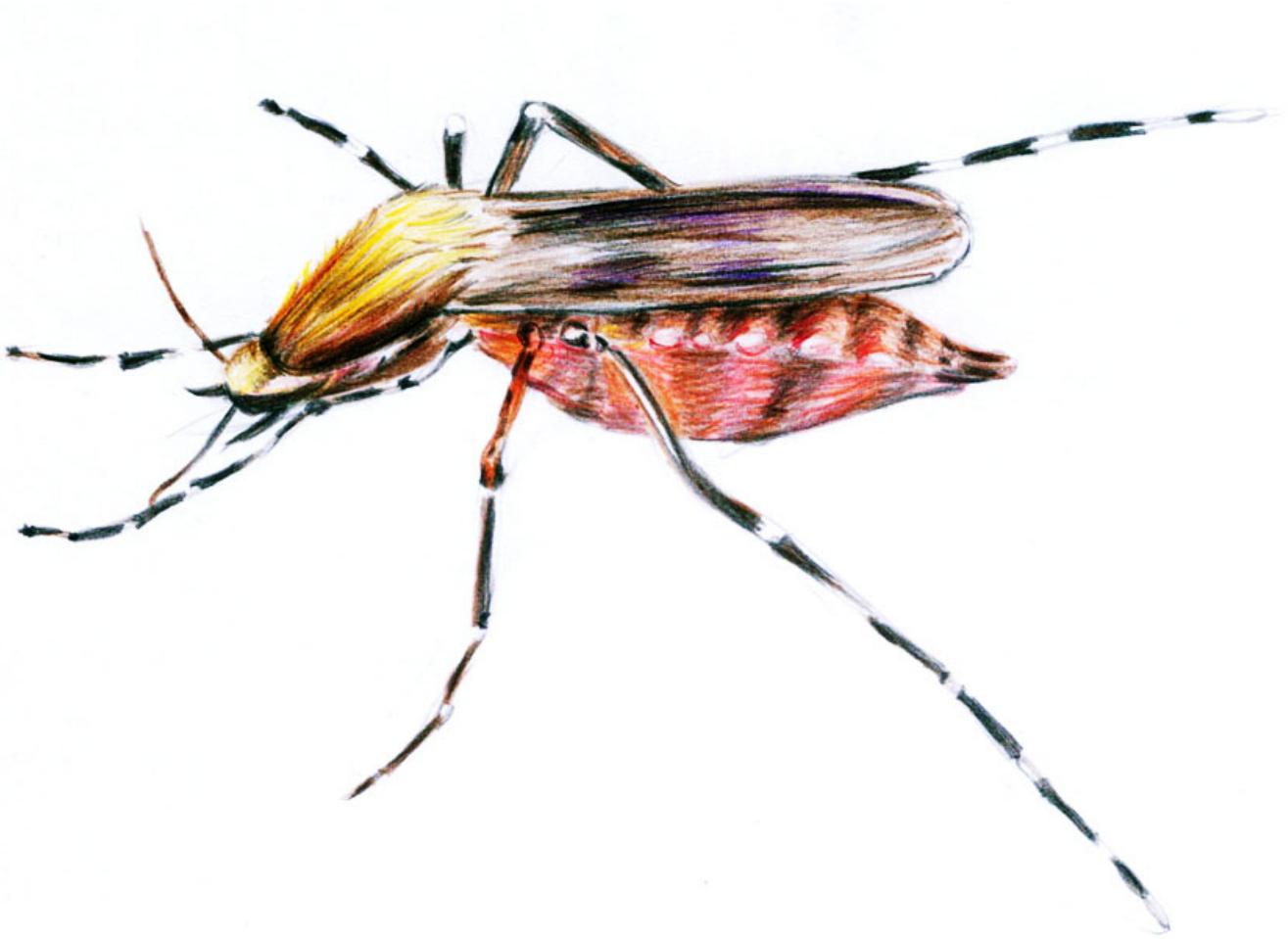
MOSQUITO CONTROL

PROFESSIONAL DEVELOPMENT
CONTINUING EDUCATION COURSE



Technical Learning College

Printing and Saving Instructions

The best thing to do is to download this pdf document to your computer desktop and open it with Adobe Acrobat DC reader.

Adobe Acrobat DC reader is a free computer software program and you can find it at Adobe Acrobat's website.

You can complete the course by viewing the course materials on your computer or you can print it out. Once you've paid for the course, we'll give you permission to print this document.

Printing Instructions: If you are going to print this document, this document is designed to be printed double-sided or duplexed but can be single-sided.

This course booklet does not have the assignment. Please visit our website and download the assignment also.

Internet Link to Assignment…
http://www.abctlc.com/downloads/PDF/Mosquito Control Ass.pdf

State Approval Listing Link, check to see if your State accepts or has pre-approved this course. Not all States are listed. Not all courses are listed.

Call your State agency to see if the course is accepted. No refunds.

State Approval Listing URL…
http://www.ABCTLC.com/downloads/PDF/CEU%20State%20Approvals.pdf

You can obtain a printed version from TLC for an additional $149.95 plus shipping charges.

All downloads are electronically tracked and monitored for security purposes.

Copyright Notice

Precept-Based Training Course

This training course is made of "micro-content" or "precepts"– small chunks of information that can be easily digested. Using bite-size pieces of technical information is considered to be one of the most effective ways of teaching people new information because it helps the student to retain knowledge easier.

Micro-learning or precept-based training doesn't rely on the student to process a large amount of information before breaking it down. Our method includes short modules with clearly defined learning goals for each section. This method allows a student to hone in on a particular skill, then demonstrate their knowledge in the final assessment.

Many States and employers require the final exam to be proctored.

Important Information about this Manual

This CEU course manual has been prepared to educate pesticide applicators and operators in general safety awareness of dealing with the often-complex and various pesticide treatment devices, methods, and applications.

This manual covers general laws, regulations, required procedures, and accepted policies relating to the use of pesticides. It should be noted, however, that the regulation of pesticides and hazardous materials is an ongoing process and subject to change over time. For this reason, a list of resources is provided to assist in obtaining the most up-to-date information on various subjects.

This manual is not a guidance document for applicators or operators who are involved with pesticides. It is not designed to meet the requirements of the United States Environmental Protection Agency or your local State environmental protection agency or health department.

This CEU course manual provides general pesticide safety awareness and should not be used as a basis for pesticide treatment method/device guidance. This document is not a detailed pesticide information resource or a source or remedy for poison control.

Technical Learning College or Technical Learning Consultants, Inc. make no warranty, guarantee or representation as to the absolute correctness or appropriateness of the information in this manual and assumes no responsibility in connection with the implementation of this information. It cannot be assumed that this manual contains all measures and concepts required for specific conditions or circumstances. This document is to be used solely for educational purposes only and is not considered a legal document.

Pesticides are poisonous. Always read and carefully follow all precautions and safety recommendations given on the container label. Store all chemicals in the original labeled containers in a locked cabinet or shed, away from food or feeds, and out of the reach of children, unauthorized persons, pets, and livestock.

Confine chemicals to the property being treated. Avoid drift onto neighboring properties, especially gardens containing fruits and/or vegetables.

Dispose of empty containers carefully. Follow label instructions for disposal. Never reuse containers. Make sure empty containers are not accessible to children or animals.

Never dispose of containers where they may contaminate water supplies or natural waterways.

Do not pour down sink or toilet. Consult your county agricultural commissioner for correct ways of disposing of excess pesticides. Never burn pesticide containers.

Individuals who are responsible for pesticide storage, mixing, and application should obtain and comply with the most recent federal, state, and local regulations relevant to these sites and are urged to consult with the EPA and other appropriate federal, state, and local agencies.

Technical Learning College's Scope and Function

Welcome to the Program,

Technical Learning College (TLC) offers affordable continuing education for today's working professionals who need to maintain licenses or certifications. TLC holds several different governmental agency approvals for granting of continuing education credit.

TLC's delivery method of continuing education can include traditional types of classroom lectures and distance-based courses or independent study. TLC's distance-based or independent study courses are offered in a print - based distance educational format. We will beat any other training competitor's price for the same CEU material or classroom training.

Our courses are designed to be flexible and for you to finish the material at your convenience. Students can receive course materials through the mail or electronically. The CEU course or e-manual will contain all your lessons, activities and instruction to obtain the assignments. All of TLC's CEU courses allow students to submit assignments using e-mail or fax, or by postal mail. (See the course description for more information.)

Students have direct contact with their instructor—primarily by e-mail or telephone. TLC's CEU courses may use such technologies as the World Wide Web, e-mail, CD-ROMs, videotapes and hard copies. (See the course description.) Make sure you have access to the necessary equipment before enrolling; i.e., printer, Microsoft Word and/or Adobe Acrobat Reader. Some courses may require proctored closed-book exams, depending upon your state or employer requirements.

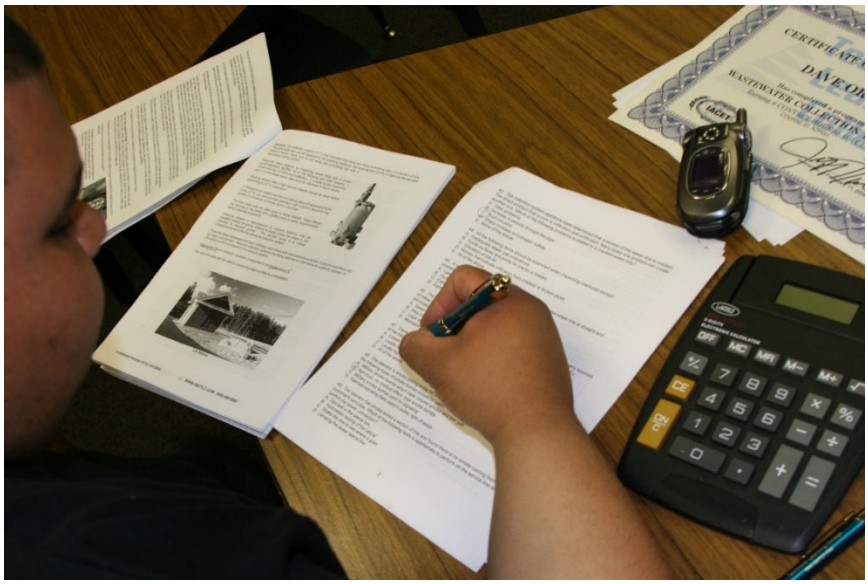
Flexible Learning
At TLC, there are no scheduled online sessions or passwords you need contend with, nor are you required to participate in learning teams or groups designed for the "typical" younger campus - based student. You will work at your own pace, completing assignments in time frames that work best for you. TLC's method of flexible individualized instruction is designed to provide each student the guidance and support needed for successful course completion.

Course Structure
TLC's online courses combine the best of online delivery and traditional university textbooks. You can easily find the course syllabus, course content, assignments, and the post-exam (Assignment). This student-friendly course design allows you the most flexibility in choosing when and where you will study.

Classroom of One
TLC offers you the best of both worlds. You learn on your own terms, on your own time, but you are never on your own. Once enrolled, you will be assigned a personal Student Service Representative who works with you on an individualized basis throughout your program of study. Course specific faculty members (S.M.E.) are assigned at the beginning of each course providing the academic support you need to successfully complete each course. Please call or email us for assistance.

No Data Mining Policy
Unlike most online training providers, we do not use passwords or will upload intrusive data mining software onto your computer. We do not use any type of artificial intelligence in our program. Nor will we sell you any other product or sell your data to others as with many of our competitors. Unlike our training competitors, we have a telephone and we humanly answer.

Satisfaction Guaranteed
We have many years of experience, dealing with thousands of students. We assure you, our customer satisfaction is second to none. This is one reason we have taught more than 20,000 students.



We welcome you to do the electronic version of the assignment and submit the answer key and registration to us either by fax or e-mail. If you need this assignment graded and a certificate of completion within a 48-hour turn around, prepare to pay an additional rush charge of $50.

We welcome you to complete the assignment in Word.

Once we grade it, we will mail a certificate of completion to you. Call us if you need any help.

Contact Numbers
Fax (928) 468-0675
Email Info@tlch2o.com
Telephone (866) 557-1746

Course Description

Mosquito Control CEU Training Course

This CEU course is intended to serve as a source of basic information needed to implement an integrated pest management program for mosquitoes and to provide continuing education for the pesticide applicators. Any pest management plan or activity must be formulated within the framework of the management zones where it will be implemented. Recommendations in this course must be evaluated and applied in relation to these broader considerations.

This CEU course reviews basic mosquito control and identification training and application methods. This course is general in nature and not state specific. No other materials are required for this course.

Prerequisites: None

Course Procedures for Registration and Support
All of Technical Learning College's (TLC) correspondence courses have complete registration and support services offered. Delivery of services includes, e-mail, web site, telephone, fax, and mail support. TLC will attempt to provide immediate and prompt service.

When a student registers for a distance or correspondence course, he/she is assigned a start date and an end date. It is the student's responsibility to note dates for assignments and keep up with the course work. If a student falls behind, he/she must contact TLC and request an end date extension in order to complete the course. It is the prerogative of TLC to decide whether to grant the request.

All students will be tracked by an unique number assigned to the student.

Instructions for Written Assignments
The Mosquito Control CEU training correspondence course uses a multiple-choice and a true/false style answer sheet. You need to download the assignment and complete the assignment from our website under the Assignment Page.

Feedback Mechanism (examination procedures)
A feedback form is included in the front of the assignment. You can find this on the Assignment webpage.

Security and Integrity
All students are required to do their own work. Lesson sheets and final exams are not returned to the student to discourage the sharing of answers. If any fraud or deceit is discovered, the student will forfeit all fees and the appropriate agency will be notified.

Grading Criteria
TLC offers the student either pass/fail or a standard letter grading assignment. If TLC is not notified, a pass/fail notice will be issued.

Required Texts
The course will not require any other materials. This course comes complete.

Pesticide Terms, Abbreviations, and Acronyms
TLC provides a glossary that defines, in non-technical language, commonly used environmental terms appearing in publications and materials. You can find the glossary in the rear of this manual.

Recordkeeping and Reporting Practices
TLC will keep all student records for a minimum of five years. It is your responsibility to give the completion certificate to the appropriate agencies.

ADA Compliance
TLC will make reasonable accommodations for persons with documented disabilities. Students should notify TLC and their instructors of any special needs. Course content may vary from this outline to meet the needs of this particular group.

Note to students: Keep a copy of everything that you submit. If your work is lost, you can submit your copy for grading. If you do not receive your certificate of completion or quiz results within two or three weeks after submitting it, please contact your instructor.

Students have 90 days from receipt of this manual to complete it in order to receive Continuing Education Units (**CEUs**) or Professional Development Hours (**PDHs**). A score of 70% is necessary to pass this course. If any assistance is needed, please email all concerns or call us. If possible, e-mail the final test to info@tlch2o.com or fax (928) 272-0747.

Course Objective
To provide continuing education training in Mosquito identification, Mosquito control, Midge identification, vector-borne disease awareness, and to provide the student the information necessary to control the mosquito population and to protect the public from illness due to mosquito-borne infections.

Educational Mission
The educational mission of TLC is:
To provide TLC students with comprehensive and ongoing training in the theory and skills needed for the pesticide application field,

To provide TLC students with opportunities to apply and understand the theory and skills needed for pesticide application,

To provide opportunities for TLC students to learn and practice environmental educational skills with members of the community for the purpose of sharing diverse perspectives and experience,

To provide a forum in which students can exchange experiences and ideas related to pesticide application education,

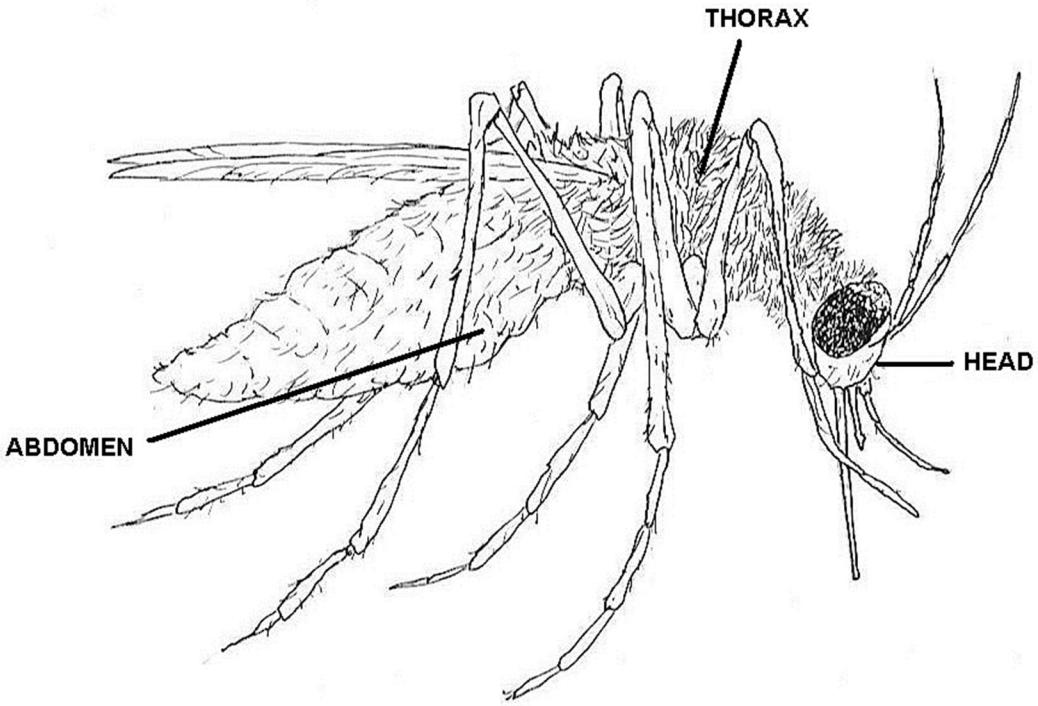
To provide a forum for the collection and dissemination of current information related to pesticide application education, and to maintain an environment that nurtures academic and personal growth.

Table of Contents

Topic 1 – Mosquito Introduction Section

Topic 1 - Section Focus: You will learn the basics of mosquitoes. At the end of this section, you will be able to understand and describe the mosquito. You will learn about the mosquito family class, genera, life cycle and related subjects. There is a post quiz at the end of this section to review your comprehension and a final examination in the Assignment for your contact hours.

Topic 1 – Scope/Background: Mosquitoes are the deadliest animal or insect to humans, therefore we must be educated on this target. It is critical that pesticide applicators master control of this pest target in that we do not destroy other wildlife during treatment operations.

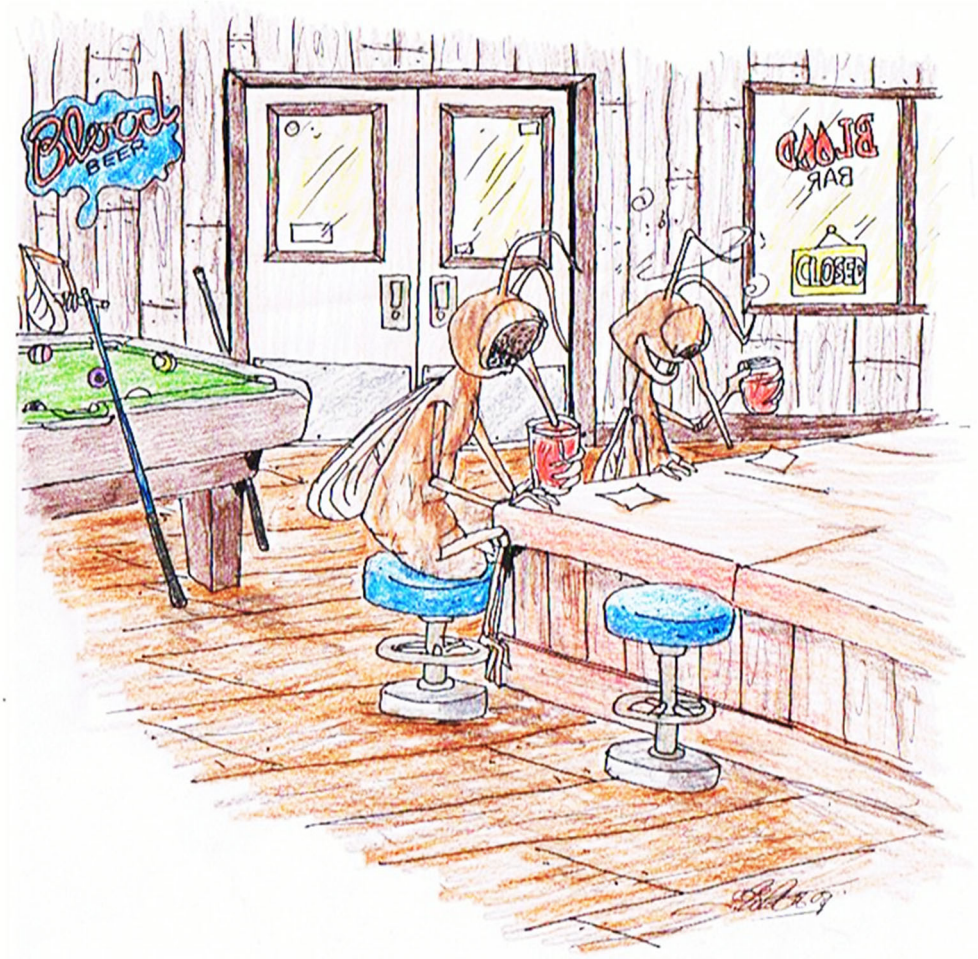


MOSQUITO ANATOMY DIAGRAM #1

Mosquitoes are the #1 killer of humans in the world. About 2 million people die each year from one disease resulting from a mosquito bite. The primarily disease is Malaria, and is caused by a small animal, called a *Plasmodium,* that gets into people through a mosquito bite. We will cover this area in detail in the Mosquito Disease Section.

Only the female mosquito bites humans. She uses protein from blood to make the shells of their eggs. Male and female mosquitoes eat nectar from flowers, like butterflies and hummingbirds. The female mosquitoes have a problem, though, when they try to suck our blood. When our blood gets outside of our body, the cells tend to stick together.

We know this as “clotting” and it's why you get a scab when you cut your skin, its scientific name is "coagulation". Coagulation is a big problem for a mosquito who has a very thin tube through which to suck blood.



Female Mosquito

To combat coagulation, the mosquito first *spits* into us when she bites. The coagulated blood cells clog her tube and she cannot get good blood through it. She spits a chemical called an "anti-coagulant" that keeps the blood cells from sticking together so she can suck as much as she wants! It is during the spitting phase of biting that the Malarial *Plasmodium* gets into us. Once inside a mammal, the *Plasmodium* goes through the bloodstream and into the liver, where it reproduces.

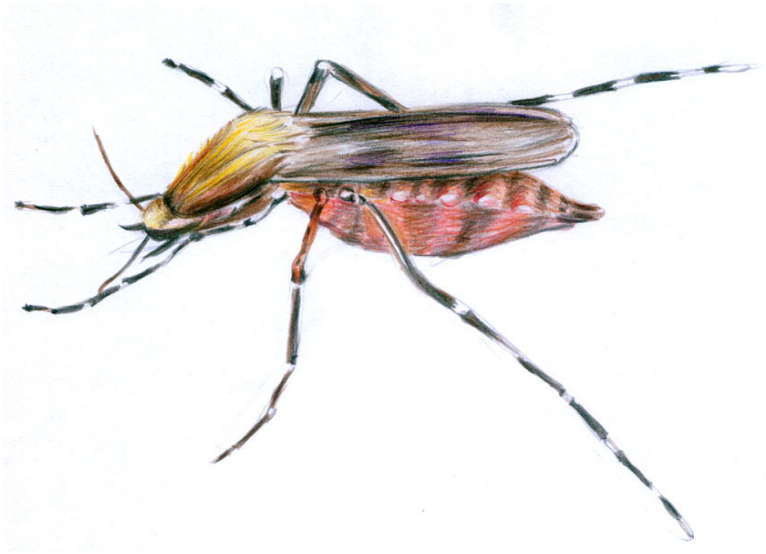
From the liver, the *Plasmodium* cells get into red blood cells and begin to feed. Inside the red blood cells, the *Plasmodium* cells divide and eventually split the red blood cells open, and a bunch of new *Plasmodium* cells infect other red blood cells.

The cycle continues as the host animal gets sicker and sicker, and often dies. Fortunately, the type of *Plasmodium* that causes malaria and the species of mosquito (in the genus *Anopheles* "an-off-eh-lees") that spreads it do not live in the United States, but in many other countries (especially in tropical regions), this is a very dangerous disease. Therefore, a lot of research money is available for the study of malaria and mosquitoes (which also spread other diseases in much the same fashion).

Mosquito Terms and Definitions

Mosquito are Gnats

Any one of various species of gnats of the genus Culex and allied genera. The females have a proboscis containing, within the sheath-like labium, six fine, sharp, needlelike organs with which they puncture the skin of man and animals to suck the blood. These bites, when numerous, cause (in many persons) considerable irritation and swelling, with some pain. The larv[ae] and pup[ae], called wigglers, are aquatic. A mosquito has three body parts; the head, the thorax, and the abdomen. It has six legs, two wings, and two antennae. (The male and female have different antennae.) The part that sucks our blood is called the proboscis.

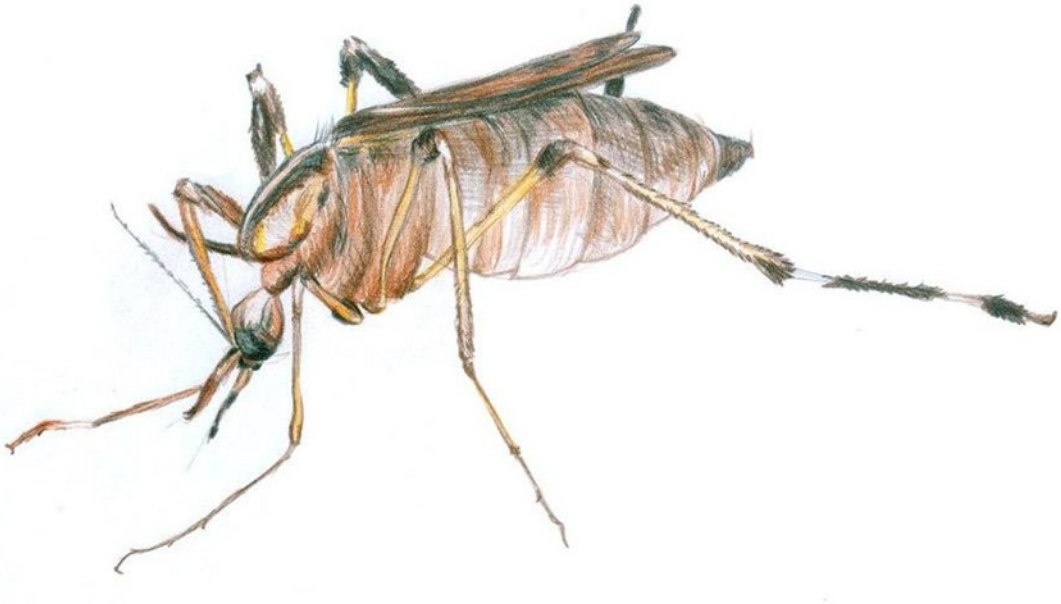


BLOOD ENGORGED FEMALE AEDES MOSQUITO

Term	Definition
Arbovirus	Any of various viruses transmitted by arthropods and including the causative agents of encephalitis, yellow fever, and dengue.
Biological Control	The use of parasites or pathogens to control a pest.
Disease	Condition of the living animal or plant body or of one of its parts that impairs the performance of a vital function.
Encephalomyelitis	Concurrent inflammation of the brain and spinal cord.
Monitoring	Method in which an area is appraised for its mosquito numbers and/or evidence of disease agents within the mosquito population.
Pathogen	Specific causative agent of disease.
Reservoir	Organism in which a parasite that is pathogenic for some other species lives and multiplies without damaging its host.
Surveillance	Method in which an area is appraised for its risk of providing mosquito breeding grounds and subsequent mosquito populations.
Vector	Organism that transmits a pathogen.

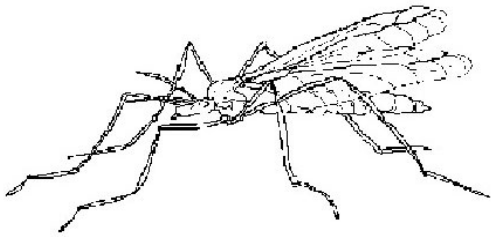
AEDES VEXANS

Floodwater mosquitoes, such as *Aedes vexans,* lay their eggs in damp places just above the water line of temporary ponds. The eggs hatch after a warm rain and may produce a new generation of adults in as little as a week. Eggs can also remain dormant for over two years during drought conditions. The adults will die from desiccation if exposed to dry sunny conditions and will only emerge from wooded areas at dusk or on dull, humid days.



PSOROPHORA CILIATA

Psorophora ciliata is found only during wet summers when other mosquitoes are abundant. Their larvae are carnivorous and each one consumes dozens of smaller mosquito larvae.



(Drawn to scale)

CRANE FLY

- LOCAL GENUS: Tipula ultima
- SIZE: 3/8 to 2 1/2 inch
- HABITAT: Humid Areas
- HARMLESS TO HUMANS
- ADULTS ARE A FAVORITE FOOD OF MANY BIRDS AND SMALL MAMMALS

MOSQUITO

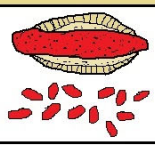
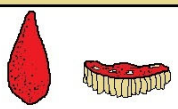
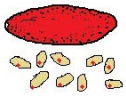
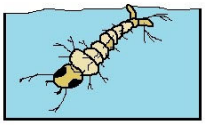
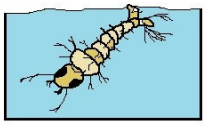
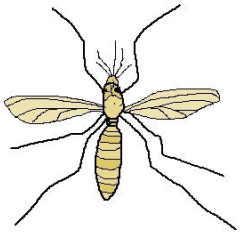
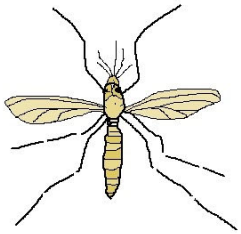
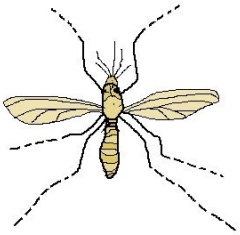
- LOCAL GENUS: Culex pipiens
- SIZE: 1/8 to 1/4 inch
- HABITAT: Any still water
- CAN BE HARMFUL TO HUMANS AS THEY MAY CARRY VARIOUS TYPES OF DISEASES

Technical Learning College

CRANE FLY / MOSQUITO COMPARISON

 MALE MOSQUITO	 FEMALE MOSQUITO
USUALLY LIVE FOR ONE TO TWO WEEKS	USUALLY LIVE FOR A FEW DAYS
HAVE BUSHY PROBOSCISES	HAVE SMOOTHER AND NEEDLE-LIKE PROBOSCISES
HAVE FEATHER-LIKE HAIR ON THEIR ANTENNAE	DOES NOT HAVE FEATHER-LIKE HAIR ON THEIR ANTENNAE
OFTEN QUITE SMALLER	OFTEN BIGGER
SUCK FRUIT AND NECTAR JUICE	SUCK BLOOD, NECTAR AND FRUIT JUICE
TEND TO HATCH EARLY	TEND TO HATCH LATER
DOES NOT CARRY DISEASES	CARRY DISEASES
BUZZ AT A LOWER PITCH	BUZZ AT A HIGHER PITCH
TEND TO STAY AWAY FROM HUMANS	MORE PROXIMAL TO HUMANS
PRIMARY ROLE IS TO CARRY SPERM	ROLES ARE TO MATE AND CARRY, FERTILIZE & LAY EGGS
CAN MATE MANY TIMES	MATES ONLY ONCE
LESS LIKELY TO TAKE OFF IN RESPONSE TO INSECT REPELLENTS	LIKELY TO TAKE OFF IN RESPONSE TO INSECT REPELLENTS

MALE / FEMALE MOSQUITO COMPARISON CHART #1

	ANOPHELLES	CULEX	AEDES
EGGS			
LARVA			
PUPA			
ADULT MOSQUITO			
HEAD	 MALE FEMALE	 MALE FEMALE	 MALE FEMALE

Technical Learning College

MOSQUITO SPECIES / STAGES

World's Deadest Insect/Animal of all Time

Mosquitoes are estimated to transmit disease to more than 700 million people annually in Africa, South America, Central America, Mexico, Russia and much of Asia with millions of resulting deaths. At least 2 million people annually die of these diseases. Mosquitoes are a vector agent that carries disease-causing viruses and parasites from person to person without exhibiting symptoms themselves.

The principal mosquito borne diseases are the viral diseases yellow fever, dengue fever and Chikungunya, transmitted mostly by the Aedes aegypti, and malaria carried by the genus Anopheles. Though originally a public health concern, HIV is now thought to be almost impossible for mosquitoes to transmit.

Methods used to prevent the spread of disease, or to protect individuals in areas where disease is endemic include Vector control aimed at mosquito eradication, disease prevention, using prophylactic drugs and developing vaccines and prevention of mosquito bites, with insecticides, nets and repellents. Since most such diseases are carried by "elderly" females, scientists have suggested focusing on these to avoid the evolution of resistance

Mosquito control requires knowledge of the behavioral and habitat differences among species in order to plan and carry out a treatment program. The trained worker first identifies the problem species. With identity established, useful correlations are immediately available, such as the type of breeding habitat and where to search for larvae. A working knowledge of the behavior and habitats frequented by various species aids in determining the kinds of survey and control strategies best suited for the task. Mosquitoes are not adapted to life in moving waters, but they can occupy the quiet pools and seepage areas near flowing streams.

Integrated Pest Management -Introduction
The Centers for Disease Control (CDC) and the U.S. Environmental Protection Agency (EPA) collaborate on mosquito control activities throughout the United States to control diseases. By looking at biological information about the life and reproduction of the mosquito and epidemiological information about the disease, the two organizations have developed a methodology on how best to control mosquitoes. Both CDC and EPA are helping Puerto Rico apply this methodology to develop a successful, sustainable program and approach to controlling mosquitoes that transmit Zika, dengue, chikungunya, and other diseases.

Successful mosquito management requires intervening at some point during the mosquito's life cycle before they bite and infect a human. The best approach to controlling mosquitoes takes advantage of every life stage of a mosquito to achieve control, using a unified approach referred to as integrated pest management (IPM).

EPA and CDC encourage all communities and mosquito control districts, including those in territories like Puerto Rico, to strictly adhere to IPM. IPM is a science-based, common-sense approach for managing pests and vectors, such as mosquitoes.

IPM uses a variety of pest management techniques that focus on pest prevention, pest reduction, and the elimination of conditions that lead to pest infestations. IPM programs also rely heavily on resident education and pest monitoring.

A successful IPM strategy can use pesticides. IPM uses a combination of ways to control mosquito populations with decisions based on surveillance, such as keeping track or count of the numbers and types of mosquitoes in an area. Surveillance is a critical component to any successful IPM program because the results from the surveillance will help determine the appropriate response to an infestation. Extensive infestations, or those where disease is present, merit a different response than will lower levels of infestations.

Both CDC and EPA recognize a legitimate and compelling need for the use of chemical interventions, under certain circumstances, to control adult mosquitoes. This is especially true during periods of mosquito-borne disease transmission or when source reduction and larval control have failed or are not feasible.

Puerto Rico
Puerto Rico has been actively working to control mosquitoes that transmit Zika (and dengue and chikungunya) for about six months; however, mosquito populations are increasing and additional methods are needed to control the mosquitoes during their adult stage.

A successful integrated mosquito control strategy includes several tactics to eliminate mosquitoes and their habitat.

Four critical tactics include:
1. Remove Mosquito Habitats
2. Use Structural Barriers
3. Control Mosquitoes at the Larval Stage
4. Control Adult Mosquitoes

Aquatic Environment Introduction

Aquatic environments differ chiefly in the chemistry of the water (acid or alkaline; fresh, salt or brackish). These environments may be natural or man-made and may also differ in the amount or type of vegetation present and the amount of sun or shade. Coquillettidia perturbans, Mansonia dyari and Ma. titillans, for example, are found in association with specific aquatic plants — water lettuce, water hyacinth and cattails. Wyeomyia spp. are found in association with bromeliads and pitcher plants. In this regard, the distinctive egg-laying habit of each species of mosquito determines its larval habitat.

Although some species use more than one type of habitat, most mosquitoes can be categorized in general terms by their preference for either permanent water, floodwater, transient water or artificial container and tree-hole habitats. These categories can be combined into two major larval habitat categories: standing water (permanent and transient) and floodwater (including natural and artificial containers as well as floodwater).

