Environmental Determinants of Landmine Detection by Dogs: Findings From a Large-scale Study in Afghanistan

This article’s purpose is to examine the strengths and weaknesses of mine-detection dogs in different environments. The experiments employed a total of 39 dogs in Afghanistan between October 2002 and July 2003. The results are discussed here.

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Mine-detection dogs were first used during and after World War II and have been used with increasing frequency in Afghanistan since the first humanitarian mine-clearance operations began there in 2003. The results are discussed here.

Methods

The researchers supplied two teams, between two and four people each. The supervisor has a broader view to ensure complete coverage of ground and safety. The experimental trials employed the same practice. All photos courtesy of the authors.

Results

-detection experience was 3.4 years (s.d. = 1.7). The average number of strips searched by one dog was 3.8 (s.d. = 1.6, range 1-11). “Strips” are defined below. None of the 39 dogs shared a handler. All handlers were male with an average operational experience of 5.4 years (s.d. = 3.9).

One dog, Axel, was used in October 2002 and July 2003 (when four dogs were employed for the entire trial), this dog searched an unusually high number of strips (11). All other dogs were used for one trial only.

During operational search in Afghanistan, a handler and dog work closely with a supervisor who observes the search and monitors details such as ground missed by the dog (see Image 1). This practice allows the handler to concentrate on the details of the dog’s search behavior, while the supervisor has a broader view to ensure complete coverage of ground and safety. The experimental trials employed the same practice.

The researchers supplied two teams, between two and four people each. The observer used a video-camera to record the dog throughout the search and verbalized details of the search into a microphone connected to the camera (see Image 1). The data were noted when the dog crossed a mine (see Image 2). Thus, at any one time during a trial, two pairs of teams worked: a dog, handler and supervisor; and a research team consisting of observer and datum recorder(s) (see Images 1 and 2).

MDC's dogs located some mines and explosives, which could be dangerous to people working on the site. However, it was not possible to determine the exact location of the mines. Therefore, at any one time during a trial, two pairs of teams worked: a dog, handler and supervisor; and a research team consisting of observer and datum recorder(s) (see Images 1 and 2).

Table 1. Mine types, names and sizes used in the Kharga test field.

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<th>Mine type</th>
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Table 2. Number of mines of each type laid at each depth in the Kharga test field.

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Table 1. Mine types, names and sizes used in the Kharga test field.

The site. The test field was established in a step-sided valley at Kharga, 15 km north of Kabul just below a reservoir dam (see Image 3). The site was originally established as a mine-hole golf course as part of a larger recreational and commercial development. In previous history, it was a battlefield. When GICHD first visited the site in 2001, a crater from a large bomb was in the middle of the site, some artillery pieces were stored on site and most of the buildings were destroyed.

Prior to establishment as a research minefield, the site was searched using MDC’s dogs. The dogs found some explosive items, a large number of indications at which nothing was found suggested that considerable explosive contamination occurred on-site. Battlefield clearance was conducted in the hills surrounding the site during early 2003. Up to 30 cm of topsoil was therefore removed from about two-thirds of the site prior to the test mines being laid, with the aim of removing most of the contamination left by the partially exploded bomb. After topsoil removed, the site was cleared using dogs, and the indication rate was considerably reduced. Although not ideal for the trials, the site was realistic, because dogs routinely work in highly contaminated situations in Afghanistan. The MDC training area in Kabul where the dogs are trained is also a highly contaminated site.

Table 2. Number of mines of each type laid at each depth in the Kharga test field.
The research team arrived at a strip before the dog team. The camera operator’s clothing allowed voice recording of observed behavior, including notification of the dog crossing a mine. Cross referencing between observer (on tape) and datum recorder (on paper) was achieved using coordinated time records. The observer and the datum recorder also held a mapped layout of each trial strip to ensure that weather records, dog behavior and mine position could be linked.

After completion of the study, all mines were dug up to ensure that they were still in position. All were in place except one, which was displaced 0.5 m from its assigned location. Whether this discrepancy was an error in original placement or the mine had shifted after burial is uncertain. However, the mine was considered close enough to the assigned position for data associated with that mine to be used normally.

