Behavioural differences between three breed groups of hunting dogs confronted with domestic sheep

Article *in* Applied Animal Behaviour Science · May 2001

DOI: 10.1016/S0168-1591(00)00202-1 · Source: PubMed

3 authors, including:

Bjarne O. Braastad
Norwegian University of Life Sciences (NMBU)
82 PUBLICATIONS **2,728** CITATIONS

SEE PROFILE

ELSEVIER

Applied Animal Behaviour Science 72 (2001) 115–129

APPLIED ANIMAL BEHAVIOUR SCIENCE

www.elsevier.com/locate/applanim

Behavioural differences between three breed groups of hunting dogs confronted with domestic sheep

Frank O. Christiansen[a,*], Morten Bakken[b], Bjarne O. Braastad[b]

[a]*North Trondelag Research Institute, P.O. Box 2533, N-7729 Steinkjer, Norway*
[b]*Department of Animal Science, Agricultural University of Norway, P.O. Box 5025, N-1432 Ås, Norway*

Accepted 7 November 2000

Abstract

When running free in open fields, domestic dogs occasionally display predatory behaviour towards domestic sheep. This has not yet been studied scientifically. The aim of the present study was to investigate the inclination to chase sheep in three breed groups of hunting dogs that are most frequently used in areas with grazing sheep. We studied 41 elkhounds, 29 hare hunting dogs and 68 English setters. Behaviours indicative of motivation for chasing or attacking sheep were examined in three different ways. A path test examined functional traits such as hunting ability, contact willingness, reactivity to sudden noise, and response towards a lone sheep. In a sheep confrontation test, loose-leashed dogs were observed in a fenced enclosure with sheep and given electric shocks through an electronic dog collar if within 1–2 m from the sheep. A questionnaire to the dog owners supplied information on their dog's previous experience with sheep and behavioural responses to various types of novel stimuli. No significant sex differences were found. The elkhounds showed the highest interest in a lone sheep in the path test, and displayed the highest initial hunting motivation, the highest percentage of dogs starting a sheep attack, the highest attack severity, and were most frequently given el. shocks. The hare hunting dogs were intermediate, while setters showed the lowest values for these variables. Dogs reported as showing low fearfulness more frequently acted as potential sheep chasers in the tests. Dogs up to 3 years of age showed a more pronounced initial hunting motivation and more frequent attacks than older dogs, although there were no age differences in the number of el. shocks given in the test. The latter may be related to the more frequent abruption of attacks among younger dogs. The main factors predicting a high hunting motivation and attack severity were lack of previous opportunity to chase sheep, low fearfulness towards gunshots and unfamiliar people, and general interest in sheep shown when encountering them. Probability of sheep chasing differed between dog breeds and age groups. Previous experience and certain character traits were indicative of a high predatory motivation towards sheep.

Keywords: Aversion learning; Character test; Dog; Sheep; Predation

* Corresponding author. Tel.: +47-74-13-46-77; fax: +47-74-13-46-61.
E-mail address: fc@ntforsk.no (F.O. Christiansen).

0168-1591/01/$ – see front matter
PII: S0168-1591(00)00202-1

1. Introduction

In several countries, sheep graze on unfenced pasture. These sheep may be chased and attacked by predators, particularly the great carnivores, brown bear (*Ursus arctos*), wolverine (*Gulo gulo*), lynx (*Felis lynx*), and wolf (*Canis lupus*), as well as golden eagle (*Aquila chrisaetos*) (The Office of the North Trondelag County Governor, 1998). Predation by canids has been studied in several countries; wolves (Meriggi and Lovari, 1996), wolves and feral dogs (Ciucci and Boitani, 1998), and coyotes (Andelt et al., 1999). Though the dog (*Canis familiaris*) positively affects the physical and mental wellbeing of humans, as well as being beneficial for society in several ways, some dogs may show undesirable behaviours. The domestic dog's need for running freely in nature may be a threat to wildlife and livestock. In Norway, approximately 2.2 million sheep and 80,000 goats graze in open fields during the summer season (Skurdal, 1997). Loose dogs chase and kill sheep in grazing areas and separate lambs from their mothers. During the period 1991–1998, 66 sheep were killed by dogs in North Trondelag county, Norway (The Office of the North Trondelag County Governor, 1998). This problem may be underestimated, as sheep owners do not receive any economical compensation for dog-killed sheep, as they do for wild-killed sheep.

Although not documented scientifically, among the most potent sheep hunters are probably hunting dogs, which may run far out of sight of the owner during training and hunting. The hunting dogs have been selectively bred for specific hunting behaviours; elkhounds (e.g. Norwegian Elkhound, grey) hunt by scent and tracking (on leash) or by following the prey while barking (off leash), hare hunting dogs (e.g. Finnish stoever) follow the prey with a specialised kind of barking, whereas gun dogs (e.g. English setter) search in open field and mark the prey by pointing at (setting) the bird. In order to counteract the needs for stricter regulations on the use of hunting dogs and other breeds, efficient measures must be developed to ensure that such dogs refrain from chasing sheep (Christiansen, 2000).