Standing water species deposit their eggs (either singly or in rafts) on the surface of permanent or transient pools of standing water. They usually produce several generations (broods) each year and overwinter or survive harsh environmental circumstances as mated, engorged females. In contrast, floodwater species deposit their eggs out of the water but in locations subject to periodic flooding, such as damp soil in depressions or inside tree holes, crab holes and artificial containers.

They produce one to several broods annually and overwinter or survive harsh environmental circumstances in the egg stage. Mosquitoes are adaptable to changing environmental conditions and are thus associated with multiple habitat types.

Why do Mosquitoes Bite?
Mosquitoes belong to a group of insects that require blood to develop fertile eggs. Males do not lay eggs, thus, male mosquitoes do not bite. The females are the egg producers and "*host-seek*" for a blood meal. Female mosquitoes lay multiple batches of eggs and require a blood meal for every batch they lay. Few people realize that mosquitoes rely on sugar as their main source of energy.

Both male and female mosquitoes feed on plant nectar, fruit juices, and liquids that ooze from plants. The sugar is burned as fuel for flight and is replenished on a daily basis. Blood is reserved for egg production and is imbibed less frequently.

Why do Mosquitoes Leave Welts When They Bite?
When a female mosquito pierces the skin with her mouthparts, she injects a small amount of saliva into the wound before drawing blood.

Adult mosquitoes are terrestrial and capable of flight. With piercing-sucking mouthparts, the females feed mostly on animal blood and plant nectar. Males' antennae have dense bristles, and their mouthparts are modified to suck nectar and plant secretions, where no piercing is required. The adults of some species remain within a few hundred feet of where they spent the larval stage, whereas others may migrate up to 50 miles or more. Eggs develop a few days after females take a blood meal. Females oviposit on the water, in crevices in the soil, or on other favored substrates or special niches that are or will subsequently be flooded, such as natural and artificial containers or tree holes, and the cycle repeats itself.

Females of some floodwater species may live up to a month after they emerge, whereas those of some permanent water or standing water species can survive for several months by overwintering as mated, engorged adults. Some species, including those whose eggs require freezing temperatures, are limited to a single generation per year, whereas others have multiple generations.

Those casually acquainted with mosquitoes may believe that all types are much the same, and, indeed, the similarities between species is considerable. There are, however, many differences in appearance from species to species and even among some varieties within species.

These morphological differences, especially notable in the larval and adult stages, permit accurate identification of most species. Behavioral differences permit various species to occupy numerous ecological niches with relatively little overlap. Thus, knowledge of the source or breeding habitat of mosquitoes can provide strong clues to their identification.

Why are some People More Attractive to Mosquitoes than others?
Scientists are still investigating the complexities involved with mosquito host acceptance and rejection. Some people are highly attractive to mosquitoes and others are rarely bothered. Mosquitoes have specific requirements to satisfy and process many different factors before they feed.

Many of the mosquito's physiological demands are poorly understood and many of the processes they use to evaluate potential blood meal hosts remain a mystery. Female mosquitoes use the CO_2 we exhale as their primary cue to our location. A host-seeking mosquito is guided to our skin by following the slip stream of CO_2 that exudes from our breath.

Short Range Attractants
Once they have landed, they rely on a number of short-range attractants to determine if we are an acceptable blood meal host. Folic acid is one chemical that appears to be particularly important. Fragrances from hair sprays, perfumes, deodorants, and soap can cover these chemical cues. They can also function to either enhance or repel the host-seeking drive. Dark colors capture heat and make most people more attractive to mosquitoes. Light colors refract heat and are generally less attractive to mosquitoes. Detergents, fabric softeners, perfumes and body odor can counteract the effects of color. In most cases, only the mosquito knows why one person is more attractive than another.

How Long Do Mosquitoes Live?
Mosquitoes are relatively fragile insects with an adult life span that lasts about 2 weeks. The vast majority meets a violent end by serving as food for birds, dragonflies, and spiders, or are killed by the effects of wind, rain or drought. The mosquito species that only have a single generation each year are longer lived and may persist in small numbers for as long as 2-3 months if environmental conditions are favorable. Mosquitoes that hibernate in the adult stage live for 6-8 months, but spend most of that time in a state of torpor. Some of the mosquito species found in arctic regions enter hibernation twice and take more than a year to complete their life cycle.

What Happens When Mosquitoes Bite?
The saliva makes penetration easier and prevents the blood from clotting in the narrow channel of her food canal. The welts that appear after the mosquito leaves is not a reaction to the wound but an allergic reaction to the saliva injected to prevent clotting. In most cases, the itching sensation and swellings subside within several hours. Some people are highly sensitive and symptoms persist for several days. Scratching the bites can result in infection if bacteria from the fingernails are introduced to the wounds.

Where do Mosquitoes go in the winter?
Mosquitoes, like most insects, are cold-blooded creatures. As a result, they are incapable of regulating body heat, and their temperature is essentially the same as their surroundings. Mosquitoes function best at 80^{o}F, become lethargic at 60^{o}F and cannot function below 50^{o}F.

Saliva
In order for the mosquito to obtain a blood meal it must circumvent the vertebrate physiological responses. The mosquito, as with all blood-feeding arthropods, has mechanisms to effectively block the hemostasis system with their saliva, which contains a mixture of secreted proteins. Mosquito saliva negatively affects vascular constriction, blood clotting, platelet aggregation, angiogenesis and immunity and creates inflammation. Universally, hematophagous arthropod saliva contains at least one anticlotting, one anti-platelet, and one vasodilatory substance. Mosquito saliva also contains enzymes that aid in sugar feeding and antimicrobial agents to control bacterial growth in the sugar meal. The composition of mosquito saliva is relatively simple as it usually contains fewer than 20 dominant proteins.

Despite the great strides in knowledge of these molecules and their role in blood feeding achieved recently, scientists still cannot ascribe functions to more than half of the molecules found in arthropod saliva. One promising application is the development of anti-clotting drugs based on saliva molecules, which might be useful for approaching heart-related disease, because they are more user-friendly blood clotting inhibitors and capillary dilators.

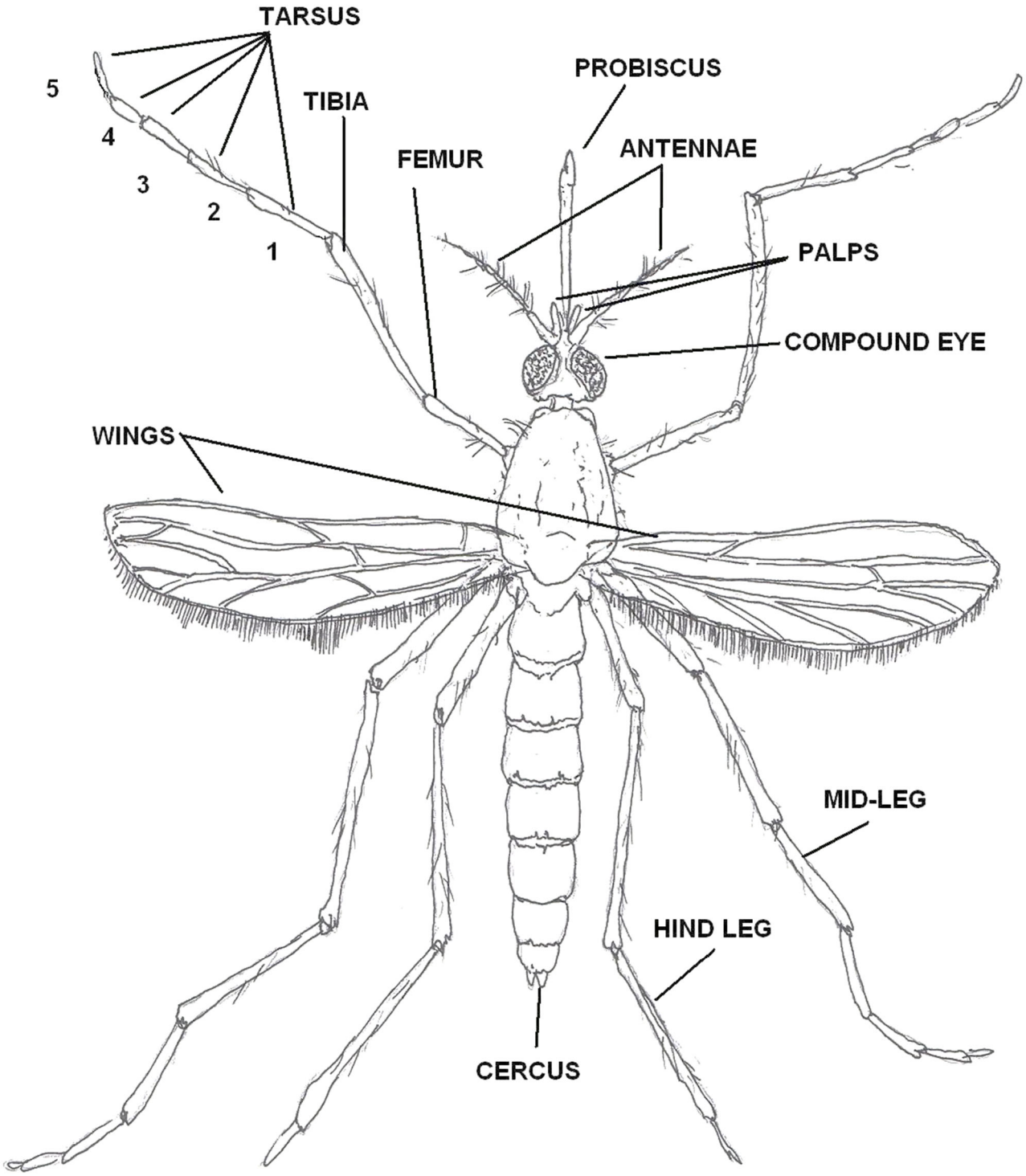
Modulate the Immune Response
It is now well recognized that the feeding ticks, sandflies, and, more recently, mosquitoes have an ability to modulate the immune response of the animals (hosts) they feed on. The presence of this activity in vector saliva is a reflection of the inherent overlapping and interconnected nature of the host hemostatic and inflammatory/immunological responses and the intrinsic need to prevent these host defenses from disrupting successful feeding. The mechanism for mosquito saliva-induced alteration of the host immune response is unclear, but the data has become increasingly convincing that such an effect occurs.

Early work described a factor in saliva that directly suppresses TNF release, but not antigen-induced histamine secretion, from activated mast cells. Experiments by Cross et al. (1994) demonstrated that the inclusion of Ae. aegypti mosquito saliva into naïve cultures led to a suppression of interleukin (IL)-2 and IFN production, while the cytokines IL-4 and IL-5 are unaffected by mosquito saliva. Cellular proliferation in response to IL-2 is clearly reduced by prior treatment of cells with SGE.

Correspondingly, activated splenocytes isolated from mice fed upon by either Ae. aegypti or Cx. pipiens mosquitoes produce markedly higher levels of IL-4 and IL-10 concurrent with suppressed IFN production. Unexpectedly, this shift in cytokine expression is observed in splenocytes up to 10 days after mosquito exposure, suggesting that natural feeding of mosquitoes can have a profound, enduring, and systemic effect on the immune response.

A recent study suggests that mosquito saliva can also decrease expression of interferon during early mosquito-borne virus infection. The contribution of type I interferons (IFN) in recovery from infection with viruses has been demonstrated in vivo by the therapeutic and prophylactic effects of administration of IFN-inducers or IFN, and recent research suggests that mosquito saliva exacerbates West Nile virus infection, as well as other mosquito-transmitted viruses.

Canine Heartworm
Dogs are quite susceptible to canine heartworm, a nematode that can be transmitted by certain mosquitoes. Infected animals may develop severe circulatory problems and display symptoms such as coughing, labored breathing, and loss of vitality. Preventive drug treatment is available through your veterinarian.



MOSQUITO ANATOMY DIAGRAM #2

Mosquito Genera Introduction

Genera or Genus Definition

A principal taxonomic category that ranks above species and below family, and is denoted by a capitalized Latin name, e.g. Leo.

How Many Kinds of Mosquitoes Are There?

About 3,000 species of mosquitoes have been described on a world-wide basis. Approximately 150-200 are known to occur in North America. Scientists group species by genus on the basis of the physical characteristics they share.

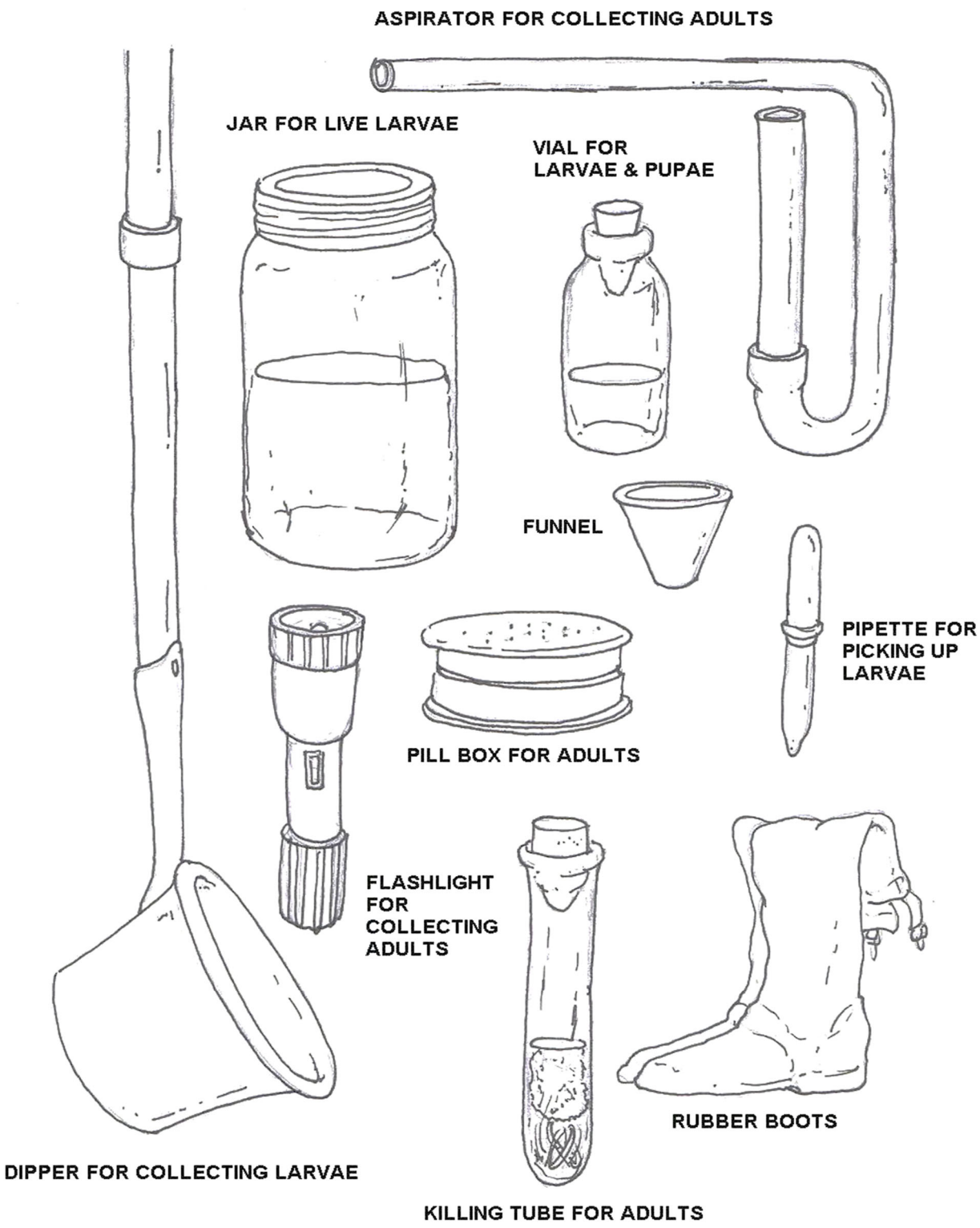
The 3,000 mosquito species found in the world are divided among 28 different genera. The genus *Aedes* contains some of the worst pests. Many members of the genus *Anopheles* have the ability to transmit human malaria.

Mosquito Genera

Here are just a few major genera that occur in the United States: *Aedes*, *Anopheles*, *Culex*, *Culiseta*, *Coquillettidia*, *Psorophora*, *Orthopodomyia*, *Uranotaenia*, *Toxorhynchites* and *Wyeomyia*. It is sometimes more convenient to group mosquitoes by the breeding habitat they use.

The major habitat groups found include: "*Snowpool Mosquitoes,* "*Floodwater Mosquitoes,"* "*Swamp Breeding Mosquitoes,*" and "*Container Breeding Mosquitoes.*

Common Name	Scientific Name	Importance
Asian Tiger Mosquito	Aedes albopictus	LAC, EEE, SLE, Pest
Banded spring mosquito	Aedes canadensis	LAC, Pest
Eastern Treehole Mosquito	Aedes triseriatus	LAC
Flood-water mosquito	Aedes tivittatus	Pest
Vexans Mosquito	Aedes vexans	Pest
Common Malaria Mosquito	Anopheles quadrimaculatus	Malaria, Pest
Cattail Mosquito	Coquillettidia perturbans	EEE, Pest
Northern House Mosquito	Culex pipiens	SLE
Key: **LAC** = LaCrosse Encephalitis **EEE** = Eastern Equine Encephalomyelitis **SLE** = St. Louis Encephalitis		



TYPICAL MOSQUITO SAMPLING EQUIPMENT

Mosquito Family, Subfamily, Genus and Related Classifications

Aedes
Aedes is a genus of mosquito originally found in tropical and subtropical zones, but now found on all continents excluding Antarctica. Some species have been spread by human activity. Aedes albopictus, a most invasive species was recently spread to the new world, including the US, by the used tire trade. First described and named by Meigen in 1818, the name comes from the Ancient Greek word, meaning "unpleasant" or "odious". Some species of this genus transmit serious diseases, including dengue fever and yellow fever. In Polynesia, the species Aedes polynesiensis is responsible for the transmission of human lymphatic filariasis including species of Brugia as well as others. Aedes can be detected and monitored by Ovitraps.

Anopheles (Genus)
Subfamily Anophelinae. A total of 465 formally recognized species and more than 50 unnamed members of species complexes are recognized as distinct morphological and/or biological species of the genus. The formally named species are placed in seven subgenera, Anopheles (182 species), Baimaia (1), Cellia (217), Kerteszia (12), Lophopodomyia (6), Nyssorhynchus (35) and Stethomyia (5).

World-Wide Distribution
Anopheles has an almost world-wide distribution. Species of the genus occur in temperate, subtropical and tropical areas, but are absent from the majority of the Pacific Islands, including the large ones of New Zealand, Fiji and New Caledonia, and isolated islands in the Atlantic. Anopheles species are found at elevations from coastal areas to mountainous terrain.

Mosquitoes of genus Anopheles are the sole vectors of human malarial parasites. Some species are effective vectors of microfilariae and some may be involved in the transmission of encephalitis viruses. Anopheles are vectors of numerous animal pathogens, including species of malaria protozoa that do not affect humans.

Largest Subgenus
Cellia is the largest subgenus with all species occurring in the Old World. The subgenus is segregated into six Series (Cellia, Neocellia, Myzomyia, Neomyzomyia, Paramyzomyia and Pyretophorus). Each series contains vectors of malarial protozoa and microfilariae. The most important malaria vectors include An. arabiensis, An. funestus, An. gambiae and An. moucheti in the Afrotropical Region; An. balabacensis, An. baimaii, An. culicifacies, An. dirus, An. latens, An. leucosphyrus, An. maculatus, An. minimus, An. fluviatilis s.l., An. sundaicus and An. superpictus in the Oriental Region; members of the An. farauti and An. punctulatus complexes in the Australasian Region; An. sergentii and An. stephensi in the Middle East and the Indian Subcontinent.

Anopheles
Subgenus Anopheles is also divided into six series, but only the Myzorhynchus and Anopheles Series contain vector species. Some primary vectors of historical and contemporary importance in the transmission of malaria protozoa include An. freeborni in western North America, An. sinensis in southeastern areas of the Palaearctic Region, An. atroparvus in Europe and eastern Asia, and An. pseudopunctipennis at higher elevations in Central and South America.

Nyssorhynchus
Subgenus Nyssorhynchus contain species that are variously distributed from Argentina to the southern USA. Anopheles albimanus, An. aquasalis, An. argyritarsis, An. darlingi and An. nuneztovari are vectors of malarial protozoa. Anopheles albitarsis and An. aquasalis also transmit arboviruses, and some species also transmit Wuchereria bancrofti.

Kerteszia
Subgenus Kerteszia occurs in Central and South America. Six species are known to transmit malarial protozoa, but only An. bellator in Trinidad and An. cruzii in Brazil are important vectors. Anopheles bellator also transmits the helminths that cause Bancroftian filariasis.

Species of the remaining subgenera, Baimaia in the Oriental Region and Stethomyia and Lophopodomyia in the Neotropical Region, are not of medical importance to humans.

Anophelinae (Genus subfamily)
Subfamily Anophelinae includes 478 formally recognized species. Many genetic species of sibling species complexes await formal names. The subfamily is divided into three genera: Anopheles, Bironella and Chagasia. Mosquitoes belonging to these genera are referred to as 'anophelines' Most species of the subfamily belong to genus Anopheles, which occurs in temperate, subtropical and tropical areas of the world except for island groups in the Pacific and isolated islands in the Atlantic. Bironella and Chagasia are small genera, restricted to the Australasian and Neotropical Regions, respectively. Adult anophelines are easily recognized by their appearance. Most species stand with the body inclined at an angle of 30-45° to the surface and have dark and pale spots of scales on the veins of the wings. Some species have the wing veins entirely covered with dark scales. The maxillary palpi of both sexes are about as long as the proboscis (except in Bironella). The palpi of females sometimes have semi-erect scales that give them a rather shaggy appearance. The scutellum is evenly rounded in Anopheles and Bironella and tri-lobed in Chagasia. The abdominal sterna, and usually the terga, are completely or nearly devoid of scales. Anopheline larvae lack a respiratory siphon, the head is longer than wide and pairs of palmate setae are normally present on some or all of abdominal segments I-VII.

Chagasia (Genus)
Chagasia is a small genus of only five species. Four species of Chagasia are restricted to South America and one (Ch. bathana) extends from Ecuador, Colombia and Venezuela through Central America into southern Mexico. Chagasia has been considered an ancient group showing affinities with non-anophelines. Cladistic analyses of morphological data and DNA sequences of various ribosomal, mitochondrial and nuclear genes strongly support the monophyly of Chagasia and its placement in an ancestral relationship to all other anophelines.

Similar to Anopheles
The adults of Chagasia are similar to those of Anopheles, but the resting posture is like culicine mosquitoes with the head and abdomen at angles to the thorax, and the scutellum is tri-lobed with setae in three distinct groups. The wings have dark scales or a mixture of dark and pale scales, but there are no distinct spots as there are in most Anopheles. Larvae have uniquely shaped palmate setae (seta 1) on abdominal segments III-V, and the spiracular apparatus bears a long median process and a fringe-like row of setae on either side. See Anophelinae.

Chagasia larvae are usually found in shaded streams among the roots of trees and in grassy margins or dead leaves and other debris.

They sometimes occur in clear rock-pools along shaded streams. Adults remain in vegetation near the larval habitats or enter nearby forest canopy. Females bite during the day and night, but seldom feed on humans. Species of Chagasia are not known to transmit any pathogens of human diseases.

Chironomidae (Chironomidae family) (Non-Biting Midges)
Chironomidae (informally known as chironomids or non-biting midges) are a family of nematoceran flies with a global distribution. They are closely related to the Ceratopogonidae, Simuliidae, and Thaumaleidae. Many species superficially resemble mosquitoes but they lack the wing scales and elongate mouthparts of the Culicidae. This is a large group of insects with over 5000 described species and 700 species in North America alone.

Plumose Antennae
Males are easily recognized by their plumose antennae. Adults are sometimes known as "lake flies" in parts of Canada, as "sand flies", "muckleheads", or "muffleheads" in various regions of the USA Great Lakes area, and as "blind mosquitoes" or "chizzywinks" in Florida, USA. Their amazing biodiversity often goes unnoticed because Chironomidae are notoriously difficult to identify and are usually recorded by species groups by ecologists. Each morphologically distinct group consists of a number of morphologically (sibling) identical species that can only be identified by rearing adult males or by cytogenetic analysis of the polytene chromosomes.

Polytene chromosomes were originally observed in the larval salivary glands of Chironomus midges by Balbiani in 1881. They form through repeated rounds of DNA replication without cell division, resulting in characteristic light and dark banding patterns which can be used to identify inversions and deletions which allow species identification.

Bloodworms
Larval stages of Chironomidae can be found in almost any aquatic or semiaquatic habitat, including treeholes, bromeliads, rotting vegetation, soil, and in sewage and artificial containers. They form an important fraction of the macro zoobenthos of most freshwater ecosystems. They are often associated with degraded or low biodiversity ecosystems because some species have adapted to virtually anoxic conditions and are dominant in polluted waters. Larvae of some species are bright red in color due to a hemoglobin analog; these are often known as "bloodworms". Their ability to capture oxygen is further increased by making undulating movements.

Adults can be pests when they emerge in large numbers. They can damage paint, brick, and other surfaces with their droppings. When large numbers of adults die they can build up into malodorous piles. They can provoke allergic reactions in sensitive individuals

Culex
Carl Linnaeus used the Latin term for midge or gnat, culex, as the name of this taxon. Culex is a genus of mosquito, and is important in that several species serve as vectors of important diseases, such as West Nile virus, filariasis, Japanese encephalitis, St. Louis encephalitis and avian malaria. The adult mosquito can measure from 4–10 millimeters (0.16–0.39 in), and morphologically has the three body parts common to insects: head, thorax, and abdomen.

As a fly, it has one pair of wings. Scientists at the University of California, Davis and the Swedish University of Agricultural Sciences (SLU), have identified nonanal as a compound that attracts Culex mosquitoes. Nonanal acts synergistically with carbon dioxide.

The developmental cycle takes two weeks and is by complete metamorphosis. Eggs are laid singularly or in batches, depending on the species. Eggs will only hatch in the presence of water. During the larval stage the mosquito lives in water and feeds on organic matter and plants, then develops into a pupa. The pupa is comma-shaped and also lives in water. It does not feed and becomes an adult after one or two days.

Culex Tarsalis

Tarsalis is a North American species of mosquito that occupies a large swath of territory between northern Mexico and southern Canada, spreading from the Pacific to the Atlantic coast. It is most commonly seen in California, at elevations ranging as high as 3000 meters. The species is much less abundant in areas east of the Mississippi River, although there have been several reported cases of C. tarsalis occurrences as far as New Jersey, which were found exploiting freshwater impoundments constructed to eliminate the salt marsh species Aedes sollicitans. (Crans and McCuiston, 1987; Reisen, 1993)

Associated Species

Larval habitats frequently are shared with Culiseta inornata, Culex quinquefasciatus, Cx. pipiens and Cx. stigmatosoma; other species include Culex erythrothorax, Cx. restuans and several species of Aedes and Anopheles.

Rafts

Rafts averaging about 190 eggs are oviposited in newly-created sunlit surface water pools that are frequently surrounded by grasses and annual vegetation. Larvae tolerate a wide range of water conditions and may be abundant in agricultural tailwater, alkaline lake beds, fresh and saline wetlands, secondary treated sewage effluent and oil field run-off. Permanent water with fixed depth rarely supports abundant populations unless intermittently perturbated. Excessive organic pollution is not tolerated.

Cx. tarsalis are among the first colonizers of newly-created surface pools and thus exploit microfloral blooms produced by the release of nutrients from decomposing vegetation. Larval development ranges from 7 days to <4 weeks and progresses as a curvilinear function of water temperature and food availability. Larval survivorship is typically <5%, with most losses attributable to predation. Some females mature their initial egg batch without a blood meal and oviposit 4-5 days after emergence. The frequency of this trait is dependent upon temperature, photoperiod and nutrition and affects the vectorial capacity of a population. At northern latitudes, females overwinter in facultative diapause as inseminated nullipars (never developed eggs) that require a blood meal to produce their initial eggs in the spring.

Blood Feeding

In spring, when population abundance is low, most females feed on birds shortly after sunset. During late summer when abundance is high, bird mosquito-avoidance behavior diverts many females to feed on mammals including rabbits, horses, cattle and man. This host shift may be important in virus transmission to horses and man. Dispersal is primarily during host-seeking flights (up to 17 miles) which average about l00 yards a day from breeding sites in riparian and agricultural habitats.

Culicidae (Mosquito family)

Mosquitoes undergo complete metamorphosis with four stages. The female mosquito lays her eggs on the surface of fresh or standing water; some species lay eggs on damp soil prone to inundation. Larvae hatch and live in the water, most using a siphon to breathe at the surface. Within one to two weeks, the larvae pupate. Pupae cannot feed, but can be active while floating on the water's surface. Adults emerge, usually in just a few days, and sit on the surface until they are dry and ready to fly. Adult females live two weeks to two months; adult males may only live a week.

Identifying characteristics for the family Culicidae include:

- Antennae with 6 or more segments (suborder Nematocera), plumose on males and short-haired on females.
- Proboscis long.
- Wings with scales on veins and along the margins.

Additional information:

- Females vector pathogens of major diseases including malaria (protozoan), yellow fever (virus), filariasis (nematode), dengue (virus), and certain types of encephalitis (virus).
- Larvae are aquatic, most feeding on algae, protozoans, and organic debris; a few species are predaceous on other mosquito larvae.
- Males and females feed on nectar and plant juices. Only females feed on blood.
- There are about 150 species of mosquitoes in North America.
- Yellow fever decimated the French army stationed in Haiti, contributing to Napoleon's decision to sell Louisiana to the United States in 1803 and assisting the Haitians in securing their independence in 1804.

Mansonia

Adults of Mansonia are generally large mosquitoes characterized by the presence of broad, asymmetrical scales on the wing veins. There is often a mixture of dark and pale scales that imparts a speckled appearance to the wings. Mansonia resemble some species of Culex, Aedini and Coquillettidia, but the tarsal claws are simple, the abdomen is truncate in females (distinctions from aedine genera), pulvilli are not evident (distinction from Culex) and postspiracular setae are present (distinction from Old World species of Coquillettidia).

New World species of Coquillettidia possess postspiracular setae, but differ from Mansonia in having a conspicuous preapical white band on the anterior surface of the femora. The larvae of Mansonia resemble those of Coquillettidia in having the spiracular apparatus and siphon distinctively modified for piercing plant tissues. They differ from Coquillettidia in having the distal part of the antenna fused with and much shorter than the basal part.

Mansonia titillans of subgenus Mansonia is an important pest in South and Central America and in the southern USA. It is known to transmit various arboviruses, including Venezuelan equine encephalitis.

Some species of subgenus Mansonioides transmit several arboviruses, but they are mainly important as vectors of the helminths that cause Brugian filariasis in India and Southeast Asia. Mansonia uniformis, which is widely distributed from western Africa through southern Asia to Japan and the Australasian Region, is a vector of Wuchereria bancrofti in Western New Guinea. Mansonia and Coquillettidia larvae do not have to breathe at the water surface like most others. They have a sharp pointed siphon to pierce the roots or stems of aquatic plants for oxygen.

Phlebotominae (Sand Flies Family)

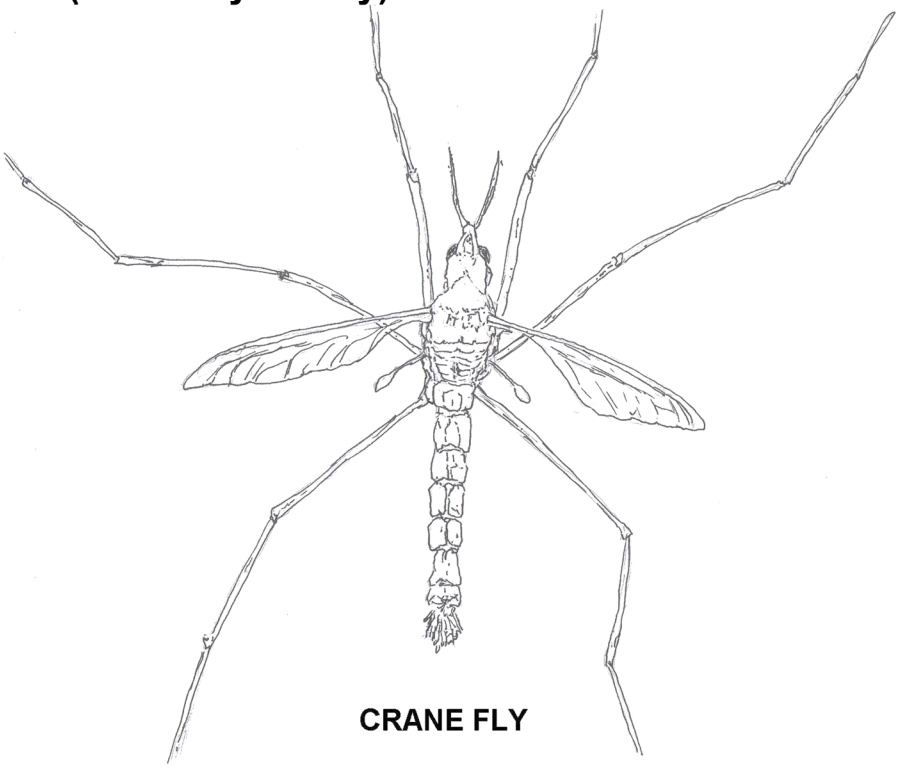
Members of the subfamily Phlebotominae are known outside of the United States by the name sand fly. This subfamily includes numerous genera of blood-feeding (hematophagous) flies, including the primary vectors of leishmaniasis, bartonellosis and pappataci fever. In the New World, leishmaniasis is spread by sand flies of the genus Lutzomyia, which are common inhabitants of caves, where they feed on bats. In the Old World, the disease is spread by sand flies of the genus Phlebotomus.

Female Sand Flies

Female sand flies suck blood from many warm-blooded animals because the blood helps them to make eggs. Only female sand flies bite, and use their mouthparts to create a pool of blood, which is then sucked up. They inject histamine to prevent blood clotting, similar to the feeding habits of a female mosquito. Females lay their eggs in humid soil rich in organic matter.

One blood meal can result in the creation of up to 100 eggs. Sand flies are small (with a body size of about 3mm in length), making them hard to detect. Their bite is sometimes not felt and leaves a small round, reddish bump that starts itching hours or days later. Use of insect repellent is recommended in areas where sand flies are present.

Tipulidae (Crane Fly Family)



CRANE FLY

A crane fly is an insect in the family Tipulidae. Adults are very slender, long-legged flies that may vary in length from 2–60 millimeters (0.079–2.4 in) (tropical species may exceed 100 millimeters or 3.9 inches).

In the United Kingdom, Ireland and Newfoundland they are commonly referred to as daddy long-legs, but this name can also refer to two unrelated arthropods: members of the arachnid order Opiliones (especially in the United States and Canada) and the cellar spider Pholcidae (especially in Australia). The larva of the European Crane Fly is commonly known as a leatherjacket. These larvae can cause damage to lawns by feeding on the roots of grass plants. Numerous other common names have been applied to the crane fly, many of them more or less regional, including mosquito hawk, mosquito wolf, mosquito eater (or skeeter eater), gallinipper, and gollywhopper.

