Efficiency of Livestock Carcass Detection Dogs

Authors: Hansen, Inger, and Winje, Erlend

Source: Rangelands, 43(5) : 194-199

Published By: Society for Range Management

URL: https://doi.org/10.1016/j.rala.2021.03.004

Research Article

Efficiency of livestock carcass detection dogs

By Inger Hansen and Erlend Winje

On the Ground

- There is an increasing use of carcass detection dogs to find remains of dead livestock in Norwegian rangelands. But how effective are these dogs actually?
- We compared the efficiency of approved carcass detection dog equipages (CDEs, i.e., dog and man) with people searching for sheep carcasses without dogs.
- CDEs found significantly more carcasses than people without dogs, and kilometers traveled and minutes spent per carcass detection indicated that dogs were >3x as effective in their search. However, CDEs found only 1 in 4 of the carcasses laid out experimentally.
- The training program for CDEs in Norway is now adjusted to improve the quality of the equipages.
- The effort of sheep CDEs is important to Norwegian sheep farmers applying for compensation because of the increase in percentage of proven losses caused by protected carnivores.
- In the future carcass detection dogs in Norway could be used for wildlife conservation and management tasks.

Keywords: efficiency, cadaver, predation, rangeland, sheep losses, sniffing dogs.

Rangelands 43(5):194–199
doi 10.1016/j.rala.2021.03.004

Introduction

Close to 2 million sheep graze on open rangeland pastures in Norway each summer and around 100,000 of these are lost as a result of carnivores, diseases, and accidents every year.[1] In 2019, compensations were paid for 17,567 ewes and lambs that were documented or assumed killed by protected carnivores (wolverines [*Gulo gulo*], lynx [*Lynx lynx*], brown bears [*Ursus arctos*], gray wolves [*Canis lupus*], and golden eagles [*Aquila chrysaetos*]).[2] Although inspections of sheep in Norwegian mountain and forest ranges are frequent,[3] it is challenging to find sheep carcasses within large grazing areas and carcasses can be hidden in vegetation or an inaccessible location. Furthermore, carnivores, scavengers, and maggots (i.e., fly larvae found in decaying matter) consume parts of the carcass leaving only dry bones to be found. In fact, lamb carcasses can be gone within 24 hours after dying.[4] To receive compensations for sheep killed by large carnivores, farmers need to locate carcasses and the Norwegian Nature Inspectorate (NNI) has to prove that protected carnivores most likely are the cause of death, or there are other circumstances showing predominance of probabilities that the sheep are killed by large carnivores.[5] However, <10% of livestock losses compensated are proven by the NNI as depredated.[6]

Dogs' sense of smell is far better than that of humans. Humans have about 5 million olfactory receptors, whereas dogs (bloodhounds) have >100 million.[7] Dogs can smell an item with particle concentration levels at one to two parts per trillion.[8] Thus, dogs have been used for olfactory discrimination (nonbiological scents and biological scents) for decades, such as detection of bombs, drugs, cancer, and human remains.[9-12] Owing to their extensive olfactory capabilities, dogs are increasingly being used in wildlife management and conservation in a range of tasks including 1) locating wildlife and assessing population status, 2) facilitating specimen and carcass collection, 3) detecting scat, 4) capturing and marking wildlife, 5) studying wildlife behavior, and 6) managing wildlife damage.[13]

Dogs searching for bird and bat carcasses at wind farms had a higher detection rate than humans (80% vs. 20%).[14] In another study, songbird carcasses were recovered approximately 12:1 to those missed for dogs and 1:1 for humans.[15] However, only recently have dogs been trained to locate the remains of livestock carcasses. Which odors are used by dogs in their search for carcasses are not known, but some typical volatile odors from cadavers are cadaverine and putrescin.[16]

Norwegian Carcass Detection Dogs[17] (NCDD) is an organization aimed at improving the competence of carcass detection equipages (CDEs, i.e. specially trained dogs with guides). With experience from preparation of rescue and military dogs, the association has developed a course and an approval test for CDEs. The basic course consists of 3 hours of theory and 4 hours of individual training. To become an approved equipage, one must complete the basic course, find

3 out of 4 carcasses or objects placed in a limited forest area (approval test), and document ≥30 hours of active searching for sheep carcasses in open rangelands. As of August 2019, 207 equipages have been approved. The training of dogs is basic with a low threshold, meaning that classic conditioning/positive reinforcement is used to encourage the dogs to find carcasses.[18-20] Positive reinforcement strengthens a behavior by rewarding the dog. Indeed, for a canine, finding a carcass is a positive reinforcement in itself. Furthermore, it is possible for "ordinary" dog owners to join the course. Thus, the level is adjusted to sheep farmers (and others) who would like to increase the success of sheep carcass discoveries in their own (and others) grazing areas.