**Apparatus**

Mines were laid following strict International Mine Action Standards protocols, involving washing and sterilizing the mines three times over several days. All handling and digging tools were sterilized in boiling water. Once sterilized, mines were handled with plastic gloves. All soil not returned to a hole was removed completely from the site.

**Site preparation.** After soil preparation, the site was laid out into 31 strips, each 40 m x 8 m. The length of 40 m provided a realistic search baseline, and the width of 8 m was the standard line search distance for Afghanistan dogs.

**Test mines were laid in March and May 2002.** Table 1 (page 75) gives details of the mine types. Using eight mine types, a total of 114 mines were laid at five different depths (as shown in Table 2 on page 75). The number of mines in a strip was randomly assigned using a weighted distribution. Mines in the analyses. Detection success was calculated as a logit transform of proportion of mines found. Specifically, detection success is shown as logit \( p \), which is calculated as logit \( p = \log\left(\frac{p}{1-p}\right) \), where \( p \) is proportion found (found mines/total mines). Logit \( p \) has the advantage of being an equal-interval scale and is not bounded by upper and lower limits, as is proportion found, enabling the use of parametric statistical analyses. In the situation in which proportion found was \( k/0 \) (indicating zero misses), misses were recorded as \( 1.25 \) in order to avoid an infinite logit \( p \).

Higher values of logit \( p \) reflect higher detection success, much in the same way as proportion correct. If 199% of the available mines were detected, logit \( p \) would be two, while a 50% find rate would result in a logit \( p \) value of zero. A find rate less than 10% produces negative logit \( p \) values, and the larger the negative number, the poorer the detection success.
Detection success under different weather conditions. Mean detection success (logit \( p \)) differed significantly across the five trials according to a one-way analysis of variance using the success scores for individual dogs (F(4, 38) = 3.41, p = 0.04). Detection success was significantly higher in October 2002 (mean = 1.23) than for any of the other trials and was lowest in June 2003 (mean = 0.00), although the other four trials did not significantly differ from each other (Fisher’s LSD post-hoc test) (see Figure 2). The false-alarm rate was lowest in October 2002 and rose to higher and similar levels in all subsequent trials, supporting the hypothesis that heavy rains hampers detection success.

Informal observations suggested that the heavy spring rains may have distributed mine odor around the site, particularly during drainage. Dogs tend to move through the strips. Chemical analysis of soil samples supported this conclusion.

The detection success achieved in October 2002 is most representative of field conditions. Given the rarity of rain in Afghanistan before spring 2003, the dogs were unfamiliar with wet soils or working conditions, and detection success seemingly decreased as a result of rainfall. It is important that training of mine-detection dogs should include the full range of environmental conditions that may be encountered (even if that requires simulation of unusual conditions) or that mine-detection agencies withdraw dogs for retraining and licensing when unusual weather patterns occur. This precautionary approach may be particularly necessary when dogs move from dry to wet conditions (and vice versa).

Miner type and depth. The proportion of each mine type found for each trial was converted to logit \( p \) and averaged across all trials (see Figure 3). Detection success was significantly positively correlated with the increasing size of mine. Type 72 anti-personnel mines (see Table 1) was the most difficult to find, and TM57 the easiest. Although a one-way analysis of variance showed no significant variation in detection success for the different mine types (F(3, 12) = 1.47, p = 0.21), a Fisher’s LSD post-hoc test showed that P44L (p = 0.01) and T72 (p = 0.02) mines were significantly harder to find than TM57 mines.

Detection success varied significantly with mine depth (one-way analysis of variance (F(4, 20) = 2.97, p = 0.04) and was significantly negatively correlated with mine depth (r = –0.39, p = 0.05)). Thus, detection success decreased as depth increased, although with exceptions. The small T72 mines were poorly detected at all depths; for small YM1 mines, detection was poorest at the shallowest depth (5.7 cm), and the large TM57 mines were more successfully at depth. The overall mean in Figure 4 represents the mean of all mine types at all mine depths and shows mostly the decrease in detection success as a function of mine depth.