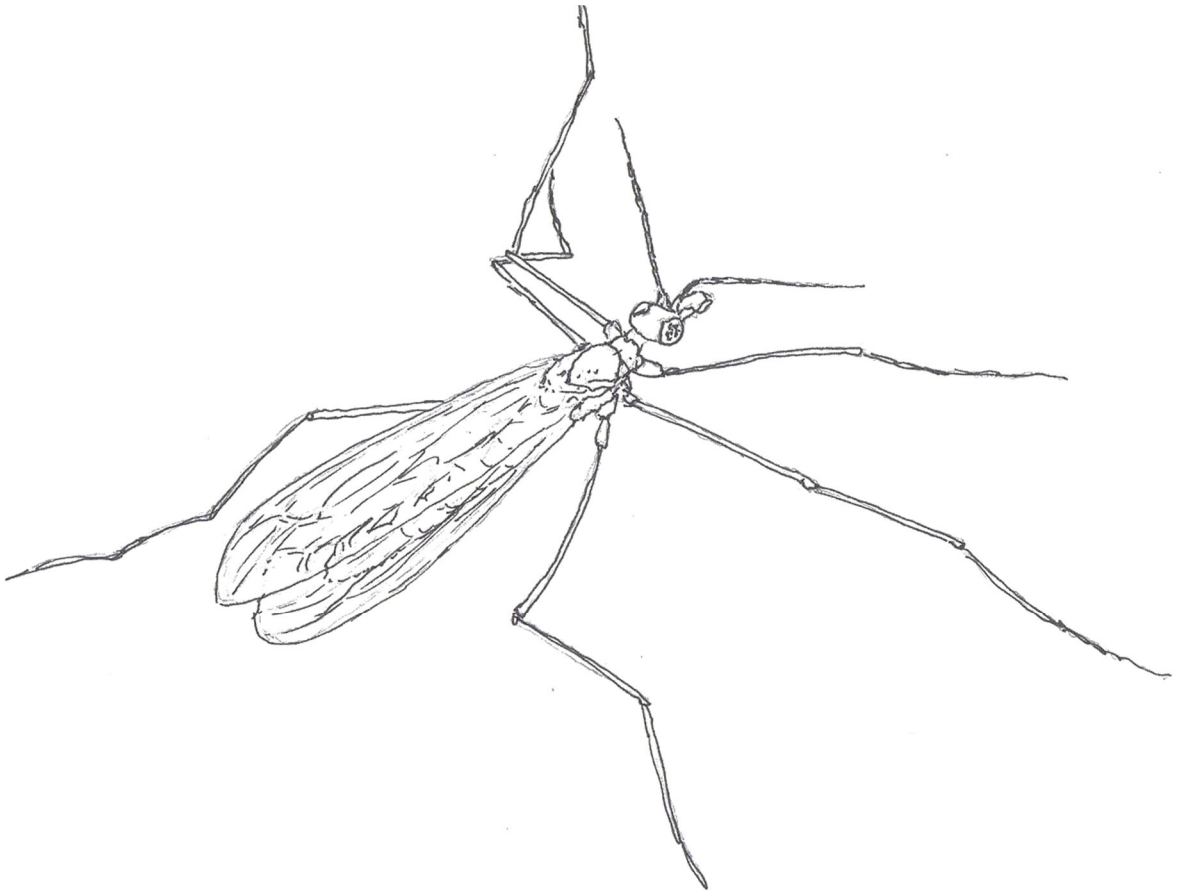
Largest Families of Diptera

At least 4256 species of crane flies have been described, most of them (75%) by the specialist Charles Paul Alexander. This makes Tipulidae one of the largest families of Diptera (although smaller than Limoniidae, one of the other extant families of crane flies). In appearance crane flies seem long and gangly, with very long legs, and a long slender abdomen. The wings are often held out when at rest, making the large halters easily visible. Unlike most flies, crane flies are weak and poor fliers with a tendency to "wobble" in unpredictable patterns during flight, and they can be caught without much effort. Crane flies vary in size, with temperate species ranging from 2 to 60 millimeters (0.079 to 2.4 in), while tropical species have been recorded at over 100 millimeters (3.9 in). The giant crane fly (Holorusia rubiginosa) of the western United States can reach 38 millimeters (1.5 in). Some Tipula species are 64 millimeters (2.5 in).

Many smaller species (known as bobbing gnats) are mosquito-sized, but they can be distinguished from mosquitoes by the V-shaped suture on the thorax, non-piercing mouthparts, and a lack of scales on the wing veins.

Females
Adult mouthparts may occur on the end of the crane fly's long face, which is sometimes called a snout or a short rostrum. Female abdomens contain eggs, and as a result appear swollen in comparison to those of males. The female abdomen also ends in a pointed ovipositor that may look somewhat like a stinger, but is in fact completely harmless.

Larvae have a distinct head capsule, and their abdominal segments often have long fleshy projections surrounding the posterior spiracles (almost like tentacles). Little is known of the juvenile biology of many crane fly species. The larvae of less than 2% of the species have been described. Of those that have been described, many prefer moist environments, and some leatherjackets are aquatic.



WINTER CRANE FLY

Genera and Important Mosquito species in the United States (Family Culicidae)

Only the most important species in each genus are listed by name.
Subfamily Anophelinae (anophelines)

Genus Anopheles 17 spp.
albimanus, bradleyi, crucians, franciscanus, freeborni, hermsi, psuedopunctipennis, punctipennis, quadrimaculatus spp. complex, walkeri.
Subfamily Culicinae (culicines)

Genus Aedes 4 spp.
aegypti, albopictus, cinereus, vexans

Genus Coquillettidia 1 spp.
perturbans

Genus Culex 29 spp. & subspecies
erraticus, nigripalpus, peccator, pipiens, pilosus, quinquefasciatus, restuans, salinarius, stigmatosoma, tarsalis

Genus Culiseta 8 spp.
incidens, inornata, melanura

Genus Deinocerites 3 spp.
cancer, mathesoni, pseudes

Genus Haemogogus 1 spp.

Genus Mansonia 2 spp.
dyari, titillans

Genus Ochlerotatus 77 spp.
abserratus, atlanticus, canadensis, cataphylla, communis, deserticola, dorsalis, excrucians, fitchii, hexadontus, increpitus, monticola, nigromaculis, punctor, sierrensis, sollicitans, spencerii, sticticus, stimulans, taeniorhynchus, triseriatus, trivittatus, varipalpus,

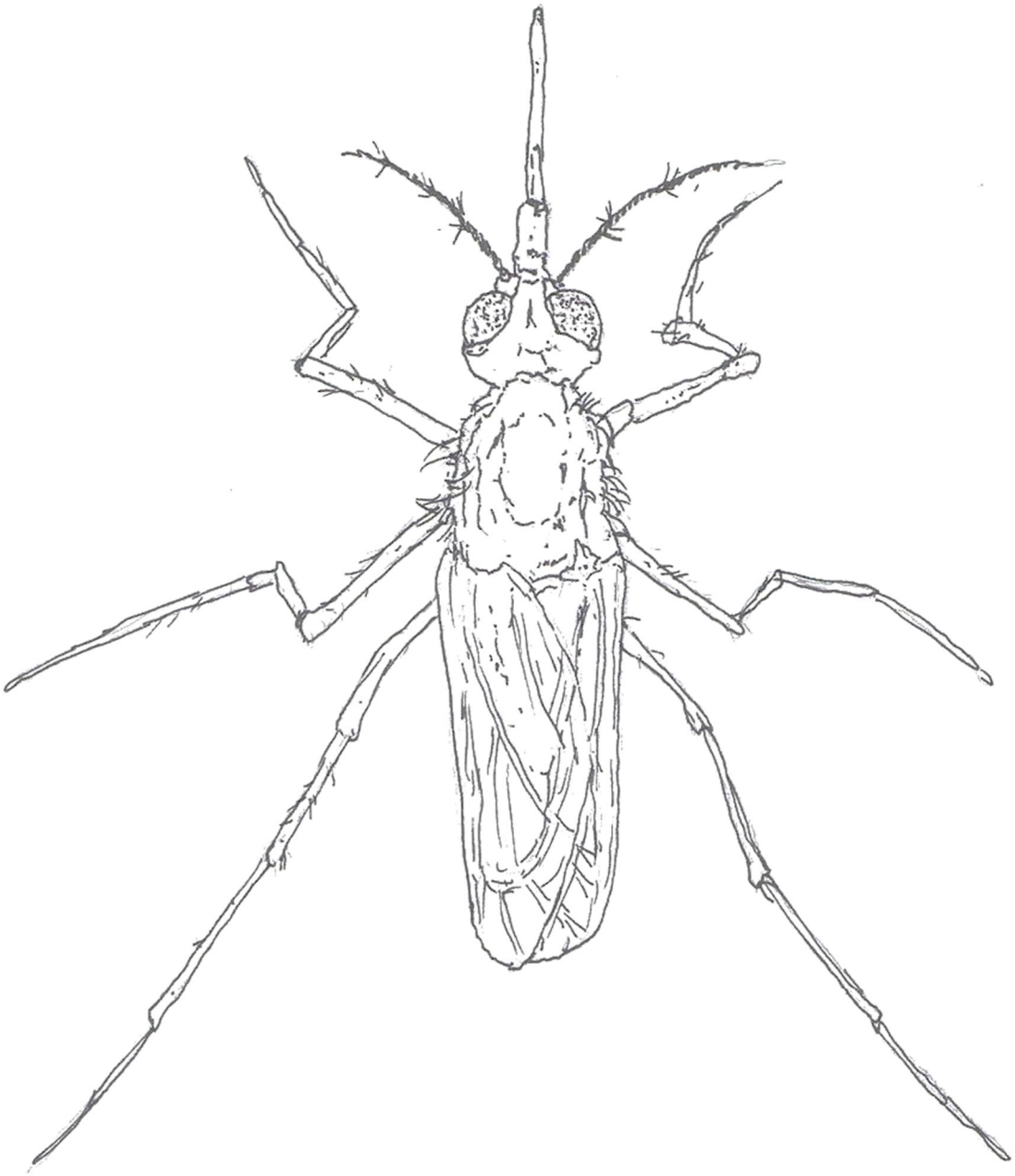
Genus Orthopodomyia 3 spp. signifera, alba

Genus Psorophora 15 spp. ciliata, columbiae, cyanescens, ferox, signipennis

Genus Toxorhynchites 2 subspecies

Genus Uranotaenia 3 spp. & subspecies
Sappharina

Genus Wyeomyia 4 spp. mitchellii



MOSQUITO
(CULICIDAE FAMILY SPP.)

Key Mosquito Species in Arizona

Although there are about 180 species of mosquitoes in the U.S. and more than 40 in Arizona, only a few are problems for residents, the Culex and Aedes mosquitoes being of greatest concern because of the disease-causing pathogens they vector. Here we focus on mosquito species of concern:
1) Western encephalitis mosquito, Culex tarsalis
2) Southern house mosquito, Culex quinquefasciatus
3) Yellow fever mosquito, Aedes aegypti 4) Western malaria mosquito, Anopheles hermsi
5) Inland floodwater mosquito, Aedes vexans
6) Dark ricefield mosquito, Psorophora columbiae form toltecum
7) Asian tiger mosquito, Aedes albopictus Females of both Culex species deposit their eggs on water surfaces in tight groupings or rafts. Females prefer egg-laying habitats including most standing water sources ranging from mud-puddles, bird baths, outdoor trash cans, landscape ponds, pet water dishes/troughs, and empty flower pots, to larger sources such as school playing fields, over-irrigated lawns, drainage ditches, septic tanks and wells (Gouge 2004a, b). Agricultural fields and other flood irrigated fields also can support high populations of Culex mosquitoes (Gouge 2004a, b).

Key Mosquito Species in California

Two invasive (non-native) mosquito species have recently been found in several California cities (see map below), and there is a potential for them to spread into other areas of California. They are named *Aedes aegypti* (the yellow fever mosquito) and *Aedes albopictus* (the Asian tiger mosquito). Unlike most native mosquito species, *Aedes aegypti* and *Aedes albopictus* bite during the day. Both species are small black mosquitoes with white stripes on their back and on their legs. They can lay eggs in any small artificial or natural container that holds water. *Aedes aegypti* and *Aedes albopictus* have the potential to transmit several viruses, including dengue, chikungunya, Zika, and yellow fever.

None of these viruses are currently known to be transmitted within California, but thousands of people are infected with these viruses in other parts of the world, including in Mexico, Central and South America, the Caribbean, and Asia. The presence of *Aedes aegypti* and *Aedes albopictus* mosquitoes in California poses a threat that Zika, dengue, and chikungunya viruses can be transmitted in infested areas from returned infected travelers. Travelers can protect themselves by preventing mosquito bites. When traveling to countries with dengue, chikungunya, or Zika, use insect repellent, wear long sleeves and pants, and stay in places with air conditioning or with window and door screens.

- *Aedes taeniorhynchus*
- *Aedes squamiger*
- *Aedes sierrensis*
- *Aedes washinoi*
- *Anopheles franciscanus*
- *Anopheles punctipennis*
- *Anopheles hermsi*
- *Anopheles occidentalis*
- *Culex erythrothorax*
- *Culex quinquefasciatus*
- *Culex restuans*
- *Culex stigmatosoma*

- *Culex tarsalis*
- *Culiseta incidens*
- *Culiseta inornata*
- *Culiseta particeps*

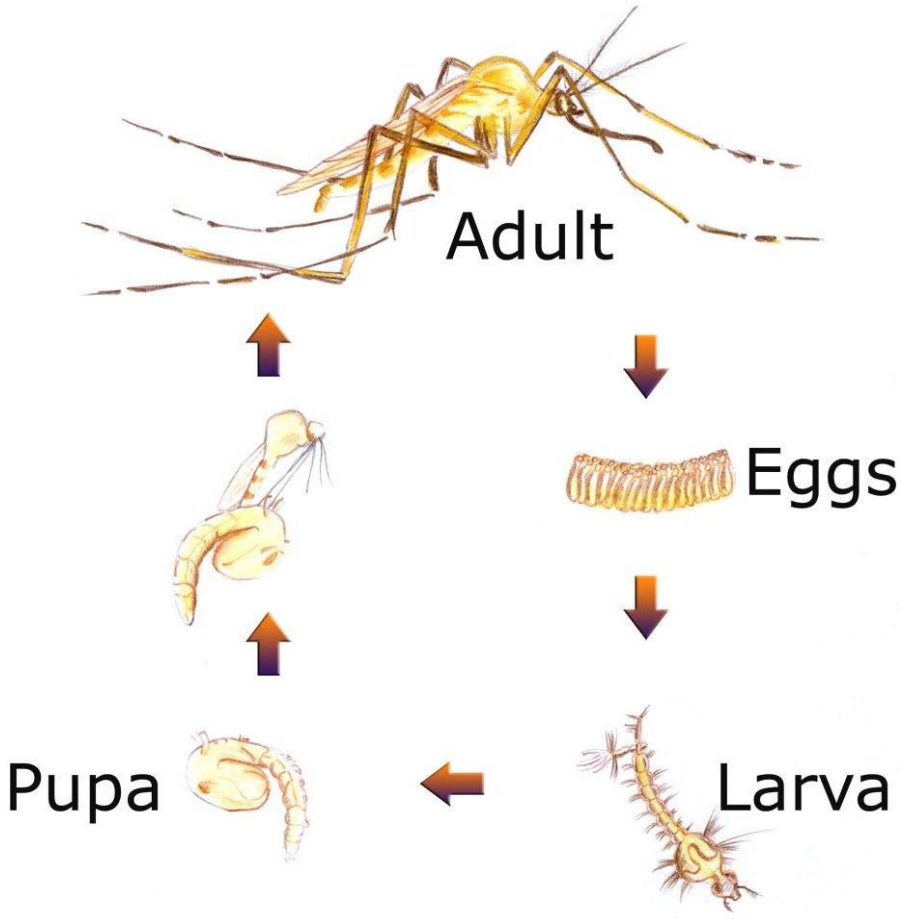
Here's the Bad News…

Recent documents found in terrorist's hideout have confirmed the worst possible scenario. Insects are a viable method of carrying diseases that can destroy mankind. Researchers have discovered that 25 species successfully carry viruses and toxins that can easily destroy mankind. A suitcase of these insects can potently wipe an entire city of all human life.

Mosquito Life Cycle Sub-Section

The type of standing water in which the mosquito chooses to lay her eggs depends upon the species. The presence of beneficial predators such as fish and dragonfly nymphs in permanent ponds, lakes, and streams usually keep these bodies of water relatively free of mosquito larvae.

However, portions of marshes, swamps, clogged ditches, and temporary pools and puddles are all prolific mosquito breeding sites. Other sites in which some species lay their eggs include tree holes and containers such as old tires, buckets, toys, potted plant trays, and saucers and plastic covers or tarpaulins.



LIFE CYCLE DIAGRAM #1

Some of the most annoying and potentially dangerous mosquito species, such as the Asian tiger mosquito, come from these sites. The mosquito goes through four distinct stages during its life cycle:

- **Egg:** hatches when exposed to water;
- **Larva** (plural. - larvae)**:** lives in the water; molts several times; most species surface to breathe air;
- **Pupa** (plural - pupae)**:** does not feed; stage just prior to emerging as adult;
- **Adult:** flies short time after emerging and after its body parts have hardened.

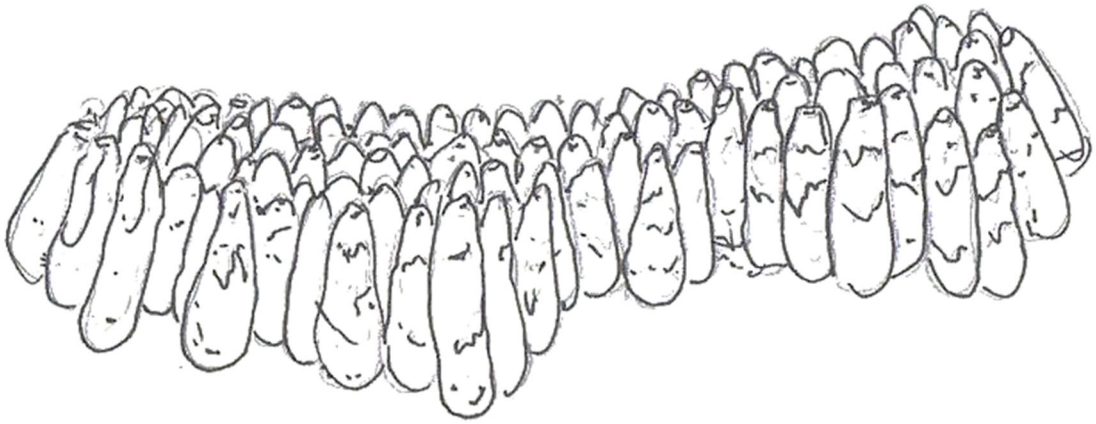
Wrigglers and Tumblers

The mosquitoes in the United States, all of which live in specific habitats, exhibit unique behaviors and bite different types of animals. Despite these differences, all mosquitoes share some common traits, such as a four-stage life cycle.

After the female mosquito obtains a blood meal (**male mosquitoes do not bite**), she lays her eggs directly on the surface of stagnant water, in a depression, or on the edge of a container where rainwater may collect and flood the eggs. The eggs hatch and a mosquito larva or "**wriggler**" emerges.

The larva lives in the water, feeds, and develops into the third stage of the life cycle called a pupa or "**tumbler**". The pupa also lives in the water, but no longer feeds.

Finally, the mosquito emerges from the pupal case and the water as a fully developed adult female, ready to bite.



MOSQUITO EGGS (RAFT)

Mosquitoes may overwinter as eggs, fertilized adult females or larvae. Eggs, larvae, and pupae must have water to develop. Some female mosquitoes lay their eggs directly on the water surface.

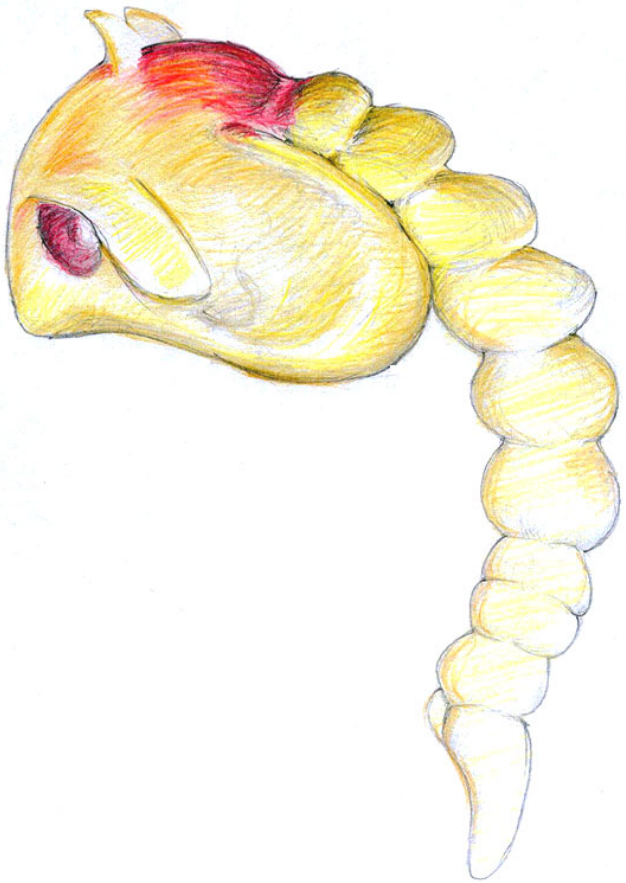
Others lay their eggs on substrates above the water line (flood pool mosquitoes); the eggs hatch upon flooding. In some cases, the eggs will remain viable for several years until further flooding occurs.

Mosquitoes belonging to the genus Culex lay their eggs in bunches or "*rafts*."

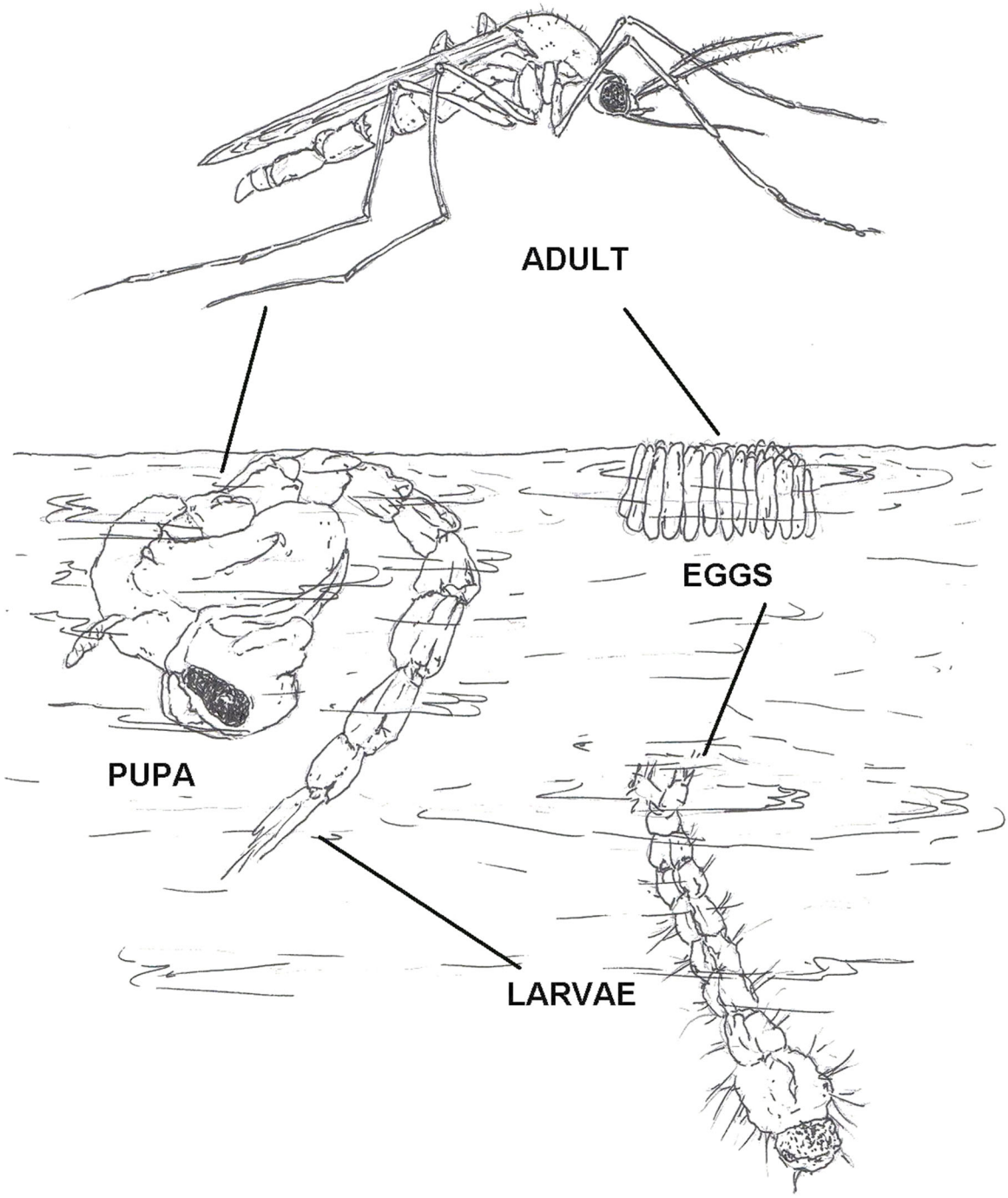
Each raft may contain up to 400 individual eggs. Larvae feed on bits of organic matter dispersed in the water, becoming full grown in about one week. The pupal stage lasts two to three days.

Female mosquitoes are ready to bite one to two days after adult emergence.
Male mosquitoes do not bite but feed on flower nectar or plant juices. Some mosquitoes have only one generation per year, whereas others may have four or more.

Adults may fly 5 to 10 miles, but usually rest in grass, shrubbery, or other foliage close to the water breeding area.



PUPA OF ANOPHELES FARAUTI



MOSQUITO LIFE CYCLE DIAGRAM #2

Mosquito Egg Classification

Mosquito eggs are generally cylindrical in shape, tapered at the top and rounded at the bottom. Each mosquito species prefers certain localities for depositing eggs. Some prefer very clean water, others slightly polluted water, while others thrive in extremely polluted water.

Oviposition Definition
An insect laying an egg or eggs with their ovipositor.

Ovipositor Definition
The ovipositor is a tube-like organ used by some animals for the laying of eggs. In insects, an ovipositor consists of a maximum of three pairs of appendages. The details and morphology of the ovipositor vary, but typically its form is adapted to functions such as transmitting the egg, preparing a place for it, and placing it properly. For insects, the organ is used merely to attach the egg to some surface, but for many parasitic species (primarily in wasps and other Hymenoptera), it is a piercing organ as well.

There are Five Distinct Types of Oviposition:
Single On Water: Anopheles and Toxorhynchites lay their eggs one at a time on the water surface.

Single in Soil: most Aedes and Psorophora lay their eggs one at a time on a moist substrate, such as mud and decomposing leaf litter.

Single On Cavity Walls: Wyeomyia, Orthopodomyia, and certain Aedes deposit eggs in tree holes, water-holding plants, or artificial containers. The eggs are placed just above the waterline.

Rafts On Water: Most Culex, Culiseta, Coquillettidia, and Uranotaenia lay eggs in masses, called rafts or boats, on the water surface.

On Plants: Mansonia eggs are deposited on the underside, and sometimes on top of the leaves of certain floating aquatic plants.

Weather
Mosquito development and population dynamics are closely tied to weather. When and how much rain is received, wind speed and direction, maximum and minimum temperatures, and the total amount of heat energy accumulated are all critical to mosquito development.

Water Source
The water (or lack thereof) in a habitat directly affects mosquito reproduction. All mosquitoes need standing water to complete their development. Factors such as when it first collects in sufficient quantities, how long it persists, quality, depth profile, vegetation and predator species (often lacking in artificial containers) and geographical distribution all affect mosquito development. Different species variously exploit nearly all combinations of these factors.

Mating most commonly occurs in twilight swarms within 2-3 days after females emerge. Most, but not all, females mate before they take blood.

Both sexes feed frequently on plant nectar; females take blood in order to obtain protein for egg development. A few species are autogenous, meaning they do not need a blood meal to produce eggs.

One Massachusetts species, the pitcher plant mosquito (Wy. smithii), never takes blood. Most females begin seeking hosts 2-4 days after emergence but some species (e.g., Cs. morsitans) may delay feeding for 2 weeks or more. Thus, the time period between adult emergence and the first egg laying (first gonotrophic cycle) is usually 7-10 days.

Subsequent host-feeding to egg-laying cycles in most temperate species require 4-6 days. Species that transmit disease (vectors) must feed at least twice, once to acquire the infection, and once to transmit it, unless the infection is acquired transovarially (into the egg while in the ovary) from their mother. This means that females must normally survive for 12-14 days in order to be a vector.

If the extrinsic incubation period of the pathogen/parasite in the mosquito is longer than the gonotrophic cycle, as is often the case, the survival time required for transmission is even longer. Most females do not survive beyond the first oviposition but a few individuals in all mosquito populations live a long time (i.e., several weeks). Exceptionally, overwintering adults live 5-7 months. Males generally survive for shorter periods than females and never overwinter.

Key Mosquitoes in Oklahoma

Very few mosquitoes in Oklahoma are able to transmit diseases. Of the 60 plus species present in Oklahoma, only 7 to 10 species are considered medically important because of their pest status to people. Disease transmission by mosquitoes is complex, and being bitten by a mosquito does not mean an individual will develop an illness. If a mosquito-borne disease is detected in Oklahoma the mosquito species transmitting the disease must be identified. Control measures targeting the biology and behavior of that particular species are then implemented to reduce pest populations and prevent further disease transmission.

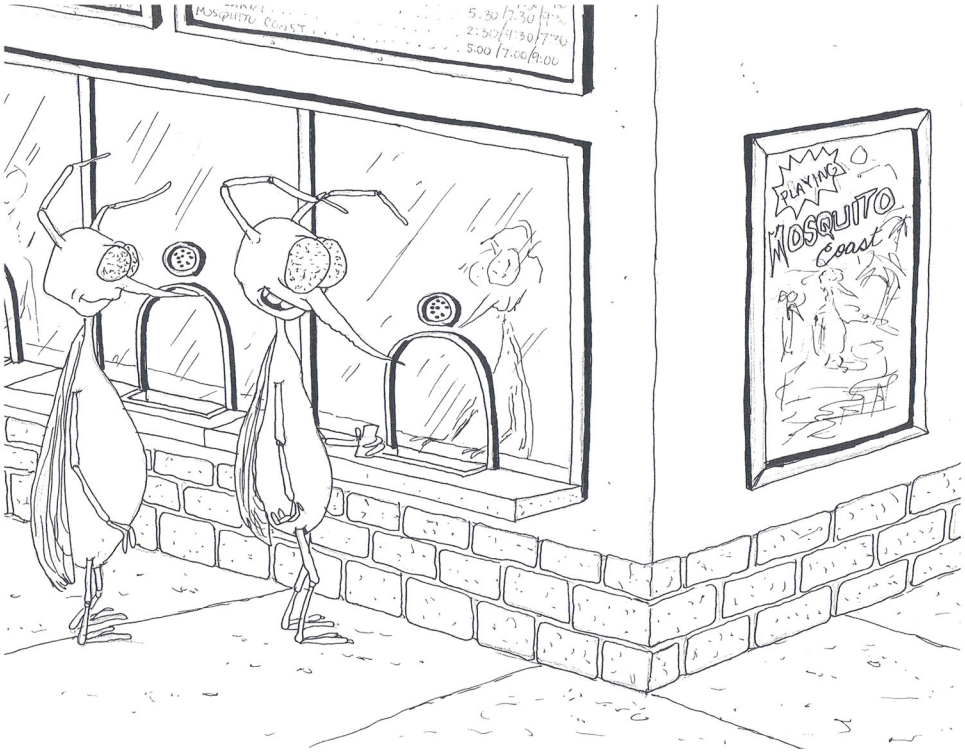
Most likely mosquito species (**based on relative abundance**) present in Oklahoma which could transmit the West Nile Virus: (* Denotes species from which WNV disease isolates have been reported to CDC/Arbonet in 2002.)

*Aedes albopictus**
*Culex pipiens/quinquefasciatus**
*Culex restuans**
*Culex salinarius**
*Culex tarsalis**
*Culiseta inornata**

Other vector species present from which WNV has been isolated:

Aedes cinereus
*Aedes vexans**
*Anopheles punctipennis**
*Anopheles quadrimaculatus**
*Coquillettidia perturbans**
Culex nigripalpus
Culiseta melanura
Ochlerotatus canadensis
*Ochlerotatus sollicitans**
Ochlerotatus taeniorhynchus
*Ochlerotatus triseriatus**
*Ochlerotatus trivittatus**
Psorophora columbiae
*Psorophora ciliata**

No disease isolates have been made as of yet from Aedes aegypti for West Nile Virus. However, this is a medically important species which has transmitted other diseases and should be suspect for WNV transmission in Oklahoma.



Key Mosquitoes in Pennsylvania

The mosquito most often discovered in urban areas of Pennsylvania is the northern house mosquito, *Culex pipiens.* This is also the mosquito that is thought to transmit the most cases of WNV (human cases) in Pennsylvania and consequently poses the greatest annoyance and risk to our citizens.

Although the risk of contracting serious illness from mosquitoes is low, much can be done to increase protection from mosquito-borne disease. This includes the reduction of breeding sites, use of repellents, repair of home screens and the limitation of outdoor activities to periods of time when mosquitoes are less active.

(1) During the 5-year period from 2001 through 2005, the number of west Nile virus human cases reported were: 2001 - 3; 2002 – 62; 2003 – 237; 2004 – 15; 2005 – 25.
(2) Only 2 cases of eastern equine encephalitis occurred in Pennsylvania during the 37-year period from 1964 through 2000.

Mosquito Habitat Section - Introduction

Mosquitoes can live in almost any environment, with the exception of extreme cold weather. They favor forests, marshes, tall grasses and weeds, and ground that is wet at least part of the year. Because they must have water in order to thrive, their habitats break down into two basic types:

Permanent water mosquitoes tend to lay their eggs in clumps, called rafts, of 50 to 300 on the surface of standing water at the edges of lakes and ponds and among the vegetation in swamps and marshes. Some species prefer clean water, while *Culex pipiens*, the northern house mosquito, prefers stagnant or polluted water.

Culex* and *Anopheles mosquitoes are among the most common permanent water mosquitoes. These mosquitoes are most active when the average temperature is above 70 degrees. Their eggs must stay in water in order to survive and usually will hatch within a couple of days, releasing larvae to begin the development process.
Many permanent water mosquitoes can also breed in containers that collect and hold water, such as wading pools, buckets or toys left outside.

Floodwater mosquitoes lay their eggs in moist soil. The eggs, as many as one million per acre, will dry out as the ground does, then hatch when rains saturate the ground and water levels begin to rise. Floodwater habitats include:

- Drainage **ditches** that fill during storms.
- **Woodland pools** created by melting snow, or spring and early summer rains.
- **Floodplains** along the banks of streams and rivers.
- Irrigated **pastures** and **fields**.
- **Meadows** and other soft ground where depressions form.

Common species include the *Aedes vexans*, also known as the inland floodwater mosquito. Mosquitoes that breed in floodwater habitats usually become a problem about seven to 10 days after a heavy rain, and subside in about a week or two. Floodwater mosquitoes also breed in containers. *Aedes albopictus*, the Asian tiger mosquito, prefers the insides of old tires where dirty water collects, and *Aedes triseriatus* prefers treeholes that gather rainwater.

Stagnant Water
Eliminate standing water around the property to reduce the numbers of potential mosquito breeding sites. Ideally, this should be a community goal because most mosquitoes can fly long distances.
The types of modifications include:

- Removing old tires, cans, buckets, pots, and similar items that can trap rainwater.
- Position tarps and boat covers to allow rain runoff and limit ‘ponding.’
- Potted plants with water-capture bases should be drained or screening applied to the overflow vents.
- Turn plastic wading pools and wheelbarrows upside-down when not in use.
- Change birdbath water at least once a week.
- Keep swimming pools chlorinated and stock ornamental ponds with surface-feeding minnows.
- Rain gutters should be installed with sufficient slope to prevent the pooling of water; remove leaves and other obstructions from downspouts.

Running Water
Few mosquito species in the U.S. breed in running waters, such as streams. Larvae can be flushed out when stream volume increases, and to remain in the stream requires a large amount of energy. The tropical genus *Chagasia* and some *Anopheles* species are stream breeders. In addition, *Anopheles quadrimaculatus, Culex territans, and Uranotaenia sapphirina* have all been found in streams, although they prefer other habitats. Stream breeders will find vegetation along banks with which to anchor themselves or attempt to remain away from the main flow of the stream by seeking isolated eddies.

Chagasia is one of the three mosquito genera in the subfamily Anophelinae. The other two genera are *Anopheles* Meigen (nearly worldwide distribution) and *Bironella* Theobald (Australia only). The genus is found in the Neotropics. *Bironella* appears to be the sister taxon to the *Anopheles*, with *Chagasia* forming the outgroup in this subfamily. The species *Chagasia bathana* has eight chromosomes.

Anopheles is a genus of mosquitoes (Culicidae). Of about 484 recognized species, over 100 can transmit human malaria, but only 30–40 commonly transmit parasites of the genus *Plasmodium* that cause malaria, which affects humans in endemic areas. *Anopheles gambiae* is one of the best known, because of its predominant role in the transmission of the deadly species *Plasmodium falciparum*.

