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Controlling Adult Mosquitoes with Pesticides Part III: **Risk Assessment & Risk Mitigation** — by Karl Malamud-Roam, IR-4 Public Health Pesticide Manager

Control of adult mosquitoes with pesticides is an important public health practice (see Parts I & II of this series), but it does entail some risks, both to human health and to the environment. This article explores how direct toxicant risks are assessed and how they are mitigated or managed to ensure that they are acceptable. The benefits and risks of mosquito repellents, barrier sprays, and attractants for traps are explored in the next article in this series.

Mosquito Adulticide Drift into a Florida Forest (Courtesy City of Gainesville, FL)

Killing adult mosquitoes with pesticides requires that the pesticides move into and through the environment. Inevitably, this means that some non-target organisms, potentially including humans, are exposed to mosquitocides when they are applied. The risks associated with this exposure are primarily evaluated with the standard EPA process for assessing outdoor uses of pesticides. Some distinct features of mosquito adulticide risk assessment are discussed here.

EPA's formal pesticide risk assessments follow four basic steps – hazard identification, dose-response assessment, exposure assessment, and risk characterization – that take into account the potential toxic consequences (hazards) of the material, the amounts needed to cause these effects, and the likelihood of being exposed to these hazardous doses (www.epa.gov/pesticides/about/overview_risk_assess.htm). Substantial safety factors are built into the process where data on either toxicology or exposure is incomplete.

The active ingredients in most modern mosquito adulticides are either pyrethins (which are botanical extracts) and pyrethroids (synthetic pyrethrin analogues), or organophosphates (OPs), and all of these have gone through the four-step risk assessment process in the last few years. Starting in 2010, all pesticides will be reevaluated at least every 15 years through the registration review process (www.epa.gov /oppsrrd1/reevaluation/
pyrethroids-pyrethrins.html) and will include risk assessment and risk mitigation measures to ensure that identified risks are reasonable.

Pyrethrins, pyrethroids, and OPs all impact mosquitoes through disruption of the insect nervous system,

and the primary hazard or potential effect of these materials on humans or non-target organisms, if exposures are sufficiently high, is neuro-toxicity. What makes these materials acceptable as public health pesticides is the high degree of selectivity toward insects, especially when synergized (with PBO), and the consequent high safety factor that exists for mammals and most other nontarget organisms relative to the very small doses that are neurotoxic for mosquitoes (www.regulations.gov/#!documentDetail;D=EPA-HQ-OPP-2005-0284-0033). A particular concern of assessors is ensuring the safety of workers using these materials.

Mosquito control technician in FL (courtesy City of Jacksonville)

Other potential hazards that have been reviewed, including chronic toxicity, cancer risk, developmental and reproductive impacts, etc., also demonstrate the need to integrate dose and exposure data to fully assess potentially toxic hazards. As with neuro-toxicity, some of these materials demonstrate potential impacts at high doses but insignificant risks at real-world exposure frequencies and application rates (Peterson et al 2006). For example, resmethrin is classified as "Likely to be Carcinogenic to Humans" by EPA's Cancer Assessment Review Committee (CARC) based on the results of very high exposures in lab studies; however, EPA concluded that "the resmethrin risk assessment estimates that an adult could be exposed to resmethrin when applied as an aerial ULV mosquito adulticide spray up to 365 times a year for 70 years before the Agency's cancer risk level of concern is exceeded." (Resmethrin RED, 2006, p32) In other words, the qualitative hazard can only be interpreted in a meaningful way when dose and exposure are included.

Risk assessments for mosquito adulticides as well as other pesticides include evaluation of constituents other than the active ingredients, and a particular concern with adulticides is the potential impact of the synergists. This is not a particular concern with organophosphates, but most types of animals have mechanisms for detoxifying pyrethrins and pyrethroids, and synergists such as piperonyl butoxide (PBO) are commonly used to preclude rapid detoxification by insect enzymes. While PBO and other such synergists have very low direct toxicity to people or other non-target organisms (www.epa.gov/ fedrgstr/EPA-PEST/2006/July/ Day-26/ p11717.htm), a recent focus of research has been the potential impacts of these molecules in settings where they might unintentionally synergize persistent pyrethroid residues (www.cdpr.ca.gov/docs/registration/reevaluation/chemicals/pyrethroids.htm).

Another research question is the extent to which the cumulative effects of mosquitocides and other pesticides may cause toxic impacts beyond those estimated by single-molecule risk assessments. Pesticide cumulative risk assessments were mandated by the Food Quality Protection Act (FQPA) in 1996, and have been completed for organophosphates and some other pesticide classes, but not yet for the pyrethrins and pyrethroids (www.epa.gov/pesticides/cumulative/). EPA's FIFRA Scientific Advisory Panel (SAP) has reviewed this topic for the pyrethrins and pyrethroids in 2009 and 2010, and proposed that the majority of these chemicals share two common modes of action. When the final SAP report is issued, there may be new restrictions imposed, possibly in the area of allowable residues on foods or animal feed. Few adulticides have explicit residue tolerances established at this point, and IR-4 is helping determine appropriate protocols for establishing these for mosquitocides.

While risk assessments for mosquitocides generally follows the standards for other pesticides, control of adult mosquitoes has some unique attributes, which led EPA to issue Pesticide Registration Notice 2005-1. The most significant elements of this PR Notice are: the recognition that drift is necessary for adult mosquito control, rather than an adverse source of impacts; that applications over water are acceptable if the anticipated drift moves the pesticide cloud to and through areas of mosquito habitat; and that careful control of pesticide droplet size and frequency of application are the keys to mitigating potential pesticide impacts.

Air Force C-123 cargo plane applying malathion over Dallas during 1966 outbreak of St. Louis Encephalitis (courtesy AFPMB).