J Forensic Sci, May 2003, Vol. 48, No. 3
Paper ID JFS2002296_483
Available online at: www.astm.org

TECHNICAL NOTE

Alanna E. Lasseter,[1] *B.A.; Keith P. Jacobi,*[1,2] *Ph.D.; Ricky Farley,*[3]*; and Lee Hensel*[3]

Cadaver Dog and Handler Team Capabilities in the Recovery of Buried Human Remains in the Southeastern United States

ABSTRACT: The detection of human remains that have been deliberately buried to escape detection is a problem for law enforcement. Sometimes the cadaver dog and handler teams are successful, while other times law enforcement and cadaver dog teams are frustrated in their search. Five field trials tested the ability of four cadaver dog and handler teams to detect buried human remains. Human and animal remains were buried in various forested areas during the summer months near Tuscaloosa, Alabama. The remains ranged in decomposition from fresh to skeletonized. Cadaver dogs detected with varying success: buried human remains at different stages of decomposition, buried human remains at different depths, and buried decomposed human and animal remains. The results from these trials showed that some cadaver dogs were able to locate skeletonized remains buried at a significant depth. Fresh and skeletonized remains were found equally by the cadaver dogs along with some caveats. Dog handlers affected the reliability of the cadaver dog results. Observations and videotape of the cadaver dogs during field trials showed that they were reliable in finding buried human remains.

KEYWORDS: forensic science, forensic anthropology, cadaver dog, buried remains, detection, decomposition

There is a need for further studies concerning cadaver dogs, specifically when locating buried human skeletal remains. Cadaver dogs are used for many different types of searches including burial, surface, and even water searches (1). These dogs are air scent dogs trained to recognize the generic scent of human decomposition. They are trained to give an "alert" when they detect any type of human decomposition, whether it is a recently dead body or just remnants of fluid and tissue from a decomposed body, and to communicate to their handler that this material is in a location. A false alert is when a cadaver dog communicates to its handler that decomposing human remains are in a location where in fact there are no decomposing remains (2).

There are many different ways a dog can be trained to communicate an alert to its handler. The dog can give an aggressive or passive alert. An aggressive alert is one in which the dog digs at the site of the human remains. A passive alert is when the dog lays down on the site of interest or jumps on the handler to indicate the remains are present. It is better to give a passive alert than an aggressive alert because crime scenes can be disturbed or altered by the anxious digging of a dog (2). Specifically, cadaver dogs are trained to find scents, not bodies (3).

The current theory is that dogs use a scent cone to locate decomposing remains when on a cadaver search. A scent cone is the place where the decomposing remains shed scent-containing molecules throughout the air in an invisible cone shape (1). The scent radiates out from its apex, the decomposing remains, and the cadaver dog goes from one side of the scent cone to the other until it reaches the apex. Many variables can affect the scent cone, including wind, humidity, and air temperature. Wind is possibly the most important factor that can affect the scent cone. The wind speed should be at least 5 mph (4).

The weather conditions have an enormous impact on the cadaver search overall. The optimal conditions for using cadaver dogs are when the ground is moist, the soil is loose, there is a light breeze to circulate the scent, and there is cool air temperature (40 to 60°F). The worst conditions for using cadaver dogs is when it is hot and dry with little or no air movement and when it is raining or snowing heavily (5).

When a human body decays over time it does so in five stages. Galloway (6), in research conducted through the Human Identification Laboratory of the Arizona State Museum, University of Arizona, found that the five stages of decomposition begin with remains that are fresh and progress through early and advanced decomposition to skeletonization and finally to extreme decomposition. Galloway (6), Rebmann et al. (2), Anderson (7) and Roksandic (8) provide information on the decomposition of human remains, and their findings are combined and described below.

Fresh remains (first stage), whether they are burned or not, include flesh with little change to the surface or exterior of the body. There is no discoloration of the body. Within the body, bacteria are hard at work decomposing tissues. No smell is obvious to humans, but dogs will be able to detect fresh remains from a distance. No insect activity is obvious.

[1] Department of Anthropology, University of Alabama, Tuscaloosa, AL.
[2] Alabama Museum of Natural History, University of Alabama, Tuscaloosa, AL.
[3] Alabama Canine Law Enforcement Officers Training Center, Inc. (ACLEOTC).

