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

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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 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 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.

1. 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.

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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,b,c). 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; dog function; breed; the number of training sessions and change in behaviour over repeated test sessions.

2. Material and methods

2.1. 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. Past history of the dogs and training experience was not recorded.

Dog function 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.

2.2. 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 by Pet Training Products, New Plymouth, New Zealand) which delivered 0.0092 J 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 program 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 2.3 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. There is only a requirement to do annual KAT training if the dog requires a DOC hunting permit to hunt in kiwi habitat. This annual requirement is regardless of what behaviours the dogs displays towards the KAT training stimuli.

2.3. 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 (2m+), 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. For the repeat training session (2nd–6th) the behaviours of the dogs to the training stimuli were recorded prior to being shocked (if required).

2.4. 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

Table 1
The demographic make-up of the 1156 dogs that underwent Kiwi Aversion Training in the Coromandel, New Zealand 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	–	–	–	–	–	–	–	–	–	–	0
		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 function	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

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 Cohen's *r* and power analysis was conducted using GPower (Version 3). Alpha was set to 0.05 for all statistical analysis.

3. 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 (57%) to strong interest (0.1%), with the majority of dogs avoiding the training stimuli (86%).

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 (80%). Table 4 shows the demographic data for the 83 dogs that required electric shocks during repeat KAT training sessions (n = 96). 94% of these dogs were from a pig hunting dogs and were from a multi-dog household.

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 significantly affect avoidance to the training stimuli in the second training session but no other sessions ($H(4) = 24$, $p \leq 0.01^*$, $r = 0.226$). When compared with pig dogs, more avoidance was observed both for pet ($U = 2694.5$, $z = -2.65$, $r = 0.16$, $1\text{-}\beta = 0.47$) and goat dogs ($U = 1648.5$, $z = -4.32$, $r = -0.26$, $1\text{-}\beta = 0.79$). There was no statistically 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 ($H(3) = 15.87$, $p \leq 0.01$, $r = 0.038$). When compared with non-sporting breeds, terrier breeds and working breeds showed more avoidance ($U = 6123$, $z = -3.34$, $r = -0.21$, $1\text{-}\beta = 0.94$; $U = 17894$, $z = -4.27$, $r = -0.17$, $1\text{-}\beta = 0.92$ 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 ($H(3) = 42.84$, $p \leq 0.01$, $r = 0.118$; $H(4) = 20.21$, $p \leq 0.01$, $r = 0.056$). Dogs undergoing their second training session in 2006 displayed significantly more avoidance when compared with 2001 ($U = 270.5$, $z = -3.78$, $r = -0.44$; $1\text{-}\beta = 0.98$).

Repeated training sessions showed a statistically significance difference in avoidance toward the training stimuli ($x^2(4) = 10.85$, $p = 0.03$: 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 2
The behavioural responses towards the Kiwi Aversion Training (KAT) training stimuli during the 1647 KAT sessions held in the Coromandel, New Zealand between 1998 and 2007.

Responses to training stimuli	Training sessions						Total (n = 1647)
	1st (post training) (n = 1156)	2nd (n = 313)	3rd (n = 128)	4th (n = 42)	5th (n = 7)	6th (n = 1)	
Strong avoidance	691 (60%)	145 (46%)	82 (64%)	31 (74%)	6 (86%)	1 (100%)	956
Moderate avoidance	380 (33%)	73 (23%)	31 (24%)	5 (12%)	1 (14%)		490
Indifference	85 (7%)	14 (4%)	4 (3%)	2 (5%)			105
Moderate interest		79 (25%)	11 (9%)	4 (9.5%)			94
Strong interest		2 (1%)					2

Table 3
The number of electric shocks required during the 1647 Kiwi Aversion Training sessions held in the Coromandel, New Zealand between 1998 and 2007 for the dog to display avoidance of the training stimuli.

Number of electric shocks required	Training sessions						Total (n = 1674)
	1st (n = 1156)	2nd (n = 313)	3rd (n = 128)	4th (n = 42)	5th (n = 7)	6th (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
The demographic make-up of the 83 dogs that required electric shocks at repeat Kiwi Aversion Training sessions in the Coromandel, New Zealand.