Transient Water
Transient water sources, such as flooded areas, snowpools, and ditches, are used as breeding grounds for mosquito species whose eggs can withstand desiccation, such as *Aedes* and *Psorophora*. Their life cycles require alternating periods of wet and dry. Other species, like an opportunistic *Culex,* might be able to pull off a single generation during an extended flooded period. Transient water generally shows water quality changes which result in various mosquito species using the same pool over a period of time.

Standing Water Mosquitoes
Permanent water group. Mosquito groups assigned to the permanent water group are Anopheles spp., Culex (Melanconium) spp., Cx. salinarius, Cx. territans, Coquillettidia spp. and Mansonia spp. As examples, the following permanent water habitat types and resident species are more or less typical of those found throughout the nation.

Freshwater Marsh
Mosquito species often found in freshwater marshes include An. walkeri, An. crucians, Psorophora columbiae, Cx. nigripalpus, Cx. salinarius, Cx. tarsalis, Cx. erraticus and Cx. peccator.

Lakes
Larvae may be found when many species of floating or emergent plants are present, but where vegetation occurs only in a narrow band along the lakeshore, larvae are confined to this littoral zone. Lake species include An. crucians, An. quadrimaculatus spp. complex, An. walkeri, Uranotaenia sappharina, Ur. lowii, Cx. salinarius, Cx. nigripalpus, Cx. erraticus, Cx. peccator, Cq. perturbans, Ma. dyari and Ma. titillans.

Ponds and Seepage Areas
There is no clear distinction between a pond and a lake except that ponds are generally smaller. Grassy woodland ponds or fluctuating ponds occupy shallow depressions and are filled by rainwater or surface run-off. They are usually of uniform depth, but the area they cover will vary, depending on rainfall.

Sinkhole ponds are usually quite deep and may be covered with vegetation or free of all except marginal plants. Both types of ponds may contain larvae of An. crucians, An. quadrimaculatus spp. complex, Culiseta inornata, Cs. melanura, Cx. nigripalpus, Cx. quinquefasciatus, Cx. restuans, Cx. salinarius, Cx. erraticus, Cx. peccator, Cx. pilosus, Cx. territans and Ochlerotatus canadensis. The seepage areas around hillsides and ponds or streams most often breed An. punctipennis, An. quadrimaculatus spp. complex, Oc. sticticus and Ps. ferox.

Springs
Mosquito breeding in springs is restricted to the quiet edges where vegetation affords cover for the larvae and there is little, if any, water movement. The only species recorded from are An. quadrimaculatus spp. complex and An. perplexens.

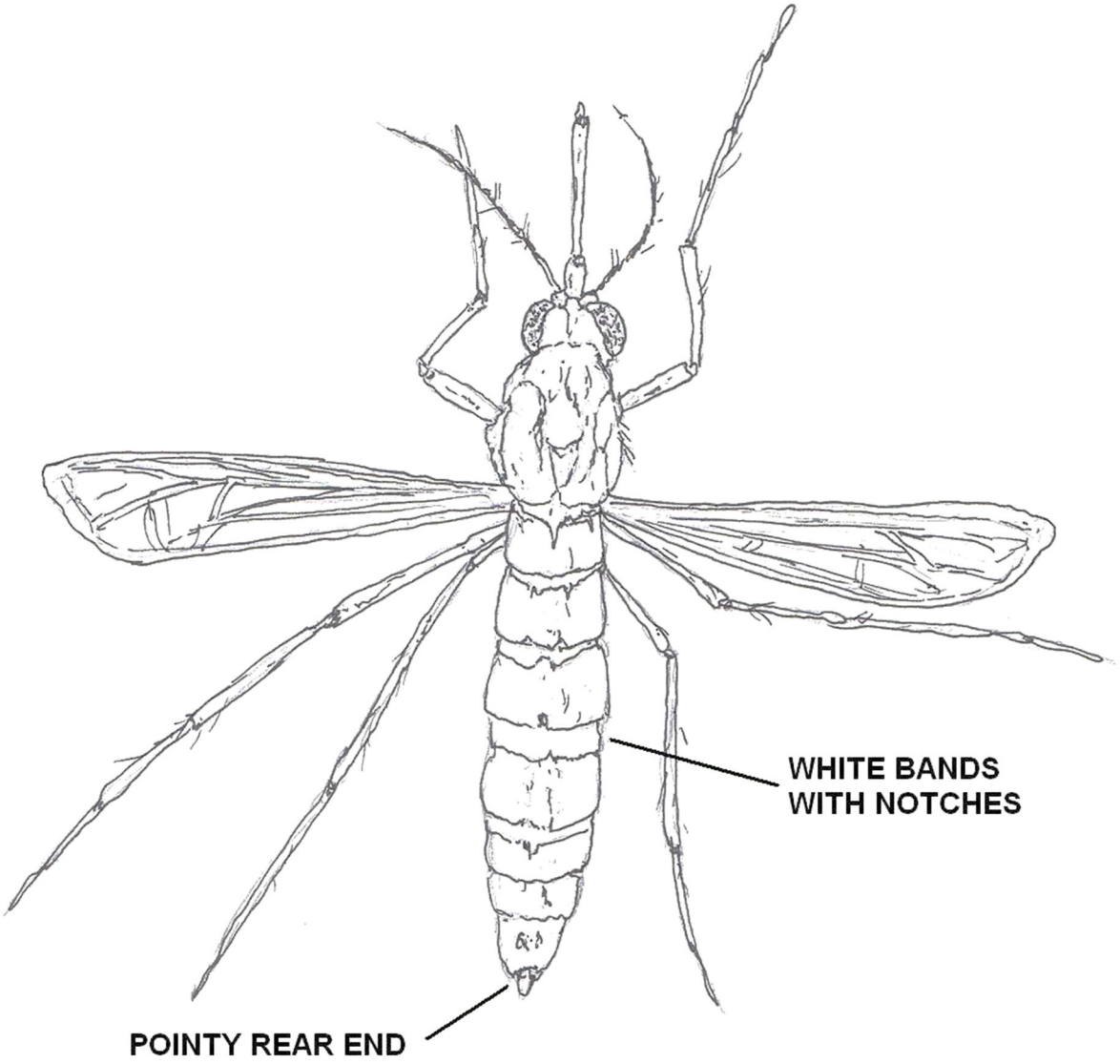
Swamps
Swamps differ from marshes principally in having dense cover from larger trees. The most common species of mosquito larvae found here are An. crucians, An. quadrimaculatus spp. complex, Cs. melanura, Oc. canadensis, Mansonia spp. and Cq. perturbans.

Transient Water Group
Mosquito groups assigned nationally to the transient water group are Cx. quinquefasciatus, Cx. tarsalis, Cx. restuans, Cs. inornata and Cs. melanura. As examples, the following specific habitat types and resident species are more or less typical of those found throughout the nation.

Salt or Brackish Water Ditches
The ditches adjacent to saltwater marshes contain many species of grasses and support a large mosquito fauna, including Oc. taeniorhynchus, Oc. sollicitans and An. bradleyi.

Borrow Pits and Canals
These man-made bodies of open water produce more mosquitoes as they silt-in and become overgrown with vegetation. They yield An. quadrimaculatus spp. complex, Cs. inornata, Ps. columbiae, Oc. canadensis, Cx. nigripa1pus, Cx. quinquefasciatus, Cx. restuans, Cx. salinarius, An. albimanus, Cq. perturbans and Mansonia spp.

Freshwater Drainage Ditches
In pastures, at the bottom of road shoulders, in old fields and in lowland groves, freshwater ditches will often yield the following species of mosquito larvae: Ps. columbiae, Cx. nigripalpus, Cx. pilosus, Cx. erraticus, Cx. quinquefasciatus, An. crucians, An. walkeri, Oc. atlanticus, U. sappharina, U. lowii, Ps. ciliata and Oc. sollicitans.



INLAND FLOODWATER MOSQUITO
(Aedes vexans)

Floodwater Mosquito Section

Floodwater Group
Mosquito groups assigned nationally to this floodwater group are Oc. sollicitans, Oc. taeniorhynchus, Oc. tormentor/atlanticus, Oc. thelcter, Oc. dorsalis, Oc. nigromaculis, Ae. vexans, Ps. ferox and Ps. columbiae. As examples, the following specific habitat types and resident species described are more or less typical of those found throughout the nation.

Mangrove Swamp
In the transitional zone from normal high tide to above all but the highest spring and storm tides, the heaviest mosquito breeding occurs. Plant and grass cover keep moisture conditions suitable for egg laying. Eggs are usually laid on sloping sides of potholes, ditches, sloughs, marsh edges or on the sides of small depressions, and sometimes over extensive, level, grass-covered areas. The eggs of some species require alternate flooding and drying before hatching. Species most often occurring are Oc. taeniorhynchus, Oc. sollicitans, An. atropos and Cx. nigripalpus.

Salt Marsh
Salt-tolerant herbaceous plants and typical salt grasses dominate this type of habitat. Extensive areas are often covered by a single plant species such as Distichlis spicata, Batis maritima or Salicornia perennis. It is in association with one of these plants or with black mangrove (Avicennia germinans) that breeding of Oc. taeniorhynchus and Oc. sollicitans occurs.

Rain and Floodwater Pools
These pools form the breeding place for a large number of species, especially Psorophora, Aedes and Ochlerotatus. The pools disappear in dry weather and support no true aquatic vegetation, though usually a layer of leaves and other detritus settles on the bottom. Mosquito species found in this habitat are Ps. johnstonii, Ps. pygnaea, Oc. atlanticus, Oc. bahamensis, Oc. dupreei, Oc. fulvus pallens, Oc. infirmatus, Oc. mitchellae, Oc. sticticus, Oc. tormentor, Ae. vexans, Ae. cinereus, Cx. atratus, Cx. pilosus and Cx. nigripalpus.

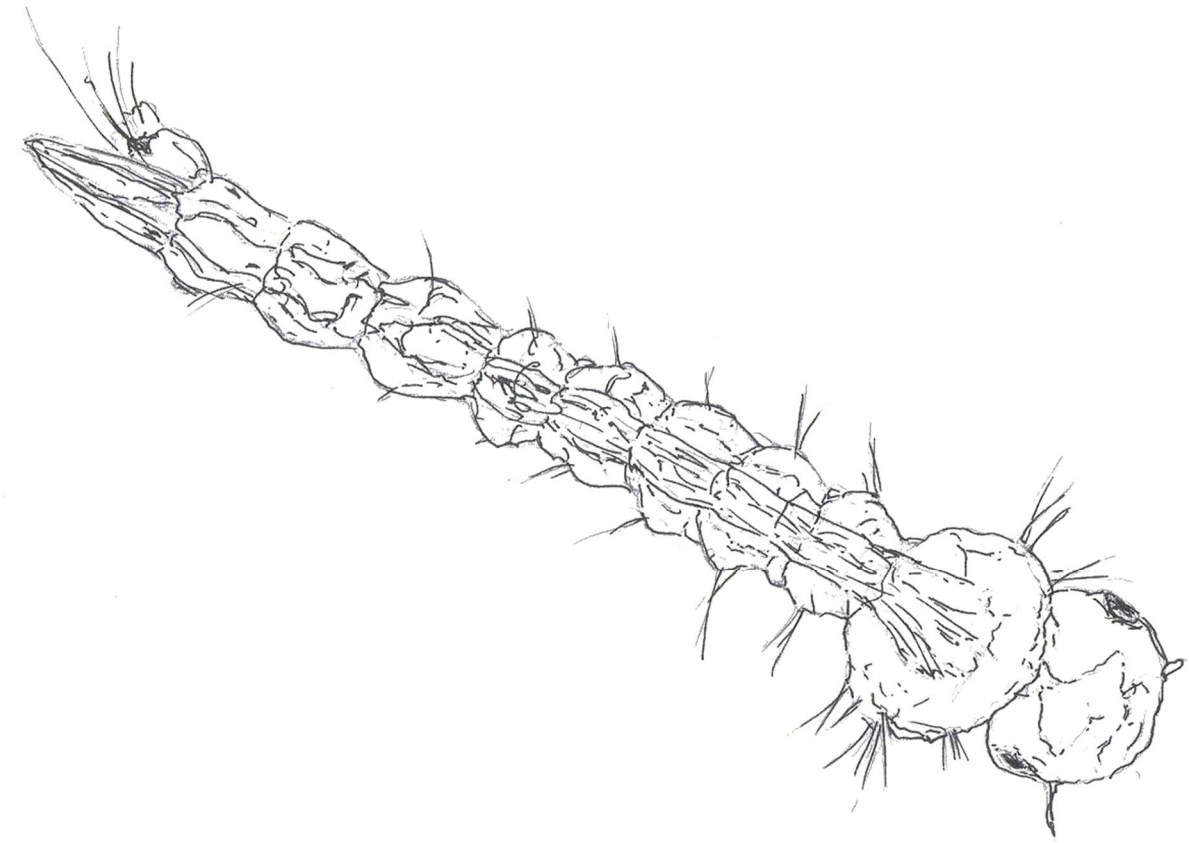
Artificial Container and Tree-hole Group
Mosquito groups assigned nationally to the artificial container and tree-hole group are Ae. aegypti, Oc. triseriatus, Oc. sierrensis, Ae. albopictus, Cx. quinquefasciatus, Toxorhynchites spp. and Orthopodomyia spp. As examples, the following specific habitat types and resident species described are more or less typical of those found throughout the nation.

Tree Holes
Tree holes or rot cavities support a rather extensive and unusual mosquito fauna, with many species breeding almost exclusively in this habitat. Resident species are An. barberi, Tx. rutilis, Tx. r. septentrionalis, Oc. triseriatus, Oc. hendersoni, Or. signifera, Or. alba, Oc. thibaulti and Ae. albopictus.

Crab Holes
Along the eastern coast the holes of the large land crab, Cardisonza guanhumi, serve as the larval habitat for Deinocerites cancer and Cx. opisthopus.

Artificial Containers
Several species breed in human-created situations around human dwellings. Tin cans, fish pools, cisterns, rain barrels, gutters and old tires, etc., containing water serve as excellent larval habitat. Species most often encountered are Ae. aegypti, Oc. triseriatus, Cx. quinquefasciatus, Cx. restuans, Cx. salinarius, Cx. nigripalpus and Ae. albopictus. That many species are found in multiple habitat types and some in very specialized habitats illustrates the complexity of the problem faced by control agencies. While habitat association with many species is quite specific, others thrive in a variety of situations. Thus, the detection of adults of these latter species in routine surveys does not provide an immediate indication of the related breeding site(s).

Permanent water - These waters (also known as semi-permanent) are present for extended periods of time and support characteristic aquatic vegetation. Cattail, rushes and sedges are typical freshwater swamp vegetation. Genera associated with permanent water are *Anopheles, Culex, Culiseta, Coquillettidia,* and *Uranotaenia*. Eggs of these species are not desiccant-resistant and must be laid directly on the water. *Aedes* adults will oviposit near the edge of the swamp or within tussocks of vegetation, requiring later flooding to inundate the eggs for hatching. As with transient waters, there is a seasonal change in the vegetation, water quality, and mosquito species present. Permanent waters include:



MOSQUITO LARVAE

Mosquitoes and Aquatic Plant Habitats Section

The three most important mosquito species that utilize aquatic plants as a primary habitat for egg deposition and larval development are Mansonia dyari, Mansonia titillans, and Coquillettidia perturbans.

If adult Mansonia species are discovered through routine surveillance monitoring, a thorough survey of the immediate area is conducted to locate fresh water sources containing water hyacinths and water lettuce. If a suspected fresh water source is found, a larval survey is conducted. Mansonia mosquitoes attach to the root structures of floating aquatic plants. If disturbed, the larvae will immediately release and fall to the bottom. When collecting these larvae, place a shallow pan under the floating vegetation. Care must be taken not to disturb the aquatic plants or surrounding area. Once in place, slowly lift the pan and plant out of the water. Clean water may be added to the pan to accurately view and count the mosquito larvae.

Asymmetrical Scales
Adults of Mansonia are generally large mosquitoes characterized by the presence of broad, asymmetrical scales on the wing veins. There is often a mixture of dark and pale scales that imparts a speckled appearance to the wings. Mansonia resemble some species of Culex, Aedini and Coquillettidia, but the tarsal claws are simple, the abdomen is truncate in females (distinctions from aedine genera), pulvilli are not evident (distinction from Culex) and postspiracular setae are present (distinction from Old World species of Coquillettidia).

New World species of Coquillettidia possess postspiracular setae, but differ from Mansonia in having a conspicuous preapical white band on the anterior surface of the femora. The larvae of Mansonia resemble those of Coquillettidia in having the spiracular apparatus and siphon distinctively modified for piercing plant tissues. They differ from Coquillettidia in having the distal part of the antenna fused with and much shorter than the basal part.

Cattail Mosquito
Coquillettidia perturbans can travel several miles. Therefore, a more widespread survey of fresh water sources containing cattails, sedges, aquatic grasses, or arrowhead may have to be done. The eggs and larvae of this mosquito are usually found in the detritus material at the base of the aquatic plants. A mosquito dipper or siphon can be used to collect the larvae.

However, the water may have to be placed in a pan containing clean water for accurate viewing and counting. Because aquatic plants can, at times, produce heavily vegetated stands, the use of conventional mosquito management techniques may be ineffective.

Predator fish are usually not effective because of the dense vegetation. Monomolecular oils do not work because the immature mosquitoes are located below the water surface. Bti may be effective if the product is applied directly to the infested areas. This may be difficult and labor intensive if the aquatic vegetation is dense. Eradication or maintenance level control of the aquatic plants is the best method of managing these mosquitoes.

The first step in identifying the breeding habitat was to determine where to check for breeding. Knowing that Cq. perturbans is always found associated with the roots and stems of emergent vegetation surrounding bogs, ponds, lakes, etc., all possible breeding sites were selected and inspected.

These sites were selected with the use of topographic maps and aerial photographs of the area. Once all possible areas were identified, each of the areas was surveyed, both by ground and air, for the presence of emergent vegetation

Mission of the Environmental Protection Agency
The mission of the Environmental Protection Agency (**EPA**) is to protect human health and the environment. The EPA reviews and approves pesticides and their labeling to ensure that the pesticides used to protect public health are applied by methods which minimize the risk of human exposure and adverse health and environmental effects.

In relation to mosquito control, the Agency (**EPA**) also serves as a source of information about pesticide and non-pesticide controls to address the concerns of the general public, news media, and the state and local agencies dealing with outbreaks of infectious diseases or heavy infestations of mosquitoes.

The following sections provide some basic information on mosquito control, safety precautions, and information on insecticides used for mosquito control programs.

Topic 1 – Mosquito Introduction Section Post Quiz

This is not your final assignment; you can find the final assignment at
http://www.abctlc.com/downloads/PDF/Mosquito Control Ass.pdf

Answers for the Quiz is found after the Glossary.

Integrated Pest Management -Introduction

1. Both CDC and EPA recognize a legitimate and compelling need for the use of biological interventions, under certain circumstances, to control adult mosquitoes.
True or False

Short Range Attractants

2. Light colors capture heat and make most people more attractive to mosquitoes. Dark colors refract heat and are generally less attractive to mosquitoes.
True or False

How Long Do Mosquitoes Live?

3. Mosquitoes that hibernate in the adult stage live for 6-8 months, but spend most of that time in a state of torpor.
True or False

Canine Heartworm

4. Dogs are quite susceptible to canine heartworm, a nematode that can be transmitted by certain mosquitoes.
True or False

World-Wide Distribution

5. Anopheles are _____of numerous animal pathogens, including species of malaria protozoa that do not affect humans.

Anophelinae (Genus subfamily)

6. Adult anophelines are easily recognized by their appearance. Most species stand with the body inclined at an angle of 30-45° to the surface and have _____on the veins of the wings.

Tipulidae (Crane Fly Family)

7. Numerous other common names have been applied to the crane fly, many of them more or less regional, including mosquito hawk, mosquito wolf, mosquito eater (or skeeter eater), gallinipper, and gollywhopper.
True or False

Wrigglers and Tumblers

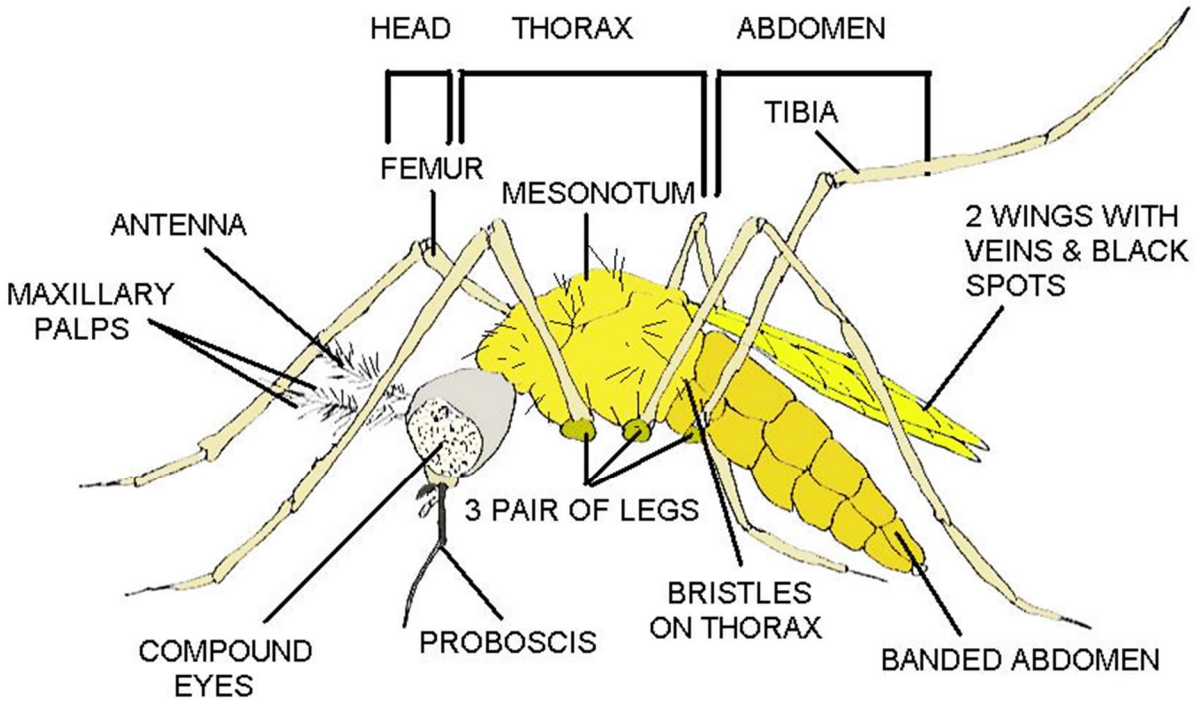
8. After the female mosquito obtains a blood meal, she lays her eggs directly on the surface of stagnant water, in a depression, or on the edge of a container where rainwater may collect and flood the eggs. The eggs hatch and a mosquito pupa or "tumbler" emerges.
True or False

9. The larva lives in the water, feeds, and develops into the third stage of the life cycle called a larva or "wriggler". The pupa also lives in the water, but no longer feeds.
True or False

10. Finally, the mosquito emerges from the pupal case and the water as a fully developed adult female, ready to bite.
True or False

Topic 2 – Mosquito Identification Section

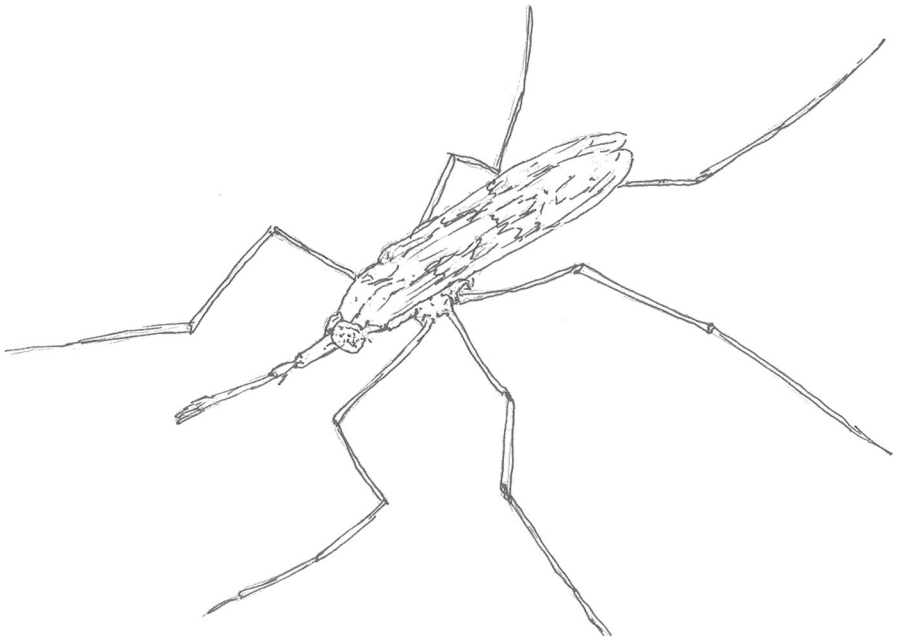
Topic 2 - Section Focus: You will learn to properly identify mosquito species. At the end of this section, you will be able to understand and describe specific mosquitoes and their habitats. There is a post quiz at the end of this section to review your comprehension and a final examination in the Assignment for your contact hours.
Topic 2 – Scope/Background: This training section has been prepared for use as an identification to mosquitoes. It is critical that we master identifying your target in that we do not destroy other wildlife during treatment operations.



ADULT FEMAL MOSQUITO (Anopheles Spp.)

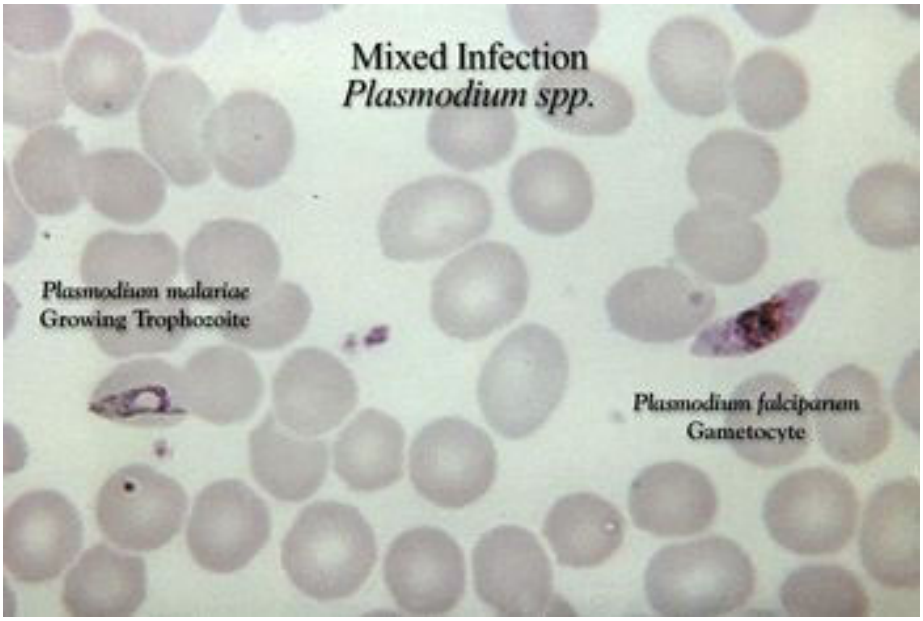
***Anopheles* spp.**
(Life; Kingdom: Metazoa; Phylum Arthropoda; Class: Hexapoda; Order: Diptera; Suborder: Nematocera; Family: Culicidae; Subfamily: Anophelinae)

Of the insects that serve as vectors for parasitic diseases, this genus is arguably the most important. Of the approximately 422 species of *Anopheles*, about two dozen serve as vectors for malaria (*Plasmodium* spp.) in humans. Mosquitoes also serve as the vector for canine heart worm (*Dirofilaria immitis*).



WOODLAND MALARIA MOSQUITO
(Anopheles punctipennis)

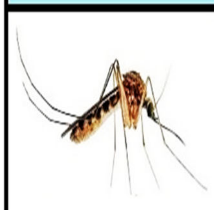
There are about 422 species of *Anopheles* worldwide, many of them sibling species that can only be identified using genetic techniques. Of these, about 70 are vectors of the protozoan *Plasmodium* that causes malaria, but only about 40 are important. Malaria infects 300-500 million people and kills 1.5-2.7 million people each year, making it by far the most serious of the diseases spread by insects.



SCIENTIFIC NAME	COMMON NAME	HABITAT	MEDICAL IMPORTANACE
Aedes albopictus	Asian Tiger Mosquito	Lucky bamboo plants in nurseries and man-made containers	Potential vector for dengue fever, WNV, and other encephalitis viruses
Aedes aegypti	Yellow Fever Mosquito	Urban environment indoors and outdoors in containers that can hold water.	Yellow fever, chikungunya and dengue fever
Aedes notoscriptus	Australian Backyard Mosquito	Urban environment in outdoor containers that can hold water.	Canine heartworm vector
Anopheles franciscanus	none	Shallow sunlit pools with algae	Not known to carry disease in California
Anopheles hermsi	Western Malaria *Mosquito*	Clear pools with matted algae	Malaria vector
Culex erythrothorax	Tule Mosquito	Ponds, lakes, wildlife refuges, and marshes with tules and cattails	Potential vector for WNV
Culex stigmatosoma	Banded Foul Water Mosquito	Polluted water (e.g., industrial and agricultural wastes); prefers to bite birds	Secondary SLE vector
Culex quinquefasciatus	Southern House Mosquito	Polluted water (e.g.,septic tanks, dairy drains, catch basins, and underground storm drains)	Vector of WNV; secondary for SLE and WEE

Culex tarsalis	Western encephalitis Mosquito	Agricultural, commercial, man-made or natural sources	Principal SLE, WEE, and WNV vector
Culex thriambus	none	Foothill riparian habitats, in sunlit pools, along streams and other water courses	Potential vector for WNV
Culex restuans	none	Found in foul water	Potential vector for WNV
Culiseta incidens *Culiseta inornata* *Culiseta particeps*	Cool Weather Mosquitoes	Fresh and brackish waters and containers	Not known to carry disease in California
Ochlerotatus sierrensis	Western treehole mosquito	Treeholes (particularly oak), tires, and containers	Canine heartworm vector
Ochlerotatus washinoi	Woodland pond Mosquito	Occurs in floodwater habitats	Not known to carry disease in California

6 NOTORIOUS MOSQUITOS

	CULEX TARSALIS	CULEX PIPIENS / QUINQUEFASCIATUS	AEDES AEGYPTI	AEDES ALBOPICTUS	AEDES VEXANS	ANOPHELES
						
FOUND	RURAL AREAS THROUGHOUT NORTH AMERICA	URBAN AREAS OF THE TROPICS, SUBTROPICS THROUGHOUT THE WORLD	TROPICS & SUBTROPICS, BUT CLIMATE CHANGE IS CAUSING TRAVEL NORTH	NATIVE TO TROPICAL ASIA, BUT HAS BEEN INTRODUCED TO EUROPE, AND PARTS OF THE AMERICAS & AFRICA	ONE OF THE MOST COMMON SPECIS IN THE U.S. & EUROPE, IT CAN ALSO BE FOUND IN PARTS OF ASIA AND NORTHERN AFRICA	EVERYWHERE EXCEPT ANTARTICA
DISEASES	ENCEPHALITIS	WEST NILE AND SOMETIMES ENCEPHALITIS	ZIKA, YELLOW FEVER, DENGUE AND CHIKUNGUNYA	ZIKA, DENGUE, CHIKUNGUNYA YELLOW FEVER & ENCEPHALITIS	IT RARELY TRANSMITS DISEASE TO HUMANS, BUT LAB TESTS HAVE FOUND IT IS CAPABLE OF WEST NILE & ENCEPHALITIS	ABOUT 30 - 40 DIFFERENT SPECIES, ALL TRANSMIT MALARIA AND SOME CAN SPREAD ENCEPHALITIS
BITES	AT DUSK AND AFTER DARK	AT DUSK AND AFTER DARK	DURING THE DAY	DURING THE DAY	LATE AFTERNOON / NIGHT, BUT THEY ARE USUALLY KILLED SEASONALLY BY AUTUMN FROST	DURING DUSK, DAWN & NIGHT

Technical Learning College

AEDES AEGYPT		STILT MOSQUITO
		
DAYTIME (Can sting at night)	HABITS	NOCTURNAL
DARK (With white stripes)	COLOR	BROWN
ALMOST CLEAN WATER (Little organic matter)	BREEDING SITES	POLLUTED WATER (Contains lots of organic matter)
4 - 6 mm	SIZES	4 - 10 mm
SEVERAL (In multiple locations)	EGGS	TOGETHER (In clusters)

Technical Learning College

MOSQUITO COMPARISON

Mosquito Identification Section
Alphabetical Common Name Order

Asian Mosquito AKA Asian Tiger Mosquito
(*Aedes albopictus*)

Aedes albopictus

Aedes albopictus, an Asian mosquito, probably was introduced into Hawaii late in the last century. Until its discovery in Houston, Texas, in August 1985, this species was unknown in the New World. It is believed to be established in 866 counties in 26 states in the continental U.S.

The northernmost established infestation in the U.S. is Chicago, Illinois, although an infestation was found in Minnesota in 1997. In the Northeast, it has been reported from New Cumberland (York County), Pennsylvania and, in 1995, from Cumberland, Salem, and Monmouth counties in New Jersey. It has been found as far south as Cameron County, Texas, and Monroe County, Florida. In the West, it occurs in Del Rio (Val Verde County) and Lubbock (Lubbock County), Texas, and Omaha (Douglas County), Nebraska.

Limited focal infestations in at least three northern states, Indiana, Minnesota, and Ohio, apparently have been eliminated through persistent control efforts by state and local agencies, perhaps coupled with severe winter temperatures. Nonetheless, other areas in Indiana and Ohio continue to be infested. During 1994, Georgia became the first state to document Ae. albopictus in all counties of the state and has since been joined by Florida, South Carolina, and Tennessee.

Aedes albopictus is a maintenance (occasionally epidemic) vector of dengue viruses in parts of Asia and is a competent vector of several other viruses under experimental conditions. Since the discovery of Ae. albopictus in the United States, five arboviruses (eastern equine encephalomyelitis, keystone, Tensaw, Cache Valley, and Potosi) have been isolated from this mosquito. Of these five viruses, only eastern equine encephalomyelitis and Cache Valley viruses are known to cause disease in humans.

Aedes albopictus was independently introduced into Brazil in 1986 and is now widespread in seven Brazilian states. In May, 1993, it was found to be established in the Dominican Republic, the first established infestation by this species of a Caribbean Island. In September, 1993, Ae. albopictus was also discovered in two border cities in Coahuila State, Mexico.

Subsequent studies indicate that areas of Tamaulipas and Nuevo Leon are also infested. In 1995, the Guatemalan Ministry of Health and Japanese entomologists in Guatemala reported finding Ae. albopictus at three sites in the Department of Izabal on the Atlantic seacoast. Also in 1995, infestations were reported from Cuba and Bolivia, but the current status of those infestations is uncertain. In 1996, infestations were reported from El Salvador and Colombia. In 1997, this species was reported from the Cayman Islands. In 1991, Ae. albopictus was found in Delta and Benue states in Nigeria. During 1994, additional infestations were found in Imo, Anambra, and Enugu states. In Europe, Ae. albopictus has been present in Albania since at least 1979.

More recently, infestations have been found in Italy (Genoa in 1990 and Padua in 1991) with a suggestion that the Padua introduction could have resulted from tire imports from the United States. Eighty-five percent of the imported tires came from a single source in Atlanta, Georgia; the remaining 15% came from the Netherlands. Ae. albopictus has rapidly become the most important pest mosquito species in areas of northern Italy and is now present in nine of Italy's 21 political regions, i.e., Veneto, Lombardy, Emilia Romagna, Liguria, Tuscany, Lazio, Piedmont, Campania, and Sardinia. Aedes albopictus is also expanding its distribution in the Pacific. Infestations were discovered in Palau in 1988 and in Yap in 1995. This mosquito was first discovered in Fiji on the island of Viti Levu in 1988, and has since spread to the next two largest islands in the group. Ae. albopictus has been found in port cities of both the north and south islands of New Zealand, and in Queensland and the Northern Territory of Australia, but apparently, has not become established.

Aedes albopictus is a potential vector of epidemic dengue. It is unclear what effect the presence of this species might have on transmission dynamics in the Americas. Ae. albopictus may also affect the disease potential for yellow fever in Brazil by bridging the ecological niche between jungle and urban transmission cycles. DVBID maintains a national database (under construction for web posting) on the distribution of Ae. albopictus, with particular emphasis on detecting its spread in areas in which La Crosse and eastern equine encephalitis viruses are enzootic. DVBID also studies the biology and vectorial capacity of Ae. albopictus and is the primary source of information about its distribution, vector competence, biology, and control in the Americas.

