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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.

by Dr. Rebecca J. Sargisson | University of Waikato | Dr. Ian G. McLean | Consultant | Dr. Jennifer Brown | University of Canterbury | and Håvard Bach | Norwegian People’s Aid

M
tine-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 1989.1-2 Employing dogs to detect landmines and explosive remnants of war is comparable to the use of dogs to detect cryptic animal species, such as ground squirrels, which may occur at low densities and tend to burrow underground.3 Dogs may offer advantages over other methods of detection in these situations due to their ability to cover large areas more quickly than other detection methods, while minimizing damage to fragile ecosystems.4

Given the long history of mine-detection dogs, it is reasonable to assume that the limitations on their use as mine detectors are thoroughly understood. Unfortunately, little research accompanied the original training and deployment of dogs as mine detectors. Essentially no published research existed on the principles underlying a dog’s ability to detect mines before the Geneva International Centre for Humanitarian Demining began its work in 2000. Handicap International’s 1998 Center for Humanitarian Demining began its experimental trial, and the research team was 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 safety.5 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 recorded ensured that weather 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 team consisting of dog, handler and supervisor; and a research team consisting of observer and datum recorder(s) (see Images 1 and 2).

Mine Origin Explosives Weight of
4 4 4 4 4
Type 72 AP Pakistan TNT 50 g 140 g
PMN2 State factories TNT/RDX 100 g 420 g
PMN State factories TNT 240 g 550 g
PMN State factories TNT 6 kg 8.4 kg
TC-6 Italy, various TNT/RDX 6 kg 8.4 kg
TMS2 State factories various 6.3 kg 8.5 kg

<table>
<thead>
<tr>
<th>Mine</th>
<th>Origin</th>
<th>Explosive</th>
<th>Weight of explosives</th>
<th>Weight of mine</th>
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<tr>
<td>P4AP</td>
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<td>Tetryl</td>
<td>30 g</td>
<td>140 g</td>
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<tr>
<td>Type 72 AP</td>
<td>China</td>
<td>TNT</td>
<td>50 g</td>
<td>140 g</td>
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<tr>
<td>YM1</td>
<td>Slovenia</td>
<td>RDX</td>
<td>50 g</td>
<td>190 g</td>
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<tr>
<td>PMN2</td>
<td>State factories</td>
<td>TNT/RDX</td>
<td>100 g</td>
<td>420 g</td>
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<td>PMN</td>
<td>State factories</td>
<td>TNT</td>
<td>240 g</td>
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<td>PMN</td>
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<td>TNT</td>
<td>6 kg</td>
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<td>Italy, various</td>
<td>TNT/RDX</td>
<td>6 kg</td>
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<td>TMS2</td>
<td>State factories</td>
<td>various</td>
<td>6.3 kg</td>
<td>8.5 kg</td>
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</table>

Table 2: Number of mines of each type laid at each depth in the Kharga test field.

Image 1. Dog, handler and supervisor, observer with camera in the background. All photos courtesy of the authors.

Image 2. Datum recorders with portable weather station (the temperature gauge is shaded by the box).

Image 3. The Kharga site showing an old pond (center right), a derelict clearance site (center left) and the old golf-course clubhouse. Kharga dam in the background.

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 removal, 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 1: Mine types, names and sizes used in the Kharga test field.7

The test field was conducted in the Kharga reserve, 15 km north of Kabul, near a reservoir dam. A total of 39 dogs were used in the five trials. Of the 39 dogs, 28 were German Shepherds and 11 were Malinois (Belgian Shepherds). The average operational experience was 3.4 years (s.d. = 1.7). The average number of strips searched by one dog was 3.8 (s.d. = 1.9, 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 deployed 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 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 recorded ensured that weather 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 team consisting of dog, handler and supervisor; and a research team consisting of observer and datum recorder(s) (see Images 1 and 2).

The constraints defined. Specifically, for any mine-clearance technology, it will be valuable to define the environmental conditions under which detection reliability declines or the limits beyond which the technology should not be used. This study was designed to sample the full range of conditions under which dogs are utilized in hot, dry, semi-arid environments in order to determine the ideal conditions in which to use dogs.

Mines were laid in an unaided golf course near Kabul, Afghanistan. Dogs from the Mine Dog Centre were filmed while attempting to detect those mines using normal operating procedures. Weather conditions were recorded in the long-term and at the precise moment that a dog crossed a mine. These data enabled us to link detection success to context (season, vegetation) and weather (wind speed, temperature, humidity) during the search.

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.

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time (mean = 42, s.d. = 14). The time required to search a strip in Trial 2 was significantly longer (mean = 53 min; F(1, 41) = 16.86, p < .001) than in any other trial (mean range 33 to 40 min for the other four trials). After completing the search of a strip, the dog team left the trial area, returning about 30 minutes later to search the next strip. Once the dog team had left, the datum recorders moved into the strip to measure the distance from the dog’s indications to the mines and to measure vegetation cover around the mines. Total vegetation cover was measured on a 4-point scale: 0–25%, 25–50%, 50–75%, 75–100%. Cover was viewed as any vegetation that could be a barrier between the dog’s nose and the ground, and thus included all dead vegetation. The presence of spiky or aromatic plants was measured separately on 4-point scales 0–absent, 1–present, 2–common, and 3–dominant.

