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Does kiwi aversion training reduce
canine (*Canis familiaris*) predation on
kiwi (*Apteryx* spp.)?

Arnja Rose Dale

A thesis submitted in fulfilment of the requirements
for the degree of Doctor of Philosophy in Psychology,
The University of Auckland, 2014

Abstract

The use of positive punishment in dogs (*Canis familiaris*) is controversial, in particular, the use of electric training collars. The aim of the research presented in this thesis was to investigate the effectiveness and potential welfare compromise of using electric collars in dogs. This was explored using the New Zealand Department of Conservation Kiwi Aversion Training (KAT) programme which was developed to mitigate the significant predation risk that dogs pose to the endangered, ground-dwelling kiwi (*Apteryx* spp.). KAT aims to balance kiwi conservation and the need, or desire, for dogs to be used for hunting purposes within kiwi habitat. It involves a training session in which a dog is presented with kiwi aversion training stimuli (taxidermist and frozen kiwi; kiwi feathers, faeces and nesting material; two-dimensional kiwi) and a brief period (0.5-1.5 s) of aversive electrical stimulation from an electric shock collar is applied when the dog makes contact with the training stimuli. This research indicates that KAT effectively produces aversion towards the training stimuli that generalizes to another location, is independent of the electric collar being worn, and that lasts at least one year after training. Lower levels of avoidance were seen in older dogs being trained for the first time, dogs from single-dog households, dogs used to hunt pigs, non-sporting breed dogs and dogs that had a three-year gap or longer between KAT sessions. Increased sessions of KAT, increased the avoidance the dogs displayed to the training stimuli. In simulated hunting conditions, the majority of dogs avoided the training stimuli with the presence of human or canine conspecifics not significantly changing the dog's behaviour, although there was less avoidance exhibited when the dogs were with their hunting pack. Hunting dogs showed more avoidance than pet dogs to the training stimuli, took less time to detect it, and did so from the furthest distance. The individual aversion training stimuli were investigated to see if they were ecologically valid when tested with a live bird. The majority of dogs did not generalise from the training stimuli to the live bird, however, all dogs that underwent KAT using a live bird did. All dogs displayed behaviours indicative of pain and stress from the electric shock, with the response being significantly affected by the shock intensity, number and timing of the shocks. Post-shock the occurrence of stress behaviours significantly increased, with the majority of dogs displaying at least four stress behaviours. When presented with the training stimuli one month later, all dogs displayed stress behaviours, with the majority of dogs displaying at least four stress behaviours. When present with the training stimuli one year later, 87% of the dogs displayed stress behaviours with two-thirds of the dogs displaying at least four stress behaviours. Significant differences were seen between the training competencies of the KAT trainers. 64% of dog owners considered the use of electric collars to be an effective training technique, with 59% considering that their use poses a welfare concern for the dogs. This study found that the use of electric collars was extremely effective at producing avoidance to the KAT training stimuli, however this avoidance did not translate to the avoidance of live birds; and negatively impacted on the short-term and long-term welfare of the dogs. Whilst it is acknowledged that there are ethical and practical difficulties, it is recommended that the use of live kiwi for aversion training be explored, on the proviso that it can be categorically proven to effectively reduce canine predation on kiwi. Further investigation on the minimum electric shock intensity required to produce avoidance using live kiwi is required, in conjunction with improvements to training standards in order to safe guard the welfare of the dogs, combined this may make this aversion training justifiable from a kiwi preservation and conservation perspective.

Key words: *Canis familiaris*, *Apteryx*, aversion conditioning, electric collar training, shock, depredation

*This thesis is dedicated to all
those who walked before us,
and all those who walk alongside us*

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Thesis related publications

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Dale, A.R. 2011. Does the Department of Conservation Kiwi Aversion Training programme work? Regional International Society for Applied Ethology Meeting: Australasia and Africa. Auckland, New Zealand. 8th October, 2011.

Dale, A.R., Statham, S. 2011. Can Kiwi Aversion Training Reduce Canine Predation on Kiwi (*Apteryx* spp.)? Research Symposium, Unitec Institute of Technology, Auckland, New Zealand. 20th October, 2011.

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Dale, A.R., Podlesnik, C.A., Elliffe, D. 2013. Does the use of models in canine aversion training mimic the real thing? Research Symposium, Unitec Institute of Technology, Auckland, New Zealand. 3rd October, 2013.

Dale, A.R. 2013. Electric Collars and the Animal Welfare Act 1999. New Zealand Companion Animal Council Conference, Auckland, New Zealand. 7th - 8th October, 2013.

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Dale, A.R., Podlesnik, C.A., Elliffe, D. 2013. Can models be used successfully to mimic the real thing to prevent canine predation of an endangered species? Inaugural Australian Working Dog Conference, Sydney, Australia. 4th - 5th November 2013.

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Dale, A.R., Podlesnik, C.A., Elliffe, D. 2014. Evaluation of an aversion-based programme designed to reduce predation of native birds by dogs: An analysis of training records for 1156 dogs. Submitted to *Applied Animal Behaviour Science*.

Table of contents

Chapter One: General Introduction.....	1
1.1 Introduction	1
1.2 Methods of mitigating the risks that dogs pose to kiwi.....	2
1.3 Research aims and thesis structure	3
1.4 References	5
Chapter Two: The use of electric collars in dog training	9
2.1 Introduction	9
2.2 The use of positive punishment.....	10
2.3 Electric collars	12
2.4 Canine stress and welfare	17
2.4.1 Behavioural measurements	19
2.4.2 Physiological measurements.....	21
2.5 Aversive conditioning	23
2.5.1 Responses to the actual electric shock.....	24
2.5.2 Timing of the electric shock	25
2.5.3 Strength of electric shock	26
2.5.4 Increasing the level of electric shock.....	27
2.5.5 The ability to control and predict electric shocks	28
2.5.6 Learned helplessness.....	29
2.5.7 Importance of relevant neutral stimulus	30
2.5.8 Individual and breed differences in response to electric shock	32
2.5.9 Brain changes resulting from electric shocks	32
2.6 Conclusion and animal welfare implications	33
2.7 References	35

Chapter Three: The acquisition and maintenance of dogs' aversion responses to kiwi (<i>Apteryx</i> spp.) training stimuli across time and locations	73
3.1 Abstract	73
3.2 Introduction.....	73
3.3 Methods.....	76
3.3.1 Animals	76
3.3.2 Procedures	76
3.3.3 Canine response rating	77
3.3.4 Statistical analysis	77
3.4 Results.....	78
3.5 Discussion.....	79
3.6 References.....	82
Chapter Four: Evaluation of an aversion-based program designed to reduce predation of native birds by dogs: An analysis of training records for 1156 dogs.....	85
4.1 Abstract	85
4.2 Introduction.....	85
4.3 Material and methods.....	87
4.3.1 Test subjects	87
4.3.2 Aversion training methodology.....	88
4.3.3 Behavioural response to the training stimuli.....	89
4.3.4 Statistical Analysis	90
4.4 Results.....	90
4.5 Discussion	96
4.6 References.....	100
Chapter Five: Do hunting dogs receiving Kiwi Aversion Dog Training Programme (KAT) change their hunting behaviour when alone, with their handler, or with their pack?.....	103
5.1 Abstract	103

5.2	Material and methods	105
5.2.1	Test subjects.....	105
5.2.2	Aversion-training methodology	106
5.2.3	Site location	108
5.2.4	Experimental Procedure.....	108
5.2.5	Behavioural observations.....	109
5.2.6	Statistical Analysis.....	110
5.3	Results	110
5.3.1	Time to detect the presence of the KAT stimuli.....	111
5.3.2	Detection distance of the KAT stimuli	111
5.3.3	Behaviour when the dog was alone	112
5.3.4	Behaviour when the dog was with its handler	112
5.3.5	Behaviour when the dog was with its hunting pack	113
5.3.6	Repeat exposure to the KAT stimuli.....	113
5.3.7	Demographic effects	114
5.3.8	Pack size effect	114
5.3.9	Number of times through the KAT programme	115
5.3.10	Effect of temperature	116
5.3.11	Effect of humidity.....	116
5.3.12	Effect of wind speed.....	116
5.4	Discussion.....	117
5.4.1	Time taken to detect the presence of the KAT stimuli	117
5.4.2	Distance that the KAT stimuli was detected.....	117
5.4.3	Dogs with their handler.....	118
5.4.4	Dogs with their hunting pack.....	118
5.4.5	Order of testing sessions	119
5.4.6	Demographic variables	119

5.4.7	Environmental conditions	121
5.4.8	KAT stimuli compared to live prey.....	123
5.5	Conclusion	124
5.6	References.....	125
Chapter Six: Can dogs generalise from 'ecologically relevant' training stimuli of the endangered kiwi (<i>Apteryx</i> spp.) to live kiwi?.....		131
6.1	Abstract	131
6.2	Introduction.....	132
6.3	Material and methods.....	133
6.3.1	Test subjects	133
6.3.2	Field Sites.....	134
6.3.3	Group allocations	134
6.3.4	Aversion-training methodology	135
6.3.5	Live chicken testing methodology	135
6.3.6	Behavioural response to the training stimuli.....	136
6.3.7	Statistical Analysis	137
6.3.8	Ethical approval.....	137
6.4	Results.....	137
6.4.1	Time taken to detect the presence of the live chicken.....	139
6.4.2	Distance taken to detect the presence of the live chicken	141
6.4.3	Response to the live chicken in the test sessions	141
6.4.4	Response to the live chicken in the five minute and ten minute exposure tests	141
6.5	Discussion.....	141
6.6	References.....	147
Chapter Seven: Short and long-term reactions of 220 dogs to different intensity levels of an electric shock collar in a large-scale canine depredation conditioning programme.		157
7.1	Abstract	157

7.2	Introduction	158
7.3	Methods	159
7.3.1	Test subjects.....	159
7.3.2	Field sites	161
7.3.3	Aversion-training methodology	161
7.3.4	Canine response rating to electric shock.....	162
7.3.5	Stress responses measured	163
7.3.6	Owner survey	163
7.3.7	Statistical analysis.....	164
7.3.8	Ethics approvals	164
7.4	Results	164
7.4.1	Response to the electric shock	164
7.4.2	Comparison of stress responses before and after the electric shock.....	166
7.4.3	Occurrence of stress responses after the electric shock.....	168
7.4.4	Stress behaviours one-month and one-year later when presented with the KAT stimuli.....	168
7.4.5	Effect of the trainer on the response to the shock.....	168
7.4.6	Owners' survey responses	169
7.5	Discussion.....	171
7.6	References	176
	Chapter Eight: General conclusions and recommendations.....	179
8.1	Conclusions	179
8.2	Recommendations for the Department of Conservation Kiwi Aversion Training programme	184
8.3	Recommendations for dog training in New Zealand.....	186
8.4	Final conclusion.....	186

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Chapter 2 is a published paper entitled 'The acquisition and maintenance of dogs' aversion responses to kiwi (*Apteryx* spp.) training stimuli across time and locations'. This paper was published in 2013 in the journal of Applied Animal Behaviour Science, volume 146, pages 107-111.

Nature of contribution by PhD candidate: Had the research idea, designed the research experiment, undertook the fieldwork, analysed the data and wrote the manuscript.

Extent of contribution by PhD candidate (%): 80%

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Dr Christopher Podlesnik	Supervision and editing of the manuscript for publication (7%)
Shivaun Statham	Assisted with the fieldwork and filming (6%)

Certification by Co-Authors

The undersigned hereby certify that:

- ❖ the above statement correctly reflects the nature and extent of the PhD candidate's contribution to this work, and the nature of the contribution of each of the co-authors; and
- ❖ in cases where the PhD candidate was the lead author of the work that the candidate wrote the text.

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Chapter 3 is a manuscript that has been submitted for consideration of publication to the journal of Applied Animal Behaviour Science.

Nature of contribution
by PhD candidate

Had the research idea, designed the research experiment, obtained the data, analysed the data and wrote the manuscript.

Extent of contribution
by PhD candidate (%)

80%



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Dr Christopher Podlesnik	Supervision and editing of the manuscript for publication (10%)

Certification by Co-Authors

The undersigned hereby certify that:

- ❖ the above statement correctly reflects the nature and extent of the PhD candidate's contribution to this work, and the nature of the contribution of each of the co-authors; and
- ❖ in cases where the PhD candidate was the lead author of the work that the candidate wrote the text.

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Associate Professor Doug Elliffe		23/04/2014
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Chapter One: General Introduction

This chapter includes background information relevant to the overall aims of the experimental work and an overview of the structure of the thesis.

1.1 Introduction

Domestic dogs (*Canis familiaris*) and humans have had a close relationship for over 15,000 years (Driscoll and Macdonald, 2010; Vila et al., 1997) with the current global population estimate being 500 million dogs (Vanak and Gompper, 2009; Wandeler et al., 1993). Dogs have diverse and complex roles within human communities, predominantly being owned for companionship in the Western world (Serpell, 1995). In New Zealand, dogs are the most significant threat to the survival of the endangered, endemic kiwi (*Apteryx* spp.) (Robertson, 2011). The kiwi is *taonga* (treasure) to Māori (indigenous people of New Zealand), is equally treasured by all cultures in New Zealand, and is a significant national icon (Holzapfel et al., 2008). The North Island brown kiwi is classified as “Nationally Vulnerable” (Robertson et al., 2013) and kiwi abundance in most North Island forests has declined by at least 90% over the last century (McLennan et al., 1996). Habitat destruction is an important factor in this, but most of the decline is due to predation by introduced pests such as ferrets (*Mustela putorius*), possums (*Trichosurus vulpecula*), stoats (*Mustela erminea*), cats (*Felis catus*) and dogs (McLennan et al., 1996; Pierce and Sporle, 1997). Dogs are the primary killer of adult kiwi (Holzapfel et al., 2008), and this predation can cause catastrophic declines in local populations (Pierce and Sporle, 1997; Taborsky, 1988) and can strongly influence population trends by significantly reducing the life expectancy of adults in some areas (e.g. Northland) (Holzapfel et al., 2008).

Given the threat that dogs pose to kiwi, banning dogs from areas where kiwi live would appear to be the simplest solution but this is impractical for many reasons. Some kiwi habitats are either privately owned or adjacent to private land, or are publicly owned land where dogs are allowed. Dogs also provide benefits in reducing introduced predators and grazing species that damage kiwi habitat by assisting hunters to locate

these animals, and dogs are commonly used and considered necessary for hunting feral pigs (*Sus scrofa*), deer (*Cervus* spp.) and goats (*Capra hircus*), especially in remote areas. The Department of Conservation (DOC) considers this an essential method of pest control. In addition to this, it is considered that the prohibition of dogs from kiwi habitat may impact negatively on kiwi conservation if DOC's dog-control approach is perceived by dog owners as too rigid or inconsistent, even though kiwi conservation is an issue that is well supported by the New Zealand public (James, 2000).

1.2 Methods of mitigating the risks that dogs pose to kiwi

Given that there are approximately 700,000 dogs in New Zealand (Mackay, 2011), a solution was sought that would allow dogs to be used for recreational and professional hunting in conservation areas containing kiwi populations while minimizing the risk to kiwi. Accordingly, the DOC developed the Kiwi Aversion Dog Training Programme (KAT), which is predominantly funded by the Bank of New Zealand Kiwi Recovery Trust. The KAT procedure involves a training session in which a dog is presented with one or more kiwi stimulus (taxidermist kiwi; frozen dead kiwi; kiwi faecal material, feathers and nesting material; and a two-dimensional wooden kiwi) and a brief period (0.5-1.5 s) of electrical stimulation from an electric shock collar is applied when the dog makes contact with the KAT training stimuli. The dog is considered to 'pass' the training if the dog displays avoidance to the KAT stimuli after being shocked, i.e. not looking at or going near the training stimuli. Information regarding the dangers of dogs to kiwi is also provided to owners along with a KAT certificate. The purpose of KAT is to train dogs to associate the sight and/or odour of kiwi training stimuli with the shock so that they will avoid kiwi if encountered in the future.

KAT is not mandatory for all dogs but is encouraged for dogs that live in kiwi habitat and is required if hunting on DOC land as part of the requirement for a hunting permit in kiwi habitat (e.g. Waikato and East Coast/Hawke's Bay conservancies). Some forestry companies and private landowners have also made KAT a requirement for hunting in kiwi territory. There is a large community uptake and support of the importance of this training programme throughout the Coromandel region. However, the usefulness of the programme is relatively controversial due to the time, effort, and money invested in the KAT by the DOC without knowing if it is actually working to stop or reduce the number of dogs killing kiwi.

A number of studies have demonstrated that response-contingent electric shock can in certain conditions reduce or eliminate predatory behaviour for a period of time in Canidae species such as coyotes (*Canis latrans*; e.g. Linhart et al., 1976; Andelt et al., 1999), foxes (*Urocyon littoralis*; e.g. Cooper et al., 2005), wolves (*Canis lupus*; e.g. Schultz et al., 2005; Hawley et al., 2009), and dogs (e.g. Christiansen et al., 2001). These studies all used live prey for training purposes rather than training stimuli and all involved multiple training sessions. Most of the studies investigating aversion conditioning in canids have been conducted while searching for non-lethal methods of controlling predation of domesticated animals, such as sheep, by non-domestic canids, as opposed to trying to protect an endangered ground-dwelling bird, as is the case with the KAT programme in New Zealand.

There are a number of other initiatives the Department of Conservation have in place to reduce the amount of predation of kiwi by dogs. For example, Operation Nest Egg is a programme dedicated to removing and incubating kiwi eggs and returning subadults once these are large enough to fend off predators at approximately 1000 grams (Colbourne, 2002; Colbourne et al. 2005; Pickard 2009; Robertson et al. 2011). This programme received 942 eggs from the wild and produced 475 young released back into the wild between 1995 and 2008 (Pickard, 2009). Other initiatives include, dog owner education campaigns (Impey, 2009) and advocacy (James, 2001); encouraging legislative and policy changes, as well as greater community involvement (Robertson, 1998; Holzapfel et al., 2008); working with local councils and the Resource Management Act to achieve new subdivision areas that are designated cat and dog free (Hamilton, 2009); poisoning (Eason et al., 2010); and live trapping and shooting (Moorcroft, 2009).

1.3 Research aims and thesis structure

This research aims to examine whether dogs avoid KAT stimuli during the initial KAT training, for how long and under what conditions the avoidance is able to be retained, whether the training stimuli used is ecologically valid to the dogs, and if there is any welfare compromise during the training. The thesis has been structured in the following manner. Chapter two is a review of the use of electric collars in dogs. Chapter three investigates if avoidance can be taught using an electric collar, and if so, for how long this lasts, and if it matters that the electric collar is worn or tested in a difference

geographical location. Chapter four quantifies 1647 aversion training records involving 1156 dogs to investigate the effects of gender, age, social group size, use of dog, breed, number of training sessions and responses to training for evidence of learning differences. Chapter five investigates assessing the aversion conditioning during simulated hunting conditions, when the dogs are alone, when with their hunter, and also when with their canine hunting pack. Chapter six investigates the ecological validity of the KAT training stimuli that is used in the aversion training, and compares using a live bird in the training. Chapter seven assesses the potential welfare compromise associated with using electric collars in aversion conditioning, as well as dog owner views regarding the use of electric collars. Chapter eight provides the conclusions and recommends from this research.

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Chapter Two: The use of electric collars in dog training

2.1 Introduction

Dogs (*Canis familiaris*) have lived alongside human societies in feral and semi-feral populations for thousands of years resulting in a mutually beneficial interdependence (Breed, 2006; Hare et al., 2002). Archaeological evidence suggested the human-dog relationship began during the Pleistocene age 14 000 years ago (Clutton-Brock, 1995), however, molecular genetics suggest it was between 35 000-100 000 years ago (Vilá et al., 1997; Savolainen et al., 2002). The role of the dog in modern society varies depending on cultural differences (Miklòsi, 2007), with companionship being the most common reason for owning dogs in Western societies (Bennett et al., 2007; Staats et al., 2008). The dog is one of the most popular companion animals in New Zealand with almost a third of all households owning a dog, and an estimated 700,000 dogs registered (MacKay, 2011). The nature of this human-dog relationship impacts on the quality of life for both dog, and owner (Crawford et al., 2006; Marinelli et al., 2007; Julius et al., 2013), and affects ownership practices (Rohlf et al., 2010, 2012). Methods of improving the human-dog relationship are beneficial to the welfare of both owners and dogs (Meyer and Forkman, 2014).

Owner preference is for calm, compliant, faithful and non-aggressive dogs (Clark and Boyer, 1993; King et al., 2009). The display of behavioural problems by dogs has a negative impact on the human-dog relationship (Bennett and Rohlf, 2007; Serpell, 1996), and increases the risk of relinquishment (Kwan and Bain, 2013; Mondelli et al., 2004; Patronek et al., 1996), and euthanasia (Marston and Bennett, 2003; Yin et al., 2008). Training is an integral part of the human-canine bond (Batchelor, 2003), increasing the strength of the relationship (Lindsay, 2001), and reduces the incidence of behaviour problems in dogs (Blackwell et al. 2007; Eskeland et al., 2007), except when punishment is the primary training method (Hiby et al., 2004).

There is a wide range of training methods used in the training of dogs, and considerable debate about the relative benefits of using different approaches with respect to welfare implications (Lindsay, 2005; Rooney and Cowan, 2011), the relationship with undesired behaviours (Blackwell et al., 2008; Heron et al., 2009) and efficacy (Herron et al., 2009;

Hiby et al., 2004). Training methods can be described with definitions of reinforcement and punishment (Leiberman, 2000; Lindsay, 2000). These are: positive punishment, where the probability of a behaviour occurring in the future is decreased when the behaviour is associated with application of a stimulus perceived as aversive; negative reinforcement, where the probability of a behaviour occurring in the future is increased when the behaviour is followed by the removal or avoidance of a stimulus perceived as aversive; positive reinforcement, where the probability of a behaviour occurring in the future is increased when the behaviour is associated with application of a stimulus perceived as rewarding; and negative punishment, where the probability of a behaviour occurring in the future is decreased when the behaviour is associated with the removal of a stimulus perceived as rewarding (Blackwell et al., 2012; Lindsay, 2000, 2001). The aim of this review is to discuss the benefits, limitations and welfare concerns of using electric collars as positive punishment for training dogs.

2.2 The use of positive punishment

The use of positive punishment in dog training is controversial (McGreevy and McLean, 2009; Peace and Bayley, 2001), and considered by some to be morally and ethically problematic (Lamb, 2012; Mills et al., 2012). There are many different forms of positive punishments used in dog training, for example, physical, verbal, and the use of punishment inflicting devices, such as electric collars, prong collars and choke collars (Lindsay, 2000). It is recommended that punishments that are behaviour-issued, rather than person-issued are better at maintaining the human-dog bond (Azrin and Hotz, 1966; Lindsay, 2005). With several authors arguing the combined advantages of immediate and reliable delivery of an electric shock make electronic training a viable and humane alternative to many traditional punishment techniques (Lindsay, 2005; Polsky, 1994).

The incorrect use of punishment can cause substantial pain and injury to the animal. For example, the incorrect use of choke collars has produced mechanical and ischemic damage to the larynx, oesophagus, thyroid, and trachea (Brammeier et al., 2006); intraocular pressure (Pauli et al., 2006); cervical instability, degenerative arthritis and recurrent laryngeal nerve paralysis (Overall, 2007a); and severe ischemic brain damage from ‘helicoptering’ a dog (form of punishment involving swinging or lifting a dog off

the ground by the collar) (Grohmann et al., 2013; Miller, 2008). Flat collars can put pressure on the airway and cause gagging (Mills et al., 2012), and dog head halter collars can damage the throat and neck by causing muscle strain with forceful use that can result in sustained throbbing, local irritation, or bruising (Lindsay, 2005). Muzzles that prevent dogs from opening their mouths can cause overheating due to the dog's inability to pant (Mills et al., 2012). Prong collars are banned in New Zealand (NAWAC, 2010), yet their use is common in other countries and has been found to be more aversive to dogs than electric collars and negative reinforcement (Salgirli et al., 2012). Hitting and kicking can result in bruising (Herron et al., 2009). However, there is also the ability to incorrectly use positive reinforcement and overuse of food rewards can cause an overweight condition which is also a welfare concern for the animal (Mills et al., 2012).

Several authors argue strongly against the use of punishment in dog training and think that the use is unethical and unnecessary regardless of the severity of the training situation or problem behaviour (Overall, 2007a,b). Mills (1998) states that punishment presents a range of problems that amount to abuse, and both are best avoided. Punishment can result in fear in the animal (Overall, 1997), and good welfare is thought to include freedom from fear (Fraser, 1993). Jones and Josephs (2005) found that punitive behaviours by their owners (yelling and physical pushing) increased the dog's stress levels, whereas play and petting decreased cortisol levels. The authors suggest that dogs who frequently had elevated cortisol levels may suffer from illness, including cognition degradation and physical problems that could shorten their lives.

Several authors have found that positive reinforcement training methods result in better performance of the dogs compared with punishment (Alexander et al., 2011; Yin, 2006); are less resistant to extinction (Smith and Davis, 2008); result in less behavioural problems (Haverbeck et al., 2008; Hiby et al., 2004); are preferred by owners (Blackwell et al., 2012; Loftus et al., 2010); and also result in an increase in the central dopaminergic level which enhances learning (Rooney and Cowan, 2011). Other forms of learning including observational learning (Rasa, 1997; Scott and Charles, 1954; Slabbert and Mineka, 1990) and model-rival learning (McKinley and Young, 2003) have also been shown to be effective in dogs.

Martin and Pear (1996) state that positive punishment is not the only effective training method, but that the use of negative punishment, and positive reinforcement, rarely work as quickly or as completely. Azrin and Holz (1966) and Mackintosh (1974) state that in the correct circumstances, punishment can result in complete, long-term suppression of a particular behaviour with very few repetitions. Solomon and Wynne (1953) state that negatively reinforced behaviours tend to be learned more quickly, are performed reliably, and maintained for lengthy periods of time with little or no explicit positive reinforcement of the desirable behaviour. Negatively reinforced behaviour also tends to be highly resistant to extinction, because the animal that successfully avoids the aversive event each time has no way of detecting whether the aversive event has been discontinued, so it continues to avoid forever (Solomon et al., 1953). Some researchers have also reported positive side effects to the use of positive punishment, such as increased sociability and responsiveness to reinforcement (Lovaas et al., 1965, Luckey et al., 1968; Newsom et al., 1983), increased emotional responsiveness, and increases appropriate play and improved attentional behaviour (Lindsay, 2005). Others researchers warn that there is the potential for negative side effects, such as a more general suppressive effect and emotional distress associated with circumstances surrounding the punishment (Harris and Ersner-Hershfield, 1978; Overall, 2007b; Sidman, 2001).

Similarly, Eskeland et al. (2007) report that dog owners that used a high harshness or frequency of punishment and several methods of punishment, had a significantly higher level of training problems and lower obedience, while the use of frequent rewards was correlated significantly with lower level of training problems and higher levels of obedience. A study by Roll and Unshelm (1997) found a correlation between the amount of aggression exhibited by dogs that were trained using punishment, e.g. hitting. These dogs were also significantly more likely to be instigators of dog fights. In addition to this, some researchers suggest that epidemiological studies of dog bites should question training methods used for the dog that has bitten (e.g. de Keuster et al., 2006).

2.3 Electric collars

The most controversial use of punishment in dog training, causing the most heated and emotionally-charged debates is the use of electronic shock collars (e-collar) (Cooper et

al., 2013a; Jacques and Myers, 2007; Overall, 2013). E-collars are devices through which a trainer can remotely deliver a shock, using pain as a positive punisher in order to suppress target behaviour (Blackwell and Casey, 2006; Lindsay, 2000). E-collars have been widely condemned by some (e.g. Cheetham, 2003; Overall, 2013; Tynes, 2011), but there are also numerous supporters (e.g. Alderman, 2003; Brudecki, 2008; Lindsay, 2005). Mills et al. (2012) considers there to be inconsistency in the prevailing moral attitude towards e-collar use in dogs, as electric fencing is widely accepted for the use with horses and livestock. E-collars are banned in a number of countries Austria, Norway, Sweden, Denmark, Finland, Switzerland, Slovenia, Germany, Wales, most of Australia, parts of Canada, and there are legal restriction on their use in the Czech Republic, Hungary and Italy (Anon, 2010). E-collars use have been widely criticised by almost all international animal behaviour and welfare associations (e.g. CABTSG, 2003; MacKellar and Ward, 2009; Waddle et al., 2009)

There are three types of e-collars that are available for use with dogs in New Zealand. The first is a hand-held remote-activated e-collars and it is this type of e-collar that is the focus of this doctorate. The second type of e-collar is a bark-activated collar that operates automatically in response to a dog barking. The third type of e-collar used is with a boundary fence that is meant to keep dogs within a defined area. In all cases, the dog wears a collar with box containing the battery and circuits to provide a pulse of current between two electrodes on the ventral surface of the dog's neck (Blackwell and Casey, 2006; Jacques and Myers, 2007). The intensity and duration of the stimulus from an e-collar can be varied and some collars, though not all, produce a warning sound, prior to the shock (Cooper et al., 2013a).

The most controversial of the three e-collars is the hand-held electric training devise (Cooper et al., 2013a,b; Lindsay, 2005). Mills et al. (2012) considers there to be a meaningful distinction in animal welfare risk between a device which is activated by the animal's behaviour (e.g. bark-activated collar); and that which depends on a person for the discharge of the stimulus. E-collars are also known as “shock collars”, “remote collars”, “electronic collars”, “electronic training devices”, “remote trainers” and “remote static pulse systems”.

E-collars have been widely available for over 30 years with over 170 different models being produced by at least 14 different manufactures and being sold in retail outlets,

through mail order catalogues, and online (Cooper et al., 2013a). E-collars are marketed to the general public for general obedience training, as well as a wide range of specific behaviour problems, including aggression, predatory behaviour, toilet training, separation-related behaviour and compulsive behaviour (Lindsay, 2005). In America, e-collar sales to pet owners have grown steadily from approximately 200,000 collars being sold in 1996, to more than 2 million in 2007, with sales projected to reach 5 million annually by 2015 (ECMA, 2007). In England, e-collar use is estimated to be by 3.3% of dogs owners equating to approximately 560,000 dogs, with use being more common by men than women (Blackwell et al., 2012; Murray et al., 2010). The prevalence of e-collar use in New Zealand is not known, but does warrant investigation.

There is no standardisation of e-collars (Jacques and Myers, 2007); and in a recent review of e-collar characteristics large difference in stimulus and quality between e-collar models was found, including some being faulty (Lines et al., 2013). Some e-collars have been found to not have a safety cut-out feature allowing for unlimited shock potential, the cut-out feature being vital in the event of failure, or mitigation of potential abuse (Mills et al., 2012).

The effective use of e-collars requires significant skill and understanding of learning theory (Cooper et al., 2013a). Most e-collars come with some form of written instruction which is considered by some to be woefully inadequate, in turn posing a significant welfare concern (Lindsay, 2005). In addition to this, advice in manuals is not always taken up by end-users (Cooper et al., 2013b). Mills et al., (2012) considers the e-collar instruction to be adequate in terms of using the actual device, but lacking in information relating to learning theory, which is vital for their correct usage.

Several studies have demonstrated that impaired learning arising when there is inconsistent and variable timing in dog training (McGreevy, 2007; McGreevy and Boakes, 2007). The timing of reinforcement particularly in the acquisition of behaviour is of key importance, with learning occurring much faster with no delay (Okouchi, 2009; Ploog and Williams, 2010). A delay of reinforcement can slow, or even prevent learning altogether, depending on the length of delay (Keely et al., 2007; Lattal, 2010; Metzger, 1994). Browne et al. (2011) in their study of dog training practices in obedience schools in New Zealand found inconsistent use of reinforcement, and a wide range of latencies to reinforcement which resulted in task acquisition being suboptimal

at times, as well as allowing for unintentional feedback to occur. Polsky (2000) warns that poorly timed or inappropriately painful electric stimulation, may increase the intensity and frequency of behavioural problems, and may elicit an aggressive response.

The use of e-collars has been reported to be effective in treating dominance aggression (Borchelt and Voith, 1996); human- and canine-directed aggression (Tortora, 1983); predatory behaviours in dogs (Christinson et al., 2001a,b; Stichnoth, 2002), deterring cattle from an attractant (Lee et al., 2007; 2008); acral lick dermatitis (Eckstein and Hart, 1996); pica and coprophagia (Polsky, 1994); barking (Steiss et al., 2007); their use is said to result in calmer, “more settled” dogs (Coleman and Murray, 2000), and to be effective for any size combination of owner and the dog (Giroux, 2001). Their use has also been reported to have short-term success with depredation in coyotes (Andelt et al., 1999; Linhart et al., 1976) and wolves (Schultz et al., 2005; Shivak et al., 2002, 2003).

