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About the Cover: The cover image was contributed by Katie Hegge meier, Mosquito Control Manager, Lee County Mosquito Control District, Lehigh Acres, FL. The photograph, showing newly emerged Aedes taeniorhynchus adults clinging to vegetation, was taken in June 2010, near the Orange River in Buckingham, FL.

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INTRODUCTION
When mosquito research turns from an emphasis on field work to laboratory testing, the need for a dependable source of test subjects becomes essential. To raise mosquitoes in the lab in sufficient numbers for testing and propagation requires a reliable source of protein, ie, blood, for them to produce viable eggs. Formerly, lab animals served this function, including rats, mice, rabbits and birds.

The chicken proved to be the best choice for ease of care and use and expense relative to the other animals. There are pros and cons to chicken use. Pros include consistent egg production and acceptability by most species. Cons include the expense of chicken feed, ketaset (used to anesthetize lab animals), alcohol, syringes and time and labor, general care, cleaning and ultimate humane disposal. Concerns over the humane treatment of animals have led to ever increasing costs in housing and maintenance, prompting the need for an alternative source of blood. Some people who are keeping only a small number of female mosquitoes might be tempted to use their own arm to feed the cage. Unless the mosquitoes are from an absolutely proven disease-free source this is risky when other methods are available. It is also very uncomfortable!

ARTIFICIAL DELIVERY METHODS
Although using live anesthetized chickens for blood meals result in optimal mosquito egg production, for financial and humane reasons, artificial methods of delivering purchased chicken blood are now used by most that rear mosquitoes; see Figure 1. A few of these methods will be discussed in this article.

Figure 1: A chicken is injected with ketaset to anesthetize it for about 2 hours for mosquitoes to feed.
Suppliers of chicken blood offer a variety of anti-coagulants in a range of doses. Past in-house research at the Public Health Entomology, Research and Education Center (PHEREC), Panama City FL, showed EDTA (ethylene-diamine-tetra-acetic acid) provided sufficient and economical anticoagulation without any noticeable effect on the mosquitoes. Some species feed well on blood-soaked-cotton, but others, like all of PHEREC’s Aedes species, require a blood-filled lambskin condom suspended in the cage and kept warmed for adequate feeding levels. While some mosquitoes will feed off latex condoms, natural membranes have been preferred by most of PHEREC’s colony mosquitoes.

*Culex quinquefasciatus* is one species that will feed readily on cotton soaked in blood and placed in a bowl. All that is needed is a beaker to hold the blood, a beaker of hot water to warm it, a bowl for each cage to be fed and cotton to act as a sponge; see Figures 2-4. The blood is poured over the cotton until it is soaked but not pooling. If any blood pools in the bowl, cotton can be added to soak it up. The bowl is then placed in the cage for 24 hours. The drawback to this method is that as the blood dries it gets sticky and many mosquitoes can be caught in it. However, observations at PHEREC have shown these to be mostly males.

Many newer cages have a screen “trough” in the top where a blood-filled condom can be placed and the mosquitoes will feed on it from below; see Figure 5. This eliminates the problem of mosquitoes escaping into the room when introducing blood or removing old blood from cages. It also eliminates the need for a “spacer” to save on blood as the condom will lie on its side maximizing the amount of blood always available to the mosquitoes below. The condom only needs to be filled, tied off and heated. The date of each feeding is written on a tag on the front of the cage. *Culex* species should not be “egged” until they have been fed at least 3 times or they may try to lay before their eggs are ready and drowned.
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For cages without screen troughs the “tower” method may be used; see Figure 6. A small tower is made from a plastic refrigerator dish with the sides cut out for mosquito access. The condom is filled with blood and a “spacer” test tube of hot water is inserted to take up space inside and decrease the amount of blood used. This is tied off and warmed in a beaker of hot water. Once warm, the end of the condom is inserted through the hole on top and is wrapped around a thin stick (chop sticks cut up in short lengths work best) and a metal clip holds it in place. This helps prevent the condom from falling from the tower and breaking on the bottom of the cage. The whole tower is then put inside the colony cage. Care must be taken to minimize mosquitoes from escaping when putting the tower in or taking it out of the cage.

Figure 4: Inside the cage, *Culex quinquefasciatus* swarm the blood cottons.

Figure 5: A blood-filled condom is placed in a screen trough for easy access by mosquitoes without having to open the cage.
A less expensive alternative to the lambskin condoms is natural sausage casing; see Figures 7-9. It is more delicate than lambskin and must be handled with care. Prior to use, it should be stored in a humid area or it will dry out and break when used. One end is tied with a double knot, a funnel is fitted into the open end and the blood is poured in. The open end is tied off and the blood filled casing is put in hot water to warm up the blood. When it is heated it is carefully patted dry and either placed in the trough or hung from the plastic tower. It can be re-heated several times but risk of breakage increases with more handling.