Different methods have been used in order to prevent dogs from chasing sheep. Traditionally, young dogs were placed inside sheep barns to experience being attacked by ewes. Dogs have also been trained to refrain from attacking sheep by owner's commands. None of these methods have been scientifically assessed. More recently, electronic dog collars have been used to teach dogs to avoid attacking sheep. The effectiveness of such collars has been assessed in coyotes in the USA (Andelt et al., 1999). The collars greatly reduced the probability of subsequent attempted attacks on lambs, and caused coyotes to avoid and retreat from lambs for over 4 months. Details of the predatory behaviour of the coyotes were not analysed. The electronic dog collars give electric shocks, which has created concern for the welfare of the dogs being trained. This scepticism is connected to a widespread use of devices that deliver electric shocks to dogs for the purpose of training or curing several types of behaviour problems. Incorrect use could result in unwanted side effects; e.g. the dog becoming afraid of the test area or potentially aggressive towards owners, children, strangers, or other dogs (Association of Pet Behaviour Counsellors, APBC, 1997). Scientific experience with such shock collars is to our knowledge non-existent. In order to be able to develop efficient methods to suppress the chasing of sheep among dogs, knowledge of the dogs' hunting behaviour and their reaction to shocks is needed.

Behavioural tests on dogs have been used for 60 years as a tool in the selection of service dogs for various types of work (Wilsson and Sundgren, 1997). Reviews on the hereditary aspects of working dogs' abilities have been presented by Mackenzie et al. (1986) and by Willis (1989, 1995). Most of these studies were conducted in order to select dogs for a specific type of work, involving only one breed. A few studies have analysed various hunting traits towards breed-specific prey in hunting dog breeds; trail-barking (Whitney, 1929), and genetic and phenotypic correlations and heritabilities (Vangen and Klemetsdal, 1988). To our knowledge there are no previous studies evaluating behavioural tests related to dogs' hunting behaviour towards sheep. It is important to gain knowledge about which breeds are the most potent chasers and hunters of sheep.

The aim of this study was to investigate the inclination to chase and attack sheep in three breed groups of hunting dogs, and describe individual, sex, and age variation in behaviour. The dogs' sheep predation tendencies were examined in three different ways, by a path test, by observation of the dogs fenced in with sheep, in addition to a questionnaire to the dog owners. The path test examined functional traits; hunting ability, contact willingness, reactivity, and the response towards a lone/hidden sheep. Learning effects of the electronic dog collar are presented in a subsequent paper (Christiansen et al., 2001a), while social facilitation of sheep chasing is shown in a third one (Christiansen et al., 2001b).

2. Materials and methods

2.1. Animals

During June–August 1995–1996, behaviour related to sheep predation of 138 dogs from three different breed groups (Table 1) were observed in standardised tests in the same fenced enclosure with different individuals of the Dala sheep breed. The dogs' behaviour towards sheep had not been tested previously. The age distribution and sex distribution of the dogs is shown in Table 1. As hunting dogs are considered to be fully grown by 3 years of age, age groups were formed below and above this age. The dogs were grouped according to the classification system used by the Féderation Cynologique Internationale (FCI, 1993).

Table 1
Dog breeds in behavioural tests

FCI group	Breed	Sex		Age group		Numbers
		Male	Female	≤3 years	>3 years	
5: spitz and primitive types	Norwegian Elkhound, grey	19	22	25	16	41
6: scent dogs	Hare hunting dogs	16	13	21	8	29
7: pointing dogs	English setter	40	28	47	21	68
Total		75	63	93	45	138

2.2. Breed classification

All breeds in this study belong to the hunting dogs, and are categorised according to their typical prey or hunting behaviour (elkhounds, hare hunting dogs and pointing dogs).

Norwegian Elkhound, grey is a Nordic spitz type bred among hunters on the Scandinavian peninsula, and is believed to originate from crossing of Russian palustris types (*C. familiaris palustris*) and wolves (*C. lupus*; Brinkmann, 1924; Lorenz, 1965). The breed belongs to the spitz types that represent an earlier stage of domestication than most modern dog breeds (Zimen, 1978). The breed is used as a loose dog or leashed, primarily hunting moose (*Alces alces*) or deer (*Cervus elaphus*).

The hare hunting (scent) dogs are suggested to have a common ancestor in *C. familiaris intermedius* (Roig, 1974), though skeleton evidence is rare (Christiansen, 1981). All breeds in this group are specialised hunters of hare, while low-boned breeds also hunt fox and red deer. In this study, the breeds Drever ($N = 4$), Dunker ($N = 12$), Hamilton stoever ($N = 6$), and Finnish stoever ($N = 7$) were used.

English setter originated from the British ''setting'' spaniels used for bird hunting as early as the middle of the 16th century (Adlercreutz, 1994). The breed is the most common gun dog in Norway for hunting grouse, because of its ability to set or point upon prey.

The Dala sheep breed is the most common breed in Norway (Eikje, 1991). It originated from the crossing between the British breeds Sjeviot, Leicester, and Sutherland. The individuals are calm, and show a scattered distribution on pasture. It is the heaviest of the Norwegian sheep breeds, and adult ewes have a live weight more than 90 kg (Ådnøy, 1994; Vangen et al., 1994). This breed is, therefore, the most susceptible for predation and may show inadequate antipredator behaviour in comparison with other breeds (Hansen et al., 2001).

