Mosquito Management and Risk by Robert K D Peterson

In his inauguration speech on January 21, 2009, President Obama said "We'll restore science to its rightful place..." Although he was referring primarily to the role of science in economic and technology development, it is appropriate to extend his statement to include science's role in societal decisions about technology and the regulation of technology. In particular, what does restoring science to its rightful place mean when it comes to the regulation of technology? Because technology is based on science, scientific evidence must be afforded its proper place in decisions about the proper use of technology. Of course, in our democratic system, science does not – nor should not – serve as the sole arbiter of societal decisions about technologies and how to use them. These decisions should use science as a foundation, but then also incorporate economic, legal, ethical, aesthetic, and cultural factors.

What does "restoring science to its rightful place" have to do with mosquito management and risk? Quite a lot, actually. Since the infectious pathogen West Nile virus invaded the United States in 1999, causing the largest encephalitis disease epidemic in US history (1), renewed public attention has been focused on mosquito management. Most of this attention and concern has involved using insecticides as an outdoor space application targeting adult mosquitoes, often called "adulticiding" (2). The concerns have revolved around two major areas: the effectiveness of adulticiding, and the risks posed by adulticiding. These concerns have led directly to opposition to adulticiding by organized activist groups and have led to misinformation and opinions that are not consistent with facts. The risks and benefits of adulticiding and other management tactics have been extensively studied. So, let's look at each of the two major areas identified above and see what the prevailing science has to say.

We have long known that using adulticides in outdoor space applications reduces populations of adult mosquitoes, although the results can be quite variable. What has been more uncertain is the effect of adulticiding on reducing pathogen infection rates in mosquitoes and on reducing disease incidence in people and other animals. Although it is reasonable to assume that if adulticiding reduces adult mosquito populations there will also be reductions in pathogen-infected mosquitoes and disease in people and other animals, research to evaluate this has been lacking until very recently. Results from these studies suggest that adulticiding has a significant effect on reducing pathogen infections in mosquitoes and disease (3-5).

What about the ecological and human-health risks from adulticiding? Before we can examine these issues, we need to take a step back and look more broadly at the scientific discipline of risk assessment. To assess risk, one needs to understand both *effect* and *exposure*. Risk is really nothing more than an interaction of these two factors (6). And, risk assessment is simply the objective evaluation of risk in which the assumptions and uncertainties that are part of the assessment are clearly considered and presented (6,7).

In the case of adulticides, we need to know the toxicity of, and exposure to, the insecticide in question to properly estimate the risks. Like all chemical risk assessments, researchers have estimated or measured the exposure of a person or other organism to the insecticide and then compared that exposure to a threshold exposure level. The threshold level is usually determined by a regulatory agency such as the US Environmental Protection Agency (EPA). Threshold exposure levels usually incorporate safety factors that increase the protection of people and wildlife. In the case of exposure and risk to people, the threshold level is the exposure to the insecticide that has been shown in a series of studies with laboratory animals to have no toxic effects on individuals. For exposure and risk to non-target organisms, like wildlife, the threshold level varies and may be an exposure in which no toxic effects are observed, or it may be an exposure that is a small fraction of the concentration needed to kill 50% of the test-animal population. In other words, there may be a toxic effect, but it has been determined that it will not affect the populations of organisms in the short or long term.

What do the risk assessments that have been conducted for outdoor space applications have to say? Because risk assessment of insecticides is dependent on the amount and frequency of exposure, the application rate tells us a lot about the resulting risk. Insecticides used for outdoor space applications are applied at a very low rate compared to agricultural and residential applications. For example, in agricultural applications permethrin is often applied at a rate thirty-five times greater than is applied for adult mosquito management. In a sense, then, the risk from outdoor space applications for adult mosquitoes is just a small fraction of the risk from agricultural applications. But is that risk acceptable or unacceptable?