Except for *Culex quinquefasciatus*, most of the mosquito species at PHEREC prefer blood to be warm for vigorous feeding. Whichever method is chosen for delivery, the use of the blood may be maximized by either reheating or keeping it warm to approximate the body temperature of humans or animals. For a single cage with a trough net, a heating pad may be placed over the condom or casing to keep it warm all day. For many cages this may be impractical, but hot water bottles could substitute for heating pads. To warm from underneath, heated “reptile rocks” or hot water bottles could be used. Simply dropping loose condoms into a beaker of hot water to soak for several minutes will reheat the blood and can be done several times a day. For the tower method, attaching the condom to a support while submerged in a beaker of hot water will work. If the condom is too short to be submerged putting something under the beaker will raise it up enough to heat all the blood. The condoms or casings will need to be carefully patted dry after each warming.
CONCLUSION

The use of artificial methods of blood delivery can seem time consuming and expensive compared to the reliable chicken in the cage. However, the costs are usually less in the long run and free the employees from chicken care and euthanasia. Although the rate of blood intake and the egg production may be less in mosquitoes fed with artificial methods, it is possible to feed cages around the clock if necessary. It is also possible to feed a larger number of cages than most would want to feed with live birds. Materials are relatively inexpensive and easy to dispose of, and blood may be stored frozen for months or years. Discontinuing live animal use is now possible with these easy-to-use artificial methods of blood feeding mosquitoes. Humane concerns about animal care and treatment are no longer an issue.

Figure 8: Two blood casings being warmed.

Figure 9: Two blood casings heated and ready to put in cage or trough.

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Effective insecticide resistance management is essential to all integrated mosquito management programs. The Insecticide Resistance Action Committee (IRAC) was established to make this a reality.

IRAC is an inter-company organization that operates as a Specialist Technical group within the industry association Crop-Life International. IRAC is also recognized by the Food and Agricultural Organization (FAO) and the World Health Organization (WHO) of the United Nations as an advisory body on matters pertaining to insecticide resistance.

IRAC was formed in 1984 to provide a coordinated crop protection industry response to prevent or delay the development of resistance in insects and mites (McCaffery and Nauen, 2006). Essentially, the goal of IRAC is stewardship of agricultural and public health pesticides.

In 2011 IRAC published the second edition of “Prevention and Management of Insecticide Resistance in Vectors of Public Health Importance” a manual targeted at managers of mosquito control programs, operational staff, and policy makers. The manual clearly presents the importance of insecticide resistance, why avoiding it is essential and provides tools to do so. Dr Bill Brogdon and Dr Bob Wirtz of the Centers for Disease Control and Prevention (CDC) contributed to the second edition.

The objectives of the manual are:

- To offer basic information on insecticide resistance mechanisms;
- To provide a better understanding of the factors that may lead to the development of resistance in insect vectors;
- To present the basic principles for maintaining susceptibility and avoiding the development of resistance;
- To effectively manage resistance where it has already developed.


The IRAC web site http://www.irac-online.org provides resources on the mode of action of all currently used pesticides. The document http://www.irac-online.org/wp-content/uploads/2009/09/MoA_Classification.pdf is particularly useful. Understanding mode of action and rotating active ingredients is one of the basic principles of effective insecticide resistance management.

We encourage Wing Beats readers to become familiar with IRAC and its useful resources.

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A Customer Satisfaction Survey Analysis of Anastasia Mosquito Control District
by J Adam Holt, Rui-De Xue, Jeanne Moeller and Gina LeBlanc

St Augustine, Florida is considered the oldest city in the nation and one of the top tourist destinations in the world. This reinforces the fact that the residents require constant satisfaction of their intense desire to live in an environment free of vectors and nuisance pests. Although it is virtually impossible to eliminate nuisance pests, St Johns County has been free of any human cases of mosquito-borne arboviruses such as West Nile virus and Eastern Equine Encephalitis since 2003. The goal of the Anastasia Mosquito Control District (AMCD) is to protect the residents of St Johns County from mosquitoes and the diseases they transmit. In early 2006, AMCD decided to begin an annual customer satisfaction survey in hopes to gain invaluable knowledge on how the local residents viewed the services they were receiving. The purpose of the survey was to improve the district’s customer service program.

Geographically, St Johns County covers 631 square miles. AMCD services and protects approximately 185,000 residents.

In 2006 and 2007, AMCD randomly chose 500 residents from the local St Johns County phonebook to survey.

In 2008, AMCD randomly chose 250 residents from the local St Johns County phonebook and 250 residents from the VCMS (Vector Control Management System) database to survey.

In 2009 and 2010, AMCD randomly chose 500 residents from the VCMS database to survey. The reason for change in the survey distribution method is because the residents randomly chosen from the VCMS database are residents who previously submitted customer service requests. The information was more pertinent if it came from residents who were actually receiving the mosquito control service versus residents chosen from the phonebook who might not have received any service, much less even known what mosquito control operations include, ie, inspection, monitoring, adulticiding and larviciding, arbovirus surveillance, public education, etc.

The cost for each survey was about $1,000 per year, including stamps, envelops, copies, and labor. The average cost per individual survey was about $2.

During the period 2006-2010:

The survey return rate averaged approximately 30%, and the respondent rate from residents chosen from the local phonebook (22.7%) was less than the response from residents chosen from the VCMS database (37%); see Figure 1.