Our study documented the efficiency of CDEs in finding dead sheep. Our research questions were 1) how much better are CDEs compared with humans without dogs in detecting sheep carcasses, and 2) are CDEs as good at finding fresh and hidden carcasses as old and open sited ones?

Material and methods

Dogs and field staff

A total of 16 trained CDEs that had passed the NCDD approval test and 16 trained persons (sheep farmers or shepherds) without dogs participated. NCDD helped us in selecting CDEs within the geographical regions of each test site, and the regional agricultural office assisted us in finding experienced sheep handlers. Wind speed (calm, moderate, windy) and precipitation (none, moderate, heavy) were noted. All the CDEs carried out their searches in headwinds, as far as possible, and all dogs were on a 20-m long leash due to the protection of wild animals and grazing livestock during 1 April to 20 August.[21] Tracks and carcass positions were GPS-logged.

Experimental trials

Intensive searches were conducted in 10 fields of 0.5 km^2 (123.6 acres) each, at first with a dog (n = 10 CDEs) and then by a person without dog (n = 10). Within each field, 8 lamb carcasses weighing 2 to 4 kg were put out in an 2 × 2 factorial design; 2 carcasses were "fresh" (frozen when day-fresh, thawed, and placed in test field the same day) and "hidden" (under vegetation, stones, etc.); 2 were fresh and located "open" (laid right at the ground); 2 were "old" (frozen when day-fresh, thawed and laid out in test field after 3-4 days) and hidden; and 2 were old and placed in the open. A total of 4 hours searching time was given (8 hours per km^2 [8 hours per 247.1 acres]). All experimental fields were located within scattered mountain forest areas.

Field trials

Parts of 6 outfield pastures for sheep, sized 4 km^2 (988.4 acres) each, were investigated for dead sheep by CDEs (n = 6) and persons without a dog (n = 6) simultaneously. The searching time was set to 32 hours (intensive search; 8 hours per km^2), but in order for the pair of personnel with and without a dog working in the same field not to see each other, 9 days separated them. The average rates of lambs lost in the grazing areas selected had to be ≥10% over the last 3 years. All types of carcass discoveries were recorded, ranging from whole carcasses to small bone remnants and pieces of wool/fur, regardless of animal species (Fig. 1). Any carcass remains within a 20-meter radius was considered as one carcass finding. Staff from the NNI trained for documenting whether livestock are killed by protected carnivores or not were used to discriminate predation from other causes of mortality.

Statistics

All measures were standardized to 8 hours search per km^2 (i.e., amount of effort). In order to measure the search efficiency, the mean number of kilometers and minutes spent per carcass detection were calculated. Number of carcasses found with and without dogs, both in the experimental trials and in the field trials did not follow the normal distribution (Kolmogorov-Smirnov Test). Thus, pairwise differences with and without dogs regarding the total number of carcass detections and number of finds by carcass type (fresh and open; fresh and hidden; old and open; old and hidden) were tested using Wilcoxon Signed Rank Test. Chi-squared goodness-of-fit tests were used to test if the types of carcasses found by dogs in the experimental trials were randomly distributed. Differences in distance (kilometer) searched with and without dogs in both type of trials, and kilometers and minutes per carcass find in the field trials were normally distributed and tested with paired t-tests. The significance level was set to 0.05. Data was processed with the statistics software package Minitab 17.[22]