Received 18 August 2002; and in revised form 9 Dec. 2002; accepted 9 Dec. 2002; published 12 Mar. 2003.

Early decomposition (second stage) is characterized by a change in color of a cadaver. First, the color is of a "pink-white appearance" that changes to a gray to green discoloration; then a brownish discoloration at the fingers, nose, and ears is apparent (6). There is progression to a green color on a bloated body, and finally the color darkens from green to brown to black discoloration seen in the arms and legs. Odor from the remains is noticeable to humans and animals at a distance (2).

The appearance of the body in early decomposition includes bloating from internal body gases, skin slippage, and hair loss with some areas of the body looking fresh while other areas are bloated. After bloating, the skin can take on a leathery appearance. Insects are present and help with decomposition (2,6).

In advanced decomposition (third stage), the flesh on the body collapses due to body gases escaping with a "caving in of the abdominal cavity, often accompanied by extensive maggot activity" (2,6). Remaining flesh can be black in color (2). Mummification takes place in environments conducive to this process. Moist decomposition includes beginnings of bone exposure and the development of adipocere, a soapy crumbly material that forms from soft tissue after it has been in a water environment for awhile. The odor of the remains is strong and easily discernable by humans and animals at a distance (2).

Skeletonization (fourth stage) involves the tissue undergoing liquefaction. Decayed tissues have liquefied and have penetrated the surrounding dirt matrix. Bone becomes dry with some remaining human grease. The odor of the remains has become weaker. It can smell "cheesy or musty," and animals can detect this smell from a distance (2). Finally, the bone becomes a dry bone skeleton.

Extreme decomposition (fifth stage) involves the skeleton itself undergoing deterioration due to the natural elements. Bone exposed to sun will bleach and cause drying and cracking. Bone will exfoliate in this fifth stage. It may have a "musty odor," and an animal cannot detect the odor from as far away (2).

There have been few studies on the reliability of cadaver dogs in the detection of human remains. One study was conducted in Canada during the months of November, December, and January. It used eight different dog and handler teams with varying skills and training (9). There were weekly training sessions, and the handlers were informed as to what kinds of articles were to be used and where they were to be hidden. After the initial training sessions, field trials were conducted with the handlers uninformed as to the type of article used and where they were located. The items included dry human and animal bone, gauze soaked in human decompositional fluid and placed in a container, and clothing soaked in decay fluids. All items were hidden to the handlers' eyes, but not buried beneath the ground (9).

The overall rate for recovery in the field trials was 81%, whereas the rate per individual dog team ranged from 55 to 95% (9). The temperature ranged from –30 to 10°C (–22 to 14°F). Surprisingly, snow did not hinder the dogs' performances. The dogs would dig their noses into the snow and pick up the scent contained in air pockets to find the source. However, the recovery rate for dogs decreased when they were introduced to dry old human bones (9).

A second study of cadaver dogs was also conducted in a cold climate in northern New England (1). The study included 41 searches from 1991 to 1996 in Maine. Two dogs and one handler were used in these searches. Out of the 41 searches, nine resulted in the discovery of human remains. Three of the nine searches were new discoveries of human remains, while six searches were discoveries of additional bones of previously searched areas. Only one of the searches conducted did not result in an alert when human remains were present (1).

Whereas these studies took place in northern environments with colder and less humid conditions, our study took place in the hotter and more humid climate of the southeastern United States. There appears to be a significant decrease in the cadaver dog's ability to conduct a search when exposed to high heat temperatures, generally over 29°C (85°F). The heat causes discomfort to the dog and affects the cooling system inherent in the dog, forcing it to pant. When a dog pants it cannot sniff. Sometimes the cadaver dog is still able to locate the scent, but the scent must be within 1 m of the dog (5).