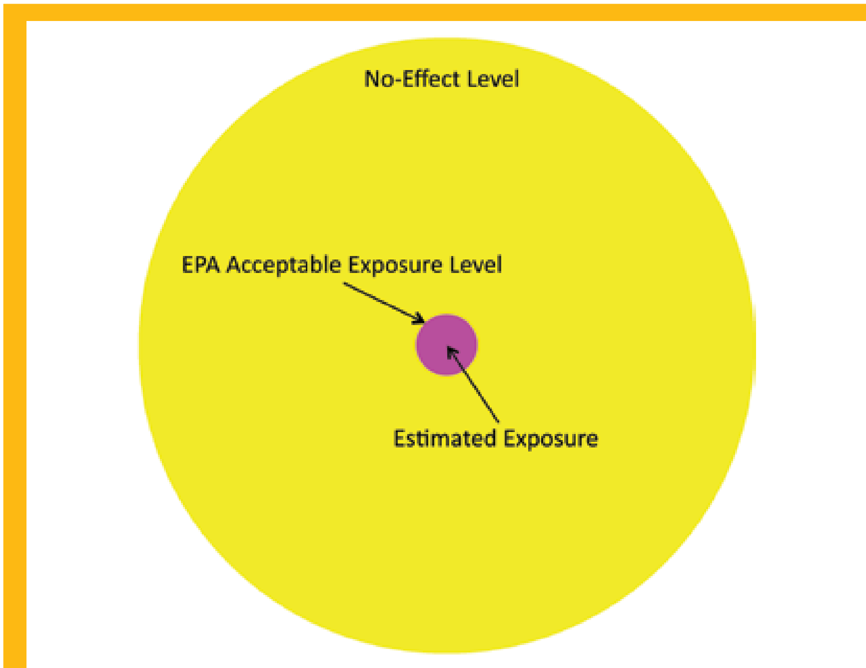

Figure 1: Estimated exposure of a person to the adulticide permethrin (0.000025 mg/kg body weight), compared to the US EPA's Acceptable Daily Exposure Level (0.25 mg/kg body weight) and the No-Effect Level (25 mg/kg body weight). The Acceptable Daily Exposure Level is the amount of chemical that an individual can be exposed to over a lifetime without experiencing any toxic effects. The No-Effect Level is the exposure at which no toxic effects have been observed in a series of laboratory animal experiments.

The weight of scientific evidence from independent research and regulatory agency assessments strongly suggests that exposures to people from outdoor space applications of mosquito adulticides are well below threshold levels of concern (2,5,8-20). Epidemiology and biomonitoring studies (21-25) support the results from these risk assessments. Exposures to mammals, birds, fish, and aquatic invertebrates are also below levels of concern (19,26-35). These assessments include short- and long-term exposures from single and multiple applications. Risks are low even for many terrestrial insects because the applications target flying mosquitoes at night (26,27,32,35,36). Risks to people, mammals, and birds are extremely low. For example, a person's exposure to permethrin as a result of an outdoor space application would be less than one ten-thousandth of the threshold exposure level (8,19,37); see Figure 1.

What about the risks from other mosquito management tactics such as larvicides, personal repellents, and insecticide-treated clothing and bednets? Here, too, research over many years and from many researchers indicates that exposures are below levels of concern, provided that these tactics are properly used (18,29,38-44). However, the use of the western mosquitofish, a biological control organism, may present unacceptable risks to fish and aquatic invertebrates where the fish is not currently endemic (45).

Mosquito management is essentially part of a broader public and environmental health enterprise. In mosquito management, we use an Integrated Pest Management (IPM) approach. This involves identification of mosquito species and surveillance of their populations. When populations of larvae, pupae, adults, or pathogen-infected adults reach pre-established threshold levels, actions may be taken to lower those populations below the thresholds. These actions may involve several tactics. When adult mosquito or disease thresholds have been breached, adulticides may be used. As we have seen above, the use of adulticides by health professionals can reduce infected mosquitoes and resultant disease. And, as we have seen, when these adulticides are used in outdoor space applications, the risks are below levels of concern.

In the US, West Nile virus and many other pathogens are alien, invasive organisms. The diseases these pathogens cause pose human health and economic problems for our society, and they pose environmental problems for ecosystem functioning and biodiversity. As part of the public and environmental health enterprise, mosquito management professionals are charged with the well-being of their particular local areas. If we are to put science in its rightful place, science should inform our understanding of risk and the societal decisions that need to be made about mosquito and disease management. The weight of scientific evidence shows that mosquitoes and the pathogens they carry can cause appreciable risks to public and environmental health. When mosquito populations need to be managed, IPM tactics are used that have been shown to be effective and to result in risks that are below levels of concern. Science, then, is put in its proper place by providing the facts that are used to make the best decisions to protect our health and the environment.

For more information and a complete list of citations from this article, see the West Nile Virus, Mosquito Management, and Risk website at: http://landresources.montana.edu/WNV/.

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