DISTRIBUTION PATTERN OF ABATE GRANULES APPLIED BY HELICOPTER[1]

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ABSTRACT. The uniformity of the helicopter (Bell 47G2) application of 24–48 mesh 2 and 5% Abate/celatom granules applied at 5 and 2 pounds per acre respectively was investigated by sampling multiple and single passes. While granular deposition averaged close to the recommended rate per acre, it was extremely variable. Variability was so high that the chance of a sampling area receiving 0.5–2x the expected amount was as low as 50%. Contributors to this variability include wind and the pilot's ability to maintain ground speed, altitude and swath line.

The use of the helicopter in mosquito control appears to be increasing because of its maneuverability for close inspection and treatment of breeding areas, and the ability to restrict insecticide treatment to a specific area. Because of the latter factor, the helicopter was chosen as application equipment in studies of the impact of larvicides on salt marshes in New Jersey (Ward, 1973). Monitoring of applications of 2% Abate granules indicated that the level of uniformity was lower than expected and suggested that research on the subject of helicopter application of granules was necessary. Such research also became important recently because of interest in increasing the economy of helicopter larviciding by using 5% granules instead of 2% with the same range of particle sizes. It might be expected that the reduced particle numbers per unit dosage of the 5% formulation would further reduce the uniformity of application. The objective of the present study was to examine more fully one type of helicopter delivery system for its ability to apply Abate/celatom granules uniformly.

METHODS. Granules were applied with a Bell 47 G2 helicopter fitted with twin hoppers, from each of which a basal metering tube led into a blower system (Colonial Helicopter Inc., Norfolk, Va.). Target flight speed was 60 mph at an altitude of 50 feet. Formulations of Abate were 2% and 5% on celatom granules 24–48 mesh (Gabriel Chemicals, Inc., Robbinsville, New Jersey).

Granular application and deposition was monitored on relatively level ground. Collecting devices, placed at ground level, were aluminum foil pans of two sizes (12 in. x 20.25 in. and 4 in. x 8 in.) with sides 2 in. high. Close observation confirmed that granules did not bounce out of these devices. Granular samples were gathered with small brushes and funnels into vials for laboratory weighing.

Two types of sampling were employed:

1) continuous sampling wherein contiguous pans sampled the entire swath and
2) discontinuous sampling wherein pans were not contiguous, but spaced at fixed intervals.

Single and multiple helicopter passes were monitored by one or both types of sampling.

RESULTS. The profiles of discontinuous sampling of nine experiments in which the helicopter made multiple passes and applied 5% Abate are given in Figure 1. In all these profiles, there were five passes of the helicopter with the exception of profile 1 in which the far right pass was not performed. The locations of the passes

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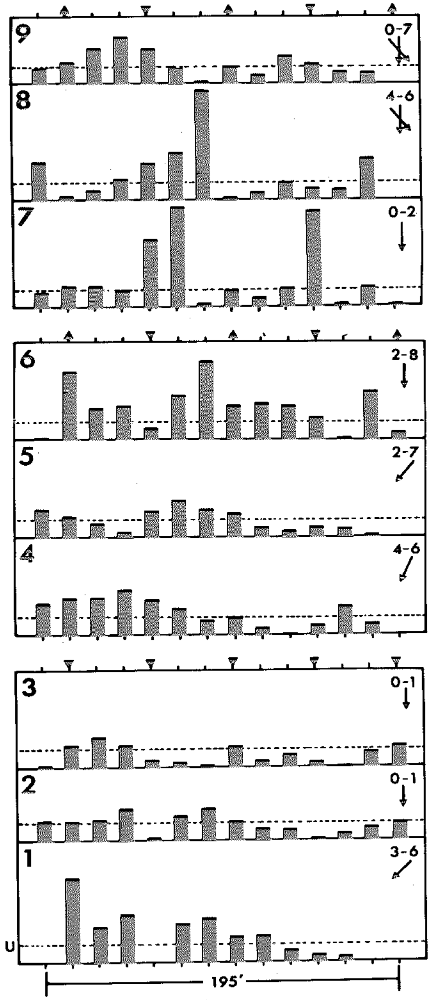

