor for gastric dilatation or gastric dilatation and volvulus is truly the New Zealand Huntaway, or if gastric dilatation or gastric dilatation and volvulus is related to differences in the management of New Zealand Huntaways compared to New Zealand Heading dogs.

2.8.4 Neuter status

Neutering of a dog renders them sterile (Blood and Studdert, 1988, p. 622), which enables a degree of control over dog population numbers. Neutering may also reduce the risk of development of health disorders associated with the reproductive system. Specifically, orchiectomy in male dogs is protective for the development of testicular tumours (Valentine and Kutzler, 2007) and may also reduce the incidence of health problems associated with the prostate gland such as prostatitis (Brownlee, 2007) and benign prostatic hyperplasia (Johnson, 2007). In female dogs, ovariohysterectomy before the first estrus is thought to offer protection against mammary gland tumour (Valentine, 2007). Ovariohysterectomy also prevents pyrometra (Onclin and Verstegen, 2007).

Neutering of a dog also has the potential to modify problematic behaviours such as inter-male aggression. One of the most extensive surveys on the effects of gonadectomy in dogs indicated a 60% reduction in inter-male aggression after neutering, with gradual reduction observed in 35% of dogs, and rapid reduction in 25% (Fogle, 1990, p. 53). The results of this survey support conclusions reached by Hopkins et al. (1976) after their small scale observational study of 42 dogs (Knol and Alink, 1989); Hopkins et al. (1976) found a 50% reduction in inter-male aggression post castration, along with a 50% reduction in mounting and urine marking behaviour, and a 90% reduction in roaming behaviour. The study did not find any correlation between age at castration and behavioural outcome, or breed of castrated dog and behavioural outcome.

Irrespective of the positive health and behaviour outcomes associated with neutering, neutering of a dog is not without risk. For example, intra-operative and post-operative surgery complications such as haemorrhage, inflammation, infection, adverse reaction to anaesthesia, urogenital disorders, abscesses, and rupture of surgical wound can occur during or after the procedure; though the death rate due to neutering is reported to be low at 0.1% (Pollari et al., 1996). Neutering has also been identified as a potential risk factor for obesity owing to either post-neutering decrease in metabolic rate (German, 2006), change in feeding habit after surgery leading to increased food consumption (Houpt and Hintz, 1978), or a reduction in physical activity after surgery without a reduction in food intake. Neutering may also increase the risk of a dog developing diabetes (Marmor et al., 1982), and hypothyroidism (Panciera, 1994), and may lead to undesirable behavioural problems in bitches. With respect to the later, a study of 150 spayed and 150 un-spayed bitches group-matched for breed and age found ovariohysterectomy significantly increased the occurrence of indiscriminate appetite and dominance aggression towards humans (O'Farrell and Peachey, 1990). Notably, the spayed bitches more likely to demonstrate an increase in dominance aggression were those less than 12 months of age and who had shown aggressive tendencies prior to being neutered.

Review of literature indicates a complex situation with regards to the long-term health and behavioural outcomes for neutered dogs, however much of this literature is companion dog based and the findings may not be relevant to the working and living environment of the New Zealand LH Dog population. For example, the risk of developing obesity due to a reduction in physical activity after surgery may not be of relevance to LH Dogs given their exercise schedule (i.e., herding) after recovering from surgery is unlikely to be significantly different from before surgery. Further, the risk of post-operative surgery complications may be more likely in LH Dogs. For example, the risk of post-surgery infection may be of more concern to LH Dogs given their tendency to return home to unsterile shelters. Given the value of LH Dogs to their owners, and given the variety of long-term health and behavioural outcomes associated with neutering of a LH Dog, studies specifically designed to investigate neutering as a risk factor for adverse health events in LH Dogs would be valuable.

2.8.5 Diet

Our understanding of LH Dog diet as a risk factor for disease is limited to cases reports that have identified dietary related adverse health events in LH Dogs. A meat and water diet has been associated

with development of an iodine-deficiency goitre (Thompson, 1979; Nuttall, 1986), and what was considered to be a selenium deficiency (Manktelow, 1957) that caused the death of an adult 'working collie's' pups soon after birth. This selenium deficiency was considered to have occurred because the meat was sourced from areas known to farm sheep with selenium-responsive diseases. In 1969 a case report of dogs with thiamine deficiency suggested a link between the deficiency and feeding commercial dog rolls or farm-produced mutton that had been boiled (Mayhew and Stewart, 1969). However, the report included a small number of cases (n = 4) and lacked a comparison group and as such it cannot indicate a causal link. It is also important to note that between the publishing of the Mayhew and Stewart case report (1969) and now (2013) there have been many changes in the dog food industry and as such the relevance of the Mayhew and Stewart case report to diet related risk factors for disease in a LH Dog is uncertain. Overall, while it is possible that certain diets are risk factors for adverse health events in the general LH Dog population, case reports do not enable risk factors to be identified. Subsequently, our understanding of the relationship between adverse health events in LH Dogs and what and how LH Dogs are fed in New Zealand is weak and there is much room for improvement.

2.9 Barriers to population studies in New Zealand Livestock Herding Dogs

One of the barriers to the production of scientific literature pertaining to LH Dogs in New Zealand has been the absence of a frame from which to sample LH Dogs. Such a complete and accurate list is important for research since it facilitates the generation of a representative sample.

One possible sampling frame is the National Dog Database which holds information pertaining to registered dogs in New Zealand (The Department of Internal Affairs, 2012). The National Dog Database acquires this dog information from local councils. Councils attain dog information when dogs are registered with their local council, which in accordance with the Dog Control Act 1996 should occur when the dog reaches three months of age. Other details recorded for each dog include the following: full name, date of birth, and address of the dog's owner; the address at which the dog is usually kept; a description of the dog such as their breed, colour and distinguishing marks; age of the dog; whether the dog is classified as dangerous or menacing; sex of the dog and whether it is neutered; description of anything that provides permanent identification of the dog such as a tattoo or microchip transponder; and the registration number of the collar, label or disc issued to the dog. The National Dog Database has the potential to provide a list of New Zealand LH Dogs as it is a requirement of the Act to indicate whether the dog being registered is a working dog. Unfortunately, the National Dog Database is not available to the general public and researchers. Furthermore, the database is unlikely to provide a complete and accurate sampling frame for two reasons. Firstly, an owner may choose not to register their dog for a variety of reasons including cost of registration (see Hutt News (1945), Otago Witness (1886), and The Ashburton Guardian (1889) for historical examples). Secondly, a number of dogs recorded as LH Dogs may not actually be used for herding livestock. Instead, the dog's owner may have falsely reported that the dog is a working dog as the fees for working dogs are less than for other dogs (see Whangarei District Council (2012) and Palmerston North City Council (2012) for list of fees).

Other sources for lists of LH Dogs include the New Zealand Companion Animal Register or LH Dog patient lists from veterinary clinics. The New Zealand Companion Animal Register is unlikely to include a complete list of all New Zealand LH Dogs because under the Dog Control Act 1996 LH Dogs are exempt from being micro-chipped and as such their details are not required to be listed within the companion animal register. With respect to veterinary clinic patient lists, we cannot assume that all LH Dogs are enrolled with or attend a veterinary clinic so a list of LH Dogs generated from veterinary clinic patient lists is unlikely to be complete.

Another option for generating a sampling frame of LH Dogs would be to sample farms from a database such as AgriBase™. AgriBase™ is a national database of rural properties found in New Zealand and it is maintained by AgriQuality (AsureQuality, 2012). Data stored in AgriBase™ includes (but is not limited to) the size of the property, the number and types of farm animals found on the property, spatial positioning, and contact details for the key decision maker of the property (Sanson and Pearson, 1997; Environment Waikato Regional Council 2010).

Without access to a complete and accurate list of LH Dogs the generation of knowledge that is representative of all New Zealand LH Dogs is challenging. Lack of such a list is likely to have impacted on the ability of researchers to investigate New Zealand LH Dog health in the past.

2.10 Conclusion

Livestock Herding Dogs have made a significant contribution to development of New Zealand's agricultural sector. After reviewing the literature it is clear that further work is needed to better understand the demographic features of the LH Dog population, LH Dog husbandry and management, and the health experience of the general LH Dog population of New Zealand. This substantial knowledge gap exists because there is almost a complete absence of population based studies. Studies that include a random sample of the general LH Dog population rather than focusing on particular subsets would provide baseline knowledge that can be used to improve the health of LH Dogs. The aim of this thesis was to conduct a population based study to investigate the demographic, and husbandry and management practises relating to LH Dogs in New Zealand. More specifically the thesis aimed to achieve the following:

- Describe the environments within which LH Dogs work and the number of LH Dogs per farm.
- Describe the age, and different breeds and types of LH Dogs.
- Describe the reproductive status of LH Dogs and factors associated with neutering.
- Describe the career progression of LH Dogs and identify variables associated with death or euthanasia of LH Dogs.
- Describe the number of puppies bred on farms and the fate of these puppies.
- Describe training methodology including age at the commencement of training, and methods and devices used to train LH Dogs.

- Describe how LH Dogs are sheltered and fed; and whether LH Dog owners had provided and LH Dogs had received anthelmintic drugs, vaccinations and flea control treatments over the previous 12 months.

Chapter 3: Livestock Herding Dog demographics

3.1 Abstract

AIM: To describe the demographic features of Livestock Herding (LH) Dogs in the Manawatau-Wanganui region of New Zealand.

METHODS: Using a cross-sectional survey demographic data for 1,194 LH Dogs was gathered from 119 randomly selected Manawatau-Wanganui region farms between July 2008 and July 2009. The questionnaire had four parts. Part one gathered data pertaining to the farm such as size and contour. Part two collected information about the LH Dog owners such as age, sex, and LH Dog management practises. Part three collected the following data for all LH Dogs that had been on the farm over the previous 12 months: demographic data such as breed and sex; information about livestock the LH Dog worked; and the neuter status, life stage and career stage of the LH Dog at the time of the survey. Part four collected information relating to litters and pups that had been on the farm over the previous 12 months such as number of litters bred and fate of each pup. Categorical data were summarised as counts and percentages. The distribution of continuous variables was described using a histogram. Kruskal-Wallis tests were used to compare the distributions of non-normal continuous variables, while Pearson's chi-square tests were used to test for independence between factors.

RESULTS: Three hundred and sixteen farms were randomly sampled of which 119 were eligible to partake, agreed to partake, and were surveyed. Of the 1,194 LH Dogs surveyed 572 were New Zealand Huntaways while 415 were New Zealand Heading dogs. The median age of LH Dogs was four years. Neuter status was reported for 1,152 LH Dogs of which 642 were entire males, 439 were entire females, 23 were neutered males, and 48 were neutered females. Female LH Dogs were 2.85 times more likely to be neutered than male LH Dogs ($P < 0.001$). Career stage was described for 1,157 LH Dogs of which 698 were fully trained. Of the 1,173 LH Dogs whose life stage was identified 176 had died over the previous 12 months. One hundred and seven litters had been bred over the preceding 12 months on 45 of the 119 farms producing a total of 768 pups. Of these pups 464 were dead. Three hundred and fifty-six of the pups that were dead had been euthanised.

CONCLUSION: This study described demographical features of LH Dogs in the Manawatau-Wanganui region of New Zealand. The New Zealand Huntaway and the New Zealand Heading dog were identified as being the most popular LH Dogs used to herd livestock. Neutering of LH Dogs was higher in females and older dogs. However, overall rates of LH Dog neutering were very low and efforts should be made to address this for LH Dog health and behavioural reasons, and to reduce the number of pups euthanised.

3.2 Introduction

Livestock Herding (LH) Dogs play an incremental role in livestock management in New Zealand. Livestock Herding Dogs assist stock-men to carry out a variety of livestock management activities such as herding livestock between pastures or controlling livestock in confined areas; subsequently, the ability of the LH Dog to herd effectively and efficiently is important to New Zealand's livestock farming industry (Redwood, 1980; Dalton, 2008; Lithgow, 1995; Cavanagh, 1990; Coppinger and Coppinger, 2000).

Experience of poor health may interfere with a LH Dog's ability to herd. For example Worth and Bruce (2008) suggest a possible link between degenerative osteoarthritis, which can cause long-standing pain and lameness, and reduced working life-expectancy of a working dog. New Zealand's livestock-farming industry may also be negatively impacted if farm protocols are not designed and carried out in a way that promotes LH Dog health. For example routine disregard for farm and/or dog-feeding hygiene may leave a LH Dog vulnerable to infection with *Taenia ovis* (Sweatman, 1962; Ovis Management Limited, 2012). Such an infection may lead to sheep infected with *Cysticercus ovis*, condemned sheep carcasses, reduced income for the producer, and compromised reputation of New Zealand carcass exports.

To promote the health of LH Dogs we need to understand the demographics and health of the general New Zealand LH Dog population. To date, information about the health of LH Dogs in New Zealand has been limited to special interest books and a small number of observational studies. Special interest books write of topics such as LH Dog breeding, training, housing, nutrition, and other maintenance practises (Redwood, 1980; Dalton, 2008; Lithgow, 1995; Oliver et al., 2004; Rennie, 1984). Problematically special interest books cannot be considered scientifically accurate because they are typically shaped by tradition and ideology. Historically the majority of the observational studies have been case reports or case series focusing on specific problems including LH Dog nutritional deficiencies (Thompson, 1979; Mayhew and Stewart, 1969), surgical repair (Worth and Bruce, 2008; Fox and Bray, 1993; Worth et al., 2004), poisoning (Gumbrell and Bentley, 1995; McSporran and Phillips, 1983; Bruere, 1980; Harrison and Manktelow, 1960), lameness (Dillon et al., 1989), skin disorders (Fairley, 1982; Munday et al., 2009), genetic disorders (Munday et al., 2006; Hughes, 2001; Jolly et al., 2002), and retinal diseases (Hughes et al., 1987; Hughes and Joyce, 1981). Veterinary case reports are based on one-off adverse health events that while interesting cannot be extrapolated to the general LH Dog population. Furthermore the absences of a control group mean that inferences about risk factors for disease are limited.

More recently two larger population based studies have been undertaken to better understand the demographics and health problems of New Zealand LH Dogs (Cave et al., 2009; Singh et al., 2011). The first by Cave et al. (2009) was a 12 month survey that described the demographics and health problems of LH Dogs that attended veterinary clinics. Unfortunately this study systematically excluded LH Dogs that did not attend a veterinary clinic and health problems that did not warrant veterinary attention. Therefore the demographics and health problem insights gained from this study may not be representative of the general population of New Zealand LH Dogs. The second study by Singh et al.

(2011) described the demographics and nutrition of LH Dogs whose owners were members of the New Zealand Sheep Dog Trial Association (NZSDTA). Since not all LH Dogs are owned by affiliates of NZSDTA and since dogs involved with competition are likely to be cared for differently than LH Dogs in the general population the results do not necessarily reflect the features of the general population of New Zealand LH Dogs. Thus, despite growing understanding of the demographics, health, and management of LH Dogs in New Zealand, there are still significant gaps.

This chapter reports on a study designed to be representative of one part of the general LH Dog population - LH Dogs from the Manawatau-Wanganui region of New Zealand. Specifically it presents LH Dog demographic data information pertaining to the following: the working environment of a LH Dog; the number of LH Dogs on farms; LH Dog breeds or types; the age, sex, neuter status, career stage and life stage of LH Dogs; the number of dog litters born on farms; and the fate of pups born on farms.

3.3 Materials and methods

This was a cross-sectional survey of sheep and beef farms within the Manawatau-Wanganui region of New Zealand. The survey was conducted between July 2008 and July 2009. For the purposes of this study the Manawatau-Wanganui region encompassed the entire area of the following eight New Zealand territorial land areas: Stratford, Ruapehu, Wanganui, Rangitikei, Manawatau, Tararua and Horowhenua districts, and Palmerston North City (Figure 3.1).

A two stage sampling strategy was used to select the study population. Stage one was the selection of farms. In stage two farms that were selected provided information about all LH Dogs on the farm at the time of the visit or that had been on the farm in the previous 12 months.

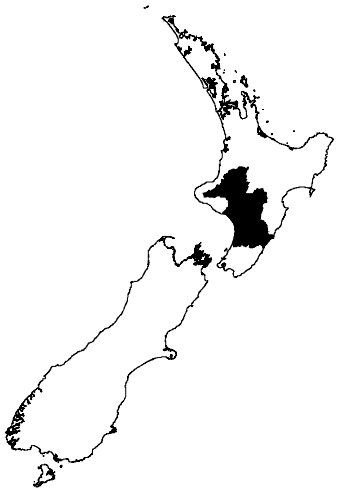

Figure 3.1: Map of New Zealand. Shaded area represents the target area investigated, the Manawatau-Wanganui region.

3.3.1 Sampling frame

The sampling frame comprised of farms from the Manawatau-Wanganui region that were registered in AgriBase™, a national database of farms maintained by AgriQuality (AsureQuality, 2012), and which meet the inclusion criteria. The criteria were that the farms were recorded in AgriBase™ as having the following features:

- Sheep and/or beef cattle present on the farm.
- Greater than or equal to 20 stock units. When determining number of stock units one sheep equated to a single stock unit and one beef cattle equated to 5.5 stock units.
- Greater than or equal to 100 hectares.

