Statistical Correlations Between GLC Assay and Smaller European Elm Bark Beetle[1] Bioassay[2]

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ABSTRACT

American elm trees, *Ulmus americana* L., were sprayed with methoxychlor by helicopter or mist blower, and twig crotches were collected from sprayed trees for bioassay of *Scolytus multistriatus* (Marsham) and GLC assay. Correlations established between the 2 assays were dependent on method of application and amount of methoxychlor residue. Correlations were low and variable for helicopter-sprayed trees and high and uniform for mist-blower-sprayed trees.

Dutch elm disease, caused by the fungus *Ceratocystis ulmi* (Buisman) C. Moreau, is a serious shade tree problem in the United States. The smaller European elm bark beetle, *Scolytus multistriatus* (Marsham), the primary vector of *C. ulmi,* inoculates healthy elms with fungal spores by feeding on twig crotches. Generally, arborists and city foresters control Dutch elm disease with sanitation programs and with spray applications of methoxychlor.

In this study, 2 laboratory assays were used to quantify deposits on elm trees sprayed with methoxychlor: (1) smaller European elm bark beetle bioassays, and (2) gas-liquid chromatography (GLC) assay.

The objective was to establish correlations between beetle feeding failure[5] and amount of methoxychlor residue.[6] A correlation between the 2 assay methods is needed for predicting the degree of beetle feeding failure by estimating methoxychlor residues on living elms.

METHODS AND MATERIALS.—*Description of Treatments.*—In spring 1969, 762 American elm trees, *Ulmus americana* L., were sprayed with an average of 2½ gal/tree of 12½% methoxychlor emulsion, using a John Bean Model 300G Rotomist mist blower equipped with 3 no. 5 nozzles.[7] The 2 outer and 1 center nozzles had no. 45 and no. 46 cores, respectively. Also, 854 elm trees were sprayed with an average of 1 gal/tree 12½% methoxychlor emulsion, using a Bell 47G-2 helicopter equipped with a 32-ft boom and 34 no. D6 nozzles with no. 45 cores. For both groups of trees, the mean DBH was 1.3 ft and the mean height was 45 ft.

Sampling Plan.—Fifteen twigs were collected from each of 16 sectors on each sample tree (Fig. 1). Ten of these twigs were used in the bioassay and 5 were used in the chemical assay of methoxychlor. Twigs were collected in May, June, July, and September 1969. Six trees in each treatment were selected randomly each time.

Assay.—The bioassay and GLC assay were performed as described by Barger et al. (1971) and Cuthbert et al. (1973).[8] The criterion for the bioassay is the beetle-feeding-failure rate; for the GLC assay it is the methoxychlor residue.

Analysis.—The feeding-failure rate (q) and the average methoxychlor residue (m) were calculated for each of the 16 tree sectors for every sample tree and then averaged over the 24 trees in each treatment. Then the correlation between the feeding failure rate and methoxychlor residue was computed within each treatment and tree sector. The correlations were calculated from the 24 values of (m, g) in each sector.

RESULTS AND DISCUSSION.—*Mist blower.*—Methoxychlor residues on trees sprayed by mist blower were relatively heavy and variable (Table 1). On some sectors, residue values were ca. 50 times more than on other sectors. Both assays showed that some tree sectors caught no spray whereas others received much. By tree sectors, feeding failure ranged from 0.0 to 100%,[9] and the methoxychlor residue ranged from 0.0 to 3.18 $\mu g/mm^2$ of bark surface. Generally, residues were heavier and beetle feeding failures were greater at the bottom of the tree crowns than at the top.

Helicopter.—On helicopter-sprayed trees (Table 2), feeding failure and methoxychlor residue were ca. ½ and ¼, respectively, those of trees sprayed by mist

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[5] Mean percentage failure of the smaller European elm bark beetle to feed to the xylem of methoxychlor-treated elm-twig crotches.
[6] Mean μg of methoxychlor/mm^2 of elm-twig crotch bark surface.
[7] Mention of a proprietary product does not constitute endorsement by the USDA.