The Asian tiger mosquito, Aedes albopictus (Skuse), was first documented in the United States in Texas in 1985 (Sprenger and Wuithiranyagool 1986). A year later, the Asian tiger mosquito was found in Florida at a tire dump site near Jacksonville (O'Meara 1997). Since that time, this species has spread rapidly throughout the eastern states, including all of Florida's 67 counties (O'Meara 1997).

The arrival of Aedes albopictus has been correlated with the decline in the abundance and distribution of the yellow fever mosquito, Aedes aegypti (Linnaeus). There are a number of possible explanations for the competitive exclusion of Ae. aegypti by Ae. albopictus. The decline is likely due to a combination of (a) sterility of offspring from interspecific matings; (b) reduced fitness of Ae. aegypti from parasites brought in with Ae. albopictus and; (c) superiority of Ae. albopictus in larval resource competition (Lounibos 2002). The distribution of Ae. aegypti currently is limited to the southeastern quadrant of the U.S., and small areas in New York and Arizona (Darsie and Ward 2005).

Aedes albopictus is a competent vector of many viruses including dengue fever (CDC 2001) and Eastern equine encephalitis virus (Mitchell et al. 1992). Its life cycle is closely associated with human habitat, and it breeds in containers with standing water, often tires or other containers. It is a daytime feeder and can be found in shady areas where it rests in shrubs near the ground (Koehler and Castner 1997). Aedes albopictus feeding peaks in the early morning and late afternoon; it is an opportunistic and aggressive biter with a wide host range including man, domestic and wild animals (Hawley 1988).

Bold Black Shiny Scales

Adult Aedes albopictus are easily recognized by the bold black shiny scales and distinct silver white scales on the palpus and tarsi (Hawley 1988). The scutum (back) is black with a distinguishing white stripe down the center beginning at the dorsal surface of the head and continuing along the thorax. It is a medium-sized mosquito (approximately 2.0 to 10.0 mm, males are on average 20% smaller than females). Differences in morphology between male and female include the antennae of the male are plumous and mouthparts are modified for nectar feeding.

The abdominal tergites are covered in dark scales. Legs are black with white basal scales on each tarsal segment. The abdomen narrows into a point characteristic of the genus Aedes. Field identification is very easy because of these distinct features.

After entering the United States almost twenty years ago, Aedes albopictus has spread throughout much of the eastern states. The mosquito was most likely transported along highways and other major roadways in shipments of used tires imported from other countries for retreading. On January 1988, the U.S. Public Health Service required all used tires entering the U.S. from known endemic countries be dry, clean and treated with fumigants (Moore and Mitchell 1997). Surveillance for Ae. albopictus was initiated in 1986 and this species continues to be monitored by public health agencies (Morbidity and Mortality Weekly Report 1989).

Tolerance to Pesticides

Management of adult populations is more complicated than for other species due to insecticide tolerance to malathion, temephos and bediocarb (Morbidity and Mortality Weekly Report 1987). In many suburban areas, complaints to health departments are more frequently due to Ae. albopictus than in former years when Ae. aegypti was the most commonly reported nuisance mosquito (Morbidity and Mortality Weekly Report 1989). Source reduction is an effective way for people in the community to manage the populations of many mosquitoes, especially container breeding species such as the Asian tiger. The removal of mosquito breeding habitat can be an effective method for mosquito control (Dame and Fasulo 2003).

Eliminate any standing water on the property, change pet watering dishes, overflow dishes for potted plants, and bird bath water frequently. Do not allow water to accumulate in tires, flower pots, buckets, rain barrels, gutters etc. Use personal protection to avoid mosquito bites. Long sleeves and insect repellent such as DEET will reduce exposure to bites. The Asian tiger mosquito is a day biter with feeding peaks early morning and late afternoon, so by limiting outdoor activities during crepuscular periods (dawn and dusk) when mosquitoes are generally most active, bites can be avoided.

Life Cycle

Female tiger mosquitoes are the sex of most concern to humans because, as in the case for all mosquitoes, only females bite. The reason for the particular lust for blood by the female mosquitoes is the drive to reproduce. Blood is a rich source of protein which nourishes mosquito egg development and has since the age of the dinosaurs. Blood is not a food to sustain mosquito physiology aside from ovarian development. Carbohydrates from flower nectar fuel the daily activity of male and female mosquitoes.

Female tiger mosquitoes seek water-holding containers in which to lay their eggs. Any container from a tire casing to a tree hole is a possible breeding site, but this mosquito has preferences. Outdoor containers are greatly preferred over indoor containers and outdoor containers in the shade are preferred over those in full sunlight. Containers holding dark stained water high in organic content are preferred over containers holding clear, clean water.

Eggs are deposited along the sides of a container, just above the water surface. The rate of hatching success increases if the eggs remain unflooded for a few days after being laid and the eggs can remain viable for long periods before flooding, such as during prolonged droughts.

The eggs are stimulated to hatch when the water level in the container rises and floods the eggs, provided the water temperature is above 60¤F. If colder water temperatures prevail, the eggs will not hatch, but can remain viable for long periods (overwinter) until warmer temperatures return. After hatching, mosquito larvae live in the water for one to several weeks, depending on water temperature and the amount of food present.

Immature mosquitoes go through four growth stages and molt their skins four times as their size increases. The last immature stage is known as the pupa. In the pupal stage, changes occur allowing the transformation from an aquatic larva to a terrestrial, free-flying adult mosquito. During the summer, the immature life stage typically lasts five to ten days.

Mating takes place shortly after adults emerge from breeding sites. Females mate only once in their lifetime. Sperm is stored in the females' bodies and they can lay fertile eggs several times during a life span. Two to three days after emergence, female mosquitoes take their first blood meal. Tiger mosquitoes rest, fly and bite close to the ground. They bite in the daytime, rarely at night.

Early morning and late afternoon are peak biting times. Tiger mosquitoes are strongly attracted to bite humans, but will feed on cats, dogs and other mammals, as well as birds active on the ground. They will bite any exposed skin surface, but prefer to feed around the ankles and knees. They bite outdoors and indoors, but are usually found outside. On average, tiger mosquitoes ingest 2 - 6 milliliters of blood per bite.

Egg Laying
Female tiger mosquitoes lay 40 to 150 eggs after obtaining a blood meal. The cycle of blood feeding and egg laying will continue throughout the mosquito's life span. Egg laying occurs about once per week. The maximum number of eggs laid per lifetime by female tiger mosquitoes is about 300. Adult tiger mosquitoes live from a few days to several weeks, largely depending on weather conditions. Hot, dry weather reduces life expectancy. Regardless of life span, adult tiger mosquitoes seldom move far from the containers in which they were born. Most adults will be found within a few hundred yards of the breeding container.

In many states, tiger mosquito eggs are present year round. Larvae are present from April through October. Adult tiger mosquitoes are found May through October. The period of peak population is June through September.

Tiger mosquitoes are known to transmit the causative agent of dog heartworm disease. In New Orleans, the tiger mosquito is a principal vector of dog heartworm. In Polk County, Florida, field populations of tiger mosquitoes were found to carry eastern equine encephalitis virus in 1991. In Asia, this species is a vector of dengue fever and Japanese encephalitis. Laboratory studies have found the tiger mosquito to be an efficient vector of many viral disease agents including yellow fever, West Nile virus, St. Louis encephalitis and LaCrosse encephalitis.

Monitoring Population (Surveillance)
Adult tiger mosquitoes are not readily attracted to standard light traps which are used for determining the population level of most Maryland mosquito species. Traps using carbon dioxide as an attractant are useful for monitoring population trends of adult tigers. The most efficient and widely used surveillance technique in Maryland is the landing rate count. Landing rate counts are taken by inspectors using themselves as "bait" to attract female tiger mosquitoes. As they land on the inspector to bite, mosquitoes are identified, killed and tallied. Counts are taken for two to five minutes, during which the inspector tallies the total number of mosquitoes landing. Inspectors wear dark colored clothing and, of course, are not allowed to use mosquito repellent. Trap collections and landing rate counts are taken between the hours of sunrise to sunset when tiger mosquitoes are most active.

Larval surveillance is carried out by visual inspection of containers and by dipping. The larvae are easily disturbed by vibration or shadows passing over their surface, and either event will send the larvae to the bottom of the container where they are difficult to find.

Tiger Mosquito Control
Control of tiger mosquitoes by conventional methods in the United States has proven to be difficult. The impact of several predators and parasites as biological control agents of larvae has been investigated. In general, these agents have been found to play a small role in regulating the number of mosquitoes but not a significant impact.

The most promising predators of tiger mosquito larvae are mosquito fish (Gambusia spp.) and cannibal mosquitoes (Toxorhynchitus spp.). Fish are very effective when stocked in cisterns, water barrels and ornamental ponds, but many of the breeding sites of tiger mosquitoes are so small and cryptic as to make the use of fish of limited value. Cannibal mosquitoes are predaceous as larvae on a wide range of aquatic organisms, including mosquito larvae. These mosquitoes are also container breeders and would seem to be an ideal candidate species as a biocontrol agent of tiger mosquitoes.

Tiger mosquito larvae are susceptible to the toxic spores produced by the bacteria Bacillus thuringiensis israelensis (Bti). The insect juvenile hormone mimic methoprene does not kill tiger mosquito larvae, but prevents maturation to adult mosquitoes.

The problem of controlling tiger mosquitoes with Bti and methoprene is how to deliver the products to the breeding sites. Due to the large number and cryptic location of breeding sites, application of larvicides is labor intensive and beyond the resources of public agency mosquito control programs.

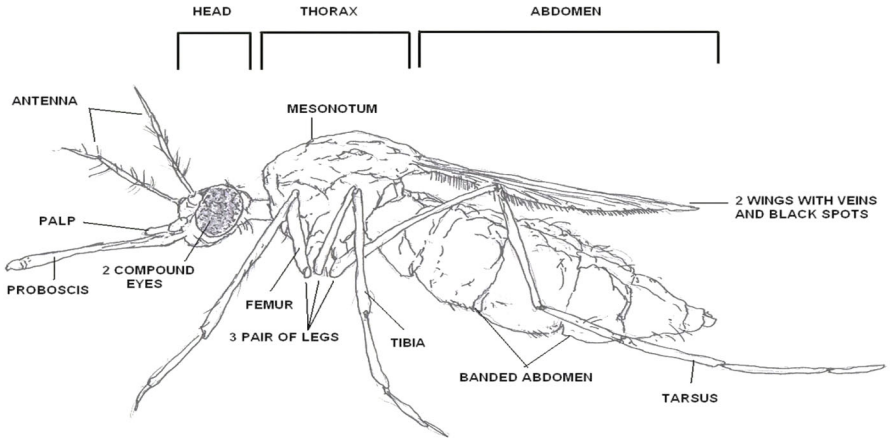
Insecticides

Control of adult tiger mosquitoes by various insecticides can be effective, providing temporary relief from biting annoyance and can reduce the risk of disease transmission. Spraying is most effective when done during early evening (one hour before to two hours after sunset) and early morning (two hours before to one hour after sunrise).

Those mosquitoes killed by spraying can be replaced by newly emerged adults because of the rapid breeding cycle of the tiger mosquito. In communities infested by moderate to high populations of tiger mosquitoes, adult mosquito control spraying may be necessary once per week, or more frequently, from June through September.

The most effective method of controlling tiger mosquitoes is reducing or eliminating the containers which are the source of the problem. Draining or removal of water holding containers, even on a localized basis, will produce remarkable long-term reductions in mosquito annoyance. The list of breeding sites is extensive and includes any water holding containers, but the primary sites in residential areas include clogged rain gutters, tires, buckets, cans, bottles, boats, flower pots, bird baths, outdoor statuary, ornamental pools, plastic or canvas tarpaulins, children's toys, rain barrels, and pet food and water dishes.

The elimination of the breeding containers for tiger mosquitoes is largely the responsibility of the individual to conduct thorough and repeated efforts to remove or drain all such containers on his/her property. On an individual basis, this is not a large task. The original cleanup of containers on a residential area should take no more than a few hours and periodic maintenance to keep each yard free of breeding containers will require a minimal time investment by individual residents.



ANOPHELES MOSQUITO

Black Salt Marsh Mosquito *(Aedes taeniorhynchus)*

Aggressive biting contributes to its notoriety as a pest insect

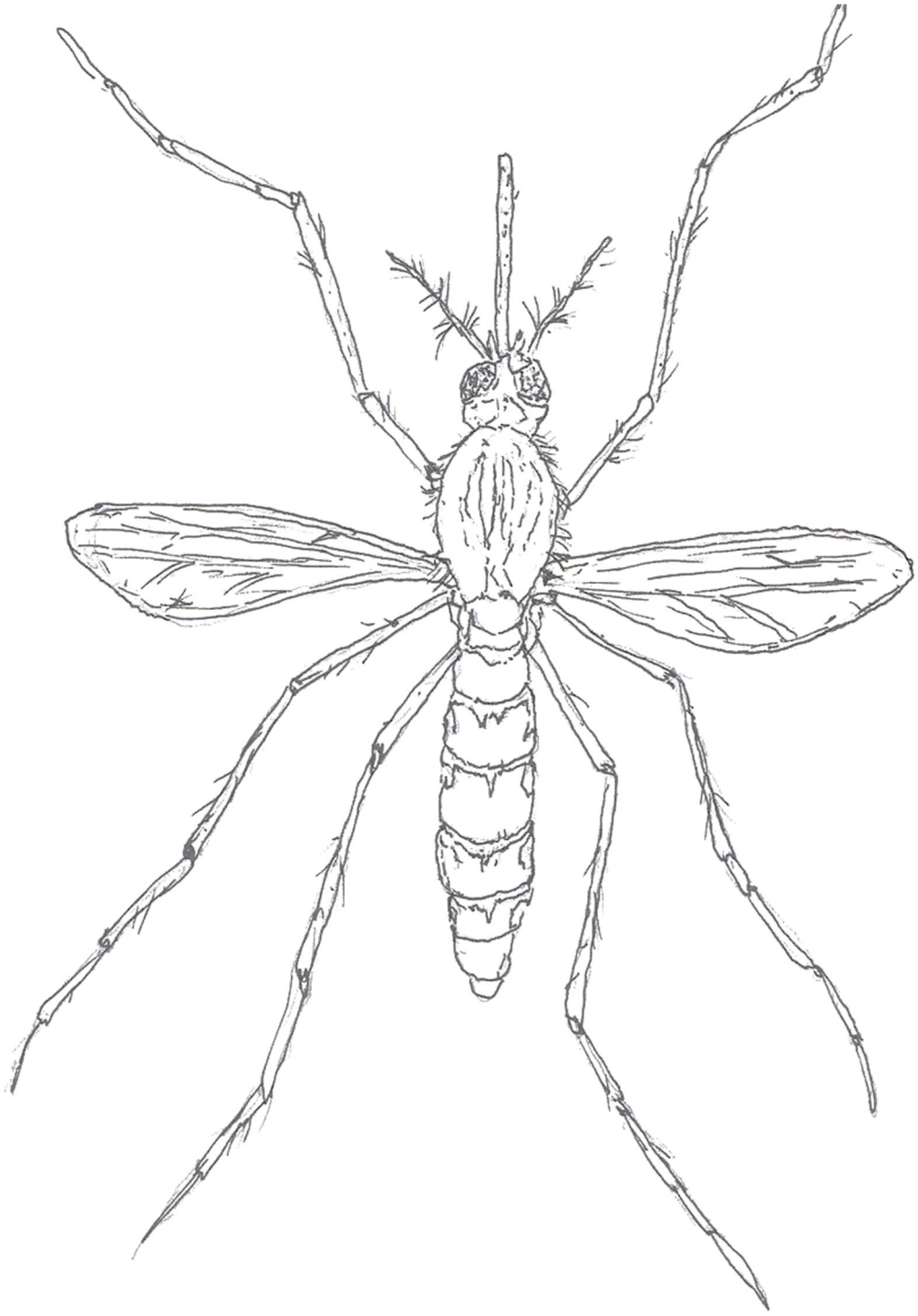
The black salt marsh mosquito, *Aedes taeniorhynchus* (Wiedemann), is very common in the eastern coastal areas of the Americas, and is responsible for a large part of mosquito insecticide applications in Florida (Connelly and Carlson 2009, Koehler and Castner 2008). Although it is not a primary vector of major concern, it can transmit pathogens to humans and other animals. Its characteristic emergence in large numbers after rains and flooding events as well as its aggressive biting contribute to its notoriety as a pest insect.

The black salt marsh mosquito is considered a nuisance in Florida, parts of Mexico and now in California. It is sheltered from large-scale mosquito control as part of the Everglades National Park conservation program to preserve their delicate ecosystem (Day et al. 2004).

Like other true flies, *Aedes taeniorhynchus* has four distinct life stages: adult, egg, larva, and pupa (Borror and White 1970).

Adults: Like other flies (order Diptera), *Aedes taeniorhynchus* possess a pair of wings for flight and a pair of knobby halteres for directional perception and stability. Like other mosquitoes, black salt marsh mosquitoes have long, narrow wings with scales along the wing veins. Female mosquitoes of the subfamily Culicinae, like *Aedes taeniorhynchus,* also possess palps shorter than the proboscis. The mouthparts of mosquitoes are made up of a pair of stylets for piercing and a feeding tube for sucking. Collectively these mouth parts are referred to as a proboscis.

Male and female mosquitoes can be distinguished by their antennae. Males have feather-like or plumose antennae, while females have antennae with only a few hairs (Borror and White 1970). Bands of white scales found in characteristic body locations are useful markings for identification of this species. The white banding on the basal section of abdominal segments, typical of *Aedes* mosquitoes, as well as the white coloration on the tip of the palps and a ring of white scales on the middle of the proboscis, can be used to distinguish *Aedes taeniorhynchus* from similar species (Darsie and Morris 2003).



AEDES AEGYPTI

Black-Tailed Mosquito (*Culiseta melanura)*

Primarily take their blood meals from birds.

The beautiful black-tailed mosquito, *Culiseta melanura* (Coquillett, 1902), belongs to the family Culicidae. This species of mosquito is considered unusual because it overwinters as larvae while most mosquito species overwinter as either adults or eggs. *Culiseta melanura* is important because of its role in the transmission cycle of eastern equine encephalitis virus and potentially West Nile virus (Cupp et al. 2003, Molaei and Andreadis 2006).

Larvae: The larvae of most mosquito species have a siphon (breathing tube) for acquiring air from just above the surface of water while submerged. *Culiseta melanura* larvae have long siphons that can be distinguished from those of other mosquito larvae by the presence of two or three setae (hairs) located at the very base of their siphons (Darsie and Ward 2005).

Other identifying characteristics of *Culiseta melanura* larvae are a row of 8-14 setae running horizontally down the siphon and a single row of bar-like comb scales located on the eighth section of the abdomen (Darsie and Ward 2005, Crans 2010).

Pupae: Mosquito pupae are comma-shaped because the head and thorax are fused and enlarged and the segmented abdomen attached to this region hangs down below it (Jackman and Olson 2002) and have two horn-like breathing structures. *Culiseta* pupae can usually be distinguished from *Aedes* pupae by the placement of small hairs on the ninth segment of their abdomens (Barr 1963).

More specifically, a *Culiseta melanura* pupa can be recognized by the long hairs present on the second segment of its abdomen (Barr 1963). A second apical seta on the paddle distinguishes *Culiseta melanura* from other *Culiseta* pupae (Darsie et al. 1962).

Adults: *Culiseta melanura* is a medium-sized mosquito that resembles *Culex* species because of its bluntly rounded abdominal tip (King et al. 1960). This species can easily be recognized by its unusually long, curved dark-scaled proboscis which is a cluster of tube-shaped mouth parts used for feeding (King et al. 1960). Palpi are also dark in color and short. The occiput of the head is covered with narrow yellow scales and dorsally divided by dark scales that stand upright. The lateral part of the head has a patch of white scales while the antennal tori are brown, turning darker on the interior. Its thorax is covered in scales that are mostly bronze-brown and golden-brown (Carpenter and LaCasse 1955).

Pre-spiracular setae are present, post-spiracular setae absent. The pleura is speckled with dirty-white scales. The tergites of the abdomen are covered with dark-brown to black scales with a bronze to slightly purple reflection with small yellow-white patches on the lateral bases. Some segments may appear to have narrow yellow-white light bands. The ventral abdomen is covered in dirty white or yellow with sporadic dark-colored scales. The legs are primarily dark-scaled except at the posterior, which is pale. (Carpenter and LaCasse 1955). Wings are approximately 4.0 mm in length and cross veins 3-4 and 4-5 on vein 4 are set apart from each other at a length larger than the largest cross vein. The scales on cross veins are absent. Longitudinal veins are covered in dark, broad strap-like scales. The base of the subcosta on the underside of the wing has a cluster of dark setae (Carpenter and LaCasse 1955).

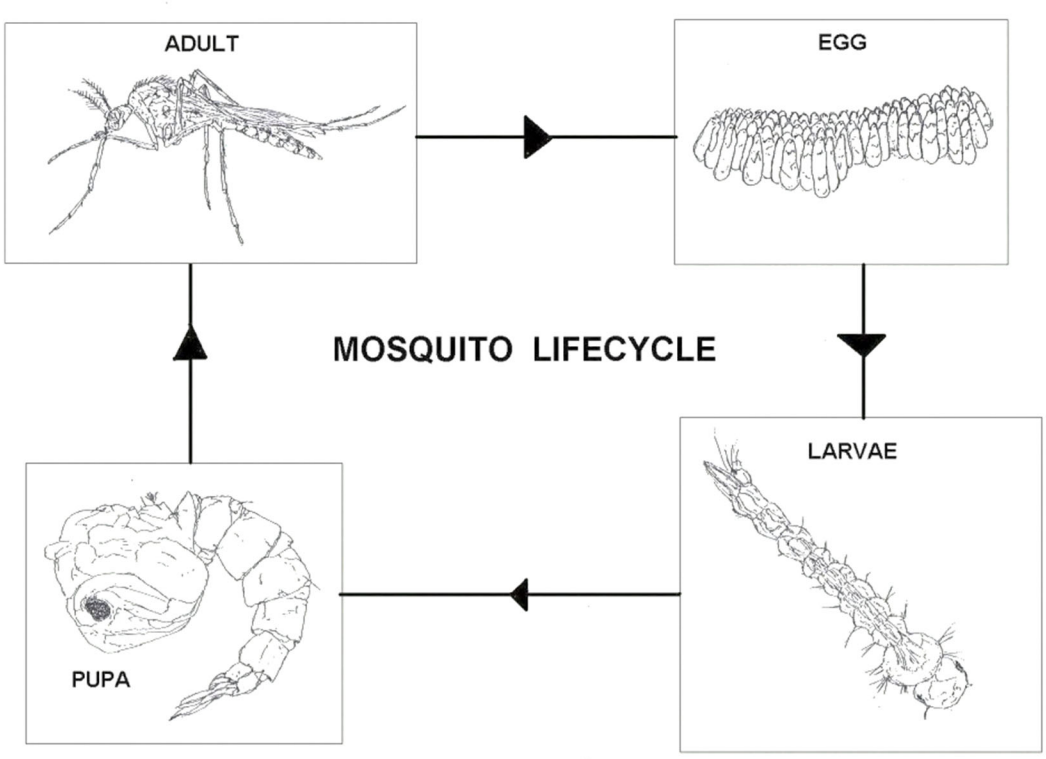


DIAGRAM #3

Life Cycle
Culiseta melanura has multiple generations per year in the southern part of its range (Horsfall 1955), but Mahmood and Crans (1998) suggest that the species has only two generations per year in the northeastern portion of its range due to cold temperatures. Adult females favor laying their eggs in habitats with acidic water and are normally captured near water with a pH of 5.0 or lower (Crans 2010). Females lay their eggs on the surface of water in underground crypts such as around the base of cypress, white cedar, or red maple trees or in rotted out stumps (Carpenter and LaCasse 1955).

Larvae typically hatch within two days (Mattingly 1972). *Culiseta melanura* larvae are filter feeders and use their brush-like mouthparts to feed on decaying plant matter suspended in the water (Jackman and Olson 2002). Like most mosquito larvae, *Culiseta melanura* larvae mature in 4 to 10 days and then enter the pupal stage (Jackman and Olson 2002).

If temperatures are cold larvae do not pupate and instead burrow into the bottom sediment and overwinter as 3rd and 4th instar larvae depending upon how late in the season eggs hatch. Those that hatch in the late summer to early fall overwinter as 4th instar larvae while those that are oviposited after the water temperatures have cooled overwinter as 2nd or 3rd instar larvae. Late instar larvae will pupate in April and emerge as adults by early May with several generations occurring each summer with two major peaks in adult populations approximately one month apart (Crans and Mahmood 1998, Crans 2004, Hickman and Brown 2003).

The pupae remain in the water and do not eat. Temperature affects the length of the pupal stage which may last several days (Jackman and Olson 2002).

Adult males feed only on nectar and other plant juices. Females also feed on nectar and plant juices but also require blood meals as a source of protein in order to mature their eggs (Jackman and Olson 2002). Adult female *Culiseta melanura* primarily take blood meals from birds such as the American robin, wood thrush, and gray catbird (Molaei and Andreadis 2006). Blood-feeding is at its highest during the first two hours after sunset but continues at a lower, constant level until sunrise (Hickman and Brown 2003).

A few studies have shown that *Culiseta melanura* females take a low percentage of their blood meals from mammalian hosts, specifically, white-tailed deer, raccoons, domesticated cats, and humans (Molaei and Andreadis 2006, Molaei et al. 2006). Adult female mosquitoes typically live for about a week to a month, while males usually die shortly after mating (Jackman and Olson 2002).

Medical and Veterinary Importance
Because adult female *Culiseta melanura* primarily take their blood meals from birds, they are responsible for transmitting eastern equine encephalitis virus between birds (Crans 2010). Humans, horses, and other mammals become infected with eastern equine encephalitis virus when other mosquito species besides *Culiseta melanura*, such as *Aedes*, *Coquillettidia*, and *Culex* species take blood meals first from infected birds and then later take blood meals from mammals, transferring the virus to these hosts (CDC 2009). Molaei et al. (2006), showed that a small percentage of *Culiseta melanura*'s blood meals were from mammals, which suggests that *Culiseta melanura* can be involved in the transmission of eastern equine encephalitis virus directly to mammals.

Eastern equine encephalitis virus can cause severe disease in human, horses, dogs, and some bird species (Zacks and Paessler 2010). Fever, headache, vomiting, seizures and coma may occur in humans infected with eastern equine encephalitis virus (Zacks and Paessler 2010). Neuroinvasive disease due to eastern equine encephalitis virus causes fatality in up to 70% of human cases, and over 200 human cases due to eastern equine encephalitis virus have been recorded in the U.S. since 1964 (CDC 2009, Zacks and Paessler 2010). It is particularly pathogenic in children, the elderly, and those with compromised immune systems although even healthy individuals can exhibit severe symptoms.

A vaccine is available for horses, but not humans. Over 70 horses positive for eastern equine encephalitis virus are typically reported each year in the state of Florida alone, and eastern equine encephalitis virus can be fatal in up to 90% of unvaccinated horses (Bronson and Holt 2010, Zacks and Paessler 2010). Humans and equines are dead-end hosts for eastern equine encephalitis virus, meaning mosquitoes do not acquire the virus from them.

Eastern equine encephalitis virus was detected in mosquitoes one hour after feeding on infected blood, which shows that this virus is highly virulent. Eastern equine encephalitis virus can affect the reproductive fitness of *Culiseta melanura.* Laboratory experiments showed a reduction in the number of surviving larvae from infected females although the infected females oviposited more eggs than uninfected females. Female mosquitoes infected with eastern equine encephalitis virus also had shorter life spans than uninfected mosquitoes (Scott and Lorenze 1998).

Culiseta melanura is not considered to be an important vector of West Nile virus to humans. However, West Nile virus has been isolated from this mosquito species in many studies (Andreadis et al. 2001, Apperson et al. 2004, Godsey et al. 2005, Molaei and Andreadis 2006). Therefore, it is likely that *Culiseta melanura* may transmit West Nile virus between birds that then serve as part of the mechanism sustaining West Nile virus in a region (Godsey et al. 2005). For more information on West Nile virus, see the UF/IFAS publication West Nile Virus.

Management

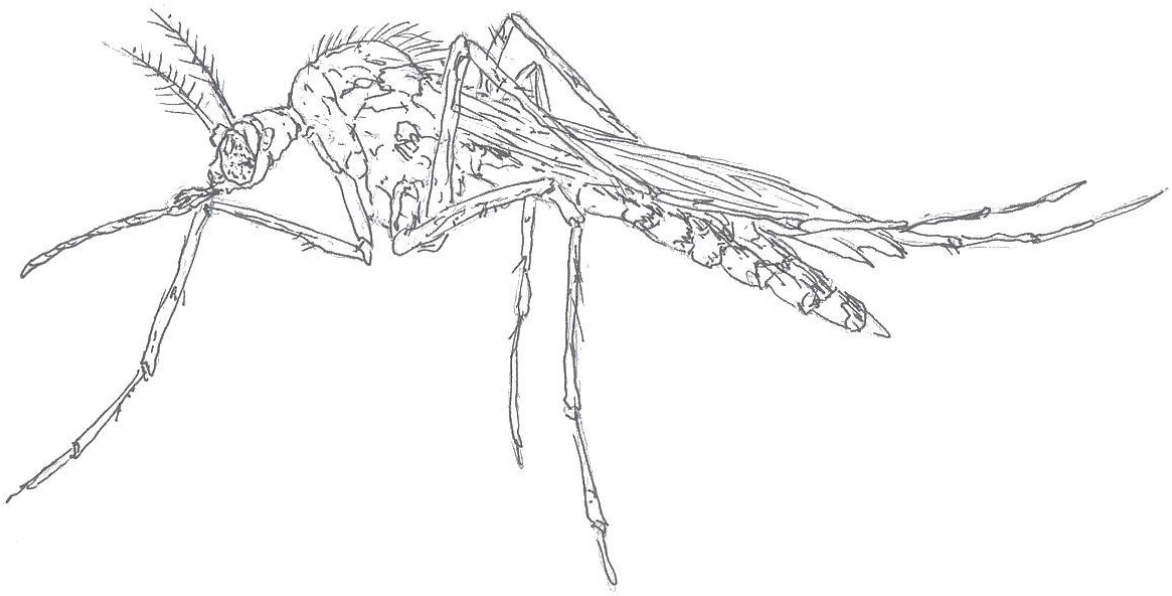
Because *Culiseta melanura* is not a major nuisance to humans it is not usually targeted for mosquito control. Efforts to reduce *Culiseta melanura* mosquito populations are usually made upon the appearance of eastern equine encephalitis virus seropositive sentinels in an area (Morris 1990). Large *Culiseta melanura* populations can be mitigated through aerial applications of insecticide (Morris 1990).

Less effective ground-based adulticiding techniques may be used to control mosquitoes where aerial applications are not possible (Morris 1990). Applying larvicide to larval habitats may control larvae but reaching larval habitats can be difficult. Larval habitat reduction can be employed in an integrated pest management program.

Because *Culiseta melanura* larval habitats are in swamps, typically protected by environmental laws, habitat manipulation is not possible. For this reason, control of this species is difficult. However, unlike mosquito species that spend a portion of their life in temporary water environments, fish that feed on mosquito larvae can be used with some success to control *Culiseta melanura* (Rusmisel et al. 1999).

Cattail Mosquito (*Coquillettidia perturbans*)
AKA Salt and Pepper Mosquito

Seek humans for blood meals in shady places where adult mosquitoes are resting during the day.



Coquillettidia perturbans can travel several miles. Therefore, a more widespread survey of fresh water sources containing cattails, sedges, aquatic grasses, or arrowhead may have to be done. The eggs and larvae of this mosquito are usually found in the detritus material at the base of the aquatic plants. A mosquito dipper or siphon can be used to collect the larvae. However, the water may have to be placed in a pan containing clean water for accurate viewing and counting.

Because aquatic plants can, at times, produce heavily vegetated stands, the use of conventional mosquito management techniques may be ineffective. Predator fish are usually not effective because of the dense vegetation. Monomolecular oils do not work because the immature mosquitoes are located below the water surface. Bti may be effective if the product is applied directly to the infested areas. This may be difficult and labor intensive if the aquatic vegetation is dense. Eradication or maintenance level control of the aquatic plants is the best method of managing these mosquitoes.

This species is rather large, speckled brown and pale colored and has characteristic pale bands at the lower thirds of the hind leg segments. They are aggressive biters and readily enter homes. Larvae are unusually slow to develop and spend the entire development through pupa underwater. They are found attached to stalks of vegetation and do not need to rise to the surface to breath.

Larval habitat: Cattails marshes and in thick growth at edges of ponds, lakes and ditches
Biting time: Day and dusk
Preferred host: Mammals, including humans
Flight range: 1-5 miles from breeding site

Proboscis: dark, sprinkled with white scales basally and with broad median ring of pale scales.

Palpi: about one fifth as long as proboscis, dark-scaled, lightly speckled with pale scales.

Head: Occiput with pale-golden lanceolate scales and dark erect forked scales, a few pale forked scales on anterior part. Tori light brown on outer surface, darker and with a patch of grayish-white scales on inner surface.

Thorax: Integument of scutum mottled dark brown and black; scutum clothed with dark brown lanceolate scales intermixed with pale-golden lanceolate scales; The golden scales are more numerous anteriorly, laterally and on the pre-scutellar space. Scutellum with pale-golden scales and brown setae on the lobes. Pleura with patches of grayish-white scales. Spiracular and post-spiracular bristles absent.

Abdomen: First tergite dark-scaled; remaining tergites dark-scaled, with white or pale-yellow basolateral patches and occasionally with narrow basal segmental bands of pale scales. Venter with intermixed dark and pale scales, the pale scales more numerous on the basal part of the sternites. 8th segment bluntly rounded. 8th tergite without short stout spines.

Legs: Femora dark, speckled with pale scales, the apices almost entirely dark-scaled. Hind femur with narrow sub-apical, more or less distinct ring of pale scales. Posterior surface of middle and hind femora predominantly pale-scaled except near apices.

Front and middle tibiae dark-scaled, speckled with white, narrowly ringed with white scales at apices; hind tibia dark-scaled, speckled with white, ringed with white scales at outer third and at apex. 1st tarsal segment of all legs with narrow white ring basally and a broader white ring a little beyond middle; remaining tarsal segments each with basal half white apical half dark.

Wings: Length about 4.0 mm, scales broad, mixed dark and white.

Egg Rafts
The eggs are laid on the surface of water in areas of heavy emergent vegetation, after hatching the larvae attach themselves with their modified siphon to the roots or submerged stems of plants where they remain throughout development until they are ready to emerge as adults. They overwinter as larvae ...adults emerge in Spring and Summer.

They bite during night but will bite in shade if disturbed. They are strong fliers (1 to 5 miles) and are important pest in areas near shallow with emerged aquatic vegetation. They are attracted to light traps. They can transmit Eastern Equine Encephalitis.

Breeding Habitat
The first step in identifying the breeding habitat was to determine where to check for breeding. Knowing that Cq. perturbans is always found associated with the roots and stems of emergent vegetation surrounding bogs, ponds, lakes, etc., all possible breeding sites were selected and inspected.

These sites were selected with the use of topographic maps and aerial photographs of the area. Once all possible areas were identified, each of the areas was surveyed, both by ground and air, for the presence of emergent vegetation.

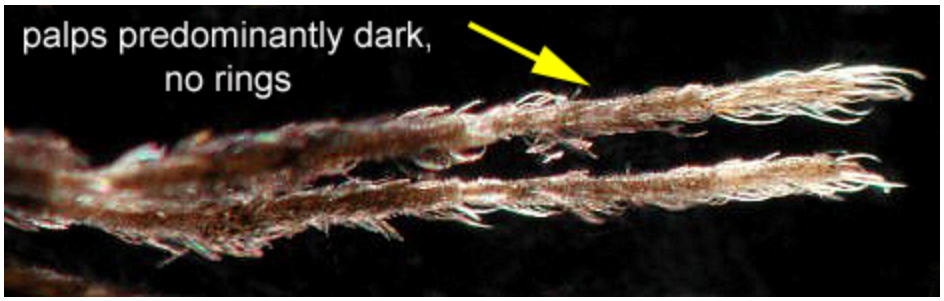
Common Malaria Mosquito (*Anopheles quadrimaculatus*)

Anopheles sp.
Another example of *Anopheles* sp.