Demographic data of dogs requiring electric shocks at repeat training sessions		*Training sessions*				Total repeat electric shocks (n = 96)
		2nd		*3rd*	*4th*	
		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	2	7	2	48
	Male	42	0	4	2	48
Age (in years)	0–2	32	1	4	0	37
	2–4	33	0	2	2	37
	4–6	6	1	2	2	11
	6–8	8	0	3	0	11
	8–10	0	0	0	0	0
	10+	0	0	0	0	0
Breed group	Toy	0	0	0	0	0
	Terrier	7	0	0	0	7
	Gundog	9	0	0	1	10
	Hound	2	0	2	0	4
	Working	36	1	2	3	42
	Utility	18	1	2	0	21
	Non-sporting	7	0	5	0	12
No. of dogs	Single-dog	6	0	2	0	6
	Multi-dog	73	2	11	4	90
Dog function	Pig	75	2	9	4	90
	Pet	4	0	2	0	6
	Goat	0	0	0	0	0
Gap between prior and this session (in years)	1	52	1	6	2	61
	2	20	1	2	2	25
	3	5	0	3	0	8
	4	2	0	0	0	2
	5	0	0	0	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 4th session; 2 of the 4th 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 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.

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Table 5
The statistical analysis results for the demographic variables to the 1156 dogs that underwent Kiwi Aversion Training sessions held in the Coromandel, New Zealand between 1998 and 2007.

Demographic variables		Training sessions (Total $n = 1674$)				
		1st ($n = 1156$)	2nd ($n = 313$)	3rd ($n = 128$)	4th ($n = 42$)	5th ($n = 7$)
Gender	Female (n = 546; 47%) Male (n = 610; 53%)	$H(3) = 1.53$, $p = 0.73$, $r = 0.018$	$H(4) = 7.54$, $p = 0.1$, $r = 0.226$	$H(3) = 6.784$, $p = 0.076$, $r = 0.126$	$H(3) = 0.39$, $p = 0.93$, $r = 0.228$	$H(1) = 1$, $p = 1$, $r = 1.509$
Age (in years)	0–1 ($n = 416$; 36%) 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%)	$H(3) = 7.51$, $p = 0.04^*$, $r = 0.051$ ($J = 19970.5$, $z = 2.63$, $r = 0.08$)	$H(4) = 1.47$, $p = 0.84$, $r = 0.056$	$H(3) = 4.79$, $p = 0.19$, $r = 0.077$	$H(3) = 2.51$, $p = 0.5$, $r = 0$	$H(1) = 0.17$, $p = 1$, $r = 1.509$
No. of dogs	Single ($n = 203$; 18%) Multi ($n = 953$; 82%)	$H(3) = 7.56$, $p = 0.05^*$, $r = 0.049$) Single: Mdn = 1, range = 2; Multi: Mdn = 1, range = 2) ($U = 92072$, $z = -1.254$, $r = -0.037$, $1\text{-}\beta = 0.239$)	$H(4) = 3.39$, $p = 0.49$, $r = 0.093$	$H(3) = 9.18$, $p = 0.04^*$, $r = 0.154$ Single: Mdn = 2.5, range = 3; multi: Mdn = 1, range = 3)($U = 210.5$, $z = -2.063$, $r = -0.182$, $1\text{-}\beta = 0.216$).	$H(3) = 0.36$, $p = 1$, $r = 0.617$	$H(0) = 1$, $p = 1$, $r = 1.509$
Dog function	Pig ($n = 1011$; 87%) Pet ($n = 112$; 10%) Goat ($n = 33$; 3%)	$H(3) = 7.58$, $p = 0.06$, $r = 0.046$	$H(4) = 24$, $p = 0.00^*$, $r = 0.226$ '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)	$H(3) = 1.46$, $p = 0.69$, $r = 0.131$	$H(3) = 9.41$, $p = 0.11$, $r = 0.188$	$H(0) = 0$, $p = 1$, $r = 1.509$
Breed group	Toy (n = 0) 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%)	$H(3) = 15.87$, $p = 0.01^*$, $r = 0.038$ '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)	$H(4) = 10$, $p = 0.35$, $r = 0.021$	$H(3) = 4.75$, $p = 0.19$, $r = 0.077$	$H(3)3.66$, $p = 0.32$, $r = 0.069$	$H(1) = 0.7$, $p = 1$, $r = 1.509$
Location of training site	43 locations utilised	$H(3) = 16.71$, $p = 0.00^*$, $r = 0.118$	$H(4) = 120.58$, $p = 0.00^*$, $r = 0.226$	$H(3) = 5.37$, $p = 0.14$, $r = 0.095$	$H(3) = 3.37$, $p = 0.36$, $r = 0.049$	$H(1) = 1.17$, $p = 0.58$, $r = 0.079$
Year of first training	1998–2007	$H(3) = 42.84$, $p = 0.00^*$, $r = 0.118$ 2006 (Mdn = 1, range = 3); 2001 (Mdn = 3, range = 3) (0.002 level of significance Bonferroni)	$H(4) = 20.21$, $p = 0.00^*$, $r = 0.056$ 2006 (Mdn = 1, range = 3); 2001 (Mdn = 3, range = 3) (0.002 level of significance Bonferroni)	$H(3) = 5.47$, $p = 0.14$, $r = 0.095$	$H(3) = 7.12$, $p = 0.07$, $r = 0.227$	$H(1)0.29$, $p = 1$, $r = 1.509$