Vegetation. A significant effect of the amount of vegetation cover on detection success was found (F(1, 16) = 3.28, p = 0.05), with detection success decreasing with increasing vegetation cover near the mine. Little air movement happens overnight, thus displaced odor tends to concentrate immediately on and near the ground. When the sun first hits the ground (the time at which the dogs begin work), evaporation of surface moisture that overnight accumulation of odor together increases an increased concentration of mine odor near the ground surface for a short period (probably 20 minutes to 1 hour, depending on local conditions). This resulted in the most effective detection of mines that were relatively easy in the early morning, giving the initially high detection rate.

Second, as the soil surface dries warming and evaporation increases the overnight accumulation of dew, humidity begins interacting antagonistically with detection success. Relatively high humidity makes detection difficult, and detection success improves as relative humidity declines through the morning. This effect is predicted because, when sniffing, the dog rapidly alternates exhalation and inhalation of moist air over the ground surface. This moist air displaces odor from surfaces and results in the vapor, allowing inhalation. When humidity is high, the process is less effective than with lower humidity, because the key factor influencing odor molecules release is the high moisture content of the dogs’ exhaled breath.

The focus on these results on detection success through the morning suggests that some micromanagement of dog work could improve overall detection success in arid environments. Specifically for the conditions experienced near Kabul, on calm mornings, dogs should take a break during the second hour after dawn, which is the period when detection success is predicted to be lowest as a result of humidity effects.

The reality is that use of dogs in arid environments exposed to hot temperatures later in the day, and mid-morning is a desirable time of day to be working dogs. It may not be realistic to stand dogs down for part of the morning.

Fortunately, there are other options. For example, maintenance training could include humidity management (such as spraying of water on training fields) in order to mimic the relatively difficult high humidity conditions experienced during mid-day, and maintenance training could be focused on that part of the day at which humidity in high. We encourage monitoring of relative humidity through the day in any operational theatre in which dogs are being used, but particularly in arid environments. Further, regularly conducted maintenance training should be conducted under the most challenging conditions likely to be experienced by the dogs—in general terms, meaning that part of the day when relative humidity is highest.

An issue that arose in this study was the distribution of heavy rainfall in arid environments. Odor of mines was clearly transferred downstream in runoff channels, resulting in the distribution of individual mines by dogs at distances well outside the standard clearance perimeter for manual demining. While the mine itself should still be found, the consequence is numerous, apparently false indications. Recognition of this effect may help to improve the efficiency of using demining resources in operational situations.

Summary

The overall aim of this study was to explore the effects of environmental variables on mine detection by dogs working in Afghanistan. Data were gathered during five trials carried out in October 2002 and April, June, July.
when dew on the ground's surface appeared to humidity results in poorer detection (in arid
environment). While standard weather variables (tem-
perature, relative humidity, wind speed) had no
overall significant effects on detection suc-
cess, humidity appeared to be the most im-
portant variable. Evidence indicated that high
humidity results in poorer detection in arid
environments, except in the early morning,
when dew on the ground's surface appeared to
facilitate detection.

A key implication arising from this re-
search is that relative humidity should be
monitored in any operational theatre in which
dogs are used, particularly in environments
where humidity varies considerably through
the day. Variation in humidity appeared to
affect detection success, and this effect
could be dealt with by either standing dogs
down when humidity is high, or by under-
taking maintenance training under the most
challenging humidity conditions experienced in
the operational theatre.

Odoí was clearly conducting downstream
from mines during severe rainfall events in
the arid environment in which we studied the
success of dogs was undertaken, resulting in numerous appar-
ently false indications in drainage channels.
Understanding this phenomenon could lead to
more efficient use of clearance resources in
operational situations.

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Brett Wise, interview with author. April 2011.

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His previous work included Head of the
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este, Mozambique, and other countries.

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volunteers after non-traumatic deaths.

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Endnotes

8. ‘Tanzania blasts: At Least 20 Dead in Dar es Salaam.”

10. “UNMAS and UNAMI to continue humanitarian mine action in Angola.”
11. A forthcoming Small Arms Survey study by Jasna Lazarevic on the impact and
end of conflict, and humanitarian mine action in Angola.

12. “UNMAS and UNAMI to continue humanitarian mine action in Angola.”
13. Golden West Humanitarian Foundation [from page 30]

15. “From Ideas to Actions.”
16. “Physical Security and Stockpile Management (PSSM) Identification Cards.”

17. “About Danish Demining Group.”
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