The objective of this research was to have cadaver dogs participate in field trials in Tuscaloosa, Alabama. Alabama has a climate that represents southeastern weather conditions. The state has hot and humid weather that is typical of the Southeast as a whole. Temperatures for summer range from 88 to 104°F, and winter temperatures are mild, ranging in the past few years from 30 to 58°F in Tuscaloosa, Alabama. Cadaver dog and handler teams performed five trials in the summer months (July and August). These trials tested a cadaver dog's ability to locate human decompositional scent at different stages of decomposition during the summer months. It tested a cadaver dog's ability to distinguish between human and animal decompositional scents, and it tested a cadaver dog's ability to locate human decompositional scent at different depths. The research involved five different detection field trials located in five separate forested locations. The following hypotheses were generated for research purposes: (1) Could the cadaver dogs detect human scent at different stages of decomposition? (2) Could cadaver dogs detect human cadaver scent at different buried depths at different stages of decomposition? (3) Could a cadaver dog distinguish between animal and human scent at different stages of decomposition?

Materials and Methods

Beginning in May of 2001, fresh human samples were collected for use in this project. Using latex gloves, sterile gauze was placed inside a cadaver prepared for autopsy and left for 20 min. The gauze was then placed in perforated plastic Ziploc containers. This was done on three separate occasions, and each sample was labeled and stored in a refrigerator until it was buried. The human and animal skeletal remains consisted of donated forensic material and was obtained from the scientific collection at The University of Alabama. All of the skeletal samples were buried in early May of 2001. The fresh animal remains were obtained from the meat department of a local grocery store. The fresh human and animal remains were buried the last week in May and remained at their locations until all of the cadaver dog and handler teams had completed the trials. Thus, the first cadaver dog and handler teams had the benefit of fresher scent, whereas the last teams come to participate did not, but the scent had penetrated into the ground. In all of the trials, all samples were enclosed in chicken wire so as to prevent animal tampering. In addition, disturbances were made throughout the trial areas with a posthole digger and shovel. This was to test the dog's ability to locate the remains by scent, not by soil disturbance.

All five cadaver dog and handler team field trials took place at the Alabama Canine Law Enforcement Officers Training Center, Inc. (ACLEOTC). The training center is located some 25 miles north of Tuscaloosa, Alabama. There are approximately 68 acres that are currently being used to train canine law enforcement officers. Acreage includes both forested and open fields. A portion of this land was offered to set up field trials for this study. Each field trial was conducted on a portion of land approximately 50 by 100 yd. The first field trial was located in an open grassy field sur-

rounded by woods on all sides. The second field trial was located on the edge of a wooded area. The third, fourth, and fifth field trials were located deep within the wooded area. All field trials were separated by at least a quarter of a mile.

Cadaver dog and handler team participants in this study were volunteers from a list of approximately 20 known teams from the Southeast. Of the 20 teams that were contacted, four teams were able to participate in this project. There were several different breeds of dogs that participated in this study (Table 1). The first of the four dog participants was a ten-year-old Rottweiler. This dog was certified and had seven years of cadaver work experience. The second dog was a certified four-year-old German shepherd who is regularly used in cases that require a cadaver dog. A 20-month-old chocolate Labrador was the third dog used in the trials. Unlike the other dog participants, it was the only dog that was not certified. The last dog participant was a three-year-old German shepherd who was certified and has been used on numerous wilderness search-and-rescue operations as well as cadaver searches.

The cadaver dog handlers also had varying experience in cadaver searches (Table 2). Our first handler had worked on at least 100 cases with her Rottweiler, and 50 to 60% of those cases were cadaver searches. The second team had worked on 38 cadaver cases. Unlike the other teams, the third team had not worked on any cadaver searches. Finally, the fourth team had been participants in 35 cadaver cases.

Weather conditions during the cadaver dog and handler team trials were entirely sunny and hot (Table 3). Trials began in the morning, and the temperature would increase as the day progressed. The temperature by the end of each trial was always in the high 80s and lower 90s. It did not rain during any of the trials, and it rained only once on the night before a team participated in the trials (Team 3). The humidity was also high, and the wind was usually calm. During some of the trials there was no wind at all, making detection difficult.

The first and second field trials tested the dog's ability to locate human remains at different depths (Table 4). The first field trial consisted of two fresh human samples: one buried 1 ft deep and the other 2 ft deep. These samples were each buried 15 ft apart. In the second trial, skeletonized human samples were buried 1 and 2 ft deep in replication of the second trial. The third field trial tested the ability of the dog and handler team to locate remains in different stages of decomposition. One fresh human sample and one skeletonized human sample each were buried 1 ft deep and 15 ft apart. The fourth and fifth trials tested the dog's ability to differentiate between human and animal decompositional scent. In the fourth trial, one skeletonized human sample was buried 1 ft deep and 15 ft away from a skeletonized animal sample buried at the same depth. The fifth trial consisted of one fresh human sample buried 1 ft deep and 15 ft apart from a fresh animal sample that also was buried 1 ft deep.