3.3.2 Sample size calculation

The study aimed to estimate a number of variables including age of LH Dogs, proportion of LH Dogs that were neutered, and proportion of LH Dogs that had died or that had been euthanised. For the purposes of the sample size calculation, we focused on estimating the number of dogs required to estimate a proportion if 10% of farms had at least one LH Dog that experienced the event of interest (e.g., neutering). The second step involved the stratification of the sampling frame into three farm size groups to ensure data from a variety of farm sizes was generated. The three farm size stratum were 100 to 227 hectares, 228 to 440 hectares, and greater than 440 hectares. Breaks for strata were based on the terciles of the sampling frame's farm size distribution. Step three involved determining the number of farms required per stratum if the proportion of farms that experienced the event was within 5% of the true population value (i.e., 10%) and the non-response rate was 20%. The required sample sizes were 63 farms between 100 and 227 hectares, 63 farms between 228 and 440 hectares, and 65 farms greater than 440 hectares in size.

R Version 2.7.0 (R Development Core Team, Vienna, Austria) and package 'epiR' (Stevenson et al., 2009) calculated the sample sizes.

3.3.3 Generalised random tessellation stratified survey design

Use of a Generalised Random Tessellation Stratified (GRTS) survey design (Stevens and Olsen, 2004) produced a spatially well-balanced random sample of 191 farms from the sampling frame.

Early on in the recruitment it was apparent that the non-response was likely to exceed 20% (e.g., letters were returned to sender). Therefore a second draw was undertaken to create a pool of additional farms to select from. This second draw which comprised of 133 farms per stratum formed a 'replacement farm list' to replace farms as necessary. The GRTS survey design method selected the second draw using the sampling frame minus farms that had already been selected.

R Version 2.7.0 (R Development Core Team, Vienna, Austria), package 'spsurvey' (Kincaid et al., 2009), and farm spatial position information stored in AgriBase™ produced the GRTS survey design.

3.3.4 Recruitment of study farms

An introductory letter was sent to the person listed in AgriBase^{TM} as the key decision maker for the farm. The introductory letter described the purpose of the study and advised that participation would involve a face to face interview. The letter notified that the researcher would telephone the key decision maker shortly to determine if they were eligible to participate, and to ask them if they were willing to do so. A farm was considered eligible to participate if they met the following criteria:

- The farming enterprise was involved in farming livestock in the previous 12 months.
- The farm had at least one LH Dog on the farm in the previous 12 months.
- The farm was not operated in conjunction with a farm that had already been sampled.

If the farms met the criteria and the key decision maker agreed to participate in the study the key decision maker was asked to provide contact details for all LH Dog owners affiliated with the farm. An introductory letter was sent to these LH Dog owners and the researcher telephoned the LH Dog owners to invite them to partake.

If the farm did not meet the criteria, or the key decision maker did not agree to participate, then a replacement farm in the same size strata was selected from the replacement list (see section 3.2.3).

3.3.5 Questionnaire design

The initial questionnaire was pre-tested on competitors at the national sheep dog trials held in Blenheim in 2008. Following comments the initial questionnaire was revised. The farms studied for the research had not been involved with the initial questionnaire pre-test.

The questionnaire had four parts. Part one gathered data pertaining to the farm. The farm comprised of the sampled farm and any other farm(s) the sampled farm operated in conjunction with. For each farm the following was recorded: the number of sheep, beef cattle, and other animals on the farm; the farm's size (in hectares); and types of land contours found within the boundaries of the farm. Part two collected information about the LH Dog owners on the farm such as sex (male or female), age (in years), the number of years experience the LH Dog owner had working with LH Dogs, and job title. Livestock Herding Dog owners were also asked to describe what LH Dog husbandry and management practises they had used over the previous 12 months. Occasionally some of these factors varied between LH Dogs owned by the same individual. When differences occurred this information was recorded in the third section of the survey.

Part three gathered data pertaining to all LH Dogs that were on the farm at the time of the interview or that had been on the farm in the 12 months prior to the survey. A LH Dog was considered eligible for the study if it was greater than six months of age and met one of the following criteria:

- Acquired or bred to be trained to herd livestock but was not yet fully trained.
- Currently herding livestock.
- Previously herded livestock.

For each dog eligible to be enrolled in the study the following was recorded: breed or type; livestock the LH Dog worked; and age (in years), sex (male or female), and neuter status (neutered or entire). For those LH Dogs that were not on the farm at the time of the survey because they had died or because they had been euthanised, given away, or sold, the age the LH Dog was at the time the LH Dog died or left the farm was recorded. The researcher also determined the following: life stage of the LH Dog at the time of the visit (alive and on the farm, sold, given away, dead, euthanised by the LH Dog owner, or euthanised by a veterinarian); career stage of the LH Dog (no training, initiated training, partly trained, fully trained, semi-retired or retired; see Table 3.1 for a description of career stage categories); what stage of training the Livestock Herding Dog was at when it was acquired (fully trained, partly trained, or un-trained); and what age (in years) the LH Dog had been when its training was initiated. The final piece of information gathered for each LH Dog was a detailed description of adverse health events the LH Dog had experienced over the preceding 12 months.

Part four gathered data relating to dog litters and pups that had been bred on the farm over the previous 12 months. To be included in the study the pups had to be less than six months of age and on the farm at the time of the survey, or less than six months of age at the time they left the farm. The number of litters bred per farm was recorded as was the number of pups per litter. Further the breed or type of litters, fate of each pup (alive and on the farm, sold, given away, dead, or euthanised by the LH Dog owner) and age (in weeks) of the pup was recorded. For those pups that were not on the farm at the time of the survey because they had died or because they had been euthanised, given away, or sold, the age the pup was at the time the pup died or left the farm was recorded.

3.3.6 Data collection and management

One researcher drove to the farm to carry out the face to face interviews with the LH Dog owners. Five farms were telephoned because of an inability to find a compatible time to carry out or finish interviews. During the interview the researcher asked the research questions and filled in the answers on behalf of the LH Dog owner. Interviewing LH Dog owners individually was impractical in some instances due to the large number of LH Dog owners on the farm. In these instances interviewing occurred in a group setting where the researcher read the research questions aloud then the LH Dog owners wrote their answers (or circled the appropriate answer) to the questions on the questionnaire. The group also discussed their individual responses aloud. This enabled the researcher to take separate notes to add to each questionnaire afterward.

Gathered data were entered into and managed in a purpose built relational database, Microsoft Access 2007 (Microsoft Corporation, Redmond, WA, USA).

3.3.7 Classification of variables

3.3.7.1 Career stage of Livestock Herding Dog

The amount of training the LH Dog had received and the amount of herding work the LH Dog performed determined the career stage of the LH Dog. The six career stages were the following: no training,

initiated training, partly trained, fully trained, semi-retired, and retired. The career stage of the LH Dog on the day of the interview was recorded. A description of these six career stages can be found in Table 3.1.

Table 3.1: A description of categories used to describe career stages of Livestock Herding Dogs.

Level	Description
No training	Livestock Herding Dog had received no training.
Initiated training	Livestock Herding Dog had received basic training. For example the Livestock Herding Dog could return when called.
Partly trained	Livestock Herding Dog understood and performed most (but not all) commands. The Livestock Herding Dog practised commands and developed skills during livestock control activities.
Fully trained	Livestock Herding Dog understood and performed all commands. The Livestock Herding Dog performed commands and showed skill during livestock control activities.
Semi-retired	Livestock Herding Dog (typically) understood and could perform all commands. The Livestock Herding Dog did not partake in livestock control activities regularly because of health or behavioural problems, age, or a change in farming practise.
Retired	Livestock Herding Dog (typically) understood and could perform all commands. The Livestock Herding Dog did not partake in livestock control activities because of health or behavioural problems, age, or a change in farming practise.

3.3.7.2 Group of Livestock Herding Dog

Group categorisation was based on a review of literature relating to herding styles typically used by different breeds and types of LH Dog. Group categorisation was not based on how the dog actually moved livestock. The group categories were the following:

- Hunt–away.
- Heading.
- Handy.

The hunt-away group category included the Bearded Collie, Bearded Collie cross, and Smithfield dog breeds, and the New Zealand Huntaway and New Zealand Huntaway cross types. The heading group category incorporated the Border Collie and Australian Cattle Dog breeds, and the New Zealand Heading dog and New Zealand Heading dog cross types. The handy group category included the Australian Kelpie dog breed and the New Zealand Handy dog type. Since the group a LH Dog was classified in was determined by the LH Dog's breed or type, the phrase 'breed or type' is used throughout this chapter, where applicable. A number of LH Dogs were breeds not typically used to herd livestock, or the breed of the LH Dog was unknown. In these cases the group the LH Dog belonged to could not be determined and thus the LH Dog was classified under 'not typical LH Dog breeds'.

3.3.8 Statistical analysis

The number of LH Dogs on the farm was determined by adding the number of LH Dogs on the farm at the time of the interview and the number of LH Dogs that had been on the farm in the previous 12 months. The distribution for the number of LH Dogs per farm was described using a histogram. Also presented was the number of LH Dogs on farm stratified by the following: farm size (ha), number of livestock units, number of sheep, number of beef cattle, and the presence or absence of steep and or high country contours on farm. The number of stock units was determined using the following formula (see Parker (1998), p. 244) which was:

> ∑ Livestock units = ∑ store and fattening lambs + breeding ewes + ewe replacements + (rams x 0.8) + (beef cattle x 5.5) + (dairy cattle x 7.0) + (hind x 1.9) + (other deer x 1.8) + (stags x 2.1) + (goats x 0.8).

The distribution of the number of LH Dogs on farms was non-normal. Therefore the number of LH Dogs per farm was summarised using minimum, maximum, and percentiles. Kruskal-Wallis tests determined if the number of LH Dogs per farm varied significantly by any of the factors.

The number and percentage of LH Dogs was determined stratified by group, and breed or type. Group categorisation was based on a review of literature relating to herding styles typically used by different breeds and types of LH Dogs and was not based on how the dog actually moved livestock.

The number and percentage of hunt-away, heading, and handy LH Dogs was determined stratified by whether or not the LH Dog owner used the LH Dog to herd sheep. Similarly, the number and percentage of hunt-away, heading, and handy LH Dogs was determined stratified by whether or not the LH Dog owner used the LH Dog to herd beef cattle. Pearson's chi-square tests determined if livestock herded by LH Dogs varied significantly by group.

The age of each LH Dog was determined in years. For those LH Dogs that were not on the farm at the time of the visit because they had died or because they had been euthanised, given away, or sold, the age at the time the LH Dog died or left the farm was recorded. The distribution of the age of LH Dogs was described using a histogram. Age of LH Dogs was described stratified by farm and LH Dog level variables. The farm level variables were the following: presence or absence of steep and or high country contours on farm, farm size (ha), and number of LH Dogs on farm. The dog level variables were as follows: neuter status, whether the LH Dog was used herd beef cattle, whether the LH Dog was used to herd sheep, life stage, career stage, group, and sex. The distribution of the age of LH Dogs was non-normal. Thus, the age of LH Dogs was summarised using minimum, maximum, and percentiles. Kruskal-Wallis tests determined age of LH Dogs varied significantly by any of the factors.

The proportion of neutered or entire LH Dogs was determined stratified by farm and LH Dog level variables. The farm level variables were the number of LH Dogs on farm, and the presence or absence of steep and or high country contours on farm. The dog level variables were the following: sex, group, whether the LH Dog was used to herd sheep, age, career stage, life stage, and whether the LH Dog was

used to herd beef cattle. Pearson's chi-square tests determined if neuter status varied significantly by any of these factors.

The number of percentage of LH Dogs that fell into six career stage groups was determined stratified by location status of LH Dog at the time of the interview. A binary variable was then created to code the LH Dog's outcome on the day of the interview as either dead or alive. Deceased LH Dogs were those that had died or that had been euthanised by the owner or a veterinarian. Alive LH Dogs included sold or given away LH Dogs, or LH Dogs that were alive and on the farm. The proportion of LH Dogs alive or dead was determined stratified by a number of farm and LH Dog level variables. The farm level variables were the number of LH Dogs on farm, and the presence or absence of steep and or high country contours on farm. The LH Dog level variables were as follows: age, career stage, whether the LH Dog was used to herd sheep, whether the LH Dog was used to herd beef cattle, group, sex, and neuter status. Pearson's chi-square tests determined if the outcome of the LH Dog on the day of the interview varied significantly by any of these factors.

The number and percentage of pups bred on farms over the preceding 12 months was determined stratified by breed or type, and several fate variables. The fate variables were as follows: alive and on the farm, died of natural causes, euthanised by the LH Dog owner, euthanised by a veterinarian, given away, or sold. The age of the pup at the time of the interview, or when the pup had died or been euthanised, given away, or sold was determined and stratified by the fate of the pup.

Statistical analysis was conducted using R Version 2.7.0 (R Development Core Team, Vienna, Austria). Differences were considered statistically significant at $P < 0.05$.

3.4 Results

Figure 3.2 summarises the recruitment process. Of the 191 farms from the initial sample 84 were not enrolled because of the following reasons: letters were returned to sender (n = 32), properties had not been involved with farming livestock in the previous 12 months (n = 20), the key-decision maker could not be contacted (n = 12) or refused to participate in the study (n = 10), farms had not had any LH Dogs on the farm in the previous 12 months (n = 5), farms operated in conjunction with a farm that had already been sampled (n = 3), and because two key decision makers were not well enough to participate.

Of the 72 farms of the first sample that had to be replaced 53 had to be replaced again for the following causes: letters were returned to sender and the key decision maker could not be contacted (n = 40), farms had not been involved with farming livestock in the previous 12 months (n = 7), farms had not had any LH Dogs on the farm in the previous 12 months (n = 5), and one farm was operated in conjunction with a farm that had already been sampled.

By the end of the study period 125 farms had been used from the replacement farms list and a total of 316 farms had been sampled. Of the 316 farms 72 were unable to be contacted, 44 had not met study criteria, and 11 had declined to partake. Thirty-eight farms were not enrolled because the key decision maker could not be contacted. Overall 151 farms agreed to participate however 32 of these could not be interviewed before the end of the study period due to poor weather conditions and conflicting work schedules. Therefore, the study population comprised of 119 farms.

Figure 3.3 displays the spatial distribution of interviewed farms. The 119 farms farmed livestock as per the following: 81 farms farmed sheep and beef cattle; 13 farmed sheep, beef cattle and dairy cattle; 12 farmed sheep, beef cattle and deer; eight farmed sheep only; two farmed beef cattle only; two farmed dairy cattle only; and one farmed deer only. The median farm size was 477 ha although this ranged from two hectares to 9996 ha. Eighty-two farms had steep and/or high country contours.

In total 1,194 LH Dogs were enrolled in the study and the median number of LH Dogs per farm was seven (minimum = one LH Dog, maximum = 59 LH Dogs; Figure 3.4). The number of LH Dogs on farms increased as farm size and the number of stock units, sheep, and beef cattle carried by the farm increased ($P < 0.001$; Table 3.2). Farms with steep and or high country contours on farm had significantly more LH Dogs than farms that did not ($P < 0.001$).

Of the 1,194 LH Dogs the New Zealand Huntaway (n = 572) and the New Zealand Heading dog (n = 415) were the two most common LH Dogs (Table 3.3). Livestock Herding Dogs from the hunt-away group were 1.14 (95% CI = 0.99 – 1.32) times more likely to be used to herd sheep than LH Dogs from the handy group. Similarly, LH Dogs from the heading group were 1.12 (95% CI = 0.96 – 1.29) times more likely to be used to herd sheep than LH Dogs from the handy group ($P = 0.04$; Table 3.4).

The median age of LH Dogs in this study was four years (minimum = 0.50 years, maximum = 18.00 years; Figure 3.5). Farms with steep and or high country contours on farm had significantly younger LH

Dogs than farms without steep and or high country contours, and LH Dogs that were entire were significantly younger than LH Dogs that had been neutered ($P < 0.001$; Table 3.5).

Of the 1,152 LH Dogs whose neuter status was known 642 were entire males, 439 were entire females, 23 were neutered males and 48 were neutered females. In comparison to males female LH Dogs were 2.85 times more likely to be neutered ($P < 0.001$; Table 3.6). The likelihood of being neutered increased with age ($P = 0.004$).

The number and percentage of LH Dogs stratified by career and life stage is shown in Table 3.7. Of the 1,173 LH Dogs whose life stage was known 176 had died over the previous 12 months. Livestock Herding Dogs between the ages of two and four years were 0.36 (95% CI = 0.22 – 0.58) times less likely to be dead than LH Dogs less than two years of age. Similarly LH Dogs between the ages of four and seven years were 0.37 (95% CI = 0.24 – 0.55) times less likely to be dead than LH Dogs less than two years of age ($P < 0.001$; Table 3.8). If not used to herd sheep a LH Dog was 3.33 (95% CI = 2.55 – 4.34) times more likely to be dead ($P = 0.001$), and if not used to herd beef cattle a LH Dog was 3.53 (95% CI = 2.75 – 4.53) times more likely to be dead ($P = 0.001$).

One hundred and seven litters were bred on 45 of the 119 farms over the previous 12 months. The median number of litters per farm was two (minimum = one litter per farm, maximum = six litters per farm). In total 768 pups had been bred of which 356 had been euthanised and 108 had died (Table 3.9). Reasons for death not caused by euthanasia included the following: were still born (n = 32), were eaten by other dogs on the farm (n = 12), were killed by another bitch (n = 2), were squashed by the mother (n = 2), crawled away from the mother and died of exposure (n = 2), became trapped under the kennel (n = 1), and was born with a fatal deformity (n = 1). The cause of death for 56 pups that had died not because of euthanasia was unknown. The distribution of the age (in weeks) of pups was significantly different when stratified by life stage ($P < 0.001$; Table 3.10).