About 78% of the population surveyed agreed that the goal of AMCD is to protect the community from mosquitoes and mosquito-borne diseases by

Figure 1: The Anastasia Mosquito Control District survey return rate has averaged approximately 30% over a 5 year period.
reducing nuisance and disease spreading mosquito populations; see Figure 2.

About 79% agreed that AMCD staff is informative and professional; see Figure 3.

About 77% agreed that AMCD’s staff responds to service requests within 1-2 business days; see Figure 4.

About 96% agreed they were aware of the measures they could take to protect themselves from mosquitoes and mosquito-borne diseases by practicing the 5 D’s of Prevention; see Figure 5.

- Do not go outdoors at DUSK & DAWN when mosquitoes are most active;
- Protect against bites, DRESS so your skin is covered with clothing;
- Apply mosquito repellent containing DEET to bare skin and clothing;
- Empty containers and DRAIN stagnant water so mosquito larvae do not grow up to become biters.

Public opinion regarding mosquito problems and the need for controlling these insects in an organized mosquito control district is a very complex social issue to assess. John, Stoll and Olson (1987) received 40.5% responses through a mail survey of randomly-selected property owners and renters. Farmer et al. (1989) observed 88% of their responses were received through a random sample of 600 residents by telephone. Those that responded to the survey varied based on if they had directly received service in the past (Morris and Clanton, 1992; Read et al, 1994). People who requested mosquito control services before usually provided more responses. Survey methodology must still be considered even if most responses originated from the residents chosen from the VCMS database.

Over the past five years, AMCD has developed new survey methods, using a new technologically advanced website to include online service requests and up-to-the-minute fogging information integrating VCMS and MapVision, a real-time database management program.
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INTRODUCTION

Florida’s warm subtropical and tropical climate, abundant rainfall, and extended coastline support an extraordinarily rich fauna, including at least 80 species of mosquitoes. Chemical control, one of the principal components of Integrated Mosquito Management (IMM) in Florida, is frequently conducted, either by ground or aerial applications, in highly populated areas which may be adjacent to water bodies and wetlands. In order to enforce the label application rate and ensure the proper usage of pesticides for mosquito control in Florida, the Florida Department of Agriculture and Consumer Services (FDACS) mosquito control section, the leading state agency responsible for regulating and supervising mosquito control activities, and enforcing the Florida Mosquito Control Law (Chapter 388, Florida Statutes), instituted a program requiring about 60 state-approved mosquito control programs to submit monthly pesticide use records to the Department. This was mandated so that the chemical usage in the State for mosquito control could be tracked systematically. The resulting FDACS database contains information including the pesticide product name, active ingredient, total amount of product and active ingredient used, total acres treated, application rate (lbs/acre) and frequency of use by ground and aerial application. In this paper, ground and aerial applications of pesticides for mosquito control in the State have been compiled and analyzed for the years 1998 through 2010.

CHEMICAL CONTROL OF MOSQUITOES IN FLORIDA

When large numbers of immature mosquitoes are detected in the areas where source reduction or biological control is not available, larvicidal treatment offers the best option in preventing the emergence of adult mosquitoes. Three categories of larvicides have been registered and used extensively in Florida. These include contact pesticides (organophosphates, pyrethroids, insect growth regulators, and chitin-synthesis inhibitors), surface control agents (larviciding oils, monomolecular surface films), and stomach toxins (Bacillus thuringiensis israelensis [Bti] and Bacillus sphaericus [Bs]). Insecticide applications directed against mosquito larvae is an important component of an IMM program. Larviciding is the most efficient type of temporary control. An important part of the mission is to prevent, or significantly reduce, adult mosquito annoyance to humans, pets, and domestic livestock, as well as mitigate mosquito-borne disease outbreak. It is easier and more economical to control or substantially diminish a brood of mosquitoes while they are concentrated as larvae in an aquatic habitat, than to control them as adults. Larvicides are applied using manually carried or vehicle-mounted spraying equipment or from specially equipped aircraft. Ground equipment application is economical and has the advantage of being able to specifically apply insecticides to larval development sites only. In contrast, with aerial application an entire area is treated and much insecticide can fall on non-aquatic habitat. However, aerial applications are needed when large areas must be treated within the available treatment window. Aircraft are able to apply insecticide evenly over large areas that would be difficult or impossible to traverse on the ground.

The disadvantage to the use of larvicides is the requirement for extensive logistical preparation, trained personnel, relatively high product cost, and specialized
Efforts to prevent large flights or swarms of mosquitoes in Florida are impacted by a variety of factors including local heavy precipitation, flooding, high tides, hurricanes, inaccessible or missed larval habitats, or human disease outbreaks. Adulticiding is the most effective technique to control large adult mosquito populations, resulting from these conditions, particularly when the population is localized or when spraying is carried out uniformly over a large area to prevent re-infestation of treated areas. It is also one of the most visible forms of mosquito control and can contribute to public apprehension. Both ground and aerial application of adulticides are common methods to combat these pestiferous and disease vectoring mosquitoes in Florida. Typically, the treatments are either through ultra low volume (ULV) or, less frequently, thermal fog spraying.