Each trial took approximately 4 to 5 h to complete. Any time during the trials the dogs had access to coolers of water, and dog and handler teams were encouraged to take breaks. The dogs and

TABLE 2—*Handler experience.*

Team	Number of Cases	Agency Involvement
Team 1	100 cases 50 to 60% cadaver cases	State Police, Naval, and F.B.I.
Team 2	38 cadaver cases	F.B.I., G.B.I., state and local law enforcement
Team 3	No cadaver cases	Not applicable
Team 4	35 cadaver cases	F.B.I., Local law enforcement, Department of Defense

TABLE 3—*Weather conditions.*

Team	Temperature Range	Humidity	Wind
Team 1	86°–92°F	55%	Variable at 5 miles per hour
Team 2	85°–93°F	65%	Calm
Team 3	83°–89°F	74%	Variable at 6 miles per hour
Team 4	82°–89°F	71%	Variable at 5 miles per hour

TABLE 4—*Description of field trials.*

Trials	Samples Used and Depth of Samples
Trial 1	Trial A—Fresh Human Buried at 1 ft Trial B—Fresh Human Buried at 2 ft
Trial 2	Trial A—Human Skeletal Buried at 1 ft Trial B—Human Skeletal Buried at 2 ft
Trial 3	Trial A—Fresh Human Buried at 1 ft Trial B—Human Skeletal Buried at 1 ft
Trial 4	Trial A—Human Skeletal Buried at 1 ft Trial B—Animal Skeletal Buried at 1 ft
Trial 5	Trial A—Fresh Human Buried at 1 ft Trial B—Fresh Animal Buried at 1 ft

TABLE 1—*Breed of dogs and experience.*

Team	Breed	Age	Certification	Training Materials Used	Years of Training
Team 1	Rottweiler	10 years	Yes C,W,SR,WT,D*	Pseudo and real	7 Years
Team 2	German shepard	4 years	Yes C,W,WT*	Pseudo and real	8 Weeks
Team 3	Labrador	1 year and 8 months	No	Real	Sporadic
Team 4	German shepard	6 years	Yes C, W, SR, W, D*	Real	5 Years

* C = Cadaver training, W = Wilderness training, SR = Search and Rescue training, WT = Water training, D = Disaster training.

handlers were cooled in an air-conditioned environment provided at ACLEOTC between some of the trials. Each dog and handler team started a trial at a position given to them by the investigators. Parameters of the area to be searched were also provided to the handler. The handler commanded the dog to search the area and began the usual search pattern that the specific team would use in an actual cadaver search investigation.

During the field trials the investigators were participant observers collecting data through written documentation, videotaping, and photographing. The investigators kept a record of the performance for each cadaver dog and handler team for all five trials. For the five field trials, the dog and handler teams were scored using one of five different detection statuses: alert, unrecognized alert, narrowed area, false alert, and no alert. A simple check sign within a table indicated which alert the dog and handler team gave for each trial.

Results and Discussion

The total dog and handler team results in the field trials are given in Table 5. Table 6 provides a breakdown of the type of success each team had at each specific trial. The first dog participant (Team 1) alerted on fresh human scent in the third trial. She also narrowed the area that contained skeletal human and animal remains at the fourth trial. The term "narrowed area" means that the dog and handler team accurately felt that the remains were in an area in which the remains were situated, but the handlers were not able to specifically identify the exact location. The participants forwarded no inaccurate "narrowed areas." The second dog had two unrecognized alerts at the third trial, the trial that included the fresh and old human scent. For this study an "unrecognized alert" was defined as a positive alert in which the dog located the decomposing human remains but the dog handler did not recognize the signal because it was not the alert the dog was trained to give. The chocolate Labrador had an unrecognized alert for the old human scent and a narrowed area for the fresh human scent in Trial 3. She also narrowed the area for both the animal and human skeletal remains in the fourth trial. Finally, the fourth dog, the second German shepherd, alerted on the deepest skeletal remains at the second trial. The dog also gave an unrecognized alert on the fresh human scent and narrowed the area for the skeletal remains in the third trial.