2.3. Test area

All tests were located in the same area in Malm, North Trondelag county, Norway, at 64°4′N, 11°13′E. A flock of five Dala sheep were kept on pasture inside a 2 ha fenced enclosure (200 m × 100 m), the average area grazed during 1 day (Nedkvitne et al., 1995). The test area was a flat, open pasture with birch vegetation on the left side and spruce trees on the right and rear sides as seen from the gate.

2.4. Test procedures

Tests were conducted either between 1100 and 1400 h or between 1800 and 2100 h. Dogs were tested individually, first with a path test, subsequently with a test within the sheep fenced enclosure. The purpose of the path test was to define and describe some basic skills needed by dogs in order to behave adequately in daily life. The test was a modified version of a character test used by the Norwegian Kennel Club (1994). During the path test, the dog walked on a 5 m long leash with its owner, while the observer walked a few meters behind. The dog was led along a 100 m predetermined track (path) along which the dog was exposed to four different sudden encounters with novel stimuli: a rag being pulled across the track 6–8 m in front of the dog, an unfamiliar human 3–4 m away, a bundle of tin cans

being thrown upon stones on the track 7 m in front of the dog, and a single sheep tied at the end of the track 5 m from the dog. The stimuli were invisible beyond these distances and were manipulated by two hidden assistants. For rag, human, and sheep, the time was recorded from detection of the stimulus to the dog's presence close to it or avoidance of it. When the dog approached the stimulus, the owner followed the dog if necessary. For the tin cans, the time until recovery from the noise was recorded as the time from the dog's detection of the stimulus until it either started walking towards the cans or resumed walking along the path. Detection of the stimulus was indicated by the dog's ears and direction of gaze. For the rag and the human, we recorded the distance to the dog at the time of detection. When exposed to a lone sheep, the behaviour was ranked according to a withdrawal–approach scale — 1: withdrawal from sheep, 2: indeterminate behaviour towards sheep, 3: uninterested in sheep, 4: observes sheep, 5: slow approach towards sheep, 6: fast approach towards sheep (Table 2). Direct attack was prohibited by the leash.

The sheep confrontation test was conducted in order to examine the dog's motivation for chasing a free-roaming sheep flock. After the path test, an electronic collar (Dog Radartron™ manufactured by D.T. Systems Inc., Dallas, TX) was fixed to the dog, which was subsequently released in the fenced area with the sheep flock. Although not held by humans, a long leash (about 15 m) was connected to the dog's collar, to make it easier to stop the dog if the electric shocks did not stop the attack on sheep. The distance between the dog and the sheep flock at release was approximately 70–100 m.

The dogs' immediate behaviour towards the sheep when released was recorded on a seven-point ordinal scale from withdrawal to attack — 1: withdrawal from sheep; 2: indeterminate towards sheep; 3: uninterested in sheep; 4: observes sheep; 5: interested in sheep; 6: chase attempt; 7: attacks sheep (Table 2). This variable was termed initial behaviour towards a sheep group and considered to reflect hunting motivation. Barking and other vocalisations were included on our observation forms, but never observed in this test. Latency time was measured from the time the dog was placed in the fenced area until start of the first attack. The attack severity was defined as the most severe attack degree shown

Table 2
Definitions of behavioural categories in dog behaviour tests, in usage sequence

Behaviour towards sheep	Test type[a]	Definition
Withdrawal	P, S	Walking away from sheep
Indeterminate	P, S	Looked at sheep intermittently, with normal or slightly lowered posture, no intention movements towards sheep, no withdrawal
Uninterested in sheep	P, S	Any other behaviour not related to the sheep
Observes sheep	P, S	Gaze directed towards sheep, observing
Interested in sheep	S	Moving while observing sheep, without approaching
Slow approach	P, S	Trotting towards sheep
Fast approach	P	Galloping towards sheep
Chase attempt	S	Tries to move sheep being close to flock
Slow attack	S	Trotting towards sheep followed by attack
Moderate approach and attack	S	Moderate galloping towards sheep followed by attack
Severe attack	S	High speed attack, the dog appearing to maximise its speed

[a] P: path test, S: sheep confrontation test.

by the individual during the test and was categorised into — 1: slow approach; 2: moderate approach usually with an attack; 3: severe attack (Table 2). In order to prevent unnecessary disturbance and damage to the sheep, the dogs were not allowed to spread or follow the sheep. If the dog came within a distance of 1–2 m from the sheep, one push on the device button was administered. One push caused electric shock impulses for 1 s. The shocks were of 3000 V and 0.4 A. Shocks were repeated if the dog did not leave the 1–2 m zone or if it re-entered it. The number of times shock impulses were given during the test was recorded. During the whole sheep confrontation test, we recorded the time after start of test at which 11 categories of behaviour, and vocalisations, were performed. Behavioural categories which are not self-explanatory are defined in Table 2. A maximum of 5 min was used for this test. For both behavioural tests, check sheets were used for recording observations.

In addition to test observations, the dog owners completed a questionnaire concerning their own experiences of the dog's behaviour. Questions were asked about the residential place (rural or countryside); the frequency of taking the dog on pasture/open field; if the dog is confronted by sheep in training areas; the dog's earlier interest in sheep; the owner's description of the dog's fear of gunshots and unfamiliar humans and dogs; the owner's description of the dog's aggressiveness towards humans and dogs. The behavioural variables were reported on ordinal five-point scales (from small to large, or always to never).