Electrical stimulation from e-collars can be broadly categorised by levels: low, medium and high. Low-level electric stimulation (LLES) creates a tickle and tingle effect; mid-level electrical stimulation enables the handler to annoy or startles (MLES); and high-level electrical stimulation is believed to produce significant pain and distress to dogs (HLES) (Lindsay, 2005). How the electrical stimulus is actually perceived by the dog depends of a range of variables that all interact and relate to the amount and pattern of energy being discharged (Lines et al., 2013). These include the voltage, current, intensity, frequency, duration, types and distance between the electrodes; and location of electric shock (Lindsay, 2005; Mills et al., 2012). Additional factors also affect the electric stimulus such as the density of hair overlying the skin, the hydration level of the skin, how the dog holds its head, the amount of dirt and debris on the dog; the size, and the impedance of the tissue at the sites of contact (Ahn et al., 2005; Jacques and Myers, 2007; Tagliabue et al., 2001). Lines et al. (2013) developed a ‘stimulus strength perception index’ in order to give some indication of the potential impact of the different forms of e-collar stimuli available in dogs, which was developed based on human volunteers perception of e-collar stimulus.

Once electric stimulation has occurred, the subjective experience of electricity arises from the activation of cutaneous mechanoreceptors transmitting tactile sensations along myelinated A-delta and A-beta fibres to the brain that damage or a threat of physical injury has occurred (Lindsay, 2005). This is the mechanism for LLES and MLES,

however, with HLES C-fibres are activated which produce sensations of ‘burning’, despite no physical skin or tissue damage usually occurring (Sang et al., 2003). The subjective experience of pain is modulated by a number of variables, including stress, fear, frustration, and anger, and that pain thresholds can be significantly elevated by the elicitation of incompatible emotional and motivational states associated with olfaction, food, sex, massage, affection, and the effect of person (Lindsay, 2005).

The most common use of an e-collar is as positive punishment using HLES with the aim of stopping ongoing behaviour (Lindsay, 2005; Stafford, 2007) and is what this doctorate focuses on. E-collars can also be used to deliver negative reinforcement using MLES, whereby the correct behaviour is rewarded through the termination of discomfort. They may also be used as a disruptive stimulus to interrupt on-going behaviour and gain attention before rewarding correct behaviour using LLES (Lindsay, 2005; Mills et al., 2012). There have been no published studies on the latter two uses (Cooper et al., 2013a).

The use of HLES delivered as positive punishment via an e-collar has been reported to produce a number of undesirable side effects, such as impeded learning (Mendl, 1999; Walker et al., 1997); significant pain, fear, and distress (Lindsay, 2005; Overall, 2007a); pressure necrosis (Blackwell and Casey, 2006); burnt skin (Mills et al., 2012; Seksel, 1999); inappropriate associations with neutral stimuli (Jacques and Myers, 2007; Overall, 2007b); with poor contingency giving rise to both behaviour and welfare problems (Dess et al., 1983; Schalke et al., 2005); as well as not altering any of the underlying behavioural issues a dog may have (Overall, 2003; 2008; 2013; Overall and Love, 2001). There has been a prosecution in England on cruelty charges for an electric collar having severely burned a dog’s neck (Wellington, 1999). Lindsay (2005) suggests that HLES in e-collars far exceeds what is needed by the average dog and that owners should be given appropriate counselling and referrals to trainers to help reduce the risk of accidental painful shock above a certain level; and to prevent activation by unauthorised users (e.g., children). As many researchers suggest, there is a need for devising refined and easily applicable methods of training and evaluation grounded in empirical and testable approaches to behaviour for more appropriate practices toward dogs (Deldalle and Gaunet, 2014; Stafford, 2012; Udell et al., 2008; Udell and Wynne, 2008).

2.4 Canine stress and welfare

It is important to assess the possible welfare compromise associated with electric collars. Canine welfare has been studied in a range of situations, such as in research laboratories (Hetts et al., 1992; Ogata et al., 2006); animal shelters (Bellaio et al., 2009; Coppola et al., 2006); and veterinary clinics (Döring et al., 2009). Assessment of an animals' welfare can be done by investigating neurobiological, cognitive, subjective, physiological and behavioural factors (Boissy et al., 2007; Paul et al., 2005; Yeats and Main, 2008). Animal welfare science has historically focussed on the identification of negative welfare states, using physiological parameters, aggression, boredom, and abnormal behaviour as markers of pain and stress (Fraser, 2008; Harding et al., 2004), but recently the focus of attention has also turned towards the assessment of positive emotions displayed by the animals (Burman et al., 2011; Désiré et al., 2002; Reefmann et al., 2009) and investigating judgement bias (Mendl et al., 2010) and brain lateralization (Lobue and DeLoache, 2008; Quaranta et al., 2007; Siniscalchi et al., 2010).

Canine stress is often correlated with compromised welfare status and can be a reaction from the dog to an endogenous or exogenous threat (Scholz and Von Reinhardt, 2007). It can have positive and negative effects on the dog's health (Duncan, 2006; King et al., 2011), and is highly dependent on its emotional state (Boissy et al., 2007). Positive effects, such as agility, are seen with motivation and in competitive sports (Boissy et al., 2007; Jensen, 2007). Negative effects are seen in long-term physiological arousal without relief of symptoms (Beerda et al., 1997; Chrousos and Gold, 1992). Studies have found that gender differences (Beerda et al., 1999a); breed differences (Corson, 1971) differences in response to stress, as well as differences seen in dogs from single dogs households compared with dogs from multi-dog households (Dreschel and Granger, 2005).

Evidence from laboratory, clinical, and epidemiological trials suggests that acute and chronic psychogenic stress can cause health implications for animals, including susceptibility to infection (Glaser and Kiecolt-Glaser, 2005; Kemeny and Schedlowski, 2007) and slowed wound healing (Detillion et al., 2004; Vitalo et al., 2009). Short term acute stress may enhance the ability to store information, but it also leaves the brain susceptible to injury (Casey, 2010) and can lead to long term neurochemical changes

(Koolhaas et al., 1997). Long term chronic stress can result in learning and memory problems, depression, anxiety (Dreschel, 2007), obesity, insulin resistance, cardiovascular disease, altered endocrine responses, nervous system disorders (McEwen 2005); cognitive defects and hippocampal neuron loss resulting in memory loss (Casey, 2010); activation of the autonomic nervous system, immune activation, proinflammatory cytokine release, displacement, and redirected behaviours (Kuhne et al., 2012; Pastore et al., 2011; Raison and Miller, 2003). Diseases from chronic stress can affect the cardiovascular, gastrointestinal, immune, and urinary systems (Chrousos and Gold, 1992; Scholz and Von Reinhardt, 2007).

Different dogs respond differently to stress and coping styles and have been defined as “alternative response patterns to a stressor” (Koolhaas et al., 2010), with individuals differing in their response to the same set of conditions by active or passive coping (Henry and Stephens, 1977). According to that theory, active or proactive copers are more prone to activate the sympathetic-adrenal-medullary system, whereas passive or reactive copers activate the hypothalamic-pituitary-adrenal-cortical system (Koolhaas et al., 1999). Recently, Koolhaas et al. (2010) has suggested that animals also vary on two independent dimensions which gives four different types; shy (high stress reactivity and reactive coping), panicky (high stress reactivity and proactive coping), bold (low stress reactivity and proactive coping) and docile (low stress reactivity and proactive coping).

Fear can have a profound effect on the welfare state of the dogs. Fear is a reaction caused by the perception of actual danger which results in physiological reactions and behavioural responses (Forkman, et al., 2007; Sherman and Mills, 2008) that start in the brain and may end with the fight or flight reaction (Cannon, 1929). Fearfulness is a self-protective response that leads to avoidance or defensive behaviours and thereby helping the individual to cope with a challenging environment (Koolhaas et al., 1999). However, excessive fear can cause behavioural problems (King et al., 2003; Wells, 2001; Wells and Hepper, 2000), including aggressive behaviour towards humans (King et al., 2003); impaired health (Koolhaas et al., 1999); and can lead to relinquishment (Segurson et al., 2005); and euthanasia (Poulsen et al., 2010). Fearfulness has been reported to be a hereditary trait in dogs, this should be taken into consideration in breeding (Overall, 2000; 2010; Overall et al., 2008), with the incidence of anxiety

within lines and families of pure-bred dogs able being able to be mapped over generations (Reese, 1979; Shekhar et al., 2001). McCobb et al. (2001) found herding breeds were over-represented in a study of thunderstorm phobia.

2.4.1 Behavioural measurements

Behavioural indicators are the most widely used and readily detectable measurement used in the assessment of animal welfare (Deldalle and Gaunet, 2014; King et al., 2011; Martin and Bateson, 2010). An animal's behaviour provides an immediate reflection of its internal emotional and/or motivational state (Dawkins, 2003; Serpell, 2008; Walker et al., 2010; Wemelsfelder and Farish, 2004); and physical manifestation of its integrated physiological response (Paul et al., 2005). Behavioural responses to a noxious experience have an advantage in that they occur immediately, provide a good indication of the duration and different phases of a painful experience and can be measured non-invasively (Cromwell-Davis, 2008; Mellor et al., 2000, 2002).

Validated behavioural signs of stress in dogs that have been correlated to physiological indices include body shaking, oral behaviours, mouth opening, paw lifting, restlessness, trembling, yawning, yelping, urinating, defecating, pacing, startle responses, panting, pupillary dilation, trembling, whining, excessive licking, hiding and a low body posture (Abrantes, 1997; Aloff, 2005; Beaver, 1999; Beerda, 1997; Beerda et al., 1998, 1999a,b; Dreschel and Granger, 2005; Handelman, 2008; Hydbring-Sandberg et al., 2004; Rugaas, 1997). Many of the behavioural symptoms of pain are similar to those of stress including panting, whining, barking, and restlessness (Firth and Haldane, 1999; Holton et al., 2001; Morton et al., 2005).

Although observation of activity can give rise to hypotheses on dog welfare, individual coping styles have to be considered (Rooney et al., 2009); and assessment needs to be made holistically (Walker et al., 2010). Some dogs when they are stressed engage in motion activity such as panting, pacing, trembling or perform eliminative behaviours (Hiby et al., 2006; Sherman and Mills, 2008), while other dogs appear quiet, inactive, trying to hide or escape (King et al., 2011; Rooney et al., 2009). Vocalisation is a commonly used indicator of acute stress and discomfort (Boissy, 1995), but dogs bark under several circumstances, to greet, invite to play, seek contact, when reacting to loneliness or pain, and as defence or threat (Pongrácz et al., 2010).

Certain stress behaviours have been identified to occur in specific situations or challenges. For example, lip licking, yawning, and body shaking were the most common indicators of stress in rescue dogs during training sessions (Bellaio et al., 2009); and, submissive gestures, displacement activities, and redirected behaviours are seen in physical human–dog interactions (Haug, 2008; Kuhne et al., 2014; Luescher and Reisner, 2008). Paw-lifting is thought to indicate a state of conflict, confusion, and fear of punishment (Schilder and van der Borg, 2004); and dogs often use physical contact to get the humans attention (Fallani et al., 2006, 2007).

During electric stimulation, some authors have found dogs tend to show lowered body posture, high pitched yelping, barking, squealing, avoidance, redirected aggression and tongue licking (Schilder and van der Borg, 2004), whereas other have found varying grades of jumping, head shaking, vocalisation, and withdrawal (Christiansen et al., 2001a). The behavioural difference may be directly related to the level of shock received by the dogs, but this information is not available in a comparable format (Cooper et al., 2013a,b; Lines et al., 2013). Long-term effects of the use of electric shocks in training has been detected using cortisol in the absence of overt behavioural signs of stress (Stichnoth, 2002; Vincent and Michell, 1992).

Assessing the emotional state (positive or negative) in animals using behavioural measurements is an important aspect in order to establish the quality of their welfare (Boissy et al., 2007; Duncan, 1996). Methods have included approach/avoidance behaviour and looking at eye white exposure (Paul et al., 2005; Sandem et al., 2002). This is useful as certain indicators of stress, such as lip licking can be expressed both when animals are in a positive (Rehn and Keeling, 2011) and in a negative emotional state (Beerda et al., 1997; Palestrini et al., 2005). In trying to assess the valence of arousal, investigation of intentional approach and avoidance behaviours displayed by the dogs could be a helpful tool to use. Approach behaviour is often displayed when the animal is exposed to positive stimuli (e.g. reunion with the owner) and avoidance behaviour is often elicited when the animal is exposed to negative stimuli (e.g. a snake) (Elliot et al., 2006). Subtle behavioural indicators of stress are seldom recognised by owners, and only some specific stressful situations will be identified (Mariti et al., 2012).

2.4.2 *Physiological measurements*

Physiological measures of welfare assessment in dogs include measurements of elements of the hypothalamic-pituitary-adrenal axis or sympatho-medullary-adrenal axis. Short-term physiological responses include elevated or variable heart and respiratory rates, body temperature increases, adrenalin and corticosteroid secretion, and plasma levels of glucose, lactate or acute phase proteins, all of which may indicate changes in welfare status (Broom and Fraser, 2007; Dawkins, 2003; Serpell, 2008). Longer-term measures of welfare include indicators such as elevated cortisol, adrenal gland enlargement, or suppressed IgA secretion and immune function (Accorsi et al., 2007; Geers et al., 2003; Kikkawa et al., 2003). Non-invasive measurements of physiological parameters in dogs mainly comprise of heart rate, blood pressure, respiratory rate, and salivary levels of cortisol (King et al., 2003; Kuhne et al., 2009; Ogburn et al., 1998; Maros et al., 2008; Pastore et al., 2011).

Heart rate and heart rate variability (HRV) is most commonly used measurement of sympatho-medullary-adrenal axis activation (Dreschel, 2007; Tilley and Smith, 2004). Heart rate is a practical and sensitive measure of a dog's reaction to novelty and fear with a reactive pattern of cardiac acceleration and deceleration in response to social and environmental stressors (King et al. 2003; Vincent and Leahy, 1997; Vincent and Michell, 1996). Heart rate and blood pressure are highly sensitive to traumatic events with conditioned cardiovascular changes persisting or worsening long after the escape/avoidance behaviour has ceased (Dykman and Gant, 1997). HRV measures are more valuable to use when assessing the emotional state in the animals since they are not equally affected by physical activity (Maros et al., 2008). Vincent and Michell (1996) found with a population of 227 trainee guide dogs, that 42% were stress prone, with a propensity correlated with a trend towards higher blood pressure and heart rate. Dogs exhibiting a heightened vulnerability to stress will likely respond to shock in a more reactive and stressful way than dogs less prone to stress (Lindsay, 2005).

Cortisol is the most commonly used measure of hypothalamic-pituitary-adrenal axis activation (Dreschel and Granger, 2009), and is an established biochemical marker for stress in dogs (Beerda et al., 1998; Castillo et al., 2009; Clark et al., 1997a,b; Haubenhofner and Kirchengast, 2007; Kobelt et al., 2003; Schalke et al., 2007). In dogs, cortisol has been used to measure the stress related to ground transport (Frank et al.,

2006), air transport (Bergeron et al., 2002), animal shelters (Bergamasco et al., 2010; Coppola et al., 2006; Hennessy, et al., 1998, 2001, 2006); laboratories (Spangenberg et al., 2006); veterinary hospitals (Hekman et al., 2012; Kim et al., 2010; Siracusa et al., 2008; Väisänen et al., 2005); working dogs (Horváth et al., 2008; Tomkins et al., 2011); companion dogs (Kotrschal et al., 2009; Pastore et al., 2011); pain (Brown et al., 2007; Hudson et al., 2004; Morton et al., 2005); when prevented from barking (Cronin et al., 2003); quality of life (Mullan and Main, 2007; Wiseman-Orr et al., 2004); environmental challenges (Haverbeke et al., 2008a,b); e-collars and startle challenges (Beerda et al., 1999a,b; Overall, 1997).

Cortisol can be collected from blood, saliva, faeces, hair and urine in dogs (Bennett and Hayssen, 2010; Blackwell et al., 2010; Kobelt et al. 2003; Schatz and Palme 2001; Stephen and Ledger, 2006) and higher concentration of this adrenal glucocorticoid hormone are widely considered to be indicative of stress or poor welfare (Chrousos, 2009; Houpt, 2004). Less invasive methods for collection have been recommended and their measurement has been validated (Beerda et al., 1996, 1998; Hellhammer et al., 2009). In particular, as already mentioned, salivary cortisol in dogs has become the most important marker of non-invasive stress assessment (Bennet and Hayssen, 2010; Dreschel and Granger, 2009), and to a lesser degree urine cortisol (Bodnariu et al., 2006). Cortisol levels exhibit a high degree of intra-individual variation (Schatz and Palme, 2001; Stephen and Ledger, 2006), but not gender differences (Stephen and Ledger 2006; Tuber et al., 1996); and are thought to be affected by a number of variables, such as social status (Mulleder et al., 2003), reproductive state (Bell et al., 1991), and activity levels (Fisher et al., 2002). There is also evidence that cortisol secretion in dogs is influenced by contact with humans (Coppola et al., 2006; Kotrschal et al., 2009; Lynch and McCarthy, 1997). Positive behaviours, interactions, and quiet play with humans can decrease cortisol in dogs (Coppola et al., 2006; Hennessy et al., 1997, 2006; Horváth et al., 2008, Shiverdecker et al., 2013), whereas punitive behaviours and threats have the opposite effect (Beerda et al., 2000; Jones and Josephs, 2006; Horváth et al., 2007).

Cortisol levels are also subject to ultradian, diurnal, circadian and seasonal rhythms of secretion (deJong et al., 2000; DePew et al., 1994; Feldman and Nelson 2004; Lefcourt et al., 1993). For example, Beerda et al. (1999b) recorded significantly higher mean

salivary cortisol levels in her canine subjects in the morning than during the rest of the day. Measurement and comparison of single samples across individuals has little meaning, and baseline measurements need to be taken as well as individuals serving as their own controls (Dreschel, 2007). Salivary stimulants (e.g. citric acid crystals, powdered drink mix) have been frequently used in canine research to obtain greater quantities of saliva for testing (Bergeron et al., 2002; Coppola et al., 2005), as the use of food and dog chews has been found to affect measures (Dreschel and Granger, 2009; Kobelt et al., 2003).

Cortisol concentration as a marker for stress has limitations. Examples for these limitations include: (1) cortisol can be released during courtship which may not be stressful; (2) species differences exist related to adrenal functioning; and (3) there is a cascade of cortisol from blood in to saliva, urine and faeces that require careful consideration and validation (Broom and Johnson, 1993; King et al., 2011).

2.5 Aversive conditioning

The use of an electric shock in aversive conditioning has been studied in the field of psychology for several decades. Aversive conditioning occurs when neutral and aversive stimuli are paired together in such a way that the order, timing and frequency of these pairings determine the strength of the association (Lindsay, 2000). It is usual to firstly present the neutral stimulus, followed closely by the aversive unconditioned stimulus (Pavlov, 1932; Rescorla, 1968). If the order is reversed, a marginal association between the aversive and neutral stimuli occurs and the association is usually of an inhibitory nature (Pavlov, 1932; Rescorla, 1968). The unconditioned stimulus used in aversive conditioning is aversive by nature, usually in the form of an electric shock (van Nobelen, 2009) and the conditioned stimulus comes to elicit a reliable, measurable conditioned emotional response activated upon later presentation of the conditioned stimulus (Davis, 2000; Fendt and Fanselow, 1999). The conditioned emotional response elicited by the conditioned stimulus produces behavioural and physiological stress responses to the unconditioned stimulus (Lindsay, 2000). Using HLES as positive punishment via an e-collar is a form of aversive conditioning, once the link is made between the behaviour and the aversive stimuli (electric shock), which by definition, causes discomfort, pain, or an otherwise negative experience (Jacques and Myers, 2007).

Aversive conditioning can take place rapidly and can influence the suppression of unwanted behaviour; however, this suppression can be restricted to the presence of the conditioned stimulus after full conditioning has taken place (Maier et al., 1969; Seligman, 1968). The aversive stimulus needs to be sufficient but not excessive for conditioning to take place (Leaton and Borszcz, 1985). The critical point whereby learning has occurred is when the 'neutral' stimulus elicits the same internal fear state without the aversive stimulus being present (Davis, 1986, 1979; Pavlov, 1932), and these pairings may also have a neural representation (Noebelen, 2009; Pare et al., 2004). Lubow and Moore (1959) suggested that non-reinforced exposure to the conditioned stimulus weakens the conditioned response and makes it more difficult to later learn an association between the conditioned stimulus and unconditioned stimulus (Killcross et al., 1998a,b). Aversion learning responses are likely to be long lasting, and resistant to extinction and counter-conditioning, compared to positive reinforcement methods (Brush, 1957; Solomon et al., 1953).

The basolateral amygdala is a site where associations between a conditioned stimulus and unconditioned stimulus are formed (Davis, 2000; Fendt and Fanselow, 1999; Miserendino et al., 1990; Romanski et al., 1993; Schafe et al., 2005; Wilensky et al., 2006). The basolateral amygdala does not appear to be involved in pain perception (Manning et al., 2003; Neugebauer et al., 2004), whereas the central amygdala is (Neugebauer, 2007; Neugebauer et al., 2003; 2004; Neugebauer and Li, 2003). It is thought that the central amygdala receives most of its unconditioned stimulus and conditioned stimulus information from the basolateral amygdala (Fendt and Fanselow, 1999; Sah et al., 2003). There is also a theory that the central amygdala may also receive information directly (Pare et al., 2004).

2.5.1 Responses to the actual electric shock

Numerous researchers have used electric shocks to investigate avoidance conditioning in dogs (e.g. Church et al., 1966; Cooper et al., 2013a,b; Solomon and Wynne, 1953). Vocalisations are considered to indicative of pain (Conzemius et al., 1997; Hellyer, 1999; Noonan et al., 1996), especially the higher frequency squeals, yelps and barks (Schalke et al., 2007; Schilder and van der Borg, 2004). The lowering of the ears, tail,

head and body are related to submission and fear (Fox, 1974; van Hooff and Wensing, 1987) and harsh training (Haverbeck et al., 2008; Schwizgebel, 1982).

Electric shocks have been found to elicit pain and emotive responses in rats (Borszcz, 1993, 1995; Borszcz and Leaton, 2003; Crown et al., 2000). Lynch and McCarthy (1969) found an increased heart rate in response to electrical stimuli in dogs. In aversion conditioning it is important to start with a punishment that is aversive enough for the dog (Azrin and Holz, 1966).

Cooper et al. (2013b) compared training with an e-collar with reward based training methods. The e-collar trained group had more negative emotional responses, yawned more, were tenser, held a lower tail carriage, moved away from trainer more, yelped more and panted more in the training session. They also found that for a subset of dogs tested, the use of e-collars in training are associated with behavioural and physiological responses that are consistent with significant negative emotional states indicative of having a negative impact on welfare.

2.5.2 Timing of the electric shock

Many researchers consider that poor timing of electric shocks carries a high risk that dogs will show severe and persistent stress symptoms that are likely to have a negative impact on the dogs' welfare, with the possible development of problem behaviours, including aggression, fear, learned helplessness, or even the unwanted association between shock and coincidental stimuli, such as the trainer (Polsky, 2000; Schalke et al., 2005, 2007; van der Borg, 2004). Poor timing may also confuse and frustrate the dog (Lindsay, 2000; McGreevy and McLean, 2009); and reduce the rate of learning (Costa and Boakes, 2007; Overmeir and Seligman, 1967).

The optimum timing is when the neutral stimulus is presented for a longer duration than the aversive stimulus, and co-terminates at the same time. If the time interval between the neutral stimulus and the aversive stimulus is long, conditioning is poor (Gallistel and Gibbon, 2000; Pavlov, 1932). The longer the time lapse between the response, and the subsequent punishment, the less effective the punishment is in suppressing the response (Brudecki, 2008) with the highest level of response in dogs displayed when

there is no delay of punishment, compared with longer time periods of up to 15 seconds resulting in significantly lower responses (Solomon et al., 1968).

Brudecki (2008) and McGreevy (2007) state that often processes of positive punishment and negative reinforcement operate hand-in-hand. The dog exhibits an unwanted behaviour for which it is punished; the punishment persists until the dog exhibits the desired behaviour, the desired behaviour terminates the aversive event, and the desired behaviour is thereby reinforced. With repetitions, the dog learns to engage in the desired behaviour immediately and to avoid the aversive stimulus completely. The frequency of the neutral and aversive stimulus pairings is important; with more pairings the strength of the association increases (Gallistel and Gibbon, 2000; Pezze and Feldon, 2004). Conversely, when the punisher is not available, the desired behaviour may not be performed. This is likely to be due to any behaviour that decreases the chance of being punished is reinforcing (Azrin and Holz, 1966; Skinner, 1953; Pryor, 1999).

2.5.3 Strength of electric shock

Boe and Church (1967) found the intensity of the aversive stimulus was important in determining the magnitude and duration of its effect, and that short exposure to an intense punisher could have a lasting effect on behaviour. Moderate footshocks of short duration are painful and very effective in aversion conditioning; whereas severe shock presented for longer durations attenuates pain and impairs learning (Meagher et al., 2001). Even mild shocks have been found to result in increased cortisol and fear behaviours in goldfish and trout (Dunlop et al., 2006).

The incorrect use of HLES can cause tissue damage, physical lesions and, obviously pain (Haupt et al., 2007; Seksel, 1999), however, others argue that despite the pain, physical damage may be unlikely to occur (Klein, 2000). Long-duration electric shock results in a reduction in cutaneous impedance, it is also associated with stimulus fatigue and a reduced sensitivity to the aversive stimulus (Tursky et al., 1970).

Punishment is more effective if it is introduced abruptly at moderate intensity rather than faded in from low intensity (Azrin et al., 1963). However, the ethical implications of imposing punishment can lead to a desire to use less severe forms of punishment (Sargisson et al., 2011). Mills et al. (2012) say that there is a genuine risk of serious

welfare compromise associated with the unpredictable use of high intensity electrical stimulation.

2.5.4 Increasing the level of electric shock

Domjan (2006) considers that punishment is most effective when it is applied immediately, consistently, more intensely initially, and without contingencies signalling its application. The effectiveness of punishment is said to increase with its intensity (Brethower and Reynolds, 1962; Sargisson et al., 2011). The use of strong aversive stimuli can often leave subjects overly sensitive, to noise for example (Bishop and Morgan-Jones, 1982). In some cases, sensitivity is seen to increase with continued use of punishment (Crosbie et al., 1997; Rachlin, 1966) but punishment can also have the opposite effect in that animals become immune to its effects with continued use e.g. the appearance of learned helplessness.

Azrin et al. (1963) found that incremental increases in aversive stimulus intensity, a strategy sometimes advocated to find the right level of stimulation to suppress a behaviour, may result in the application of potentially much more harmful stimuli, even if they are not immediately perceived as such. The authors found that pigeons, pecking for food, could be suppressed by a standardised electrical stimulus of 80V, but if the initial stimulus was set at 60V and then gradually increased, pigeons would still be pecking when the potential difference had risen to 300V. Lindsay (2005) also found that the presentation of brief non-painful pre-pulses of electric shock also serves to elevate pain thresholds. Kaczmarek et al. (1991) found that prior exposure to electric shock exerts a number of modulatory influences over electrocutaneous thresholds, with experienced human subjects tolerating at least twice the electrical intensity tolerated by a naïve subject. Starting at too high an intensity can cause an extremely fearful or aggressive response, but starting at too low an intensity can cause habituation (Blackwell and Casey, 2006). Brush (1957) found that the efficiency of avoidance learning increases with aversive intensities up to 4.8 mA, with latencies to escape appearing to increase at intensity levels above 5.0 mA.

Temporally contingent consequences are more effective at modifying behaviour than delayed punishment (Mazur, 2002). The punisher must be applied at a level that causes

decreases in the subsequent displays of the behaviour; and must be aversive enough to create a negative emotional response (Blackwell and Casey, 2006). High intensity shocks may be overwhelming or cruel, causing skin lesions (Polsky, 1994), chronic stress (Schalke et al., 2007), fear and pain responses (Schilder and van der Borg, 1994), and even death (Campbell, 1973).

2.5.5 The ability to control and predict electric shocks

The more an animal can predict and/or control its situation, the lower the stress levels (Jensen and Toates 1997; Solomon and Wynne, 1953; Weiss 1972). Beerda (1997) found that dogs that are not able to anticipate stresses tended to exhibit very low posture, trembling and increased saliva levels when exposed to stresses, whereas the dogs that anticipating the stresses showed a moderate lowering of body posture, body shaking and oral behaviours. In studies where dogs can learn to avoid the e-stimulus, their acute behavioural and physiological stress response to electrical stimuli is moderated in intensity and duration, compared with application of unpredictable or uncontrollable stimuli (Dess et al., 1983; Gantt and Dykman, 1957; Schalke et al., 2005, 2007). Initially the dogs show signs of fear, such as elimination, when the predictive stimulus is presented but once the response is established, these signs apparently disappear (Solomon et al 1953; Solomon and Wynne, 1953). Mills et al. (2012) says that this would suggest that the anxiogenic effects of predictors of electric shock are short-lived, if a reliable response leading to avoidance can be established, i.e. the response is not maintained by an anxiety or fear of punishment. If fear/anxiety were the motivation for the behaviour, then it would be expected that both the behavioural signs of anxiety would persist and the response would extinguish with time as the aversive stimulus is no longer being delivered in association with the conditioned stimulus. These results are now more widely interpreted as avoidance being motivated by an expectation that the aversive stimuli will be avoided rather than fear of the aversive stimuli (Seligman and Johnston, 1973). Lindsay (2005) refers to this as “escape to safety” rather than “escape from danger”.

It is well established in literature from other species that anticipated punishment can result in an inhibition of other behaviours within that context (Imada and Okamura, 1975; Seligman and Meyer, 1970). This has been suggested as an explanation for the

response of dogs to different types of training methods (McGreevy and Boakes, 2007). Solomon and Wynne (1953) found a strong tendency of dogs to develop stereotypic behaviours in anticipation of electric shock.

Rats exposed to inescapable shock develop ulcers; if the shocks are escapable or avoidable, the incidence of ulcers is significantly reduced (Weiss, 1968; Weiss, 1971). Rats have also been found to perform a ‘sigh of relief’ when able to predict shock (Soltysik and Jelen, 2005). Dess et al. (1983) found that dogs given signalled shocks were much less reactive to novel subsequent shock than the dogs that were previously exposed to signalled shocks. Whereas dogs exposed to chronic unavoidable shock, later fail to learn to escape from escapable shock, potentially indicating behavioural inhibition and a state of depression, known as learned helplessness (Overmaier and Seligman, 1967). Seligman and Groves (1970) found that dogs with a history of prior exposure to aversive stimulation had a greater resistance to the adverse effects of inescapable shock.

2.5.6 *Learned helplessness*

There are several examples of when dogs exposed to inescapable and/or unpredictable shock, or increased levels of shock, and unpredictable shock demonstrate impaired ability to escape (learned helplessness) (e.g. House and Pare, 1975; Overmaier and Seligman, 1967; Overmaier and Wiekiewicz, 1983; Seligman, 1975; Seligman et al., 1968; Seligman and Groves, 1970; Seligman and Johnson, 1968; Seligman and Maier, 1967). Weinraub and Schulman (1980) state that it is the uncontrollability of the experience, rather than the experience of shock itself that interferes with subsequent avoidance learning and with long-lasting effects that persist well after the experiment concluded. Symptoms of learned helplessness such as diminished aggression, a loss of appetite, apathy (Weinraub and Schulman, 1980), anhedonia, depression, motivational, emotional, and cognitive deficits have been identified in dogs and rats (Seligman and Alenior, 1980); and some examples of death (Seligman and Maier, 1967; Weiss et al., 1975). Mills et al. (2012) suggests that if learned helplessness is established during the development of the dog the effects are long lasting and potentially permanent.