The overall number of alerts, unrecognized alerts, and narrowed areas was 30%, and 20% of these were recognized by the handlers (alerts and narrowed areas). Only 5% were positive alerts where the handlers specifically located the remains in conjunction with their dogs. The dogs were varied in their performances in the trials, giving a range of 20 to 40% alert rate and a 10 to 20% false alert rate. In the two trials that included distinguishing human remains at different depths, only one location was identified by a dog and handler team. The cadaver dogs may have been affected by depth of sample, but it is difficult to generate any conclusions due to the limited number of alerts that were made. In addition, it did not appear that the cadaver dog and handler teams could distinguish between human and animal remains due to the fact that no positive alerts were made. Only two of the teams were able to narrow the area, and the narrowed areas included both human and animal remains.

Unlike Komar's (9) study, we found that the dogs were consistent in finding dry human bone. All of the dogs were able to narrow or give an unrecognized alert for the areas that contained skeletal remains at some point throughout the trials. Human bone was discovered through alerts, unrecognized alerts, and narrowed areas in 15% of the tests, while fresh human remains were found in 10% of the tests. The fourth team made the most surprising positive alert because they were able to locate one small skeletal cervical vertebra buried 2 ft deep in the large heavily wooded area. This dog's success was in August, some two months after burial of the skeletal remains. In addition, the bone piece was a very dry element of an individual who was skeletonized over 15 to 20 years ago. All dog and handler teams were also able, in varying degrees, to locate both fresh and skeletonized human remains that were buried at least 1 ft. This is important because some previous studies have focused on surface fresh and skeletal human remains as opposed to buried human remains (9).

There was only one alert in the first two trials that tested distinguishing depths and that alert involved remains buried 2 ft deep. There were a number of false alerts on the first trial distinguishing depth between fresh human remains, but that may be due to the fact that it was the first trial and the participants knew that remains were buried at each location. The participants gave false alerts in 15% of all tests, but 12.5% of these were made in the first trial. The handlers may have felt some pressure to give an alert. On the third trial that tested the team's ability to locate fresh and skeletal remains, all of the dogs gave some alert and most of them gave an alert for both types of decompositional remain stages. Two of the dog and han-

TABLE 5—*Results of field trials.*

Team	Alert	Alert Not Recognized	Narrowed Area	No Alert	False Alert
Team 1	1	0	2	6	1
Team 2	0	2	0	7	1
Team 3	0	1	3	4	2
Team 4	1	1	1	5	2

TABLE 6—*Dog and handler team success in field.*

	Trial 1		Trial 2		Trial 3		Trial 4		Trial 5	
Team	A	B	A	B	A	B	A	B	A	B
Team 1	F	/	/	/	A	/	N	N	Did not attempt	
Team 2	/	/	/	F	U	U	/	/	/	/
Team 3	F	F	/	/	N	U	N	N	/	/
Team 4	F	F	/	A	U	N	/	/	/	/

*F = false alert, / = no alert, A = alert, N = narrowed area, U = unrecognized alert.

Trial 1 (A = fresh human at 1 ft; B = fresh human at 2 ft); Trial 2 (A = skeletal human at 1 ft; B = skeletal human at 2 ft); Trial 3 (A = fresh human at 1 ft; B = skeletal human at 1 ft); Trial 4 (A = skeletal human at 1 ft; B = skeletal animal at 1 ft); Trial 5 (A = fresh human at 1 ft; B = fresh human at 1 ft).

dler cadaver dog teams were able to narrow the areas that contained both human and animal skeletal remains. Thus, the dogs did not distinguish between animal and human, but narrowed the area in which they were both located. This would be useful to law enforcement officers in an actual case, and multiple dogs might be brought in to search that area. None of the dog and handler teams were able to locate either of the animal or human fresh remains at the fifth trial. This could have been because it was the last trial of the day and the dogs were hot, tired, and distracted. One dog and handler team did not even attempt the fifth trial because they knew they could not perform well under the increasing temperatures.