The methods were approved by the Norwegian Committee for the Ethical Treatment of Research Animals.

2.5. Analyses and statistics

Statistical analyses were made with the Statistical Package for the Social Sciences (SPSS). Descriptive statistics are presented as mean $\pm$ S.E., or as median for ordinal variables. Variance analyses on breed, sex, and age, and their interactions, were made for parametric variables. One-way analyses of variance were made with Kruskal–Wallis tests for ordinal variables. Comparisons between the three hunting dog types were made with two-tailed *t*-tests, Mann–Whitney *U*-tests or Chi-square tests. Pearson correlations between variables were calculated. A maximum-likelihood factor analysis with varimax rotation was performed to determine the degree to which variability in the behavioural test results could be explained by common underlying factors.

3. Results

3.1. Breed differences in behaviour related to sheep chasing

We found no significant sex differences in any recorded variable. Results are therefore pooled for sexes.

The behaviour of the dogs of the three breed groups in the path test and their initial behaviour in the fenced enclosure with sheep is presented in Table 3. The breed groups differed in their behaviour towards a lone sheep in the path test; the elkhounds showing a higher interest than the setters ($U = -2.87$, $P = 0.004$, Mann–Whitney *U*-test), with hare

Table 3
Behaviour of three groups of hunting dog breeds in the path test and the sheep confrontation test, and el. shocks administered

	Elkhounds ($N = 41$, mean ± S.E. or median[a])	English setters ($N = 68$, mean ± S.E. or median)	Hare dogs ($N = 29$, mean ± S.E. or median)	Statistic[b]	P
Path test					
Object attack latency (s)	4.39 ± 0.41	4.87 ± 0.46	4.52 ± 0.56	$F = 0.38$	0.69
Human contact latency (s)	2.12 ± 0.20	2.61 ± 0.33	2.03 ± 0.36	$F = 1.13$	0.33
Noise recovery time (s)	6.02 ± 0.48	5.63 ± 0.38	6.14 ± 0.56	$F = 0.41$	0.66
Degree of interest in lone sheep	5	3	5	$H = 7.52$	0.031
Reaction latency towards lone sheep (s)	8.22 ± 0.53	9.55 ± 0.57	9.52 ± 0.71	$F = 1.83$	0.16
Sheep confrontation test					
Initial behaviour towards a sheep group	6	4.5	5	$H = 6.26$	0.044
Sheep attack latency (s)[c]	47.8 ± 6.73	36.1± 2.04	51.7 ± 6.06	$F = 0.85$	0.43
Attack frequency (%)	61.0	31.0	45.0	$\chi^2 = 5.01$	0.008
Attack severity	2	0	0	$H = 10.91$	0.004
Number of el. shocks administered	0.93 ± 0.29	0.04 ± 0.03	0.10 ± 0.08	$\chi^2 = 9.71$	<0.01

[a] Median is presented for the three ordinal variables.
[b] Breed differences were tested with analyses of variance (F), Kruskal–Wallis tests (H), and a Chi-square (χ^2) test.
[c] $N = 24$, 16, and 13 dogs, respectively.

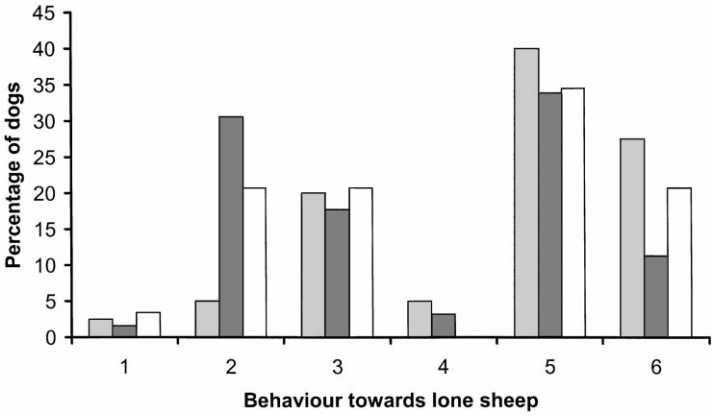

Fig. 1. Behaviour towards a lone sheep in the path test. Grey columns: Norwegian elkhound, grey; black columns: English setters; white columns: hare hunting dogs. Behaviour categories ranked according to hunting motivation; 1: withdrawal from sheep, 2: indeterminate behaviour towards sheep, 3: uninterested in sheep, 4: observes sheep, 5: slow approach towards sheep, 6: fast approach towards sheep. For further explanation, see Section 2. The behaviour differs significantly between dog breeds ($H = 7.52$, $P = 0.031$, Kruskal–Wallis test).

hunting dogs being intermediate. The distribution of behaviours towards a lone sheep is shown in Fig. 1. Within the fenced enclosure, the three breed groups showed similar differences in their initial behaviour, in the percentage of dogs starting an attack, and in the attack severity (Table 3). The distribution of initial behaviours towards the sheep group is presented in Fig. 2. More elkhounds than other breeds showed the most intense form of