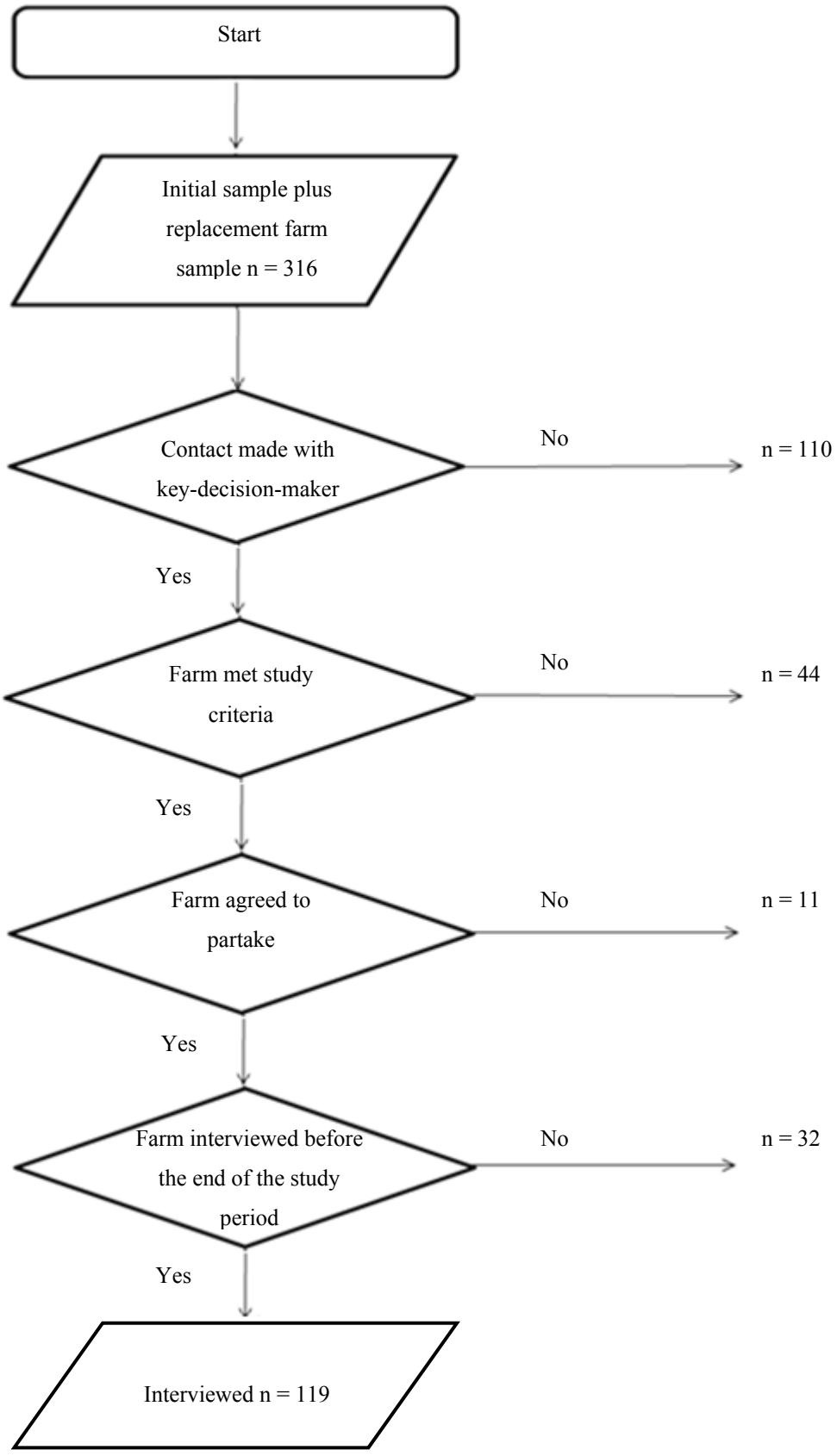

Figure 3.2: Flow chart of recruitment of Manawatau-Wanganui region farms for a cross-sectional study of Livestock Herding Dogs.

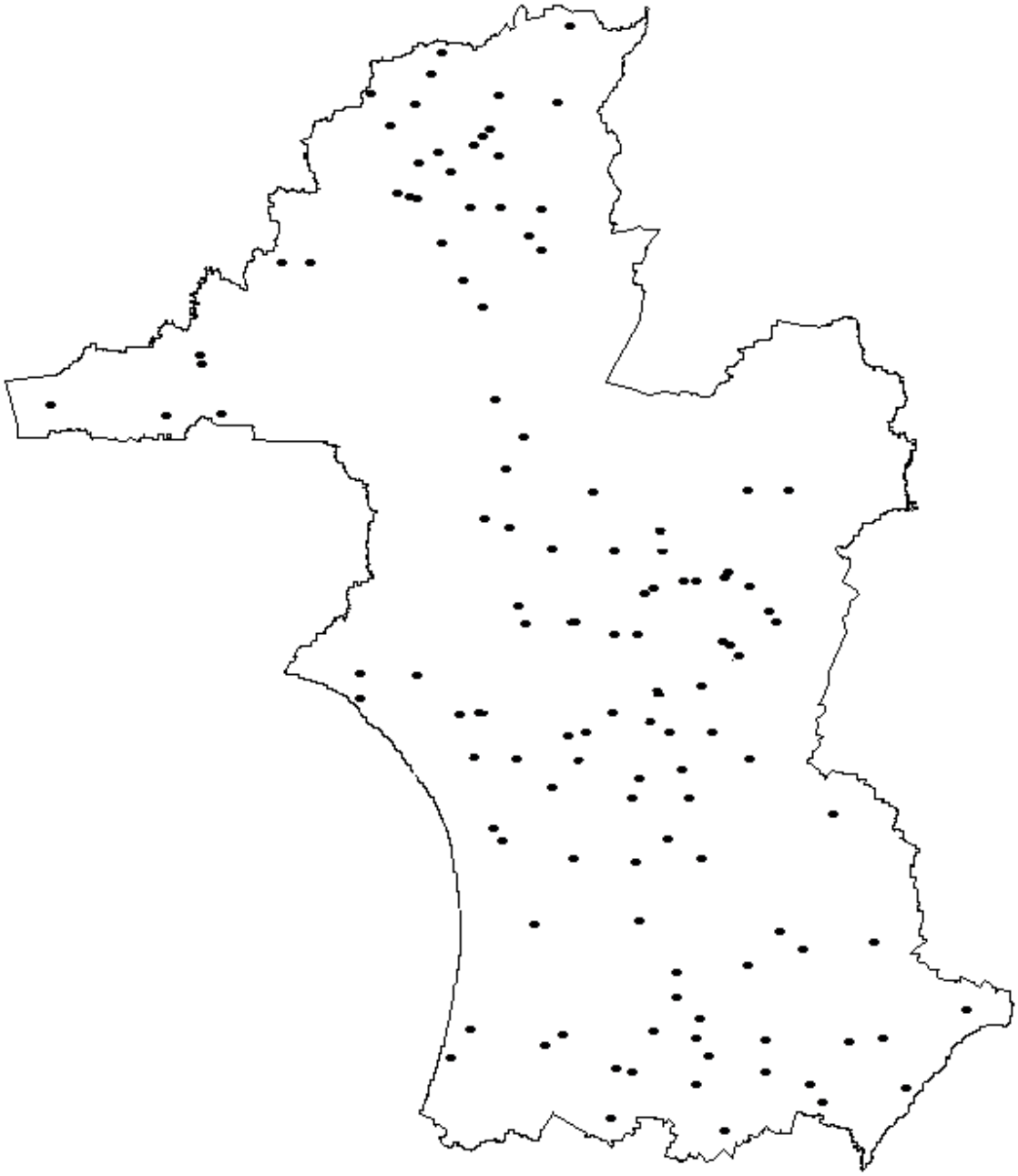

Figure 3.3: Spatial distribution of 119 interviewed farms located within the Manawatau-Wanganui region of New Zealand.

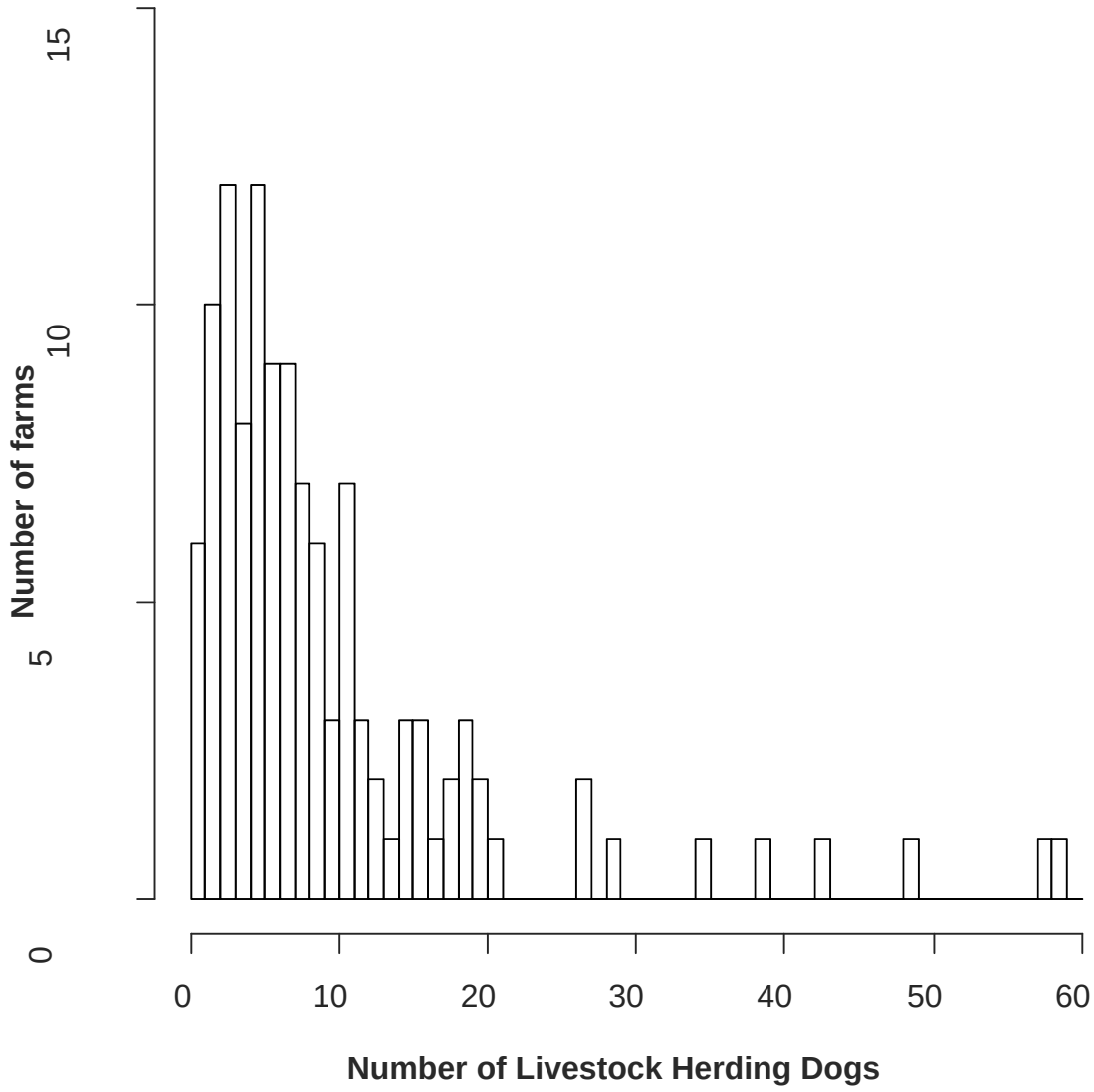

Figure 3.4: Histogram of the total number of Livestock Herding Dogs on the farm over a 12 month period. Data gathered from a cross-sectional survey of 1,194 Livestock Herding Dogs on 119 Manawatau-Wanganui region farms.

Table 3.2: Descriptive statistics for the number of Livestock Herding Dogs on the farm stratified by a number of independent variables. Data gathered from a cross sectional survey of 1,194 Livestock Herding Dogs on 119 Manawatau – Wanganui region farms.

Variable	Level	Number of farms	Minimum	Percentiles			Maximum	
				25th	50th	75th		
Farm size	< 200 hectares	28	1	2	3	5	17	< 0.001
	200 to 469 hectares	31	1	4	5	9	15	
	470 to 899 hectares	31	2	6	7	12	20	
	> 900 hectares	29	5	8	16	27	59	
Number of livestock units on farm	< 2, 400	30	1	2	3	5	17	< 0.001
	2,400 to 4,199	29	1	3	5	9	19	
	4,200 to 7,500	30	2	5	8	11	18	
	> 7,500	30	3	10	17	27	59	
Number of sheep on farm	< 900	30	1	2	3	6	19	< 0.001
	900 to 2,799	30	2	4	5	9	16	
	2,800 to 5,099	31	2	6	7	11	20	
	> 5,100	28	3	10	17	28	59	
Number of beef cattle on farm	< 60	28	1	2	5	8	17	< 0.001
	60 to 149	31	1	3	5	8	20	
	150 to 329	30	2	5	8	12	19	
	> 330	30	3	7	12	27	59	
Steep and or high country contour on farm	Present	82	1	5	8	15	59	< 0.001
	Absent	37	1	3	4	6	18	

Table 3.3: Number and percentage of Livestock Herding Dogs stratified by Livestock Herding Dog group, and Livestock Herding Dog breed or type. Data gathered from a cross-sectional survey of 1,194 Livestock Herding Dogs on 119 Manawatau – Wanganui region farms.

Group	Breed or type	Number of Livestock Herding Dogs	%
Hunt- away	New Zealand Huntaway	572	48
	Bearded Collie	35	3
	New Zealand Huntaway cross [a]	27	2
	Smithfield	4	0
	Bearded Collie, Border Collie cross	1	0
	Total	639	54
Heading	New Zealand Heading	415	35
	New Zealand Heading cross [b]	21	2
	Border Collie	19	2
	Australian Cattle Dog	4	0
	Total	459	38
Handy	New Zealand Handy	44	4
	Australian Kelpie	7	1
	Total	51	4
Unknown	Unknown	25	2
	Not typical Livestock Herding Dog breeds [c]	20	2

Total	45	4
Total	1,194	100

[a] New Zealand Huntaway crosses included Australian Kelpie, Bearded Collie, English Springer Spaniel, Fox Terrier, and Labrador Retriever.
[b] New Zealand Heading crosses included Australian Cattle Dog, Australian Kelpie, Bearded Collie, Fox Terrier, Rhodesian Ridgeback, and Staffordshire Terrier.
[c] Not typical Livestock Herding Dog breeds included English Springer Spaniel, Fox Terrier, German Shorthaired Pointer, Jack Russell, Labrador Retriever, Labrador Retriever – Golden Retriever cross, Miniature Schnauzer, Old English Sheep Dog, Poodle, and Staffordshire Bull Terrier.

Table 3.4: Number and percentage of 1,135 [a] Livestock Herding Dogs stratified by group and whether the Livestock Herding Dog was used by the Livestock Herding Dog owner to herd sheep or beef cattle. Relative risk (RR) and 95% confidence intervals (CI) for use of handy, hunt-away, and heading Livestock Herding Dog groups to herd sheep or beef cattle are also presented. Data gathered from a cross sectional survey of 1,194 Livestock Herding Dogs on 119 Manawatau – Wanganui region farms.

Livestock herded by the Livestock Herding Dog	Group	Yes		No		RR (95% CI)	P-value [b]
		n	%	n	%		
Sheep	Handy	40	78	11	22	Ref	0.04
	Hunt-away	561	90	64	10	1.14[c] (0.99 – 1.32)	
	Heading	402	88	57	12	1.12 (0.96 – 1.29)	
Beef cattle	Handy	41	80	10	20	Ref	0.37
	Hunt-away	528	84	97	16	1.05 (0.91 – 1.20)	
	Heading	374	81	85	19	1.01 (0.88 – 1.17)	

[a] Excludes 59 Livestock Herding Dogs because of the following: their breed was unknown (n = 25), the Livestock Herding Dog could not be assigned to a group (n = 20), and whether the Livestock Herding Dog was used to herd sheep or cattle was not recorded (n = 14).
[b] P- value for Pearson's chi-squared test statistic.
[c] Livestock Herding Dogs within the hunt-away group were 1.14 times more likely to be used to herd sheep than Livestock Herding Dogs from within the handy group.