Results

Experimental trials

The CDEs found 19 out of 80 lamb carcasses (detection rate 23.8%), whereas persons without dogs only found 2 (detection rate 2.5%; confidence intervals do not overlap, $P < 0.05$, Fig. 2). Five carcasses detected by the dogs were fresh and located in the open, four were fresh and hidden, whereas five were old and in the open and five were old and hidden ($\chi^2 = 0.158$, $P > 0.5$). Thus, the dogs found carcasses that were assumed the most difficult to detect (fresh and hidden) just as often as the ones that were assumed easier. The two carcasses found by people were old and located in open site. The mean distances searched per field with and without dogs were indifferent (9.6 vs. 9.7 km, $T = -0.1$, $P > 0.5$). The dogs showed individual variation in detection rate, ranging from two dogs finding no carcasses (trials F and G, Fig. 2) to two dogs that found 50% of the carcasses (trials A and H, Fig. 2).

In general, the track logs showed extensive and systematic searches, both with and without dogs. However, searchers

Figure 1. A carcass detection dog during a field trial that has found an old bone from a sheep. The GPS position (universal transverse mercator projection (UTM) coordinates) of the carcass is logged.

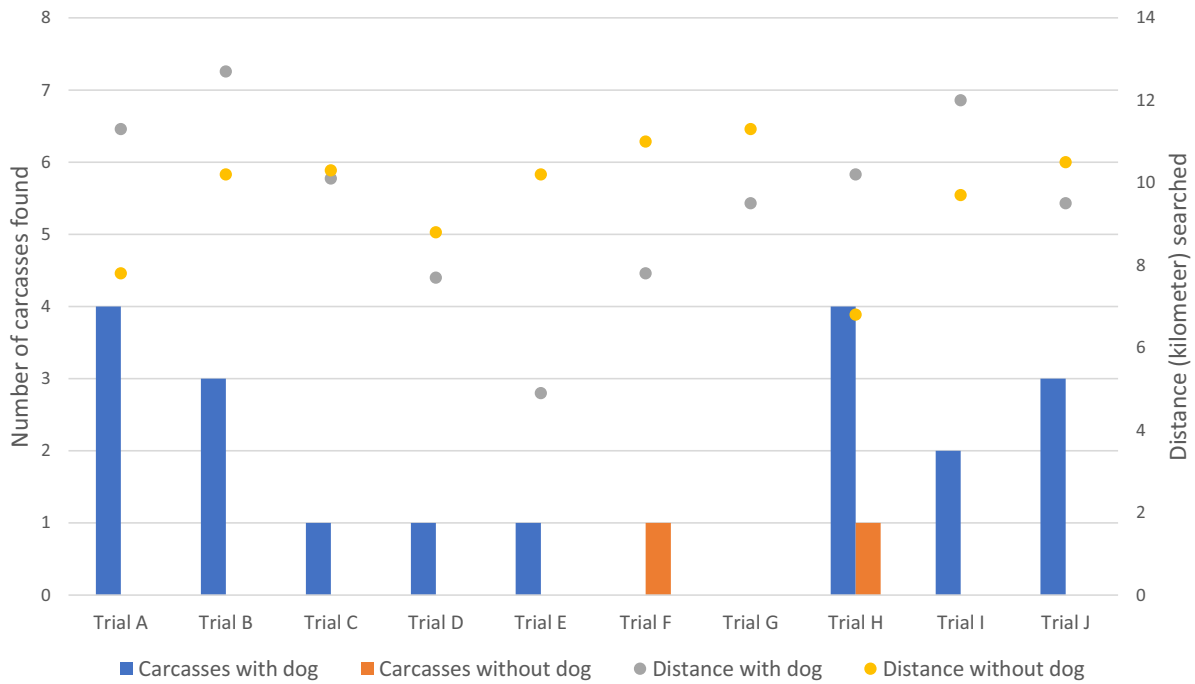

Figure 2. Number of carcasses found, and distance (kilometers) searched per field with and without dogs in the 10 experimental trials.

without a dog, but also some of the CDEs, passed several of the carcasses close (<10 meters) without finding them.