Adulticides registered and used in Florida include two classes of pesticides: organophosphates (malathion, fenthion, naled and chlorpyrifos) and pyrethroids (natural pyrethrins, permethrin, resmethrin and others). Reports indicate that as of FY08, 100% of MCDs have adulticiding programs that utilize either ground or aerial application of pesticides. In terms of aerial adulticiding, it may be the only means of quickly controlling severe mosquito outbreaks in a large area following a hurricane or during an outbreak of mosquito-borne diseases.

APPLICATION DATA ANALYSIS: LARVICIDING vs ADULTICIDING

Figure 1 shows the total acreage treated by mosquitoicides (both larvicides and adulticides) in Florida from FY98 to FY10. During this period, a total of 366 million acres were treated, an average of 28.2 million acres annually, with a range of 18.5 (FY07) to 35.7 (FY03) million acres. The total acreage

![Figure 1: Acres treated with larvicides and adulticides during the reporting period FY98 - FY10.](image1)

![Figure 2: Total acres treated by aerial and ground application of larvicides during the reporting period FY98 - FY10.](image2)
treated by mosquitocides varied annually, presumably due to fluctuation in mosquito density, risk of mosquito-borne diseases, meteorological conditions and mosquito control budgets. The total acreage treated peaked in FY03 with a total of 35,658,990 acres. The highest occurrence of West Nile virus (WNV) activity in the State was reported that year, with a total of 122 human cases, 119 equine cases and 1,194 positive sentinel birds (http://diseasemaps.usgs.gov/).

Large areas were treated in FY03 (32,479,004 acres) and FY04 (31,316,988 acres) as the result of successive hurricanes directly hitting Florida. The resultant flooding caused widespread mosquito populations in the State. The acreage treated declined in FY06 and FY07 due to severe drought and decreasing incidence of WNV: 3 human and no equine cases in 2006, and 3 human and 7 equine cases in 2007. Mosquito control activities increased moderately in FY08 and FY09, partially due to natural disasters such as Tropical Storm Fay in 2008 and spring flooding in 2009.

Despite the fact that larvicide use in Florida has never contributed significantly to the total acreage treated with mosquitocides each year (no more than 2%), larviciding is still believed to be one of most effective mosquito control strategies and has played a significant role in preventing a larger number of larvae from emerging into adults. Choosing an appropriate larvicide control product and formulation, timing of application and application rate are crucial for a successful larviciding program. Larviciding is particularly effective against floodwater mosquito species, such as Aedes taeniorhynchus, Ae sollicitans, Psorophora columbiae and...
Culex nigripalpus, when highly concentrated broods of larvae exist. Figure 2 shows the acreage treated by larvicides during this period. Records indicate that the total larviciding acreage has never exceeded 450,000 acres, with an average of 378,943 acres annually. The peak larvicide activity was recorded in FY01, with a total of 428,784 acres, over 60% being treated by ground applications. Interestingly, a steady increase of both actual acres and percentage treated by aerial larviciding has been noticed in the last 5 years. This is presumably due to a rise in the aerial larviciding capacity in some MCDs.

Figure 3 shows only FY01-10 data because the data were not separated between aerial and ground prior to FY01. Clearly, aerial larvicide applications can be accomplished on a large scale within a short period of time, and overcome unsuitable and/or inaccessible ground conditions where ground application is not a viable alternative. In terms of the choice of larvicides, temephos and Bti are the two most popular choices for MCDs, as over 80% of the total acreage was treated by these two combined; see Figure 4. In terms of formulation and products, emulsifiable concentrate (Abate 4E) and aqueous suspension (VectoBac 12AS) were the top choices, respectively. In terms of percentage of treated

Figure 3: Acres treated by aerial and ground application of larvicides to control mosquitoes in Florida during the reporting period FY01 - FY10. The number on top of each bar indicates the percentage treated by air.

Figure 4: Acres treated (combined aerial and ground) by individual larvicides to control mosquitoes in Florida during the reporting period FY98 - FY10. The number on the top of each bar indicates the percentage of total acres treated with an individual larvicide.
acreage, temephos was the greatest used prior to FY00 when compared with Bti (46% vs 25% in FY98, and 52% vs 27% in FY99). The use of Bti surpassed temephos for the first time in FY00 and thereafter except FY01. Bti’s greatest use was in FY04, accounting for over 74% of total larvicide treated acreage. Even though total acres treated by temephos has rebounded moderately between FY06 and FY08, Bti is still the larvicide of choice, accounting for an average of 45% of the total area treated, due to its low mammalian toxicity and favorable environmental profile. In contrast, only 41% of the area was treated with the larvicide temephos between FY06 and FY08.

Between FY98 and FY10, adulticiding remained the most common and accepted method of mosquito control in Florida, with over 97% of treated areas using adulticides; see Figure 1. Synthetic pyrethroids, such as permethrin, have replaced organophosphates (OPs) as the adulticide of choice for mosquito control in recent years; see Figure 5. Pyrethroids are being more widely used by MCDs due to less odor and less impact on vehicle finishes. They are easier to handle in terms of required personal protective equipment, and cost less than other products. However, most notable is the public perception that pyrethroid active ingredients are “natural” chemicals, and therefore more acceptable. The most common product formulations used containing a pyrethroid were Biomist and Kontrol 30-30 and Biomist and Kontrol 4-4.