Anopheles quadrimaculatus Say is historically the most important vector of malaria in the eastern United States. Malaria was a serious plague in the United States for centuries until its final eradication in the 1950s (Rutledge et al. 2005). Despite the ostensible eradication, there are occasional cases of autochthonous (local) transmission in the U.S. vectored by An. quadrimaculatus in the east and Anopheles freeborni in the west (CDC 2005).

In addition to being a vector An. quadrimaculatus can also be a pest species (O'Malley 1992). This species has recently been recognized as a complex of five sibling species (Reinert et al. 1997) and is commonly referred to as An. quadrimaculatus (sensu lato) when in a collection or identified in the field. The preferred hosts are large mammals including humans.

Distribution
Anopheles quadrimaculatus mosquitoes are primarily seen in eastern North America. They are found in the eastern United States, the southern range of Canada, and parts of Mexico south to Vera Cruz. The greatest abundance occurs in the southeastern U.S. (Carpenter et al. 1946, Carpenter and LaCasse 1955).



Mosquito Egg Classification
Mosquito eggs are generally cylindrical in shape, tapered at the top and rounded at the bottom. Each mosquito species prefers certain localities for depositing eggs. Some prefer very clean water, others slightly polluted water, while others thrive in extremely polluted water.

There are five distinct types of oviposition:
Single On Water: Anopheles and Toxorhynchites lay their eggs one at a time on the water surface.

Single in Soil: most Aedes and Psorophora lay their eggs one at a time on a moist substrate, such as mud and decomposing leaf litter.

Single On Cavity Walls: Wyeomyia, Orthopodomyia, and certain Aedes deposit eggs in tree holes, water-holding plants, or artificial containers. The eggs are placed just above the waterline.

Rafts On Water: Most Culex, Culiseta, Coquillettidia, and Uranotaenia lay eggs in masses, called rafts or boats, on the water surface.

On Plants: Mansonia eggs are deposited on the underside, and sometimes on top, of the leaves of certain floating aquatic plants.

Cool Weather Mosquito (*Culiseta incidens*)

Attacks large mammals and humans at night.

Culiseta is a genus of mosquitoes. Most *Culiseta* species are cold-adapted, and only occur in warmer climates during the colder parts of the year or at higher elevations where temperatures are lower. Species found in Southern California are larger than most mosquitoes species, specifically *Cs. inornata*, *Cs. particeps*, and *Cs. incidens*.

These species are found throughout the year in Southern California and feed on several vertebrate species, such as birds, livestock, rodents, reptiles, and humans.

The larvae of most species are found bogs, marshes, ponds, streams, ditches, and rock pools, but an African species occurs in tree holes ("phytotelmata"), a common eastern Palaearctic species occurs in water wells and rock pools, and several Australian species occur under ground. Little is known about the blood-feeding habits of females. Most species feed on birds and mammals, but a few feed on reptiles.

The cool-weather mosquito is a large species that seeks to bite large mammals and humans at night. It travels up to five miles from the shaded, clear water sources in which this species develops.

Eggs are laid in rafts on the water surface. *C. incidens* is found throughout California, and is active in fall, winter, and spring.

Cs. inornata

Eastern Treehole Mosquito (*Aedes triseriatus*)

Small mammals are the preferred meal for the females.

Aedes triseriatus is a treehole mosquito, breeding in the wild in holes left in trees when a branch breaks off and/or insect damage causes a part of the tree to rot out. Within the shaded forest it is a ready biter but it does not venture far from its breeding areas. Because it's larval habitat is widely dispersed (and often well above the height that a person could reasonably be expected to reach), larval control is not possible. Fortunately, because it stays within the woods, control targeting Ae. triseriatus is rarely necessary. Adult mosquitoes are small, fragile insects with slender bodies; one pair of narrow wings (tiny scales are attached to wing veins); and three pairs of long, slender legs. They vary in length from 3/16 to 1/2 inch. Mosquitoes have an elongate "beak" or piercing proboscis. Eggs are elongate, usually about 1/40-inch-long, and dark brown to black near hatching. Larvae or "wigglers" are filter feeders that move with an S-shaped motion. Larvae undergo four growth stages called instars before they molt into the pupa or "tumbler" stage. Pupae are comma-shaped and nonfeeding and appear to tumble through the water when disturbed.

Overwinter

Aedes triseriatus overwinter as eggs in the larval habitat; hatching occurs in early spring and development to the adult stage takes about 3 months. The first biting adults appear in late June. Larval populations are often crowded and asynchronous so some emergence continues until early August. A second generation of larvae has been observed, especially in tires, where water is usually warmer and development is faster. However, it is doubtful that many adults from this generation are successful at this latitude. This mammal-feeding, diurnal species does not normally disperse far from its sylvan larval habitats. Biting adults are particularly active in the late afternoon, pre-twilight period (i.e., 4-7 PM).

Tire Removal
If Ae. triseriatus stayed in the trees, it would be a minor pest, but it has become well adapted to breeding in tires, particularly where they are shaded. As a result, Ae. triseriatus can be a locally important pest wherever rimless tires are stored. Tire removal, and the prevention of illegal tire dumping along wooded roads, is an important part of mosquito control.

Vexans Mosquito
Aedes vexans. Aedes vexans is the most ubiquitous floodwater mosquito in North America and is the predominant summer re-flood mosquito. Aedes vexans is found in lake and river flood plains, shrub swamps, flooded meadows, and shallow grassy depressions associated with open habitats such as roadside ditches, pastures, golf courses and athletic fields. It will also breed in woodland pools and shallow cattail marshes, such as those that develop in some retention ponds. The first Ae. vexans are normally not on the wing before mid-June. Populations of Ae. vexans are unpredictable because they depend entirely on the frequency and spacing of major rains. Rainfall of 1 inch many produce some Ae. vexans but it usually requires 3” of rain within a short period of time (several days) to produce a large brood.

Larval Broods
Larval broods of Ae. vexans have been observed as late as mid-September. It is not always clear whether such late season broods result from the delayed and staggered hatching of eggs that are a year or more old or from the hatching of non-diapausing eggs laid earlier the same season. Brust and Costello (1967) and Horsfall et al (1973) have shown that many species such as Ae. vexans lay some eggs that will hatch without cold conditioning. Sequential hatching of eggs is also well documented in five reflood Aedes species (i.e., canadensis, cinereus, sticticus, trivittatus, and vexans). Larval development is rapid, 4-6 days, and the pupal stage lasts for about 2 days. Hence, the window for effective larval/pupal control is narrow. Moreover, a large number of scattered pools all need to be treated within the same brief time span following major rains.

Control efforts suffer from the same difficulties as described for Ae. canadensis, as Ae. vexans will often breed in mid-summer in the same pools used by Ae. canadensis in the spring.

Where possible, the best approach is to prevent mosquitoes from breeding by eliminating or modifying breeding sites. This can be accomplished best by eliminating containers which are capable of holding water. Where breeding sites exist in standing or slow-moving water, corrective action to permanently eliminate them by such means as filling, pumping, ditching or draining is recommended. Close coordination with your local mosquito abatement district and environmental regulatory authorities is recommended. An important consideration in the practice of mosquito control is the advisability, whenever possible, to target control operations against immature populations. These stages are usually concentrated, relatively immobile and therefore occupy minimum acreage compared with adults, which may rapidly disperse over large areas. By targeting the immatures, it is possible to minimize the area treated and often avoid treating populated areas.

Conversely, targeting adult mosquitoes may require highly visible and extensive applications of adulticides within residential and urban areas. The adulticides registered for this use are applied at levels 100 to 10,000 times below rates that would be cause for concern about exposure risk for the general public or the environment. Nevertheless, achieving good larval control while at the same time minimizing the use of adulticides is environmentally and client friendly, and appreciated by the public. Most states have specific regulations governing the decision to apply pesticides for mosquito control. These usually involve the collection of data that substantiate the need for the application. Thus, standardized ultra-low-volume (ULV) operation on a fixed schedule is not allowed in most areas. Each application must be justified by documentation of increased mosquito activity, such as trap collections, landing or biting counts, telephone complaints, etc.

Mosquito Repellents

The CDC traveler's page on preventing dengue fever suggests using mosquito repellents that contain DEET (N, N-diethylmetatoluamide, between 20% to 30% concentration, but not more). It also suggests the following:

1. The mosquito usually bites at dusk and dawn but may bite at any time during the day – especially indoors, in shady areas, or when the weather is cloudy.
2. The mosquito's preferred breeding areas are in areas of stagnant water, such as flower vases, uncovered barrels, buckets, and discarded tires, but the most dangerous areas are wet shower floors and toilet tanks, as they allow the mosquitos to breed in the residence. Research has shown that certain chemicals emanating from bacteria in water containers stimulate the female mosquitoes to lay their eggs. They are particularly motivated to lay eggs in water containers that have the correct amounts of specific fatty acids associated with bacteria involved in the degradation of leaves and other organic matter in water. The chemicals associated with the microbial stew are far more stimulating to discerning female mosquitoes than plain or filtered water in which the bacteria once lived.
3. Wear long-sleeved clothing and long trousers when outdoors during the day and evening.
4. Spray permethrin or DEET repellents on clothing, as mosquitos may bite through thin clothing.
5. Use mosquito netting over the bed if the bedroom is not air conditioned or screened. For additional protection, treat the mosquito netting with the insecticide permethrin.
6. Spray permethrin or a similar insecticide in the bedroom before retiring.

Foul Water Mosquito *(Culex stigmatosoma)*

Adult females feed predominantly on birds at night.

Culex stigmatosoma is known as the Banded Foul Water Mosquito due to its association with polluted water and can be found in most California counties. The Banded Foul Water Mosquito is a dark bodied, medium-sized mosquito with a prominent white band on its proboscis (beak) and white bands on the tarsi (feet). It is further characterized by black scales which form "o" spots on the underside of the blunt-tipped abdomen. This mosquito most closely resembles Culex tarsalis but lacks the white stripe on the hind legs.

Adult Daily Activity

These mosquitoes may live for two or three weeks in the summer, but under cooler conditions the females may live for several months. In areas of moderate climate, adults and larvae may be found in every month of the year, but in areas with cold winters this species usually passes the winter as hibernating females in protected natural or artificial shelters such as cellars, outbuildings, wood piles, caves, culverts, etc. Mating may take place in conjunction with the male swarms.

Adult Flight Range

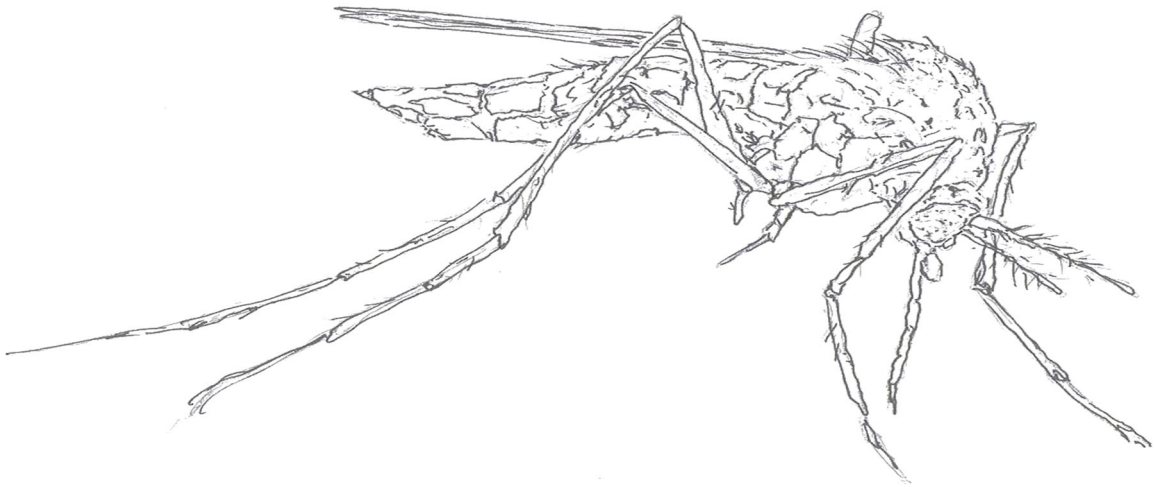
This species is capable of traveling 1-2 miles to seek a host, but is most commonly found near its aquatic habitat. The maximum recorded flight range is less than ten miles.

Adult Feeding

Female foul water mosquitoes seem to prefer feeding on birds, but on occasion will feed on livestock and humans. Males feed on nectar and plant juices. Females may also feed on plant juices, but usually must have a blood meal in order to develop their eggs. Nighttime is the peak feeding time for females of this species.

Eggs and Larvae

An adult female lays about 150-200 eggs in clusters called rafts, which float on the surface of the water until they hatch in about one to two days. The female usually prefers laying eggs in standing, polluted water such as sewage, street drainage, industrial wastes, dairy ponds, log ponds and backyard sources such as unused swimming pools, fouled ornamental ponds, cooler drain-water, and water in containers. A wide variety of other water sources may also be infested with the aquatic stages of this common mosquito.



FLOODWATER MOSQUITO

Disease Vector
Foul Water Mosquitoes do occasionally create domestic, industrial and agricultural pest problems when they are present in large numbers. Although Western Equine Encephalitis and St. Louis Encephalitis have been isolated from natural populations of these mosquitoes, their reluctance to bite humans reduces their efficiency as disease carriers. This species has recently been identified as a carrier of West Nile Virus, a mosquito-borne disease that is rapidly spreading across the United States.

Life Cycle
Foul Water Mosquitoes have four life stages: egg, larva, pupa, and adult. The immature stages need standing water to complete their life cycle. After an adult female lays her eggs they hatch into larvae (wrigglers), which feed on small organic particles and microorganisms in the water.

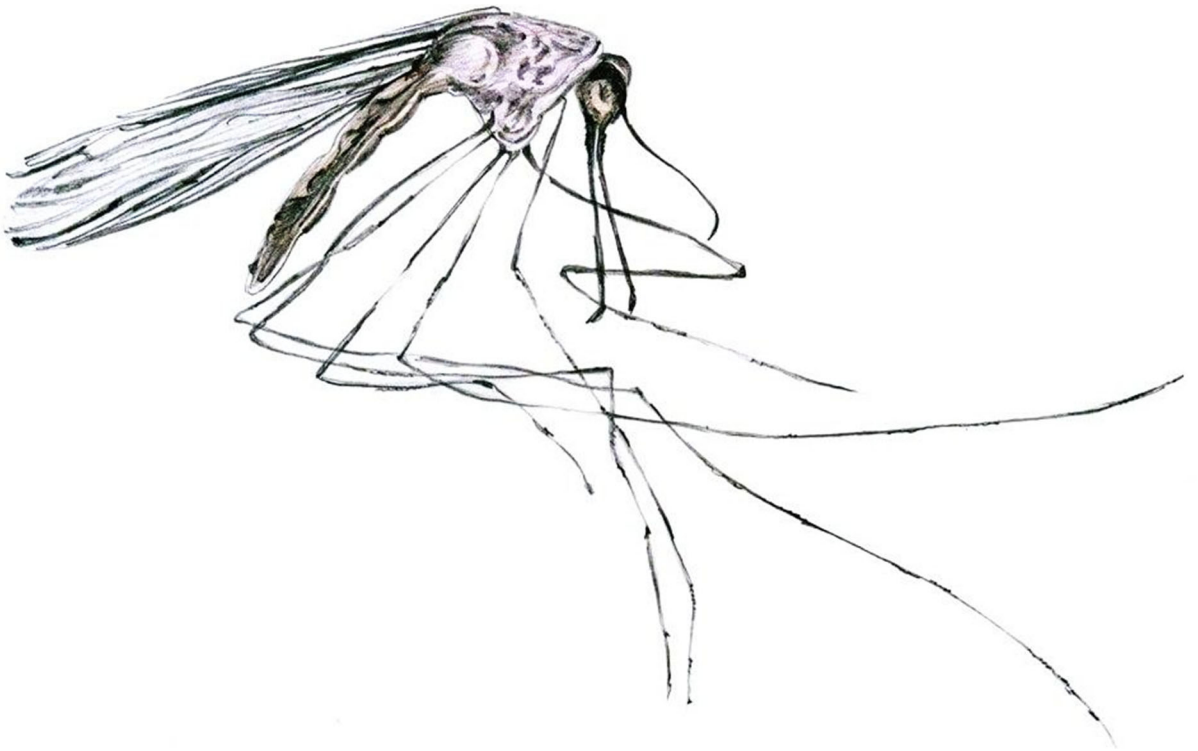
Feeding occurs when they hang from the water's surface by the tip of their tail (siphon) or by browsing along the bottom of their habitat. Because they are air breathing organisms they must return to the water's surface to breathe. About one to two weeks are required for larval development. At the end of the larval stage, the mosquito molts and becomes the aquatic pupa (tumbler).

The pupa is active only if disturbed, for this is the resting stage where the larval form is transformed into the adult. This takes about two days during which time feeding does not occur. When the transformation is completed, the new adult splits the pupal skin and emerges. Under optimum conditions, development from egg to adult takes about a week.

However, all mosquito developmental times are dependent on the temperature and nutrients of the water in which they mature. Where possible, the best approach is to prevent mosquitoes from breeding by eliminating or modifying breeding sites. This can be accomplished best by eliminating containers which are capable of holding water. Where breeding sites exist in standing or slow-moving water, corrective action to permanently eliminate them by such means as filling, pumping, ditching or draining is recommended. Close coordination with your local mosquito abatement district and environmental regulatory authorities is recommended.

Inland Floodwater Mosquito (*Aedes vexans*)

They are opportunistic feeders, taking blood meals from a variety of animals as available, but apparently preferring larger mammals, including cattle, horses, deer, and humans when present.



The name "*vexans*" is from the Latin word "*vexāre*" meaning to annoy, torment, or harass. In many parts of the world, this species is a major nuisance, the females biting in the evening, peaking in activity an hour or so after sunset. They are opportunistic feeders, taking blood meals from a variety of animals as available, but apparently preferring larger mammals, including cattle, horses, deer, and humans when present.

This is a medium sized brown mosquito with v-shaped notches in the upper abdomen scales. It is one of the most common floodwater mosquitoes and a reported problem species in most states. They are vicious biters and can harbor many viruses including SLE, WEE, eastern equine encephalitis (EEE), and La Cross encephalitis (LAC), in addition to WNV.

Eggs are laid in mud and hatch when flooded in the spring or early summer. Several hatches may occur each season as water levels recede and rise, however the eggs can remain viable for several years if flooding does not occur.

Larval habitat: Floodwaters, irrigated pastures and other grassland pools
Biting time: dusk through dawn
Preferred host: Birds and mammals
Flight range: 5 to 15 miles from breeding site

A. vexans is a known vector of *Dirofilaria immitis* (dog heartworm), myxomatosis (a deadly rabbit viral disease), and Tahyna virus, a seldom-diagnosed *Bunyaviridae* virus, which affects humans in Europe, causing a fever which disappears after 2 days, but afterward can cause encephalitis or meningitis.

A. vexans is the most common mosquito in Europe, often comprising more than 80% the European mosquito community. Its abundance depends upon availability of floodwater pools.

In summer, up to 8,000 mosquitoes can be collected per trap per night. *A. vexans* exhibited significantly higher transmission rates of Zika virus than *A. aegypti*, and its wide geographic distribution, periodic extreme abundance, and aggressive human biting behavior increase its potential to serve as a Zika virus vector in northern latitudes outside the range of the primary vectors *A. aegypti* and *A. albopictus*.

Aedes vexans is often one of the first mosquito species that new surveillance technicians learn to identify – abundant in the trap samples early in the season, very distinctly marked, and easy to recognize.

Against a background of black scales, this mosquito has narrow white bands on the base of each leg segment, and the base of most abdominal segments is adorned with white-scaled bands, indented in the middle so that they look like the letter “B” when viewed sideways.

Japanese Rockpool Mosquito (*Aedes japonicus*)

Being a day feeder, it prefers humans and mammals for its blood meal.

Aedes japonicus is an Asian species of mosquito generally found in Japan, Korea, the Ryukyu Archipelago (Okinawa and associated islands), Taiwan, South China, and Hong Kong. In 1998, the subspecies Aedes japonicus japonicus was first detected in the United States in New York and New Jersey. Since that time, Aedes japonicus has been found in six other states: Ohio, Maryland, Connecticut, Massachusetts, Pennsylvania, and Virginia.

Appearance

The adult female of Aedes japonicus is a medium-sized mosquito of dark- to blackish-brown appearance, with white scales on the body and legs.

Breeding Areas

Larvae are found in a wide variety of natural and artificial containers, including rock holes and used tires. Preferred sites usually are shaded and contain water rich in organic matter. The similarity of breeding habitats used by Aedes japonicus to those of other Aedes species suggests that the transport of eggs, larvae, and pupae in used tires may be an important mechanism for introducing the species into previously uninfested areas.

Eggs are resistant to desiccation and can survive several weeks or months under dry conditions. Aedes japonicus overwinters as eggs in the more northern parts of its range. However, it is found throughout the winter as larvae as far north as Tokyo (37° N), which is equal in latitude to Norfolk, Virginia.

Disease Associations
Although few studies have been done to assess the public and veterinary health importance of Aedes japonicus, this species is suspected of being a vector of Japanese encephalitis (JE) virus to swine in northern Japan. Under experimental conditions it has been shown to transmit JE virus to mice and also to transmit the virus to its progeny through the eggs.

Unpublished studies conducted at the United States Army Medical Research Institute of Infectious Diseases in Fort Detrick, MD, indicate that Aedes japonicus is also a competent experimental vector of West Nile virus, a flavivirus closely related to JE and St. Louis encephalitis viruses.

Behavior
Adult species of Aedes japonicus rest in wooded areas and prefer to bite during the daytime. In the laboratory, they feed readily on chicks and mice, but not on reptiles or amphibians. Further studies on Aedes japonicus are needed to more clearly define their feeding preferences in a variety of situations.

Protection
As with other biting insects, the use of protective clothing (i.e., long-sleeved shirts and long pants) and insect repellent is recommended to prevent bites.

Key Mosquito in Minnesota

Faced with a new mosquito species that could transmit disease in Minnesota, state health and mosquito control officials are urging residents to rid their property of water-holding containers. The Minnesota Department of Health (MDH) and the Metropolitan Mosquito Control District (MMCD) confirmed that the Japanese rock pool mosquito (*Aedes japonicus*) is established in at least five southeastern Minnesota counties. This mosquito could potentially transmit LaCrosse encephalitis virus (LAC) and West Nile virus (WNV) to humans.

"Spring is the perfect time to take simple steps to prevent mosquito-transmitted disease later this summer," said David Neitzel, an MDH epidemiologist who specializes in mosquito-borne diseases. "Several types of disease-carrying mosquitoes use water-holding containers, such as old tires, buckets, or cans, as breeding sites.

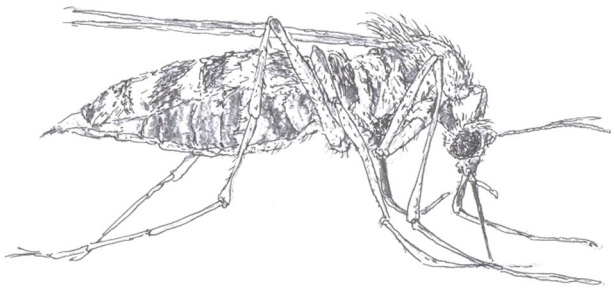
If everyone dumps the water out of these containers and removes them during their spring yard work, we can reduce the number of mosquitoes that could transmit disease later this summer."

The Japanese rock pool mosquito, an Asian mosquito that was accidentally imported into this country, has been steadily moving across the United States since it was first found in New Jersey in 1998. It was first identified in Minnesota in Scott County in 2007. During 2008, it was also detected in Dakota, Goodhue, Wabasha and Houston counties. This spring, it was determined that these mosquitoes' eggs had survived the Minnesota winter. "We suspect that we will soon find this mosquito in other counties as well," Neitzel said.

Northern House Mosquito or House Mosquito (*Culex pipiens)*

It is a vector for diseases, including Japanese encephalitis, amplify the infection in urban birds.

Common Associate Species: *Cx. restuans, Cs. inornata, An. punctipennis*



MOSQUITO *(culex pipiens)*

Culex pipiens*,* the Northern House Mosquito has a distribution that roughly includes the northern half of the United States. This species' range begins just north of Maine, along the Atlantic seaboard, and extends to the state of Washington in the west with some extension into southern British Columbia. The range along the Pacific coast extends into northern California and then east on a relatively straight line to North Carolina. The species is replaced by *Culex quinquefasciatus*, the Southern House Mosquito, in the southern United States with limited overlap in portions of the Midwest.

This species is medium-sized, brownish with pale bands around the abdominal segments. The quickly developing larvae may be continuously present spring through fall. Although they occur in rural environments, they reach their greatest numbers in urban and suburban areas and readily enter homes. Culex pipiens are known to vector St. Lewis encephalitis (SLE).

Larval Habitats
Nearly anything retaining water, clean or polluted— artificial containers, catch basins, ground pools, animal waste lagoons, tires, hoof prints, etc.

Biting time: Night
Preferred host: Mostly birds, but will readily bite mammals, including humans
Flight range: ¼ to ½ mile from breeding site

Culex pipiens provides the life cycle model for most of the domestic *Culex* in temperate areas. Inseminated adult females from the last generation of the season build body fat by feeding on carbohydrates and enter hibernation in fall. The females pass the winter in diapause and do not become active during periods of warm winter weather. Hibernating females are common in basements, outbuildings, and subterranean enclosures. Like *Culex restuans*, the females congregate near moisture and move their resting location during the winter to remain in a humid atmosphere.

Mortality can be extensive during periods of winter drought. Females emerge from hibernation during May and begin depositing egg rafts in suitable habitat. Populations of this mosquito usually peak during August, but breeding continues well into September. The adults from the last generation of the season lose all interest in blood meal hosts but will move in and out of overwintering sites during periods of mild fall weather. Larvae rarely persist in breeding habitats after females have entered hibernation.

Culex pipiens can be found in a fairly wide range of larval habitats, but are generally associated with water that has a high organic content. The species utilizes temporary ground water that ranges from mildly to grossly polluted. The species also deposits its eggs in artificial containers, including tin cans, tires, and any refuse that allows stagnant water to puddle. The species is decidedly urban and reaches greatest numbers in large urban centers. Catch basins and storm drains provide ideal habitat for *Cx. pipiens*. The species becomes particularly abundant in areas where raw sewage leaks into subterranean drainage systems.

Meat packing plants and slaughter house drainage ponds support high populations of this species. *Culex pipiens* can always be collected in the effluent from sewage treatment plants.

Collection
No special techniques are required to collect *Cx. pipiens* larvae. This species is common in urban settings and can usually be found in significant numbers in a variety of habitats where stagnant water collects. *Culex pipiens* will oviposit readily in buckets containing prepared straw infusions. Most piles of discarded tires contain a mixture of *Cx. pipiens* and *Cx. restuans* in addition to the tire-breeding *Aedes*.

Culex pipiens occurs on every continent except Antarctica and is the most widely distributed mosquito in the world. In North America, two races range north (*Cx. pipiens pipiens*) and south (*Cx. pipiens quinquefasciatus*) of 39ºN latitude, about the level of Sacramento. *Cx. p. pipiens* lives in the milder coastal climate areas, while *Cx. p. quinquefasciatus* is found in the warmer inland valleys.

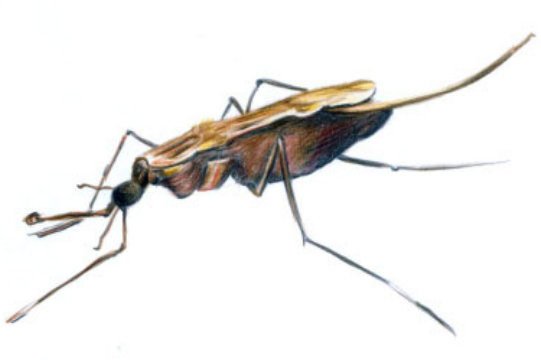
***Culex pipiens*'** main host is wild birds, but it also feeds freely on a wide variety of warm-blooded vertebrates, including man. In northern California, it currently plays only a lesser role as a carrier of human disease, while in southern California and the Gulf Coast region, it is a major carrier of Saint Louis encephalitis. It is also the best known carrier of West Nile Virus, a severe encephalitis virus newly arrived in the Americas that is spreading along the eastern seaboard.

Culex pipiens is a serious pest, called the "*house mosquito*" because it commonly develops in small containers around the home. It shows great skill in finding ways to get into the house, where it feeds on the occupants at night. It also occurs in containers and sumps on farms and industrial plants, in polluted waters, and will feed out-of-doors at night.

Culex pipiens larvae typically develop best in dirty, stagnant water containing abundant organic matter, in ground pools and natural and man-made containers. Vector technicians often find improperly installed or maintained underground septic tanks producing huge numbers of this species.

The mosquitoes gain entrance thorough cracks in the ground, through poorly fitting or unsealed covers, or by the vent pipes made for removal of gases. We recommend that all vents be covered with window screening, preferably aluminum screen, to exclude adults. Polluted habitats do not generally support a very wide variety of species. Most larval samples from polluted water sources consist mainly of *Cx. pipiens* and *Cx restuans*. *Culex pipiens* larvae are easily distinguished from *Cx. restuans* by the length and shape of the antennae.

Culex tarsalis is widely distributed in North America west of the Mississippi River, between southern Canada and northern Mexico. It primarily occurs throughout California, from sea level up to nearly 10,000 in feet elevation, and is especially abundant in the Central Valley and coastal regions, including Marin and Sonoma Counties.



As its name suggests, *C. tarsalis* has bands of white scales around the joints of its tarsi (legs).

There is also a pale band around the center of the proboscis, a line of white scales extending along the hind tibia and femur, and a series of V-shaped spots made of dark scales on the underside of each abdominal segment.

This mosquito develops rapidly and produces multiple generations. In the hot summer season, egg to adult development occurs in as few as four to ten days. A female can lay six or seven times, with some 300 eggs in a batch. Without control efforts, local populations can reach huge numbers in a short time.

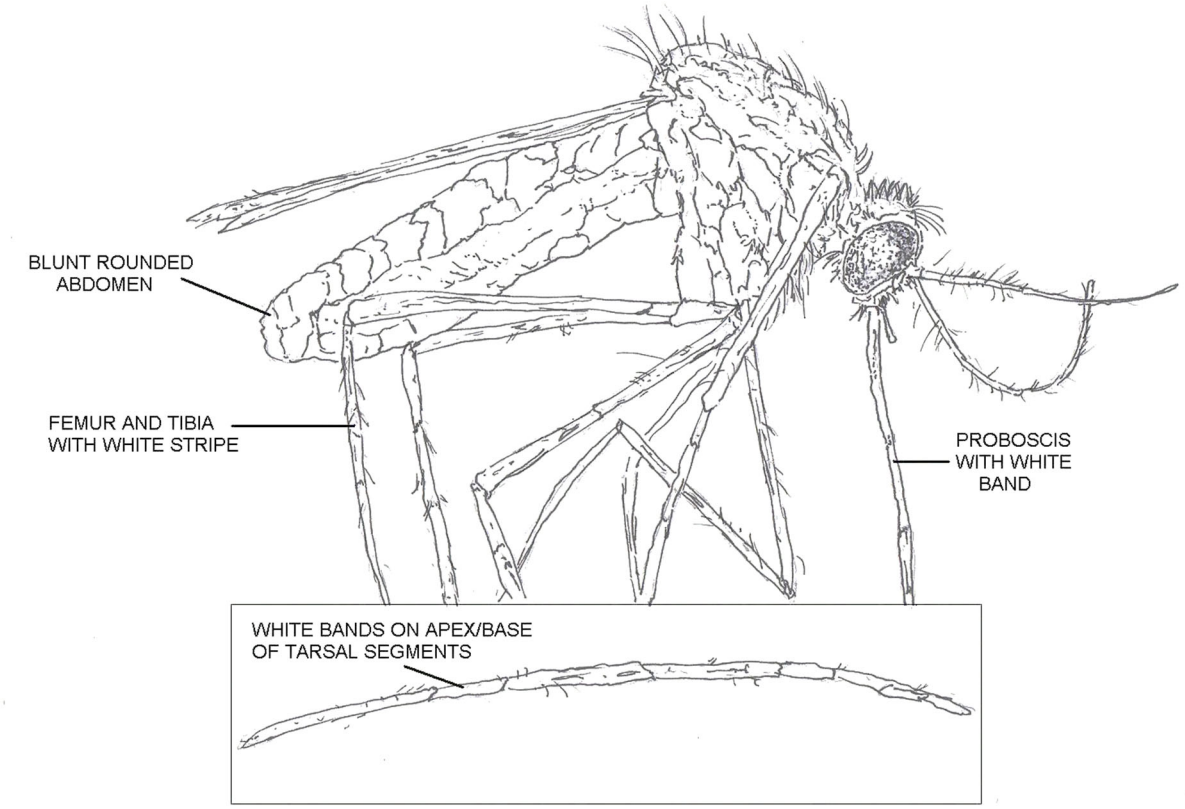
Culex tarsalis breeds in nearly every freshwater source except treeholes. Larvae are found in all but the most polluted ground pools.

Summer agricultural irrigation produces an especially favorable environment, with highest population densities coinciding with the months of most intense irrigation.

During the daytime, adults rest in tree cavities, animal burrows, and artificial habitats like barns, chicken houses, and culverts. In most areas, they feed equally on birds and mammals, including man, depending on availability. After years of intense efforts to keep them under control, vast populations in the central valley have become resistant to nearly all the common chemical insecticides.

Culex tarsalis is the most important carrier of western equine and Saint Louis encephalitis in much of the western U.S. It occurs together with wild birds - the natural reservoir of infection, and the virus is often discovered in field-collected specimens. It is also readily infected after taking an infected blood meal, and easily transmits the virus during its later blood meals.

The appearance of antibodies against encephalitis virus in the flocks of sentinel chickens kept in several parts of the state is a signal alarm to the districts to begin quickly and aggressively reducing *Culex tarsalis* numbers around populated areas.



Mosquitoes of the *Culex tarsalis* species have a distinct ring around the proboscis.

Also, they have apical and basal tarsal bands. With 11 species, Culex is one of the largest genus of mosquitoes. Females of this group have short palpi and a blunt, rather than pointed abdomen.

Unlike most Ochlerotatus, they tend to have numerous generations in a year. Several hundred eggs are laid packed together in rafts. A female can lay six or seven times in her forty to fifty-day life span.

Where does this Mosquito normally lay its Eggs?

- In tin cans, buckets, discarded tires and other artificial containers that hold stagnant water.
- In untended bird baths, clogged rain gutters and plastic wading pools that hold stagnant water.
- In storm drains and catch basins in urban areas.
- In septic seepage and other foul water sources above or below ground level.

How does this Mosquito Overwinter?

- The last generation of adult females' mate and build body fat by feeding on carbohydrates.
- Mated females find refuge in culverts, basements, and protected areas that stay above freezing.
- The body metabolism slows considerably and winter is spent in a state of torpor.
- Females that survive the winter blood feed in spring and lay eggs that produce the summer populations.

Antennal Shape

The characteristic antennal shape is difficult to see in the dipper, but the slightly longer, constricted antennae and prominent antennal tufts can be discerned with practice. The multiple hair tufts on the siphon can be used as a diagnostic character under the microscope. *Culex salinarius* is a closely related species that is easily distinguished by the longer, slenderer siphon.

