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Application of soil in Forensic Science: Residual odor and HRD dogs

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ABSTRACT

Decomposing human remains alter the environment through deposition of various compounds comprised of a variety of chemical constituents. Human remains detection (HRD) dogs are trained to indicate the odor of human remains. Residual odor from previously decomposing human remains may remain in the soil and on surfaces long after the remains are gone. This study examined the ability of eight nationally certified HRD dogs (four dual purpose and four single purpose) to detect human remains odor in soil from under decomposing human remains as well as soils which no longer contained human remains, soils which had been cold water extracted and even the extraction fluid itself. The HRD dogs were able to detect the odor of human remains successfully above the level of chance for each soil ranging between 75% and 100% accurate up to 667 days post body removal from soil surface. No significant performance accuracy was found between the dual and single purpose dogs. This finding indicates that even though there may not be anything visually observable to the human eye, residual odor of human remains in soil can be very recalcitrant and therefore detectible by properly trained and credentialed HRD dogs. Further research is warranted to determine the parameters of the HRD dogs capabilities and in determining exactly what they are smelling.

1. Introduction

1.1. Human decomposition

The rate of soft tissue decomposition can be dramatically affected by factors that impact the body such as cause of death, animal scavenging, environmental conditions (temperature, rainfall, humidity, soil type), presence or absence of clothing, body mass, mummification and adipocere formation [7,19,21,22,31,34]. Decomposition progresses from autolysis to putrefaction, liquefaction, and finally skeletonization over the course of time [9]. Microbes and enzymes within the body begin the process of autolysis within minutes after death [11,31,34–37]. However, Dent et al. [9] noted that during autolysis, hydrolytic enzymes began the breakdown of carbohydrates, fats, and proteins, followed by putrefaction generally no earlier than 48 h post mortem. Carbohydrates are broken down into sugars by microorganisms in the soil while fats are broken down into fatty acids which under specific conditions will convert to adipocere [11–13]. Adipocere is a waxy soap like substance formed from the decomposition of fats in warm, moist anaerobic environments [11–13]. Some products of the protein breakdown include skatole and indole, carbon dioxide, hydrogen sulfide, ammonia, and methane [9]. This large purge of nutrients into the soil results in a noticeable cadaver decomposition island (CDI) which may benefit insects, microbes and plants [2,29]. Eventually, liquefaction of tissues and organs result in complete disintegration, leaving only the dry skeletal remains. After the body has purged and created the CDI this will remain as trace evidence of human decomposition, even if the body has been disarticulated and scattered by scavengers or moved by criminals to a different "hiding place". On some very rare occasions a "body burn" may be observed (Fig. 1).

1.2. Human remains detection dogs

Human remains detection (HRD) dogs are trained to search for and pinpoint the strongest concentration of the odor of human remains and thus can be used as tools to locate trace evidence. HRD dogs are trained to communicate to their handlers they have located human remains (HR) through a trained final response (TFR)

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Fig. 1. Body stain from Soil G at the STAFS facility in Hunstville, TX, USA. Source: With permission from Kevin Derr, STAFS, Huntsville, TX, USA.

such as a "down", "sit", or "bark". HRD dogs are often trained to locate everything from a single drop of blood to an entire body [3,4,8,10,15,30]. There are currently no instruments that can detect the minimal amount of human decomposition product that a dog can detect [23], however, Furton and Myers [14] estimated a dog's sensitivity to odors at least as low as 1 ppt. Most HRD dog handlers can only obtain small amounts of training materials that will provide the odor of human decomposition. Common training materials include teeth, blood, body fluids, and placenta. Bone of 20+ years old can be purchased on the internet from Skulls Unlimited [32] and the Bone Room [5]. Use of these materials may result in dogs with low sensitivity thresholds and as a consequence, HRD dogs that are very sensitive to small amounts of decomposing human tissue, bone or blood in the natural environment.