The key determinations of learned helplessness are that once an animal is exposed to an inescapable aversive event such as shock, when placed in a situation where the aversive

event can be escaped or avoided; dogs suffering from learned helplessness are unable to escape (Maier and Seligman, 1976; Seligman and Maier, 1967). Learned helplessness is said never to develop if dogs are exposed to escapable shock (Maier, 1990; Maier and Watkins, 2005). It is thought that the dogs with learned helplessness cannot recognise the relationship between their own behaviour and outcomes and therefore cannot initiate an escape response (Maier and Testa, 1975). Brudecki (2008) considers that learned helplessness contrasts to the general indiscriminate suppressive effect suppression of all behaviours that can be sometimes seen during exposure to an aversive event. This effect is thought to be temporary and indicative of an animal that has not yet learned which aspect of its behaviour links with shock (Bolles et al., 1980; Bolles and Riley, 1973). Mills et al. (2012) suggest that learned helplessness might manifest by the animal failing to respond to training with an e-collar which would suggest that the animal's welfare will have suffered long-term welfare compromise.

Maier et al. (1969) found that pre-training of avoidance with an electrical aversive increased resistance to the development of learned helplessness, perhaps increasing psychological resilience in the face of inescapable aversion. Early experience and other factors contributing to individual differences may also affect the tendency to develop learned helplessness in the response to non-contingent punishment (Seligman and Groves 1970).

The neural tissues responsible for generating learned helplessness and experimental neurosis are similar to those that generate depression in humans and their mechanisms seem to share a profound inhibition of dopamine release in the nucleus accumbens (Cabib, 2006). Due to this similarity learned helplessness has been used as an animal model of human reactive depression and post-traumatic stress syndrome (Hall et al., 2007; Miller and Seligman, 1975; Seligman, 1975). To date learned helplessness has not been induced in a controlled setting other than by exposing an animal to inescapable shock or some other uncontrollable aversive event (Maier and Seligman, 1976).

2.5.7 Importance of relevant neutral stimulus

The evolutionary relevance of the neutral stimulus improves the rate of acquisition. It is suggested that it is easier to acquire fear to large predators than it is to palatable food (Cook and Mineka, 1990; Mineka and Ohman, 2002). The choice of behaviour being

targeted for electronic stimulation is also important (Brudecki, 2008; Shettleworth, 1972), with certain responses being extremely difficult to establish (Solomon and Brush, 1956). For example, rats rarely learn to reliably press a lever to avoid shock (Macphail, 1968), and pigeons rarely learn to peck a key to avoid shock (Modaresi, 1990). It is suggested that this difference has to do with how “biologically prepared” the animal is to associate the specific response with aversive events in terms of flight, flight or freeze responses and if desired behaviour fits into one of these categories of *species-specific defence reactions*, learning proceeds rapidly. (Bolles, 1970, 1973; Brudecki, 2008; Reid, 1996; Tortora, 1982a,b,c). Hutchinson et al. (1971) warns that if the aim to suppress a behaviour that is naturally elicited as part of the animal's defensive system with an aversive stimulus, such as an e-collar, punishing that behaviour may actually cause it to be *more* likely to occur. Brudecki (2008) says that certain responses such as coming when called, remaining within a specified area, avoiding particular objects, and releasing items are easily learned by dogs through the use of an e-collar, whereas responses such as manipulating objects or discriminating between items may not be so easy to establish and therefore could cause distress in the dog. Punishment delivered that is unconnected with the owner, reducing the likelihood that the owner will become a conditioned aversive stimulus and that the dog learns to become fearful or become aggressive towards them (Azrin and Holz, 1966).

Additionally, rewarding alternative behaviour and ensuring the punishment is evolutionarily relevant improves efficacy (Blood et al. 2007). Research on has shown that animals easily form associations between pain stimuli and a sound or light cue, and between taste stimuli and nausea (Garcia et al., 1974). However, mammals do not easily form associations between stimuli that are not evolutionarily relevant such as between sound and nausea, or between food and pain (Garcia et al., 1966).

Animals do not appear to be capable of making associations between food and externally applied pain (Garcia, 1974). Examples of aversive conditioning not working after the aversive conditioning trial concluded include seals not decreasing salmon consumption (Wright et al. 2007); white-tailed deer not decreasing foraging on feed stations (Gallagher and Prince 2003); cattle not learning to avoid preferred forage (Cibilis et al. 2004), wolves continuing to predate (Shivik et al. 2003, Hawley et al.

2009); black bears still eating from rubbish bins (Beckman et al., 2004; Leigh and Chamberlain, 2008; Mazur, 2010).

2.5.8 Individual and breed differences in response to electric shock

Sensitivity and tolerance differences to punishment and electrical stimulation exist between individuals (Christiansen et al., 2001a; Cooper et al., 2013a,b); and breeds (Scott and Fuller, 1965), with Border Collies, German Shepherds and Australian Shepherds considered to be more sensitive to shock (Reisner, 2003). Titcomb (2005) suggests breeds with high-prey drive, such as Jack Russell Terriers, are more difficult to train in snake avoidance training. Lessac and Solomon (1969) found that thresholds for shock do not significantly differ between puppies and adult dogs. Marschark and Baenninger (2002) suggest that the inclusion of an aversive in some training programmes with herding dogs may make them more efficient.

Behavioural states such as nervousness (Hall, 1945), and anxiety (Stern et al., 1984; Tanaka and Yamaoka, 1993) and stress may affect learning (Mendl, 1999; Overall, 2011; Schwabe and Wolf, 2010). Lindsay (2005) states that dogs that show signs of reactive aggression, fear, persistent anxiety, insecurity, or depression in response to electric shock are not considered to be good candidates for e-collar training.

2.5.9 Brain changes resulting from electric shocks

Brain changes have been seen in the amygdala during the acquisition of fear, including the duration and increasing intensity to the expression of these fears (Bloschakov et al., 2002). Tsevtkov et al. (2002) found evidence of low intensity electric shock accompanied with sound resulted in the sound-alone increasingly becoming aversive in rats with their fear increasing over time and pathways to the amygdala were modified. The acquisition of a fear response, and the physiological changes occurring during emotional learning contribute to intense anxiety disorder, including post-traumatic stress disorder (PTSD) and are what makes these fears so resistant to extinction. The authors also found brain changes that lasted over two years (Tsevtkov et al., 2002). Overall (2007a) also found that if the electric shock and pain are severe, it is possible to

induce almost immediate long-term potentiation (LTP), the molecular changes associated with hippocampal memory that will lead to a strong aversion or phobia.

Gapp et al. (2014) found evidence that stress also leaves ‘epigenetic marks’ that are chemical changes that affect how DNA is expressed without altering its sequence. The authors have reported that stress in early life alters the production of small RNAs, called microRNAs, in the sperm of mice; the mice also show depressive behaviours that persist in their progeny, which also show glitches in metabolism. The exact mechanism through which this has occurred is unknown but it is suggested that one potential route is through glucocorticoid receptors that are expressed in sperm or that stress hormones circulating in the blood make their way to the testes and bind to these receptors, somehow triggering changes in microRNA expression.

2.6 Conclusion and animal welfare implications

E-collars have wide-spread availability and are becoming increasingly affordable, yet in order for owners to evaluate the intrinsic risk to the animals from electric collars, the reliability, electrical discharge features, and current and voltage over a range of resistances should be readily available (Lindsay, 2005, Mills et al., 2012) and in a format that is understandable and comparable between different e-collars (Lines et al., 2013). It is highly likely that there is substantial e-collar use by those with little knowledge of learning theory, skill in administering a shock, or on inappropriate dogs (Mills et al., 2012). Several possibilities have been suggested to mitigate the extrinsic risks to animal welfare associated with e-collars: last resort training method only (Cook, 2008; Jacques and Myers, 2007;); or regulated to canine learning theory professionals only (Christiansen et al., 2001b; Lindsay, 2005;); for specific use only (Christianson et al. 2001b); an e-collar licencing system (Tortora, 1982d,e; Schalke et al., 2007); or be banned (Overall, 2007b; Schilder and van der Borg, 2004). In addition to this, Mills et al. (2012) suggests that e-collars themselves must have the following: mandatory safety key to limit voltage; non-invasive conditional stimulus which can be used to predict the potential delivery of the aversive stimulus; should not be used alone and be part of a programme including the provision of identifiable rewards; and, registration or licensing or practitioners who operate under a clear code of conduct recognising the knowledge and skill required for the human use of e-collars with informed consent from the owner concerning the process, contra-indications and potential risks.

There is ample evidence to highlight the importance of trainers needing to have a solid understanding of learning theory and good timing for reinforcement (Cooper et al., 2013a,b; Mills et al., 2012). Yet there is a lack of training standards, qualifications, licensing or criteria required by any governing body, and professionalism in the dog training field (Blackwell and Casey, 2006; Glenk et al., 2014; Salgirli et al., 2012). Several authors suggest that the average pet owner does not have the sufficient knowledge about training and skill to avoid the risk that dogs will show severe and persistent stress symptoms (Schalke et al., 2007; Schilder and van der Borg, 2004). It is for these reasons that many conclude that the general unregulated use of electronic shock collars are an unnecessary risk to animal welfare and not compatible with the moral climate underpinning the spirit of animal welfare legislation (Cooper et al., 2013b; Lamb, 2012; Mills et al., 2012; Schalke et al., 2007). Mills et al. (2012) states that the precautionary principle suggests that until sufficient safeguards can be put in place to prevent deliberate or unintentional harm or misuse can be established, viable lower risk alternatives should be used.

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Chapter Three: The acquisition and maintenance of dogs' aversion responses to kiwi (*Apteryx* spp.) training stimuli across time and locations

3.1 Abstract

Dogs (*Canis familiaris*) pose a significant threat to kiwi (*Apteryx* spp.) through predation. In an attempt to balance kiwi conservation and the need for dogs to be used for hunting purposes in kiwi habitat, the New Zealand Department of Conservation (DOC) developed the Kiwi Aversion Training (KAT) programme. KAT involves a training session in which a dog is presented with KAT stimuli (stuffed kiwi, frozen kiwi, and kiwi feathers) and a brief period (0.5-1.5 s) of aversive electrical stimulation from an electric shock collar is applied when the dog makes contact with the training stimuli. This paper reports three experiments: (1) investigating whether dogs can learn to avoid the KAT stimuli through aversion training; (2) investigating maintenance of aversion to the KAT stimuli one month after initial training; and (3) investigating maintenance of aversion to the KAT stimuli one year after initial training. All dogs showed aversion responses to the KAT stimuli during the initial KAT training and also when exposed to the KAT stimuli one month after training without an electric collar being worn. One year after initial training, 87% (48/55) of dogs avoided the KAT stimuli. This research indicates that KAT effectively produces aversion toward the KAT stimuli that generalizes to another location, is independent of the electric collar being worn, and that lasts at least one year after training.

3.2 Introduction

Kiwi (*Apteryx* spp.) populations have been in decline since the arrival of humans to New Zealand more than 700 years ago, resulting in all species currently being at risk, and some precariously close to extinction (Holzapfel et al., 2008). The kiwi is *taonga* (treasure) to Māori (indigenous people of New Zealand), is equally treasured by all cultures in New Zealand, and is a significant national icon (Holzapfel et al., 2008). The North Island brown kiwi is classified as “Nationally Vulnerable” (Robertson et al., 2013) and kiwi abundance in most North Island forests has declined by at least 90%

over the last century (McLennan et al., 1996). Habitat destruction is an important factor in this, but most of the decline is due to predation by introduced pests such as ferrets (*Mustela putorius*), possums (*Trichosurus vulpecula*), stoats (*Mustela erminea*), cats (*Felis catus*) and dogs (*Canis familiaris*) (e.g. McLennan et al., 1996; Pierce and Sporle, 1997). Dogs are the primary killer of adult kiwi (Holzapfel et al., 2008) and this predation can cause catastrophic declines in local populations (Pierce and Sporle, 1997; Taborsky, 1988) and can strongly influence population trends by significantly reducing the life expectancy of adults in some areas (e.g. Northland) (Holzapfel et al., 2008).

Given the threat that dogs pose to kiwi, banning dogs from areas where kiwi live would appear to be the simplest solution but this is impractical for many reasons. Some kiwi habitats are either privately owned or adjacent to private land, or are publicly owned land where dogs are allowed. Dogs also provide benefits in reducing introduced predators and grazing species that damage kiwi habitat, with dogs being commonly used and necessary for hunting feral pigs (*Sus scrofa*), deer (*Cervus* spp.) and goats (*Capra hircus*), often in remote areas. This is considered an essential method of pest control by the Department of Conservation (DOC). In addition to this, prohibition of dogs from kiwi habitat may impact negatively on kiwi conservation if DOC's dog-control approach is perceived by dog owners as too rigid or inconsistent, even though kiwi conservation is an issue that is well supported by the New Zealand public (James, 2000).

Given that there are approximately 700,000 dogs in New Zealand (Mackay, 2011), a solution was therefore sought that would allow dogs to be used for recreational and professional hunting in conservation areas containing kiwi populations while minimizing the risk to kiwi. Accordingly, the Kiwi Aversion Dog Training Programme (KAT) was developed, funded by the Bank of New Zealand Recovery Trust in association with DOC. The KAT procedure involves a training session in which a dog is presented with one or more kiwi stimulus (frozen dead kiwi and stuffed kiwi) and a brief period (0.5-1.5 s) of electrical stimulation from an electric shock collar is applied when the dog makes contact with the KAT stimuli. The dog passes the training if the dog displays aversive behaviours to the KAT stimuli after being shocked, i.e. not looking at or going near the training stimuli. Information regarding the dangers of dogs to kiwi is also provided to owners along with a KAT certificate. The purpose of KAT is

to train dogs to associate the sight and/or odour of kiwi prop(s) with the shock so that they will avoid kiwi if encountered in the future.

While there is anecdotal evidence from dog owners and DOC staff that suggests the KAT training results in kiwi aversion when dogs encounter live kiwi, only one study has examined the efficacy of the programme (Jones, 2006). That study had a very small sample size of 13 dogs and concluded that the KAT training is not effective. However, a number of studies have demonstrated that response-contingent electric shock can in certain conditions reduce or eliminate predatory behaviour in Canidae species (e.g. Andelt et al., 1999; Christiansen et al., 2001; Hawley 2009; Linhart et al., 1976). Most of the studies investigating aversion learning in canids have been conducted while searching for non-lethal methods of controlling predation of domesticated animals by non-domestic canids such as coyotes (*Canis latrans*), foxes (*Vulpus vulpus*), wolves (*Canis lupus*), and feral dogs (*Canis familiaris*), as opposed to endangered ground-dwelling birds as is the case with the KAT programme in New Zealand.

The KAT programme started in 1997 by the DOC Hauraki Area Office which has issued more than 1,500 permits for dogs in the Coromandel region in the North Island of New Zealand. KAT is not mandatory for all dogs but is encouraged for dogs that live in kiwi habitat and is required if hunting on DOC land as part of the requirement for a hunting permit in kiwi habitat (e.g. Waikato and East Coast/Hawke's Bay conservancies). Some forestry companies and private landowners have also made KAT a requirement for hunting in places with kiwi. There is a large community uptake and support of the importance of this training programme throughout the Coromandel region. However, the usefulness of the programme is relatively controversial due to the time, effort, and money invested in the KAT by the DOC without knowing if it is actually working in stopping or reducing the number of dogs killing kiwi. This research examines whether dogs (1) avoid KAT stimuli during the initial KAT training, (2) retain that learning in tests one month and one year after initial training, and (3) generalize their learning to locations other than that used in training.

3.3 Methods

3.3.1 *Animals*

Pig and/or goat hunting dogs ($n = 120$) were sourced from consenting owners during DOC run KAT sessions. There were three groups of dogs: the 'Naïve' group consisted of naïve dogs undergoing their first KAT session (65 dogs); the 'One Month Retest' group consisted of dogs returning one month after their first KAT session (15 dogs sourced from 'Naïve' group); and the 'One Year Retest' group consisted of dogs returning one year after their first KAT session (55 dogs).

3.3.2 *Procedures*

The KAT training took place at sites consisting of a walking path in native forest with KAT stimuli set up in the middle of the track. The KAT stimuli consisted of two stuffed kiwi, and one partly thawed frozen kiwi carcass. Dogs were fitted with an Agtronics Smart Aid 4 electric training collar (manufactured by Pet Training Products) which delivered 0.0092 joules of electric shock when operated. Each dog was individually walked past the KAT stimuli with its owner/handler, either on a long lead or under voice control (depending on the site and the owner's control over the dog). Dogs were given the opportunity to observe and approach the KAT stimuli, and when contact was made (defined as sniffing the training stimuli), an electric shock was administered via a remote control handset controlled by the DOC trainer/assessor. For dogs undergoing KAT for the first time (Naïve group), if the dog did not voluntarily sniff the KAT stimuli, the dog would be encouraged to do so by the DOC trainer/assessor and once contact was made would be shocked. The majority of the dogs were walked past the KAT stimuli for a second time to assess the behaviours the dogs made towards the KAT stimuli. If contact was made with the KAT stimuli, a second shock was administered. Some dogs were not walked past the KAT stimuli for a second time because they refused to return to the KAT training area – this was regarded as a sufficient demonstration of avoidance. Dogs from the 'One Month Retest Group' and the 'One Year Retest Group' were not encouraged to sniff the training stimuli. Electric collars were not worn for the 'One Month Retest Group', but were for the 'One Year Retest Group'. Seven of the 'One Month Retest' group dogs (15 dogs sourced from 'Naïve' group), were presented with the KAT stimuli one month after the initial KAT training at

the initial KAT training location and 8 at a novel location but still in a forest setting. These dogs were presented with the same KAT stimuli in the same manner used in the initial KAT training, but these 15 dogs did not wear the electric collar, and no shock was administered. Twenty-nine of the annual KAT retest dogs ('One Year Retest' group) were retested at the same location where they were initially KAT trained and 26 were retested at a novel site.

3.3.3 *Canine response rating*

Responses of the dogs to the KAT stimuli were rated on the following scale: (1) Strong aversion of KAT stimuli: did not approach vicinity of KAT stimuli, has to be forcibly led to walk past KAT stimuli, runs away; (2) Moderate aversion of KAT stimuli: reluctant to approach vicinity of KAT stimuli, gives KAT stimuli a wide berth when walking past, does not sniff KAT stimuli, no physical contact with KAT stimuli; (3) Indifferent to KAT stimuli: Shows no interest or aversion of KAT stimuli walks past KAT stimuli, does not sniff KAT stimuli, no physical contact with KAT stimuli, is not reluctant to stay in vicinity of KAT stimuli; (4) Shows moderate interest in KAT stimuli: air sniffs in direction of KAT stimuli, slowly approaches KAT stimuli, sniffs close to the KAT stimuli, no physical contact made with KAT stimuli; and (5) Shows strong interest in KAT stimuli: quickly approaches KAT stimuli, sniffs KAT stimuli, makes physical contact with KAT stimuli.

Each dog was assigned its own identification number and received a rating number from the above scale. For the 65 naïve dogs ('Naïve' group), a response to KAT stimuli was recorded before and after the KAT. Dogs from the 'One Month Retest' and 'One Year Retest' group received a response to the KAT stimuli only. All responses were rated by two observers. Interobserver reliability analysis using the Kappa statistic was performed to determine consistency among raters. There was perfect interobserver reliability ($\kappa=+1$).

3.3.4 *Statistical analysis*

Statistical comparisons using the following tests were then made between the three groups of dogs to the KAT stimuli using non-parametric tests reflecting the lack of normal distribution within the data. The Wilcoxon matched-pairs signed-rank test was

employed to compare responses of dogs before and immediately after KAT training, and immediately after training and one month later. The difference between location of KAT training and the location of the KAT stimuli re-exposure one-month or one-year later was tested using the Mann-Whitney U test, as was the comparison between responses to the KAT stimuli during the initial KAT training and during the one-year annual KAT retest. Cohen's r was used to test the effect size and power analysis was conducted using GPower (Version 3) (Faul et al., 2007). It is acknowledged that alternative statistical analysis methodologies could also have been employed in this study, such as multinomial logistic regression modelling.

3.4 Results

Table 1 illustrates the responses of dogs to the KAT stimuli for all three groups. Naïve dogs ('Naïve' group, $n = 65$) showed significantly higher levels of interest in the KAT stimuli immediately before KAT training (median = 4) than immediately after (median = 1), $T = 0$, $z = -7.2$; $P < 0.001$; $r = -0.93$; $1-\beta = 1.0$. The responses of dogs ('One Month Retest' group, $n = 15$) to the KAT stimuli before KAT training (median = 5) and one month after KAT training (median = 2) were also significantly different, $T = 0$, $z = -3.571$; $P < 0.001$; $r = -0.92$; $1-\beta = 1.0$, but the responses immediately after (median = 1) and one month after KAT training (median = 2) were not significantly different, $T = 8$, $z = -1.134$; $P = 0.257$; $r = -0.29$; $1-\beta = 0.702$. This result occurred despite the 'One Month Retest' dogs not wearing an electric collar. There was also no significant difference in response to the KAT stimuli one month after KAT when comparing the original training site (median = 2) and the novel site (median = 2), $U = 26.00$, $z = -0.267$; $P = 0.789$; $r = 0.069$; $1-\beta = 0.081$. All dogs showed either moderate (rating = 2) or strong aversion (rating = 1) immediately after KAT, one month after KAT and one year after KAT training. There was no significant difference in the responses of Naïve dogs ('Naïve' group, median = 1) after KAT training and the responses of dogs to the KAT stimuli in the 'One Year Retest' group (median = 1), $U = 1700.00$; $z = -0.511$; $P = 0.609$; $r = 0.047$; $1-\beta = 0.181$. There was also no significant difference in response to the KAT stimuli one year after KAT when comparing the original training site (median = 1, $n = 29$) and the novel site (median = 1.5, $n = 26$), $U = 326.00$, $z = -0.280$; $P = 0.780$; $r = 0.038$; $1-\beta = 0.085$. Of the 55 dogs returning one year after their initial training, only 12.7% (7 dogs) showed interest in the kiwi stimuli and had to receive a shock. After which all 7 dogs showed strong aversion to the KAT stimuli.

Table 1: Responses of dogs to the Kiwi Aversion Training stimuli.

KAT session	Response to KAT training stimuli				
	Strong aversion (n=87)	Moderate aversion (n=42)	Indifference (n=5)	Moderate interest (n=47)	Strong interest (n=19)
Pre initial KAT (n=65)	0	1	5	40	19
Post initial KAT (n=65)	52	13	0	0	0
One month post initial KAT (n=15)	7	8	0	0	0
One year post initial KAT (n=55)	28	20	0	7	0

3.5 Discussion

The results suggest that KAT training produced aversion responses to the kiwi stimuli in the absence of the shock collar, and that aversion was not solely linked to the original training site. In addition, these aversion responses consistently lasted for at least one month after training and for one year in a large majority of dogs. In some cases, avoidance was so strong that we were unable to get the dogs within 50 m of the kiwi stimuli. Only a small percentage of dogs (13%) were required to be re-shocked for displaying behaviours that indicated interest in the KAT stimuli one year after KAT training, all of these dogs were restrained on a long line. If the one year retest dogs were not wearing the electric collar it is possible that this figure may have been higher. This research is consistent with a number of published reports that pairing electric shock with potential prey can establish prey aversion in canid species (e.g. Andelt et al., 1999; Christiansen et al., 2001; Cooper et al., 2005; Hawley et al., 2009; Linhart et al., 1976; Schultz et al., 2005). The present study arranged much larger sample sizes but used training stimuli of prey species, rather than live prey, as in the previous studies. This study also used a single training session, rather than multiple training sessions as seen in other research (e.g. Christiansen et al., 2001; Linhart et al., 1976). It is acknowledged that alternative statistical analysis methodologies could also have been employed in this study, such as multinomial logistic regression modelling. Future research should expand on the present study by testing the effectiveness of KAT training with live kiwi. However, we acknowledge that there are many practical and ethical issues in using live

kiwi in KAT. As an alternative, the question of generalization of avoidance to live birds could be explored at least initially with species of less conservation value (e.g., chickens).

13% of dogs displayed moderate interest in the KAT stimuli one year after KAT training. While 100% of dogs displaying aversion behaviours would be ideal, it is unlikely that any training technique can achieve this level of effectiveness, as there are a myriad of confounding factors (e.g. implementation differences among trainers, different electric collars used, and different training stimuli used) that affect learning in individuals. The level of kiwi avoidance at which the KAT programme is viewed as effective by DOC is one that is debatable and likely to involve a cost-benefit analysis.

Some dogs displayed such strong aversion behaviours to the KAT stimuli that it was difficult to get the dogs within 50 m proximity to the KAT stimuli. Such strong aversion might indicate a potential welfare concern for the impact of KAT training on the health of the dogs. The use of electric training collars in dog training is controversial due to injury, stress, unwanted associations, and poor timing of shock administrations (Hiby et al., 2004; Houpt et al., 2007; Schalke et al., 2007; Schilder and van der Borg, 2003). The welfare impact of electric training collars in dogs can be reduced with dogs being able to predict shocks and control their response to it (Schalke et al., 2007). Despite the welfare and/or ethical issues surrounding electric collars, there is research to support punishment being more effective in reducing herding behaviours in dogs when compared to reward based training (Marschark and Baenninger, 2002). The use of conditioned taste aversion to reduce predation by canids is very controversial, with mixed results, welfare concern and non-replicability being an issue (Gese, 2003). Further research comparing the effectiveness in alternate training methods in reducing canine predation on kiwi is recommended. The goal of protecting kiwi from being killed by dogs needs to be contrasted with the impact of KAT training on dog health and safety. Nonetheless, KAT training might provide a more humane canine management option than lethal control methods (e.g., poisoning, trapping, and shooting).

Other variables that might influence the effectiveness of KAT and that require further examination are breed, type, sex and age. In addition, the purpose for which the dog is kept, such as for companionship or hunting, should be examined. This is of interest as KAT trainers might not implement the same rigor in the training regime for pet dogs

compared to working dogs, such as hunting dogs or DOC dogs. Conversely, some hunting dogs were extremely wary of the KAT stimuli in this research even before KAT training, perhaps because many owners actively discourage their dogs from interacting with any animals other than those that they are trained to hunt.

It is possible that if hunting dogs were to become lost or injured, food deprivation might override the aversion training. Also, it is unknown how KAT-trained hunting dogs would respond to kiwi in the absence of the hunter, which often can be for long periods of time (up to 5 hrs). Finally, it is unknown how dogs might respond to the KAT stimuli after multiple KAT training sessions, nor how far beyond one year these aversion responses are maintained. These questions are important to understand and require further investigation as some DOC conservancies are moving from an annual KAT permitting system to a three-year permitting system.

In conclusion, this research has demonstrated that KAT is effective in that the majority of dogs avoided the KAT stimuli, regardless of whether an electric collar was worn, and that the training generalized to other locations and lasted for at least one year. KAT also offers public-relations value for DOC and for kiwi conservation in general. With the educational value that KAT provides in the dangers of dogs to kiwi, it is hoped that owners will display higher levels of dog control in known kiwi-populated areas, and attend KAT training and retest sessions. Given how vulnerable and important kiwi are to New Zealand, further research into KAT is warranted, especially examining how the current KAT training with kiwi stimuli translates to live kiwi for dogs.

3.6 References

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Chapter Four: Evaluation of an aversion-based program designed to reduce predation of native birds by dogs: An analysis of training records for 1156 dogs

4.1 Abstract

The aim of this study was to quantify 1647 aversion training sessions involving 1156 dogs conducted between 1998 and 2007 at Coromandel sites (North Island, New Zealand). The effects of gender, age, social group size, function of dog, breed, number of training sessions and responses to training were explored for evidence of learning differences. The behaviour of dogs presented for up to five further training sessions was analysed for change with repeated exposure. The effect of one-, two- or three-year gaps between training sessions was also investigated. All 1156 dogs displayed avoidance to the training stimuli after the first training session. When presented with the training stimuli at the second training session, 69% of the dogs displayed avoidance, 88% did so at their third training session, 86% at the fourth session and 100% at their fifth session. Where avoidance was not displayed at a repeated training session, the dog underwent aversion training again. Lower levels of avoidance to the training stimuli was seen in older dogs being trained for the first time, dogs from single-dog households, dogs used to hunt pigs, non-sporting breed dogs and dogs that have a three-year gap or longer between sessions. While the majority of dogs avoided the kiwi training stimuli, it is recommended that the ecological translation of the training stimuli be investigated.

4.2 Introduction

Dogs (*Canis familiaris*) pose a significant threat through predation to land-dwelling endangered birds in New Zealand, in particular the kiwi (*Apteryx* spp.) (Holzapfel et al., 2008). Dogs also provide conservation benefits in pest control, and are commonly used to hunt feral pigs (*Sus scrofa*), deer (*Cervus* spp.) and goats (*Capra hircus*), especially in remote areas which serve as kiwi habitat. The New Zealand Department of Conservation (DOC) developed the Kiwi Aversion Dog Training Programme (KAT) as a solution to allow dogs to be used for recreational and professional hunting in conservation areas containing kiwi populations while minimizing the risk to kiwi. In this program, dogs are trained to avoid stimuli related to kiwi through the use of

response-contingent electric shock training. The training stimuli that are used are: taxidermically stuffed kiwi, dead frozen kiwi, kiwi faecal material, a two-dimensional kiwi cut-out and kiwi nesting material. Dogs that have undergone the training are then certified with a permit. Permits are issued annually so every dog, in theory, should be periodically retested to ascertain levels of avoidance towards the training stimuli, and potentially re-trained should avoidance behaviours not be displayed. There is a move by some conservancies (i.e., sections of the DOC that manage particular geographical regions) to issue three-year permits to dogs rather than annual permits. A KAT permit is needed if hunting on DOC land as part of the requirement for a hunting permit in kiwi habitat (e.g. Waikato and East Coast/Hawke's Bay conservancies). In addition, some forestry companies and private-land owners have also made it a requirement for access to hunting on their land in kiwi territory. The aversion training is also encouraged for dogs living in habitat where kiwis live that is privately owned, adjacent with private land or is in public areas where dogs are allowed.

There are a number of published studies that demonstrate that response-contingent electric shock can, in certain conditions, reduce or eliminate predatory behaviour in canid species for a period of time, such as coyotes (*Canis latrans*; e.g. Linhart et al., 1976; Andelt et al., 1999), foxes (*Urocyon littoralis*; e.g. Macdonald and Baker, 2004; Cooper et al., 2005), wolves (*Canis lupus*; e.g. Schultz et al., 2005; Hawley et al., 2009), and dogs (e.g. Christiansen et al., 2001a; 2001b; 2001c). These studies had comparatively small sample sizes and used live prey for training purposes rather than training stimuli that are assumed to bear a relation to the live prey to which avoidance is to be trained.

Dale et al. (2013) directly observed the behaviour of dogs undergoing KAT training and at follow-ups at different times. All dogs showed avoidance of the KAT stimuli during training and one month later, and most (87%) continued to show avoidance after one year. Avoidance also generalized successfully to locations other than that used during training. The present study expands on Dale et al.'s (2013) findings by examining DOC's training records of 1156 dogs that received KAT training at sites in the Coromandel Conservancy between 1998 and 2007. We explored the effects on avoidance behaviour of gender; age; social group size; use of dog (e.g. pet or kept for

hunting purposes); breed; the number of training sessions and change in behaviour over repeated test sessions.

4.3 Material and methods

4.3.1 Test subjects

Data were obtained from all KAT sessions conducted between 1998 and 2007 in the Coromandel Peninsula, North Island, New Zealand, and comprised records of 1647 training sessions on 1156 dogs (see Table 1). The date(s) and location(s) of the training trial(s), the age, gender, predominant breed, number of dogs in the household, and use of dog, and their response(s) to the training stimuli were analysed.

Table 1: Demographic make-up of the 1156 dogs that underwent KAT training in the Coromandel between 1998 and 2007.