[8] R. A. Cuthbert, A. C. Lincoln, J. H. Barger, and P. A. Reed. Formulation and application of methoxychlor for spraying elms. Manuscript in preparation.
[9] 0.0% = all beetles fed; 100% = no beetles fed.

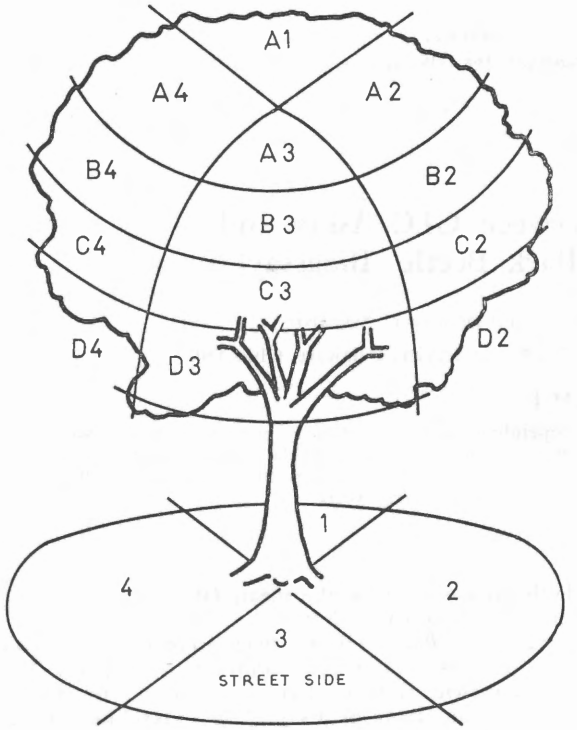

FIG. 1.—Schematic of an elm tree, showing the 4 vertical levels and 4 quadrants from which twig-crotch samples were taken for bioassay and GLC assay.

blower. Trees sprayed by helicopter had a small variation of methoxychlor residues. Methoxychlor residues and beetle feeding failures were heaviest at tree tops and progressively lower at each lower crown level.

Correlation Between Assay and Bioassay.—The data suggest a correlation between the assay and bioassay. Table 3 gives correlations by tree sector for each

Table 1.—Mean feeding-failure rates of bark beetles in bioassays and mean methoxychlor deposits by GLC assay. Trees sprayed with 12½% methoxychlor emulsion by mist blower. Milwaukee, Wis. Spring 1969.

Tree level	Tree quadrant 1	2	3	4	Mean
	Elm bark beetle bioassay, Mean residue (µg/mm²)				
A (top)	46.6[a]	35.7	37.6	49.0	42.2
B	59.5	51.9	66.6	63.3	60.3
C	59.0	55.7	73.8	71.4	65.0
D (bottom)	45.2	55.7	67.1	63.3	57.8
	Gas-liquid chromatography assay Mean residue (µg/mm²)				
A (top)	0.26[b]	0.21	0.28	0.39	0.29
B	.51	.42	.59	.58	.53
C	.59	.48	.77	.73	.64
D (bottom)	.44	.55	.80	.79	.65

[a] Each mean based on 240 twigs.
[b] Each mean based on 120 twigs.

Table 2.—Mean feeding-failure rates of bark beetles in bioassays and mean methoxychlor deposits by GLC assay. Trees sprayed with 12½% methoxychlor emulsion by helicopter. Milwaukee, Wis. Spring 1969.

Tree level	Tree quadrant 1	2	3	4	Mean
	Elm bark beetle bioassay Mean feeding failure rate (%)				
A (top)	31.6[a]	36.6	34.5	30.4	33.3
B	22.5	26.2	27.0	25.0	25.2
C	16.2	15.8	25.0	24.1	20.3
D (bottom)	10.0	15.4	16.2	15.4	14.3
	Gas-liquid chromatography assay Mean residue (µg/mm²)				
A (top)	0.12[b]	0.15	0.17	0.12	0.14
B	.12	.10	.13	.09	.11
C	.07	.07	.12	.11	.09
D (bottom)	.06	.07	.06	.06	.06

[a] Each mean based on 240 twigs.
[b] Each mean based on 120 twigs.

treatment. There are obvious differences in the correlation coefficients between the 2 methods of application. The differences appear to be the result of the amount of methoxychlor sprayed.