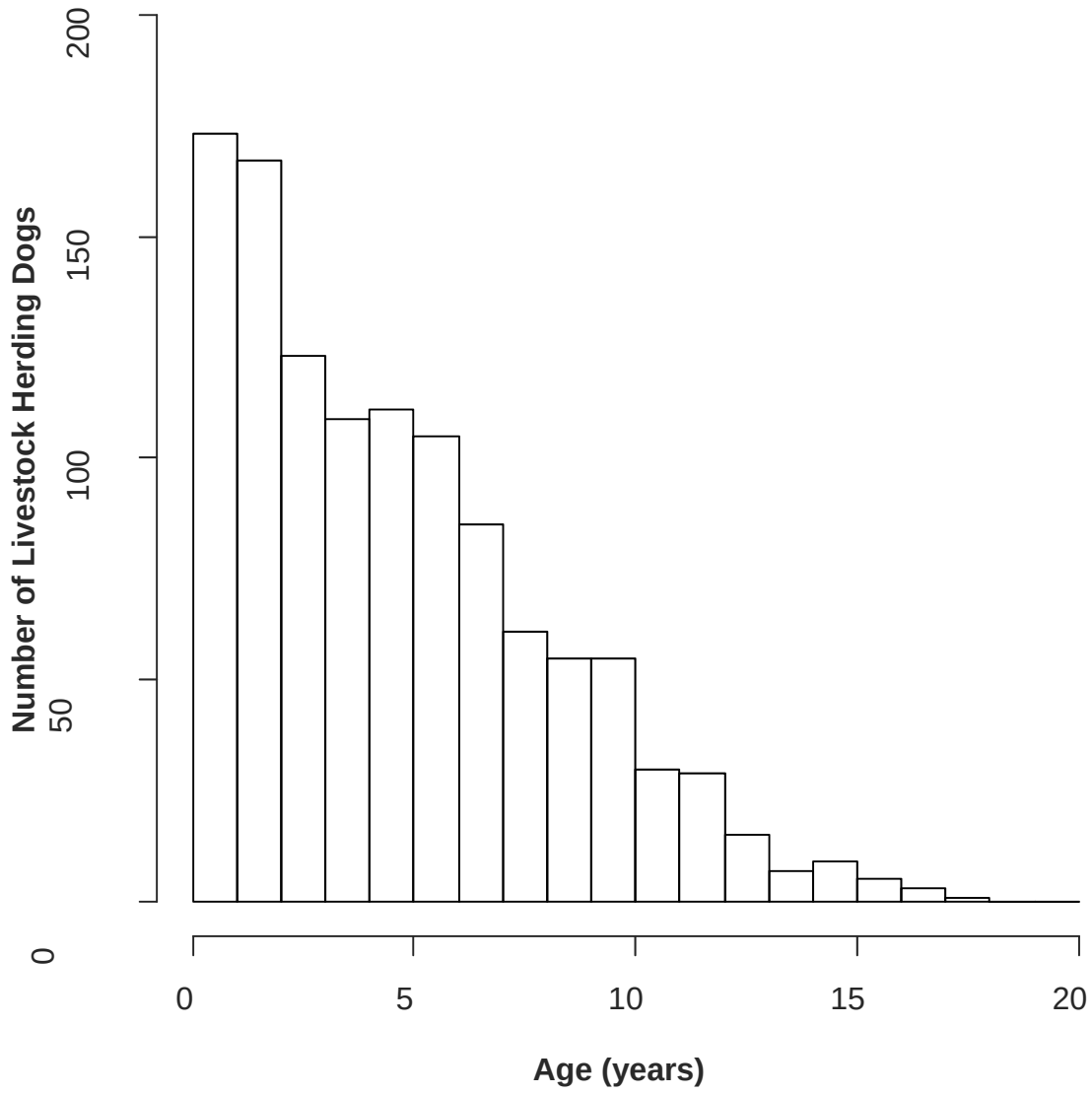

Figure 3.5: Histogram of the age (in years) of Livestock Herding Dogs with known age. Data gathered from a cross-sectional survey of 1,194 Livestock Herding Dogs on 119 Manawatau-Wanganui region farms.

Table 3.5: Descriptive statistics for the age (in years) of 1,157 [a] Livestock Herding Dogs stratified by a number of independent variables. Data gathered from a cross-sectional survey of 1,194 Livestock Herding Dogs on 119 Manawatau-Wanganui region farms.

Variable	Level	Number of Livestock Herding Dogs	Minimum	Percentiles 25th	Percentiles 50th	Percentiles 75th	Maximum	P-value [b]
Career stage [c]	No training	48	0.50	0.50	1.00	1.50	7.00	< 0.001
	Initiated training	87	0.50	0.75	1.00	1.50	16.00	
	Partly trained	190	0.50	1.00	1.50	2.00	9.00	
	Fully trained	683	0.50	3.50	5.00	7.00	16.00	
	Semi-retired	63	2.50	8.50	10.00	12.00	17.00	
	Retired	70	4.00	7.00	11.00	13.00	18.00	
Steep and or high country contour	Present	965	0.50	2.00	4.00	7.00	18.00	< 0.001
	Absent	192	0.50	2.50	5.00	9.00	17.00	
Neuter status [d]	Entire	1065	0.50	2.00	4.00	7.00	17.00	< 0.001
	De-sexed	71	1.00	4.00	6.00	9.00	18.00	
Used to herd beef cattle [e]	Yes	945	0.50	2.50	5.00	8.00	17.00	< 0.001
	No	198	0.50	0.75	1.00	5.00	18.00	

Variable	Level	Number of Livestock Herding Dogs	Minimum	Percentiles			Maximum	P-value [b]
				25th	50th	75th		
Used to herd sheep [e]	Yes	1003	0.50	2.50	5.00	7.00	17.00	< 0.001
	No	140	0.50	0.75	1.00	4.75	18.00	
Farm size	< 200 hectares	115	0.50	2.00	5.00	8.00	14.00	<0.001
	200 to 469 hectares	187	0.50	2.00	5.00	9.00	18.00	
	470 to 899 hectares	276	0.50	2.00	5.00	8.00	17.00	
	> 900 hectares	572	0.50	1.50	4.00	6.00	17.00	
Number of Livestock Herding Dogs on farm	< 4	62	0.50	0.75	3.00	6.25	13.00	< 0.001
	4 to 6	146	0.75	3.00	6.00	9.00	18.00	
	7 to 11	201	0.50	1.50	4.00	6.25	17.00	
	> 11	748	0.50	2.00	5.00	7.00	18.00	

Variable	Level	Number of Livestock Herding Dogs	Minimum	Percentiles 25th	50th	75th	Maximum	P-value [b]
Life stage	Euthanised by owner	102	0.50	1.00	1.00	4.00	17.00	< 0.001
	Given away	37	0.50	1.00	2.00	6.00	12.00	
	Sold	41	0.50	1.00	5.00	6.00	10.00	
	Alive and on the farm	907	0.50	2.00	5.00	7.00	18.00	
	Dead	36	1.50	3.75	7.00	9.00	14.00	
	Euthanised by veterinarian	34	2.00	7.00	10.00	11.00	16.00	
Group [f]	Hunt-away	634	0.50	1.50	4.00	7.00	18.00	0.17
	Heading	451	0.50	2.00	5.00	7.00	17.00	
	Handy	50	0.50	2.00	5.00	9.00	14.00	
Sex [g]	Male	668	0.50	2.00	4.50	7.00	17.00	0.42
	Female	482	0.50	2.00	4.00	7.00	18.00	

[a] Excludes 37 Livestock Herding Dogs whose age was unknown.
[b] P value of Kruskal-Wallis test statistic for non-normally distributed continuous data.
[c] Excludes 16 Livestock Herding Dogs whose career stage was unknown.
[d] Excludes 21 Livestock Herding Dogs whose neutered status was unknown.
[e] Excludes seven Livestock Herding Dogs whose use in the herding of beef cattle or sheep was not recorded.
[f] Excludes 22 Livestock Herding Dogs because their breed or type was unknown (n = 2) or because the Livestock Herding Dog's group was unknown (n = 20).
[g] Excludes seven Livestock Herding Dogs whose sex was unknown.

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Table 3.6: Number and percentage of 1,152 [a] Livestock Herding Dogs that were neutered or entire, stratified by a number of independent variables. Relative risk (RR) and 95% confidence intervals (CI) for risk of neuter status by factors are also presented. Data gathered from a cross-sectional survey of 1,194 Livestock Herding Dogs on 119 Manawatau – Wanganui region farms.

		Neutered		Entire			
Variable	Level	n	%	n	%	RR (95% CI)	P-value [b]
Sex	Male	23	3	642	97	Ref	< 0.001
	Female	48	10	439	90	2.85 (1.76 – 4.62)	
Used to herd sheep	Yes	53	5	960	95	Ref	0.001
	No	18	13	121	87	2.46 (1.49 – 4.10)	
Age of Livestock Herding Dog [c]	< 2 years	6	2	248	98	Ref	0.004
	2 to 4 years	11	5	206	95	2.15 (0.81 – 5.71)	
	4 to 7 years	21	7	293	93	2.83 (1.16 – 6.91)	
	> 7 years	33	9	318	91	3.98 (1.69 – 9.36)	
Number of Livestock Herding Dogs on farm	< 4	5	8	57	92	Ref	0.02
	4 to 6	12	8	137	92	1.00 (0.37 – 2.72)	
	7 to 11	20	10	181	90	1.23 (0.48 – 3.15)	
	> 11	34	5	706	95	0.57 (0.23 – 1.40)	
Steep and or high country contour	Present	52	5	917	95	Ref	0.02
	Absent	19	10	164	90	1.93 (1.17 – 3.19)	

Variable	Level	Neutered		Entire		RR (95% CI)	P-value [b]
		n	%	n	%		
Career stage [d]	Initiated training	10	11	77	89	Ref	0.05
	No training	1	2	46	98	0.19 (0.02-1.40)	
	Partly trained	7	4	183	96	0.32 (0.13-0.81)	
	Fully trained	41	6	653	94	0.53 (0.27 – 0.99)	
	Semi - retired	4	6	58	94	0.56 (0.18 – 1.70)	
	Retired	8	11	62	89	0.99 (0.41 – 2.38)	
Life stage	Euthanised by owner	3	3	101	97	Ref	0.10
	Given away	1	3	29	97	1.16 (0.12-10.71)	
	Alive and on the farm	58	6	856	94	2.20 (0.70 – 6.90)	
	Euthanised by veterinarian	4	12	29	88	4.20 (0.99 – 17.82)	
	Dead	5	14	31	86	4.81 (1.21 – 19.14)	
	Sold	0	0	35	100	NC [e]	
Group [f]	Hunt-away	29	5	593	95	Ref	0.21
	Heading	28	6	428	94	1.32 (0.79 – 2.18)	
	Handy	5	10	45	90	2.14 (0.87 – 5.29)	
Used to herd cattle	Yes	54	6	846	94	Ref	0.66
	No	17	7	235	93	0.89 (0.53– 1.51)	

a Excludes 42 Livestock Herding Dogs whose neuter status was unknown.
b P- value for Pearson's chi-squared test statistic.
c Excludes 16 Livestock Herding Dogs whose age was unknown.
d Excludes two Livestock Herding Dogs whose career stage was unknown.
e Not calculable as no Livestock Herding Dogs that were sold had been neutered.
f Excludes 24 Livestock Herding Dogs because their breed/type was unknown (n = 4) or because the Livestock Herding Dog's group was unknown (n = 20).

Table 3.7: Number and percentage of 1,157 [a] Livestock Herding Dogs stratified by career stage and life stage. Data gathered from a cross-sectional survey of 1,194 Livestock Herding Dogs on 119 Manawatau – Wanganui region farms.

Career stage	Life stage	Number of Livestock Herding Dogs	% of career stage by life stage	% of career stage
No training	Euthanised by owner	44	92	
	Dead	2	4	
	Sold	2	4	
	Total	48	100	4
Initiated training	Alive and on the farm	49	56	
	Euthanised by owner	19	22	
	Given Away	13	15	
	Sold	3	3	
	Dead	2	2	
	Euthanised by veterinarian	1	1	
	Total	87	100	8
Partly trained	Alive and on the farm	165	87	
	Euthanised by owner	8	4	
	Given Away	8	4	
	Sold	7	4	
	Dead	1	1	
	Euthanised by veterinarian	1	1	
	Total	190	100	16
Fully trained	Alive and on the farm	608	87	
	Dead	26	4	
	Euthanised by owner	26	4	
	Euthanised by veterinarian	21	3	
	Given Away	7	1	
	Sold	10	1	
	Total	698	100	60
Semi-retired	Alive and on the farm	56	89	
	Dead	3	5	
	Euthanised by owner	3	5	
	Euthanised by veterinarian	1	2	
	Total	63	100	5
Retired	Alive and on the farm	40	56	
	Sold	13	18	
	Euthanised by veterinarian	10	14	
	Dead	4	6	
	Euthanised by owner	4	6	
	Total	71	100	6
Total		1,157	-	100

[a] Excludes 37 Livestock Herding Dogs whose career stage was unknown.

Table 3.8: Number and percentage of 1,173[a] Livestock Herding Dogs that were deceased or alive at the time of the survey stratified by a number of independent variables. Relative risk (RR) and 95% confidence intervals (CI) for risk of outcome by factors are also presented. Data gathered from a cross-sectional survey of 1,194 Livestock Herding Dogs on 119 Manawatau – Wanganui region farms.

		Deceased		Alive			
Variable	Level	n	%	n	%	RR (95% CI)	P-value [b]
Age of Livestock Herding Dog [c]	< 2 years	65	24	203	76	Ref	< 0.001
	2 to 4 years	19	9	200	91	0.36 (0.22 – 0.58)	
	4 to 7 years	28	9	287	91	0.37 (0.24 – 0.55)	
	> 7 years	60	17	295	83	0.70 (0.51 – 0.95)	
Career stage [d]	No training, initiated training or partly trained	78	24	247	76	Ref	< 0.001
	Fully trained	73	10	625	90	0.44 (0.33 – 0.58)	
	Semi-retired or retired	25	19	109	81	0.78 (0.52 – 1.16)	
Used to herd sheep [e]	Yes	121	12	898	88	Ref	<0.001
	No	55	39	85	61	3.33 (2.55 – 4.34)	
Used to herd beef cattle [e]	Yes	98	11	826	89	Ref	<0.001
	No	88	37	147	63	3.53 (2.75 – 4.53)	
Group [f]	Heading	78	17	381	83	Ref	0.18
	Hunt-away	83	13	556	87	0.76 (0.57 – 1.01)	
	Handy	8	16	43	84	0.92 (0.47 – 1.80)	

Variable	Level	Deceased		Alive		RR (95% CI)	P-value [b]
		n	%	n	%		
Number of Livestock Herding Dogs on farm	< 4	6	10	56	90	Ref	0.24
	4 to 6	16	11	130	89	1.13 (0.47 – 2.76)	
	7 to 11	30	15	173	85	1.52 (0.67 – 3.50)	
	> 11	124	16	638	84	1.64 (0.75 – 3.56)	
Sex [g]	Male	97	14	577	86	Ref	0.46
	Female	79	16	413	84	1.12 (0.85 – 1.47)	
Neuter status [h]	Neutered	12	17	59	83	Ref	0.61
	Entire	161	15	920	85	0.88 (0.52 – 1.50)	
Steep and or high country contour	Present	148	15	832	84	Ref	0.91
	Absent	28	15	165	84	0.96 (0.66 – 1.39)	

a Excludes 21 Livestock Herding Dogs whose life stage was unknown.
b P- value for Pearson's chi-squared test statistic.
c Excludes 16 Livestock Herding Dogs whose age was unknown.
d Excludes 16 Livestock Herding Dogs whose career stage was unknown.
e Excludes 14 Livestock Herding Dogs whose use in the herding of beef cattle or sheep was not recorded.
f Excludes 24 Livestock Herding Dogs because their breed/type was unknown (n = 4) or because the Livestock Herding Dog's group was unknown (n = 20).
g Excludes seven Livestock Herding Dogs whose sex was unknown.
h Excludes 21 Livestock Herding Dogs whose reproductive status was unknown.

Table 3.9: Number and percentage of pups bred on farms stratified by their fate, and breed or type. Data collected from a cross-sectional survey of 768 pups on 119 Manawatau – Wanganui region farms.

Fate	Breed/type	Number of pups	% of pups
Euthanised by owner	New Zealand Huntaway	151	20
	New Zealand Heading	144	19
	Bearded Collie	42	5
	New Zealand Handy	10	1
	Australian Kelpie	9	1
	Total	356	46
Dead	New Zealand Huntaway	55	7
	New Zealand Heading	47	6
	Bearded Collie	6	1
	Total	108	14
Sold	New Zealand Huntaway	100	13
	New Zealand Heading	67	9
	Bearded Collie	9	1
	Total	176	23
Given away	New Zealand Huntaway	36	5
	New Zealand Heading	26	3
	Fox Terrier	9	1
	Australian Kelpie	9	1
	Unknown	2	0
	Bearded Collie	2	0
	New Zealand Handy	1	0
	Total	85	11
Alive and on the farm	New Zealand Huntaway	16	2
	New Zealand Heading	16	2
	Bearded Collie	11	1
	Total	43	6

Table 3.10: Descriptive statistics for the age (in weeks) of pups bred on farms over the preceding 12 months stratified by life stage. Data gathered from a cross-sectional survey of 768 pups on 119 Manawatau – Wanganui region farms.

Life stage	Number of farm pups	Minimum	Percentiles			Maximum	P-value [b]
			25th	50th	75th		
Euthanised by owner	356	0.00	0.00	0.00	0.00	8.00	< 0.001
Dead	108	0.00	0.00	0.00	0.00	2.00	
Alive and on the farm	43	0.80	2.00	4.00	8.00	11.00	
Given away	85	0.00	8.00	12.00	12.00	16.00	
Sold	176	4.00	12.00	12.00	12.00	20.00	

[a] P value of Kruskal-Wallis test statistic for non-normally distributed continuous data.

3.5 Discussion

This chapter reports on LH Dog demographics as determined from a study designed to be representative of the general LH Dog population in the Manawatau-Wanganui region. Specifically it presents LH Dog demographic information pertaining to the following: the working environment of a LH Dog; the number of LH Dogs on farms; LH Dog breeds and types; the age, sex, neuter status, career stage, and life stage of LH Dogs; the number of dog litters born on farms; and the fate pups born on farms.