Demographics			Year										Total
			1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	
First KAT session	Total		35	60	87	40	51	126	157	255	119	226	1156
	Gender	Female	15	26	46	20	26	53	82	116	54	108	546
		Male	20	34	41	20	25	73	75	139	65	118	610
	Age (in years)	0-1	5	7	12	14	13	49	57	126	59	74	416
		2-3	17	22	41	15	21	31	55	87	43	123	455
		4-5	10	17	13	6	11	25	33	60	11	17	173
		6-7	3	10	11	3	6	15	11	7	1	5	72
		8-9	-	3	8	2	-	4	1	4	3	3	28
		10+	-	1	2	-	-	2	-	1	2	4	12
		Breed Group	Toy	-	-	-	-	-	-	-	-	-	-
	Terrier		16	7	30	1	13	14	8	23	9	50	171
	Gundog		5	3	9	4	3	15	18	43	21	10	131
	Hound		4	3	5	5	4	6	4	8	7	12	58
	Working		7	23	25	15	10	60	78	133	57	104	512
	Utility		-	9	9	4	9	26	40	47	22	26	192
	Non-sporting		3	15	9	11	12	5	9	1	3	24	92
	N. of dogs	Single	15	14	12	9	7	10	25	57	23	31	203
		Multi	20	46	75	31	44	116	132	198	96	195	953
	Dog use	Pig	26	57	87	40	51	111	115	212	103	209	1011
		Pet	9	3	-	-	-	51	32	21	15	17	112
		Goat	-	-	-	-	-	-	10	22	1	-	33
Repeat training sessions	Second		-	-	22	22	14	22	68	79	51	35	313
	Third		-	-	-	11	14	8	19	40	21	15	128
	Fourth		-	-	-	-	5	7	3	5	10	12	42
	Fifth		-	-	-	-	-	3	3	-	-	1	7
	Sixth		-	-	-	-	-	-	-	-	1	-	1
Total number of dog through KAT training per year			35	60	109	73	84	166	250	379	202	289	1647

Dog use refers to the main reason for having the dog and was classed as either 'pet', 'pig', or 'goat' dogs. Pig dogs were owned predominantly to assist with pig hunting. Pet dogs were owned for the purpose of companionship and goat dogs were used to assist with goat hunting. Dog breeds were categorised by owner-identified breed, or predominant breed, classification. The dogs were assigned to one of the following seven recognised New Zealand Kennel Club (www.nzkc.org.nz) groupings: Toy Group: these are small companion or lap dogs (e.g. Chihuahua, Yorkshire Terrier and Pug); Terrier Group: dogs originally bred and used for hunting vermin (e.g. Staffordshire Bull Terrier, English Bull Terrier and Jack Russell Terrier); Gundog Group: dogs that were originally trained to find live game and/or to retrieve game that had been shot and wounded (e.g. Labrador, Golden Retriever, German Shorthaired Pointer); Hound Group: breeds originally used for hunting either by scent or by sight (e.g. Greyhound, Whippet and Beagle); Working Group: herding dogs that are associated with working cattle, sheep and other cloven-footed animals (e.g. Australian Kelpie, Australian Cattle Dog and Border Collie); Utility Group: this group consists of an extremely mixed and varied bunch, most breeds having been selectively bred to perform a specific function not included in the sporting and working categories (e.g. Boxer, Mastiff and Schnauzer); Non-Sporting Group: this group consists of miscellaneous breeds of dogs mainly of a non-sporting origin, e.g. Bulldog, Dalmatian and Poodle.

4.3.2 Aversion training methodology

All dogs were trained using the DOC Hauraki Area Office KAT program methodology as described in Dale et al. (2013). Each training session involved fitting the dog with an Agtronics Smart Aid 4 electric training collar (manufactured training products) which delivered 0.0092 joules of electric shock with each shock. Each dog was individually walked past the training stimuli (two stuffed kiwi, and one frozen kiwi carcass partly thawed) with their owner, either on a long lead or under voice control (depending on the site and the owner's control over the dog). Dogs were given the opportunity to observe and approach the training stimuli and when contact was made (sniffed the training stimuli), a brief period (0.5-1.5 s) of aversive electrical stimulation was discharged from the two electrodes on the collar administered via a remote control handset controlled by the DOC trainer. Most of the dogs were walked past the training stimuli for a second time to assess the dogs' behaviour toward the training stimuli. If contact was made with

the training stimuli for a second time, a second shock was administered. Some dogs were not walked past the training stimuli for a second time because they refused to return to the training area and this was counted as sufficient evidence of avoidance. For dogs undergoing the training programme for the first time, if the dog did not voluntarily sniff the training stimuli, the dog was encouraged to do so by the DOC trainer and shocked once contact was made. This was continued until each dog displayed avoidance behaviours (or at least no interest behaviours) towards the training stimuli (see Section 2.1.3 below for outline of behavioural response measurement). Dogs returning for an annual KAT permit renewal were 'tested' with the training stimuli and, if avoidance behaviours were displayed, the permit was re-issued. If avoidance behaviours were not displayed then the dog was retrained. Once avoidance behaviours were displayed, dogs were then given certification. Information regarding the dangers of dogs to kiwis was also provided to dog owners. There was one KAT trainer for 1998-2007. In the latter half of 2007 two new trainers replaced the first trainer.

4.3.3 Behavioural response to the training stimuli

The behaviours of the dogs in response to the training stimuli were scored by the DOC KAT trainer. The following scale was used to classify the responses: (1) Strong avoidance of training stimuli: did not approach vicinity of training stimuli, refused to walk past training stimuli, ran away; (2) Moderate avoidance of training stimuli: reluctant to approach vicinity of training stimuli, gave training stimuli a wide berth when walked past, did not sniff training stimuli, no physical contact with training stimuli; (3) Indifferent to training stimuli: Showed no interest or avoidance of training stimuli when walked past training stimuli, did not sniff training stimuli, no physical contact made with training stimuli, was not reluctant to stay in vicinity of training stimuli, any other behaviour not related to the training stimuli; (4) Moderate interest in training stimuli: air sniffed in direction of training stimuli, slowly approached training stimuli, sniffed close to the training stimuli, no physical contact made with training stimuli; and (5) Strong interest in training stimuli: quickly approached training stimuli, sniffed training stimuli, made physical contact with training stimuli.

4.3.4 Statistical Analysis

Statistical analyses were performed using the Statistical Package for the Social Sciences (SPSS) (Version 18). The avoidance data were not normally distributed and, therefore, non-parametric tests were employed. Kruskal-Wallis ANOVA by ranks was used to test for demographic variable differences within each of the training sessions and to assess the effect of varying lengths of time between the sessions. When statistical significance was found, *post hoc* analyses using Mann-Whitney *U* tests with a Bonferroni correction for multiple testing were employed. The Jonckheere-Terpstra test was also used to assess monotone trends in the data. Friedman's ANOVA by ranks was used to assess changes in behaviour in dogs that had repeat KAT sessions. When statistical significance was found, *post hoc* analyses using Wilcoxon matched-pairs signed-rank tests with a Bonferroni correction were employed. The effect size was reported using *r* and power analysis was conducted using GPower (Version 3) (Faul et al., 2007). Alpha was set to .05 for all statistical analysis. It is acknowledged that alternative statistical analysis methodologies could also have been employed in this study, such as multinomial logistic regression modelling.

4.4 Results

Table 2 shows the level of avoidance displayed towards the kiwi training stimuli in 1674 KAT sessions involving 1156 dogs. The dogs' responses to the kiwi training stimuli ranged from strong avoidance to strong interest, with the majority of dogs avoiding the training stimuli.

Table 3 shows the number of electric shocks given for avoidance to be displayed to the kiwi training stimuli in each training session. In the first training session, 89% of dogs required only one shock with 11% requiring two shocks. In the repeat KAT sessions, the majority of dogs avoided the training stimuli and were not shocked. Table 4 shows the demographic data for the 83 dogs that required electric shocks during repeat KAT training sessions (n=96).

Table 2: Behavioural responses towards the KAT training stimuli during the 1647 KAT sessions held in the Coromandel between 1998 and 2007.

Responses to training stimuli	Training sessions						Total (n=1674)
	1 st (immediately post training) (n=1156)	2 nd (n=313)	3 rd (n=128)	4 th (n=42)	5 th (n=7)	6 th (n=1)	
Strong avoidance (1)	691 (60%)	145 (46%)	82 (64%)	31 (74%)	6 (86%)	1 (100%)	956
Moderate avoidance (2)	380 (33%)	73 (23%)	31 (24%)	5 (12%)	1 (14%)		490
Indifference (3)	85 (7%)	14 (4%)	4 (3%)	2 (5%)			105
Moderate interest (4)		79 (25%)	11 (9%)	4 (9.5%)			94
Strong interest (5)		2 (1%)					2

Table 3: Number of electric shocks required during the 1647 KAT sessions held in the Coromandel between 1998 and 2007 for the dog to display avoidance towards the training stimuli.

Number of electric shocks required	Training sessions						Total (n=1674)
	1 st (n=1156)	2 nd (n=313)	3 rd (n=128)	4 th (n=42)	5 th (n=7)	6 th (n=1)	
No electric shocks		232 (74%)	117 (91%)	38 (90%)	7 (100%)	1 (100%)	395
One electric shock	1029 (89%)	79 (25%)	11* (9%)	4** (10%)			1123
Two electric shocks	127 (11%)	2 (1%)					129

* Three of these eleven dogs had been shocked in the first and second sessions, 8 were only shocked in the first session only.

** Two of these 4 dogs had been shocked in the first and second training sessions, the other 2 were shocked only in the first training session.

Table 4: Demographic information of the 83 dogs that required electric shocks at repeat training sessions.

Demographic data of dogs requiring electric shocks at repeat training sessions		Training sessions				Total repeat electric shocks (n=96)
		2 nd		3 rd	4 th	
		Moderate interest (n=79 of 313)	Strong interest (n=2 of 313)	Moderate interest (n=11 of 128)	Moderate interest (n=4 of 42)	
Gender	Female	37 (of 157)	2 (of 157)	7 (of 64)	2 (of 20)	48
	Male	42 (of 156)	0 (of 156)	4 (of 64)	2 (of 22)	48
Age	0-2	32 (of 131)	1 (of 131)	4 (of 52)	0 (of 14)	37
	2-4	33 (of 109)	0 (of 109)	2 (of 40)	2 (of 14)	37
	4-6	6 (of 48)	1 (of 48)	2 (of 25)	2 (of 10)	11
	6-8	8 (of 22)	0 (of 22)	3 (of 11)	0 (of 4)	11
	8-10	0 (of 2)	0 (of 2)	0 (of 0)	0 (of 0)	0
	10+	0 (of 1)	0 (of 1)	0 (of 0)	0 (of 0)	0
Breed group	Toy	0 (of 0)	0 (of 0)	0 (of 0)	0 (of 0)	0
	Terrier	7 (of 17)	0 (of 17)	0 (of 7)	0 (of 3)	7
	Gundog	9 (of 27)	0 (of 27)	0 (of 8)	1 (of 2)	10
	Hound	2 (of 3)	0 (of 3)	2 (of 3)	0 (of 1)	4
	Working	36 (of 149)	1 (of 149)	2 (of 50)	3 (of 16)	42
	Utility	18 (of 73)	1 (of 73)	2 (of 29)	0 (of 8)	21
	Non-sporting	7 (of 44)	0 (of 44)	5 (of 31)	0 (of 12)	12
No. of dogs	Single-dog	6 (of 33)	0 (of 33)	2 (of 6)	0 (of 1)	6
	Multi-dog	73 (of 280)	2 (of 280)	11 (of 122)	4 (of 41)	90
Dog function	Pig	75 (of 259)	2 (of 259)	9 (of 110)	4 (of 40)	90
	Pet	4 (of 29)	0 (of 29)	2 (of 6)	0 (of 0)	6
	Goat	0 (of 25)	0 (of 25)	0 (of 12)	0 (of 2)	0
Gap between prior and this session (in years)	1	52 (of 244)	1 (of 244)	6 (of 78)	2 (of 33)	61
	2	20 (of 60)	1 (of 60)	2 (of 32)	2 (of 8)	25
	3	5 (of 7)	0 (of 7)	3 (of 18)	0 (of 1)	8
	4	2 (of 2)	0 (of 2)	0 (of 0)	0 (of 0)	2
	5	0 (of 0)	0 (of 0)	0 (of 0)	0 (of 0)	0
Numbers of dogs shocked		79	2	3 (shocked in the first, second and third training sessions)	0 (no dogs were shocked in third session that attended a 4 th session; 2 of the 4 th sessions dogs had been shocked in the second session and 2 only in the first session)	Total number of dogs: 83 (comprising of 96 sessions)

Table 5: Statistical analysis results comparing the response of the dogs to the KAT stimuli ranging from strong avoidance to strong interest with the demographic variables of the 1156 dogs that underwent 1674 KAT sessions held in the Coromandel between 1998 and 2007.

Demographic variables		Training sessions (Total $n=1674$)				
		1 st ($n=1156$)	2 nd ($n=313$)	3 rd ($n=128$)	4 th ($n=42$)	5 th ($n=7$)
Gender	Female ($n=546$; 47%)	$H(3)=1.53$, $p=.73$, $r=0.018$	$H(4)=7.54$, $p=.1$, $r=0.226$	$H(3)=6.784$, $p=0.076$, $r=0.126$	$H(3)=0.39$, $p=.93$, $r=0.228$	$H(1)=1$, $p=1$, $r=0.151$
	Male ($n=610$; 53%)					
Age (in years)	0-1 ($n=416$; 36%)	$H(3)=7.51$, $p=.04^*$, $r=0.051$ ($J=19970.5$, $z=2.63$, $r=0.08$)	$H(4)=1.47$, $p=.84$, $r=0.056$	$H(3)=4.79$, $p=0.19$, $r=0.077$	$H(3)=2.51$, $p=.5$, $r=0$	$H(1)=0.17$, $p=1$, $r=0.151$
	2-3 ($n=455$; 39.4%)					
	4-5 ($n=173$; 15%)					
	6-7 ($n=72$; 6.2%)					
	8-9 ($n=28$; 2.4%)					
	10+ ($n=12$; 1%)					
No. of dogs	Single ($n=203$; 18%)	$H(3)=7.56$, $p=.05^*$, $r=0.049$ Single: $Mdn=1$, range=2; Multi: $Mdn=1$, range=2) ($U=92072$, $z=-1.254$, $r=-0.037$, $1-\beta=0.239$)	$H(4)=3.39$, $p=.49$, $r=0.093$	$H(3)=9.18$, $p=.04^*$, $r=0.154$ Single: $Mdn=2.5$, range=3; multi: $Mdn=1$, range=3)($U=210.5$, $z=-2.063$, $r=-0.182$, $1-\beta=0.216$).	$H(3)=0.36$, $p=1$, $r=0.617$	$H(0)=1$, $p=1$, $r=0.151$
	Multi ($n=953$; 82%)					
Dog function	Pig ($n=1011$; 87%)	$H(3)=7.58$, $p=.06$, $r=0.046$	$H(4)=24$, $p=.00^*$, $r=0.226$ 'pet' ($Mdn=1$, range=3); 'DOC' goat dogs ($Mdn=1$, range=1); hunting dogs ($Mdn=2$, range=4) (0.017 level of significance Bonferroni correction)	$H(3)=1.46$, $p=0.69$, $r=0.131$	$H(3)=9.41$, $p=.11$, $r=0.188$	$H(0)=0$, $p=1$, $r=0.151$
	Pet ($n=112$; 10%)					
	Goat ($n=33$; 3%)					
Breed group	Toy ($n=0$)	$H(3)=15.87$, $p=.01^*$, $r=0.038$ 'Terrier' breeds ($Mdn=1$, range=2); working breeds ($Mdn=1$, range=2); non-sporting breeds ($Mdn=2$, range=2) (0.003 level of significance Bonferroni correction)	$H(4)=10$, $p=.35$, $r=0.021$	$H(3)=4.75$, $p=0.19$, $r=0.077$	$H(3)=3.66$, $p=.32$, $r=0.069$	$H(1)=0.7$, $p=1$, $r=0.151$
	Terrier ($n=171$; 15%)					
	Gundog ($n=131$; 11%)					
	Hound ($n=58$; 5%)					
	Working ($n=512$; 44%)					
	Utility ($n=191$; 17%)					
	Non-sporting ($n=92$; 8%)					
Location of training site	43 locations utilised	$H(3)=16.71$, $p=.00^*$, $r=0.118$	$H(4)=120.58$, $p=.00^*$, $r=0.226$	$H(3)=5.37$, $p=0.14$, $r=0.095$	$H(3)=3.37$, $p=.36$, $r=0.049$	$H(1)=1.17$, $p=0.58$, $r=0.079$
Year of first training	1998-2007	$H(3)=42.84$, $p=.00^*$, $r=0.118$ 2006 ($Mdn=1$, range=3); 2001 ($Mdn=3$, range=3) (0.002 level of significance Bonferroni)	$H(4)=20.21$, $p=.00^*$, $r=0.056$ 2006 ($Mdn=1$, range=3); 2001 ($Mdn=3$, range=3) (0.002 level of significance Bonferroni)	$H(3)=5.47$, $p=.14$, $r=0.095$	$H(3)=7.12$, $p=.07$, $r=0.227$	$H(1)=0.29$, $p=1$, $r=1.509$

*Significant

Please note: 1=strong avoidance; 2=moderate avoidance; 3=indifference; 4=moderate interest; 5=strong interest. The degrees of freedom relate to the range of responses by the dogs in each particular group that is being compared minus 1.

Table 5 shows the results of the statistical analysis for the demographic variables for the 1156 dogs that underwent aversion training using kiwi training stimuli. Gender had no effect on the avoidance of the training stimuli in any of the sessions. Age had a significant effect on avoidance in the first training session but no other sessions, with younger dogs showing more avoidance. Dogs from single-dog households avoided the training stimuli significantly less than dogs from multi-dog households in the first and third training sessions.

The main function of the dog did affect avoidance to the training stimuli in the second training session but no other sessions. When compared with pig dogs, more avoidance was observed both for pet ($U=2694.5$, $z=-2.65$, $r=0.16$, $1-\beta=0.47$) and goat dogs ($U=1648.5$, $z=-4.32$, $r=-0.26$, $1-\beta=0.79$). There was no significant difference between pet dogs and goat dogs ($U=287.5$, $r=-0.23$).

Predominant breed significantly affected avoidance to the training stimuli in the first training session, but no other sessions. When compared with non-sporting breeds, terrier breeds and working breeds showed more avoidance ($U=6123$, $z=-3.34$, $r=-0.21$, $1-\beta=0.94$; $U=17894$, $z=-4.27$, $r=-0.17$, $1-\beta=0.92$ respectively).

There were 43 different locations where the training sessions were conducted. Where the dog was trained for the first session and second session appeared to affect the avoidance observed, but the number of locations precluded post hoc analysis.

The year (1999-2007) that the first and second training sessions took place had a significant impact on the avoidance to the training stimuli observed. Dogs undergoing their second training session in 2006 displayed significantly more avoidance when compared with 2001 ($U=270.5$, $z=-3.78$, $r=-0.44$; $1-\beta=0.98$).

Repeated training sessions showed a statistically significant difference in avoidance toward the training stimuli ($\chi^2(4)=10.85$, $p=0.03$: Table 6). The second training session resulted in more avoidance observed than in any other training session (including the first session), but this trend did not continue and further repeated sessions did not result in higher levels of avoidance towards the training stimuli. There were no differences between the third and fourth sessions, the third and fifth sessions, and the fourth and fifth sessions.

Table 6: Statistical analysis results of comparison of repeated training sessions of KAT.

Repeated KAT sessions*				
	Second (Mdn=2, range=4)	Third (Mdn=1, range=3)	Fourth (Mdn=1, range=3)	Fifth (Mdn=1, range=1)
First (Mdn=1, range=2)	$z=-6.022$, $r=-0.340$, $1-\beta=1.0$	$z=-0.766$, $r=-0.068$, $1-\beta=0.439$	$z=-0.387$, $r=-0.060$, $1-\beta=0.184$	$z=-1.134$, $r=-0.175$, $1-\beta=0.203$
Second		$z=-3.740$, $r=-0.577$, $1-\beta=1.0$	$z=-2.835$, $r=-0.443$, $1-\beta=1.0$	$z=-2.220$, $r=-0.839$, $1-\beta=1.0$
Third			$z=-0.219$, $r=-0.034$, $1-\beta=0.110$	$z=0.816$, $r=0.308$, $1-\beta=0.433$
Fourth				$z=0$, $r=0$, $1-\beta=0.05$

*A Bonferroni correction of 0.005 level of significance was applied in post-hoc analysis.

Table 7 shows the statistical results comparing the length of time elapsed between training sessions. The period of time elapsed between the first training session and the second session significantly affected the avoidance observed to the training stimuli. There was no difference when comparing a one- or two-year gap, but a three-year gap resulted in significantly less avoidance. There was no difference with respect to the amount of time elapsed between the second and third training sessions, or between the third and fourth trainings session. There was only ever a one-year gap between the fourth and fifth training sessions so the effect of this gap could not be explored. Only one dog was brought back for a sixth repeat session, after a three-year gap.

Table 7: Effect of length of time between training sessions on the behavioural response to the training stimuli.

Time elapsed between training sessions	Amount of time since previous session			
	1 year gap	2 year gap	3 year gap	4 year gap
First to second training session (0.0167 level of significance Bonferroni correction)	78% ($n=244$) (Mdn=2, range=4)	19% ($n=60$) (Mdn=2, range=4)	2.3% ($n=7$) (Mdn= 4, range=3)	0.7% ($n=2$) (Mdn= 4, range=0)
	$(H(3)=11.091, p=0.011, r=0.129)$			
	Comparison of a 1 & 2 year gap: ($U=6562, r=-0.0765, 1-\beta=0.280$)			
	Comparison of a 1 & 3 year gap: ($U=416, r=-0.1567, 1-\beta=0.206$)			
	Comparison of a 1 & 4 year gap: ($U=54, r=-0.130, 1-\beta=0.100$)			
Second to third training session	$(H(2)=2.903, p=0.234, r=0.064)$			
Third to fourth training session	$(H(2)=.372, p=0.830, r=0.148)$			

4.5 Discussion

This is the first large scale study investigating the effect of aversion learning in canids, or any species. The large sample size allowed us to investigate the effects of gender, age, social group size, dog function, breed, repetition of training sessions, time between training sessions, and responses to training for evidence of learning differences. While avoidance ranged from strong avoidance to strong interest, most dogs did avoid the training stimuli.

Gender did not affect the response to the training stimuli. Similar results have been found in other studies (Christiansen et al., 2001a; 2001b; 2001c) and no gender differences have been identified in the olfactory apparatus in dogs (McGreevy et al., 2004).

Age at the time of the first training session affected the training responses, with younger dogs generally showing higher levels of avoidance than older dogs, as has been found in other studies (e.g. Christiansen et al., 2001a; 2001b; Ogburn et al., 1998). In their study on the use of electric collars to reduce sheep predation, Christiansen et al. (2001a; 2001b) suggested increased maturity and lessened fear resulted in higher levels of sheep attacks in older dogs. Because we found that avoidance in the initial training decreased with age, we recommend that training start as early as possible.

Dogs from single-dog households generally displayed less avoidance toward the training stimuli when compared to dogs from multi-dog households in the training sessions. The main function of most dogs from single-dog households was as pets, whereas most dogs from multi-dog households were used mainly for hunting. It is possible that pet dogs are not subject to the same training regime as hunting dogs, and therefore respond differently to the training stimuli.

Breed was found to influence the effectiveness of the training, with terrier and working breed dogs showing higher levels of avoidance of the training stimuli, and non-sporting dogs showing the lowest levels of avoidance. Breed differences in training have also been seen in other studies (e.g. Christiansen, 2001c; Holmes, 1991; Pryor, 1999; Scott and Fuller, 1965; Turcsán et al., 2011). Christiansen (2001a) reported that elkhounds required higher levels of electric shocks to train them to refrain from attacking sheep than other breeds and Hansen et al. (1997) stated that the Spitz breeds (e.g. Siberian

Husky, Samoyed, Akita) do not readily respond to electric collar training to establish a conditioned aversion to sheep. Breed differences in terms of visual ability (McGreevy et al., 2004; Gasci et al., 2009a) and olfactory ability (Rooney and Bradshaw, 2004; Tacher et al., 2005, Lesniak et al., 2008; Robin et al., 2009) have also been reported. Olfactory ability has also been reported to vary within individuals (Fuller, 1955; Gasci et al., 2009b; Isser-Tarver and Rine, 1996) and well as from one day to the next (Schoon, 1997). These last points are relevant to explanations of variations in response to training because the KAT stimuli include both visual and olfactory components.

The location and year of first kiwi aversion training was also found to affect avoidance, with some years and locations producing higher levels of avoidance. Given that the same trainer performed almost all of the training sessions, it difficult to understand why this may have occurred. Several factors may have affected the dogs' responses during training, including temperature (Gazit and Terkel, 2003), wind direction and speed, and extraneous odours (Waggoner et al., 1998) or the differences may simply be the result of equipment changes, such as new batteries in the electric collar. It is also possible that the time lapse between the first and second training sessions was too long for the memory of the training session to be retained. It is also a possibility that kiwi had been encountered in the time period between the training sessions, without the associated punishment, and extinction of learning may have occurred.

No dog avoided the KAT stimuli before its first training session. After the first session, 60% of dogs showed strong avoidance, 33% moderate avoidance, and the remaining 7% showed indifference rather than interest (Table 2). That is, no dog showed interest in the KAT stimuli after training. Nevertheless, training was clearly less than completely effective, and there are several possible reasons for this.

Firstly, only one avoidance conditioning trial was conducted in the first session. It has previously been reported (e.g. Linhart et al., 1976; Christiansen et al., 2001b; Hawley et al., 2009) that multiple training sessions are required to produce avoidance. One shock was, in the present study, sufficient to eliminate interest in the KAT stimuli, but it did not always produce strong avoidance. Perhaps, a single conditioning trial is not always sufficient to produce a clear association between the KAT stimuli and the aversive electric shock. Supporting this interpretation, repeated training sessions, even if separated by one year, produced more consistent strong avoidance (Table 2). Similarly,

the shock may not have been punishing enough fully to eliminate the behaviour of approaching the stimuli for all dogs. It is clearly established in the basic behavioural literature that greater magnitudes of aversive stimuli (e.g., shock) lead to more effective punishment (e.g., Azrin et al., 1963). This may be a particular possibility in this situation, given dogs' strong predatory instincts. Increased motivation is known to reduce the effectiveness of a constant punishing stimulus (Azrin et al., 1963). Finally, kiwi predation could have already occurred before the first KAT session. Schultz et al. (2005) reported that electric collars have been found to be moderately successful in deterring predation of calves by wolves but was less successful if used after depredation of livestock had already occurred.

Table 2 shows that 26% of the dogs showed interest in, rather than avoidance of or indifference to, the KAT stimuli at their second training session (i.e., before receiving a second shock for approaching the stimuli). This suggests a second reason for less than complete effectiveness of training. The time lapse of one year between KAT sessions may simply have been too long for the memory to be retained. Further, dogs may have encountered kiwi during the interval between sessions without experiencing the associated punishment. This would be expected to lessen learned avoidance, because it is well established that continuous, rather than intermittent, punishment more effectively decreases behaviour (Azrin, 1960; Miller, 1960).

There was no difference found in avoidance of the training stimuli if the dogs were trained annually or biannually. However, a gap of three years did significantly decrease avoidance. This is the longest period of time assessing the retention of avoidance conditioning to date. Andelt et al. (1999) reported four-month retention of avoidance and Christiansen et al. (2001b) and Dale et al. (2013) both reported one-year retention of avoidance. Once a dog has been through training twice, the length of time till the next session did not significantly alter the dogs' avoidance of the training stimuli. It is recommended that there is a minimum of annual sessions for at least the first two training sessions. It is acknowledged that alternative statistical analysis methodologies could also have been employed in this study, such as multinomial logistic regression modelling.

In conclusion, this study reports the outcomes of the first very large sample of dogs undergoing kiwi avoidance training. We found that the vast majority of dogs that

undergo repeated regular training sessions do display avoidance when presented with the training stimuli, implying that the aversive conditioning is effective. We also noted several factors that influence the effectiveness of such training and should therefore be considered in attempts to maximize the likelihood of avoidance. However, the ecological validity of the training is not yet established. That is, further research is needed to demonstrate that KAT-trained avoidance generalizes to live birds, and not just to the stimuli used during training.

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Chapter Five: Do hunting dogs receiving Kiwi Aversion Dog Training Programme (KAT) change their hunting behaviour when alone, with their handler, or with their pack?

5.1 Abstract

Hunting dogs often spend large periods of time away from their hunter, either alone or in a pack, yet the hunting behaviour of dogs without human hunters has never been systematically investigated. The aim of this study was to investigate this behaviour in pig- and goat-hunting dogs and in pet dogs having undergone the Kiwi Aversion Dog Training Programme (KAT). KAT is a conditioned-avoidance programme pairing training stimuli (e.g., stuffed kiwi; cut-out wooden kiwi) with an aversive electric shock to establish avoidance of live kiwi birds in their natural habitats in New Zealand. When tested approximately one-year later with the same stimuli as used in training, an average of 77% of the hunting and pet dogs avoided the stimuli when alone and with their handler. 70% of hunting dogs avoided the stimuli when tested with their hunting pack but larger packs (ranging from 4 to 6 dogs) showed less avoidance toward the KAT stimuli. Compared with hunting dogs, pet dogs took longer to detect KAT stimuli, detected it from a shorter distance, and showed less avoidance of KAT stimuli when alone and with handlers. In hunting and pet dogs, the type of test did not influence the level of avoidance to the KAT stimuli. Therefore, the mere presence of human handlers or canine conspecifics appear not to influence the effectiveness of the conditioned-avoidance programme in hunting dogs. However, larger packs could reduce the programme's effectiveness in training avoidance of live kiwi.

1.1 Introduction

Dogs (*Canis familiaris*) have a high predation impact on non-flying birds in New Zealand (Holzapfel et al., 2008; Robertson et al., 2013). Given the threat that dogs pose to the endangered kiwi (*Apteryx* spp.), banning dogs from areas where kiwi live would appear to be the simplest solution; however, dogs provide benefits in reducing introduced predator numbers and for hunting feral pigs (*Sus scrofa*), deer (*Cervus* spp.) and goats (*Capra hircus*) often in remote areas. Furthermore, recreational hunting is

seen as an important wild animal control tool by the Department of Conservation (DOC; especially for pigs), as well being a significant part of New Zealand's culture for more than 100 years (Fraser, 2000). The New Zealand Sport and Recreation (2009) survey showed that 143,598 (4%) of the population went deer stalking or pig hunting at least once over 12 months. Pig hunting is distinguished from other big-game hunting by its reliance on dogs (Clarke, 1991) with Nugent (1989) estimating 87% of pig hunters use dogs.

A solution was sought that would allow dogs to be used for recreational and professional hunting in conservation areas containing kiwi populations whilst minimizing the risk to kiwi and, therefore, the Kiwi Aversion Dog Training Programme (KAT) was developed. In this programme, dogs are trained to avoid stimuli related to kiwi through the use of response-contingent electric-shock training. The KAT stimuli that are used are: taxidermically stuffed kiwi, dead frozen kiwi, kiwi faecal material, a two-dimensional kiwi cut-out and kiwi nesting material (see Dale et al., 2013). Dogs that have undergone the training are then certified with a permit. Permits are issued annually so every dog, in theory, should be periodically retested to ascertain levels of avoidance towards the KAT stimuli, and potentially re-trained should avoidance behaviours not be displayed. The aversion training is also encouraged for dogs living in habitat where kiwis live that is privately owned, adjacent with private land or is in public areas where dogs are allowed. The purpose of KAT is to train dogs to associate the sight/or odour of kiwi KAT stimuli with the shock so that they will avoid kiwi if encountered in the future.

Pairing electric shocks with potential prey can, under some conditions, establish prey aversion in canid species (e.g. Linhart et al., 1976; Andelt et al., 1999; Christiansen et al., 2001a; 2001b; 2001c; Cooper et al., 2005; Schultz et al., 2005; Hawley et al., 2009). Dale et al. (2013) directly observed the behaviour of dogs undergoing KAT training both immediately following training and during follow-up tests. All dogs showed avoidance of the KAT stimuli immediately following testing and one month later. Most dogs (87%) continued to show avoidance after one year. Avoidance also generalized successfully to locations other than those used during training. The aim of the present study is to expand on Dale et al.'s (2013) findings by investigating whether different

social environments affect avoidance of KAT stimuli in simulated hunting and recreational walking conditions.

Several researchers have suggested that dogs behave differently when they are without their owner (e.g. Lund and Jorgensen, 1999, Frank et al., 2007; Cannas et al., 2010; Rehn and Keeling, 2011). Hunting dogs can spend much of the hunt without being in sight of, or auditory communication with, their owner; they often hunt in a pack and are occasionally left lost or injured in the bush (Ruhe et al., 2006; Brenoe et al., 2002; Shier and Owings, 2006). Therefore, one aim of the present study was to test dogs' avoidance of KAT stimuli in the absence of their owner. In addition, given the social aspects of hunting in canines, we also assessed how dogs behaved toward the KAT stimuli when accompanied by other dogs – observing predatory behaviour has been found to stimulate predatory chase among dogs (Christiansen et al., 2001c). To assess whether different social environments affect avoidance of KAT stimuli by KAT trained dogs, we tested goat-hunting, pig-hunting, and pet dogs with the KAT stimuli when on their own, with their handler and with their hunting pack.