Weather affected the dogs' performances in the four trials. Even with multiple breaks and water availability at all times, dogs panted and thus were limited in their smelling ability. In addition, both dogs and handlers became tired toward the end of the tests. The last few tests of the trials coincided with increasing temperatures during the day. The dogs did not alert at all on over 50% of the tests, but 20% of these were on the fifth trial during the heat of the day. When dogs tired, the search was ended. The investigators felt that had the participants resumed the last trial at an early hour the next morning the teams would have been successful.

All dog-handler teams except for the first team were videotaped during their participation in the field trials. The tapes document the way the handler communicates with the dog and vice versa. It records how handlers fail to read what their dog is telling them and how the handler at times will pull a dog away from its search when the dog is not finished searching. The tapes also show the unrecognized alerts. The handlers can look at the tapes and can improve their search methods and communication with their dogs. The tapes have in some cases recorded a running commentary by a handler explaining how they conduct their search and how they "read" their dog. These tapes now comprise the beginnings of a cadaver dog handler videotape archive that will prove invaluable for future reference and study.

Conclusions

The recently completed cadaver dog and handler trials this past summer showed that there is a definite need for standardized training for all dog and handler teams. Because there is some success in finding buried human skeletal remains, perhaps it would be wise to incorporate human skeletal remains into cadaver dog training programs. Even some of the most experienced cadaver dog teams outside this study do not train on skeletal material. Unless there is fresh material present, many of these cadaver dog and handler teams will not and do not find skeletal remains. Civilian volunteers and even cadaver dog handlers employed by law enforcement have little or no access to the appropriate materials needed to accurately train a cadaver dog. Availability of appropriate materials and methods through sanctioned dog training facilities might assist handlers in accurately training dogs for discovery of not only buried fresh human remains, but also buried human skeletal remains.

Through already archived videotape from these summer trials, handlers notice that the dogs are giving signals indicating that human remains are present, but the handler ignores those cues. This could be a problem in actual cadaver search cases. If the handler misses the signals the dog is trying to communicate, this information is not relayed to law enforcement.

Acknowledgments

We would like to thank: the McNair Scholars Program, Tuscaloosa Medical Examiner's Office, Alabama Canine Law Enforcement Officers Training Center, Inc. (ACLEOTC), Tracy Sargent, and the Laboratory of Human Osteology at The University of Alabama for their assistance in this research project.

References

1. Sorg HM, David E, Rebmann, JA. Cadaver dogs, taphonomy, and postmortem interval in the northeast. In: K. Reichs, editor. Forensic osteology: advances in the identification of human remains. Springfield: Charles C. Thomas, 1998;120–44.
2. Rebmann A, David E, Sorg MH. Cadaver dog handbook: forensic training and tactics for the recovery of human remains. Boca Raton: CRC Press, 2000.
3. Dold C, Warren SS. For rescue dogs "nothing's better than a live find." Smithsonian 1997 Aug;28(5):72–80.
4. France DL, Griffin TJ, Swanburg JG, Lindemann JW, Davenport GC, Trammell V, et al. NecroSearch revisited: further multdisciplinary approaches to the detection of clandestine graves. In: Haglund WD, Sorg HM, editors. Forensic taphonomy: the postmortem fate of human remains. Boca Raton: CRC Press, 1997;497–509.
5. Killam WE. The detection of human remains. Springfield: Charles C. Thomas, 1990.
6. Galloway A. The process of decomposition: a model from the Arizona-Sonoran Desert. In: Haglund WD, Sorg MH, editors. Forensic taphonomy: the postmortem fate of human remains. Boca Raton: CRC Press, 1997;139–50.
7. Anderson GS. Insect succession on carrion and its relationship to determining time of death. In: Byrd JH, Castner JL, editors. Forensic entomology: the utility of arthropods in legal investigations. Boca Raton: CRC Press, 2001;143–75.
8. Roksandic M. Position of skeletal remains as a key to understanding mortuary behavior. In: Haglund WD, Sorg MH, editors. Advances in forensic taphonomy: method, theory, and archaeological perspectives. Boca Raton: CRC Press, 2002;99–117.
9. Komar D. The use of cadaver dogs in locating scattered, scavenged human remains: preliminary field test results. J Forensic Sci 1999;44(2):405–8.

Addition information and reprint requests:
Keith P. Jacobi, Ph.D.
Department of Anthropology
Box 870210
University of Alabama
Tuscaloosa, AL 35487-0210