Field trials

In the six rangeland pastures, CDEs detected a total of 132 carcass remains, whereas searchers without dogs found 76 (Table 1). Two of the dog finds were hidden (buried) and 25 were from the present grazing season. All carcasses found by people laid on open ground and 13 were from the present year. Only three carcasses were found in a condition in which the cause of death could be documented (i.e., fresh and enough left of the body). Two of these were located by people without dogs (one documented by NNI being killed by wolverine and

Table 1
Number of carcasses found, distance searched per field trial (kilometer), and kilometers and minutes spent per carcass detected (mean ± SEM), and range (minimum-maximum), with and without dogs in the 6 field trials

	With and without dogs	Mean ± SEM	Range (min-max)	Difference with and without dogs
Number of carcasses found	With a dog	21.7 ± 7.6	4.0-58.0	CIs overlap P > 0.5
	Without a dog	12.7 ± 5.3	0.0-30.0	
Kilometers searched per field	With a dog	63.4 ± 6.8	41.0-83.7	T = −1.34 P > 0.05
	Without a dog	75.9 ± 4.1	63.3-88.8	
Kilometers traveled per carcass detected	With a dog	5.8 ± 2.7	0.8-18.6	T = −1.31 P > 0.05
	Without a dog	20.4 ± 14.4	2.8-77.5	
Minutes per carcass detected	With a dog	161 ± 65.6	33.1-480.0	T = −1.27 P > 0.05
	Without a dog	516 ± 356	64.0-1920.0	

Confidence interval (CI) indicates; SEM, standard error of means.

one died in an accident), and the third (documented by NNI as possibly killed by wolverine) was found by a CDE. More than 95% of the finds conducted both by dogs and people consisted of small bone fragments and/or wool.

By combining the detection rates (d.r.) in the experimental trials for CDEs (23.8%) and people (2.5%), we estimated the total number of carcasses in the fields to be between 555 (based on the CDEs' d.r.) and 3,040 (based on the peoples' d.r.). The "best" CDE in the field trials detected 13 times more carcasses than the person without a dog (13 vs. 1), whereas the "least" effective CDE detected 1.4 times less carcasses than the searcher alone (19 vs. 26). The other CDEs found 1.2 to 4.2 times more carcasses than persons without dogs.

Due to the variation in number of carcasses found in the field trials and a limited number of fields (Table 1), no significant differences with or without dogs were found regarding number of carcasses detected, distance searched or kilometers, and minutes spent per carcass found. Nevertheless, the mean numeric values of kilometers and minutes spent per carcass find were >3x of that for people without dogs, indicating that CDEs were more efficient than people alone (Table 1).

Discussion

The experimental trials showed that CDEs were 9.5 times better than people alone at finding sheep carcasses (success rate: 23.8% vs. 2.5%), and the field trials indicated that CDEs were >3 times as effective in their search, measured in kilometers, and minutes per carcass detection. Furthermore, the dogs found all types of carcasses just as easily. The dogs were superior to people in finding hidden carcasses. Our results are in accordance with other studies comparing dogs and humans for carcass detection, such as finding passerine carcasses in dense vegetation[15] and bird and bat carcass detection at wind farms.[14] del Valle et al.[14] found that humans performed poorly at detecting small carcasses (~20% detection rate) and more so in dense vegetation. We did not measure the sizes of the carcasses, but predominantly the carcasses detected in the field trials consisted of small bone remains and/or wool.

Results from the experimental trials, however, documented that the CDEs did not find more than every fourth carcass out in the fields. As discussed in the review article by Troisi et al.,[23] and based on experiences from our study, we believe that wind direction, overly wide search loops, distractions by other scents, or misinterpreted or absence of communication between dog and handler may explain some of the failure of CDEs to detect carcasses. Furthermore, we experienced that some dogs being "on duty" several days in advance of the test failed. NCDD believes a day-long intensive search is too much for a dog to maintain full motivation and concentration. The dog handler should know how to motivate the dog and apply this to training and working situations. The relationship between the handler and the dog is significant for working dogs.[23,24] Likewise, hot temperatures will affect the activity level of dogs and their sniffing efficiency negatively because dogs cannot pant and sniff at the same time. In one of the field trials the temperature increased above 30°C (85°F) on 8 August, and the dog handler noted the dog was "lazy" all day.