Several of the design features of this survey contributed positively towards the internal validity of the study. By gathering data pertaining to all LH Dogs that had been on the farm over the preceding 12 months, irrespective of whether they had died or moved off the farm, the study was not bias towards those with favourable survivorship. Further, inclusion of LH Dogs that had yet to be trained, that were semi-retired, or that were retired, meant the study did not exclude LH Dogs that were not currently working. That said given the sensitive nature of some of the questions, in particular questions about the cause of death of LH Dogs and information about pups born on the farm, it is possible that some LH Dog owners gave answers they believed to be more socially, legally, or politically acceptable, or avoided reporting the truth. However, while 31 LH Dog owners did not report the cause of death for 38 LH Dogs 41 of LH Dog owners did report that 464 of the 768 pups bred had died or had been destroyed, suggesting the impact of obsequiousness or response bias may be minimal. Irrespective, it is unlikely that the internal validity of results of this study were not affected by some degree of obsequiousness or response bias.

Sending an introductory letter to a potential study participant, following this letter with a telephone call, arranging to carry out the interview at a site convenient to the participant, and organising an interview time that works around the participant's schedule are methods that have been shown previously to improve response rates (DeLeeuw et al., 2007). These study design features were incorporated into this research. Since only 5% farms from the initial sample and 3% from the total sample of 316 farms refused to participate it is possible that the letters and follow up phone calls assisted with minimisation of the non-response rates in this research.

The variable 'career stage' should be interpreted with caution because the career stage category a LH Dog was placed in was based on the LH Dog owner's interpretation of what constituted each career stage and not by a pre-defined set of criteria. Therefore categorisation of a LH Dog into a career stage is likely to vary between LH Dog owners. Specifically it is possible the line between initiated training and partly trained, or between semi-retired and retired, differed between LH Dog owners since the only readily identifiable feature of these career stages is that they lead up to or away from the fully trained career stage. That noted it is the author's opinion that the fully trained career stage would have been most consistently identified by LH Dog owners because LH Dog owners should be able to identify LH Dogs that understand and perform all relevant commands, and whose frequency of use is not permanently hindered by health or behavioural problems. If career stage is a risk factor for poor LH Dog health the lack of a pre-defined and understood set of criteria for the career stage of LH Dog is a problem for

research. Possibly the division of career stages into pre-fully trained, fully trained, and post-fully trained categories would be more relevant.

The variable ‘group’ should be interpreted with caution because categorisation of LH Dog into a group was based on the dog’s breed or type and not on how the LH Dog actually herded livestock. This distinction is important because during data collection the researcher observed LH Dogs that did not herd ‘appropriately’ for their breed or type. For example some LH Dogs, which because of their breed were considered to belong to the ‘heading’ group and so deemed to herd silently, were observed to bark while herding. Therefore, using a dog’s breed or type to determine how it is likely to behave while herding may not be appropriate. Interestingly, 20 LH Dogs could not be categorised into a group because literature pertaining the breed’s herding style could not be found. These breeds may have unique herding behaviours that do not fit into any of the ‘hunt-away’, ‘heading’ or ‘handy’ group categories used in this chapter. Future LH Dog research should take the time to describe how each individual LH Dog herds. Such detail would facilitate understanding of style of herding as a potential risk factor for poor LH Dog poor health.

Whether a LH Dog was deemed to have been used to herd sheep or beef cattle should also be interpreted with caution. This is because these results reflect what the LH Dog was used to herd on the day of the survey not what the LH Dog was going to be trained to herd in the future or what the LH Dog had the ability to herd. This means a number of the LH Dogs classified as ‘not working’ sheep or beef cattle were actually LH Dogs that had yet to be trained.

Like the studies of Singh et al. (2011) and Cave et al. (2009) this study identified New Zealand Huntaway and New Zealand Heading dogs to be the principle type of LH Dog used to herd livestock in New Zealand. Still the studies of Singh et al. (2011) and Cave et al. (2009) had opposing views as to which of the two LH Dog types were more predominant. Specifically, while the study of Singh et al. (2011) comprised of 53% New Zealand Heading and 41% New Zealand Huntaway dog, the study of Cave et al. (2009) was made up of 39% New Zealand Heading and 51% New Zealand Huntaway dog. The study reported in this thesis comprised of 37% New Zealand Heading and New Zealand Heading dog crosses, and 50% New Zealand Huntaway and New Zealand Huntaway dog crosses, and is therefore most similar to the findings of Cave et al. (2009). A possible explanation for the percentage of New Zealand Heading dogs being higher in the study by Singh et al. (2011) than either the current study or Cave et al. (2009), is Sheep dog trialists may keep more New Zealand Heading dogs than average. This could be Sheep Dog Trial Association events reserved exclusively for Heading dogs – namely the ‘Long Head’ and ‘Short Head and Yard’ (see New Zealand Sheep Dog Trial Association Inc. (2013) for explanation of the events). Overall identification of Heading dogs and Huntaways as the principle type of LH Dog used to herd livestock is important; the findings vindicate a focus in research into to the genetic or behavioural problems of New Zealand Heading dogs and New Zealand Huntaways given such research is likely to serve a wide audience. It is noteworthy that 44 LH Dogs were a breed not typically associated with livestock herding. These breeds were English Springer Spaniel, Fox Terrier, German Shorthaired Pointer, Jack Russell, Labrador Retriever, Labrador Retriever–Golden Retriever cross,

Miniature Schnauzer, Poodle and Staffordshire Bull Terrier. It is not known whether these breeds do, or have the capacity to, herd like 'typical' LH Dog breed or types such as the New Zealand Heading dog.

Similar to the findings of Singh et al. (2011) our study population was reasonably young; while the study population of Singh et al (2011) had a median age of three years our study population had a median of four years. That noted, it is worth highlighting that the reported median age of LH Dogs on farms in our study and that of Singh et al. (2011) differed by one year. There are two possible explanations for this. Firstly, Singh et al. (2011) investigated dogs whose owners were members of the New Zealand Sheep Dog Trial Association rather than the general LH Dog population, and Sheep Dog Trial Association members may sell, give away, or euthanise their LH Dogs earlier than the general LH Dog owner population resulting in a lower LH Dog median age. Another reason is that the results in Singh et al. (2011) may be biased by the 'healthy worker' effect as the survey only asked about dogs currently in their care. In contrast, the current survey asked about dogs that had been on the farm in the previous 12 months.

In the current study only 2% of the investigated population were neutered male LH Dogs while 4% were neutered female LH Dogs. These findings are similar to that of Cave et al. (2009) whose study population comprised of 2% of neutered male LH Dogs and 3% neutered female LH Dogs. It is interesting to note that our research identified older LH Dogs to be more likely to be neutered than younger LH Dogs. This finding would support the hypothesis of Cave et al. (2009) that owners of LH Dogs delay breeding from a LH Dog until adulthood when their ability to perform, and so their worth to breed from, has been established. Be that as it may, all neutering rates for all age groups were extremely low and efforts should be made to address this for several reasons. Firstly, dogs that are sexually intact may display certain types of behavioural problems, such as inter-dog aggression (Overall, 2007), which may be a risk factor for experience of an adverse health event caused by trauma. Secondly, Cave et al. (2009) reported a number of reproductive tract complaints in LH Dogs that would have been prevented had the dog been neutered. Specifically, of the 197 veterinary visits relating to the reproductive tract in the study of Cave et al. (2009) 21% were cases of mismating, 9% were cases of pyometra/endometritis, and 8% were cases of dystocia; neutering of LH Dogs, in particular female LH Dogs, should result in a reduction in these health problems. Furthermore, given 46% of the pups bred on farms were euthanised soon after they were born, and given that neutering of LH Dogs may alter this trend, castration and spaying of LH Dogs is important.

A distinction between puppies that were euthanised and puppies that died should be made. Specifically, the 'euthanised' group included pups that were put down for reasons such as being unwanted, while pups in the 'died' group included pups that died from avoidable events. Livestock Herding Dog owners can minimise the occurrence of death via an avoidable event by checking under kennels for trapped pups, by separating new born pups from other dogs and bitches in order that the risk of being attacked or eaten is minimised, and by returning pups that have crawled away from the den back to the mother. Education programs for LH Dog owners pertaining to the care of new born LH Dog puppies may help to reduce rates of pup death. Owner education could also focus on increasing neutering rates so as to reduce the number of unwanted pregnancies.

Initially the farms were sampled to ensure a spatially balanced sample. Unfortunately 38% of the farms in the initial GRTS farm sample had to be replaced with a second sample. However, a number of farmers in the second sample also could not be contacted or refused to participate. In addition, 10% of the 316 farms that agreed to partake were unable to be interviewed before the end of the study period owing to poor weather conditions preventing the researcher from reaching the interview point, or because the participant and researcher had had persistently conflicting work schedules and a mutually agreeable time had not been identified and dogs in these areas were not investigated. Consequently, the study population was not spatially balanced as some areas of the Manawatau-Wanganui region not being researched at all (see Figure 3.3). That said, this study did achieve a random sample of Manawatau-Wanganui sheep and beef farms. Subsequently, while results in this thesis may not be representative of the Manawatau-Wanganui region in *entirety,* the findings should be considered representative of the areas that were investigated and to provide insight pertaining to LH Dog breed and type, age, sex, neuter status, career stage, and life stage for these locations. Two main factors suggest the results of this study cannot be extrapolated to the general population of LH Dogs of New Zealand. Principally this is because the study experienced facets which threatened its internal validity, such as non-response and sampling bias, which by extension threatened the study's external validity. Additionally, the Manawatau-Wanganui region has a unique climate and geography which affects the way livestock are farmed and this variability in farming style may influence the demographics of LH Dogs found on Manawatau-Wanganui region farms. For example, the steep and/or high country contours found on many Manawatau-Wanganui region farms (69% of this study) may mean Huntaways are present in higher numbers in comparison to other areas of New Zealand; Huntaway LH Dogs are likely valued on steep and/or high country contours because their noise facilitates the movement of livestock up steep hills, or out of the bushes or gullies often found on high country properties. Given all the former points the writer of the thesis concludes the following: the findings presented in this chapter describe some of the demographical features of New Zealand LH Dogs; the results should only be considered representative of the areas of the Manawatau-Wanganui that were ultimately investigated; the results may not reflect the demographics of LH Dogs found on Manawatau-Wanganui region farms that have very rigid working schedules or which are difficult to access during tumultuous weather; and the findings should not be extrapolated to areas of New Zealand that do not have geographic or climatic conditions and by extension farming practises comparable to the Manawatau-Wanganui region.

3.6 Conclusion

These findings provide important information about the current state of LH Dog demographical features in the Manawatau-Wanganui region of New Zealand. The New Zealand Huntaway and the New Zealand Heading dog were identified as the principle types of dog used to herd livestock, and overall rates of LH Dog neutering were very low. Future research should endeavour to identify and understand behaviour and health problems specific to the New Zealand Huntaway and the New Zealand Heading dog since this would serve a wide audience. Further, for the purposes of reducing the number of pup euthanised, and for LH Dog behavioural reasons, efforts should be made by way of education to increase rates of LH Dog neutering.

Chapter 4: Livestock Herding Dog husbandry and management

4.1 Abstract

AIM: To describe the husbandry and management of Livestock Herding (LH) Dogs in the Manawatau-Wanganui region of New Zealand.

METHODS: Using a cross-sectional survey LH Dog husbandry and management data for 1,194 LH Dogs was gathered from 119 randomly selected Manawatau-Wanganui region farms between July 2008 and July 2009. The survey had four parts. Part one gathered data pertaining to the farm such as size and contour. Part two collected the following: LH Dog owner demographical data; information about how LH Dog owners had trained, sheltered and fed each of their LH Dogs over the previous 12 months; and data pertaining to the type and frequency with which anthelmintic drugs, vaccinations, and flea-control treatments had been given to LH Dogs. Where management differed between LH Dogs owned by the same individual differences were noted. Part three collected demographic data pertaining to all LH Dogs that had been on the farm over the previous 12 months, the stage of training the LH Dog had been at when it was acquired, and the age of the LH Dog when it initiated training. Part four collected information relating to litters and pups that had had been on the farm over the previous 12 months such as the number of litters bred and fate of each pup. Data were summarised using numbers and percentages. The distribution of continuous variables was described using a histogram.

RESULTS: Three hundred and sixteen farms were randomly sampled of which 119 agreed to partake and were surveyed. The number of LH Dogs surveyed was 1,194. The age at which training had commenced was known for 881 LH Dogs; the median age LH Dogs initiated training was six months with the age of initiation of training varying significantly between male and female LH Dogs (P = 0.004). One hundred and twenty-seven had carried out directional training in between livestock herding activities over the previous 12 months. Of the 1,180 LH Dog shelters that were recorded 970 had been built by the farmer, 170 were commercially acquired, while 40 were ad hoc. Two hundred and twenty of the 1,180 shelters had been cleaned over the previous 12 months, while bedding had been provided within 265. Food was placed on the floor of 814 of the 1,180 shelters, and 24 shelters did not have LH Dog accessible water. Of the 198 LH Dog owners 177 had fed commercial dry food to their LH Dogs over the previous 12 months, 159 had given their LH Dogs anthelmintic drugs, 37 had vaccinated their LH Dogs, and 18 had given their LH Dogs at least one flea control treatment. Of the 1,194 LH Dogs, 994 had received anthelmintic drugs, 211 had been vaccinated, and 109 had been treated for fleas.

CONCLUSION: This study described the husbandry and management of LH Dogs in the Manawatau-Wanganui region of New Zealand. Although feeding offal to a LH Dog does not appear to be common 11 LH Dog owners reported feeding their LH Dogs raw sheep offal. This may be of significance to both the livestock producer and New Zealand's export trade so efforts to better educate LH Dog owners about the implications of *Cysticercus ovis* may be warranted.

4.2 Introduction

Livestock Herding (LH) Dogs are integral to New Zealand's livestock farming industry because they enable farmers to move livestock efficiently. Such efficient movement is possible because LH Dogs can induce herd fear-flocking and flight behaviours in animals (Coppinger and Schneider, 1995, p.29); causing them to group together and move collectively a given direction. Overall LH Dogs reduce the complexities of managing livestock (Lithgow, 1995; Cavanagh, 1990; Dalton, 2008; Coppinger and Coppinger, 2000; Redwood, 1980).

Very little has been published about the husbandry and management of LH Dogs in New Zealand. Special interest books have discussed a range of topics including LH Dog breeding, training, housing and nutrition (Lithgow, 1995; Dalton, 2008; Redwood, 1980; Oliver et al., 2004; Rennie, 1984), however such writing is typically based on the ideologies and practises of a few people and cannot be considered representative of the general LH Dog population.

A study by Singh et al. (2011) has collected detailed demographic and nutrition data of LH Dogs whose owners were members of the New Zealand Sheep Dog Trial Association (NZSDTA) as of August 2007. Of the 542 LH Dog owners involved with the study 97% fed their LH Dogs once at the end of the working day. During peak work periods a 100% dry diet was fed to LH Dogs by 4% of LH Dog owners, while a 100% home-kill diet was fed to LH Dogs by 7% of LH Dog owners. Also during peak work, 50% of LH Dog owners fed a combination of dry diet and home-kill to LH Dogs, while 21% of LH Dog owners fed a combination of wet diet (canned and dog roll) and/or table scraps and/or dry diet and/or home-kill. During off-peak work 4% of LH Dog owners had fed a 100% dry diet, while 5% of LH Dog owners had fed a 100% home-kill diet to their LH Dogs. Also during off-peak, a combination of dry diet and home-kill had been fed to LH Dogs by 49% of LH Dog owners, while a combination of wet diet (canned and dog roll) and/or table scraps and/or dry diet and/or home-kill had been fed to LH Dogs by 24% of LH Dog owners. Care should be taken when extrapolating the results of Singh et al. (2011) to the general LH Dog population since the study population were members of the NZSDTA. These members represent a group of people who engage in competition and as such the diets they feed their LH Dogs may differ from LH Dog owners who use LH Dogs but do not compete. Furthermore, the study was limited to nutrition and has not provided insight into other areas of LH Dog husbandry and management.

A number of case reports have postulated a relationship between LH Dog diet and LH Dog health. A meat and water diet has been associated with the development of an iodine-responsive goitre (Nuttall, 1986; Thompson, 1979), and the diet is also hypothesised to have caused selenium deficiency in an adult 'working collie' and a litter of pups (Manktelow, 1957). In addition, LH Dogs fed processed foods such as commercial dog rolls or farm-produced mutton that has been boiled have been observed to experience thiamine deficiency (Mayhew and Stewart, 1969; Read et al., 1977). While these case reports highlight health problems it is not clear how prevalent the diseases currently are or how common the LH Dog husbandry and management practises that caused these and other problems are. Better understanding of current LH Dog husbandry and management practises such as sheltering, feeding, and training will enable recommendations that could impact on LH Dog health.

This chapter provides an account of LH Dog husbandry and management practises as determined from a study designed to be representative of one part of the general LH Dog population of New Zealand - LH Dogs from the Manawatau-Wanganui region. Specifically it presents the following: information about the stage of training LH Dogs were at when acquired; how LH Dogs were trained, sheltered and fed; and whether LH Dog owners had provided, and LH Dogs had received, anthelmintic drugs, vaccinations, and flea control treatments over the previous 12 months.

4.3 Materials and methods

This was a cross-sectional study of LH Dogs on sheep and beef farms in the Manawatau-Wanganui region of New Zealand. The survey was conducted between July 2008 and July 2009. The study aimed to describe the key features of the LH Dog population. The design and implementation of the study are described in detail in Chapter Three. Briefly, 119 farms were randomly selected and enrolled in the study. These farms were selected from a sampling frame of Manawatau-Wanganui region properties recorded in AgriBase™ as having the following features:

- Sheep and/or beef cattle present on the farm.
- Greater than or equal to 20 stock units. When determining number of stock units one sheep equated to a single stock unit and one beef cattle equated to 5.5 stock units.
- Greater than or equal to 100 hectares.