On helicopter-sprayed trees, correlations were highest for top level A, where deposits were heaviest, and lowest for bottom level D, where deposits were lightest. For example, correlation coefficients ranged from 0.58 to 0.74 within level A and from 0.02 to 0.63 within level D (Table 3).

On trees sprayed by mist blower, correlation coefficients were high at all levels, because deposits were relatively heavy throughout the trees. Correlations by sector ranged from 0.65 to 0.90, and for all sectors of all trees the correlation was 0.80. Low deposits gave low correlations, and high deposits gave high correlations.

Variation in correlations among helicopter-sprayed trees suggest that: (1) distribution of methoxychlor

Table 3.—Correlation between bark beetle bioassay and GLC assay, within tree sectors. Trees sprayed by helicopter and mist blower. Milwaukee, Wis. Spring 1969.

Tree level	Tree quadrant 1	2	3	4	Mean
	Helicopter				
A (top)	0.74[a]	0.74	0.71	0.58	0.69
B	.51	.48	.36	.61	.49
C	.37	.11	.75	.49	.43
D (bottom)	.02	.46	.30	.63	.35
	Mist blower				
A (top)	.76	.69	.90	.76	.78
B	.65	.78	.83	.85	.78
C	.70	.88	.89	.90	.84
D (bottom)	.86	.81	.78	.78	.81

[a] Each correlation calculated from the mean residue (m) and feeding failure rate (q) within tree sector on 24 sample trees.

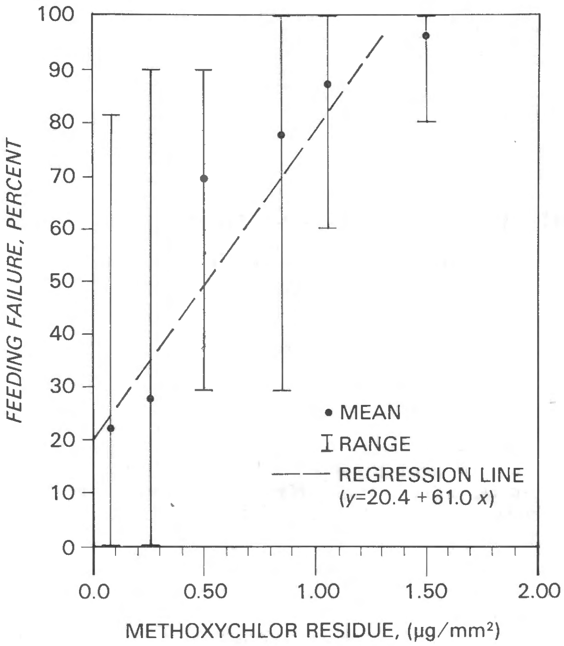

FIG. 2.—Plot of range, mean, and the linear regression of feeding failure vs. methoxychlor residue based on combined helicopter and mist blower treatments, Milwaukee. Spring 1969.

at the lower tree levels is spotty, and (2) amount of methoxychlor is too low to deter bark beetle feeding. Therefore, there is less correlation between feeding failure and methoxychlor residue. These 2 factors could explain the variation in correlation for helicopter spraying.

A linear regression line was plotted to approximate the relationship between the mean feeding failure (response) and the mean methoxychlor residue (dosage) (Fig. 2). The regression line predicts 20% feeding failure when the residue is 0.0 $\mu g/mm^2$. Similarly, 50 and 90% of the beetles are expected not to feed when the residues are 0.48 and 1.14 $\mu g/mm^2$, respectively.

Variation in feeding failure was high for low residues but decreased as the residue increased. For methoxychlor residues between 0.0 and 0.10 $\mu g/mm^2$, mean feeding failure was 24%, range 0.0–80%. Between 0.45 to 0.55 $\mu g/mm^2$, mean feeding failure was 69%, range 30–90%. When the residue was between 1.0 to 1.10 $\mu g/mm^2$, mean feeding failure was 87%, range 60–100%. No bark beetles fed into the elm-twig xylems when methoxychlor residues were over 1.5 $\mu g/mm^2$.

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