5.2 Material and methods

5.2.1 Test subjects

70 dogs were recruited from consenting owners for this research that had been KAT trained or tested within the previous 12 months. The age, gender, predominant breed, use of dog, hunting pack size and number of times through the KAT programme was recorded (Table 1). Owners with bitches in season were asked not to bring them to the research site and were excluded from this research. Dog function refers to the main reason for having the dog and was classed as either 'pet', 'pig', or 'goat' dogs. Pig and goat dogs were owned predominantly to assist with pig and goat hunting, respectively. Pet dogs were owned for the purpose of companionship. Dog breeds were categorised by owner-identified breed, or predominant breed. The dogs were assigned to one of the following seven recognised New Zealand Kennel Club (www.nzkc.org.nz) groupings: Toy Group: these are small companion or lap dogs (e.g. Chihuahua, Yorkshire Terrier and Pug); Terrier Group: dogs originally bred and used for hunting vermin (e.g.

Staffordshire Bull Terrier, English Bull Terrier and Jack Russell Terrier); Gundog Group: dogs that were originally trained to find live game and/or to retrieve game that had been shot and wounded (e.g. Labrador, Golden Retriever, German Shorthaired Pointer); Hound Group: breeds originally used for hunting either by scent or by sight (e.g. Greyhound, Whippet and Beagle); Working Group: herding dogs that are associated with working cattle, sheep and other cloven footed animals (e.g. Australian Kelpie, Australian Cattle Dog and Border Collie); Utility Group: this group consists of an extremely mixed and varied bunch, most breeds having been selectively bred to perform a specific function not included in the sporting and working categories (e.g. Boxer, Mastiff and Schnauzer); Non-Sporting Group: this group consists of miscellaneous breeds of dogs mainly of a non-sporting origin (e.g. Bulldog, Dalmatian and Poodle).

5.2.2 Aversion-training methodology

All 70 dogs had been trained using the DOC Hauraki Area Office KAT programme methodology as described in Dale et al. (2013) within the last twelve months. Each training session involved fitting the dog with an Agtronics Smart Aid 4 electric training collar (manufactured training products) which delivered 0.0092 joules of electric shock with each shock. Each dog was individually walked past the KAT stimuli (two stuffed kiwi, and one frozen kiwi carcass partly thawed) with their owner, either on a long lead or under voice control (depending on the site and the owner's control over the dog). Dogs were given the opportunity to observe and approach the KAT stimuli. When contact was made (sniffed the KAT stimuli), a brief period (0.5-1.5 s) of electrical stimulation was discharged from the two electrodes on the collar, which was administered via a remote-control handset controlled by the DOC trainer. Most of the dogs were walked past the KAT stimuli for a second time to assess the dogs' behaviour toward the KAT stimuli (see Section 2.5.2 below for outline of the response measurement). If contact was made with the KAT stimuli for a second time, a second shock was administered. Some dogs were not walked past the KAT stimuli for a second time because they refused to return to the training area and this was counted as sufficient evidence of avoidance. For dogs undergoing the training programme for the first time, if the dog did not voluntarily sniff the KAT stimuli, the dog was encouraged to do so by the DOC trainer and shocked once contact was made. This was continued

until each dog displayed avoidance behaviours (or at least no interest behaviours) towards the KAT stimuli. Dogs returning for an annual KAT permit renewal were 'tested' with the KAT stimuli and, if avoidance behaviours were displayed, the permit was re-issued. If avoidance behaviours were not displayed then the dog was retrained. Once avoidance behaviours were displayed, dogs were then given certification. Information regarding the dangers of dogs to kiwis was also provided to dog owners.

Table 1: Demographic make-up for the 70 dogs used in this research.

Demographics of dogs		‘Dog Alone’ and ‘Handler present’ sessions (n=70; %)	‘Hunting Pack’ session (n=50; %)
Gender	Male (entire)	26 (37%)	21 (42%)
	Female (entire)	20 (29%)	19 (38%)
	Male (desexed)	11 (16%)	3 (6%)
	Female (desexed)	13 (19%)	7 (14%)
Age (in years)	0 - 2	12 (17%)	11 (22%)
	2-4	20 (29%)	13 (26%)
	4-6	19 (27%)	13 (26%)
	6-8	9 (13%)	5 (10%)
	8-10	8 (11%)	6 (12%)
	10+	2 (3%)	2 (4%)
Breed Group	Toy	3 (4%)	0 (0%)
	Terrier	16 (23%)	15 (30%)
	Gundog	10 (14%)	4 (8%)
	Hound	8 (11.5%)	7 (14%)
	Working	22 (31.5%)	18 (36%)
	Utility	9 (13%)	5 (10%)
	Non-sporting	2 (3%)	1 (2%)
Type of dog	Pet	11 (16%)	0 (0%)
	Pig hunting	40 (57%)	33 (66%)
	Goat hunting	19 (27%)	17 (34%)
Pack size	2	10 (20%)	10 (20%)
	3	21 (42%)	21 (41%)
	4	8 (16%)	8 (16%)
	5	5 (10%)	5 (10%)
	6	6 (12%)	6 (12%)
Number of times through KAT	Once	48 (69%)	36 (72%)
	Twice	5 (7%)	2 (4%)
	Three times	4 (6%)	4 (8%)
	Four times	8 (11%)	4 (8%)
	Five times	5 (7%)	4 (8%)

5.2.3 *Site location*

The research site was located in Waharau Regional Park (90 kilometres south-east of Auckland on the Firth of Thames, North Island, New Zealand). Research was conducted over eight days between March and June 2008. This site was selected as this regional park is a 'no dog zone' so it is highly unlikely that any of the dogs would have been to the site before. An enclosure measuring 30m by 60m was constructed of wooden posts and shade cloth netting two meters high. The enclosure was comprised of bush area and grassland. Entry was by way of a built-in gate. The KAT stimuli comprised of two taxidermically stuffed kiwi, two partially thawed frozen kiwi; some kiwi feathers and faecal material, and a wooden painted two dimensional kiwi. These are the exact same kiwi stimuli used to train all the dogs previously. The KAT stimuli were positioned together under some trees and between two bushes. Two remote-controlled activated outdoor low lux dome IP based CCTV cameras were set up on 2m high stands within the enclosure. The first camera focused on the KAT stimuli and the second camera captured the rest of the enclosure. These cameras were controlled via a laptop computer 250 m away from the enclosure and connected by cat5 outdoor optical fibre ethernet data cable. The enclosure was divided into five area zones around the KAT stimuli to measure the distance dogs went in proximity to the KAT stimuli with markers. When the dog entered the enclosure it was 30 m from the KAT stimuli.

5.2.4 *Experimental Procedure*

Research participants (dogs and handlers) were escorted to the research site approximately 1 km away from the public car park. During sessions, dogs and hunters wore their usual hunting gear such as rip collars, transmitter collars, guns and knives to simulate natural hunting conditions. Electronic training collars were not worn, although they are during KAT training sessions. The hunters were instructed to behave as if they were going hunting (pig and goat dogs only). The hunting dogs were taken to the research enclosure three times. Firstly, each dog was individually put into the enclosure and 'sent away' by their hunter and given their specific hunting command 'to find the pig/goat' (Dog Alone session). The hunter then retreated out of sight behind trees providing the opportunity for the dog to explore the enclosure and interact voluntarily with the KAT stimuli, or not. Once the dog had located the KAT stimuli and voluntarily returned to the gate (ranged from 5 seconds – 10 minutes +); the handler then went in to

the research enclosure with their dog and walked directly past the KAT stimuli to the far side of the enclosure (60 m) and then walked back to the gate (Handler Present session). If a hunter brought multiple dogs, the first two steps happened individually for each dog. After all dogs had been in the enclosure twice, the entire pack was put in to the enclosure a third time with its hunting pack and the dogs were sent away by the hunter by being given their specific hunting command 'to find the pig/goat' (Hunting Pack session). There were 16 hunting packs ranging from two to six dogs (Mdn=3) comprising 50 of the 69 hunting dogs. This same order occurred for every single dog therefore the runs were not independent.

Pet dog owners were instructed to behave as if undertaking a bush walk and only entered the research enclosure twice. Firstly, the dog entered on their own with their owner out of sight and secondly, they were walked directly past the KAT stimuli (just as the hunting dogs experienced). The hunters/owners were asked not to communicate verbally with their dog(s) in the enclosure, other than to use words/sounds they would use when hunting, or out walking (if a pet dog). They were asked not to interact with their dog if their dog directly interacted with the KAT stimuli. Precipitation rates were recorded as were readings of temperatures recorded in Celsius, relative humidity recorded as a percentage, and wind speed was recorded in knots were taken as each dog entered the enclosure in each session.

5.2.5 Behavioural observations

The video footage was analysed using the 'Observer XT' software package (Noldus Information Technology, V7, 2007, Wageningen, the Netherlands). The zone of detection of the KAT stimuli (measured in meters) was recorded, as was the time taken to detect the KAT stimuli (measured in seconds) in the Dog Alone session. Proximity to the KAT stimuli in each of the three sessions was also recorded. Responses of each of the dogs to the KAT stimuli in each of the sessions (three for pig and goat hunting dogs and two for pet dogs) were rated on the following scale: (1) Strong avoidance of KAT stimuli: will not approach within 15m of the KAT stimuli, refuses to walk past KAT stimuli, runs away; at least two stress behaviours such as licking lips, cringing, slinking (walking hesitantly crouched low to the ground), ears back, and panting; (2) Moderate avoidance of KAT stimuli: reluctant to approach within 15m of the KAT stimuli vicinity of KAT stimuli, gives KAT stimuli a wide berth when walking past, avoids

looking at the KAT stimuli, does not sniff KAT stimuli, no physical contact with KAT stimuli; and displays at least one stress behaviour(s); (3) Indifferent to KAT stimuli: Shows no interest or avoidance of KAT stimuli walks past KAT stimuli, does not sniff KAT stimuli, no physical contact with KAT stimuli, is not reluctant to stay in vicinity of KAT stimuli, no stress behaviours displayed, any other behaviour not related to the KAT stimuli; (4) Moderate interest in KAT stimuli: air sniffs in direction of KAT stimuli, slowly approaches KAT stimuli, sniffs close to the KAT stimuli, no physical contact made with KAT stimuli; (5) Strong interest in KAT stimuli: quickly approaches KAT stimuli, sniffs KAT stimuli, makes physical contact with KAT stimuli. The proximity that the dogs went to the KAT stimuli in each of the three sessions was also recorded. Interobserver reliability analysis using the Kappa statistic was performed to determine consistency among raters. There was perfect interobserver reliability ($\kappa=+1$).

5.2.6 Statistical Analysis

Statistical analyses were performed using the Statistical Package for the Social Sciences (SPSS) (Version 18). The data were not normally distributed and, therefore, non-parametric tests were employed. Kruskal-Wallis ANOVA by ranks was used to test for demographic variable differences within each of the three sessions (Dog Alone; Handler present; Hunting Pack). When statistical significance was found, *post hoc* analyses using Mann-Whitney *U* tests with a Bonferroni correction for multiple testing were employed. The Jonckheere-Terpstra test was also used to assess monotonic trends in the data. Friedman's ANOVA by ranks was used to assess changes in behaviour in dogs over the three test sessions. When statistical significance was found, *post hoc* analyses using Wilcoxon matched-pairs signed-rank tests with a Bonferroni correction were employed. The effect size was reported using *r*. Alpha was set to .05 for all statistical analysis. It is acknowledged that alternative statistical analysis methodologies could also have been employed in this study, such as multinomial logistic regression modelling.

5.3 Results

Table 2 shows the 70 dogs' avoidance responses towards the KAT stimuli during the three test sessions: (1) dog alone; (2) with their handler; or (3) with their hunting pack

(for the 50 hunting dogs only). 77% of the dogs avoided the KAT stimuli when they were on their own and when they were with their handler. 70% of dogs avoided the KAT stimuli when they were with their hunting pack. Table 3 shows the proximity to the KAT stimuli that the dogs went in the three test sessions. 62% did not go nearer than 10 m to the KAT stimuli when alone; this reduced to 15% when with their handler due to the dogs walking to heel. 56% of the dogs did not go closer than 10 m to the KAT stimuli when with their hunting packs. Table 4 presents the statistical results that are identified below.

Table 2: Responses of the dogs towards the KAT stimuli when alone, with their handler and with their hunting pack.

Response to training stimuli	Strong avoidance <i>n</i> (%)	Moderate avoidance <i>n</i> (%)	Indifferent <i>n</i> (%)	Moderate interest <i>n</i> (%)	Strong interest <i>n</i> (%)	Total
Dog Alone session	29 (42%)	25 (36%)	5 (7%)	8 (11.5%)	3 (4%)	70
Handler Present session	23 (33%)	31 (44%)	6 (9%)	8 (11%)	2 (3%)	70
Hunting Pack session	20 (40%)	15 (30%)	1 (2%)	9 (18%)	5 (10%)	50

5.3.1 Time to detect the presence of the KAT stimuli

Of the 70 dogs, 40% detected the presence of the KAT stimuli within 10 seconds ($n=28$); 33% between 10-20 s ($n=23$); 21% between 20-30 s ($n=15$); 3% between 30-40 s ($n=2$) and 3% between 40-50 s ($n=2$). As the detection time increased, the distance at which the dogs detected the KAT stimuli decreased ($J=444.5$, $z=-4.38$, $r=0.35$); the lower avoidance of the KAT stimuli and the closer the dogs went to them when alone ($J=1091$, $z=2.898$, $r=0.346$; $J=5454.5$, $z=-4.24$, $r=-0.507$).

5.3.2 Detection distance of the KAT stimuli

71% of dogs detected the KAT stimuli from greater than 5 m (Table 3). The further the detection distance of the KAT stimuli, the shorter the time until detection ($J=538.5$, $z=-4.38$, $r=-0.53$); the more avoidance displayed when alone and with their handler

($J=723$, $z=-2.35$, $r=-0.28$; $J=567$, $z=-4.09$, $r=-0.49$ respectively); and the further away dogs stayed from the KAT stimuli ($J=1519.5$, $z=6.316$, $r=0.76$; $J=1127$, $z=2.20$, $r=0.26$ respectively).

Table 3: Proximity that the dogs detected the KAT stimuli and how close the dogs went when alone, with their handler, and with their hunting pack.

Proximity to training stimuli	Within 1 m <i>n</i> (%)	1-5 m <i>n</i> (%)	5-10 m <i>n</i> (%)	10-20 m <i>n</i> (%)	20-30 m <i>n</i> (%)	Total
Detection of KAT stimuli	4 (6%)	12 (23%)	23 (33%)	21 (21%)	12 (17%)	70
Dog Alone session	7 (10%)	14 (20%)	18 (26%)	14 (20%)	17 (42%)	70
Handler Present session	4 (6%)	23 (33%)	32 (46%)	8 (11%)	3 (4%)	70
Hunting Pack session	5 (10%)	10 (20%)	7 (14%)	12 (24%)	16 (32%)	50

5.3.3 Behaviour when the dog was alone

When alone, 78% of the dogs avoided the KAT stimuli and 70% of the dogs did not go within 5 m of it. The further away the dog stayed away from the KAT stimuli when alone, the more avoidance the dogs displayed when alone ($J=426.5$, $z=-5.94$, $r=-0.71$); when with their handler ($J=728$, $z=-2.6$, $r=-0.31$); and with their hunting pack ($J=371.5$, $z=-2.11$, $r=-0.30$). As the distance decreased to the KAT stimuli when alone, the distance to the KAT stimuli also decreased when with their handler, and their hunting pack ($J=1144$, $z=2.042$, $r=0.244$; $J=600$, $z=1.999$, $r=0.283$ respectively) (see Table 4).

5.3.4 Behaviour when the dog was with its handler

When with their handler, 61% of the dogs did not go within 5 m of the KAT stimuli, and 77% avoided it. The further away the dog stayed from the KAT stimuli when with its handler, the more avoidance the dogs displayed when alone ($J=567$, $z=-2.878$, $r=-0.344$); when with their handler ($J=424$, $z=-4.557$, $r=-0.545$); and with their hunting pack ($J=332.5$, $z=-1.856$, $r=-0.262$) (see Table 4).

Table 4. Statistical results for the time to detection of the training stimuli and the distance this occurred, as well as the level of avoidance and proximity to the training stimuli when alone, with their handler, and with their hunting pack.

Demographic variables and environmental conditions		Detection phase	Dog alone		With handler		With hunting pack	
		Distance from KAT stimuli	Response	Proximity to KAT stimuli	Response	Proximity to KAT stimuli	Response	Proximity to KAT stimuli
Detection phase	Time to detect KAT stimuli	$H(4)=21.53, p=0.00$	$H(4)=34.75, p=0.00$	$H(4)=17.6, p=0.00$	NS	NS	$H(4)=6.521, p=0.03$	NS
	Distance from KAT stimuli		$H(4)=25.57, p=0.00$	$H(4)=38.63, p=0.00$	$H(4)=6.74, p=0.15$	NS	NS	NS
Dog alone	Response			$H(4)=34.75, p=0.00$	$H(4)=10.90, p=0.03$	NS	NS	$H(4)=10.68, p=.03$
	Proximity to KAT stimuli				NS	NS	NS	NS
With handler	Response					$H(4)=20.59, p=0.00$	NS	NS
	Proximity to KAT stimuli					$H(4)=10.51, p=0.03$		NS
With hunting pack	Proximity to KAT stimuli							$H(4)=31.27, p=0.00$

5.3.5 Behaviour when the dog was with its hunting pack

70% of the dogs did not go within 5 m of the KAT stimuli when with their hunting pack, with 70% avoiding it. The further away the dog stayed from the KAT stimuli when with their hunting pack, the more avoidance was seen when the dog was alone ($J=345.5, z=-2.565, r=-0.307$); with its hunting pack ($J=138.5, z=-6.247, r=-0.883$), but not with their handler ($J=403.5, z=-1.447, r=-0.137$). The further away the dogs stayed from the KAT stimuli with its hunting packs, the further away from the KAT stimuli when alone ($J=594, z=1.999, r=0.28$) (see Table 4).

5.3.6 Repeat exposure to the KAT stimuli

The avoidance of the KAT stimuli did not significantly change with repeated exposure over the three test sessions ($\chi^2(2)=2.15, p=.34, r=0.05$). The detection distance of the

KAT stimuli and the distances that the dogs went in relation to the stimuli in the three sessions did change significantly ($\chi^2(3)=14.08$, $p=0.00$). Post hoc analysis using Wilcoxon's signed-rank tests with a Bonferroni correction of .008 applied showed that dogs went closer to the KAT stimuli than the distance from which they detected their presence when with their handler ($z=-2.80$, $r=-0.19$); when alone ($z=-2.99$, $r=-0.20$); or with their hunting pack ($z=-3.18$, $r=-0.32$).

5.3.7 Demographic effects

Table 5 shows that the gender, age and breed of the dog had no effect on how it interacted with the KAT stimuli in any of the test sessions. The function of the dog did show a significant effect and post hoc analysis found that pet dogs took significantly more time to detect the KAT stimuli than pig dogs ($U=103.5$, $z=-2.81$, $r=-0.39$) and goat dogs ($U=43$, $z=-2.77$, $r=-0.51$). Pet dogs detected the KAT stimuli from a significantly closer detection distance than pig dogs ($U=114.5$, $z=-2.49$, $r=-0.35$).

Dog function also significantly affected the avoidance to the KAT stimuli when the dogs were on their own, (Table 5). Post hoc analysis found pig dogs avoided the KAT stimuli more than pet dogs ($U=115$, $z=-2.56$, $r=-0.36$).

Dog function also significantly affected the avoidance to the KAT stimuli and how close they went when with their handler (Table 5). Post hoc analysis revealed that pig dogs avoided the KAT stimuli more than goat dogs ($U=210.5$, $z=-2.93$, $r=-0.38$). Goat dogs went closer to the KAT stimuli than pig dogs when with their handler ($U=231.5$, $z=-2.55$, $r=-0.33$).

5.3.8 Pack size effect

The size of the pack of which the dog was a member significantly affected the time taken to detect the presence of the KAT stimuli (Table 5). *Post hoc* analysis did not reveal where this difference lay. Pack size did significantly affect how close the dog would go to the KAT stimuli when on its own. Post hoc analysis revealed that dogs from 5-dog hunting packs went significantly closer to the KAT stimuli than dogs from 3-dog packs ($U=11$, $z=-2.76$, $r=-0.54$); four dogs ($U=0$, $z=-3.01$, $r=-0.83$); or six dogs ($U=0$, $z=-2.80$, $r=-0.85$). Pack size also significantly affected the avoidance of the KAT

stimuli when alone (Table 5). Jonckheere's test revealed that as the pack size increased, the avoidance of the KAT stimuli decreased ($J=572$, $z=2.10$, $r=0.31$).

The size of the pack did affect how close the dogs would go when with its pack but not its handler (Table 5). Post hoc analysis revealed that dogs from 6-dog packs went closer to the KAT stimuli than did dogs from 3-dog packs ($U=12$, $z=-2.77$, $r=-0.54$).

Table 5: Statistical results for the demographic variables with the time to detection of the training stimuli and the distance this occurred, as well as the level of avoidance and proximity to the training stimuli when alone, with their handler, and when with their pack.

Demographic variables	Detection phase		Dog Alone		With handler		With hunting pack	
	Time	Distance	Response to KAT stimuli	Proximity to KAT stimuli	Response to KAT stimuli	Proximity to KAT stimuli	Response to KAT stimuli	Proximity to KAT stimuli
Gender	NS	NS	NS	NS	NS	NS	NS	NS
Age	NS	NS	NS	NS	NS	NS	NS	NS
Breed Group	NS	NS	NS	NS	NS	NS	NS	NS
Type of dog	$H(2)=9.45$, $p=0.01^{*2}$	$H(2)=6.55$, $p=0.04^{*2}$	$H(2)=6.92$, $p=0.03^{*2}$	NS	$H(2)=10.70$, $p=0.01^{*2}$	$H(2)=7.26$, $p=0.03^{*2}$	NS	NS
Pack size	$H(4)=10.15$, $p=0.04^{*4}$	NS	$H(4)=12.25$, $p=0.02^{*3}$	$H(4)=12.13$, $p=0.02^{*3}$	NS	NS	NS	$H(4)=11.6$, $p=0.02^{*4}$
Number of times through KAT programme	NS	$H(4)=11.82$, $p=0.02^{*1}$	NS	NS	NS	NS	NS	NS
Effect of temperature	NS	NS	NS	NS	NS	NS	$H(2)=9.72$, $p=0.01$	$H(2)=9.00$, $p=0.01$
Effect of humidity	NS	NS	$H(2)=16.31$, $p=0.00$	$H(2)=8.34$, $p=0.02$	NS	NS	NS	NS
Effect of wind	NS	NS	NS	NS	NS	NS	NS	NS

(*Post hoc analysis undertaken using Mann-Whitney tests with a Bonferroni correction applied of which ¹=0.0125; ²=0.017; ³= 0.005; ⁴= 0.008).

5.3.9 Number of times through the KAT programme

The number of times a dog had been through the KAT programme did affect the distance from which it was detected (Table 5). Post hoc analysis revealed that dogs that had been through the KAT programme five times detected the KAT stimuli from significantly further away than dogs trained only once ($U=38$, $z=-2.59$, $r=-0.36$) or four

times ($U=3$, $z=-2.55$, $r=-0.28$), but this was not true of dogs trained two and three times ($U=3.5$, $z=-1.97$, $r=-0.62$; $U=12$, $z=-2.767$, $r=-0.41$).

Jonckheere's test showed that the more times a dog had been through KAT programme, the more avoidance they displayed towards the KAT stimuli when alone ($J=447.5$, $z=-2.23$, $r=-0.27$); and with their hunting pack ($J=214.5$, $z=-1.64$, $r=-0.23$); but not with their handler ($J=591$, $z=-0.34$, $r=-0.04$). Jonckheere's test also revealed that the more times a dog had been through the KAT programme, the further away from the KAT stimuli the dogs stayed when alone ($J=799$, $z=2.32$, $r=0.27$); with their handler ($J=752.5$, $z=1.81$, $r=0.22$) and with their hunting pack ($J=379.5$, $z=2.00$, $r=0.24$).

5.3.10 Effect of temperature

38.5% of the dogs were tested in temperatures ranging from 14-17°C ($n=27$), 15.5% from 17-20°C ($n=11$) and the remaining 46% in temperatures 20-24°C ($n=32$). The only effect of temperature was the avoidance of and proximity to the KAT stimuli when in their canine hunting pack (Table 5). The higher the temperature, the more avoidance seen of the KAT stimuli and from the furthest distance ($J=247$, $z=-2.08$, $r=-0.30$; $J=507$, $z=3.01$, $r=0.36$ respectively).

5.3.11 Effect of humidity

17% of the dogs were tested in humidity levels ranging from 60-75% ($n=12$), 53% with 75-90% ($n=37$), and 30% with humidity ranging 90-100% ($n=21$). The only effect of humidity levels was the avoidance of and proximity to the KAT stimuli when dogs were alone (Table 5). The higher the humidity levels, the higher the levels of avoidance of the KAT stimuli ($J=528$, $z=-2.49$, $r=-0.30$) and further away from the KAT stimuli the dogs stayed ($J=930.5$, $z=2.23$, $r=-0.27$).

5.3.12 Effect of wind speed

50% of the dogs were tested in 0-1 knots of wind ($n=35$), 27% in 1-2 knots (19), and 20% in 2-3 knots ($n=14$) and 3% in 3-4 knots ($n=2$). Wind had no effect on how the dogs behaved in any of the sessions.

5.4 Discussion

The level of avoidance of the KAT stimuli was similar regardless of whether the dogs were on their own (77%), with their handler/owner (77%), or with their hunting pack (70%). It is acknowledged that alternative statistical analysis methodologies could also have been employed in this study, such as multinomial logistic regression modelling.

5.4.1 *Time taken to detect the presence of the KAT stimuli*

Time taken to detect the presence of the KAT stimuli varied but approximately 75% of the dogs detected their presence within 20 seconds (this ranged from immediately to almost one minute). Interestingly, the time taken to detect the KAT stimuli did not decrease with the number of times a dog had been through aversion conditioning programme. Given that dogs have been trained to detect many substances, such as oestrus in dairy cows, cancer, illicit drugs and invasive species (Helton, 2009), it is surprising that some of the dogs took almost a minute to detect the presence of the KAT stimuli. Not surprisingly, as the time to detect the KAT stimuli increased, the closer the dogs were to the KAT stimuli, and the more interest they displayed of the KAT stimuli (and the closer they went to them when they were on their own). This did not occur when the handler was present.

5.4.2 *Distance that the KAT stimuli was detected*

Two-thirds of the dogs detected the KAT stimuli within 10 meters of their presence. Gazit and Terke (2003) showed that scent dogs give preference to the sense of olfaction over that of sight. It is possible that the scents of the KAT stimuli were waning and had changed from what the dogs had originally been trained with. Another explanation is that the dogs are not clearly seeing the KAT stimuli. McGreevy et al. (2003; 2004) demonstrated that skull shape influenced the visual field in dogs and concluded that different breeds of dogs see visual images differently. It is conceivable that different dogs were visually interpreting the KAT stimuli differently potentially impacting on the training, and therefore on the detection of the stimulus.

Only a few studies have reported detection distances from detection dog surveys, and measurements differ widely (Reed et al., 2011). Studies have found mean detection distances ranging from 4.8km (Ralls and Smith, 2004), 13.9km (Cablak et al., 2008), and

29.3km (Shivik, 2002) in terrestrial surveys, to detection distances up to 1.9km in marine surveys (Rolland et al., 2006). All of these far exceed the distances that the dogs in this study were detecting the KAT stimuli. This may be due to lack of exposure to, and reinforcement with, the KAT stimuli.

The distance from and time to detection of the KAT stimuli, correlated to the dogs behaviour when alone; with their handler; and also with their pack. If the KAT stimuli detection time was short and the detection distance was far, the dogs showed avoidance when alone and stayed away from the KAT stimuli. Similar results are seen in Christiansen et al., (2001a) where avoidance behaviours were displayed to sheep after shock training in novel sites without the electric collar on. In some cases in this study, the avoidance behaviours were so severe that it was difficult to get the dogs in close enough proximity to the KAT stimuli to film them. Three animals were removed from the research on welfare grounds, due to displaying too many stress behaviours.

5.4.3 Dogs with their handler

When the handler was with their dogs, this produced an interesting change in the hunting dogs and they went significantly closer to the KAT stimuli in order to stay at heel. These dogs still did not show any interest in the KAT stimuli but chose to stay close to the handler walking to heel, or very close behind their handler.

5.4.4 Dogs with their hunting pack

Levels of interest in the KAT stimuli increased when the dogs were in their hunting pack with 28% of the dogs showing interest in the KAT stimuli. This may be due to social facilitation, especially given the social aspects of hunting in canines. Hinde (1970) states that the stimulation of predatory chasing and attack in other dogs is social facilitation. Christiansen et al. (2001b) found that observing predatory behaviour stimulated predatory chase in another dog, even if they do not display this behaviour when with a non-chasing companion. Other forms of social facilitation have also been reported in dogs, such as eating if not fed ad libitum (Voith, 1994).

Social facilitation is also involved in predatory behaviour in other canid species, such as coyotes and wolves, and is involved in developing hunting strategies towards large prey which may result in inexperienced canids supporting older adults in chasing, cornering,

and fatiguing the prey (Fox, 1971). Christiansen et al. (2001b) considered that social facilitation plays such an important part in predatory behaviour that they suggest in tests certifying dogs for their propensity to chase sheep, a well-trained Border collie approaching sheep on command should be used as it would assist revealing the full predatory potential of the dog being tested. Given the risk of socially facilitated predatory behaviour, it is of concern that most previous research looking at predation and hunting has only tested dogs in isolation from other dogs (e.g. Christiansen et al., 2001a; 2001b; Brenoe et al., 2002). This factor should be considered with prey-aversion conditioning programmes, because generalization of avoidance to situations where the dog is not alone is far from certain, and may be unlikely.

5.4.5 Order of testing sessions

In this study, dogs were systematically tested; alone, with their handler, and then as a hunting pack. Due to limited animal material, we chose not to randomise this sequence. By the chosen design, the tests are not independent and learning is likely to have taken place. However, repeat sessions with the KAT stimuli did not significantly alter the behaviour of the dogs; if a dog showed interest in the KAT stimuli and went near them in one session, then they were likely to do so in all sessions. Conversely, if a dog showed avoidance towards the KAT stimuli and kept a large distance from them, then overall, it was likely to maintain that behaviour throughout the three sessions.

Potentially of concern is that 16% of the dogs displayed interest in the KAT stimuli when alone, 14% did so when with their handler, and 28% with their hunting pack. The reduction in avoidance of the KAT stimuli when the dogs were with their hunting pack may possibly be due to two prior exposures to the KAT stimuli without any associated punishment, or social facilitation as discussed above.

5.4.6 Demographic variables

There was no gender difference found in the detection of, the avoidance of, or proximity towards the KAT stimuli. This result is similar to Christiansen et al. (2001a; 2001b; 2001c) who also found no difference in gender in sheep chasing behaviours in hunting dogs. Likewise, no gender differences have been identified in the olfactory apparatus in dogs (McGreevy et al., 2004), so this result is not unexpected.

There was also no effect found of canine age or breed type of the dogs in the detection of the behavioural response towards, or proximity to, the KAT stimuli. Both age (Ogburn et al. 1998; Christiansen et al., 2001a; 2001b) and breed type (Christiansen et al., 2001a; 2001b; Pryor, 1999; Scott and Fuller, 1965; Turcsán et al., 2011) have been found to affect training and behavioural responses in other studies. Breed differences in terms of visual ability (McGreevy et al., 2004; Gasci et al., 2009a) and olfactory ability (Rooney and Bradshaw, 2004; Tacher et al., 2005, Lesniak et al., 2008; Robin et al., 2009) have also been reported and the dogs' olfactory epithelium in the nasal cavity has been found to vary by breed and individual dogs (Helton, 2009).