Data Analysis

All mines having an indication within 2 m were treated as found 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((1 – p) / (1 + p)), where p = proportion found (found mines/(found + missed 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 0.0 (indicating zero misses), misses were recorded as 0.25 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 100% 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 50% produces negative logit p values, and the larger the negative number, the poorer the detection success.

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Detection success under different weather conditions. Mean detection success was significantly lower across the five trials according to a one-way analysis of variance using the success scores for individual dogs (F(4, 36) = 3.41, p = 0.04). Detection success was significantly higher in October 2002 (mean = 1.23) than for any other trial 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 Table 2). Figure 4 shows 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 hampered detection success.

In terms of weather conditions, Kabul experienced heavy rains in the spring of 2003, and the increased humidity and soil moisture appear to have hampered the dogs’ ability to detect mines, as rainfall occurred immediately prior to the April and June trials (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 hampered detection success.

Informal observations suggested that the heavy spring rains may have distributed mine odor around the site, particularly along drainage ditches running through the strips. Chemical analysis of soil samples taken immediately prior to the April and June trials (see Figure 2) showed that P4AP (r = 0.02), and T72 (r = 0.02) mines were significantly harder to find than TM57 mines.

Detection success was highest with mine depth (one-way analysis of variance (F(4, 20) = 3.97, p = 0.04) and was significantly negatively correlated with mine depth (r = −0.55, p = 0.02). Thus, detection success decreased as depth increased, although the small T72 mines were poorly detected at all depths; for small YM1 mines, detection success was poorest at the shallowest (7.3 cm) and the large TM57 mines were detected more successfully at deeper depths. The overall mean in Figure 4 represents the mean of all mine types at all mine depths and shows most clearly 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(3, 16) = 3.28, p = 0.04), with detection success decreasing with increasing vegetation cover near the mine. Weight of explosive (r = −0.39, p = 0.22), showing that detection success improved with the increasing size of mine. Type 72 anti-personnel mines appeared to be easier to detect than other mine types (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 = 0.28), a Fisher’s LSD post-hoc test showed that P4AP (r = 0.01) and T72 (r = 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 = −0.55, p = 0.02). Thus, detection success decreased as depth increased, although the small T72 mines were poorly detected at all depths; for small YM1 mines, detection success was poorest at the shallowest (7.3 cm) and the large TM57 mines were detected more successfully at deeper depths. The overall mean in Figure 4 represents the mean of all mine types at all mine depths and shows most clearly the decrease in detection success as a function of mine depth.

A principal component analysis identified humidity as contributing the most explanatory power to the data, in that detection success decreased with increasing humidity. However, when humidity was included in a logistic-regression analysis involving month, mine type and depth, humidity did not explain significantly more variance than was already explained by month. However, Figure 10 shows that, for most months, humidity varied. For October 2002, June 2003 and July 2003, relative humidity rarely climbed higher than 30%. The greatest variability in humidity occurred in April 2003.

Overall, none of the microenvironmental variables measured at the time a mine was detected affected the probability of that mine’s discovery. We conclude that the probability of dogs finding mines was robust with respect to the environmental variation normally experienced by dogs in Afghanistan. Despite the possible effects of humidity discussed below, in general terms, dogs worked with similar effectiveness under all typical working conditions.

Detection success across the working day. Some evidence, shown in Figure 5, indicates that detection success was occasionally higher in the early morning, dropping across the morning and increasing again at midday. As shown in Figure 1, this pattern partially occurred for the trials conducted in April 2003, June 2003 and July 2003. The mean data clearly show that detection success decreased simultaneously with humidity until 9 a.m. However, after 9 a.m., humidity continued to decrease, whereas detection success increased. We suspect that, if variability in humidity was encountered during more trials and not just for April 2003, the effect of humidity on detection success would have been stronger that reported here.

We believe that two effects are operating in the data, as described by Pechen and Webb:• First, overnight dew wets the surface of the soil and displaces surface odor. 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 had accumulated overnight and a concentration of odor together provide an increased concentration of mine odor near the ground surface for a short period (probably 20 minutes to 1 hour, depending on local conditions). Therefore, dogs detected the mines relatively easy in the early morning, giving the initially high detection success. • Second, as the soil surface warms up and convection disperses 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.
Detection success decreased with increasing mine depth. Higher levels of vegetation reduced detection success, but the presence of spicy or aromatic plants did not affect detection sensitivity. While standard weather variables (temperature, relative humidity, wind speed) had no overall significant effects on detection success, humidity appeared to be the most important variable. Evidence indicated that high humidity could be dealt with by either standing dogs and workers closer together or varying the working and support routines.

Third World Quarterly

Rwanda: Ten Years After the Genocide.”


Endnotes

Unplanned Explosions at Munitions Sites: Consequences and Concerns by Berman and Roca (from page 4)


19. “About the Globe by Marek [ from page 10]


22. “About the Globe by Marek [ from page 10]