In contrast, because OPs have been used for mosquito control since the 1950s, the incidence of mosquito resistance to malathion, chlorpyrifos, and fenthion...
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have been reported in localized areas. Therefore, their usage dropped from a peak of 20 million acres in FY99 to only 5 million acres in FY07. Notably, fenthion, frequently used from FY98 to FY03, was phased out completely from the State’s mosquito control arsenal in 2003, due to concerns over impact on non-target wildlife and the environment. In terms of adulticides, naled and permethrin were most commonly chosen for aerial and ground applications, respectively.

**ADULTICIDING DATA ANALYSIS: AERIAL VS GROUND TREATMENTS**

Aerial application of pesticides to control mosquitoes has proven to be an extremely effective and flexible alternative to treat areas partially accessible or inaccessible by ground equipment. Another advantage of aerial application is when large areas need to be treated in a short period of time to achieve optimum control. This is commonly the case when mosquito outbreaks occur after hurricanes or if there is a serious threat of vector-borne disease in an area. In some cases, up to five times the amount of active ingredient is permitted by aerial application as compared to ground. However, aerial application also possesses some of disadvantages over ground applications. For example, aerial application is expensive when comparing cost per acre and maintaining the aircraft. There also safety concerns that must be addressed with aerial applications at night, as well as public concerns of pesticide exposure due to the spray drift.

Aerial adulticiding can be administered through low volume spraying, thermal fogging and ULV aerosols. The most common technique is ULV, using fixed wing and rotary aircraft as platforms. Figure 6 shows acres treated by aerial and ground applications of adulticides during FY98-FY10. During this period, aerial applications reached a maximum of 9.74 million acres in FY04, and the lowest acreage treated occurred in FY07 with only 4.25 million. The percentage of acreage treated by air ranged from 20.2% (FY01) to 35.5% (FY06). Aerial adulticiding has never accounted for the majority of total area treated, since less than one-third of the MCDs have the capacity. In terms of choice of adulticide, naled was the primary adulticide for aerial programs, because of its efficacy and environmentally friendly profile. Figure 7 indicates that naled treatments covered from 63% (FY98) to 97% (FY05) of total area treated aerially with an adulticide. Fenthion was the next most common aerially applied adulticide during the earlier part of this period, from FY98 to FY02. Malathion, natural pyrethrins and other adulticides are minor-use products in terms of acres. Etofenprox, a
Figure 7. Acres treated by aerial applications of individual adulticides for the control of mosquitoes in Florida during the reporting period FY98 - FY10.

Figure 8: Acres treated by ground applications of individual adulticides for the control of mosquitoes in Florida during the reporting period FY98 - FY10.
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non-polar synthetic “pyrethroid-like” new active ingredient and mosquito adulticide was registered and used in Florida for the first time in FY09. When permethrin first became available in the late 1980s, concerns over possible toxic effects on non-target aquatic organisms led State regulators to prohibit its aerial application, by requiring labels to state: “In Florida: Do not apply by aircraft unless approved by the Florida Department of Agriculture & Consumer Services.” However, FDACS-funded research into the non-target impact of aerial applications eased those concerns, and by 2009 FDACS began giving conditional approval for permethrin use by air.

Ground application of pesticides still remains the most popular method for controlling adult mosquitoes in Florida, averaging 73% of the total area treated; see Figure 6. All Florida MCDs have ground application capacity, possessing at least one vehicle-mounted ULV sprayer. Timing, meteorological conditions, dose and pesticide type are a few factors that can significantly affect the outcome of an application. Since different mosquito species are active at different time periods, timing the application is one of the keys to successfully target actively flying mosquitoes. Unfavorable meteorological conditions such as wind speed, heavy precipitation and temperature at the time of application may significantly reduce treatment efficacy. Depending on the target mosquito species, habitat and behavior, the adulticides to be applied and the dose rate must be well planned. Data collected from this period indicate that permethrin and malathion are two principal adulticides used in ground applications; see Figure 8. These two compounds were used to treat from 56% (FY98) to 99% (FY09) of total area treated with adulticides. As Figure 8 shows, malathion and fenthion, two OPs, were two adulticides favored early in the reporting period. However, with constantly increasing use of pyrethroids, especially permethrin, pyrethroids surpassed OPs as the top choice in adulticides starting in FY01. For instance, in FY09, permethrin was used to treat 18 million acres, accounting for 90% of the total area. In contrast, the acreage treated by malathion was down to 1.3 million acres, constituting only 6.5% of the total. Naled, pyrethrum, resmethrin and sumithrin were the minor use products used for ground application during this period.