The function of the dogs did affect the interaction with the KAT stimuli. Pet dogs took the longest time to detect the presence of the KAT stimuli and did so from the shortest distance. Pet dogs also displayed the least avoidance of the KAT stimuli both when on their own and also when their owner was with them. This may reflect that dogs kept for the purpose of companionship may not be subject to the same level of training as working dogs such as hunting dogs. Anecdotally, pet dogs showed much less interaction and reliance on their owners, whereas the hunting dogs showed heavy reliance on their handlers for cues on how to behave, and stayed in much closer proximity to their owners, which resulted in them going much closer to the KAT stimuli when their hunters were present, despite showing higher levels of avoidance than pet dogs.

Interestingly, the size of the hunting pack that the dog was from affected how they behaved when they were on their own, with interest in the KAT stimuli increasing as pack size increased. Correspondingly, the proximity towards the KAT stimuli decreased when the dogs were on their own and with their pack members. This result is of interest as no difference was seen with these dogs when they were with their handler, yet without the handler, interest in the KAT stimuli was evident. Clarke (1991) reports in a survey of 161 pig hunters found the mean size of dog pack was 4 (range 1-7) and the amount of time that dogs spend on their own in the bush is large. This may be potentially of concern, even with hunting dogs 'well-trained' but from larger packs and that Christiansen (2001b) report that the most potent sheep hunters are probably hunting dogs, which may run far out of sight of the owner during training and hunting.

Clarke (1991) found that areas in New Zealand which limited the size of the dog pack (e.g. two dogs/hunter, or four dogs per party) led to packs having to be split which

reduced effectiveness, as partial dog packs led to lack of coordination among dogs, inability to find or hold pigs, and insufficient barking to guide hunters to the dogs. These problems were stated as increasing the loss of dogs. Clarke (1991) found that hunters reported that 'lost/stolen' dogs were a factor limiting numbers of pigs harvested. It is important that lost dogs are recovered quickly from the bush as hunger has been found to be a potentiator of predatory tendency which takes precedence over food consumption (Adamec, 1976; Hall and Bradshaw, 1998). Hunger has also been found to facilitate preying in non-predators (Polsky, 1975; O'Boyle, 1974). Darrow and Shivak (2009) have found that hunger may be greater in free-roaming coyotes than in captive coyotes, causing a greater motivation to eat, and therefore, a greater propensity to habituate to frightening devices.

As expected, there was a positive correlation between the number of times a dog had been through the KAT programme and the distance from where the KAT stimuli detected; the more behavioural avoidance shown when alone and with their pack; and the further away they stayed from the KAT stimuli in all three sessions. This suggests that the more times a dog goes through the aversion conditioning, the stronger the conditioning association with the KAT stimuli. It has previously been reported (e.g. Linhart et al., 1976; Christiansen et al. 2001b; Hawley et al., 2009) that multiple training sessions are required to produce avoidance; especially where predatory behaviour is elicited by live prey.

5.4.7 *Environmental conditions*

Variability in weather conditions and the physiological condition of dogs can affect detection rates (Gutzwiller, 1990). Air temperature, vapour pressure, and the direction and variability of wind currents all affect how scent disperses through the air (Snovak, 2004; Stockham et al., 2004). Precipitation was not recorded as there was no rainfall on any of the test days, and therefore the effect could not be reviewed in this research. Air moisture has been found to slow scent evaporation rates and is essential to maintain bacterial activity, but prolonged precipitation may dampen or wash away scent vapours near the ground (Syrotuck, 1972). Precipitation has been a factor contributing to scent degradation (Smith et al., 2005; Harrison, 2006).

Weather temperature did affect the behaviour to the KAT stimuli of the dogs in their pack, and also the distance from the KAT stimuli the dogs went. The higher the temperature, the more avoidance the dogs showed and the further away from the KAT stimuli they stayed. Higher temperatures have been found to correspond to higher rates of evaporation and bacterial activity, resulting in stronger scent, however, temperatures that are too high can halt scent production (Wasser et al., 2004). Clarke (1991) reported that pig hunters found pigs were harder to find in summer because they were less mobile; and that their scent in the hotter, drier conditions often dispersed rapidly. The result that Clarke found may not be due just to issues with scent dispersal, as air temperature has also been found to affect dogs' scenting abilities differently. Increased panting in dogs with warmer weather; leads to decreased sniffing and scent detection (Gazit and Terkel, 2003). Smith et al. (2003) report that detection dogs can have highly variable panting rates in response to the same environmental conditions. Other research has not found a significant variation in scenting detection as a result of temperature (Cablak and Heaton, 2006; Long et al., 2007; Nussear et al., 2008).

The relative humidity level was found to affect the behaviour of the dogs with lower humidity levels resulting in higher levels of avoidance behaviours towards the KAT stimuli and from greater distances when the dogs were on their own. Relative humidity is thought to influence the evaporation rate of the scent source (Pearsall and Verbruggen, 1982; Gutzwiller, 1990). However, other research has not found a significant variation in detection with relative humidity rates (Long et al., 2007; Nussear et al., 2008).

All wind speeds were mild during the test days, which may account for a lack of detection distance with the dogs. Cablak et al. (2008) has found that the greater the wind speed, the greater the detection distance. Shivik (2002) also observed a positive relationship between wind variability and time to detection, suggesting that highly variable wind may disperse scent and make it more difficult for a dog to follow it to its source. Other research however has not found a significant variation in detection with wind rates (Cablak and Heaton, 2006; Nussear et al., 2008).

Scent contamination is another potential confounding factor for conservation detection dog surveys (Snovak, 2004) and potentially with this research. Although we used the same pasture for all of our controlled trials, we were unable to control for possible

temporal sources of variability in the olfactory environment, such as the proximity of livestock, trampers, and residual scent from prior sessions.

5.4.8 *KAT stimuli compared to live prey*

While this aversion conditioning programme has been successful in producing a level of avoidance displayed in over 70% of dogs towards the KAT stimuli when alone, with their handler and with their pack, the avoidance is towards stimuli as opposed to live prey that move and smell and sound different. Motion, smell and sound can all trigger the predatory instinct in dogs. The remaining 30% of dogs that did show interest in the KAT stimuli also need to be considered. It is highly likely that live kiwi would stimulate more predatory instinct within the dog with more visual stimuli (movement) than the stuffed kiwi. Likewise the odour of a live kiwi is likely to differ from a frozen kiwi carcass repeatedly thawed and refrozen. Behaviour-contingent frightening devices have been found to protect motionless food bait, but protection from live animals has been proven to be more difficult because movement of prey may elicit a chase response which could overpower or limit the repelling effect of the aversion conditioning (Connolly et al., 1976).

Killing and consumption are also driven by different motivations, so an aversion to dead prey may not be generalised to live prey (Conover et al., 1977). Nicolaus et al. (1982) reports that while raccoons have been conditioned to avoid eating live chickens after taste aversion conditioning with chicken carcasses, the results have not been so successful with canid predation. Taste aversion conditioning (TAC) describes the learning that has occurred when animals avoid ingesting substances with specific flavours (or odours) because of some prior association between that flavour (and odour) and illness. Coyote predation on sheep using TAC in some cases has reduced (Gustavson et al., 1976; Gustavson and Nicolaus, 1987); and in others it was not (Bourne and Dorrance, 1982; Hansen et al., 1997). It can also just reduce the consumption of a particular prey animal without eliminating the killing of that prey (Conover and Kessler, 1994). The use of TCA has also been reported as a potential welfare concern in dogs (Hansen et al., 1997). A further confounding factor is that Galetti and Sazima (2006) found that dogs do not normally ingest the animals they kill and the most vulnerable prey are species that cannot climb or fly while chased by dogs.

Schultz et al. (2005) found that aversion conditioning using electric collars moderately successful in deterring depredation of calves by wolves; but that it was less successful if used after depredation of livestock had already occurred. Prior kiwi predation, or even bird predation, should be taken in to consideration during the aversion conditioning programme. Every participant involved in this research stated that their dog had never killed a kiwi.

5.5 Conclusion

This research highlights the fairly consistent nature of dogs' behaviour towards the aversion conditioned KAT stimuli regardless of whether the dogs are on their own, with their hunter/owner, or in their hunting pack. Areas of potential concern in evaluating the effectiveness of the programme are the impact of the larger hunting packs and also the social facilitation potential of predatory behaviours. However, the ecological validity of the training is not yet established. That is, further research is needed to demonstrate that KAT-trained avoidance generalizes to live birds, and not just to the stimuli used during training.

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Chapter Six: Can dogs generalise from 'ecologically relevant' training stimuli of the endangered kiwi (*Apteryx* spp.) to live kiwi?

6.1 Abstract

Avoidance training has often been used as an intervention to reduce predation of threatened species. However, the threatened status of the predated species may necessitate that avoidance conditioning using live members of that species, is not possible. Rather, stimuli related with the species are paired with aversive stimulation in the hope that avoidance of the stimuli will be both learned and will generalize to live members of the threatened species. For example, New Zealand's Department of Conservation runs a kiwi aversion canine training programme (KAT), which pairs kiwi-related stimuli with aversive electrical stimulation in an attempt to train dogs to avoid live kiwi in the wild. Previous research has shown the effectiveness of KAT in producing avoidance of the training stimuli, but generalization to live kiwi is unknown. To assess this, we examined an identical arrangement using live chickens instead of live kiwi, due to greater availability of live chickens. We compared the effectiveness of training avoidance of a live chicken during testing by pairing either live chickens or ecologically relevant training stimuli with electric shock. 84 dogs received avoidance training and then were presented with a live chicken one month later at a novel location with novel dog handlers. There were five training stimuli used and dogs were randomly allocated in to one of seven treatment groups: (1) dead chicken; (2) stuffed chicken; (3) chicken faecal material; (4) chicken nesting material; (5) wooden cut-out chicken; (6) all chicken models together; (7) a live chicken. With the exception of the live chicken in training, we selected these stimuli because they are equivalent to the training stimuli used in KAT. When testing avoidance of the live chicken, behaviours towards the live chicken were quantified, as was latency and distance required to detect the chicken. The majority of dogs did not generalise from the chicken models to the live chicken. Only those dogs trained using the live chicken showed reliable avoidance of the live chicken during testing. These findings call into question haphazard use of ecologically relevant stimuli that have not been validated in training avoidance of live animals. Whilst it is acknowledged that there are ethical and practical difficulties, it is recommended that the

use of live kiwi for aversion training be explored and, in general, that generalization of avoidance of training stimuli to avoidance of a threatened species cannot be assumed.

6.2 Introduction

The hunting of wild animals has been a significant part of New Zealand's culture for more than 100 years (Fraser, 2000) with 4% ($n=143,598$) of the New Zealand population hunting deer (*Cervus* spp.) or pigs (*Sus scrofa*) at least once a year (Sport and Recreation, 2009). Recreational hunting of feral pigs, deer and goats (*Capra hircus*) often occurs in remote areas and is considered an essential method of pest control by many Department of Conservation (DOC) conservancies (Fraser, 2000). Feral pig hunting is distinguished from other big-game hunting by its reliance on dogs (*Canis familiaris*; Clarke, 1991) with 87% of pig hunters using dogs (Nugent, 1989). Interest in controlling invasive species conflicts when there is overlap in habitat with non-flying birds, in particular the endangered kiwi (*Apteryx* spp.) due to the high predation impact (Holzapfel et al., 2008; Miskelly et al., 2008). A solution was sought that would allow dogs to be used for companionship, and recreational or professional hunting, whilst attempting to minimize the risk to kiwi. Accordingly, the Kiwi Aversion Dog Training Programme (KAT) was developed where dogs are trained to avoid kiwi training stimuli through aversive electrical stimulation via an electric dog training collar.

Despite the use of electric shock collars being relatively controversial on welfare grounds (e.g. Schilder and van der Borg, 2003; Schalke et al., 2007), their use in conservation efforts to reduce predation generally is considered justifiable (e.g. Marscark and Baenninger, 2002). Response-contingent electric shocks can in certain conditions reduce or eliminate, at least for a period of time, predatory behaviour in canid species (Shivak et al., 2003) including coyotes (*Canis latrans*) (e.g. Linhart et al., 1976; Andelt et al., 1999), fox (*Urocyon littoralis*) (e.g. Cooper et al., 2005), wolves (*Canis lupus*) (e.g. Shivak, 2004; Schultz et al., 2005; Hawley et al., 2009), and dogs (e.g. Christiansen et al., 2001a; 2001b; 2001c). The main difference between the aversive training in these studies and KAT is that they have performed aversion conditioning using live prey animals as training stimuli; KAT only uses ecologically relevant training stimuli but not live kiwi.

Animals have been found to respond naturally to ‘ecologically valid’ cues of predators and prey as unconditioned stimuli (e.g. Buron et al., 2007; McGregor et al., 2002; Papes et al., 2010; Trebaticka et al., 2010; Vyas et al., 2007) but whether the same can occur through conditioning is as yet unknown. The training stimuli that are currently used throughout New Zealand involve taxidermically stuffed kiwi, dead frozen kiwi, kiwi faecal material, a two-dimensional kiwi cut out and kiwi nesting material. The untested fundamental principle of KAT is that the training stimuli are ‘ecologically valid’ and the sight and/or odour of the kiwi training stimuli represent live kiwi. Through association with shock, dogs will avoid kiwi when encountering kiwi while hunting or recreating in conservation areas. This assumption is investigated in the present study arranging a model of kiwi aversion training using chickens (*Gallus domesticus*). Given the ecological value of kiwi, chicken analogues of all the stimuli have been used in this research. Hence, in the test phase the dogs were presented with a live chicken, rather than kiwi. We assessed which of the individual training stimuli resembling chickens, if any, are ‘ecologically valid’ and result in avoidance when tested with exposure to a live chicken.

6.3 Material and methods

6.3.1 Test subjects

84 pet dogs kept predominantly for the purpose of companionship were recruited to participate in this research. Dog breeds were categorised by owner-identified breed, or predominant breed, classification. The dogs were assigned to one of the following seven recognised New Zealand Kennel Club (www.nzkc.org.nz) groupings: Toy Group: these are small companion or lap dogs (e.g. Chihuahua, Yorkshire Terrier and Pug); Terrier Group: dogs originally bred and used for hunting vermin (e.g. Staffordshire Bull Terrier, English Bull Terrier and Jack Russell Terrier); Gundog Group: dogs that were originally trained to find live game and/or to retrieve game that had been shot and wounded (e.g. Labrador, Golden Retriever, German Shorthaired Pointer); Hound Group: breeds originally used for hunting either by scent or by sight (e.g. Greyhound, Whippet and Beagle); Working Group: herding dogs that are associated with working cattle, sheep and other cloven-footed animals (e.g. Australian Kelpie, Australian Cattle

Dog and Border Collie); Utility Group: this group consists of an extremely mixed and varied bunch, most breeds having been selectively bred to perform a specific function not included in the sporting and working categories (e.g. Boxer, Mastiff and Schnauzer); Non-Sporting Group: this group consists of miscellaneous breeds of dogs mainly of a non-sporting origin, (e.g. Bulldog, Dalmatian and Poodle).

6.3.2 *Field Sites*

This research was undertaken at two sites on the Unitec Institute of Technology campus in Mount Albert in Auckland, North Island, New Zealand. Training and retest sites were in different locations so as to eliminate potential site specific responses. The aversion training using chicken training stimuli occurred at Site One in June 2008 and the exposure to the live chicken occurred at Site Two one month later in July. Both sites consisted of grassland with bush areas. Two remote controlled activated outdoor low lux dome IP based CCTV cameras were set up on 2 m high stands at Site Two to record the dogs' interaction with the live chicken. The first camera focused on the live chicken and the second camera captured the rest of the testing site. These cameras were controlled via a laptop computer 100 meters away from the research site and connected by cat5 outdoor optical fibre ethernet data cable.

6.3.3 *Group allocations*

All dogs underwent a physical health check by a qualified vet nurse prior to inclusion in this research and needed to be deemed in good physical health with signed owner consent for the dogs to be able to participate in this research. Group size was determined by the total number of healthy dogs and dog owners willing to participate in the research and split as evenly as possible amongst the groupings. Each dog was randomly allocated to be aversion trained using one of seven training stimuli. Group one was aversion trained to a 'stuffed chicken' ($n=12$), group two to a wooden, painted 'cut out chicken' ($n=12$), group three to chicken 'nesting material' ($n=12$), group four to chicken 'faecal material' ($n=13$), group five to a 'dead chicken' ($n=13$), group six to 'all the stimuli' together ($n=12$; comprising of 'stuffed', 'cut-out', 'nesting material', 'faecal material' and 'dead chicken'), and group seven was aversion trained using a 'live chicken' ($n=10$).

6.3.4 *Aversion-training methodology*

All dogs were trained using the DOC Hauraki Area Office KAT programme methodology as described in Dale et al. (2013). Each training session involved fitting the dog with an Agtronics Smart Aid 4 electric training collar (manufactured training products) which delivered 0.0092 joules of electric shock with each shock at a rate of three 10-microsecond pulses per second to the underside of a dog's neck via two steel studs. Each dog was individually walked past the training stimuli on a long lead with one handler to standardise the training. The handler did not communicate verbally with the dogs. The stimuli were positioned on the ground as per the aversion training protocol, except for the live chicken. The chicken was kept in an aviary 2 x 3 x 2 meters made of wood and chicken wire. This enabled the chicken to move around the aviary and display flight behaviours.

Dogs were given the opportunity to observe and approach the training stimuli. When contact was made (sniffed the training stimuli); a brief period (0.5-1.5 s) of electrical stimulation was discharged from the two electrodes on the collar, which was administered via a remote-controlled handset controlled by the DOC trainer. If the dog did not voluntarily sniff the training stimuli, the dog would be encouraged to do so by the handler with hand movements and once contact was made, would be shocked. Most of the dogs were walked past the training stimuli for a second time to assess the dogs' behaviour toward the training stimuli. If contact was made with the training stimuli for a second time, a second shock was administered. This was continued until each dog displayed avoidance towards the training. Avoidance was achieved in all dogs to the training stimuli. Some dogs were not walked past the training stimuli for a second time because they refused to return to the training area and this was counted as sufficient evidence of avoidance. This was continued until each dog displayed avoidance behaviours (or at least no interest behaviours) towards the training stimuli (see Section 2.1.6 below for outline of behavioural response measurement).

6.3.5 *Live chicken testing methodology*

One month later, at a novel location (Site Two), the 84 dogs were exposed to a live chicken. We arranged a new location, a new handler, and removed the electric collar to eliminate any potential location, person or electric collar specific aversion. Each dog was individually walked for 100 m away and around a corner at which point the chicken

was 8 m away. The chicken was in an aviary 2 x 3 x 2 meters made of wood and chicken wire, as described above. The dogs were walked past the live chicken restrained by a 4 meter long dog lead and permitted to interact with the chicken with no interference from the handler. The handler did not communicate verbally with the dog but when strong interest in the chicken was displayed they withdrew the dog from the area after twenty seconds. The chicken was replaced with a novel chicken after five encounters with dogs, or sooner if the chicken was displaying stress behaviours. For the group aversion trained initially with a live chicken, a different chicken cage was arranged in the one-month exposure to the live chicken session in order to eliminate any aviary specific aversion (i.e. the possible bias that the dog may have associated the shock with the cage rather than the chicken itself). For these ten dogs, they were exposed to a chicken in a new metal cage sized 0.8 x 0.8 x 0.8 m. All groups of dogs were again tested with a live chicken five minutes and ten minutes after the first exposure. At each exposure, their behavioural response was measured (see Section 2.1.6 below).

6.3.6 *Behavioural response to the training stimuli*

The video footage was analysed using the ‘Observer XT’ software package (Noldus Information Technology, V7, 2007, Wageningen, the Netherlands). The following scale, previously used by Dale et al. (2013), was used to classify the responses to the live chicken: (1) Strong avoidance: did not approach vicinity of the chicken, refused to walk past chicken, ran away; at least two stress behaviours such as licking lips, cringing, slinking (walking hesitantly crouched low to the ground), ears back, and panting; (2) Moderate avoidance: reluctant to approach vicinity of chicken, gave the chicken a wide berth when walked past; and displays at least one stress behaviour(s); (3) Indifferent: Showed no interest or avoidance of the chicken when walked past the chicken, did not sniff towards the chicken, was not reluctant to stay in vicinity of the chicken, any other behaviour not related to the chicken; no stress behaviours displayed; (4) Moderate interest: air sniffed in direction of the chicken, slowly approached the chicken, sniffed close to the chicken; and (5) Strong interest: quickly approached the chicken, sniffed at the chicken, attempted to make physical contact with the chicken. The zone of detection of the live chicken (measured in meters) was also recorded, as was the time taken to detect the presence of the chicken (measured in seconds). All responses were rated by

two observers. Interrater reliability analysis using the Kappa statistic was performed to determine consistency among raters.

6.3.7 Statistical Analysis

Statistical analyses were performed on avoidance behaviour during testing using the Statistical Package for the Social Sciences (SPSS) (Version 18). The avoidance data were not normally distributed and, therefore, non-parametric tests were employed. Kruskal-Wallis ANOVA by ranks was used to test for demographic variable differences and the training stimuli used with the live chicken presentation behaviour. When statistical significance was found, *post hoc* analyses using Mann-Whitney *U* tests with a Bonferroni correction for multiple testing were employed. Friedman's ANOVA by ranks was used to assess changes in behaviour with the repeated live chicken exposure. When statistical significance was found, *post hoc* analyses using Wilcoxon matched-pairs signed-rank tests with a Bonferroni correction were employed. The effect size was reported using *r*. Alpha was set to .05 for all statistical analysis. It is acknowledged that alternative statistical analysis methodologies could also have been employed in this study, such as multinomial logistic regression modelling.

6.3.8 Ethical approval

Ethics approval was granted by the University of Auckland Animal Ethics Committee (AEC approval # R576).

6.4 Results

Table 1 shows the demographic makeup of the 84 dogs used in this research. It reports the median and range distribution for the demographic variables and the arranged training stimulus. Measures reported were: (1) the time to detect the chicken; (2) the distance between the dog and chicken at first detection; and (3) the avoidance displayed. Table 2 shows the avoidance of the chicken across all dogs during testing in the initial exposure (45%), after five minutes (48%), and after ten minutes (57%). There was perfect interobserver reliability ($\kappa=+1$).

Table 1: Total numbers, medians and ranges for the different demographic variables in to recognising the chicken and the avoidance to it.

Demographic variable			N (Total=84)(%)	Distance till detection (in meters)		Time till detection (in seconds)		Response to live chicken	
				Median	Range	Median	Range	Median	Range
Gender	Male (n=40; 48%)	Entire	7 (8%)	3	2	2	0	3	3
		Desexed	33 (39%)	3	3	2	4	3	4
	Female (n=44; 52%)	Entire	3 (4%)	5	3	1	1	1	1
		Desexed	41 (49%)	3	3	2	4	3	4
Age (in years)	0-2		9 (11%)	2	3	2	2	3	3
	2-5		42 (50%)	3	3	2	4	2	4
	5-8		19 (22.5%)	3	3	2	4	3	4
	8+		14 (17%)	2	2	2	1	3.5	4
Breed group	Toy		6 (7%)	3	2	2	4	2.5	4
	Terrier		18 (21.5%)	3	3	2	3	3	4
	Gundog		18 (21.5%)	3	3	2	4	2	4
	Hound		1 (1%)	4	0	1	0	5	0
	Working		18 (21.5%)	3	3	2	4	3	3
	Utility		14 (16.5%)	2	3	2	4	4	4
	Non-sporting		9 (11%)	3	2	2	2	2	3
Training stimuli used	Stuffed chicken		12 (14%)	3.5	3	2	4	3.5	3
	Cut out chicken		12 (14%)	2	3	2	4	4	3
	Nesting material		12 (14%)	3	3	2	2	4	3
	Faecal material		13 (15%)	3	2	2	2	4	4
	Dead chicken		13 (15%)	2	3	2	4	2	4
	All stimuli		12 (14%)	2	3	2	2	2	3
	Live chicken		10 (12%)	4	3	1	1	1	3

Table 2: Avoidance of the live chicken during the initial, the five minute and ten minute exposure.

Response to live chicken	Strong avoidance (1)	Moderate avoidance (2)	Indifferent (3)	Moderate interest (4)	Strong interest (5)	Total
Initial exposure (Mdn=3; range=4)	17 (20%)	21 (25%)	10 (12%)	25 (30%)	11 (13%)	84
5 minute exposure (Mdn=3; range=4)	21 (25%)	19 (23%)	24 (29%)	13 (15%)	7 (8%)	84
10 minute exposure (Mdn=2; range=4)	22 (26%)	26 (31%)	14 (17%)	14 (17%)	8 (10%)	84

Table 3 shows the comparison of training stimulus with the avoidance toward the chicken in the initial, the five minute, and ten minute exposure. Table 4 shows the statistical analysis of the demographic variables and training stimuli used: (1) the time to detect the chicken; (2) the distance between the dog and chicken at first detection; (3) the initial avoidance displayed according to the above scale; (4) the avoidance displayed at 5-minutes; (5) the avoidance displayed at 10 minutes. There was no statistically significant difference in avoidance with gender, age and breed of the dog. It is a possible limitation of this research that there was no canine response to live chicken baseline data collected prior to the KAT training.

6.4.1 Time taken to detect the presence of the live chicken

Of the 84 dogs, 25% of the dogs took within 2 s to detect the presence of the live chicken ($n=21$), 56% detected the chicken within 2-5 s ($n=47$), 9.5% between 5-10 s ($n=8$), 3.5% between 10-20 s ($n=3$) and 6% dogs took between 20-30 s ($n=5$). The training stimuli used significantly affected how long it took to detect the live chicken (Table 4). Dogs trained using the live chicken detected the live chicken in testing significantly faster than dogs trained with a stuffed chicken ($U=21$, $z=-2.801$, $r=-0.597$) and chicken faecal material ($U=25$, $z=-2.790$, $r=-0.582$).

Table 3: Avoidance of the dogs towards the live chicken during the initial, the five minute and ten minute exposure comparing training stimulus.

Training stimulus	Response to the live chicken														
	Strong avoidance (1)			Moderate avoidance (2)			Indifferent (3)			Moderate interest (4)			Strong interest (5)		
	Test	5m	10m	Test	5m	10m	Test	Test	5m	Test	5m	10m	Test	5m	10m
Stuffed chicken (n=12)	1	2	2	2	2	5	3	5	2	4	1	1	2	2	2
Cut out chicken (n=12)	0	0	1	3	4	4	2	6	3	5	1	3	2	1	1
Nesting material (n=12)	0	0	0	3	2	2	2	4	4	4	4	4	3	2	2
Faecal material (n=13)	1	3	3	3	4	5	2	4	2	5	1	3	2	1	0
Dead chicken (n=13)	6	4	4	2	2	4	1	3	3	2	3	0	2	1	2
All stimuli (n=12)	3	3	4	5	4	5	0	2	0	4	3	2	0	0	1
Live chicken (n=10)	6	9	8	3	1	1	0	0	0	1	0	1	0	0	0

Table 4: Comparison of demographic variables and training stimuli on the time taken to detect the chicken, the distance this was from, the initial exposure, the 5-minute, and the 10-minute exposure.

Demographic variable	Time taken to detect the chicken	Distance to detect the chicken	Response to initial exposure of chicken	5-minute exposure response to chicken	10-minute exposure response to chicken
Gender	$H(3)=2.91$, $p=0.42$	$H(3)=1.78$, $p=0.63$	$H(3)=4.32$, $p=0.23$	$H(3)=5.85$, $p=0.12$	$H(3)=3.39$, $p=0.34$
Age	$H(3)=6.90$, $p=0.08$	$H(3)=3.97$, $p=0.27$	$H(3)=1.61$, $p=0.66$	$H(3)=1.01$, $p=0.81$	$H(3)=3.17$, $p=0.37$
Breed group	$H(6)=4.84$, $p=0.56$	$H(6)=5.15$, $p=0.52$	$H(6)=5.28$, $p=0.52$	$H(6)=3.14$, $p=0.83$	$H(6)=2.61$, $p=0.89$
Training stimuli	$H(6)=14.50$, $p=0.02^{**}$ Bonferroni correction: 0.008 level of significance	$H(6)=12.74$, $p=0.04^{**}$ Bonferroni correction: 0.0167 level of significance	$H(6)=20.87$, $p=0.00^{**}$ Bonferroni correction: 0.008 level of significance	$H(6)=23.91$, $p=0.00^{**}$ Bonferroni correction: 0.008 level of significance	$H(6)=19.12$, $p=0.00^{**}$ Bonferroni correction: 0.008 level of significance

** *Post hoc* analysis using Mann Whitney tests were conducted.

6.4.2 Distance taken to detect the presence of the live chicken

Of the 84 dogs, 40.5% reacted to the live chicken within 2 meters ($n=34$), 28.5% between 2 and 4 meters ($n=24$), 21.5% between 4 and 6 meters ($n=18$) and 9.5% between 6 and 8 meters ($n=8$). The training stimuli used significantly affected the distance that the dog detected the presence of the chicken from. Dogs trained using ‘all of the stimuli’ together detected the live chicken from a significantly shorter distance than those trained using the stuffed chicken ($U=31.5$, $z=-2.472$, $r=-0.504$) and the live chicken ($U=25.5$, $z=-2.415$, $r=-0.515$).

6.4.3 Response to the live chicken in the test sessions

The training stimuli used had a significant effect on avoidance in the presence of the chicken in the initial, five minute, and ten minute exposures. In the initial exposure, dogs trained with a live chicken showed significantly more avoidance than dogs trained with the stuffed chicken ($U=12.5$, $z=-3.275$, $r=-0.698$), wooden painted chicken ($U=7.5$, $z=-3.614$, $r=-0.771$), nesting material ($U=3$, $z=-3.870$, $r=-0.825$) and faecal material ($U=19$, $z=-2.994$, $r=-0.624$), but not with those trained with the dead chicken ($U=29$, $z=-2.383$, $r=-0.497$); or ‘all the stimuli’ together ($U=24$, $z=-2.527$, $r=-0.539$).

6.4.4 Response to the live chicken in the five minute and ten minute exposure tests

Avoidance of the chicken significantly differed across the initial, 5-minute, and 10-minute exposures ($\chi^2(2)=17.94$, $p=0.00$). Wilcoxon signed-rank test with a Bonferroni correction of a 0.0167 significance level revealed significantly greater avoidance of the live chicken between the initial and 10-minute exposure ($z=-2.71$, $p=0.01$, $r=-0.21$). No difference was seen between the initial- and five-minute exposures ($z=-2.20$, $p=0.03$, $r=-0.17$) or between the five- and ten-minute exposures ($z=-0.88$, $p=0.38$, $r=0.07$).

6.5 Discussion

The use of the live chicken as the training stimulus resulted in the highest levels of avoidance in dogs when presented with the live chicken one month after training. 60% of the dogs trained with the live chicken showed strong avoidance of the test chicken. Dogs trained with the cut-out bird, faecal material, nesting material and stuffed chicken

displayed low levels of avoidance when tested with the live chicken. These findings suggest the use of live birds for avoidance training likely will produce the most avoidance of live birds under natural conditions. Moreover, the present findings suggest KAT training of dogs with ecologically relevant stimuli resembling kiwi will not be as effective in producing avoidance of kiwi when hunting or recreating in conservation areas as has been supposed.

The gender, age or breed type of the dog did not produce a significant difference in this research. Some studies have also found that gender does not affect predatory behaviours (e.g. Christiansen et al., 2001a; 2001b; 2001c); whereas other researchers has found a gender-based behaviour differences (Goddard and Beilharz, 1982). Some research has found an effect of age (Ogburn et al. 1998; Christiansen et al., 2001a,b) and breed type (Christiansen et al., 2001a,b; Turcsán et al., 2011) neither of which was found in this research. It is possible that several other factors may have affected the dogs' responses during training, including temperature (Gazit and Terkel, 2003), wind direction, wind speed and extraneous odours (Waggoner et al., 1998), and as well as the daily olfactory ability variation found in dogs (Schoon, 1997).

A novel site was used in the live chicken test sessions to eliminate any association with the location sites with the electric shock (as seen with Christiansen 2001a; 2001b; 2001c). A novel handler was also used for the test sessions to eliminate any handler effects as some authors report dogs making associations between their handlers and the electric shocks they were given (Schilder and van der Borg, 2003). The two handlers (one for the training and one for the one-month later live bird test) were asked to communicate with the dogs as little as possible as the ability of dogs to detect subtle, inadvertent social cues from humans is well documented (Gacsi et al., 2005; Hare and Tomasello, 1999; Pongracz et al., 2001, 2005; Topal et al., 2005).

