Final Report Project #000481

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From **Jane Barber**

Characterization of Permethrin Flux: Effects of Altitude and Meteorological Change on the Dispersion of Permethrin from Aerial Applications.

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PUBLICATIONS

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- Barber J.A.S. Greer M.J. Latham M. 2008 Characterization of pesticide dispersion from aerial applications of mosquito adulticides: Meteorological effects and canopy penetration Biologists International Advances in Pesticide Applications Jan 9th -11th, 2008 Cambridge England. Aspects of Applied Biology No.84 :289-296 **Edited Book Section**
- Barber J.A.S. Greer M. Latham M. 2007. Characterization of Ultra Fine Aerosols for Mosquito Control. Part One Deposition and Non Target Effects Low Altitude. Transactions of the American Society of Agricultural and Biological Engineers **Submitted Feb. 2007. Refereed.**
- Dr. Jane Barber Mr. Mike Greer 2006. Meteorology and Flux Measurements in Vector Control. Association of Applied Biologists International Advances in Pesticide Applications Jan 9th -12th, 2006 Cambridge England. Aspects of Applied Biology No.77 :139-146 **Edited Book Section**

Presentations on project: Two presentations at the 2007 AMCA; One presentation at the FMCA 2007; One presentation at the AMCA 2008; One presentation at the AAB 2006; One presentation at the AAB 2008 and One presentation at the ASABE 2007

Summary for the Coordinating Council Members

EXECUTIVE SUMMARY

This document presents a summary of the results from FDACS funded project 000481. The results demonstrate how pesticide dispersion, both in flux and deposition changes as altitude and meteorology changes.

Deposition increased as altitude decreased and atmospheric stability increased. The deposition values were evaluated following the parameters stipulated in the Permethrin RED risk assessment. The resultant concentrations were showed that the NOAEC for marine and fresh water invertebrates was exceeded; this was most significant at the lower altitude during stable atmospheric conditions.. *The US EPA defined No Observed Adverse Effect Concentration (NOAEC) for permethrin is 0.039 ppb for freshwater invertebrates and 0.011 ppb for marine invertebrates*. Mosquito mortality, measured via cage bioassay within the canopy showed that control increased as atmospheric turbulence increased. Interestingly, those conditions which favored mosquito control also produced lowest deposition volumes.

RESULTS AND DISCUSSION POINTS

The droplet size distribution used ($Dv_{0.5}$ of 25µm) dispersed differently as altitude changed. Overall, the 30m application altitude returned higher ground deposition compared to the 45 m altitude. Deposition values were not equal from one night to the next. We wanted to investigate why there were differences and whether there would be any measurable impact. Analysis showed that atmospheric stability appeared to be the causal parameter. For the purposes of this document stability levels will only be presented via the Richardson number (Ri) a dimensionless measure of turbulence. When the Ri is 0.2 conditions are strongly stable and as you approach 0 the conditions become more neutral.

During the low altitude applications, under more stable conditions the turbulent mixing was suppressed (Table1). During the third night when the Ri was 0.02 conditions were neutral meaning there was significant atmospheric mixing. On Oct 30th 2006 the Ri was 0.35 this number indicates extreme stability, so extreme we are not entirely sure what happened that night the atmosphere was probably becoming stratified. Volumes (ng/m^2) of pesticide sampled strongly correlated with non-target mortality particularly at the lower altitude.

Table 1 Permethrin deposition on each night in ng/m2 and % mortality of the non target organism column five gives Permethrin concentration relevant to the environmental endpoint

Test Date	Altitude m	$\mu g/m^2$	% Mortality	Ri
08/02/06	30	612	99	0.19
08/17/06	30	325	85	0.18
10/03/06	30	104	2	0.02
10/30/06	30	452	43	0.35
05/02/07	45	292	9	0.01
06/12/07	45	88	2	0.14
06/13/07	45	212	12	0.03
07/25/07	45	262	54	0.21

To further understand what was happening during these tests one has to take in to consideration the wake effect of the aircraft. The Hughes 500 D has a vortex descent distance of approximately 20m at the forward speed used. That means that the spray is released from the concentrated wake (vortex) entrainment just above the canopy top resulting in less distance and time for atmospheric intervention (dispersion and dilution of the spray cloud). This is especially true on a stable night where sedimenting droplets are not significantly mixed by atmospheric dispersion and remain concentrated until ground deposition occurs. On the neutral night (Ri 0.02) turbulence was such that a significant proportion of the spray was dispersed minimizing deposits. At the 45 m altitude deposition was significantly reduced as the spray emission height was 15 m higher. This would have resulted in the concentrated spray cloud being released from aircraft wake effects 25 m above the ground allowing significant dispersion and dilution of the spray by atmospheric mixing prior to encountering the canopy or ground. The reduced deposition is likely due to stream wise wind dispersal.

The pesticide volumes measured via rotating impactor were overall higher for the 30 m altitude compared to the 45 m altitude. At 30 m the flux volume collected correlated with stability as the conditions became more neutral less compound was collected (Table 2 10/03/06 - R1 0.02 - 220 ng/m^2). The flux sampling showed that there was a correlation between the volume collected and the stability at time of application at the 30 m altitude. The 45 m altitude on the other had showed little correlation between volumes instead there was a relationship between droplet density and stability at time of application (Table 2). In terms of mosquito mortality there are no clear correlation between mortality and any of the flux measures the only correlating factor was energetic motion. At this point I should mention that the mortality recorded in the cages may seem low but caged mosquito bioassays are not indicative of wild mortality instead they are a comparable test from one night to the next especially in low wind environments. There is a great deal of data that shows that caged mosquito bioassay in the vegetation return significantly lower mortality counts compared to their counterparts in the open. All experiments showed that there was good control above the canopy in the open.

Table 2 Measures of Spray Cloud Movement (flux) through the test sites: caged mosquito mortality, droplet size (Dv0.5 in microns), volume collected by slides (ng/m2) and droplet density collected on slides (drop/cm2)

Test Date	Alt. m	% Mort. Disc	% Mort. Cylin	$Dv_{0.5}$	ng/m^2	$Drop/cm^2$
08/02/06	30	8	46	23.2	901	888
08/17/06	30	6	26	19.0	750	1305
10/03/06	30	16	25	13.1	220	827
10/30/06	30	12	19	18.2	1361	1958
05/02/07	45	14	31	15.4	708	1382
06/12/07	45	1	2	16	492	956
06/13/07	45	27	32	14	673	1594
07/25/07	45	23	19	23	543	623

On the stable nights mortality was significantly higher in cylinder cages this implies that mortality occurred due to sedimentation. During the night of 10/03/06 the mortality in the disc cages was high indicating that there had to be a horizontal component to the spray. Mosquito mortality in the cages seems to correlate with the neutral nights where there was more vertical mixing as the flux entering the canopy increased. On the neutral nights the turbulence (or power wind speed variance or kinetic energy per unit time) above the canopy u at 7m was high, meaning there was energy available for mixing within the canopy. There was a significant reduction in overall volume present during the neutral night. The increased turbulence under these circumstances reduced the amount of chemical available. The control in the disc cages however is high (similar to that of the cylinder cages) compared to the stable night implying there was horizontal movement. This increased turbulence likely improved control, but the volume and hence the dose available was low, which kept mortality low. Mosquito mortality counts do not respond directly to the dose, instead to the method in which that dose is presented.

This information provides detailed data on direct post atomization fate of permethrin which should be helpful for regulatory decisions. This information is also facilitating descriptions of atmospheric energy and how energetic motions equal spray transfer into the target zone.

Yours sincerely

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