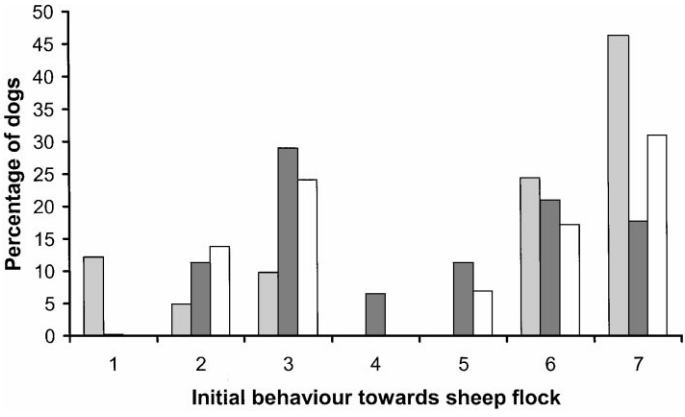

Fig. 2. Initial behaviour in three breeds of hunting dogs in the sheep confrontation test. Grey columns: Norwegian Elkhound, grey; black columns: English setters; white columns: hare hunting dogs. Behaviour categories ranked according to hunting motivation; 1: withdrawal from sheep, 2: indeterminate behaviour towards sheep, 3: uninterested in sheep, 4: observes sheep, 5: interested in sheep, 6: chase attempt, 7: attacks sheep. For further explanation, see Section 2. The behaviour differs significantly between dog breeds ($H = 6.26$, $P = 0.044$, Kruskal–Wallis test).

initial hunting behaviour: 46.3% of them attacked sheep at first sight. Among setters, 29% showed no interest in the sheep, 21% tried to chase and 17.7% attacked the sheep. Of the hare hunting dogs, 24% showed no interest in the sheep, while 31% attacked the sheep.

Also for the entire sheep confrontation test, the three hunting dog types differed in their inclination to attack fenced-in sheep ($\chi^2 = 9.5$, $P = 0.01$). Among the elkhounds, 61% attacked sheep during the test, while 44.5% of the hare hunting dogs and 30% of the setters did so. The setters that did attack, however, exhibited shorter attack latency than the elkhounds and the hare hunting dogs (Table 3).

The three breed groups differed significantly as to whether they received el. shocks or not ($\chi^2 = 22.7$, $P = 0.03$). Elkhounds were most frequently given el. shocks (31.7%, $P < 0.01$), whereas few of hare hunting dogs and setters received el. shocks (6.9 and 2.9%, respectively). Altogether, 87.7% of the dogs received no el. shocks. Elkhounds which were given el. shocks received on average 2.9 ± 0.6 shocks (maximum eight shocks), while both setters and hare hunting dogs received 1.5 ± 0.5 shocks (max two shocks; $\chi^2 = 22.7$, $P = 0.03$). No breed differences were found for the remaining variables. The dogs' reactions to being shocked differed between individuals, by displaying grades of jumping, head shaking, vocalisations, or the speed of withdrawal from the sheep.

3.2. Relations between behavioural categories

In the path test, the dogs' human contact latency correlated with object attack latency ($r = 0.59$, $P < 0.001$) and noise recovery time ($r = 0.26$, $P < 0.01$). Dogs that showed a short human contact latency in the path test also withdrew from sheep at a later stage in the sheep confrontation test ($r = -0.27$, $P < 0.05$). In the sheep confrontation test, the dogs' initial behaviour towards the sheep flock correlated with attack severity ($r = 0.74$, $P < 0.001$) and number of el. shocks given ($r = 0.26$, $P = 0.002$). The behaviour towards a lone sheep in the path test correlated with the initial behaviour towards the sheep flock ($r = 0.36$, $P < 0.001$) and with the attack severity ($r = 0.35$, $P < 0.001$). Among dogs which approached the lone sheep, 66.2% also attacked the sheep flock (index of concordance = 0.74). Among those which did not approach the lone sheep, only 16.9% attacked the sheep flock (Kappa coefficient = 0.49).

A factorial analysis of the path test and sheep confrontation test variables was conducted (Table 4). The factors were rotated using the varimax criterion to render the dimensions of the space more recognisable. Three factors provided significant contributions, accounting for 70.1% of the overall variation. The first factor (F1) had a high, positive correlation with the dogs' degree of interest towards a lone sheep, their initial behaviour towards a sheep group, and with the dogs' attack frequency and attack severity. The factor scores for F1 differed significantly between breeds (Norwegian Elkhound, grey: 0.47 ± 0.17; English setters: -0.31 ± 0.14; Hare hunting dogs: -0.09 ± 0.21; $F = 6.75$, $P = 0.002$). The second factor (F2) had a high, positive correlation with the dogs' object attack latency, human contact latency, and noise recovery time. The third factor (F3) showed a high, positive correlation with the dogs' noise recovery time and their reaction latency towards a lone sheep. This factor also correlated negatively with the number of el. shocks given.

Table 4
Varimax rotated factor analysis grouping dogs' general behaviour with their response to the sheep[a]

	Factor		
	1	2	3
Path test			
Object attack latency	−0.15	**0.84**	0.04
Human contact latency	−0.02	**0.80**	−0.23
Noise recovery time	−0.04	**0.62**	**0.50**
Behaviour towards lone sheep	**0.67**	−0.10	0.21
Reaction latency towards lone sheep	0.11	0.03	**0.83**
Sheep confrontation test			
Initial behaviour towards a sheep flock	**0.87**	−0.14	−0.20
Attack frequency	**0.93**	−0.02	−0.05
Attack severity	**0.93**	−0.02	−0.01
Number of el. shocks administered	0.10	0.08	**−0.70**
Percent of variance	33.1	19.6	17.4
Cumulative percent	33.1	52.7	70.1

[a] The values in bold show the highest loadings in the respective factors.