Data were collected for all LH Dogs that were on the farm at the time of the survey or that had been on the farm in the 12 months prior to the survey. A farm dog was considered a LH Dog and eligible for the study if it was greater than six months of age, and met one of the following criteria:

- Acquired or bred to be trained to herd livestock but was not yet fully trained.
- Currently herding livestock.
- Previously herded livestock.

In total 1,194 LH Dogs were enrolled in the study.

Data were collected using a questionnaire that comprised of four parts. Part one gathered data pertaining to the farm. The farm comprised of the sampled farm and any other farm(s) the sampled farm operated in conjunction with. For each farm the following data was collected: the number of sheep, beef cattle, and other animals on the farm; the farm's size (in hectares); and types of land contours found within the boundaries of the farm. Part two collected information about the LH Dog owner such as their sex (male or female), age (in years), the number of years the LH Dog owner had been working with LH Dogs, job title, and husbandry and management practises. Husbandry and management data included the following: methods of LH Dog training and training devices used; type of shelters used to shelter LH Dogs; frequency with which these shelters were cleaned; nature of bedding provided to LH Dogs; types of containers used within LH Dog shelters to hold food and water; type of food fed to LH Dogs; frequency of feeding; and type and frequency with which anthelmintic drugs, vaccinations, and flea-control treatments were given to LH Dogs. On occasion training or management differed between LH Dogs owned by the same individual. Any differences were noted during the interview. Part three of the

questionnaire gathered data pertaining to all LH Dogs that were on the farm at the time of the survey or that had been on the farm in the 12 months prior to the survey. The LH Dog data collected included breed, livestock the LH Dog worked, age (in years), sex (male or female), and neuter status (neutered or entire). For those LH Dogs that were not on the farm at the time of the survey because they had died or been euthanised, given away, or sold, the age the LH Dog was at the time the LH Dog died or left the farm was recorded. The researcher also determined the following: the life stage of the LH Dog at the time of the visit (alive and on the farm, sold, given away, dead, euthanised by the LH Dog owner, or euthanised by a veterinarian), the LH Dog's career stage (no training, initiated training, partly trained, fully trained, semi-retired and retired; see Table 3.1 for a description of career stage categories), what stage of training the LH Dog was at when it was acquired (fully trained, partly trained or un-trained), and what age the LH Dog had been when its training was initiated. The final piece of information gathered for each LH Dog was a detailed description of adverse health events the LH Dog had experienced over the preceding 12 months. Part four related to dog litters and pups that had been bred on the farm over the previous 12 months. To be included in the study the pups had to be less than six months of age and on the farm at the time of the survey, or less than six months of age at the time they left the farm. The number of litters bred per farm was recorded as was the number of pups per litter, breed of litters, fate of each pup (alive and on the farm, sold, given away, dead, or euthanised by the LH Dog owner) and age (in weeks) of the pup. For those pups that were not on the farm at the time of the survey because they had died or because they had been euthanised, given away, or sold, the age the pup was at the time the pup died or left the farm was recorded.

One researcher visited each farm to conduct face-to-face interviews with the LH Dog owners. The four part questionnaire used during these interviews is appended. Gathered data were entered into and managed in a purpose built relationship database, Microsoft Access 2007 (Microsoft Corporation, Redmond, WA, USA).

By the end of the study period 316 farms had been sampled. This included 191 farms from the initial sample and 125 farms from the replacement farms list. Of the 316 farms 110 were unable to be contacted, 44 did not meet study criteria, and 11 had declined to partake. In total 151 farms agreed to participate however 32 of these could not be interviewed before the end of the study period due to conflicting work schedules and poor weather conditions. Thus, the study population comprised of 119 farms.

4.3.1 Classification of variables

4.3.1.1 Group of Livestock Herding Dog

Group categorisation was based on a review of literature relating to herding styles typically used by different breeds and types of LH Dog and not based on how the dog actually moved livestock. The group categories were:

- Hunt–away.
- Heading.
- Handy.

The hunt-away group category included the Bearded Collie, Bearded Collie cross, and Smithfield dog breeds, and the New Zealand Huntaway and New Zealand Huntaway cross types. The heading group category incorporated the Border Collie and Australian Cattle Dog breeds, and the New Zealand Heading dog and New Zealand Heading dog cross types. The handy group category included the Australian Kelpie dog breed and the New Zealand Handy dog type. As the group a LH Dog was categorised in was determined by the LH Dog's breed or type the phrase 'breed or type' is used throughout this chapter, where relevant. Several LH Dogs were breeds not typically used to herd livestock, or a LH Dog's breed was unknown. In these cases the group the LH Dog belonged to could not be determined and therefore the LH Dog was categorised under 'not typical LH Dog breeds'.

4.3.1.2 Shelters and runs

LH Dog shelter was divided into three groups which were 'built by farmer', 'commercially acquired' and 'ad hoc'. A 'built by farmer' LH Dog shelter was constructed on the farm for the sole purpose of sheltering a LH Dog, while 'commercially acquired' LH Dog shelters were built-for-profit by a dog-shelter-making business.

Both 'built by farmer' and 'commercial' LH Dog shelters had similar features:

- Each sheltered a single LH Dog.
- Each comprised of a roofed box and a run. The box enclosed a space within which the LH Dog took shelter. Boxes were made from a variety of materials such as wood, tin, or plastic. Further, each box had a space through which the LH Dog could enter and exit. Figure 4.1 (a – d) shows a variety of box shapes.
- A run was typically attached to each box. A run consisted of a cage, a chain, or a staked-line. A staked-line was a solid line typically made of wire which extended out from the box a certain distance and which was staked into the ground at the farthest point. Figure 4.2 (a) presents a cage run. Figure 4.2 (b) presents a chain run.
- The floor of a run was made from one of three materials which were wood, concrete, or dirt. Figure 4.3 (a) presents a run made of wood. Figure 4.3 (b) presents a run made of concrete. Figure 4.3 (c) presents a run made of dirt.
- The position of the box was either elevated or ground level. Figure 4.4 (a, b) present examples of elevated boxes. Figure 4.4 (c) presents an example of a ground level box.

In contrast to LH Dog shelters 'built by farmer' and 'commercial acquired', 'ad hoc' shelters were defined as those that had *not* been constructed for the sole purpose of sheltering a LH Dog. Examples of 'ad hoc' shelters included vehicles (such as tractors or trucks), sheds (such as hay sheds and pig sheds), and cages without a roof.

a b c d

Figure 4.1(a – d): Photographs of a variety of box shapes, ↔ indicates box. Photographs taken while gathering data for a cross-sectional survey of 1,194 Livestock Herding Dogs on 119 Manawatau-Wanganui region farms.

a b

Figure 4.2 (a): Photograph of a cage run, ↔ indicates the cage; (b), photograph of a chain run, ↕ indicates the chain. Photographs taken while gathering data for a cross-sectional survey of 1,194 Livestock Herding Dogs on 119 Manawatau-Wanganui region farms.

a b c

Figure 4.3 (a) Photograph of a run-floor made of wood, ↔ indicates the wood; (b), photograph of a run-floor made of concrete, ↔ indicates the concrete; (c), photograph of a run-floor made of dirt, ↔ indicates the dirt. Photographs taken while gathering data for a cross-sectional survey of 1,194 Livestock Herding Dogs on 119 Manawatau-Wanganui region farms.

a b c

Figure 4.4 (a, b): Photographs of elevated boxes, ↕ indicates elevation; (c) photograph of a ground level box. Photographs taken while gathering data for a cross-sectional survey of 1,194 Livestock Herding Dogs on 119 Manawatau-Wanganui region farms.

4.3.1.3 Training

For the purposes of this chapter 'training' refers to any action by the LH Dog owner that aimed to teach the LH Dog something.

Training was divided into that which occurred during livestock herding activities, and that which occurred in between livestock herding activities. Training that occurred in between livestock herding activities included directional training. During directional training the LH Dog owner directed the movement of a LH Dog's body using training devices such as ropes, a pole, a horse halter, or a fly whip, and taught the LH Dog to move in this way upon hearing a particular command or whistle. Figure 4.5 provides an example of directional training using a harness made of a modified horse halter and rope. The LH Dog was taught how and when to move to the left. Practise was also used to train a LH Dog in between livestock herding activities. During practise the LH Dog owner enabled the LH Dog to practise their herding and response to commands on make believe livestock such as drums made to look like sheep, and small groups of livestock in stock yards or paddocks.

Figure 4.5: An example of a Livestock Herding Dog directional training. The Livestock Herding Dog is being trained to move to the left upon hearing a particular command or whistle. The Livestock Herding Dog is being trained with a harness made of a modified horse halter and rope. Photograph taken while gathering data for a cross-sectional survey of 1,194 Livestock Herding Dogs on 119 Manawatau-Wanganui region farms.

4.3.2 Statistical analysis

The number and percentage of LH Dogs acquired fully trained, partly trained, and un-trained was determined. The distribution of the age (in months) of LH Dogs when they initiated training was described using a histogram. The age of LH Dogs when they initiated training was described stratified by sex and group. The distribution of the age of LH Dogs when they initiated training was non-normal. Thus, the age of LH Dogs when they initiated training was summarised using minimum, maximum and percentiles. Kruskal-Wallis tests determined if the age of LH Dogs when they initiated training varied significantly by any of the factors.

The number and percentage of LH Dog owners that had trained during livestock herding activities and in between livestock herding activities over the previous 12 months was determined stratified by the type of training used.

The number and percentage of LH Dogs that were sheltered in built by farmer and commercial LH Dog shelters was determined stratified by position of box, run type, run-floor material. The number and percentage of LH Dogs that were sheltered in ad-hoc situations was also determined.

The number and percentage of LH Dog shelters that were cleaned over the previous 12 months was established. The number and percentage of LH Dogs that were provided with bedding, the number and percentage of LH Dogs that had this bedding changed over the previous 12 months, and the types of materials used as bedding was described.

The number and percentage of LH Dogs that had their food placed on the floor of their shelter or run, and that had access to water from the confines of their shelter was determined. The types of containers used to hold food and water was described.

The number and percentage of LH Dog owners that had fed commercial dry dog food, farm kill (sheep, beef, horse, possum, hare, rabbit, goat, or deer), commercial dog mince or roll, sheep briskets, household scraps, commercial frozen dog food, or sheep offal to their LH Dogs over the previous 12 months was determined. The number and percentage of LH Dogs fed more than once a day, once a day, every second day, or less than every second day was also determined.

The number and percentage of LH Dog owners that gave anthelmintic drugs, vaccinations, or flea control treatments, and number and percentage of LH Dogs that had received anthelmintic drugs, vaccinations, or flea control treatments over the previous 12 months was identified. The types and/or sources of anthelmintic drugs and flea control treatments used by LH Dog owners were described.

Statistical analysis was conducted using R Version 2.7.0 (R Development Core Team, Vienna, Austria). Differences were considered statistically significant at $P < 0.05$.

4.4 Results

Of the 1,194 LH Dogs enrolled in the study the age at the commencement of training was unknown for 313 LH Dogs because they were acquired fully trained (n = 127), acquired partly trained (n = 30), had not commenced training at the time of the survey (n = 46), or because the owners could not recall the age at which training had been initiated (n = 110).

The median age at which training was initiated was known for 881 LH Dogs; the median age at which training was initiated was six months (minimum = two months, maximum = 84 months; Figure 4.6). The age at which LH Dogs initiated training varied significantly between male and female LH Dogs (P = 0.004; Table 4.1). The age at which their LH Dogs initiated training varied for 75 of the 198 LH Dog owners.

Of the 198 LH Dog owners that were interviewed 190 had trained a LH Dog during livestock herding activities over the previous 12 months while 127 LH Dog owners had trained a LH Dog in-between livestock herding activities. Of the 127 LH Dog owners that had trained a LH Dog in-between livestock herding activities all had used directional training while nine had used practise.

Although 1,194 LH Dogs were enrolled in the study a shelter description for 14 LH Dogs was not recorded. For the remaining 1,180 LH Dogs, 970 had shelters that had been built by a farmer while 170 shelters were commercially acquired shelters (Table 4.2). An additional 40 of LH Dogs were sheltered in ad hoc situations these being farm sheds (n = 13), vehicles (n = 11), on the veranda or in the garden of the LH Dog owner's house (n =9), inside the LH Dog owner's house (n = 4), and non-roofed cages (n = 3). Twenty-seven of the 198 LH Dog owners had sheltered at least one of their LH Dogs in a different shelter type to the other LH dogs on the farm over the previous 12 months. Of the 1,180 LH Dog shelters 220 had been cleaned over the previous 12 months, bedding was contained within 265, and 46 beddings had been changed at least once over the previous 12 months. The materials used as bedding included the following: woollen blankets, carpet, a sac, a sac of wool, a duvet, clothing, straw, sheep wool, a commercially produced dog hammock, sections of a foam mattress, and a vehicle foot-mat. Eight hundred and fourteen of the 1,180 LH Dogs whose shelter description was obtained had their food placed on the floor of the shelter or run, while 363 had their food placed in a container. Twenty-four LH Dogs did not have access to water from the confines of their shelter. The types of containers used to hold food and water in LH Dog shelters included aluminium bowls, kitchen pots, split drench containers, and purpose built water systems with floatation devices.

Of the 198 LH Dog owners 177 had fed their LH Dogs commercial dry dog food over the previous 12 months while 117 had fed sheep killed on the farm (Table 4.3). Seven LH Dog owners had fed one or more of their dogs a different diet. Frequency of feed was unknown for 14 of the 1,194 LH Dogs. Of the remaining 1,180 LH Dogs 24 had been fed more than once a day, 947 fed once a day, 158 fed every second day, 18 fed three times a week, six fed every third day, 20 fed on the days they had worked, and seven LH Dogs had been fed occasionally and for the rest of the time the LH Dog had scavenged (e.g.,

caught rabbits or drank cow's milk from milk shed). Forty-six LH Dog owners had fed at least one of their LH Dogs at a different frequency to their other LH Dogs.

Of the 1,180 LH dogs whose medication treatment history was known 994 had received anthelmintic drugs, 211 had been vaccinated, and 109 had been given a flea control treatment. One hundred and fifty-nine of the 198 LH Dog owners had given their LH Dogs anthelmintic drugs over the previous 12 months, 37 had vaccinated their LH Dogs, and 18 had given their LH Dogs a flea control treatment. Of the 159 LH Dog owners that had given their LH Dogs anthelmintic drugs over the previous 12 months 143 had received the drugs from a veterinarian via mail, nine had picked up the drugs from a veterinary clinic, three had used livestock parasite control treatments already on the farm, and two had acquired anthelmintic drugs from Ovis Management Ltd. One LH Dog of one LH Dog owner had a different anthelmintic drug routine to the other LH Dogs on the farm. This LH Dog was treated every six months with anthelmintic drugs from Ovis Management Ltd while the remaining four LH Dogs on the farm were treated every 12 months with anthelmintic drugs picked up from a veterinary clinic.

Flea control treatments used by LH Dog owners included those put onto the body of the LH Dog and those put into the shelter of the LH Dog. The variety of flea control treatments applied included the following: spot on treatments (such as the products 'Advantage', 'Frontline', 'Spot-on' and 'Duroguard'), de-flea powder and de-flea collars, livestock parasite control treatments, motor oil, and naturopathic oils. The variety of flea control treatments put into the shelter of a LH Dog included water, sulphur granules, zinc, on-farm products such as 'Asuntol' and 'Rip Cord', and chickens which were encouraged to roam around the LH Dog shelters so that they could eat any fleas. Two LH Dog owners had treated at least one of their LH Dogs for fleas in a different manner to the other LH Dogs on farm over the previous 12 months. The first LH Dog owner had treated 12 LH Dogs for fleas using a combination of sheep dip and flea collars, but had treated the remaining six LH Dogs on farm for fleas using 'Asuntol'. The second LH Dog owner had treated 10 LH Dogs for fleas using flea powder, but had treated the remaining one LH Dog on farm for fleas using a flea collar.