The stimuli used to train the dog had significant effects on the behaviour of the dogs when exposed to a live chicken. Dogs trained using the live chicken not only displayed the highest level of avoidance, but also showed the shortest detection time, and detected the live chicken from the greatest distance. Similar results in terms of detection time and distance have been found by other researchers using live prey in avoidance training (e.g. Christiansen et al., 2001b; Hawley et al., 2009).

The live chicken in training may have been the most effective due to the movement of the prey species. The perception of movement is a critical aspect of canine vision (Duke-Elder, 1958) and dogs are much more sensitive to moving objects than they are to stationary ones (Miller and Murphy, 1995). It is also ‘ecologically relevant’ as it is the same as the test experience so there is no need to generalise between a part of the chicken and the live chicken as with some of the other training stimuli (feathers and faecal material).

Interestingly, dogs trained with the ‘stuffed chicken’ were also able to detect the presence of the live chicken from a significant distance when compared to the other stimuli. This suggests that the use of the stuffed chicken may be useful as a visual representation indicative of a live bird. Gazit et al. (2003) state that the significant advantage of canine vision remains mostly unexploited when searching for stationary objects.

Higher levels of avoidance were expected by dogs trained with the ‘dead chicken’, given that the olfactory stimulation of this training stimulus is most likely representative of the live bird. However, the dead chicken had been frequently handled and frozen, partially de-thawed and then frozen again which may have affected its smell. This may be due to killing and consumption being driven by different motivations, so an avoidance of dead prey may not be generalised to live prey (Conover et al., 1977).

Some of the dogs (in particular those trained on the cut-out chicken, chicken faecal material and all the stimuli together) did not detect the presence of the live chicken until they were in very close proximity. Given that dogs usually give preference to olfaction over that of sight (Gazit and Terke, 2003), it is possible that the scents of the training stimuli are not indicative or ecologically relevant in relation to a live chicken. It is also conceivable that different dogs were visually interpreting the training stimuli differently impacting on the aversion training, and therefore the detection of the chicken. Skull shape influences the visual field in dogs with different breeds of dogs seeing visual images differently (McGreevy et al., 2003, 2004; Miklosi, 2008). Breed also impacts on the importance of sight for some breeds of dogs with breeds classified as scent hounds being bred for their ability to hunt and track using olfactory cues, while the breeds classified as sight hounds being bred to hunt using mostly visual cues (Gazit and Terke, 2003). In spite of differential selection on the basis of olfactory acuity in various

groupings of breeds of dogs, the number of olfactory receptor genes per subfamily has remained stable (Issel-Tarver and Rine, 1996).

It is possible that the ‘cut-out chicken’ was not ‘ecologically relevant’ to the dogs. The cut-out chicken was a two dimensional visual stimuli that was made from painted wood. Whilst there is some research to suggest that animals are able to understand two dimensional images where photographs have been used (e.g. D'Eath, 1998; Kendrick et al., 2001), it is possible that the chicken was not ‘real’ enough on the two-dimensional scale and that photographic representation may be more effective.

Faecal material as a training stimulus also resulted in low avoidance of the live chicken. Faecal material has been used as a scent target for dogs for a number of species; for example, black bears and bobcats (Long et al., 2008), grizzly bears (Wasser et al., 2004), foxes (Smith et al., 2003; 2005), and right whales in marine surveys (Rolland et al., 2006). None of these studies actually suggest that the dogs generalise from the faecal material to the live species.

Biologically ‘relevant’ stimuli (i.e. stimuli designed to trigger one or more of an animal's senses [e.g. vision, sight, smell]) have been used as a method of environmental enrichment for captive animals (Schuett et al., 2001; Wells, 2009), with different types of olfactory enrichment increasing activity and to decrease stereotypic behaviour in several captive species (e.g. Baker et al., 1997; Schuett and Frase, 2001; Skibieli et al., 2007; Zar et al., 2005). This may be due to the presentation of novel stimuli in an otherwise monotone environment.

Generalisation is thought to be common among a wide variety of species, because it confers evolutionary advantage (Kramer, 2010). In part, that advantage can be conceptualised as increased cognitive economy. Cognitive economy is enhanced by the ability to categorise information – that is, the ability to treat similar, but not identical things as equivalent, by sorting them into categories and reacting to them in the same manner (e.g. Herrnstein, 1984; Huber, 2001). This allows generalisation to members of the class that have never been seen before, so that category-relevant knowledge can be applied to those novel class members. Many species have been shown to demonstrate category discrimination, such as baboons (Bovet and Vauclair, 1998), rhesus monkeys

(Sigala et al., 2001), chimpanzees (Parr et al., 2008), horses (Hanggi, 1999), cattle (Coloun et al., 2007), sheep (Ferreira et al., 2004) and dogs (Range et al., 2007).

There is evidence to suggest that dogs are able to generalise. Cablk et al., (2008) demonstrated that dogs were able to generalize to live Mojave desert tortoises when initially trained on a discrete set of tortoise residual scent training aids involving a piece of gauze wiped over a tortoises' neck and legs. Also, evidence of scent generalisation occurs when dogs trained to find missing people are able to find deceased people also (Cablk et al., 2008). Therefore, it is theoretically possible for stimuli to be able to be used in aversion training even though their effectiveness depends on generalization.

There is substantial empirical literature demonstrating that animals that initially show no detection or fear, can be conditioned to respond to live and model predators (e.g. Curio, 1993; Miller et al., 1990; Mineka and Cook, 1998; McLean et al., 1999; Griffith et al., 2000). However, anti-predator behaviours are relevant for survival and therefore may be easier to train or encourage, than a reduction in predatory behaviour which is also a highly instinctive behaviour. Success may be improved by having more than just a one off training session. Many authors corroborate the need for multiple training trials where predatory behaviour is elicited by live prey (e.g. Linhart et al., 1976; Hawley et al., 2010). These papers had much smaller sample sizes than is involved with this research (e.g. $n=4$ coyotes; $n=5$ wolves respectively).

There is also evidence that predatory skills are learned during early development (Vargas and Anderson, 1999). Consequently juveniles may learn more easily about predatory behaviours that adults do (Griffith et al., 2000) and conversely may learn not to display predatory behaviour more easily than adults do. This is an area worth exploring in relation to kiwi aversion training.

There is no published research looking at the use of stimuli to reduce predatory behaviour. The use of the live chicken as a training stimulus is consistent with what a number of published studies have reported: pairing electric shock with potential prey can, under some conditions, establish prey aversion in canid species (e.g. Linhart et al. 1976; Andelt et al. 1999; Christiansen et al., 2001; Cooper et al. 2005; Schultz et al. 2005; Hawley et al. 2009). This is less successful if used after depredation of livestock had already occurred (Schultz et al., 2005). No dogs had killed chicken in this research.

The movement of prey is an essential stimulus for eliciting predation by canids (Fox 1969).

Repeat sessions with the live chicken at 5 minutes and 10 minutes were conducted to explore for the possibility of ‘extinction’ occurring. Extinction is the loss of performance that occurs when a Pavlovian signal or an instrumental action is no longer paired with a reinforcer (Pavlov, 1927; Pierce and Hall, 1980). Exposure to the live chicken without punishment did not appear to lead to extinction of the avoidance training in this research, and in fact, avoidance levels increased significantly. This is potentially indicative of sensitisation to the live chicken although the mechanism that this may have occurred would require further investigation. Some research suggests that extinction does not destroy the first-learned information but instead reflects new learning (Bouton, 2002). It is also acknowledged that alternative statistical analysis methodologies could also have been employed in this study, such as multinomial logistic regression modelling.

In conclusion, our study indicates that aversive conditioning with the use of electronic dog collars and live birds as training stimuli is an efficient method for producing avoidance when presented with a live bird one month later. Dogs do not appear to be able to generalise from other training stimuli to the live bird using the methodology used in this research. It is important now to investigate how these results of using a live bird in training extrapolate to using live kiwi in aversion training.

6.6 References

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Chapter Seven: Short and long-term reactions of 220 dogs to different intensity levels of an electric shock collar in a large-scale canine depredation conditioning programme

7.1 Abstract

Dogs (*Canis familiaris*) pose a significant threat to kiwi (*Apteryx* spp.) through predation. In an attempt to balance kiwi conservation and the need for dogs to be used for hunting purposes in kiwi habitat, the New Zealand Department of Conservation developed the Kiwi Aversion Training (KAT) programme. KAT involves a training session in which a dog is presented with KAT stimuli (two stuffed kiwi, and one partly thawed frozen kiwi carcass) and a brief period (0.5–1.5 s) of aversive electrical stimulation from an electric shock collar when the dog makes contact with the training stimuli. Previous research shows KAT produces avoidance to the KAT stimuli that generalizes to another location, is independent of the electric collar being worn, and that lasts at least 1 year after training. The aim of this study was to investigate the reactions of 165 dogs undergoing the KAT programme for the first time; 15 dogs one month later; and a further 55 dogs one year later to assess if there are any potential short and/or long-term welfare compromises associated with the use of the electric shock collar using validated behavioural indicators of stress. This paper reports on: (1) the behavioural response to the electric shock; (2) comparison of stress behaviours before and after the electric shock; (3) the effect of electric shock intensity, timing, number of shocks, and different trainers; (4) the presence of stress behaviours one-month later when shown the KAT training stimuli; (5) the presence of stress behaviours one-year later when shown the KAT training stimuli; and (6) the dog owners' views on electric shock collar training. 100% of dogs displayed a response to electric shock, with 41% displaying a severe reaction and 47% displaying a moderate reaction. The response to the electric shock was significantly affected by the shock intensity, number, and timing of the shocks. The occurrence of all stress behaviours (except for paw-lifting) significantly increased after the shock with 79% of the dogs displaying at least 4 stress behaviours. Stress behaviours were seen in all dogs one-month later in response to the KAT training stimuli with 74% displaying at least 4 stress behaviours. 87% of the dogs one-year later

displayed stress behaviours; of which 67% displayed at least 4 stress behaviours. 64% of dog owners considered the use of electric collars to be an effective training technique, with 59% considering that their use poses a welfare concern for the dogs. This study did find that the use of electric collars negatively impacted on the welfare of the majority of dogs during the standard KAT protocol. However, if KAT reduces canine predation on kiwi, this may be justifiable from kiwi preservation and conservation perspectives.

7.2 Introduction

The use of hand-held remote activated electric collars as training devices to reduce unwanted behaviour in dogs is controversial (Cooper et al., 2013). Inappropriate use of electric collars such as failure to associate shock with the stimulus, or poor timing of the shock, can lead to welfare problems (e.g., fearful behaviour, stress-induced impeded learning; Lindsey, 2005; Schalke et al., 2007). Timing is important with punishment for dogs to learn to associate shock with a specific behaviour. For greatest effectiveness, shock should occur immediately after initiation of the target behaviour (Lindsay, 2005). Poor timing of electric shocks carries a high risk that dogs will show severe and persistent stress symptoms (Schalke et al. 2007). In the hands of inexperienced users and trainers with poor timing, electric shock collars are likely to have negative impacts on the dogs' welfare. Dogs may develop problem behaviours, including aggression, fear, learned helplessness, or even the unwanted association between the shock and coincidental stimuli, such as the trainer (Polsky, 1994). Many authors suggest fear-based training does not encourage a good learning state for dogs (e.g. Blackwell and Casey, 2006; Houpt et al., 2007; Schalke et al., 2007). Incorrect use of electric collars can also cause tissue damage, physical lesions, and obviously, pain (Houpt et al., 2007). However, several authors argue for the value of punishment when applied correctly for specific tasks (Totoro, 1982; Yeon et al., 1999; Marscark and Baenninger, 2002). Some authors suggest aversive stimuli may enhance brain mechanisms associated with learning and memory (Saal et al., 2003; Seamans and Yang, 2004).

Most studies investigating potential welfare compromises associated with electric collars have focused on specific sub-groups of dogs such as those trained for police work (Schilder and van der Borg, 2004); model populations of laboratory dogs (e.g. Schalke et al 2007); and dogs with behavioural problems (Cooper et al., 2013). These

groups may not be representative of the entire dog population and the experimental group sizes used to assess the effects of electric shock collars were small ($n=32$; $n=14$; $n=21$) compared with this study. In addition, these studies included confounding factors such as variable shock intensity applied or involved multiple trainers unsystematically. The potential short and long-term welfare compromise from the use of electric collars on the general dog population, rather than specific target groups, has received less systematic scientific investigation. Previous research shows KAT produces avoidance to the KAT stimuli that generalizes to another location, is independent of the electric collar being worn, and that lasts at least 1 year after training. Nonetheless, the potential welfare compromise associated with the use of electric collars has not as yet been investigated. This study aims to assess the short and long-term stress behaviours of dogs trained in a standardised methodology as part of the Department of Conservation (DOC) Kiwi Aversion Training (KAT) programme (a large-scale New Zealand-wide government-run depredation aversion programme).

7.3 Methods

7.3.1 Test subjects

Table 1 shows the demographic variables of the 220 dogs that were recruited to participate in this research from 133 consenting dog owners from DOC-administered KAT sessions. This was the dogs first time through the KAT programme. Hunting dogs were owned predominantly to assist with pig, goat or deer hunting ($n=80$). Pet dogs were owned solely for the purpose of companionship ($n=85$). The dogs' gender, age, weight, height, previous electric collar training experience, and breed were recorded.

Table 1 also shows the demographic variables of the dogs that were presented with the KAT training stimuli one-month ($n=15$) and one-year ($n=55$) after their initial KAT session. The 15 dogs that were shown the KAT training stimuli one-month later were recruited from the 165 that were undergoing KAT for the first time. The 55 dogs that were assessed one-year after their first KAT session are additional dogs and are not a subset of the 165 first time KAT dog group.

Table 1: Demographic variables of the 220 dogs in this research.

Dog Demographics			First time KAT participants (n=165)	One-month later (n=15)	One-year later (n=55)
Role of dog	Hunting		85 (51.5%)	15 (100%)	55 (100%)
	Pet		80 (48.5%)	0	0
Weight of dog	Small (<7 kg)		11 (11%)	0	2 (4%)
	Medium (7-20 kg)		80 (49%)	13 (87%)	24 (44%)
	Large (>21 kg)		74 (45%)	2 (13%)	29 (53%)
Height of dog	Short (<30 cm)		12 (7%)	0	2 (4%)
	Medium (30-50 cm)		81 (49%)	13 (87%)	26 (47%)
	Tall (>50 cm)		72 (44%)	2 (13%)	27 (49%)
Breed group	Toy		10 (6%)	0	0
	Terrier		35 (21%)	0	2 (4%)
	Gundog		31 (19%)	5 (33%)	19 (35%)
	Hound		12 (7%)	2 (13%)	5 (9%)
	Working		40 (24%)	7 (47%)	27 (49%)
	Utility		25 (15%)	1 (7%)	1 (2%)
	Non-Sporting		12 (7%)	0	1 (2%)
Gender	Male n=84 (51%)	Entire	35 (21%)	3 (20%)	12 (22%)
		Desexed	49 (30%)	6 (40%)	17 (31%)
	Female n=81 (49%)	Entire	27 (16%)	1 (7%)	7 (13%)
		Desexed	54 (33%)	5 (33%)	19 (35%)
Age (in years)	0-2		23 (14%)	2 (13%)	6 (11%)
	2-5		63 (38%)	7 (47%)	31 (56%)
	5-8		55 (33%)	6 (40%)	12 (22%)
	8+		24 (15%)	0	6 (11%)
Previous e-collar experience	Yes		73 (44%)	6 (40%)	42 (76%)
	No		92 (56%)	9 (60%)	13 (24%)

Dog breeds were categorised by owner-identified breed, or predominant breed, classification. The dogs were assigned to one of the following seven recognised New Zealand Kennel Club (www.nzkc.org.nz) groupings: Toy Group: these are small companion or lap dogs (e.g. Chihuahua, Yorkshire Terrier and Pug); Terrier Group: dogs originally bred and used for hunting vermin (e.g. Staffordshire Bull Terrier, English Bull Terrier and Jack Russell Terrier); Gundog Group: dogs that were originally trained to find live game and/or to retrieve game that had been shot and wounded (e.g. Labrador, Golden Retriever, German Shorthaired Pointer); Hound

Group: breeds originally used for hunting either by scent or by sight (e.g. Greyhound, Whippet and Beagle); Working Group: herding dogs that are associated with working cattle, sheep and other cloven-footed animals (e.g. Australian Kelpie, Australian Cattle Dog and Border Collie); Utility Group: this group consists of an extremely mixed and varied bunch, most breeds having been selectively bred to perform a specific function not included in the sporting and working categories (e.g. Boxer, Mastiff and Schnauzer); Non-Sporting Group: this group consists of miscellaneous breeds of dogs mainly of a non-sporting origin, (e.g. Bulldog, Dalmatian and Poodle).

7.3.2 Field sites

The research was undertaken at the Unitec Institute of Technology campus in Mount Albert in Auckland and also sites within the Coromandel Peninsula, North Island, New Zealand. All sites consisted of forested areas with the training stimuli KAT stimuli set up in the middle of the track. The KAT stimuli consisted of either one or a combination of the following KAT training stimuli and were either from a kiwi or a chicken: a taxidermist stuffed bird; one partly thawed frozen carcass; faecal material; nesting material; a two-dimensional bird wooden cut out. All KAT sessions were filmed using a Sony digital video camera recorder (model DCR-TRV27E).

7.3.3 Aversion-training methodology

All dogs were trained using the DOC Hauraki Area Office KAT program methodology as described in Dale et al. (2013) and 165 dogs were undergoing the KAT for the first time. 15 of these dogs were presented with the KAT stimuli one month later and a further 55 dogs were presented with the KAT stimuli one-year after their initial KAT session. Each training session involved fitting each dogs with an Agtronics Smart Aid 4 electric training collar (manufactured by Pet Training Products, New Plymouth, New Zealand) which delivered 0.0092 joules of electric shock when operated. This collar delivered a brief period (approx. 0.5 s but never more than 1.5 s) of electric shocks at a rate of three 10-microsecond pulses per second to the underside of a dog's neck via two steel studs. The collar has 15 settings and at the maximum setting each pulse is estimated to be 11 000 volts and extremely low amperage, although the exact current is difficult to verify because it depends in part on the resistance between the electrodes and the dog's skin. The collar was controlled by a hand-held remote control device.

Each dog was individually walked past the KAT training stimuli on a long lead by its owner or the researcher. Dogs were given the opportunity to observe and approach the training stimuli and when contact was made (sniffed the training stimuli), a brief period (0.5-1.5 s) of aversive electrical stimulation was discharged from the two electrodes on the collar administered via a remote control handset controlled by the DOC trainer. If the dog did not voluntarily sniff the training stimuli, the dog was encouraged to do so by the DOC trainer (such as by hand gestures towards it; crouching down next to it; making high-soliciting vocalisations) and then shocked once contact was made. This was continued until each dog displayed avoidance behaviours towards the training stimuli as classified by the DOC trainer. There were three KAT trainers involved in this research. Trainer 'A' trained 80 dogs, trainer 'B' trained 71 dogs, and trainer 'C' trained 14 dogs. Trainer 'A' trained the 15 dogs that were assessed one-month later and had also trained the 55 dogs that were assessed one-year later after their initial KAT session.

7.3.4 Canine response rating to electric shock

The number of electric shocks given ('1'; '2', or '3 or more' shocks) and their intensity were recorded ('low'=settings 4-7; 'medium'=settings 8-14; and 'high'=maximum collar setting 15), as was the distance of the dog to the KAT training stimuli when shocked ('when contact made'; 'within 20 cm'; or 'within 40 cm').

Responses of the dogs to the electric shock(s) were rated on the following scale: (1) No response to the electric shock: no visual or audible response; (2) Mild response: dog flinches (quick action where dog lowers body towards floor or where dog briefly backs away from training stimuli, muzzle is often tense, ear position backwards, tail positioned between legs or downwards); with or without detectable audible vocalisation (short duration, high pitched yelp); detectable head shake (movement of head side to side); (3) Moderate response: dog rears up (dog jumps up with two front paws off the ground at the same time), with or without audible vocalisation; exaggerated head shake; and (4) Severe responses: exaggerated jump (vigorous movement with all paws off the ground at the same time), short to long duration vocalisation; excessive and prolonged head shaking (vigorous and prolonged movement of head side to side), runs away.

7.3.5 *Stress responses measured*

The occurrence of stress behaviours by the dogs was recorded for approximately one minute before and for one minute after their electric shock. The stress behaviours used were derived from previous studies investigating anxiety and arousal in dogs (e.g. Beerda et al., 1997, 1998, Cooper et al., 2013; Hiby et al., 2004, Mills et al., 2006; Rooney et al., 2007). The stress behaviours assessed were: (1) Lip licking (tongue leaves and re-enters mouth); (2) Cringing (dog turning away from training stimuli involving either head movement alone or whole body movement; muzzle is often tense); (3) Slinking (walking hesitantly crouched low to the ground; tail positioned between legs or downwards); (4) Ears back (ears tense, facing backwards against the head); (5) Panting (mouth open wide, breathing vigorously); (6) Whine (long duration, high pitched vocalisation); (7) Paw lifting (one fore limb only is lifted off the ground and is not directed at any person or object and all other limbs remain on the ground); (8) Seeking human comfort (initiating physical contact with owner or researcher, for example, by leaning on owner, jumping up at, touching with nose); and (9) Attempting to escape (pulling of the lead trying to get away from the area the dog is in). The behaviours were marked as present for each individual dog if they occurred.

The occurrence of the same stress behaviours was also recorded one-month after the initial KAT session when presented with the training stimuli ($n=15$). Electric collars were not worn. Stress behaviours were also recorded for a 55 dogs that were presented with the KAT stimuli one-year later. Both were recorded for approximately one minute in the presence of the KAT training stimuli. All responses were rated by two observers. Interrater reliability analysis using the Kappa statistic was performed to determine consistency among raters. There was perfect interobserver reliability ($\kappa=+1$).

7.3.6 *Owner survey*

All 133 owners of the 165 dogs undergoing KAT for the first time completed a 5-question survey asking: (1) If they had used electric collars; (2) If not, why not; (3) If yes, what for; (4) Did they think the use of electric collars is an effective method of training dogs; and (5) Did they consider there was a welfare issue with the use of electric collars.

7.3.7 *Statistical analysis*

Statistical analyses were performed using the Statistical Package for the Social Sciences (SPSS) (Version 22). The data were not normally distributed and, therefore, non-parametric tests were employed. Wilcoxon signed-rank test was used to test the occurrence of stress behaviour(s) before and after the electric shock; and after the electric shock and one-month later when presented with the KAT training stimuli. Mann-Whitney *U* tests (when there were 2 variables) and Kruskal-Wallis ANOVA by ranks (when more than 2 variables) were used to test for demographic variable differences, response to the electric shock and stress responses; and stress behaviours after the initial electric shock and one-year later. When statistical significance was found using Kruskal-Wallis ANOVA, *post hoc* analyses using Mann-Whitney *U* tests with a Bonferroni correction for multiple testing were employed. The Jonckheere-Terpstra test was also used to assess monotonic trends in the data. The effect size was reported using *r*. Alpha was set to .05 for all statistical analysis.

7.3.8 *Ethics approvals*

Human ethics approval was gained from the Unitec Research Ethics Committee (UREC approval number 2008.842). Animal ethics approval was granted by the University of Auckland Animal Ethics Committee (AEC approval numbers #534 and # R576).

7.4 Results

7.4.1 *Response to the electric shock*

All 165 dogs responded to the electric shock; with either a mild ($n=20$; 12%); moderate ($n=78$; 47%) or severe ($n=67$; 41%). Almost half the dogs were shocked on the maximum shock intensity ($n=80$; 49%); 39% were shocked at a moderate intensity ($n=64$); and the remaining 13% were shocked at a low intensity ($n=21$). The intensity of the shock significantly affected the response to the shock (Table 2). Dogs that were shocked at the maximum intensity showed a higher level of response than dogs shocked on the low level intensity ($U=414.50$, $z=-3.97$, $p<0.00$, $r=-0.40$) and the medium level

intensity ($U=1822.50$, $z=-3.27$, $p<0.00$, $r=-0.27$). As the intensity of the shock increased, so did the reaction to the shock ($J=5254.00$, $z=4.38$, $r=-0.34$).

67% of dogs received only one shock ($n=111$); 22% received two shocks ($n=36$); and 11% received three or more shocks ($n=18$). The number of shocks the dog received also significantly affected the shock response (Table 2), with dogs receiving one shock having a stronger response than dogs receiving two shocks ($U=1076.00$, $z=-4.60$, $p<0.00$, $r=-0.38$), or three shocks ($U=667.50$, $z=-2.50$, $p=0.01$, $r=-0.22$).

67% of dogs received only one shock ($n=111$); 22% received two shocks ($n=36$); and 11% received three or more shocks ($n=18$). The number of shocks the dog received also significantly affected the shock response (Table 2), with dogs receiving one shock having a stronger response than dogs receiving two shocks ($U=1076.00$, $z=-4.60$, $p<0.00$, $r=-0.38$), or three shocks ($U=667.50$, $z=-2.50$, $p=0.01$, $r=-0.22$).

Table 2: Statistical results for the comparison of the demographic and electric shock variables to the response to the electric shock and the presence of stress behaviours after the electric shock, one-month later and one-year later.

Demographic variables	Response to the shock	Stress behaviours after the electric shock	Stress behaviours one month after	Stress behaviours one year after
Shock intensity	$H(2)=19.64$, $p>0.00^*$	$H(2)=1.90$, $p>0.05$	All maximum setting	All maximum setting
Number of shocks	$H(2)=23.51$, $p>0.00^*$	$H(2)=1.81$, $p>0.05$	All one shock	All one shock
Timing of the shock	$H(2)=17.47$, $p>0.00^*$	$H(2)=2.19$, $p>0.05$	All when contact made	All when contact made
Trainer	$H(2)=17.55$, $p>0.00^*$	$H(2)=2.69$, $p>0.05$	All Trainer A	All Trainer A
Role of dog	$U=2237.00$, $z=-4.17$, $p>0.00$, $r=-0.32$	$U=3175.00$, $z=-0.76$, $p>0.05$, $r=-0.06$	All hunting dogs	All hunting dogs
Weight of dog	$H(2)=5.17$, $p>0.05$	$H(2)=2.38$, $p>0.05$	$H(1)=0.030$, $p>0.05$	$H(2)=4.88$, $p>0.05$
Height of dog	$H(2)=9.15$, $p=0.01^*$	$H(2)=2.62$, $p>0.05$	$H(1)=0.030$, $p>0.05$	$H(2)=4.09$, $p>0.05$
Breed group	$H(6)=1.93$, $p>0.05$	$H(6)=2.95$, $p>0.05$	$H(3)=3.49$, $p>0.05$	$H(5)=17.09$, $p=0.00^{**}$
Gender	$U=3330.50$, $z=-0.256$, $p>0.05$, $r=-0.02$	$U=2984.00$, $z=-1.41$, $p>0.05$, $r=-0.11$	$U=20.50$, $z=-0.60$, $p>0.05$, $r=-0.15$	$U=323.50$, $z=-0.92$, $p>0.05$, $r=-0.12$
Age	$H(3)=3.96$, $p>0.05$	$H(3)=6.14$, $p>0.05$	$H(3)=3.20$, $p>0.05$	$H(3)=1.46$, $p>0.05$
Previous e-collar experience	$U=2879.00$, $z=-1.73$, $p>0.05$, $r=-0.13$	$U=2892.50$, $z=-1.58$, $p>0.05$, $r=-0.12$	$U=11.50$, $z=-1.48$, $p>0.05$, $r=-0.38$	$U=239.5$, $z=-0.68$, $p>0.05$, $r=-0.09$

*=Post hoc analysis conducted using Mann-Whitney U tests with a Bonferroni correction of 0.0167 applied; ** = a Bonferroni correction of 0.004 applied.

Half the dogs were shocked when contact was made with the KAT training stimuli ($n=81$; 49%); of the remaining dogs 44% were shocked within 20 cm ($n=72$); and 7% were shocked within 40 cm of the training stimuli ($n=12$). The timing of the first shock significantly affected its response to the shock (see Table 2), with dogs that were shocked ‘when contact made’ with the KAT training stimuli showing a stronger response to the shock than dogs that were shocked within 20 cm ($U=2000.00$, $z=-3.69$, $p<0.00$, $r=-0.30$); or 40 cm of the training stimuli ($U=262.50$, $z=-2.88$, $p=p<0.00$, $r=-0.30$). The majority of dogs shocked when contact was made with the training stimuli were shocked on maximum intensity.

Hunting dogs responded significantly more to the electric shock than did pet dogs (Table 2); with 55% of the hunting dogs displaying a severe response ($n=44$) compared with only 27% of the pet dogs ($n=23$). Hunting dogs received shocks of higher intensity when compared with pet dogs. The height, but not the weight of the dog, nor its breed group, affected the response to the shock also (Table 2), with medium-sized dogs and tall-sized dogs responding to the shock more than small-sized dogs ($U=253.00$, $z=-2.95$, $p<0.00$, $r=-0.31$). There was no statistically significant difference between tall-sized dogs and small-sized dogs ($U=285.00$, $z=-2.09$, $p=ns$, $r=-0.23$); or between tall-sized and medium-sized dogs ($U=2544.50$, $z=-1.49$, $p=ns$, $r=-0.12$). The age, gender or previous electric collar experience did not affect the response of the dogs to the shock (Table 2).

7.4.2 Comparison of stress responses before and after the electric shock

Table 3 shows the occurrence of stress behaviours before and after the electric shock. 27% of the dogs displayed one or two stress responses prior to the electric shock, whereas after the electric shock 100% of the dogs did; with 79% displaying at least four stress behaviours. Lip licking, cringing, slinking, ears back, panting, whining, seeking human comfort and attempting to escape from the area all significantly increased after the dogs experienced the electric shock. The only stress behaviour that did not significantly increase was paw lifting (see Table 3). Fewer stress behaviours per dog were seen before (median=0) than after (median=4) the electric shock (Table 3).

Table 3: Comparison of stress behaviour seen by the dog pre-and post- electric shock, one-month later and one-year later.