3.3. Age differences

We found significant differences between the age groups with regard to their inclination to attack sheep. Dogs up to 3 years of age showed a more frequent initial attack at the start of the test than older dogs (37% versus 14%; $\chi^2 = 22.3$, $P < 0.01$). During the entire test, 52.7% of dogs up to 3 years of age attacked sheep, compared with only 22.7% of older dogs ($\chi^2 = 10.9$, $P = 0.001$). An analysis of variance showed that older dogs started observing the sheep at a distance sooner than younger dogs (35.9 ± 5.5 s, $N = 16$, versus 55.6 ± 9.1 s, $N = 40$; $F = 6.8$, $P = 0.01$). Among sheep-attackers, younger dogs attacked sooner than older dogs (41.2 ± 3.1 s, $N = 43$, versus 62.5 ± 21.2 s, $N = 10$; $F = 7.2$, $P = 0.01$). However, there was no difference in el. shock treatment between age groups.

3.4. Previous dog behaviour reported by owners

The less a dog exhibited fear of gunshots, as reported by the owners, the more frequently it showed a moderate attack towards the sheep in the sheep confrontation test ($r = 0.36$, $P = 0.04$). Dogs that frequently exhibited fear of unknown people or unknown dogs withdrew earlier from the fenced-in sheep ($r = 0.40$, $P = 0.04$ and $r = 0.28$, $P = 0.05$, respectively).

Dogs that were frequently aggressive towards dogs of the same sex, also showed an earlier hunting interest towards fenced-in sheep ($r = 0.24$, $P < 0.01$) and started later to observe sheep at distance in the fenced enclosure ($r = -0.29$, $P = 0.038$). However, high frequency of aggression towards other dogs did not correlate with the frequency of attack on sheep flock.

The owners were asked to state the degree of interest in sheep previously expressed by the dogs. Some degree of interest was shown by 28.6% ($N = 35$) of the elkhounds, 7.4% ($N = 54$) of the setters, and 17.4% ($N = 23$) of the hare hunting dogs. For the same breed groups, 26.8% ($N = 41$), 45.5% ($N = 66$), and 50% ($N = 26$) of the dogs, respectively, had previous opportunities to chase sheep. Among the dogs aged up to 3 years, 19.5% had never seen sheep and 46.5% had previous opportunities to chase sheep, while only 2.3% of the older dogs had never seen sheep and 53.5% had previous chasing opportunities ($\chi^2 = 16.1$, $P < 0.001$). Little or no previous interest in sheep was reported for 47.9% of dogs aged up to 3 years and for 80.5% of the older dogs ($\chi^2 = 17.2$, $P < 0.01$). There was no significant difference between the age groups with regard to previous possibilities of killing sheep (only two of the dogs had previously killed sheep).

Among dogs that had previous opportunities to chase sheep, 25% attacked sheep in the sheep confrontation test. However, 68.4% of dogs that had never before seen sheep attacked sheep in the test ($\chi^2 = 19.9$, $P < 0.001$). Dogs that previously exhibited little or no interest in sheep had a 22.4% probability of attacking sheep in the test. Dogs that had shown a large or very large interest in sheep also had a 64% probability of attack in the test ($\chi^2 = 17.2$, $P < 0.01$). The dogs' general interest in chasing running prey correlated with the attack severity observed in the sheep confrontation test ($r = 0.40$, $P < 0.001$).

4. Discussion

4.1. Breed differences

The behaviour in the path test and in the sheep confrontation test showed clear differences between the breed groups. Elkhounds, which exhibited most interest in single sheep in the path test, also showed the strongest initial hunting motivation, the most frequent and stronger sheep attacks, and received the most el. shocks. The hare hunting dogs showed an almost 50/50 distribution between attacking and non-attacking individuals, while the setters displayed the least attacks. The reason for these differences may be related to the different ways the breeds have been selected as hunting dogs. In connection with their main task desired by humans, the elkhounds are intended to show great courage when hunting big game (especially moose and red deer). The elkhounds are capable of hunting alone (without contact or control by the hunter), especially when hunting moose unleashed. By contrast, the setters are primarily used as setting dogs hunting mountain grouse (*Lagopus* sp.). These dogs are selected for searching in open fields for birds, on which they have the natural instinct to set (freeze). Setters may therefore have less courage in connection with hunting large mammalian prey such as sheep. Hare hunting dogs are selected for hunting small mammals such as hare (*Lepus europaeus*) and red fox (*Vulpes vulpes*) by barking (Christiansen, 1981). It may for this reason be natural that these breeds are intermediate between the less attacking setters and the more attack-motivated elkhounds.