St. Louis Encephalitis

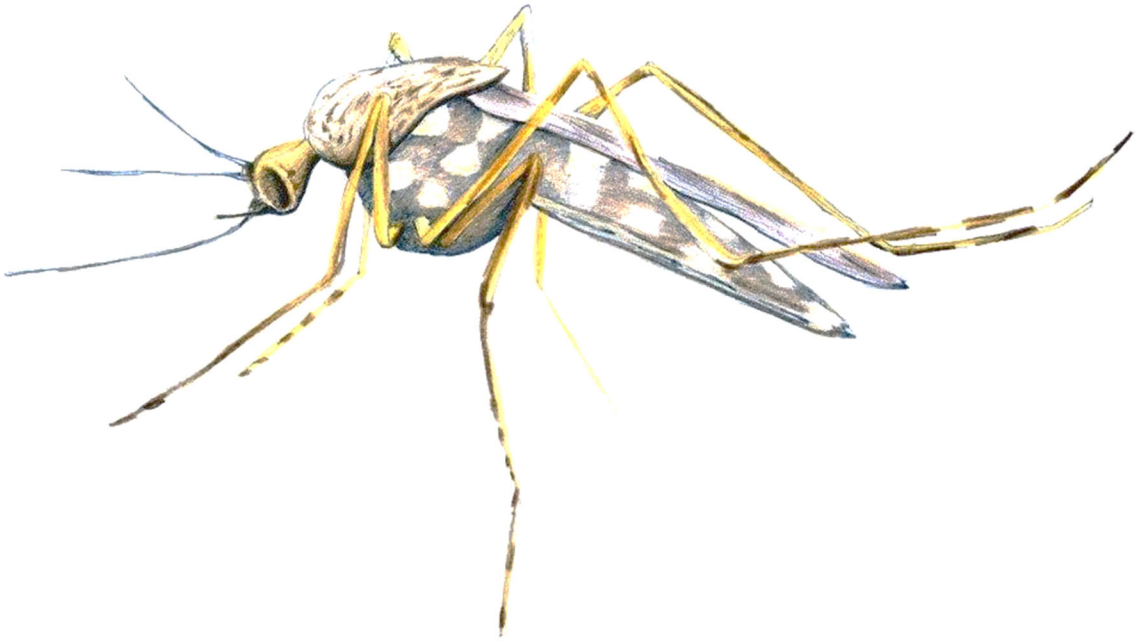
SLE is a natural infection found in a variety of wild birds. Culex pipiens can function as a vector and pass the virus from one bird to the next. If virus is introduced to an urban setting, Culex pipiens can amplify the infection in urban birds. House Sparrows, an introduced species, circulate exceptionally high levels of SLE when they become infected. Culex pipiens that bite infected birds acquire the virus and are capable of passing it on to humans.

Summary

- Culex pipiens is usually the most common pest mosquito in urban and suburban settings.
- Culex pipiens is an indicator of polluted water in the immediate vicinity.
- Culex pipiens is recognized as the primary vector of St. Louis encephalitis (**SLE**).
- Culex pipiens is normally considered to be a bird feeder.
- Some urban strains have a predilection for mammalian hosts and feed readily on humans.
- Most populations probably contain individuals that accept blood from mammals as well as birds.

Pale Marsh Mosquito (*Ochlerotatus dorsalis)*

Prefers to feed on large mammals like cattle, horses and man.



Ochlerotatus dorsalis

Ochlerotatus dorsalis' common name comes from its whitish-grey appearance: the abdomen and wings have intermixed narrow light and dark scales. Sometimes the light scales predominate. The hind legs have pale white bands overlapping the individual joints. This mosquito is found in Asia, Europe, and North America.

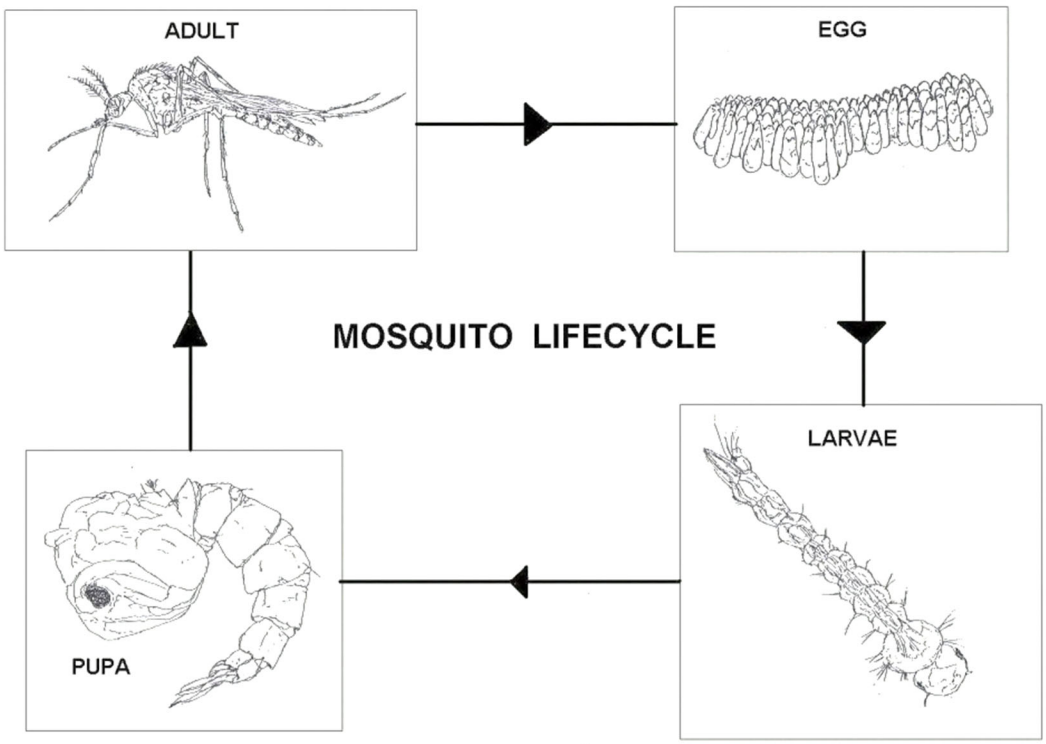
In California, it occurs along the Pacific coast and in the eastern regions of the state. It breeds along the edges of bays, marshes and lakes. It is especially frequent in the seasonally flooded marshes along the edges of the San Francisco and San Pablo Bays.

A strong flyer, ***Ochlerotatus dorsalis*** often disperses 20 miles or more from its breeding sources. Unlike most other local *Ochlerotatus*, the pale marsh mosquito is active almost year-around. Females produce continuous broods throughout the spring and summer, with 8 to 12 hatches each year, and the last adults emerging in October.

Pre-adult stages can be as short as 1 to 2 weeks in the warm summer weather. Populations sometimes build up to huge numbers in brackish marshes subject to prolonged spring flooding.

Ochlerotatus dorsalis is a serious pest mosquito and a secondary vector of the encephalitis virus. Females prefer to feed on large mammals like cattle and horses (and man) when these are available.

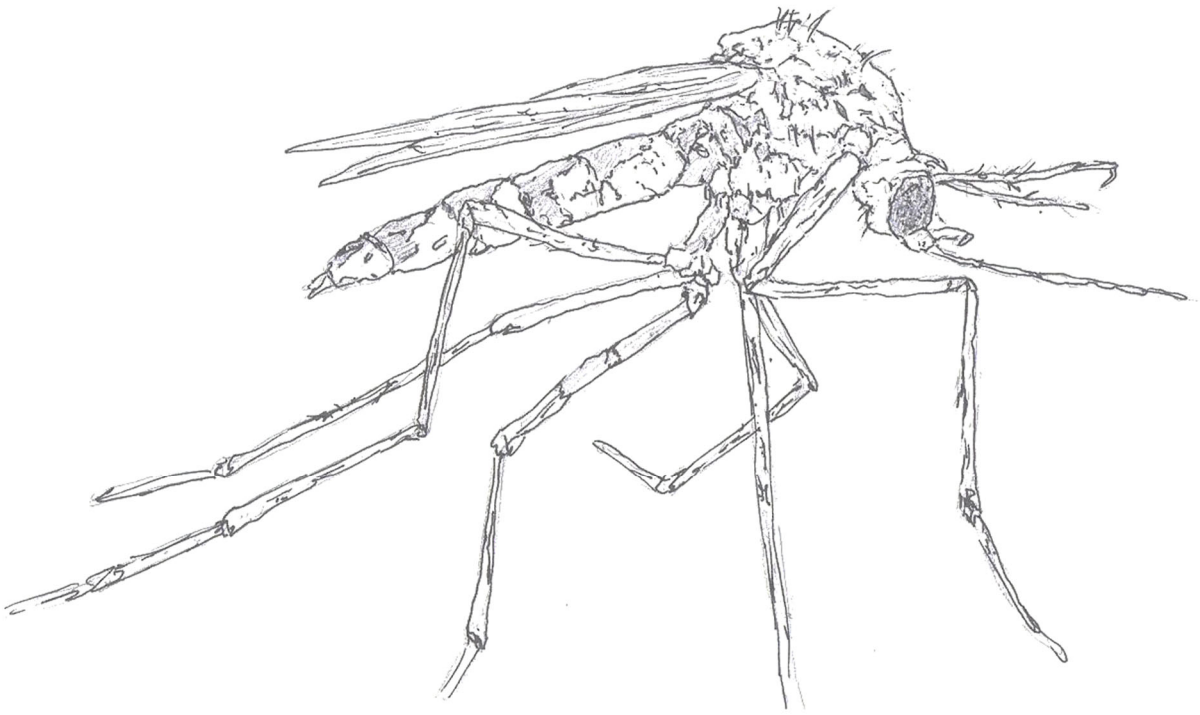
They are vicious biters, and so aggressive and persistent that livestock tend to move away from areas where they are numerous.



OCHLEROTATUS FITCHII

Salt Marsh Mosquito, Aedes (*Ochlerotatus taeniorynchus*)

Salt Marsh Mosquitoes May Live 100 Miles Away.



SALT MARSH MOSQUITO

The major salt marsh mosquito, Aedes (Ochlerotatus) taeniorynchus, is known for its fierce biting plus synchronized egg laying and hatching patterns that produce large swarms. Adult mosquitoes are small, fragile insects with slender bodies; one pair of narrow wings (tiny scales are attached to wing veins); and three pairs of long, slender legs. They vary in length from 3/16 to 1/2 inch.

Mosquitoes have an elongate "beak" or piercing proboscis. Eggs are elongate, usually about 1/40-inch-long, and dark brown to black near hatching. Larvae or "wigglers" are filter feeders that move with an S-shaped motion. Larvae undergo four growth stages called instars before they molt into the pupa or "tumbler" stage. Pupae are comma-shaped and nonfeeding and appear to tumble through the water when disturbed.

Where possible, the best approach is to prevent mosquitoes from breeding by eliminating or modifying breeding sites. This can be accomplished best by eliminating containers which are capable of holding water. Where breeding sites exist in standing or slow-moving water, corrective action to permanently eliminate them by such means as filling, pumping, ditching or draining is recommended.

Close coordination with your local mosquito abatement district and environmental regulatory authorities is recommended. An important consideration in the practice of mosquito control is the advisability, whenever possible, to target control operations against immature populations.

These stages are usually concentrated, relatively immobile and therefore occupy minimum acreage compared with adults, which may rapidly disperse over large areas.

By targeting the immatures, it is possible to minimize the area treated and often avoid treating populated areas. Conversely, targeting adult mosquitoes may require highly visible and extensive applications of adulticides within residential and urban areas.

The adulticides registered for this use are applied at levels 100 to 10,000 times below rates that would be cause for concern about exposure risk for the general public or the environment. Nevertheless, achieving good larval control while at the same time minimizing the use of adulticides is environmentally and client friendly, and appreciated by the public.

Most states have specific regulations governing the decision to apply pesticides for mosquito control. These usually involve the collection of data that substantiate the need for the application. Thus, standardized ultra-low-volume (ULV) operation on a fixed schedule is not allowed in most areas. Each application must be justified by documentation of increased mosquito activity, such as trap collections, landing or biting counts, telephone complaints, etc.

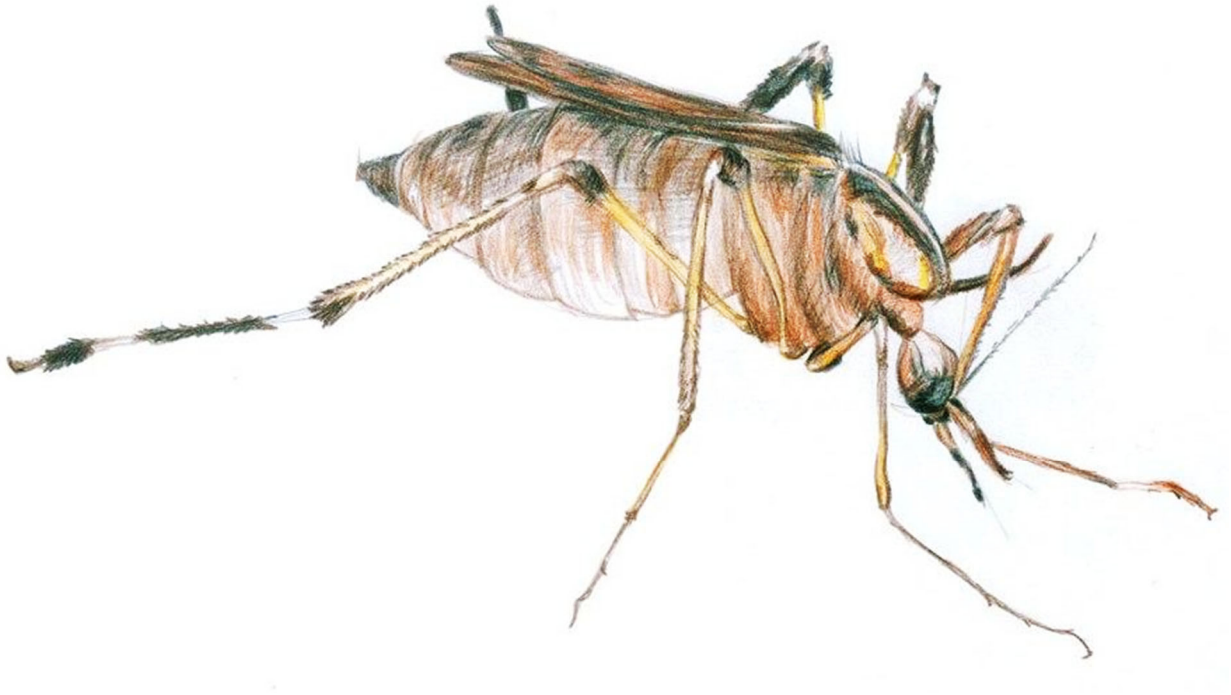
Mosquito Repellents

The CDC traveler's page on preventing dengue fever suggests using mosquito repellents that contain DEET (N, N-diethylmetatoluamide, between 20% to 30% concentration, but not more). It also suggests the following:

1. The mosquito usually bites at dusk and dawn but may bite at any time during the day – especially indoors, in shady areas, or when the weather is cloudy.
2. The mosquito's preferred breeding areas are in areas of stagnant water, such as flower vases, uncovered barrels, buckets, and discarded tires, but the most dangerous areas are wet shower floors and toilet tanks, as they allow the mosquitos to breed in the residence. Research has shown that certain chemicals emanating from bacteria in water containers stimulate the female mosquitoes to lay their eggs. They are particularly motivated to lay eggs in water containers that have the correct amounts of specific fatty acids associated with bacteria involved in the degradation of leaves and other organic matter in water. The chemicals associated with the microbial stew are far more stimulating to discerning female mosquitoes than plain or filtered water in which the bacteria once lived.
3. Wear long-sleeved clothing and long trousers when outdoors during the day and evening.
4. Spray permethrin or DEET repellents on clothing, as mosquitos may bite through thin clothing.
5. Use mosquito netting over the bed if the bedroom is not air conditioned or screened. For additional protection, treat the mosquito netting with the insecticide permethrin.
6. Spray permethrin or a similar insecticide in the bedroom before retiring.

Shaggy-legged" Gallinipper (*Psorophora ciliate*)

This creature is aggressive towards humans.



Is the largest blood sucking mosquito in the U.S. Commonly referred to as the "Shaggy-legged" Gallinipper. It is easy to identify by its large size and it inflicts a painful bite. Rarely found in large numbers. The larvae are large and are predacious upon other larvae.

Larval habitat: Breeds in fields, temporary ground pools, and ditches.
Adult habitat: Fields and yards
Biting activity: Anytime of the day when disturbed.
Flight range: 1-2 miles

Not only are these mosquitoes aggressive towards humans and other animals as adults, but *P. ciliata* larvae are known for preying on other mosquito species' larvae and even tadpoles. Campos, Fernandez, and Sy found in their 2004 study that *P. ciliata* were frequent predators to the mosquito species *Ochlerotatus albifasciatus* in Buenos Aires, Argentina and impact the populations of *O. albifasciatus*.

Females are aggressive, preferring to feed on large mammals, and are most active during spring and summer in woodlands or fields during the day or night. They lay eggs either as single eggs on moist soil, or as an egg raft on top of ephemeral pools of water.

Typically, females in the genus are capable of laying their eggs on dry or damp land to hatch months or years later, depending on the species.

Snow Mosquito (*Culisetain ornate*)

Feeds off of the blood of mammals and birds, prefer to operate in forested areas.

SNOW MOSQUITO

This species also rather large, grayish-brown with broad, pale-scaled wings. The fertilized females hibernate in winter and emerge during warm spells, even when snow is still on the ground. It continues to breed throughout spring and summer. Known to vector WEE and is implicated in WNV.

Larval habitat: often in cold, fairly clean water
Biting time: Dusk through dawn, temperature influenced
Preferred host: Wild and domestic mammals, usually not humans
Flight range: unknown

Southern House Mosquito (*Culex quinquefasciatus*)

Vector of lymphatic filariasis and a number of arboviruses including St. Louis encephalitis virus and West Nile virus.

The *Culex pipiens* complex is distributed worldwide and has two species formally recognized in the complex. One of these species is the tropical and subtropical *C. quinquefasciatus* (the southern house mosquito), vector of lymphatic filariasis and a number of arboviruses including St. Louis encephalitis virus and West Nile virus.

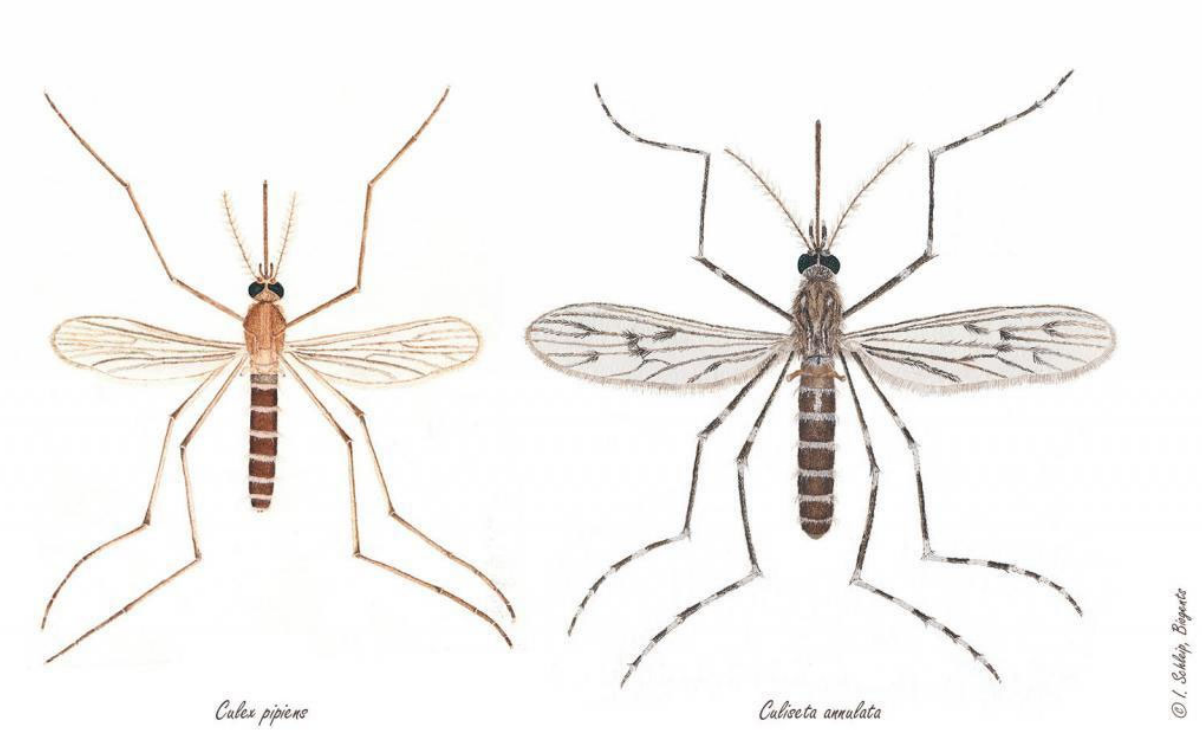
The adult *Culex quinquefasciatus* mosquito is a medium-sized, brown mosquito. The body is about 3.96 to 4.25 mm long. While the main body is brown, the proboscis, thorax, wings, and tarsi are darker than the rest of the body. The head is light brown with the lightest portion in the center.

Mature *Culex quinquefasciatus* females fly at night to nutrient-rich standing water to lay eggs. The larvae feed on organic material in the water and require between 5 to 8 days to complete their development at 30°C.

The larvae pass through four larval instars, and towards the end of the fourth instar they stop eating and undergo molting to give rise to pupae. After 36 hours (at 27°C) adults emerge. The exact timing of development can vary depending on temperature. Both males and females take nectar from plants, but after mating, the females seek a blood meal from mammals or birds. Ingested blood is necessary for egg development.

A single female can lay up to five rafts of eggs in a lifetime, with each raft containing thousands of eggs. The exact number varies depending on climatic conditions. It breeds profusely in dirty water collections, including stagnant drains, cesspools, septic tanks with leaks, borrow pits, and almost all organic polluted water sources. Under optimum temperature and humidity, the life cycle will be completed in 7 days, passing through the egg, larva, pupa, and adult stages.

Culex quinquefasciatus mosquitoes transmit zoonotic diseases that affect humans and other animals. These include **St. Louis encephalitis, Western equine encephalitis**, and **West Nile fever**. Infection occurs during feeding on blood. In southern U.S. it is the primary vector of St. Louis encephalitis virus.



Culex pipiens

Culiseta annulata

Tule Mosquito (*Culex erythrothorax*)

Vector of West Nile virus, Japanese encephalitis, or St. Louis encephalitis, but also filariasis and avian malaria.

Culex erythrothorax is a mosquito species that appears in Southern California. It is also known as the tule mosquito, due to its preference for breeding in tule plants. The species has a brownish-orange color. It is a confirmed vector of West Nile virus.

Culex is a genus of mosquitoes, several species of which serve as vectors of one or more important diseases of birds, humans, and other animals. The diseases they vector include arbovirus infections such as West Nile virus, Japanese encephalitis, or St. Louis encephalitis, but also filariasis and avian malaria. They occur worldwide except for the extreme northern parts of the temperate zone, and are the most common form of mosquito encountered in some major U.S. cities, such as Los Angeles.

Depending on the species, the adult *Culex* mosquito may measure from 4–10 mm (0.2–0.4 in).

The adult morphology is typical of flies in the suborder Nematocera with the head, thorax, and abdomen clearly defined and the two forewings held horizontally over the abdomen when at rest. As in all Diptera capable of flight, the second pair of wings is reduced and modified into tiny, inconspicuous halteres.

Formal identification is important in mosquito control, but it is demanding and requires careful measurements of bodily proportions and noting the presence or absence of various bristles or other bodily features.

In the field, informal identification is more often important, and the first question as a rule is whether the mosquito is anopheline or culicine. Given a specimen in good condition, one of the first things to notice is the length of the maxillary palps. Especially in the female, palps as long as the proboscis are characteristic of anopheline mosquitoes. Culicine females have short palps.

Anopheline mosquitoes tend to have dappled or spotted wings, while culicine wings tend to be clear. Anopheline mosquitoes tend to sit with their heads low and their rear ends raised high, especially when feeding, while culicine females keep their bodies horizontal.

Anopheline larvae tend to float horizontal at the surface of the water when not in motion, whereas culicine larvae float with head low and only the siphon at the tail held at the surface.

Life Cycle
The developmental cycle of most species takes about two weeks in warm weather. The metamorphosis is typical of holometabolism in an insect: the female lays eggs in rafts of as many as 300 on the water's surface.

Suitable habitats for egg-laying are small bodies of standing fresh water: puddles, pools, ditches, tin cans, buckets, bottles, and water storage tanks (tree boles are suitable for only a few species).

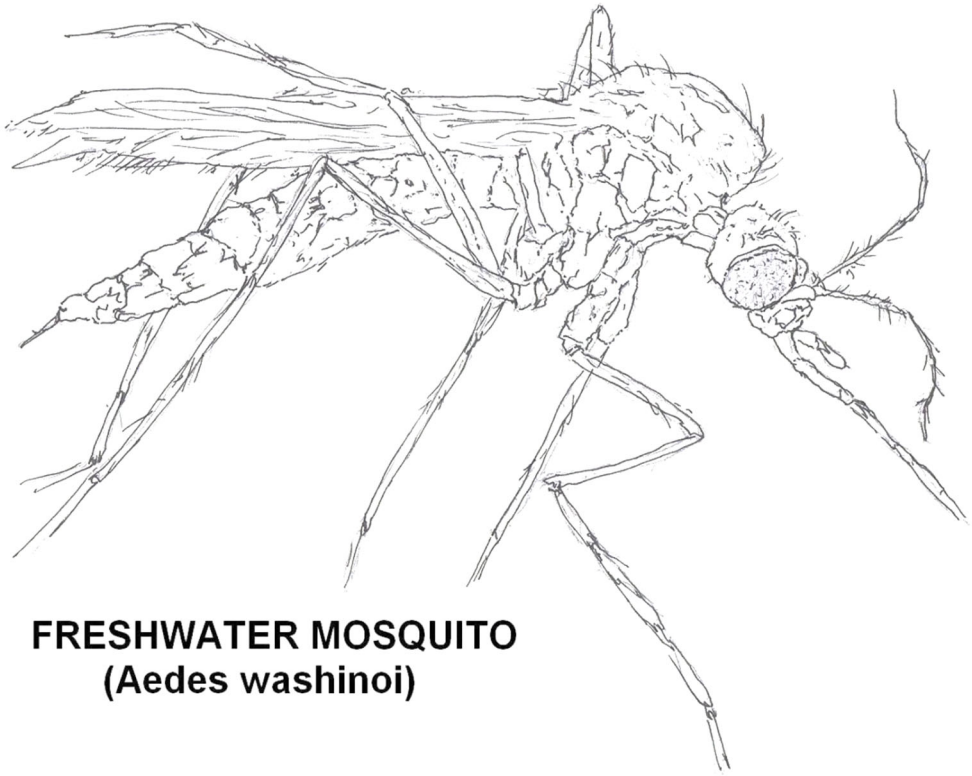
The tiny, cigar-shaped, dark brown eggs adhere to each other through adhesion forces, not any kind of cement, and are easily separated. Eggs hatch only in the presence of water, and the larvae are obligately aquatic, linear in form, and maintain their position and mostly vertical attitude in water by movements of their bristly mouthparts. To swim, they lash their bodies back and forth through the water.

During the larval stage, the insect lives submerged in water and feeds on particles of organic matter, microscopic organisms or plant material; after several instars it then develops into a pupa. Unlike the larva, the pupa is comma-shaped.

It does not feed, but can swim in rapid jerking motions to avoid potential predators. It must remain in regular contact with the surface to breathe, but it must not become desiccated. After 24–48 hours, the pupa ruptures and the adult emerges from the shed exoskeleton.

Washino's Willow Pool Mosquitoes (*Aedes washinoi)*

Aggressive day-biting mosquito.



Washino's Willow Pool Mosquito (Aedes washinoi) is an aggressive day-biting mosquito commonly found breeding in shallow ground pools and riparian sites dominated by willow or cottonwood trees. This species has also been found breeding in areas with dense blackberry thickets.

Washino's Willow Pool Mosquitoes have four life stages: egg, larva, pupa, and adult. The immature stages need standing water to complete their life cycle. Washino's Willow Pool Mosquito does occasionally create domestic, industrial and agricultural pest problems when they are present in large numbers. Although California Encephalitis virus has been isolated from natural populations of these mosquitoes, no confirmed human cases of mosquito-borne disease has been linked to this species of mosquito.

Life Cycle

After an adult female lays her eggs they hatch into larvae (wrigglers), which feed on small organic particles and microorganisms in the water. Feeding occurs when they hang from the water's surface by the tip of their tail (siphon) or by browsing along the bottom of their habitat. Because they are air breathing organisms they must return to the water's surface to breathe.

About one to two weeks are required for larval development. At the end of the larval stage, the mosquito molts and becomes the aquatic pupa (tumbler). The pupa is active only if disturbed, for this is the resting stage where the larval form is transformed into the adult. This takes about two days during which time feeding does not occur. When the transformation is completed, the new adult splits the pupal skin and emerges.

Adult Daily Activity
Adults emerge during late winter and early spring and can persist through early June. Man-made canals and natural water ways have sometimes been used by these mosquitoes as a passage way into local human developments.

Adult Flight Range
Usually stay within one mile of their breeding site. Maximum recorded flight range 1.5 miles.

Adult
Feeding
Females tend to feed during the day and at dusk. Their preferred hosts are humans and large mammals.

Eggs and Larvae
Eggs are laid in the muddy margins adjacent to the receding water line of the larval habitat and hatch the following winter when re-flooded. Larvae usually hatch during early winter after sufficient rainfall has filled their habitat with enough water to submerge the last season and prior season's eggs.

Additional hatches of larvae can occur if late winter and early spring rains refill drying larval sites. Larva of this mosquito also exhibit a late fourth instar diapause and partial synchronous adult emergence similar to that observed in the Winter Salt Marsh Mosquito (Aedes squamiger).

Where possible, the best approach is to prevent mosquitoes from breeding by eliminating or modifying breeding sites. This can be accomplished best by eliminating containers which are capable of holding water. Where breeding sites exist in standing or slow-moving water, corrective action to permanently eliminate them by such means as filling, pumping, ditching or draining is recommended. Close coordination with your local mosquito abatement district and environmental regulatory authorities is recommended.

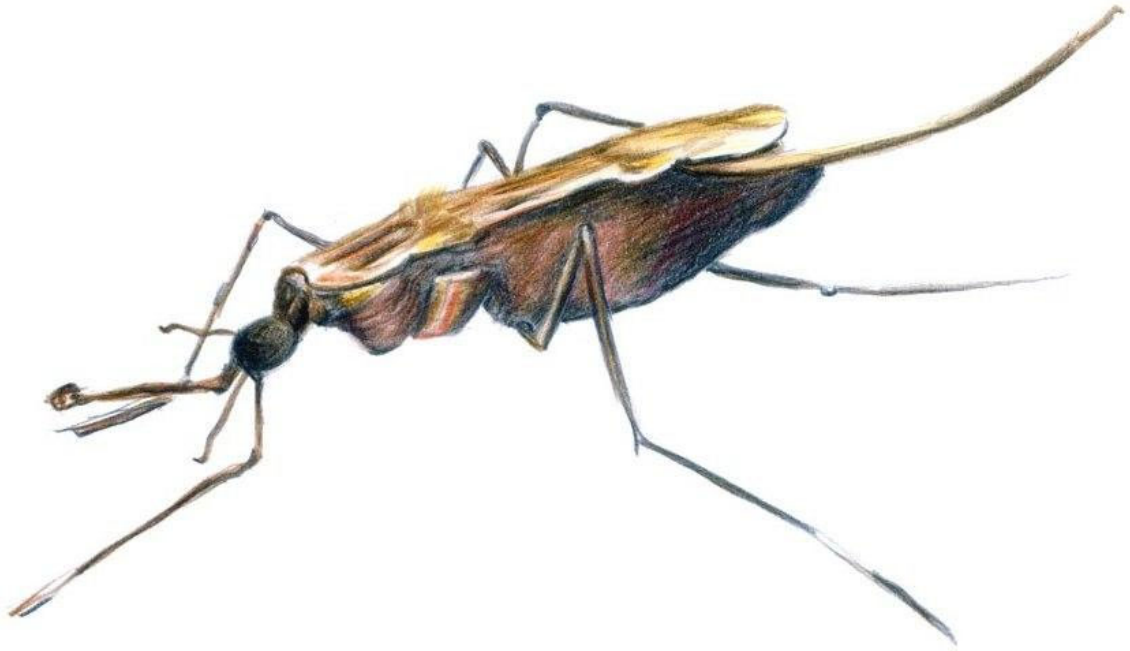
An important consideration in the practice of mosquito control is the advisability, whenever possible, to target control operations against immature populations. These stages are usually concentrated, relatively immobile and therefore occupy minimum acreage compared with adults, which may rapidly disperse over large areas.

By targeting the immatures, it is possible to minimize the area treated and often avoid treating populated areas. Conversely, targeting adult mosquitoes may require highly visible and extensive applications of adulticides within residential and urban areas. The adulticides registered for this use are applied at levels 100 to 10,000 times below rates that would be cause for concern about exposure risk for the general public or the environment.

Nevertheless, achieving good larval control while at the same time minimizing the use of adulticides is environmentally and client friendly, and appreciated by the public. Most states have specific regulations governing the decision to apply pesticides for mosquito control. These usually involve the collection of data that substantiate the need for the application. Thus, standardized ultra-low-volume (ULV) operation on a fixed schedule is not allowed in most areas. Each application must be justified by documentation of increased mosquito activity, such as trap collections, landing or biting counts, telephone complaints, etc.

Western Encephalitis Mosquito (*Culex tarsalis*)

Aggressive to humans and Animals, prefers birds.



This is medium-sized, dark mosquito that has a broad white band across the middle of the proboscis and the lower leg segments. In addition to being a potential vector of WNV this species is the most important vector of Western Equine encephalitis (WEE) and SLE.

Larval habitat: Nearly anything retaining water (see Culex pipiens)
Biting time: Most active at nightfall but also through until daylight
Preferred host: Mostly birds, but will readily bite mammals, including humans
Flight range: 5-15 miles

As mosquitoes go, the Western Encephalitis Mosquito is one of the more easily recognizable, with its distinctive scale patterns. The legs have white banding on each side of the joints, and the proboscis is adorned with a bright white band of scales in the middle. The purpose of these bands is unknown, but they may help the mosquito recognize potential same-species mates, or assist with orientation when flying, perching, and feeding on nectar-rich flowers.

Species in the genus *Culex* are known as “standing-water” mosquitoes. Unlike their “floodwater” relatives (such as *Aedes vexans*) that lay eggs above the water line, standing-water mosquitoes must lay their eggs directly on the water’s surface. *Culex* eggs are laid one at a time, but attached together to form a raft of 100 or more eggs. The structure of the individual eggs and the way in which they are attached together make the egg raft able to float on the water surface until they hatch, usually within a couple of days after being laid. These mosquitoes must have standing water for egg-laying and larval development. In the case of *Culex tarsalis*, which is highly opportunistic when it comes to seeking a water source, they usually occur in natural or man-made swamps, or other semi-permanent waters, often with high organic content. In the arid regions of the west, such watery habitats were uncommon prior to large-scale agriculture and urban development, making this species much more common today than it would have been historically.

Separating adult females of *Culex tarsalis* from *Culex coronator*			
		Culex tarsalis	***Culex coronator***
HEAD	Proboscis dark-scaled with a broad median white band	**X**	
	Proboscis dark-scaled dorsally and a broad area of pale or white scales ventrally		**X**
	Short palps, dark with white scales on the apical and the 3rd segments	**X**	
	Short, dark palps		**X**
LEGS	Hind tarsomeres with distinct basal and apical bands	**X**	**X**
	Anterior surface of fore femur and tibia with pale stripe of scales	**X**	
ABDOMEN	V-shaped dark-scaled pattern on abdominal sterna	**X**	
	Abdominal sterna without dark triangles; mostly pale scaled		**X**

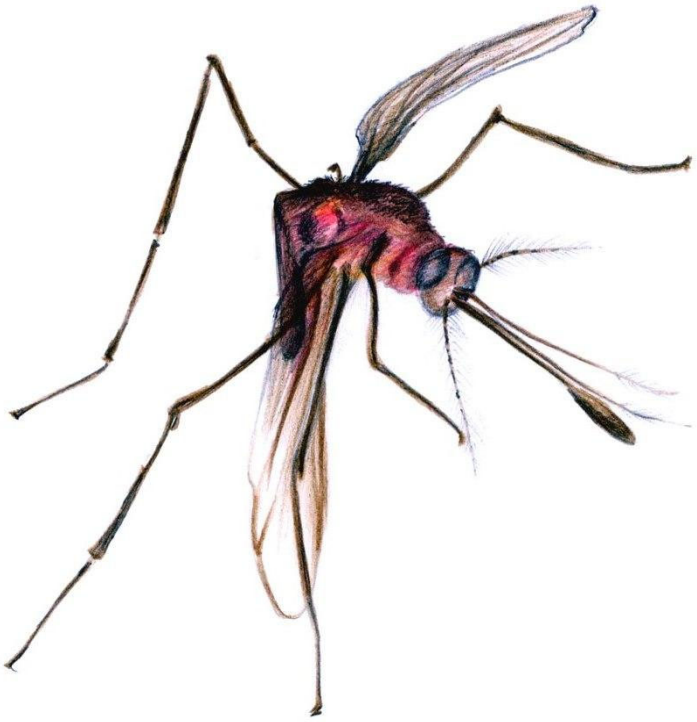
Mosquito Repellents

The CDC traveler's page on preventing dengue fever suggests using mosquito repellents that contain DEET (N, N-diethylmetatoluamide, between 20% to 30% concentration, but not more). It also suggests the following:

1. The mosquito usually bites at dusk and dawn but may bite at any time during the day – especially indoors, in shady areas, or when the weather is cloudy.
2. The mosquito's preferred breeding areas are in areas of stagnant water, such as flower vases, uncovered barrels, buckets, and discarded tires, but the most dangerous areas are wet shower floors and toilet tanks, as they allow the mosquitos to breed in the residence. Research has shown that certain chemicals emanating from bacteria in water containers stimulate the female mosquitoes to lay their eggs. They are particularly motivated to lay eggs in water containers that have the correct amounts of specific fatty acids associated with bacteria involved in the degradation of leaves and other organic matter in water. The chemicals associated with the microbial stew are far more stimulating to discerning female mosquitoes than plain or filtered water in which the bacteria once lived.
3. Wear long-sleeved clothing and long trousers when outdoors during the day and evening.
4. Spray permethrin or DEET repellents on clothing, as mosquitos may bite through thin clothing.
5. Use mosquito netting over the bed if the bedroom is not air conditioned or screened. For additional protection, treat the mosquito netting with the insecticide permethrin.
6. Spray permethrin or a similar insecticide in the bedroom before retiring.