LARVICIDING DATA ANALYSIS: AERIAL VS GROUND TREATMENTS

Knowledge of the target mosquito, properties of the larvicides and timing of the application
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are the basic requirements for a successful larviciding program. An effective larvicide treatment should result in reducing the number of adults and risk of disease transmission. However, though it is one of the most desirable methods for mosquito control, not all MCDs have reported any larviciding activity during this period. A larviciding program is more complex than adulticiding because the program must possess a thorough knowledge of target species biology, and be able to conduct field surveys, identify larvae, map breeding sites, select the appropriate control agent and formulation, and conduct follow-up efficacy checks. Therefore, MCDs with limited budget and manpower would not be able to effectively execute this strategy. Figure 3 shows the acres treated by aerial and ground applications of larvicides during the period FY01 - FY10. With the exception of FY04, the acreage treated by air has been steadily increasing. It appears that aerial larvicide application has played an important role in many mosquito control programs due to the ability to access remote areas and ease of equipment calibration. In terms of choice of larvicide, Bti and temephos were the first and second most used. For example, use of Bti plus temephos covered 90% of the total acres treated by air in FY06; Bti alone covered 55% of total area. The most common products being used in this period were 4.95% Bti and Abate 4E; see Figure 9. Methoprene and Bs accounted for less than 5% over the entire reporting period. There was also limited use of oil and film products in this period. Bti and temephos were also the most commonly used ground-applied larvicides; see Figure 10. Peak Bti applications occurred in FY04 and FY05, and to a lesser degree in FY06 and FY07. The peak in application of temephos occurred in FY01, covering almost 45% of total area treated. The lowest application occurred in FY05, where temephos was applied to only 3% of total area treated. Methoprene, Bs, oil and film have contributed insignificantly in terms of total acreage. For the first time in 50 years, a new active ingredient, spinosad, was registered and used for larval control in Florida during 2009; a total of 957 acres was treated with spinosad in FY10.

DISCUSSION

Historically speaking, mosquito control has played a prominent role in shaping the State of Florida. Chemical control, as one key IMM strategy component, must combine with others such as source reduction, biological control, and public education to accomplish long-term, sustainable and environmentally sound mosquito control.
Presently, chemical control is facing numerous challenges including significant gaps in novel control tools/chemicals, re-emerging and introduction of new mosquito-borne diseases, growing environmental concerns, and new government regulations. A perfect example is the new requirement imposed by the US Environmental Protection Agency (EPA) to obtain a National Pollutant Discharge Elimination System (NPDES) permit for mosquito control pesticides discharged to or over waters of the US. In addition, there is potential for mosquito control programs to lose two of the more important adulticides, malathion and resmethrin. The EPA is planning to revoke certain tolerances for malathion, which is used in many MCDs throughout the country as both a frontline adulticide and as an integral component of resistance management programs. The action to eliminate use will severely compromise vector-borne disease control efforts with respect to mosquito control in addition to resistance management programs. In 2010, EPA issued a notice of receipt of requests by registrants (including Bayer, which manufactures Scourge) to voluntarily cancel all remaining registrations of products containing the pesticide resmethrin due to the high cost of re-registration. The requests would terminate resmethrin products registered for use as a wide area mosquito abatement adulticide in the United States.

The recent outbreak of dengue fever in the Florida Keys provides more challenges for mosquito control. Dengue had been eradicated from Florida since the 1940s, but re-emerged in Key West in 2009. Despite these challenges, Florida’s complicated ecosystem provides countless habitats conducive to producing large populations of nuisance and disease-vectoring mosquitoes. Therefore, chemical mosquito control will remain essential for the prosperity of Florida for a long time.

Several important changes in mosquito control operations have been noted during this period: (1) pyrethroids have replaced OPs as the adulticide of choice and permethrin became the single most used adulticide for ground adult mosquito control; (2) fenthion was eliminated from the mosquito control arsenal, but etofenprox, the first new chemistry in decades, was added; (3) FDACS relaxation of the permethrin label prohibition of aerial application has increased its use in Florida; (4) an effort has been made to increase larviciding in most MCDs, particularly aerial applications; (5) a new mosquito larvicide, spinosad, was recently registered and used. These changes have brought about both challenges and great strides for future chemical control in Florida. For example, ground application of adulticides has relied almost exclusively on permethrin. Over-dependency on this product could eventually lead to resistance despite absence of documented reports from Florida. Etofenprox, although considered a new active ingredient for adult mosquito control, shares a similar mode of action with pyrethroids. Therefore, there is a potential that an increase in application frequency of etofenprox may result in cross-resistance between permethrin and etofenprox. In addition, FDACS policy changes allowing for conditional approval of aerial application of permethrin have already resulted in increasing its use, consequently putting more pressure on the development of resistance to permethrin. Thus, regular monitoring for insecticide resistance is a critical part of an IMM program and can provide early warning so that corrective measures can be taken. Use of alternative classes of active ingredient, and increased larval control, combined with other control techniques, such as source reduction and rotation of chemical classes, will result in sustainable maintenance of successful mosquito control in Florida.

We thank Dr Davis Daiker, Environmental Administrator, Bureau of Pesticides, FDACS, for his review of this paper.
The Michigan Mosquito Control Association will be hosting its 26th Annual Meeting in 2012.

The meeting will be held at the Thomas Edison Inn, located at 500 Thomas Edison Parkway, Port Huron, MI 48060.

For more information, please contact Planning Chairman Pat Hallahan at phallahan@clarke.com or visit the MMCA website at www.mimosq.org.