* Significant.

Table 6
Statistical analysis results of comparison of repeated training sessions of the Kiwi Aversion Training in the Coromandel, New Zealand.

	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, $1\text{-}\beta$ = 1.0	z = −0.766, r = −0.068, $1\text{-}\beta$ = 0.439	z = −0.387, r = −0.060, $1\text{-}\beta$ = 0.184	z = −1.134, r = −0.175, $1\text{-}\beta$ = 0.203
Second		z = −3.740, r = −0.577, $1\text{-}\beta$ = 1.0	z = −2.835, r = −0.443, $1\text{-}\beta$ = 1.0	z = −2.220, r = −0.839, $1\text{-}\beta$ = 1.0
Third			z = −0.219, r = −0.034, $1\text{-}\beta$ = 0.110	z = 0.816, r = 0.308, $1\text{-}\beta$ = 0.433
Fourth				z = 0, r = 0, $1\text{-}\beta$ = 0.05

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

Table 7
The statistical analysis of the effect of the length of time between Kiwi Aversion Training sessions on the dogs' behavioural response to the training stimuli in the Coromandel, New Zealand.

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, $1\text{-}\beta$ = 0.280) Comparison of a 1 & 3 year gap: (U = 416, r = −0.1567, $1\text{-}\beta$ = 0.206) Comparison of a 1 & 4 year gap: (U = 54, r = −0.130, $1\text{-}\beta$ = 0.100)			
Second to third training session	($H(2)$ = 2.903, p = 0.234, r = 0.064)			
Third to fourth training session	($H(2)$=0.372, p = 0.830, r = 0.148)			

4. Discussion

This is the first large scale study investigating the long-term 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 andimilar results have been found in other studies (Christiansen et al., 2001a,b,c). This is not unexpected as there has been no gender differences have been identified in the olfactory apparatus in dogs (McGreevy et al., 2004), despite gender dimorphism occurring in dogs (Frynta et al., 2012)

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,b; Ogburn et al. 1998). In their study on the use of electric collars to reduce sheep predation, Christiansen et al. (2001a,b) 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 et al., 2001c; Holmes, 1991; Pryor, 1999; Scott and Fuller, 1965; Turcsán et al., 2011). Christiansen et al. (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; Gacsi 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; Gacsi 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 is 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 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.

Our findings showed that 26% of the dogs showed interest in, rather that 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.

In conclusion, this study reports the outcomes of the first very large sample of dogs undergoing kiwi avoidance training which is conducted in an attempt to reduce canine predation. 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, for example annual training sessions for at least the first two years. 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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