Olfactory abilities vary both within and between dog breeds, according to the size of the canine olfactory bulb and the genes that control the olfactory reception.[10,12,25] Indeed, in the experimental trials we documented variation in detection rate between the two dogs that did not find any carcasses (trials F and G, Fig. 2) to the two dogs that found half of the carcasses (trials A and H, Fig. 2). In the field trials, the number of carcasses detected with dogs compared with finds made by persons alone (within each field) varied even more, from 13 to 0.7. However, these test fields differed in the number of carcasses present and the total number of carcasses was not known, thus it was not possible to compare the detection rates between dogs.

It is important that CDEs maintain a high detection rate, especially if the work is paid for. By using dogs that are fostered and trained by their owners it is possible to educate CDEs at a large scale with limited resources.[26] How high the competence level should be is a trade-off between having many "medium quality" CDEs available and a few excellent ones. NCDD was not satisfied with the results from the

experimental trials. To increase the CDEs' success rate, NCDD has now improved their training program by offering a comprehensive course and by providing approved equipages with additional training sessions.

The fact that few fresh carcasses, in which we were able to document the cause of death were found, confirms that it is difficult to be in the right place at the right time. This has also been confirmed in other trials.[27] In an acute situation with carnivore attacks (i.e., massive depredation of livestock, limited in time and space), the conditions are different; the CDEs will be searching for a cluster of fresh kills within a small part of the grazing area, helping to identify the extent of the damage. Whereas searching for carcasses throughout an entire rangeland pasture (most of them sized >50 km^2 [2,355 acres]), is like searching for a needle in a haystack. Thus, this project has strengthened our opinion that best results are achieved by CDEs when used in acute situations. Despite this, dogs are a better tool than people alone helping farmers to find dead animals, otherwise every livestock animal will need to have a GPS-transmitter with a mortality function.

Conclusions and implications

CDEs were more effective at finding sheep carcasses than searchers without dogs, measured in total number of carcasses discovered as well as kilometers and minutes spent per carcass find. The dogs found all types of carcasses just as easily and were particularly better than people alone in finding hidden carcasses. However, the experimental trials showed that CDEs detected only one in four of the carcasses laid out. Our results have led to revisions of NCDD's training program. NCDD is now offering a comprehensive course and they are following-up on approved CDEs more closely. It is important for CDEs to train on carcasses that are laid out in the field all year round. Based on experiences from this project a guide for CDEs was outlined.[28]

The effort of carcass detection dogs is important to Norwegian sheep farmers applying for compensations to increase the percentage of proven losses. In the future carcass detection dogs in Norway might also be used to document dead and injured birds at wind farms (specially protected species like golden eagle, sea eagle [*Haliaeetus albicilla*] and Eurasian eagle-owl [*Bubo bubo*]), or for other wildlife conservation and management tasks.[13]

Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Acknowledgments

We would like to thank Nils Steinvik and Johnny Mathiesen in Norwegian Carcass Detection Dogs for facilitating the field experiments, as well as the field staff with and without dogs participating in the trials. Thanks to Grete Meisfjord Jørgensen and Jo Jorem Aarseth for perusal of the text.

This work was supported by mitigating- and conflict-reducing grants from The County Governors of Finnmark, Troms, Nordland, Sør-Trøndelag, Møre og Romsdal and Oppland.