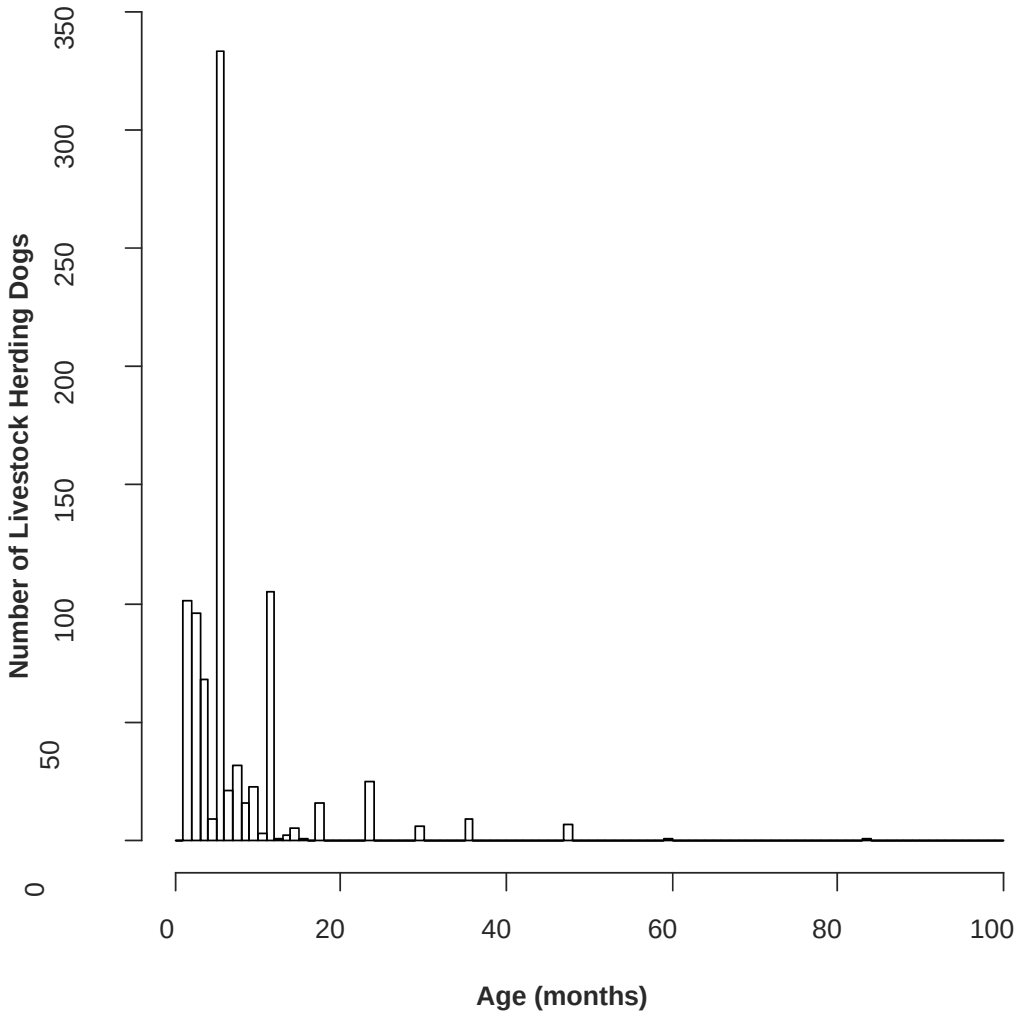

Figure 4.6: Histogram of the age (in months) that Livestock Herding Dogs initiated training. Data from 881 Livestock Herding Dogs for which the age that training was initiated was collected during a cross-sectional survey of 1,194 Livestock Herding Dogs on 119 Manawatau-Wanganui region farm.

Table 4.1: Descriptive statistics for the age (in months) at which of 881[a] Livestock Herding Dogs initiated training stratified by sex and group. Data gathered from a cross sectional survey of 1,194 Livestock Herding Dogs on 119 Manawatau – Wanganui region farms.

Variable	Level	Number of Livestock Herding Dogs	Minimum	Percentiles			Maximum	P-value [b]
				25th	50th	75th		
Sex	Female	358	2.00	3.00	6.00	7.00	48.00	0.004
	Male	523	2.00	4.00	6.00	9.00	84.00	
Group [c]	Hunt	475	1.50	4.00	6.00	9.00	84.00	0.07
	Head	352	1.50	3.75	6.00	8.00	48.00	
	Handy	39	1.50	4.00	6.00	8.00	24.00	

[a] Excludes 313 Livestock Herding Dogs because the age they commenced training was unknown. This was because of the following: the Livestock Herding Dog was acquired fully or partially trained (n = 157), the age the Livestock Herding Dog initiated training was unknown or (n = 110), or the Livestock Herding Dog had yet to begin training (n = 46).

[b] P value of Kruskal-Wallis test statistic for non-normally distributed continuous data.

[c] Excludes 15 Livestock Herding Dogs whose group was unknown or the Livestock Herding Dog was not a typical herding dog breed.

Table 4.2: Number and percentage of 1,140 [a] Livestock Herding Dogs sheltered in built by farmer and commercial Livestock Herding Dog shelters stratified by run type, run-floor material, and position of box. Data gathered from a cross sectional survey of 1,194 Livestock Herding Dogs on 119 Manawatau-Wanganui region farms.

		Built by farmer (n = 970)		Commercial (n = 170)	
Section	Description	n	%	n	%
Run type	Cage	834	86	170	100
	Chain	132	14	0	0
	Other	4	0	0	0
Run–floor material	Wood	801	83	170	100
	Dirt	126	13	0	0
	Concrete	43	4	0	0
Position of box	Elevated	712	73	137	81
	Ground level	258	27	33	19

[a] Excludes 54 Livestock Herding Dogs whose type of shelter was unknown (n = 14) and that were sheltered in ad hoc situations (n = 40).

Table 4.3: Number and percentage of 198 Livestock Herding Dog owners stratified by the types of foods they fed their Livestock Herding Dogs over the previous 12 months. Data gathered from a cross-sectional survey of 1,194 Livestock Herding Dogs on 119 Manawatau-Wanganui region farms.

Food type	Number [a]	%
Commercial dry food (any brand)	177	89
Farm kill - sheep	117	59
Commercial dog mince	58	29
Commercial dog roll	58	29
Sheep brisket	37	19
Commercial frozen dog food	25	13
Household scraps	16	8
Farm kill - beef	14	7
Other [b]	12	6
Sheep offal – raw	11	6
Sheep offal - boiled	5	3
Farm kill - horse	5	3
Farm kill - deer	3	2
Farm kill – possum, hare, rabbit	2	1
Farm kill – goat	2	1

[a] Some Livestock Herding Dog owners fed more than one food type.
[b] 'Other' included the following: dog food-supplements (n = 2), lamb or calf milk powder (n = 1), and cow milk (n = 9).

4.5 Discussion

This chapter reports on LH Dog husbandry and management practises as determined from a study designed to be representative of the LH Dog population in the Manawatau-Wanganui region of New Zealand. Specifically it presents information pertaining to following: the stage of training LH Dogs were at when acquired; how LH Dogs were trained; how LH Dogs were sheltered and feed; and whether LH Dog owners had provided and LH Dogs had received, anthelmintic drugs, vaccinations, and flea control treatments over the previous 12 months.

A discussion of the design features of this study which would have contributed positively towards the internal validity of the results is presented in Chapter Three. In summary, selection bias in this study was minimised by taking a random selection of farms. The study also collected information about all LH Dogs on the farm in the previous 12 months regardless of their current career stage thereby ensuring results were not biased towards healthier dogs and practises that prevent adverse health events. One issue that could not be removed, given the sensitive nature of some of the questions, was obsequiousness or response bias. For example, when asked questions about feeding practises and LH Dog sheltering LH Dog owners may have given answers that they believed were more politically, socially, or legally acceptable, or may have avoided reporting the truth. Nevertheless 6% of LH Dog owners noted they had fed a LH Dog raw sheep offal over the previous 12 month which is prohibited under the Control Area Notice that is in effect to limit the spread of *Echinococcus granulosus* (true hydatids). Livestock Herding Dog owners also described management practises which could be considered objectionable to society. For example, 2% of LH Dogs were described as not having access to water from within the confines of their shelter while 18% of LH Dogs were reported to have been fed less than once per day over the previous 12 months. Given LH Dog owners appeared to report LH Dog husbandry and management practises which could be considered politically, socially, or legally unacceptable the impact of obsequiousness or response bias may be minimal.

In our survey 96% of the LH Dogs whose shelter type was recorded were individually sheltered and had runs attached to the shelter. These runs varied and included cages, chains, or staked lines. Our findings were similar that of the Australian Working Dog Survey Report 2009 (Branson et al., 2009); the private industry working dog category of the Australian Survey, a category that included working farm dogs, also identified working dogs individually sheltered and confined to shelters by a chain or a yard. Interesting, both our study and the Australian Working Dog Survey Report 2009 identified the use of a vehicle to shelter a dog. Unfortunately the Australian Working Dog Survey Report 2009 did not identify what proportion of the 1,072 private industry Australian working dogs investigated were confined to an individual shelter by a chain, confined to an individual shelter by a yard, sheltered in a vehicle, or what proportion of the of private industry Australian working dogs were LH Dogs, and as such a more detailed comparison is not possible.

The results of this chapter indicate 69% of LH Dogs had their food placed on the floor of their shelter, but that only 19% of LH Dog shelters had been cleaned over the previous 12 months. The high proportion of LH Dog shelters that had not been cleaned may contribute to infection with micro-

organisms. For example, Hughes et al. (1987) suggest rural dogs may be exposed to a large number of *Toxocara canis* eggs if they are fed on grounds or kennel floors that are heavily contaminated with dog faeces, and that this may lead to the dog developing inflammatory eye disease via infection with *Toxocara* ocular larva migrans. Still, 74% of built by farmer and commercial LH Dog shelters were elevated, and may have been slatted, and as such it cannot be assumed that failure to clean a LH Dog shelter resulted in shelters or runs greatly burdened by dog faeces since the faeces may have dropped underneath.

While this study identified 82% of LH Dogs to be fed at least once per day Singh et al. (2011) identified 97% of LH Dogs to be fed once a day. It is possible this difference is due to Singh et al. (2011) investigating dogs whose owners were members of the NZSDTA as opposed to the general LH Dog population. Specifically, LH Dog owners involved with competition may feed their LH Dogs more often than LH Dog owners not involved with competition because LH Dog owners involved with dog trials are training 'high performance' LH Dogs. Noteworthy is that the impact of feeding a dog less than once per day has yet to be specifically evaluated; research to date tends to focus on what the diet of a dog with high exercise requirements should consist of (Hill, 1998; Hill et al., 1996; Hill et al., 2009; Kronfeld, 1973). Given it is reasonable to assume that LH Dogs fed less than once a day will suffer some performance issues research pertaining to the actual energy requirements of LH Dogs when under taking different activities will be valuable. In addition, education campaigns to inform LH Dog owners of the benefits of regular feeding may be warranted.

Six percent of the 198 LH Dog owners reported feeding their LH Dogs raw sheep offal over the previous 12 months. While this is a small number of LH Dog owners it is noteworthy as this practise is illegal given the whole of New Zealand is a controlled area for *E. granulosus*. Furthermore feeding of raw sheep offal (or meat that has not been cooked or frozen) is not advised as it may result in a dog becoming infected with *C. ovis,* thus facilitating the sheep measles life cycle. The tapeworm cysts (*C. Ovis)* mature into worms (*Taenia ovis)* within the dog's intestine and the worms shed eggs through the dog's faeces (Ovis Management Limited, 2012). Should the faeces fall onto grazing land sheep or goats may ingest the eggs. These eggs may later lead to cysticercosis in the sheep or goat's muscle tissue (Lawson, 1994; Blood and Studdert, 1988, p.249). Sheep and goats infected with *cysticerci* may be rejected as carcasses which therefore reduces the income of the producer. By extension the notion that New Zealand sheep and goats may be infected with *cysticerci* may reduce their export market value (Sweatman, 1962; Ovis Management Limited, 2012; Lawson, 1994). Infection with *C. ovis* is of particular concern when one considered that 15% of LH Dogs may not have been provided with anthelmintic drugs over the previous 12 months.

This study found that 80% of LH Dog owners had provided anthelmintic drugs to their LH Dogs, 19% of LH Dog owners had provided vaccinations, and 9% had treated their LH Dogs for fleas. Comparably higher provision of anthelmintic drugs over vaccinations and de-flea treatments is understandable given treating dogs with anthelmintic drugs reduces the risk of sheep measles being present in sheep carcasses, and by extension enables a LH Dog owner to safe-guard their income. Results indicate veterinary clinics provide the majority of anthelmintic drugs to LH Dog owners. This finding may suggest that veterinary

animal health promotion campaigns are more effective than those provided by other organisations such as Ovis Management Ltd. Results also indicate that the rate of vaccination was low. Still, it is important to acknowledge that LH Dogs do not often leave the farms on which they work and as such vaccination of LH Dog against diseases that are not believed present on the farm is unlikely to be a priority. Also low was the number of LH Dog owners that had treated their LH Dogs for fleas over the previous 12 months. Notably, this result does not mean to say that 91% of LH Dog owners had turned a 'blind-eye' to fleas on dogs and would not have treated a LH Dog had fleas be seen. Further on the subject of fleas it is important to recognise the variety of non-conventional de-flea agents that were used by LH Dog owners to de-flea their LH Dogs. Such alternatives included sulphur granules, livestock parasite control treatments, motor oil, and naturopathic oils. The effectiveness of these non-conventional de-flea treatments is unknown.

A relevant point with regards to training is that no clear definition of what constituted 'initiated training' was used in the questionnaire and as such when a dog was considered to enter (and leave) this category was subjective and likely to vary between owners. For example, one might consider training to have commenced when the dog is being taught basic commands such as sit, stay and come. While another owner may only consider a dog to have initiated training when they are learning how to interact with livestock The potential for there to be such variation in the interpretation of 'initiated training' means the results in Table 4.1 should be interpreted with caution because sex may not truly be an effect variable. In future, research pertaining to training should involve a clear definition of what represents 'initiated training'.

The design of this study aimed to gather data from a spatially balanced sample of farms. However 38% of farms from the primary GRTS farm sample had to be substituted with farms from sample two. Some of the farms from sample two could not be contacted or refused to participate. Additionally, 10% of the 316 farms that agreed to participate were unable to be interviewed prior to the end of the data gathering phase of the research project owing to weather conditions preventing the interviewer reaching the property, and because the participant and interviewer had been unable to meet at a mutually agreeable time. The areas where dogs were not investigated may manage their LH Dogs differently to other properties. For example, such farms may rely, more than other farms, on farm-produced dog foods owing to challenges 'getting out' to purchase commercial dog food during difficult weather patches. Properties with inflexible working schedules may manage their LH Dogs differently to other farms. For example, properties with rigid farming timelines may shelter their LH Dogs in shelters specifically designed for 'ease of access'. As the properties that were not investigated may have provided unique LH Dog management and husbandry data the results presented in this thesis cannot be said to be representative of all types of farms in the Manawatau-Wanganui region of New Zealand. Irrespective of the above points, this study did successfully achieve a random selection of Manawatau-Wanganui region farms. Subsequently the LH Dog management and husbandry data gathered ought to be representative of the areas of the Manawatau-Wanganui region that *were* examined. For two reasons, previously discussed in Chapter Three, the LH Dog husbandry and management findings of this thesis may not be applicable to the general population of LH Dogs of New Zealand. Primarily this is because the internal validity of the

study was threatened via non response and sampling bias which subsequently suggests the external validity of the research project is questionable. Secondly, the Manawatau-Wanganui region has a unique climate and geography which may impact on the way LH Dogs are managed. For example, Manawatau-Wanganui region LH Dog shelter designs may be predicated on the temperatures the region reaches. Therefore the LH Dog husbandry and management practises observed in this thesis may only be applicable to areas in New Zealand with environments comparable to the Manawatau-Wanganui region. Given all the points in the above paragraph the writer concludes the following: the results of this chapter provide insight into the way some New Zealand LH Dogs are sheltered, trained, fed, and managed; the LH Dog husbandry and management findings ought to be considered representative of areas of the Manawatau-Wanganui region that were investigated; the results may not reflect the way Manawatau-Wanganui region LH Dogs are managed on farms that are difficult to access during tumultuous weather or which have very strict farming schedules; and the findings ought only be extrapolated to areas of New Zealand with climatic and geographical conditions, and farm practises, comparable to that of the Manawatau-Wanganui region.

4.6 Conclusion

These findings provide important information about husbandry and management of LH Dogs by LH Dog owners in the Manawatau-Wanganui region of New Zealand. Six percent of LH Dog owners had fed a LH Dog raw sheep offal, 20% of LH Dog owners had not provided anthelmintic drugs to their LH Dogs over the previous 12 months, and 18% of LH Dogs were fed less than once per day. Lastly, LH Dog shelters varied greatly in their construction and in how they were managed.

Given a number of LH Dog owners had fed their LH Dogs raw sheep offal educating LH Dog owners about the importance of boiling sheep or goat offal, or cooking or freezing sheep or goat meat prior to it being consumed by a LH Dog, may be valuable. Livestock Herding Dog owners and LH Dogs may also benefit from research into the relationship between frequency of feed, and the performance, behaviour, and health a LH Dog. Such information would enable LH Dog owners to make informed decisions regarding how often they feed their LH Dogs.

Chapter 5: General discussion

5.1 Research findings

This thesis has reported on the demographics, and husbandry and management of Livestock Herding (LH) Dogs in the Manawatau-Wanganui region of New Zealand, as it was between July 2008 and July 2009.

Several of the design features of this study have contributed positively towards the internal validity of the results. Specifically, selection bias was minimised by taking a random sample of farms. Further, by gathering data for all LH Dogs that had been on the farm over the previous 12 months irrespective of their present career stage the results were not biased towards practises that prevent adverse health events or towards healthier dogs. By contrast, given the sensitive nature of some of the questions obsequiousness and response bias could not be avoided. Specifically LH Dog owners may have modified their answers to questions pertaining to the following: the cause of a LH Dog's death, the number of pups born on the farm and the fate of these pups, training methods, feeding practises, and shelter provided to LH Dogs over a 12 month period. Nevertheless LH Dog owners did appear to be prepared to provide answers that could have been considered politically, socially or legally unacceptable such as the death of 60% of pups bred on farms, and the feeding of raw sheep offal by 6% of LH Dog owners. Therefore obsequiousness and response bias may not have heavily influenced the results of this study.

Similar to the studies of Singh et al. (2011) and Cave et al. (2009) this study identified the New Zealand Huntaway (50% of our study population) and New Zealand Heading dog (37% of our study population) to be the principle type of LH Dog used to herd livestock. As per the findings of Cave et al. (2009) the neutering of LH Dogs was found to be uncommon since only 2% of our study population were neutered males while only 4% were neutered females. Such low rates of neutering are of concern because they expose a LH Dog to experience of neuter-responsive health problems such as pyometra/endometritis, mismatching, and dystocia; all of which were reported as reproductive tract health problems of LH Dogs in the study of Cave et al. (2009). In addition failure to neuter may increase the risk of a LH Dog experiencing behavioural problems such as inter-dog aggression (Overall, 2007), which may be a risk factor for adverse health events caused by trauma. Lastly LH Dogs that are not neutered are capable of reproducing unwanted pups. This may be a significant burden to LH Dog owners since 46% of pups bred on farms were euthanised by the LH Dog owner soon after they were born. Research and education surrounding the neutering of LH Dog is warranted.