FIG. 1. Profiles (1–9) of 2% Abate granule deposition from 5 passes of the helicopter with samples collected at 15-foot intervals; helicopter position and direction are indicated by the triangle and its apex, absolute uniformity level (U). Wind direction and speed during experiment appear in upper right corner of each profile.

are shown by triangles, the apex of which indicates the direction of the pass. The large pans were set at 15-foot intervals to monitor 210 feet perpendicular to the helicopter passes. Pans located 15 feet to the right of the far right helicopter pass in profiles 2–9 did not produce any weighable samples and are not shown in Figure 1. Such data are included in the analysis.

The speed (mph) and relative direction of the wind are indicated in each profile. Repeated in each profile is a horizontal dotted line (U), which is the amount of granules which would have been sampled if absolute uniformity of application had been attained.

In Table 1 are given the sample means of granules for each profile as well as an overall mean derived from all data. In most profiles the sample mean was greater than the absolute uniformity level of 35.2 mg. per pan. The overall mean of 44.92 mg. is equivalent to 2.55 lbs. 5% Abate per acre.

TABLE 1. Sample means, standard deviations, and coefficients of variation of granular deposition (discontinuous sampling) in profiles 1–9.

Date	Profile number	Mean weight of granules (mg.)	Standard deviation	Coefficient of variation
July 10	1	63.37	50.06	0.803
	2	33.75	20.79	0.616
	3	27.01	19.79	0.733
July 20	4	42.74	31.49	0.737
	5	31.96	24.36	0.762
	6	66.69	47.11	0.706
Aug. 23	7	57.19	68.09	1.191
	8	48.78	58.88	1.207
	9	38.73	29.79	0.769
Overall		44.92	42.86	0.954

For further analysis of the data, enumeration statistics was employed. An arbitrary range of 0.5 to 2 times the absolute uniformity level was established as acceptable. Estimates of probability ($\hat{P}$) for falling within this range were derived. Analysis of all data yielded a $\hat{P}$ of 0.5039, suggesting that only 50% of the time was such range achieved in the area sampled (12" x 20.25"), (Table 2).

TABLE 2. Measured probability ($\hat{P}$) of weights of collected 5% Abate granules (discontinuous sampling) occurring within the acceptance range of 0.5–2x dosage, and the 95% confidence intervals for the probability.

Date	Profile number	$\hat{P}$	95% C.I.
July 10	1	0.2727	0.0095 ≤P≤ 0.5359
	2	0.7334	0.5097 ≤P≤ 0.9571
	3	0.5000	0.2381 ≤P≤ 0.7619
July 20	4	0.5334	0.2809 ≤P≤ 0.7859
	5	0.6000	0.3521 ≤P≤ 0.8479
	6	0.4286	0.1694 ≤P≤ 0.6878
Aug. 23	7	0.4667	0.2142 ≤P≤ 0.7192
	8	0.3334	0.0948 ≤P≤ 0.5720
	9	0.6000	0.3521 ≤P≤ 0.8479
Overall		0.5039	0.4176 ≤P≤ 0.5902

The three profiles of single passes of the helicopter are given in Figure 2. Two percent Abate was applied at 5 lbs. per acre in profiles 10 and 11; 5% Abate at 2 lbs. per acre was applied in profile 12. Each application was sampled continuously (A) with 40 large pans covering 67.5 feet, discontinuously (B) with small pans within the large pans, and discontinuously (C) with large pans adjacent to every fourth pan of (A). Amounts measured by (A) included that portion collected by (B). Wind conditions and the location of the helicopter pass are noted as before. The appropriate absolute uniformity level for 2% and 5% Abate as sampled by the large pans is also indicated (U).