The factor analysis showed a relation between the dogs' behaviour towards a lone sheep in the path test and the initial behaviour towards a sheep flock and attack severity in the sheep confrontation test. The factor F1 could be regarded as reflecting predatory

motivation. To some extent, the path test predicted the subsequent hunting behaviour, revealing the potential of this test as an indicator of sheep attack probabilities. In addition, factor F1 distinguished between the breeds. The temporal relations shown in factor F2 between object attack latency, human contact latency, and noise recovery time, reflect the dogs' uncertainty towards novelty. The relation between a long noise recovery time, long reaction latency towards a lone sheep, and few el. shocks received (factor F3), may indicate that hesitation to attack sheep is related to fearfulness. A large number of shocks necessary to induce retreat from the sheep could be related to one or more of the following traits; high degree of hunting motivation, strong persistence of hunting behaviour, or poor avoidance learning capacity. The strong relation between number of el. shocks received and low reaction latency towards a lone sheep in the path test (factor F3) might point to a positive relation between el. shocks and hunting motivation. The lack of any relation with other latency measures indicate that a generally high reactivity is not involved. The somewhat weaker negative relation with noise recovery time also indicate a certain toughness which could be related to hunting persistence. Further research might reveal to what extent the number of el. shocks administered is related to the three suggested traits 1.

4.2. Sex and age differences

No significant sex differences were found in the number of el. shocks given or in the dogs' initial behaviour towards a sheep group. Therefore, both sexes are equally likely to hunt sheep and equally easy to withdraw from sheep by el. shocks. Geiger (1972) also found no sex differences in hunting traits in German wire-haired pointers.

There appears to be some stability in the predatory behaviour throughout the test, as dogs that showed the highest initial hunting motivation displayed most attacks and received most el. shocks. However, we found that younger dogs showed a more pronounced initial hunting motivation and more frequent attacks than older dogs, although there was no age difference in the number of el. shocks given in the test. The initial behaviour towards a flock of sheep with subsequent attacks by young dogs may be related to their typical behaviours; investigation motivated by curiosity, the fun of running freely, and lack of previous negative experience to inhibit the natural chasing instinct. The latter is supported by owner reports that dogs that had no previous opportunity to chase sheep showed a stronger initial hunting motivation and more attacks. The observation of younger dogs starting their attack sooner than older dogs also confirms this interpretation. Interruption of attacks in young dogs, as evidenced by the fewer el. shocks administered, may be due to uncertainty towards a novel object, or lack of experience when approaching sheep. Older dogs may have experienced sheep previously and received corrections from the owner (negative commands or signs) when showing interest towards sheep. This may result in older dogs becoming more restrictive to attack compared with younger dogs, while they more frequently may complete attacks without this experience.

4.3. Relations between owner assessment and test results

The dogs reported by the owner to show fear of gunshots and fear of unfamiliar people or dogs, showed only moderate attack towards sheep and withdrew from sheep in the sheep

confrontation test. Dogs that exhibited a high human contact latency in the path test were also reserved towards unknown objects and took longer to recover from sudden and unknown noise. These relations may reflect dogs that have a high fearfulness towards novel stimuli. General fearfulness by the dog may be exhibited in different behaviours. A dog that is reported by the owner to show fear towards various novel stimuli; shots, unfamiliar people, unfamiliar dogs, novel objects, and sudden noise, may therefore be likely to show uncertainty towards sheep. Wilsson and Sundgren (1997) reported earlier a relationship between courage and nerve stability in dogs, partly based on their reaction to loud noise. Although dogs exhibiting high frequency of aggression towards other dogs of the same sex did not attack sheep more frequently in our study, those who attacked did so more quickly.

The owners' expressions of the dogs' sheep interest, the dogs' never previously having had opportunity to chase sheep, and high interest in chasing a running prey, may all be indications that the dog would show a high hunting interest towards sheep when confronted to them. This shows that the owners' honest description of their own dogs may have some significance for the evaluation of the sheep chasing probability of their dogs.

4.4. The timing of el. shocks

Despite frequently initiated chases and attacks in the test, relatively few el. shocks were administered, for two reasons. Firstly, the trainer gave el. shock only if the dog came within 1–2 m from sheep, hence suppressing the dog's proximity to the sheep. If the el. shock had been given at the onset of chasing, the dog may associate the punishment with other stimuli by chance, e.g. stones, vegetation, people near by, and develop a conditioned fear towards such stimuli. Punishing initial hunting behaviour may also suppress hunting behaviour in general, which is undesirable for hunting dogs. Secondly, the dogs themselves, particularly young dogs, often interrupted the attack on the sheep, and therefore, received no el. shock. The potentially negative effects of using el. shock in training, particularly with unskilled timing of the el. shocks given, warrant a recommendation to avoid this method for other purposes than training dogs to avoid chasing sheep.

5. Conclusions

Dogs' experience with sheep in other situations appeared to be of importance for their later behaviour towards sheep, despite their lack of previous test experience towards sheep. We also found that dogs with general low fearfulness were potential sheep chasers. The elkhounds showed a greater potential for chasing sheep than the setters, with hare hunting dogs being intermediate. The major factors predicting a high hunting motivation and attack severity towards sheep were lack of previous opportunity to chase sheep, low fear of unfamiliar noise and people, and general interest in sheep.