Stress behaviours		Pre electric shock (n=165)	Post electric shock (n=165)	Wilcoxon signed-rank test result comparing pre and post shock (n=165)	Kruskal-Wallis Test result to see if shock response affected the stress behaviours after the shock	One month later (n=15)	One year later (n=55)	Wilcoxon signed-rank test result comparing post shock and one month later (n=15)	Mann-Whitney U Test comparing post electric shock and one year later (n=220)	Mann-Whitney U Test comparing one month later and one year later (n=70)
Lip licking		10 (6%)	70 (42%)	$z=-7.39, p<0.00, r=-0.57$	$H(2)=0.43, p=ns$	8 (53%)	28 (51%)	$z=-0.38, p=ns, r=-0.10$	$U=4152.5, z=-1.09, p=ns, r=-0.07$	$U=402.50, z=-0.17, p=ns, r=-0.02$
Cringing		0	129 (78%)	$z=-11.36, p<0.00, r=-0.88$	$H(2)=1.71, p=ns$	15 (100%)	40 (73%)	$z=-2.24, p=0.03, r=-0.58$	$U=4290.00, z=-0.83, p=ns, r=-0.06$	$U=300.00, z=-2.27, p=0.02, r=-0.27$
Slinking		0	115 (70%)	$z=-10.72, p<0.00, r=-0.83$	$H(2)=0.34, p=ns$	5 (33%)	19 (35%)	$z=-2.83, p=0.01, r=-0.73$	$U=2942.5, z=-4.62, p<0.00, r=-0.31$	$U=407.5, z=-0.78, p=ns, r=-0.01$
Ears back		0	145 (88%)	$z=-12.04, p<0.00, r=-0.94$	$H(2)=0.18, p=ns$	1 (7%)	16 (29%)	$z=-3.46, p<0.00, r=-0.89$	$U=1870.00, z=-8.50, p<0.00, r=-0.57$	$U=320.00, z=-1.78, p=ns, r=-0.21$
Panting		0	25 (15%)	$z=-5.00, p<0.00, r=-0.39$	$H(2)=1.01, p=ns$	4 (27%)	18 (33%)	$z=-1.34, p=ns, r=-0.35$	$U=3740.00, z=-2.84, p<0.00, r=-0.19$	$U=387.5, z=-0.45, p=ns, r=-0.05$
Whining		0	21 (13%)	$z=-4.58, p<0.00, r=-0.36$	$H(2)=3.72, p=ns$	3 (20%)	6 (11%)	$z=-1.00, p=ns, r=-0.26$	$U=4455.00, z=-0.36, p=ns, r=-0.02$	$U=375.00, z=-0.93, p=ns, r=-0.11$
Paw lifting		9 (6%)	13 (8%)	$z=-0.94, p=0.35, r=-0.07$	$H(2)=0.37, p=ns$	4 (27%)	5 (9%)	$z=-2.00, p=ns, r=-0.52$	$U=4482.50, z=-0.28, p=ns, r=-0.02$	$U=340.00, z=-1.79, p=ns, r=-0.21$
Seeking human comfort		34 (21%)	59 (36%)	$z=-3.01, p<0.00, r=-0.23$	$H(2)=6.87, p=0.03$	9 (60%)	35 (64%)	$z=-1.63, p=ns, r=-0.42$	$U=3272.50, z=-3.61, p<0.00, r=-0.24$	$U=397.5, z=-0.26, p=ns, r=-0.03$
Attempting to escape from the area		12 (7%)	163 (99%)	$z=-12.29, p<0.00, r=-0.96$	$H(2)=14.59, p<0.00$	15 (100%)	48 (87%)	$z=0, p<0.00, r=0.00$	$U=4015.00, z=-3.73, p<0.00, r=-0.25$	$U=360.00, z=-1.45, p=ns, r=-0.17$
Total number of stress behaviours	0	120 (73%)	0	$z=-11.18, p<0.00, r=-0.87$	$H(2)=1.14, p=ns$	0	7 (13%)	$z=-0.54, p=ns, r=-0.14$	$U=3895.5, z=-1.62, p=ns, r=-0.11$	$U=389.00, z=-0.35, p=ns, r=-0.04$
	1	29 (18%)	2 (1%)			0	0			
	2	16 (10%)	4 (2%)			0	1 (2%)			
	3	0	29 (18%)			4 (27%)	10 (18%)			
	4	0	53 (32%)			4 (37%)	16 (29%)			
	5	0	49 (29%)			7 (47%)	12 (22%)			
	6	0	21 (13%)			0	7 (13%)			
	7	0	4 (2%)			0	2 (4%)			
	8	0	2 (1%)			0	0			
	9	0	1 (1%)			0	0			

7.4.3 Occurrence of stress responses after the electric shock

The occurrence of stress behaviours after the electric shock (Table 2) was not significantly affected by the intensity or number of shocks received, or their timing, or who administered them. They were also not significantly affected by the dogs' gender, age, weight, height, breed, previous electric collar, or whether it was a pet or hunting dog. Nor were stress behaviours related to a dog's immediate response to the shock, except for two stress behaviours (Table 3). As the shock response increased, so did the seeking of human comfort ($J=267.27$, $z=2.59$, $r=0.20$) and attempting to escape from the area ($J=61.02$, $z=-2.48$, $r=-0.19$).

7.4.4 Stress behaviours one-month and one-year later when presented with the KAT stimuli

Table 3 shows the occurrence of stress behaviours one-month and one-year after their KAT session to the presence of the KAT training stimuli. There was significantly more cringing seen one-month after their KAT session, than directly after their shock, or one-year later. There was a significantly higher level of slinking and ears back after the electric shock, than seen one-month, or one-year later. Significantly higher levels of panting and seeking human attention was seen one-year later than after the electric shock. Significantly higher levels of attempting to escape the area were seen after the electric shock than one-year later. The total number of stress behaviours per dog seen after the electric shock, one-month and one-year after the electric shock in the presence of the KAT training stimuli were not significantly different (Table 3).

The occurrence of stress behaviours one-month and one-year after their initial KAT session to the presence of the KAT training stimuli was not significantly affected by the dogs' weight, height, gender, age or previous collar experience (Table 3). Breed did significantly affect the stress behaviours seen in the dogs one-year later, but not one-month later. Post-hoc analysis could not determine where the difference lay.

7.4.5 Effect of the trainer on the response to the shock

The trainers all employed different methods with the electric collars, preferring differing shock intensities and having different timing of the shock (Table 4). The different trainers significantly affected the response of the dog to the shock (see table 2),

with trainer 'A' producing higher response levels to the shock than trainer 'B' ($U=1846.00$, $z=-4.08$, $p<0.00$, $r=-0.33$); but not trainer 'C' ($U=391.00$, $z=-2.03$, $p=0.04$, $r=-0.30$). There was no significant difference between trainer 'B' and trainer 'C' ($U=465.00$, $z=-0.42$, $p=ns$, $r=-0.05$).

There was also a significant difference in the proximity of the electric shock and the training stimuli between the trainers ($H(2)=150.37$, $p>0.00$) (Table 4). Trainer 'A' having significantly more shocks administered when contact was made to the training stimuli than trainer 'B' ($U=0$, $z=-12$, $p>0.00$, $r=-0.98$); and trainer 'C' ($U=40$, $z=-9.21$, $p>0.00$, $r=-0.95$). There was no difference between trainer 'B' and trainer 'C' ($U=442.5$, $z=-1.04$, $p=ns$, $r=-0.11$).

The intensity of the shock used by the trainers varied significantly ($H(2)=149.02$, $p>0.00$) (Table 4). Trainer 'A' used a significantly higher shock intensity than trainer 'B' ($U=0$, $z=-11.78$, $p>0.00$, $r=-0.96$); and trainer 'C' ($U=0$, $z=-9.63$, $p>0.00$, $r=-0.99$). There was no difference between trainer 'B' and trainer 'C' ($U=442.5$, $z=-1.04$, $p=ns$, $r=-0.11$).

The number of the shocks used by the trainers also differed significantly ($H(2)=72.60$, $p>0.00$) (Table 4). Trainer 'A' used significantly fewer shocks than trainer 'B' ($U=1040$, $z=-8.36$, $p>0.00$, $r=-0.68$); and trainer 'C' ($U=200$, $z=-7.49$, $p>0.00$, $r=-0.77$). There was no difference between trainer 'B' and trainer 'C' ($U=465.5$, $z=-0.401$, $p=ns$, $r=-0.04$).

7.4.6 Owners' survey responses

This was completed by all 133 dog owners (pet-dog owners: $n=72$, 54%; hunting-dog owners: $n=61$, 46%). Table 5 shows the overall survey responses; and compares hunting dog and pet dog owners' responses. A third of all respondents had used electric collars previously on their dogs, mostly for 'general training purposes', followed by 'stopping chasing or killing stock and poultry'. The respondents that had not previously used an electric collar stated that it was because they did 'not need to', followed by only a small number of respondents citing 'welfare reasons' for non-use. Almost half of all respondents thought that electric collar training was an effective training technique, with a remaining stating that 'it depended on the situation', or 'weren't sure'. The majority of dog owners reported that electric collar use was 'a welfare issue'; with the

remaining respondents either being ‘not sure’ or thought that there was ‘no welfare issue’.

Electric collar use by hunting dog owners was significantly higher than by pet dog owners (Table 5). The reasons for the use or non-use did not vary significantly between pet and hunting dog owners; but their views regarding whether electric collar training is effective did. More hunting dog owners thought that electric collars were an effective training technique than pet dog owners. There was no difference of opinion in their views on the welfare issues around electric collar use.

Table 4: Comparison the use of the electric collars by the three trainers in this research.

Trainer		Trainer A (n=80)	Trainer B (n=71)	Trainer C (n=14)
Number of shocks	1	80 (100%)	26 (37%)	5 (36%)
	2	0	31 (44%)	5 (36%)
	3 or more	0	14 (20%)	4 (29%)
Shock level	Low	0	19 (27%)	2 (14%)
	Medium	0	52 (73%)	12 (86%)
	High	80 (100%)	0	0
Dogs' response	Mild	3 (4%)	15 (21%)	2 (14%)
	Moderate	33 (41%)	37 (52%)	8 (57%)
	Severe	44 (55%)	19 (27%)	4 (29%)
Number of stress behaviours after the shock	1	0	2 (3%)	0
	2	3 (4%)	1 (1%)	0
	3	14 (18%)	13 (18%)	2 (14%)
	4	26 (33%)	24 (34%)	3 (21%)
	5	28 (35%)	16 (23%)	5 (36%)
	6	9 (11%)	11 (16%)	1 (7%)
	7	0	3 (4%)	1 (7%)
	8	0	0	2 (14%)
Timing of shock	9	0	1 (1%)	0
	When contact made	80 (100%)	0	1 (7%)
	Within 20cm	0	63 (89%)	9 (64%)
	Within 40 cm	0	8 (11%)	4 (29%)

Table 5: The responses of pet dog owners and hunting dog owners to the questions asked in regarding to electric collar training.

Questions asked of dog owners		Overall (n=133)	Pet dog owners (n=72)	Hunting dog owners (n=61)	Statistical tests comparing pet dog and hunting dog owners
Have you previously used e-collars?	Yes	45 (34%)	12 (17%)	33 (54%)	$U=1374.00$, $z=-4.53$, $p<0.00$, $r=-0.39$
	No	88 (66%)	60 (83%)	28 (46%)	
If not, why not?	No need to	73 (83%)	49 (82%)	24 (86%)	$U=513.50$, $z=-0.47$, $p=ns$, $r=-0.05$
	Welfare concern	15 (17%)	11 (18%)	4 (14%)	
If yes, why?	General training	27 (60%)	9 (75%)	18 (55%)	$U=202.50$, $z=-1.23$, $p=ns$, $r=-0.18$
	Taking stock/ poultry	18 (40%)	3 (25%)	15 (45%)	
Effective training technique	Yes	59 (44%)	18 (25%)	41 (67%)	$H(3)=26.03$, $p<0.00$
	No	5 (4%)	2 (3%)	3 (5%)	
	Not sure	26 (20%)	20 (28%)	6 (10%)	
	Depends	43 (32%)	32 (44%)	11 (18%)	
Welfare concern	Yes large	32 (24%)	20 (28%)	12 (20%)	$H(3)=2.96$, $p=ns$
	Yes small	46 (35%)	27 (38%)	19 (31%)	
	No	38 (29%)	17 (24%)	21 (34%)	
	No sure	17 (13%)	8 (11%)	9 (15%)	

7.5 Discussion

This is the first large scale review of the short-term and long-term effects of electric collars on dogs. The results indicate that the vast majority of the dogs (88%) displayed moderate or severe responses to the electric shock. The responses displayed by the dogs to the electric shock are behaviours that are associated with pain, fear and distress, for example, yelping (Schilder and van der Borg, 2004); cowering (Cooper et al., 2013); panting (Voith and Borchelt 1996); and escaping (Tortora, 1982). It is therefore likely that experience of the electric shock in this study for most of the 165 dogs was stressful and potentially painful. As the intensity of the electric shock increased, the aversiveness of it also increased as evidenced by the increased response to the electric shock. Evidence that the electric shock experience was unpleasant and anxiety-causing for the dogs was the high prevalence of stress behaviours that was seen after the electric shock with every dog exhibiting stress behaviours, whereas only 27% did so before the electric shock. The high levels of stress behaviours that were seen one-month and one-year later also suggest that the unpleasant and anxiety-causing electric shock experience lasts for at least one year. It is highly likely that the dog's short-term and long-term

welfare is compromised with this training but given the goal in protecting kiwi from being killed by dogs, the decision about its use needs to be evaluated in light of other control methods for dogs in kiwi habitat that are currently used by the Department of Conservation (such as poisoning, live trapping or shooting of dogs).

The responses to the electric shock increased with poor timing of the electric shock in proximity to the training stimuli, potentially indicating that a clear message was not given to the dogs. Schalke et al., (2005) reported a significantly greater stress response in dogs that were electrically shocked at random, with the punishment being unpredictable and uncontrollable. The timing of the electric shock varied significantly between the three trainers, yet timing of the shock is crucial to facilitate an association between the behaviour to be suppressed and the punishment (Blackwell and Casey, 2006). These were all professional dog trainers so the variation in terms of the electric shock to the proximity of the training stimuli was unexpected. Blackwell and Casey (2006) had assumed the issue of poor timing to be more of an issue within the general dog owning population who use electric collars; however this does not appear to necessarily be the case. Some authors suggest restricting the use of electronic collars to experienced trainers with the intentions that it would minimise the potential for incorrect use (Christiansen et al., 2001a; 2001b; Schalke et al., 2005, Tortora, 1982d), yet it appears from this study there is large variability with timing even with experienced trainers.

Hunting dogs displayed higher responses to the electric shock than pet dogs; however, all hunting dogs were shocked at maximum intensity. The shock intensity was at the discretion of the individual trainers. All dogs that received maximum intensity electric shocks, only received one shock, rather than two, or more as was the case with lower intensity electric shocks. The welfare compromise to the dog of two moderate intensity shocks versus one high intensity shock appeared to be relatively comparable in this research based on stress behaviours seen after the shock. However, there is a risk of habituation using lower level electric shocks (Blackwell and Casey, 2006).

For punishment to be effective, it must be aversive enough to create a negative emotional response in order to decrease a particular behaviour (Blackwell and Casey, 2006). Resistance to extinction has also been found to decrease systematically as the duration and intensity of punishment increased (Seligman and Campbell, 1965). From a

theoretical perspective, the higher the punishment, in this case, the electric shock intensity, the more likely the behaviour will decrease and will resist extinction. However, from a welfare perspective, it is important to explore achieving reliable avoidance, in this case - the KAT training stimuli – with reduced electric shock intensity. This may potentially reduce the indicative welfare compromise associated with the kiwi aversion training at present. All dogs, regardless of the level of shock, avoided the KAT training stimuli. This potentially suggests that even the lowest shock is all that is needed to achieve the desired outcome, while concurrently reducing the welfare compromise of high intensity electric shocks, especially if the electric shock is provided with exact proximity to the training stimuli. The dog owners reported that the majority thought that the use of electric collars was a welfare concern, but was an effective method of training of dogs.

Even at the low setting intensity of the shock, the dogs still responded with behaviours indicative of pain and stress (Cooper et al., 2013). This is important given that the goal of the training is for dogs to avoid kiwi, yet research has shown that high levels of stress has been shown to influence a dog's ability to learn (Bodariou, 2005; Mendl, 1999). It is possible that a shock that is perceived as too severe for the dog, may in turn result in a stress response that impedes learning.

The intensity of the electric shock was at the discretion of the trainers. Trainer 'A' in this research appeared to be a more consistent electric collar operator, than the other two trainers. Trainer 'A' consistently shocked the dogs when they touched the KAT training stimuli and only ever needed to apply one shock, however, the shock that was used was consistently the maximum level of shock which as a result caused the highest level of pain and stress for the dog, and stress behaviours after the shock. Deciding on the appropriate level of shock is a difficult task as there are large individual differences between dogs (Blackwell and Casey, 2006). Even within a single breed, dogs have been shown to have a variable capacity for coping with aversive stimulation (Vincent and Mitchell, 1996). In addition to individual temperament, how the electric shock is experienced by the dog will be affected by the dog's previous experiences with electric shock, frequency of application, location of shock, thickness of hair and level of moisture on skin (Lindsay, 2005). Given that many of these factors are not easily assessed by the trainers, this makes the use of electric shock collars far less precise than

proponents have suggested; leading to difficulties in determining and administering an appropriate level of shock high enough to suppress the behaviour, but not so high that it causes a prolonged fear or anxiety response for each individual dog (Blackwell and Casey, 2006).

It is evident from this research that the electric shocks result in short-term pain and stress for the dogs, and long-term stress when presented with the KAT training stimuli. Christiansen et al. (2001a) argued that the restricted and consistent way of using this device to reduce predatory behaviours may reduce the probability of development of anxiety in the dog as a consequence of the treatment. Likewise, Christiansen et al. (2001b) found no negative behavioural changes or anxieties seen from a one-off training session, one year later, so they consider it to be an ethically acceptable device for training dogs not to display predatory behaviour. In contrast, other studies suggest that there may be long-term welfare compromise associated with the use of electric collars (Schilder and van der Borg, 2004; Schilder, 2004). This study has found that one-month, and one-year later, when presented with the KAT training stimuli, high levels of stress behaviours are seen in the dogs that are at similar levels to those seen immediately after the electric shock, potentially indicating long-term welfare compromise associated with the use of electric collars from a one-off training session. It is acknowledged that alternative statistical analysis methodologies could also have been employed in this study, such as multinomial logistic regression modelling.

It is important that if electric collars are to be used then appropriate training be provided to the users, with particular focus on timing, as there is diversity even with professional trainers. Research suggests that the more precise the message is to the dog, the easier it will be to learn and have the greatest effect when applied suddenly (Pryor, 2002) and is given immediately following the behaviour (Lindsay, 2005; O'Farrell, 1992; Solomon et al., 1968). The punishment should be applied with sufficient strength (Mills, 1997); especially in the first instance rather than having to increase the strength and risk habituation to the shock occurring (Totor, 1982). It is also important that the punishment is applied consistently (Kelsey-Wood, 1997) and is not connected with the owner (Fisher, 1995). The timing of the shock is especially important as poor timing carries a high risk that dogs will show severe and persistent stress symptoms (Schalke et al., 2007). This is likely to have negative impacts on the dogs' welfare, with possible

development of problem behaviours, aggression, fear, learned helplessness, or even the unwanted association between the shock and coincidental stimuli, such as the trainer (Polsky, 2000).

Incorrect use is also able to cause tissue damage, physical lesions, and obviously, pain (Houpt et al., 2007). Whilst there have also been reports of physical lesions on the neck caused by high intensities of shock (Seksell, 1999), none were observed in this study. It is important that the electric collar is checked regularly for correct functioning as collar malfunction has been known to occur (Umstatter, 2011).

In conclusion, the behaviours of the dogs when experiencing the aversion training are consistent with validated behavioural indicators of pain and stress; therefore potentially representing negative states of welfare that last for up to one year. In order to be an effective method of training, the intensity of the shock should be as high as possible without being detrimental to the dog. Further research regarding the level of electric shock required to achieve reliable avoidance behaviours in relation to the temperament, size, weight, hair length and breed of the dog is needed.

7.6 References

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Chapter Eight: General conclusions and recommendations

8.1 Conclusions

Dogs (*Canis familiaris*) are the main predator of adult kiwi (*Apteryx* spp.), and as such, the New Zealand Department of Conservation (DOC) has implemented a number of both lethal and non-lethal strategies to attempt to mitigate the risk that dogs pose. This risk is confounded by the New Zealand ethos of hunting introduced pigs, deer and goats, for the purpose of recreation and pest control, with the aid of dogs. Dogs are considered to be an essential component of successful hunting in the New Zealand bush, in particular, for pig hunting. The crux of this issue lies in the overlap of kiwi and pig habitat. Dogs are allowed to enter kiwi habitat for the purpose of hunting if they have been through the DOC administered Kiwi Aversion Training programme (KAT). There is also a hunting permit that the hunter is usually required to obtain if the hunting occurs on DOC land.

The KAT programme is an aversion conditioning programme that pairs an electric shock via an electric collar with the presence of KAT training stimuli consisting of taxidermist kiwi, frozen dead kiwi, kiwi faecal material, kiwi nesting material and a cut-out 2 dimensional kiwi. The intention of the KAT programme is that the dog associates the kiwi training stimuli with a live kiwi, and that it avoids the kiwi in a subsequent encounter. The permits are issued annually, but there are moves by some DOC conservancies to adopt a three year permitting system. To date the DOC have spent almost 20 years, and millions of dollars, investing in this programme without the effectiveness ever being the subject of empirical scientific review. The aim of the research presented within this thesis was twofold; firstly, it was to evaluate the effectiveness of the KAT; and secondly, to assess any potential welfare compromise experienced by the dogs during the aversion training.

There is a large body of evidence that suggests that incorrect use of positive punishment, in the form of electric collars in dogs, is problematic from a welfare perspective (reviewed in Chapter One). For punishment to be effective, it must be delivered at the same time as the neutral stimuli or behaviour; it must appear from the result of the stimuli or behaviour rather than the electric collar operator; and it must be

severe enough to cause a negative emotional response in the dog. In order to cause a negative emotional response in the dogs, the intensity of the electric shock must be high, and there is a plethora of literature that identifies high level electrical stimulation results in concerns with regard to welfare. It is likely to cause a severe behavioural response and physiological response in the dog. The effects of which can be short-term, and possibly even long-term, and can even result in learned helplessness and neurological changes. The punishment must also be concomitant with the animal's behaviour, and with the animal having control over the electric shock, or being able to predict it. Without this, the effects of electric shocks, even mild and moderate level intensity shocks, can be highly stressful for the animal, and result in short and long term stress. Using the precautionary principle, several authors suggest that more humane, lower risk training methods should be employed, rather than the use of electric collars.

To assess the effectiveness of the DOC KAT programme I investigated the aversion conditioning, any resulting avoidance of the training stimuli, and the duration of this avoidance (Chapter Two). I conclude that the KAT could successfully produce avoidance in all dogs the first time that they underwent KAT. When the dogs were tested with the training stimuli, 100% of the dogs displayed moderate or high level avoidance of the KAT training stimuli (n=65). These dogs were all considered successful graduates of the KAT programme, and were issued a KAT permit allowing them to assist hunters in kiwi habitat. This study also investigated how long this aversion conditioning lasted. Firstly, 15 dogs were selected from 65 dogs that had undergone KAT for the first time, and they were tested with the KAT training stimuli one-month later. Half of the dogs were tested in the same location (n=8), and the other half were tested in a novel location (n=7) to see if the aversion conditioning was location-specific avoidance. The dogs were also tested without wearing the electric collar, to see if the avoidance was possibly related to wearing the electric collar. The dogs were also tested without the DOC trainer there to see if the avoidance was related to the presence of the DOC officer that issued the punishment. All 15 dogs showed moderate or high level avoidance to the training stimuli, regardless of where they were tested. I then tested dogs one year after their first KAT to see if the aversion conditioning could last a year (n=55). Half of these dogs were tested at the same location that they had originally been trained, and the other half were tested at a novel location. 87% of these 55 dogs showed moderate to high level avoidance when they

were presented with the KAT training stimuli one-year later, suggesting that there is a long-term memory of the aversion conditioning, regardless of the location of testing. The seven dogs that did not show avoidance underwent the KAT again. The electric collars were worn, and the DOC officer was present at the one-year test of aversion conditioning. This study demonstrated that the DOC KAT programme was successful at causing avoidance in all dogs immediately after being trained, and that this avoidance lasted for one month, was not linked to the testing location, the presence of the electric collar, nor the presence of the DOC officer. This study also showed that the vast majority of dogs retained the memory of the aversion conditioning one-year later, regardless of where they were retested.

The second study was the first large scale investigation of aversion conditioning in canids, or any species, and reviewed KAT records for 1156 dogs involving 1647 KAT sessions (Chapter Four). The aim of this was to investigate the effects of gender, age, social group size, function of the dog, breed, number of training sessions and responses to the aversion conditioning to explore for evidence of learning differences. The behaviours of dogs presented for up to five further KAT sessions were analysed for change with repeated exposure. The effect of one-, two- or three-years gaps between training sessions was also investigated. The results demonstrated, just like the first study, that the KAT was successful in achieving avoidance to the training stimuli in all 1156 dogs. When presented with the training stimuli at the second training session, 69% of the dog displayed avoidance, 88% did so at their third session, 86% at their fourth session and 100% of the dogs did at their fifth session. There was no difference in gender, but there were lower levels of avoidance seen in older dogs undergoing KAT for the first time, dogs from single-dog households, dogs used to hunt pigs, non-sporting breed dogs and dogs that had a three-year gap, or longer, between sessions. This study showed that the vast majority of dogs that undergo repeated regular KAT sessions do display avoidance when presented with the training stimuli, implying that the aversion conditioning is effective when repeated regularly.

As these results describe, successful avoidance was displayed in test conditions, not under conditions in which a dog would come across a kiwi; and also involved a number of potential punishment cues including the presence of the electric collar and the uniformed DOC officer. Consequently, I investigated the aversion conditioning in real-

life hunting conditions, where the dogs are expected to be aroused, and away from their owner for a period of time, either alone or with their hunting pack (Chapter Five). In order to do this I built a large enclosure, deep in Waharau Regional Park, where I set up the KAT training stimuli and two cameras to record the behaviour of the dogs. 70 dogs participated in this study, all of which had been through the KAT one year previously, of which 50 were hunting dogs and 20 were pet dogs. The dogs and hunters were instructed to wear hunting gear (e.g. rip collars, GPS collars, wearing gun and knives), the hunters used the command to 'find the pig' and sent their dog(s) away. Pet dog owners used the command to 'go for a walk'. Each dog entered the enclosure firstly on their own, secondly with their owner, and thirdly, with their entire canine hunting pack (n=50). The results demonstrated that the majority of the dogs displayed avoidance to the training stimuli when they were on their own (77%), with their owner (77%), or in their canine hunting pack (70%). Pet dogs took longer to detect the KAT stimuli, detected it from a shorter distance, and showed less avoidance of KAT training stimuli, compared to hunting dogs. This potentially indicates that it may be the pet dogs, living either in or bordering on kiwi habitat that may be of concern in relation to kiwi predation. Hunting dogs from larger packs showed less avoidance in all three test conditions; which may be a concern, when out hunting. Dogs also did show slightly less avoidance of the KAT training stimuli during the pack test session, regardless of the size of hunting pack they were in, although this was not statistically significant. Dogs hunting in packs may be problematic with the potential for the social facilitation of predatory behaviours. Overall, high levels of avoidance were displayed during simulated hunting conditions to the KAT training stimuli.

I had now clearly demonstrated that the KAT was very effective at resulting in dogs avoiding the training stimuli in a wide-range of conditions, including whilst hunting. However, the ecological validity of the KAT training stimuli was still not established. That is, further research was needed to investigate if KAT-trained avoidance generalizes to live birds, and not just to the stimuli used during training. Subsequently, I investigated if dogs can generalise from 'ecologically relevant' training stimuli of the endangered kiwi, to live kiwi (Chapter Six). To assess this, I examined an identical arrangement using chickens instead of kiwi due to greater availability of chickens, and without the complication of working with live kiwi, an endangered toanga. I used the exact same 'ecologically relevant' training stimuli used in the KAT, but used chicken

equivalent versions of all these. DOC also reported that they had difficulty obtaining some of the training stimuli for the KAT, so were interested in knowing what the best training stimuli were to use, so I tested this for them also. We also included a live chicken for the purpose of training for comparative purposes. The DOC KAT trainers conducted actual aversion conditioning so as to remove a confounding variable. There were six training stimuli used and dogs were randomly allocated in to one of seven treatment groups: (1) dead chicken; (2) taxidermist chicken; (3) chicken faecal material; (4) chicken nesting material; (5) wooden cut-out chicken; (6) all chicken models together; (7) a live chicken. 84 dogs received aversion training and then were presented with a live chicken one month later at a novel location, with novel dog handlers, without the electric collar on. When testing avoidance of the live chicken, behaviours towards the live chicken were quantified, as was latency and distance required to detect the chicken. The vast majority of dogs did not generalise from the chicken training stimuli to the live chicken. Only those dogs trained using the live chicken showed reliable avoidance of the live chicken during testing. These findings call into question the haphazard use of ‘ecologically relevant’ stimuli that has not been validated in training avoidance of live animals. My study indicates that dogs do not appear to be able to generalise from training stimuli to the live bird using the KAT methodology, but that using a live bird as the training stimuli is an efficient method for producing avoidance when presented with a live bird one month later. Whilst it is acknowledged that there are ethical and practical difficulties, it is recommended that the use of live kiwi for aversion training be explored and, in general, the generalization of avoidance of training stimuli to avoidance of a threatened species cannot be assumed. It may also be worth exploring the possibility of assessing aversion conditioning using a range of live birds that hold less conservation value than kiwi, and ascertaining if dogs are able to generalise from a group of various live birds to live kiwi.

Based on the documented concerns surrounding the use of electric collars for training dogs, I investigated the welfare implications for dogs undergoing KAT (Chapter Seven). The aim of this study was to investigate the reactions of 165 dogs undergoing the KAT programme for the first time; 15 dogs one month later; and a further 55 dogs one year later to assess if there are any potential short and/or long-term welfare compromise associated with the use of the electric shock collar using validated behavioural indicators of stress. 100% of dogs displayed a response to electric shock, with 41%

displaying a severe reaction and 47% displaying a moderate reaction indicating substantial stress from the electric shock, and a negative emotional response. The response to the electric shock was significantly affected by the shock intensity, number and timing of the shocks. The occurrence of all stress behaviours investigated significantly increased after the shock (except for paw-lifting); with 79% of the dogs displaying at least four stress behaviours. Stress behaviours were also seen in all dogs one-month later in response to the KAT training stimuli with 74% of the dogs displaying at least 4 stress behaviours. 87% of the dogs' one-year later displayed stress behaviours in response to the presence of the KAT training stimuli, with 67% of the dogs displaying at least 4 stress behaviours. This study also found large variation in terms of timing of the electric shock, and the trainer's subjective determination of the shock level. When maximum intensity was used, only one shock was needed, rather than multiple shocks required at times, with lower electrical intensity. Dog owners also completed a questionnaire as part of this study on their opinion of electric collar training. 64% of dog owners considered the use of electric collars to be an effective training technique, with 59% considering that their use poses a welfare concern for the dogs. This study found that the behaviours of the dogs when experiencing the KAT are consistent with validated behavioural indicators of pain and stress; therefore potentially representing negative states of welfare that demonstrated to last for at least to one year, but is likely to be for longer. In order to be an effective method of training, the intensity of the shock should be as high as possible without being detrimental to the dog. Further research regarding the level of electric shock required to achieve reliable avoidance behaviours in relation to the temperament, size, weight, hair length and breed of the dog is needed. The short and long term welfare compromise of the majority of dogs during the standard KAT protocol may be justifiable from kiwi preservation and conservation perspectives, if KAT were to reduce canine predation on kiwi. It is extremely problematic in terms of canine welfare that the KAT is likely to not reduce canine predation on kiwi, and dogs are therefore being subjected to severe short and long term stress, with no demonstrable benefit in conserving kiwis.

8.2 Recommendations for the Department of Conservation Kiwi Aversion Training programme

The current KAT methodology of using training stimuli, is extremely effective at producing avoidance of the training stimuli. However, there is no evidence to suggest

that the KAT training stimuli are ecologically relevant to the dogs in representing live kiwi, or that the dogs generalise from the KAT training stimuli to live kiwi. In fact, allowing dogs into kiwi habitat based on a dog being KAT permitted may be resulting in more deaths of kiwi than currently exist.

Aside from the avoidance training of dogs, there are other potential benefits of the KAT, for example, if the KAT trainer is able to educate the dog owner about the dangers that dogs pose to kiwi during the KAT, this in itself may be of benefit and warrants investigation. The advocacy and educational benefits of the KAT were not investigated as part of this research.

In order to mitigate welfare compromise to the dogs, and to maintain the human-dog bond, alternative training methodologies, based on positive reinforcement methods, should be assessed for their effectiveness. However, if aversion methodology is preferred then the use of a live kiwi in the KAT, as it currently stands, is likely to result in high levels of avoidance of live kiwi by dogs. This has been successfully demonstrated with chickens (Chapter 6), as well as a range of other canid species (e.g. wolves) in reducing the predation sheep and cattle. Whilst the practical and ethical difficulties of this would be substantial, use of live kiwi would more than likely allow the DOC to demonstrate empirically that the KAT produces canine avoidance of live kiwi, unlike the current situation of using training stimuli.

There is large variability between the KAT trainers in terms of understanding of learning theory, canine behaviour, canine welfare, and timing of electric shock. It is recommended that a Standard Operating Procedure for KAT is developed to ensure consistency between trainers. It is also important the trainers themselves undertake relevant qualifications in order to be able ensure that there is a minimum understanding of learning theory which is likely to result in more consistent timing application, and intensity of the electric shock to endeavour to safeguard the short and long term welfare compromise associated with the KAT. Membership of KAT trainers to a professional dog trainer organisation is also recommended for professional development and also keeping abreast the current canine behaviour and learning theory research.

8.3 Recommendations for dog training in New Zealand

Due to the large welfare compromise evidenced during this research, the unregulated use of electric collars in dog training is not recommended. If electric collars are to be used at all, then they should only be used by qualified, certified, professional dog trainers that have a solid understanding of learning theory, good timing, and under very strict criteria. The only time that electric collars should be justifiably used is for eliminating predatory behaviour towards another species. Even then, if there is risk to another animal by a dog, then the dog should not be unrestrained in the environment.

8.4 Final conclusion

This research has demonstrated that the KAT is effective at producing avoidance to the training stimuli, but that this does not generalise to live birds. There is substantial short and long term welfare compromise for the dogs from KAT that may be ethically justified should KAT result in reduced predation of kiwi. Alternate methods of training dogs to reduce predation based on positive reinforcement methods should be investigated.