Sample data (A) from profiles 10 and 12 were subjected to enumeration analysis with and without simulated overlapping. In practice, multiple helicopter passes would be based on a 45-foot working swath. Therefore, for analysis, the central 45 feet around the peak was established and amounts outside this were added to the opposite side of the profile. As shown in Table 3, allowing for simulated overlap, the probability estimates ($\hat{P}$) of granular deposit being 0.5–2 times the desired dosage are 0.7408 for 2% and 0.6667 for 5%. The analysis indicates that the 2% granular formulation has a better chance for greater uniformity than the 5% formulation, of the same mesh classification, as applied by equipment used in this study.

DISCUSSION. The term "uniformly" generally appears on most insecticide labels. While most insecticide users would not hope for or expect absolute uniformity, we can find no discussion of the level of uniformity desired. Many people would assume uniformity if the helicopter is calibrated for delivery according to craft speed, maintains this speed in multiple passes with appropriate working swath, and if the amounts used are close to those predicted for the acreage treated. Such were the conditions actually followed in profiles 1–9 of this study, where, on the average, Abate 5% granules were applied at the rate of 2.55 lbs. per acre, only one-half pound greater than expected. However, the variation was so great that the probability estimate of this helicopter system applying to the sample area 0.5–2 times the expected dosage is only 0.5059 or 50%.

TABLE 3. Measured probability ($\hat{P}$) of weights of collected Abate granules (continuous sampling) occurring within the acceptance range of 0.5–2x dosage, and the 95% confidence intervals for the probability.

Profile	Granule Abate conc.	$\hat{P}$	95% C.I.
10 (No overlapping)	2%	0.6667	0.4903 ≤P≤ 0.8431
10 (Overlapping)		0.7408	0.5762 ≤P≤ 0.9054
12 (No overlapping)	5%	0.4815	0.2934 ≤P≤ 0.6696
12 (Overlapping)		0.6667	0.4903 ≤P≤ 0.8431