Acknowledgements

We are grateful to all the dog owners participating and to the sheep farmer K. Løvseth for his great enthusiasm and assistance and for letting us use his sheep. Thanks also to the

helpers H. Christiansen, B. Christiansen and T. Christiansen for their great support and technical assistance and to E. Bjørnstad and A. Sønstebø for excellent computer assistance. The project has been supported by private means, and received a finishing support by the Norwegian Research Council.

References

Adlercreutz, C.J., 1994. Hundar i Världen. ICA Bokförlag, Vesterås.

Andelt, W.F., Phillips, R.L., Gruver, K.S., Guthrie, J.W., 1999. Coyote predation on domestic sheep deterred with electronic dog-training collar. Wildl. Soc. Bull. 27, 12–18.

Association of Pet Behaviour Counsellors (APBC), 1997. Shock collars — the shocking truth. Article 2. Internet: http://www.apbc.org.uk/article2.htm.

Brinkmann, A., 1924. Canidenstudien V–VI. Bergenske Museums Arbeider, No. 7, Bergen, pp. 1923–1924.

Christiansen, F.O., 1981. Kommunikasjon hos Tamhund, *Canis familiaris*. M.Sc. thesis in ethology, Department of Zoology, University of Trondheim, Trondheim.

Christiansen, F.O., 2000. Predatory Behaviour of Hunting Dogs Towards Grazing Sheep. Doctor Scientiarum Theses, Agricultural University of Norway, Norway.

Christiansen, F.O., Bakken, M., Braastad, B.O., 2001a. Behavioural changes and aversive conditioning in hunting dogs at the second-year confrontation with domestic sheep. Appl. Anim. Behav. Sci. 72, 115–129.

Christiansen, F.O., Bakken, M., Braastad, B.O., 2001b. Social facilitation of predatory, sheep-chasing behaviour in Norwegian Elkhounds, grey. Appl. Anim. Behav. Sci. 72, 131–143.

Ciucci, P., Boitani, L., 1998. Wolf and dog depredation on livestock in central Italy. Wildl. Soc. Bull. 26, 504–514.

Eikje, E.D., 1991. Sauerasar. In: Ådnøy, T. (Ed.), Landbruksbokhandelen. Ås.

Féderation Cynologique Internationale (FCI), 1993. Complete Description of all FCI Acknowledged Breeds. Brussels.

Geiger, G., 1972. Prufungswesen und Leistungsvererbung beim Deutschen Drahthaarigen Vorstehhund. Giessener Beiträge zur Erbpathologie und Zuchthygiene 4, 40–43.

Hansen, I., Christiansen, F., Hansen, H.S., Braastad, B.O., Bakken, M., 2001. Variation in behavioural responses of ewes towards predator-related stimuli. Appl. Anim. Behav. Sci. 70, 227–237.

Lorenz, K., 1965. So kam der Mensch auf dem Hund. Deutscher Taschenbuch Verlag, Nördlingen.

Mackenzie, S.A., Oltenacu, E.B.A., Houpt, K.A., 1986. Canine behavioural genetics — a review. Appl. Anim. Behav. Sci. 15, 365–393.

Meriggi, A., Lovari, S., 1996. A review of wolf predation in Southern Europe: does the wolf prefer wild prey to livestock? J. Appl. Ecol. 33, 1561–1571.

Nedkvitne, J.J., Garmo, T.H., Staaland, H., 1995. Beitedyr i Kulturlandskap. Landbruksforlaget, Oslo.

Norwegian Kennel Club, 1994. Regler for Funksjonsanalyse. Norsk Kennel Klub, Oslo.

Roig, O.A., 1974. Kynologi — Hundelære. Norwegian College of Veterinary Medicine, Oslo, 76 pp.

Skurdal, E., 1997. Beiting i Utmark – i Praksis og Plansammenheng. Norwegian Sheep and Goat Breeding Association, Oslo.

The Office of the North Trondelag County Governor, Department of Environmental Affairs, 1998. Oversikt over Registrerte Hundeskader i Nord-Trøndelag 1991–1998. Steinkjer (Report).

Vangen, O., Klemetsdal, G., 1988. Genetic studies of Finnish and Norwegian test results in two breeds of hunting dog. VI. World Conference on Animal Production, Helsinki, Paper 4.25.

Vangen, O., Steine, T., Olesen, I., Hårdnes, T., 1994. Avlslære. Landbruksforlaget, Oslo, pp. 164–201.

Whitney, L.F., 1929. Heredity of trail-barking propensity in dogs. J. Hered. 20, 561–562.

Willis, M.B., 1989. Genetics of the Dog. H.F. & G. Witherby, London.

Willis, M.B., 1995. Genetic aspects of dog behaviour with particular reference to working ability. In: Serpell, J. (Ed.), The Domestic Dog: Its Evolution, Behaviour and Interactions with People. Cambridge University Press, Cambridge, pp. 51–64.

Wilsson, E., Sundgren, P.-E., 1997. The use of a behaviour test for the selection of dogs for service and breeding. I. Method of testing and evaluating test results in the adult dog, demands on different kinds of service dogs, sex and breed differences, sex and breed differences. Appl. Anim. Behav. Sci. 53, 279–295.
Zimen, E., 1978. Der Wolf. Mythos und Verhalten. Meyster Verlag GmbH, München.
Ådnøy, T., 1994. Saueavl. Lecture notes. Landbruksbokhandelen, Ås.