**FEBRUARY 1 - 2, 2012**

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**MARCH 27 - 29, 2012**

The 9th Annual Arbovirus Surveillance and Mosquito Control Workshop will be held at the Anastasia Mosquito Control District of St Johns County, at the AMCD main office in St Augustine, FL, from March 27 to March 29, 2012.

For more information, please contact Jessica Phillips at 904-471-3107 or visit the AMCD website at www.amcdsjc.org.

**PASCO COUNTY MOSQUITO CONTROL DISTRICT**

**POSITION OPENING: OPERATIONS SUPERVISOR**

Application Process: Interested individuals should submit a cover letter and a current resume that includes three verifiable references.

Please direct all correspondence to: Pasco County Mosquito Control District, Attn: Dennis Moore, Director, 2308 Marathon Rd, Odessa, FL 33556. Or electronically: dmoore@pascomosquito.org

Starting Salary: $55,000

Starting Date: March 6, 2012 • Anticipated Start Date: April 2, 2012

Minimum Requirements: BS in the Biological Sciences/Entomology is highly preferred, plus 3 years of experience in a mosquito control program or related field. Must be legally permitted to work in the United States. Must obtain a Florida drivers License and a Public Health Pest Control License issued by the state of Florida within 3 months of employment.

Nature of Work: Employee supervises and coordinates the adult surveillance and ground/aerial adulticiding programs and is responsible for monitoring the larval inspection findings with the adult surveillance results. Duties include oversight of all field staff and direct supervision of any employees while on adulticiding assignments. Technical direction is provided by the Director, but the employee is expected to exercise considerable independent judgment and to accomplish all work with minimal supervision.

Job Description: The position entails very specialized work involving all phases of mosquito control operations with supervisory responsibilities. The operations supervisor will:

• Help to coordinate evaluation of pesticides and calibration of application equipment.

• Manage personnel operating ground adulticiding equipment.

• Plan field operations involving the ground and aerial adulticiding program. Assigns the areas to be treated, schedules and maps the ground/aerial missions, monitor weather conditions and adjust missions as needed.

• Check the application equipment for compliance with the registered labels.

• Manage the adult surveillance program, including ID work and data entry as needed.

• Handle most of the service requests which are beyond the scope of the receptionist.

• Record and maintain records of the monthly inventory of all pesticides and vehicle usage.

• Manage the sentinel virus surveillance program, including the weekly bleeding of sentinel chickens.

• Initiate or participate in mosquito related research projects.

Experience desired in the use of office software such as Excel, Word, Power Point, and GIS software such as MapInfo or ArcGIS, as well as the ability to prepare reports, graphs, charts, or other visual data.
By the time you read this, the National Pollutant Discharge Elimination Permit System (NPDES) general permit will have taken effect and mosquito control agencies will have begun to feel its effects. I have sworn (at least for the time being) to forego further comment, as it’s been a painful process and has involved some of the worst aspects of regulatory and judicial overreach. The petty politics, partisan insincerence, disingenuous demagoguery, and complete disregard for the citizenry by some parties have been truly sickening to observe. To be sure the present battle to fix the process has been lost, despite the herculean efforts by Dave Brown and myriad others. But we must now reformulate strategies, remobilize resources and prepare to win the war. ‘Nuff said.

I’ll admit that the day the NPDES went in to effect was a particularly sad one for me because of the enormous amount of energy expended in our futile attempt to stave off this shining example of superfluous regulation. Yet, as luck would have it, November 1st was made even worse by the following e-mail I received (copied verbatim), for it demonstrates the mindset of the forces arrayed against us that brought about the Clean Water Act (CWA) debacle:

Are you aware that the use of the Vector Mosquito Control products is the cause of bumblebee deaths here in North Carolina? Due to the current crisis of Colony Collapse Disorder, we as a society cannot afford to poison our bees any further. Though my county sprayed mosquitocide at least one a month I was constantly bothered by the pests, bitten hundreds of times throughout the summer. Clearly, the products are not effective in their intended use but are effective in the slaughter of other insects. This is unacceptable and immoral. I ask you, as the leading informational site on mosquitocide, to include scientific surveys and articles on the damage done to other insects that may be important to our food sources, to the environment. I could find no such information on your webpage thus far.

Sincerely,

concerned citizen of the US and of this planet

---

**New Product Announcement**

**Floating Emergence Trap for Culex in Catch Basins**

This novel emergence trap was developed and evaluated in the field at Michigan State University for the collection of *Culex pipiens* and *retranz* and in Indonesia for the collection of *Aedes aegypti* and *albopictus*. Model 619. (Hamer et al. 2011. *JAMCA* 27(2):142-147)
Dear Concerned Citizen,

I share your concern about the potential devastating effects of Colony Collapse Disorder (CCD). In fact, I'm a member of an EPA advisory committee that has investigated this phenomenon along with several scientific advisory groups consisting of the world's preeminent experts on the subject. In all published peer-reviewed studies involving CCD to date, pesticides have been mentioned as, at most, a secondary or tertiary contributor to CCD. Be advised, though, that the insecticides of which they speak are those used to control Varroa mites and other colony invaders. Public health pesticides used in mosquito control have never been implicated in CCD and there are a number of reasons for this. First, the mosquitocide label (a legal document) prohibits their use when bees are active. This necessitates the district alerting beekeepers of upcoming sprays to allow the beekeepers to either move their hives or cover them. Secondly, sprays are conducted in the evening when bees are no longer foraging and back in the hive. Thus, they are not contacted by the mosquito sprays. Third, the extremely small droplet aerosols utilized in adult mosquito control are designed to impact primarily on adult mosquitoes that are on the wing at the time of the application. Degradation of these small droplets is rapid, leaving little or no residue in the target area at ground level. These special considerations are major factors that favor the use of very low application rates for these products, generally less than 4 grams active ingredient per acre, and are instrumental in minimizing adverse impacts.