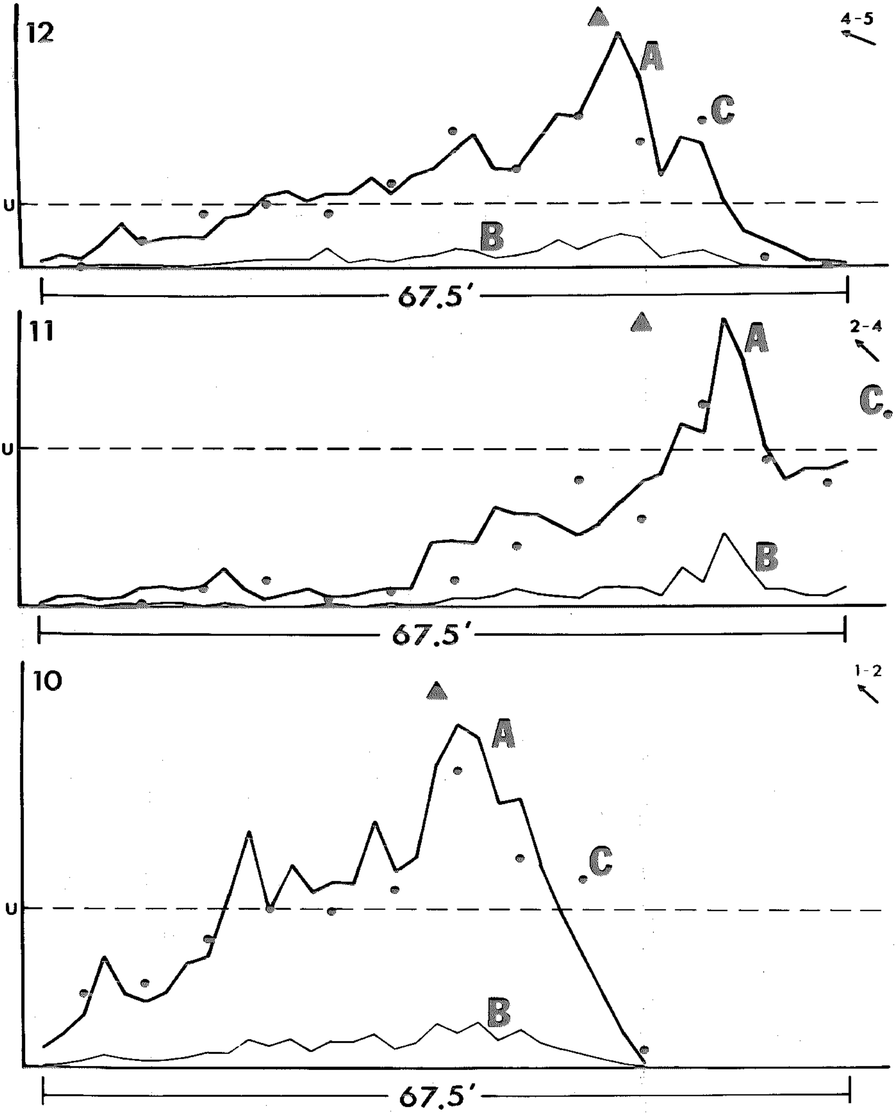

FIG. 2. Profiles (10–12) of 2% and 5% Abate granule deposition from a single helicopter pass, monitored by continuous sampling (A) with large pans, discontinuous sampling (B) with small pans, discontinuous sampling (C) with large pans; absolute uniformity level (U) for sampling A and C. Profiles 10 and 11 2%, profile 12 5%. Wind direction and speed during experiment appear in upper right corner of each profile.

This variability is probably due to several factors. Possibly the greatest influence is the difficulty in the lining up of the helicopter for successive passes at 45-foot intervals. Evidence for this is seen in the analysis of profile 12, where, through the precision of simulated overlapping, the estimate of probability to treat 0.5–2 times 5% Abate increases to 0.6667 rather than 0.5039 as in profiles 1–9.

Variability in wind conditions is also a factor and presumably is responsible for differences in the application of 2% Abate in profiles 10 and 11. The Abate/celatom granular is a relatively light formulation and, therefore, its descent is influenced by the wind. In addition, it has the disadvantage of fracturing during transit, the resultant fines bearing significant amounts of Abate. This problem could possibly be circumvented by the use of sand granules, which have been used with fixed wing aircraft for reportedly uniform distribution at 1 lb. formulation per acre (Kay, Ferguson and Morgan, 1973).

The variability measured is also dependent on the sampling method employed. In contrast to the complete sampling of the entire swath by (A) in profiles 10–12, procedure (B) monitored 40% of the swath with an equivalent number of samples; procedure (C) monitored 33% of the area of (A) with one-third the number of samples. While (C) failed to detect the central peak of overtreatment in profiles 11 and 12, (B) succeeded in doing so in all cases. The collecting surface of the small pans in (B) is 13.2% of the large pans in (A). The actual grand mean of (B) was 12.96% ($S=4.65\%$, $P\ [12.07 \leq x \leq 13.86] = 0.95$), indicating that the small pans in the numbers used in these experiments detected the variability as well as the large pans. This could influence subsequent selection of collecting devices based on economy and handling.

The significance of the lack of uniformity in helicopter application is difficult to measure and would depend on the area being treated. In most cases, larval control would be achieved at the lower limit of 0.5 times dosage (0.05 lbs. a.i./acre). In the laboratory we have found that Abate will be moved laterally in water at least one foot tending to even out an application to kill larvae. Under field conditions, bottom debris and organic matter might reduce this movement. The upper level of 2 times the desired dosage (0.2 lbs. a.i./acre) also would probably not be considered a risk to non-target organisms. We would presume, however, that there is a level of disuniformity where an overdosage in small areas could result in their death, either by release into water or by granular consumption by an organism. The studies reported here have shown the need for closer monitoring of helicopter application to prevent such an occurrence as well as the need for further development of application equipment.

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