Comparable to the results of Singh et al. (2011) our study population was relatively young; while our study population had a median age of four years the study population of Singh et al. (2011) had a median age of three years. It is worth highlighting that the median age of LH Dogs reported by Singh et al. (2011) and in our study differed by one year. A possible explanation for the difference is that Singh et al. (2011) studied dogs whose owners belonged to the New Zealand Sheep Dog Trial Association as opposed to the general LH Dog population, and Sheep Dog Trial Association members may sell, give away, or euthanise their LH Dogs sooner than the general LH Dog owner population bringing about a lower LH Dog median age. Research to validate this hypothesis would be necessary.

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With respect to LH Dog feeding practises of interest was that 6% of LH Dog owners had fed raw sheep offal to their LH Dogs over the previous 12 months. As the whole of New Zealand (bar Arapawa Island) has been declared a controlled area for *Echinococcus granulosus* (true hydatids) (Ministry for Primary Industries, 1996) this practise is illegal. Furthermore, the sheep measles life cycle is maintained via the feeding of raw sheep or goat offal to a dog which is of particular concern to livestock producers. Primarily this is because if a producer's sheep or goat carcasses are found to be infected with *Cysticercus ovis* cysts the carcasses may be rejected and thus the income of the producer may be reduced (Sweatman, 1962; Ovis Management Limited, 2012; Lawson, 1994). In addition the perception that New Zealand carcasses are infected with *cysticerci* is problematic at national level since this phenomenon may lead to suppression of their export market value. Given some LH Dog owners had fed raw sheep offal to their LH Dogs it may be pertinent to better publicise that there is still a Controlled Area Notice to limit the spread of *E. granulosus* and for Ovis Management Ltd to up their sheep measles education programmes. Further, given 20 % of LH Dog owners had not provided anthelmintic drugs to their LH Dogs over the previous 12 months new awareness campaigns regarding the applicability of anthelmintic drugs to the limitation of the spread of sheep measles and *E. granulosus* may be necessary.

Another point of interest is the variety of LH Dog shelters reported in this study. Livestock Herding Dog shelters were found to differ in the way they were constructed, in the number of times they were cleaned, where a LH Dog's food was placed within the shelter, whether the LH Dog had access to water within the confines of the shelter, whether the LH Dog was provided with bedding, and the types of containers used to hold food or water. It is possible these LH Dog shelter features are related to a LH Dog's experience of health. Subsequently, future research ought to investigate the relationship between LH Dog shelters and LH Dog health outcomes.

While this study was designed to obtain a spatially balanced sample of farms 38% of the initial GRTS farm sample were replaced with farms from sample two, and some of the sample two farms could not be contacted or refused to participate. Additionally, 10% of the 316 farms that had agreed to participate were unable to be interviewed prior to the end of the sampling period because the LH Dog owner and the researcher had persistently conflicting schedules, and because bad weather prevented the researcher from reaching the farm. Since the properties that were not investigated may have had LH Dogs with unique demographical features, or the husbandry and management of LH Dogs on these farms may have been uncommon, the results presented in this thesis cannot be said to be representative of all types of farms in the Manawatau-Wanganui region of New Zealand. Still, it is the writer's opinion that the achievement of a random sample of farms was advantageous, to the point that the findings of the studies presented here ought to be representative of the areas, and types of farms, ultimately researched. Having previously noted that the study experienced threats to its internal validity, such as non-response and sampling bias, the external validity of findings is uncertain since external validity is predicated on internal validity. Even if the internal validity of this research project had been more robust whether the results of this study could have been extrapolated to the general population of LH Dogs throughout New Zealand is debatable. Primarily this is because the Manawatau-Wanganui region has a unique climate and

geography which affects the way livestock are farmed, and this variability in farming style may influence the demographics, and husbandry and management of Manawatau-Wanganui region LH Dogs. Overall the writer concludes the following about the findings presented in this thesis: the results provide insight into the demographics of some New Zealand LH Dogs and into some LH Dog husbandry and management practises in New Zealand ; the findings should be considered representative of the areas of the Manawatau-Wanganui region that were investigated; the findings may not indicate the demographics or management of LH Dogs on Manawatau-Wanganui region farms that are challenging to access during poor weather conditions or which have very strict farming schedules; and the results should only be extrapolated to areas of New Zealand with geographic and climatic conditions, and by extension farming practises, comparable to that of the Manawatau-Wanganui region of New Zealand.

5.1.1 Topics for future research

Building on work by Cave et al. (2009) and Singh et al. (2011) the current study has identified a number of areas for future research. Given Huntaways and Heading dogs have been identified as the most common type of LH Dogs used to herd livestock Huntaways and Heading dogs should be the priority of future investigations since this will serve the widest audience. Of immediate interest may be research into diseases previously hypothesised as a concern for the New Zealand Huntaway such as hip dysplasia (Hughes, 2001), Mucopolysaccharisdosis IIIA (Sanfilippo syndrome) (Yogalingam et al., 2001; Jolly et al., 2000a), dilated cardiomyopathy (Munday et al., 2006), and gastric dilatation or gastric dilatation and volvulus (Hendriks et al., 2012). Though research specific to the relationship between New Zealand Heading dog genetics and disease has yet to be initiated neuraxonal dystrophy (Clark et al., 1982) and cerebellar degeneration (Gill and Hewland, 1980) have been identified as possible inherited diseases in ‘collie sheep dogs’ and Border Collies (respectively) and thus investigation into the inheritability of neuraxonal dystrophy and cerebellar degeneration in New Zealand Heading dogs may be a good place to start.

Previous research has identified a relationship between sexually intact dogs and certain types of behavioural problems such as inter-dog aggression (Overall, 2007). Subsequently leaving a LH Dog sexually intact may be a risk factor for experience of adverse health caused by trauma. Previous research has also identified cases of LH Dogs experiencing adverse health problems that could have been avoided had the LH Dog been neutered such as the cases of pyometra/endometritis, mismatching, and dystocia reported in the study of Cave et al. (2009). Given sexually intact dogs may be at greater risk of experiencing behavioural problems or reproductive tract health problems in comparison to neutered dogs it would not have been surprising to find the majority of LH Dogs in this study had been neutered for precautionary reasons since behavioural or reproductive tract problems have the capacity to interfere with a LH Dog’s ability to herd. However our study identified very low rates of neutering. Subsequently future research ought to identify two things. Firstly, the reason for keeping LH Dogs sexually intact ought to be ascertained. Such information would enable the design of relevant neutering awareness campaigns. Secondly, the relationship between neuter status and LH Dog performance ought to be investigated. Such insight would assist LH Dog owners to make more educated LH Dog neutering decisions.

Many elements could be investigated with regards to LH Dog sheltering given the wide variety of situations LH Dogs were sheltered in. For example the relationship between how often a shelter is cleaned and the volume and type of microorganisms in a LH Dog's shelter that could be spread to livestock ought to be researched. Overall any insights gained into the relationship between LH Dogs sheltering and LH Dog health, and LH Dog sheltering and health outcomes for the other animals on a farm, would be beneficial to the New Zealand livestock farming community.

5.1.2 Design of research

Although the methods described in this thesis offer one approach for the gathering of LH Dog demographic, and husbandry and management data it must be emphasised that travelling to highly dispersed farms to interview LH Dog owners who have full work schedules is both costly, financially and in terms of time, and complex.

Using the categories presented in this chapter it may be possible to post a survey to LH Dog owners when gathering future LH Dog demographic data. A postal survey would remove the need to travel and would allow the LH Dog owner to fill in the survey when most convenient. However it should be noted that for some of the categories used in this thesis, such as shelter types and training methods, qualitative information was gathered and the categorises were determined at the end of the study period. Therefore a LH Dog postal survey would need to include extensive explanations as to what constituted each category in order for the data gathered to be consistent. Of particular concern would be the categorisation of LH Dog career stages, group, training, and sheltering since categorisation of these variable proved to be difficult during analysis. It is also noteworthy that a postal survey requires the recipient to have a degree of literacy.

An alternative to a postal survey is a telephone survey. A telephone survey would remove the need to post category explanations to the LH Dog owner. Instead the researcher could categorise responses as they were received over the telephone. In addition a telephone survey is cheaper than travelling to a farm. That noted, whether or not a telephone survey is faster than waiting for a response via mail is dependent on whether the researcher telephoned when the LH Dog owner was available to receive a call. In the context of interviewing farmers this assumes that the researcher telephoned before the LH Dog owner left the house for the day, or after the LH Dog owner had returned home but before the LH Dog owner had gone to bed. An additional important point to note with respect to telephone surveys is that this survey method can only be conducted on those who have a telephone.

Irrespective of the mode of data collection the importance of confidentiality to a LH Dog owner cannot be overlooked. Confidentiality is especially important when gathering sensitive data such as number of pups born or fate of pups.

5.2 Conclusion

In conclusion this thesis has reported on the demographics, and husbandry and management of LH Dogs in the Manawatau-Wanganui region of New Zealand between July 2008 and July 2009. Future research ought to consider the relationship between LH Dog breed or type, neuter status, training, feeding and sheltering, and LH Dog health and performance outcomes.

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Appendices

Appendix 1: Letters sent to selected farms

The following is the first letter sent to selected farms:

[DATE]

[NAME]

[ADDRESS]

Dear [Name],

Hello, my name is Amy Jerram. I am a Masters student at Massey University, Palmerston North.

As a sheep and beef farmer's daughter I am very passionate about New Zealand agriculture. For my Masters thesis is am researching New Zealand working sheep dogs.

In order for me to complete my research I will need to collect data from farms within the Manawatau – Wanganui region of New Zealand. I have used a random sampling method to locate farms from within this region to study. You have been selected as one of these farms.

Over the next few months I would like to travel to your farm to conduct an interview relevant to your working sheep dogs. This interview will take approximately 30 minutes to complete.

The data collected will be analysed to identify common health problems and risk factors for health problems in working sheep dogs. In order for this study to be a success I need to the support of the farming community.

I will contact you shortly to discuss this with you. If you would like to contact me before this time my cell phone number is [PHONE NUMBER] and my email address is [EMAIL ADDRESS].

Thank you for taking the time to read this and I look forward to speaking to you.

Kind regards,

Amy Jerram

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The following is the second letter sent to farms that had agreed to participate:

[DATE]

[NAME]

[ADDRESS]

Dear [Name],

I am writing regarding the working sheep dog research. I spoke to you some time ago about the possibility of interviewing you about your working sheep dogs. Thank you for agreeing to partake.

I am hoping to interview you when you are available on the [DATE], between [TIME and TIME]. I hope that this gap will include a time you would normally have a break in, so as not to disturb your day schedule too much.

I will ring several days before I am due to arrive to organise an interview time and location, and to check that I am heading in the correction direction!

Thank you very much for taking the time to read this and I hope your week has been going well.

Kind regards,

Amy Jerram

Appendix 2: Forms used in data collection

The following is the form used to collect farm-level data:

SECTION 1 – FARM LEVEL DATA

S0_1 FARM ID _____ S0_2 NUMBER OF DOGS

FARMING OPERATION

S1_1_1 SHEEP ☐ S1_1_2 BEEF ☐

S1_1_3 DEER ☐ S1_1_4_1 OTHER ☐

S1_1_4_2 OTHER DESCRIPTION ☐

_____

_____

S1_2 SIZE OF FARM

CONTOUR TYPE

S1_3_1 ROLLING ☐ S1_3_2 FLAT ☐ S1_3_3 EASY HILL ☐

S1_3_4 MEDIUM HILL ☐ S1_3_5 STEEP ☐ S1_3_6 HIGH COUNTRY ☐

NUMBER OF ANIMALS

S1_4_1/2 SHEEP ☐

_____

S1_4_3/4 DEER ☐

_____

S1_4_5/6 BEEF CATTLE ☐

_____

S1_4_7/8 DAIRY CATTLE ☐

_____

S1_4_9/10 OTHER ☐

_____

The following is one of two forms used to collect owner-level data:

SECTION 2 PART ONE - OWNER LEVEL DATA						
USER ID	**FARM ID**	**GENDER**	**AGE**	**YOUR JOB TITLE**	**HOW DO YOU DECIDE WHEN A DOG IS READY TO BE TRAINED OR TO START WORKING**	**NUMBER OF YEARS WORKING WITH DOGS**
S2_1	S2_2	S2_3	S2_4	S2_5	S2_6	S2_7

The following is one of two forms used to collect owner-level data:

SECTION 2 PART TWO - OWNER LEVEL DATA		
S2_1 User ID	S2_2 Farm ID	Management of dogs
		S_2_8_1/2 Collar_____
		S_2_8_3/4Chain_____
		S2_8_5/6 Bowls_____
		S2_8_7/8 Bedding_____
		S2_8_9/10 Flea_____
		S2_8_11/12 Worms_____
		S2_8_13/14 Housing_____
		S2_8_15/16 Veterinary care_____
		S2_8_17/18 Training_____
		S2_8_19/20 Transport_____
		S2_8_21/22 Covers_____
		S2_8_23/24 Dog equipment_____
		S2_8_25/26 Food_____

The following is one of four forms used to collect dog-level data:

SECTION 3A PART ONE – INFORMATION ABOUT DOGS CURRENTLY ON FARM[8]		
S3_1 NAME OF DOG		
S3_2 USER ID		
S3_3_1 AGE (MONTHS)	S3_4_1 SEX M F	S3_4_2 ENTIRE Y N
S3_5 BREED		
S3_6 HOUSING		
S3_7 STOCK WORKED		
S3_8_1 FEED (TYPE AND TIME)		
S3_8_2 TYPICAL Y N		
S3_9 INSURED Y N	S3_10_1 REGISTERED Y N	S3_10_2 WEARING TAG Y N
S3_11_1 VAC Y N	S3_11_2 VAC TYPE	
S3_12_1 WORM Y N	S3_12_2 PRODUCT	S3_12_3 FREQ
S3_13_1 FLEA Y N	S3_13_2 PRODUCT	S3_12_3 FREQ
COMMENT		

[8] Not retired

The following is one of four forms used to collect dog-level data:

SECTION 3A PART TWO – HEALTH PROBLEMS EXPERIENCED OVER THE PREVIOUS 12 MONTHS, BY DOGS CURRENTLY ON FARM[9]					
S3_14_1/2	EYE		S3_24_1/2	FENCE	
S3_15_1/2	LEG		S3_25_1/2	LIVESTOCK	
S3_16_1/2	SKIN		S3_26_1/2	VET DIAGNOSIS	
S3_17_1/2	BARK		S3_27_1/2	WEIGHT	
S3_18_1/2	PADS		S3_28_1/2	BREATHING	
S3_19_1/2	EAR		S3_29_1/2	WORMS	
S3_20_1/2	OPERATION		S3_30_1/2	FLEAS	
S3_21_1/2	ACCIDENT		S3_31_1/2	HAIR	
S3_22_1/2	VEHICLE		S3_32_1/2	FEEDING HABIT CHANGE	
S3_23_1/2	OTHER DOG		S3_33_1/2	BEHAVIOURAL	
COMMENT					

[9] Not retired

The following is one of four forms used to collect dog-level data:

SECTION 3B PART ONE – INFORMATION ABOUT DOGS DEAD, DESTROYED (DY) OR RETIRED ON FARM OVER PREVIOUS 12 MONTHS		
S3_1 NAME OF DOG		
S4_2_0 USER ID	S4_2_2 D DY R	S4_2_3 TYPE
S4_3_1 AGE (MONTHS)	S4_4_1 SEX M F	S4_4_2 ENTIRE Y N
S4_5 BREED	S4_5_4 REASON	
S4_6 HOUSING		
S4_7 STOCK WORKED		
S4_8_1 FEED (TYPE AND TIME)		
S4_8_2 TYPICAL Y N		
S4_9 INSURED Y N	S4_10_1 REGISTERED Y N	S4_10_2 WEARING TAG Y N
S4_11_1 VAC Y N	S4_11_2 VAC TYPE	
S4_12_1 WORM Y N	S4_12_2 PRODUCT	S4_12_3 FREQ
S4_13_1 FLEA Y N	S4_13_2 PRODUCT	S4_12_3 FREQ
COMMENT		

The following is one of four forms used to collect dog-level data:

SECTION 3B PART TWO – HEALTH PROBLEMS EXPERIENCED OVER THE PREVIOUS 12 MONTHS, BY DOGS THAT DIED, WERE DESTROYED OR WERE RETIRED OVER THE PREVIOUS 12 MONTHS					
S3_14_1/2	EYE		S3_24_1/2	FENCE	
S3_15_1/2	LEG		S3_25_1/2	LIVESTOCK	
S3_16_1/2	SKIN		S3_26_1/2	VET DIAGNOSIS	
S3_17_1/2	BARK		S3_27_1/2	WEIGHT	
S3_18_1/2	PADS		S3_28_1/2	BREATHING	
S3_19_1/2	EAR		S3_29_1/2	WORMS	
S3_20_1/2	OPERATION		S3_30_1/2	FLEAS	
S3_21_1/2	ACCIDENT		S3_31_1/2	HAIR	
S3_22_1/2	VEHICLE		S3_32_1/2	FEEDING HABIT CHANGE	
S3_23_1/2	OTHER DOG		S3_33_1/2	BEHAVIOURAL	
COMMENT					