The validity of HRD dogs are often called into question when an unproductive final trained response occurs in the field. One reason for this may be that water soluble nutrients from the CDI will move off site during rain events if the topography has a slope [1]. Law enforcement often assumes these responses to be "false alerts" or "mistakes" if a body is not recovered.

Residual odor from human remains may be the culprit of non-productive alerts where nothing visible can be recovered. When a properly trained and credentialed dog offers a trained final response (TFR) in a location where no visible remains are present the handler or law enforcement may interpret this as a mistake or a clandestine grave burial, when in fact, it may be residual scent from a body previously decomposing in the location. The body may have been moved, or disarticulated by animal scavengers. It is currently unknown how long a HRD dog can detect residual scent in the soil after the body has been removed. While there are many anecdotal stories of HRD dogs detecting residual scent months to years after a body was removed, there have been no studies that have examined if HRD dogs can recognize and offer a TFR on soil of a range of post mortem intervals (PMI) from residual human decomposition within the residual cadaver decomposition island (RCDI). While all instruments, mechanical or biological have an error rate, residual odor may be a justified explanation in many cases.

1.3. Residual scent and VOC's

Residual odor is defined as odor originating from a "target substance that may or may not be physically recoverable or detectable by other means" [38]. Prior to Oesterhelweg et al. [28], no peer reviewed published scientific evidence existed to support the concept of residual odor. Oesterhelweg et al. [28] reported that three trained HRD dogs could detect the odor of human remains when there had not even been direct contact between the cadaver and the target object. Carpet squares were placed on a table then the corpse, wrapped in a sheet was placed on top of the carpet squares. Squares were left in place for 2 and 10 min. The bodies used for the sample acquisition were less than 3 h post mortem thereby substantially decreasing the possibility of fluid contamination of the carpets from decomposition. Oesterhelweg et al. [28] showed that HRD dogs correctly identified carpet squares (92–100% accuracy) up to 65 days post-exposure for 10 min (98% accuracy), and up to 35 days for post-exposure for 2 min (86% accuracy).

Residual odors are most likely emitted in the form of volatile organic compounds (VOCs). Vass et al. [36,37] noted that over 478 VOCs were emitted from buried whole human remains. Sample sizes utilized for training HRD dogs vary in size but are generally small (>2 g). There are different chemical signatures between a large sample and a smaller subsample of the same [39], suggesting that small samples may smell differently to dogs than larger samples, even if it is the same type of tissue. The National Incident Management System [27] categorizes HRD dog types by source size, with Type I dogs being certified on human remains in amounts less than 15 g and Type II dogs being certified on human remains 30 g or above. Most handlers routinely train on amounts that are 30 g or less and few have any training materials that weigh more than 500 g (~1 lb).

The Department of Justice Bureau of Alcohol, Tobacco and Firearms [6] utilizes a two part test, with the first consisting of an odor recognition proficiency test established to assess the canine's ability to recognize target odor. This method calls for the use of clean unused perforated containers holding the target odor housed within a larger external container such as paint cans. The cans are placed in a line and the dogs are allowed to sample each can up to two times working on lead with their handler. This is often referred to as a scent-line up; however, this line up contains actual known target odors. This differs from scent line-ups used for matching articles and suspects.

Canine handlers have been aware for many decades that handler gestures and body language can hinder canine performance in inadvertent cueing. Cueing occurs when their canine partners react to specific body language that is usually ritually repeated that indicates the location of the target odors the canines are searching for. This can occur through pointing, eye gaze, or body positioning. Extensive research performed by Brian Hare at the Duke Canine Cognition Center has concluded that dogs do read and act upon human pointing gestures [16,17]. Furthermore and more importantly, Lit et al. [20] showed that handler's beliefs could influence the detector dog's trained final response, specifically resulting in alerts in the absence of the target odor.

The objective of this study was to examine the use of human remains grave soil as a training aid on the sensitivity and accuracy of eight nationally credentialed HRD dogs. I hypothesized that HRD dogs will be able to correctly identify the scent of grave soils from CDI (with human remains) and the residual scent of grave soils