This mitigation of environmental damage did not come about in a regulatory vacuum. Since its inception, the Environmental Protection Agency (EPA) has regulated mosquito control through enforcement of standards instituted by the Federal Insecticide, Fungicide, and Rodenticide Act. This legislation mandated documentation of extensive testing for public health insecticides according to EPA guidelines prior to their registration and use. These data requirements are among the most stringent in the federal government and are met through research by established scientists in federal, state, and private institutions. This process costs a registrant several million dollars per product, but ensures that the public health insecticides available for mosquito control do not represent health or environmental risks when used as directed. Indeed, the five or six adulticides currently available are the selected survivors of literally hundreds of products developed for these uses over the years. The dosages at which these products are legally dispensed are at least 100-fold and usually 1000-fold less than the point at which public health and environmental safety merit consideration. In point of fact, literature posted on the websites of the EPA Office of Pesticide Programs, Centers for Disease Control and Prevention (CDC), American Association of Pesticide Safety Educators and National Pesticide Telecommunications Network emphasizes that proper use of mosquitocides by established mosquito control agencies does not put the general public or the environment at unreasonable risk from runoff, leaching or drift when used according to label specifications.

For the federal government’s position on risks associated with mosquito control insecticides, visit http://www.epa.gov/pesticides.

Highest regards,

Joseph Conlon
Technical Advisor, American Mosquito Control Association
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You did in fact ignore one of the key statements I made; that the mosquitocide is not effective, there are still millions of mosquitoes and trying to kill them off with insecticide is about as effective as trying to pick every tick out of every tree, it is impossible and I would rather not risk ANY poison no matter how safe the EPA may claim it to be. If it is meant to kill something its poison, there is no way around that fact. You cite the EPA like that organization should hold weight with me, like their position holds some kind of respect and authority. I do not trust the EPA as I know that currently the EPA employees, BP officials and Monsanto officials, which is an obvious conflict of interest. The EPA’s minimal “protection” of the environment has allowed for clear-cutting, the dumping of waste in the ocean and an “acceptable” amount of Mercury in our fish. I have no faith in the EPA’s standards.

More importantly, you claimed that the bees are no longer foraging in the evening and have returned to the hive. This statement is completely untrue as any quick research will tell you, the male bumblebees (like the ones that died at my house) do not return to the hive they actually stay in nearby brush, hiding in flowers and under leaves through the night. Not to mention that when they “hibernate” at night they reduce their body temperature to the point of paralysis practically, it is only when they can increase their body temperature (by shivering) to 30 degrees Celsius that they can move again and fly away. That means that the male bees that are out in the brush by the road where the spray is performed have to sit covered in this chemical until morning. I filmed the bees myself wiping furiously at their bodies, attempting to get some sort of residue off of them, they died very slowly and very painfully, twitching and appearing intoxicated for over 24 hrs.

I realize you probably think I’m just some ignorant American who saw some National Geographic show about the vanishing of the bees, but I have been working in conservation my entire life and have had personal, first-hand experiences with the degradation these pesticides cause. I have participated in both the field and the lab in the scientific studies of the effects. All I am asking of your website is to include scientific articles and studies concerning the effects of pesticides so that everyday ignorant Americans actually have a choice. It is completely immoral and unfair that these taxpayers didn’t even have a choice in whether they paid for this service or not. This service is inflicted on the people and they don’t even know it. I guess it is good business for the companies producing these poisons.

- concerned citizen

Well. What a way to start the day! This is one of the more difficult of my duties with the AMCA, for it’s well nigh impossible to carry on a reasoned discourse with critics with such limited scientific background. I decided to forego answering her latest diatribe.

So why do I even bring this up in light of the other pressing issues confronting our profession? I do so because the perspective of this “concerned citizen” is shared by a great many individuals who actively distort pesticide-related information and pursue political and legal avenues to ratify their ideological extremism. I meet them every day on the telephone or via e-mail. Distortions of this type are abundant on the Internet, making these challenges very difficult to counteract. This is why it is so extremely important for the AMCA membership to remain fully engaged, where and when allowed, with our elected legislators. I can guarantee that “concerned citizen” would have no compunction about regaling her congressional representatives with the ill-informed perspective that she exhibited in her missives to me, for, although frequently in error – she’s never in doubt. We would do well to use this example as impetus for becoming more active in both educating our citizenry and the legislators they elect – or be prepared to have our professional lives and the health of our constituents dictated by voting blocks of such “concerned citizens.”
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