References

1. Statistics on losses of livestock during the grazing season. Accessed 16 December 1, 2020. https://www.nibio.no/tema/landskap/kart-over-beitebruk-og-seterdrift/beitestatistikk?locationfilter=true
2. Records on number of sheep that are compensated (documented or assumed killed by protected carnivores. Accessed December 16, 2020. https://www.rovbase.no/erstatning/sau.
3. Regulations on welfare of small ruminants. Accessed February 22, 2021. https://lovdata.no/dokument/SF/forskrift/2005-02-18-160
4. Hansen I. Causes of mortality in lambs at rangeland pasture in Ørpen-Redalen, 2007 and 2008. *Bioforsk Report*. 2009; 4(19):1–21.
5. Regulations on compensations of livestock killed by protected carnivores. Accessed February 22, 2021. https://lovdata.no/dokument/SF/forskrift/2014-05-30-677
6. Information about large carnivores published by the Norwegian Environment Agency. Accessed February 22, 2021. http://www.rovviltportalen.com/
7. Rebmann A, David E, Sorg MH. *Cadaver Dog Handbook: Forensic Training and Tactics for the Recovery of Human Remains*. CRC Press; 2000.
8. Castaldo NF. *Sniffer Dogs: How Dogs (and Their Noses) Save the World*. 1st ed. Houghton Mifflin Harcourt; 2014.
9. Browne C, Stafford K, Fordham R. The use of scent-detection dogs. *Irish Veterinary Journal*. 2006; 59(2):97–104.
10. Stejskal SM. *Death, Decomposition, and Detector Dogs: From Science to Scene*. CRC Press; 2013.
11. Nawn KM. *Sniffing Out Decomposition: Investigating the Reliability of Human Remains Detecting Dogs* Master Thesis. Humbolt State University; 2018.
12. Mazzola SM, Pironne F, Sedda G, Gasparri R, Romano R, Spaggiari L, Mariangela A. Two-step investigation of lung cancer detection by sniffing dogs. *J Breath Res*. 2020; 14(2) https//doi.org/10.1088/1752-7163/ab716e.
13. Dahlgren DK, Elmore RD, Smith DA, Hurt A, Arnett EB, Connelly JW. Use of dogs in wildlife research and management. In: Silvy N, ed. *Wildlife Techniques Manual*. 7th ed. The Wildlife Society Inc; 2012:140–153.
14. del Valle JD, Peralta FC, Arjona MIJ. Factors affecting carcass detection at wind farms using dogs and human searchers. *J Appl Ecol*. 2020; 57:1926–1935. doi:10.1111/1365-2664.13714.
15. Homan JH, Linz G, Peer BD. Dogs increase recovery of passerine carcasses in dense vegetation. *Wildl Soc Bull*. 2001; 29(1):292–296.

16. Goss K-U. The physical chemistry of odors - consequence for the work with detection dogs. *Forensic Sci Int*. 2019; 296:110–114. doi:10.1016/j.forsciint.2019.01.023.
17. Norwegian Carcass Detection Dogs. www.norskekadaverhunder.no In Norwegian.
18. Skinner BF. *The Behavior of Organisms: An Experimental Analysis*. Appleton-Century; 1938.
19. McLeod S.A. Skinner - Operant Conditioning. Accessed December 16, 2020. https://www.simplypsychology.org/operant-conditioning.html
20. Chance P. *Learning and Behaviour*. Wadsworth Cengage Learning; 2009.
21. Law on dog keeping. Accessed December 16, 2020. https://lovdata.no/dokument/NL/lov/2003-07-04-74/
22. Minitab. Minitab ®17. Accessed April 17, 2020. https://www.minitab.com/uploadedFiles/Documents/getting-started/Minitab17_GettingStarted-en.pdf 2016
23. Troisi CA, Mills DS, Wilkinson A, Zulch HE. Behavioral and cognitive factors that affect the success of scent detection dogs. *Comp Cogn Behav Rev*. 2019; 14:51–76. doi:10.3819/CCBR.2019.140007.
24. Diverio S, Menchetti L, Glacomo R. Dog's coping styles and dog-handler relationships influence avalance search team performance. *Appl Anim Behav Sci*. 2017; 191:67–77. doi:10.1016/j.applanim.2017.02.005.
25. Tacher S, Quignon P, Rimbault M, Dreano S, Andre C, Galbert F. Olfactory receptor sequence polymorphism within and between breeds of dogs. *J Hered*. 2005; 96(7):812–816.
26. Byosiere S-E, Feng LC, Rutter NJ. Factors that may affect the success of scent detection dogs: Exploring nonconventional models of preparation and deployment. *Comp Cogn Behav Rev*. 2019; 14:81–86. doi:10.3819/CCBR.2019.140009.
27. Nerhoel I, Smestad K. *Searching for sheep carcasses using detection dogs in Skaret grazing area – a pilot project*. Final Report; 2013:1–17.
28. Steinvik N, Mathisen J, Hansen I, Winje E. A guide in practical searching for dead livestock with dogs – preparations, practical work and readiness. *NIBIO POP*. 2017; 3(13):1–4.

Authors are from: Norwegian Institute of Bioeconomy Research, Ås, Norway (Inger Hansen, Erlend Winje);