Western Malaria Mosquito (*Anopheles freeborni)*

Females feed mainly on medium to large mammals like rabbits, deer, cattle or horses, and they pursue and bite man aggressively.



Anopheles freeborni is the most important malaria vector in California. In our lifetime, endemic malaria has been eradicated from the U.S. But in our grandparents' time, it was so serious that education guidelines called for it to be included in the instructional program in every primary school.

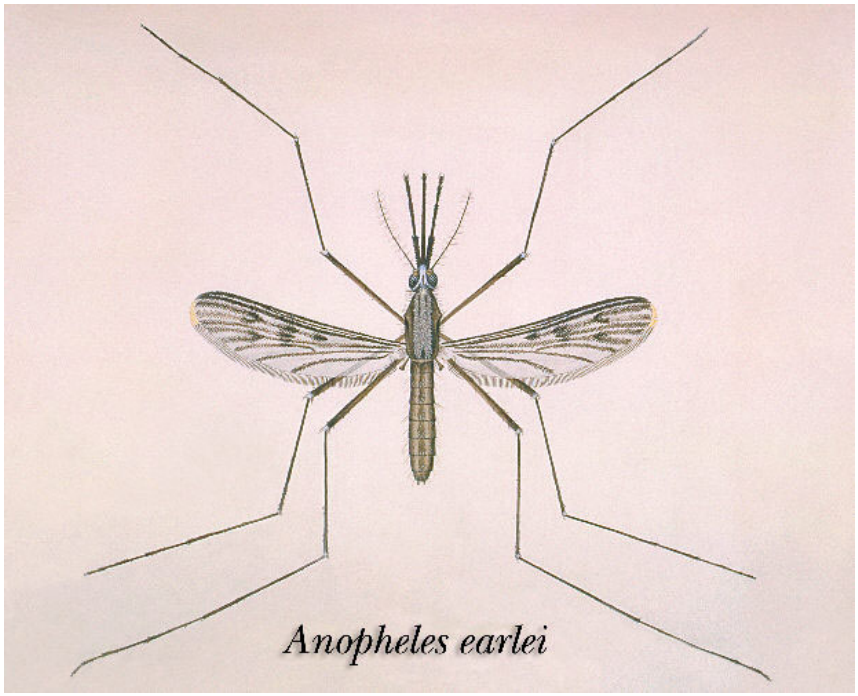
Today, carrier mosquitoes still occur throughout the state, and hundreds of active infections are discovered every year in tourists and immigrants from other countries.

Anopheles are easily distinguished from other mosquitoes: their eggs are laid individually and have small floats on each side; the larvae lack the long breathing tube found in other mosquitoes; adults have hairs, but no scales on the abdomen and both sexes have palpi as long as the proboscis. Feeding females assume a distinctive pose with their abdomen pointed high in the air.

Western malaria mosquitoes occur west of the Rocky Mountains, between southern Canada and northern Mexico, and from sea level to about 6,000 ft. elevation. The larvae prefer clear, clean water, in sunlit or partially shaded streams or ponds. They occur abundantly in both Marin and Sonoma counties, but their highest density is found in the irrigated and seasonally flooded rice fields of the great central valley, historically the region of California's highest malaria infection rates.

Adults migrate in the spring and fall, but most stay within five miles of their larval sites. Like most *Anopheles*, they are active during the hours of darkness, and find shelter in hidden places during the day. Females feed mainly on medium to large mammals like rabbits, deer, cattle or horses, and they pursue and bite man aggressively.

The blood feeding patterns of *Anopheles freeborni* Aitken and *Culex tarsalis* Coquillett were studied, and the effects of host availability on these patterns were assessed in four different habitats within a northern California rice agroecosystem. Resting mosquitoes were collected from June to September of 1991 and 1992. The source of mosquito blood meals was identified with the modified precipitin test.



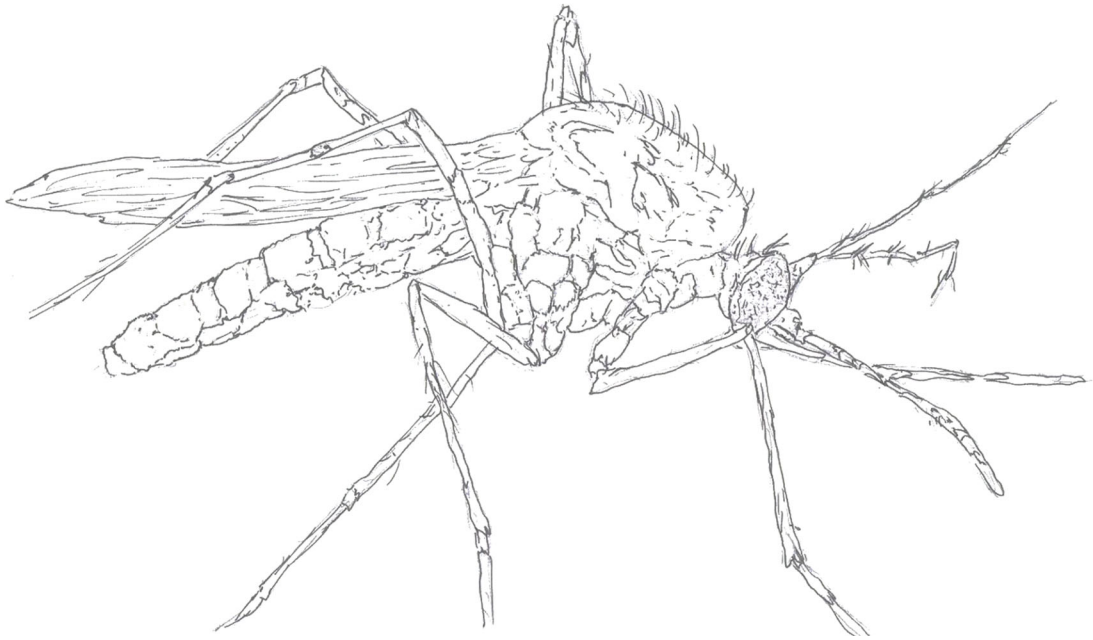
Anopheles freeborni exhibited a 'specialized' (fixed) blood feeding pattern, predominantly (99% of the time) feeding on mammalian hosts; leporids and bovids were the major hosts, while equines, suids, and other mammals were minor hosts. *Culex tarsalis* exhibited a more 'generalized' (catholic) blood feeding pattern, taking blood meals from both birds and mammals at a ratio of 3:1 with Passeriformes being the most fed upon host group.

Human blood indices were under 3% for both mosquito species, and multiple blood meals were estimated at less than 2%. The host feeding patterns for both mosquito species differed among the four (riparian, rice, pasture and mixed) habitats.

The host feeding pattern for *C. tarsalis* reflected the distribution of both mammalian and avian hosts available. On the contrary, the host feeding patterns for *A. freeborni* reflected the distribution of mammalian but not the available avian hosts. Overall, host availability may be an important determinant of population size of some mosquito taxa (e.g. *A. freeborni*) than others (e.g. *C. tarsalis*) in rice culture agroecosystems.

Western Treehole Mosquito (*Aedes sierrensis*)

Primary vector of Dog Heartworm disease in the Western United States.



WESTERN TREE-HOLE MOSQUITO
(Aedes sierrensis)

Aedes is the best represented mosquito genus in California in the number of species. Many species in this genus are commonly referred to as floodwater mosquitoes because eggs are laid in sources that will eventually fill with water. *Aedes* eggs are laid singly at the edge of drying substrate. They are resistant to drying out and may require a conditioning period before hatching. Larvae have a short siphon and hang downward at a 45-degree angle from the water surface. Adults have a pointed abdomen and rest with their bodies parallel to the surface. Most *Aedes* adults readily feed on humans and are aggressive biters. Several species are capable of transmitting diseases to humans including dengue, yellow fever, chikungunya, and many others. *Aedes sierrensis* is the primary vector of dog heartworm in California.

Twenty-seven *Aedes* species are recognized in California, one of which, *Ae. atropalpus*, has only been collected once near Folsom, CA. Two species, *Ae. albopictus* and *Ae. aegypti*, are not included in this total although they have been introduced into California several times. The most recent introductions occurred in 2011 (*Ae. albopictus*) and 2013 (*Ae. aegypti*). Efforts to eradicate these mosquitoes are ongoing.

The Western Treehole Mosquito (Aedes sierrensis) is brightly marked with white scales which contrast with its dark body. It also has an unbanded proboscis (beak), white banded tarsi (feet) and a pointed tipped abdomen. The Western Treehole Mosquito (Aedes sierrensis) received its name because the immature stages are frequently found in water contained in rot holes of trees such as oak, laurel, madrone, eucalyptus and other local species.

This mosquito is found in most California counties and is the primary vector of Dog Heartworm disease in the Western United States.

Western Treehole Mosquitoes have four life stages: egg, larva, pupa, and adult. The immature stages need standing water to complete their life cycle.

Western Treehole Mosquitoes are a serious pest problem when they are present in large numbers. This mosquito is the primary vector of Dog Heartworm Disease in the coastal and foothill communities of California.

Wrigglers
After an adult female lays her eggs they hatch into larvae (wrigglers), which feed on small organic particles and microorganisms in the water. Feeding occurs when they hang from the water's surface by the tip of their tail (siphon) or by browsing along the bottom of their habitat. Because they are air breathing organisms they must return to the water's surface to breathe. Larval development varies from ten days to five months depending on weather conditions with developmental completion occurring around the spring equinox (late March). At the end of the larval stage, the mosquito molts and becomes the aquatic pupa (tumbler). The pupa is active only if disturbed, for this is the resting stage where the larval form is transformed into the adult. This can take four or more days during which time feeding does not occur. When the transformation is completed, the new adult splits the pupal skin and emerges.

Adult Daily Activity
Adults begin to emerge with the advent of the spring equinox, requiring a 12-hour day length to trigger emergence. Males tend to hover around potential hosts of the female, seizing her in flight when she approaches, to mate with her. Male mating swarms also occur in the shaded areas of this mosquito's habitat. Adults can live up to several months depending on temperature, humidity and other climactic factors. They are frequent pests in residential and recreational areas April through August where large numbers of trees are present.

Adult Flight Range: This mosquito has a limited flight range staying very close to its breeding site.

Adult Feeding: Adults feed predominantly on small mammals but will feed on large mammals and humans when available. Peak feeding activity occurs at dusk, although host feeding does sometimes occur during the day and night. Treehole Mosquitoes prefer to feed outdoors (but sometimes enter homes) during the mid-morning and late afternoon. Like all species of mosquitoes, only the female mosquito takes a blood meal (bites).

Eggs and Larvae: Eggs are laid individually inside moist treeholes, crotches of trees, and containers with damp leafy debris. Eggs usually hatch the next season following flooding with early winter rainfall. It should be noted that the eggs of this species can survive for many years before hatching, with only part of each batch hatching during a single season. Larval development can take ten days to five months to complete, depending on quantity of rainfall and other environmental conditions.

Dog Heartworm Disease
Dog Heartworm Disease is a clinical condition in dogs caused by a roundworm, Dirofilaria immitis, which resides within the dog's heart and lungs. This disease, a serious and possibly fatal veterinary problem, is associated with dogs, coyotes and foxes. Canine Heartworm is transmitted by the bite of an infected Western Treehole Mosquito.

The adult worm lives in the right side of the heart and the adjacent large blood vessels and lungs, where it may attain a length of 6-12 inches. Many other mosquito species feed on dogs, but the Western Treehole Mosquito is the most common carrier of heartworm.

Disease Symptoms
The outward symptoms of the disease are not noticeable in most cases until reduced blood flow caused by adult worms damages the heart, lungs, liver and kidneys. Advanced symptoms of heartworm may include: rapid tiring, shortness of breath, chronic soft dry cough, listlessness and weight loss. If you live in or travel to areas where treehole mosquitoes occur, check with your veterinarian regarding treatment and prevention.

Drugs are available to prevent the disease, and it is curable if diagnosed in the early stages. The time of highest risk for dogs to contract heartworm is April through August; however, unseasonable rainfall may extend this period.

Where possible, the best approach is to prevent mosquitoes from breeding by eliminating or modifying breeding sites. This can be accomplished best by eliminating containers which are capable of holding water. Where breeding sites exist in standing or slow-moving water, corrective action to permanently eliminate them by such means as filling, pumping, ditching or draining is recommended.

Close coordination with your local mosquito abatement district and environmental regulatory authorities is recommended.

An important consideration in the practice of mosquito control is the advisability, whenever possible, to target control operations against immature populations. These stages are usually concentrated, relatively immobile and therefore occupy minimum acreage compared with adults, which may rapidly disperse over large areas.

By targeting the immatures, it is possible to minimize the area treated and often avoid treating populated areas. Conversely, targeting adult mosquitoes may require highly visible and extensive applications of adulticides within residential and urban areas.

The adulticides registered for this use are applied at levels 100 to 10,000 times below rates that would be cause for concern about exposure risk for the general public or the environment. Nevertheless, achieving good larval control while at the same time minimizing the use of adulticides is environmentally and client friendly, and appreciated by the public.

Most states have specific regulations governing the decision to apply pesticides for mosquito control. These usually involve the collection of data that substantiate the need for the application. Thus, standardized ultra-low-volume (ULV) operation on a fixed schedule is not allowed in most areas. Each application must be justified by documentation of increased mosquito activity, such as trap collections, landing or biting counts, telephone complaints, etc.

Winter Marsh Mosquito *(Culiseta inornata)*

Mosquito species that is a secondary or suspected vector of Western equine encephalitis and California group encephalitis within the U.S.

Culiseta is a genus of mosquitoes. Most Culiseta species are cold-adapted, and only occur in warmer climates during the colder parts of the year or at higher elevations where temperatures are lower.

Species found in Southern California are larger than most mosquito's species, specifically Cs. inornata, Cs. particeps, and Cs. incidens. These species are found throughout the year in Southern California and feed on several vertebrate species, such as birds, livestock, rodents, reptiles, and humans.

The larvae of most species are found bogs, marshes, ponds, streams, ditches, and rock pools, but an African species occurs in tree holes, a common eastern Palaearctic species occurs in water wells and rock pools, and several Australian species occur under ground. Little is known about the blood-feeding habits of females. Most species feed on birds and mammals, but a few feed on reptiles. Several species attack domestic animals and occasionally humans.

Winter Salt Marsh Mosquito *(Aedes squamiger)*

Major pest of humans.

The Winter Salt Marsh Mosquito *(Aedes squamiger)* is one of 53 types of mosquitoes that occur in California and is a distinctive black and white mosquito that breeds in California coastal pickle weed tidal and diked marshes. Salt marsh pools that are diluted by winter and early spring rains are especially favored breeding sites. Other sites include the cracked ground of diked wetlands and old dredge disposal sites. This species is a major pest of humans.

Winter Salt Marsh Mosquitoes are a serious pest problem when they are present in large numbers. California Encephalitis virus has been found in populations of this mosquito although transmission of this virus to humans has not yet been confirmed

Life Cycle

Winter Salt Marsh Mosquitoes have four life stages: egg, larva, pupa, and adult. The immature stages need standing water to complete their life cycle.

After an adult female lays her eggs they hatch into larvae (wrigglers), which feed on small organic particles and microorganisms in the water. Feeding occurs when they hang from the water's surface by the tip of their tail (siphon) or by browsing along the bottom of their habitat. Because they are air breathing organisms they must return to the water's surface to breathe.

Larval development varies from one to four months depending on weather conditions with developmental completion occurring near the end of February. At the end of the larval stage, the mosquito molts and becomes the aquatic pupa (tumbler).

The pupa is active only if disturbed, for this is the resting stage where the larval form is transformed into the adult. This takes about two days during which time feeding does not occur. When the transformation is completed, the new adult splits the pupal skin and emerges.

Adult Daily Activity
Adults usually emerge during the last weeks of February through the end of March depending on the amount and timing of the preceding winter rains.

Adults usually fly to areas away from their breeding sites, using ravines and natural or man-made waterways from the marshes to the local hills as passage ways.

From these passage ways the adults spread laterally into the wind protected areas of the surrounding community. Adults then mate, with the females seeking a blood meal and returning to the marshes to lay their eggs. Mature mosquitoes can live as long as three months depending on temperature, humidity and other climactic factors.

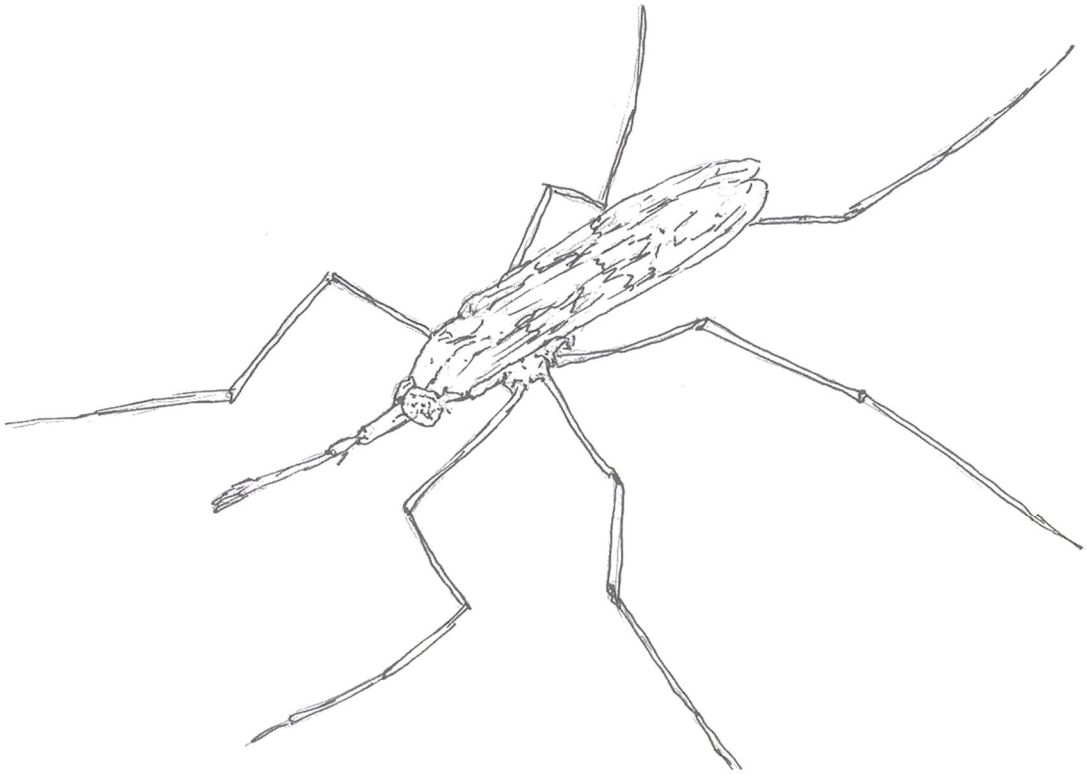
Adult Flight Range
This mosquito readily flies 10-20 miles from its breeding site.

Adult Feeding
Humans and possibly other large mammals are the preferred hosts for this mosquito. Biting activity occurs most often during the daylight hours and at dusk from April through June.

Eggs and Larvae
Eggs are laid on plants and along the muddy margins of ponds close to the water line awaiting submersion by the following years tides and/or rainfall. It should be noted that the eggs can remain viable for many years with only part of any one batch of laid eggs hatching during any single flooding event.

Woodland Malaria Mosquito (*Anopheles punctipennis*)

Aggressive biters and readily enter homes.



WOODLAND MALARIA MOSQUITO
(Anopheles punctipennis)

The wings have conspicuous pale and dark spots and palpi that are entirely dark. They are aggressive biters and readily enter homes.

Larval habitat: Woodland pools containing vegetation and in artificial containers and other environments associated with Culex tarsalis and Culex pipiens.
Biting time: Day and dusk
Preferred host: large mammals including cows, horses, and human
Flight range: 0 to ¼ mile from breeding site

Woodland Malaria Mosquitoes have four life stages: egg, larva, pupa, and adult. The immature stages need standing water to complete their life cycle. After an adult female lays her eggs they hatch into larvae (wrigglers), which feed on small organic particles and microorganisms in the water. Because they are air breathing organisms they must return to the water's surface to breathe.

About one to two weeks are required for larval development. At the end of the larval stage, the mosquito molts and becomes the aquatic pupa (tumbler). The pupa is active only if disturbed, for this is the resting stage where the larval form is transformed into the adult. This takes about two days during which time feeding does not occur.

When the transformation is completed, the new adult splits the pupal skin and emerges. Under optimum conditions, development from egg to adult takes about three weeks. However, all mosquito developmental times are dependent on the temperature and nutrients of the water in which they mature.

Where possible, the best approach is to prevent mosquitoes from breeding by modifying their breeding sites. Careful planning and coordinated efforts with landowners, regulatory agencies and concerned citizens is essential for any creek or stream enhancement project.

Where possible, the best approach is to prevent mosquitoes from breeding by eliminating or modifying breeding sites. This can be accomplished best by eliminating containers which are capable of holding water. Where breeding sites exist in standing or slow-moving water, corrective action to permanently eliminate them by such means as filling, pumping, ditching or draining is recommended. Close coordination with your local mosquito abatement district and environmental regulatory authorities is recommended.

Mosquito Repellents

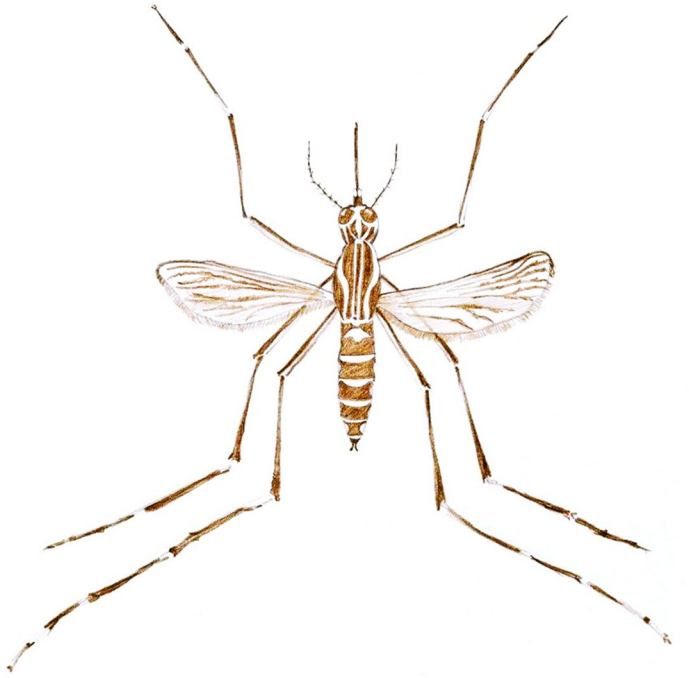
The CDC traveler's page on preventing dengue fever suggests using mosquito repellents that contain DEET (N, N-diethylmetatoluamide, between 20% to 30% concentration, but not more). It also suggests the following:

1. The mosquito usually bites at dusk and dawn but may bite at any time during the day – especially indoors, in shady areas, or when the weather is cloudy.
2. The mosquito's preferred breeding areas are in areas of stagnant water, such as flower vases, uncovered barrels, buckets, and discarded tires, but the most dangerous areas are wet shower floors and toilet tanks, as they allow the mosquitos to breed in the residence. Research has shown that certain chemicals emanating from bacteria in water containers stimulate the female mosquitoes to lay their eggs. They are particularly motivated to lay eggs in water containers that have the correct amounts of specific fatty acids associated with bacteria involved in the degradation of leaves and other organic matter in water. The chemicals associated with the microbial stew are far more stimulating to discerning female mosquitoes than plain or filtered water in which the bacteria once lived.
3. Wear long-sleeved clothing and long trousers when outdoors during the day and evening.
4. Spray permethrin or DEET repellents on clothing, as mosquitos may bite through thin clothing.
5. Use mosquito netting over the bed if the bedroom is not air conditioned or screened. For additional protection, treat the mosquito netting with the insecticide permethrin.
6. Spray permethrin or a similar insecticide in the bedroom before retiring.

Yellow Fever Mosquito (*Aedes aegypti*)

Roland Mortimer, Rio de Janeiro

Many people have died from Dengue fever and many more around the world suffer terribly because of this species.



The yellow fever mosquito belongs to the tribe Aedini of the dipteran family Culicidae and to the genus Aedes and subgenus Stegomyia. According to the recent analyses, some authors raised the subgenus Stegomyia of the genus Aedes to the level of genus. The proposed name change has not been completely accepted; at least one scientific journal, the Journal of Medical Entomology, has officially encouraged authors dealing with aedine mosquitoes to continue to use the traditional names. Although the lifespan of an adult Aedes aegypti is between two to four weeks depending on conditions. Aedes aegypti's eggs can be viable for over a year in a dry state, which allows the mosquito to re-emerge after a cold winter or dry spell.

The yellow fever mosquito (Aedes aegypti) genome is being sequenced by The Broad Institute and The Institute for Genomic Research (TIGR). The initial assembly was released in August 2005; a draft sequence of the genome and preliminary analysis was published in June 2007. Annotation of the sequence is being undertaken by VectorBase and TIGR. Aedes aegypti is a vector for transmitting several tropical fevers.

Only the female bites for blood which she needs to mature her eggs. Understanding how the mosquito detects its host is a crucial step in the spread of the disease. Aedes aegypti are attracted to chemical compounds that are emitted by mammals. These compounds include ammonia, carbon dioxide, lactic acid, and octenol.

Scientists at the Agricultural Research Service have studied the specific chemical structure of octenol in order to better understand why this chemical attracts the mosquito to its host. They found that the mosquito has a preference for “right-handed” (dextrorotatory) octenol molecules.

The term “right-handed” refers to the specific orientation of the molecule, which can either be “right-handed” or “left –handed.” This discovery helps scientists understand how the mosquito seeks out its host and may enable them to develop more effective forms of mosquito repellant. There are many types of mosquitoes living in the tropical and sub-tropical regions of the world. We can roughly divide them into two groups--Culex and Aedes--but perhaps one of the most important is ***Aedes aegypti***. According to the World Health Organization, the virus for Dengue fever is the most important arbovirus to man in the world, and since *Aedes* has been found to transmit this virus, it has been widely studied and blamed as the vector.

This mosquito is small in comparison to others, usually between three to four millimeters in length, discounting leg length. It is totally black, apart from white '*spots*' on the body and head regions and white rings on the legs. The thorax is decorated with a white '*Lyre*' shape, of which the 'chords' are two dull yellow lines. Its wings are translucent and bordered with scales.

At rest, the insect turns up its hind legs in a curved fashion and usually cleans them by rubbing one against the other, or exercises them by crossing them and alternately raising and lowering them.

Many people believe mosquitoes only live two or three days, but in actual fact, left unmolested, they can live for months. The males of all species of mosquitoes do not bite humans or animals of any species, they live on fruit.

Only the female bites for blood, which she needs to mature her eggs. The eggs of most species are laid together in a raft form, but *Aedes* lays her eggs separately, thus allowing them to spread over large surfaces of water if conditions permit. In this way, the eggs stand a better chance of survival. When freshly laid, the eggs are white, but soon turn black in color. The young larvae feed on bacteria in the water and soon cast their skins as they rapidly grow. Most types of mosquito species can lay their eggs in any type of water, mainly dirty or even polluted. Not *Aedes*, she only lays her eggs in clean water which contains no other living species.

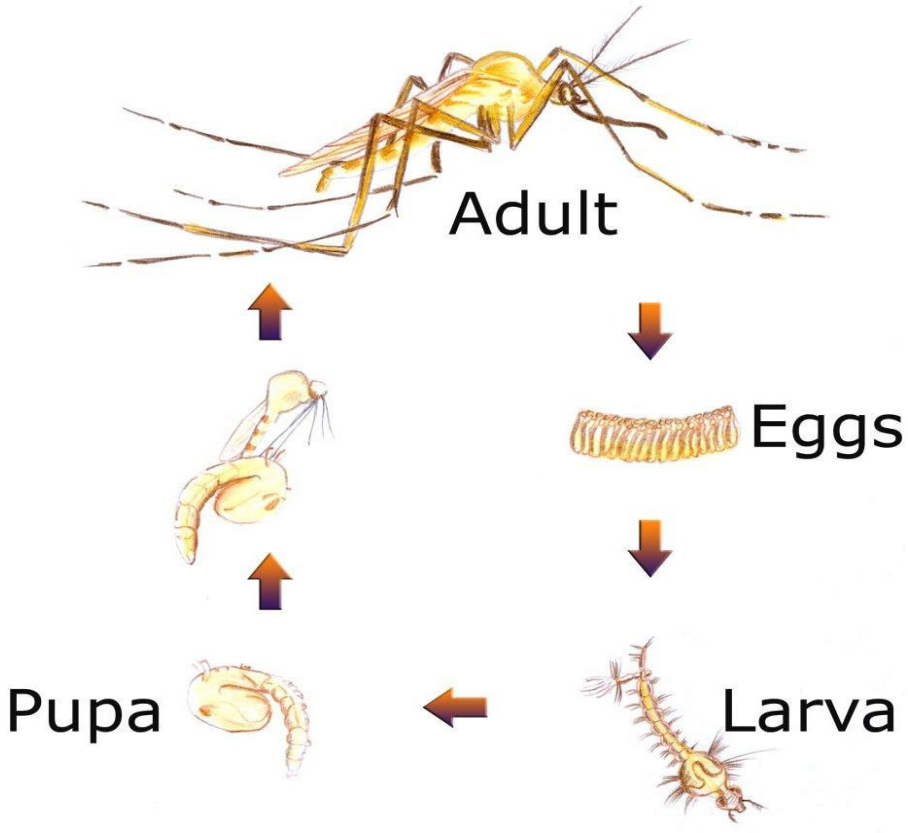
Many people have died from Dengue fever and many more around the world suffer terribly because of this species. The male mosquito is much more beautiful. His antennae looking like large plumes and the palpi long and adorned with feathery hairs. After a few weeks, or even shorter in the summer, the larvae reach the pupa stage. This stage is usually very short, and the pupae rise to the surface of the water, where the top of the pupal case opens, like the lid on a can, and out emerges the new adult.

Aedes aegypti, unlike other species, is very intelligent, if one could say that mosquitoes are intelligent. They arrived in Brazil from Ethiopia with the slave trading ships. Living near man for so long she has become totally dependent on him and has learned a lot from him. For instance, she has greatly reduced the `humming' sound she makes with her wings so man cannot hear it, unlike other species whose humming is extremely irritating and awakens the deepest sleeper.

She never lives more than ninety meters from dwellings, thus guaranteeing her meals. She attacks from below or behind, usually from underneath desks or chairs and mainly at the feet and ankles. The insect is very fast in flight, unless gorged with blood. Other types of mosquitoes even fly into your face and can be easily caught or killed--not *Aedes*, she's too smart!

The eggs can survive for very long periods in a dry state, often for more than a year. Since the virus can be passed from adult to egg, the virus, too, is guaranteed survival until the next summer and heavy rains.

The virus remains in the salivary glands of the mosquito, and when she bites for food, she injects saliva into the wound where the anti-coagulants contained in her saliva facilitate feeding. Without knowing it, she also injects the virus into the host.



Mosquito Surveillance and Monitoring Section

Effective Mosquito-Control Program
Surveys are essential for the planning, operation and evaluation of an effective mosquito-control program, whether for the prevention of mosquito-borne diseases or to reduce mosquito populations to levels permitting normal activities without undue discomfort. Initial surveys identify the species of mosquitoes present and provide general information on locations, densities and disease potential. With this knowledge it may be possible to determine life cycles and feeding preferences; predict larval habitats, adult resting places and flight ranges; and perhaps even make preliminary recommendations for control programs.

Basic Inspection Program
The next step is to embark on a formal surveillance program in which routine monitoring of mosquito presence is conducted. A basic inspection program usually addresses adult and larval population density and species composition, rainfall and tide monitoring, and breeding site locations. Additional specialized surveillance may be conducted to detect arboviral presence in birds and mosquito populations, operation of ovitraps (e.g., for Ae. aegypti and Ae. albopictus surveillance), or sampling of floodwater mosquito eggs to locate breeding sites. This information not only provides justification for source reduction and insecticide applications, but it also serves as an ongoing indicator of the effectiveness of these activities and continually adds to the database of knowledge concerning mosquitoes in the area. Such inspections do not determine the absolute population of mosquitoes, but they can show fluctuations in relative mosquito abundance and diversity over time in the various habitats visited.

Mosquito Mapping
Reasonably accurate and comprehensive maps are essential in conducting a mosquito-control operation. Maps provide information for field survey and control activities, program evaluation, and reporting and budgeting purposes. They show elevations, streets, roads and railroads, as well as ponds, lakes, streams, sewage lagoons, flooded woodlots and other breeding areas. They are used for orientation and for locating and plotting larval breeding places and adult sampling stations.

When large areas are involved, a master map may be needed for planning drainage and other field operations. The master map will indicate the treatment areas, the possible flight range of mosquitoes from breeding sites and the potential degree of penetration into populated areas. Larval and adult sampling stations can be indicated by symbols and numbers. Counts made at these stations at weekly or biweekly intervals provide information for current evaluation of the mosquito problem at any time by indicating the abundance of mosquitoes, species involved, flight range and habitat, and disease potential. This information identifies areas requiring high priority for treatment.

Narrative descriptions, sometimes necessary for exact location description, are simplified whenever possible. For example, "N.W. corner of 15th Street and Ninth Avenue" is a brief description that leaves no doubt as to the location. There may be some areas that are difficult to accurately locate (e.g., marshlands). However, maps can be subdivided into numbered or named areas for easy reference, and Global Positioning System (GPS) coordinates are very reliable.

Some common methods of subdividing maps involve the use of geographical features, artificial grids or a combination of both to set boundaries on areas that are indexed for easy reference and filing. To avoid cluttering, the larger areas may be further subdivided by the use of transparent overlays, again employing geographical features or a grid. Once the area of inspection is delineated by reference to index numbers, additional location data can be conveyed clearly by the use of cards that include a rough sketch of the area or incorporated into a Geographic Information System (GIS) format.

Mosquito Record-keeping
In order to avoid comparing dissimilar parameters, inspections should be consistent both in method and location. Keeping clear, accurate records is as important as the data gathering itself.

Surveillance records are managed in a manner that ensures subsequent inspections can be conducted in a similar manner by others less familiar with the area. They usually include the inspector's name, date of inspection and exact location in addition to the data collected. Data-recording forms and devices promote uniformity, which makes records easier to read, interpret and summarize, and serve as a reminder to the inspector to record all pertinent information. In the absence of data recorders, standardized formats lead to more consistently accurate transcription of the data into the permanent records.

Mosquito Egg Surveys
Egg surveys are carried out primarily to determine the exact breeding locations of mosquitoes. Aedes, Ochlerotatus and Psorophora mosquitoes lay their eggs on damp soil in places subject to intermittent flooding. Two types of egg surveys may be conducted for these genera: sod sampling and egg separation.

Sod Sampling
Sod samples, usually containing 8 cubic inches of soil and vegetation with a thickness of about an inch, are stored for a week or more to allow the embryos time to develop within the eggs. The sod samples are then placed in glass jars and flooded with water. The larvae are identified after they hatch.

Several sequential floodings and dryings might be necessary to get sufficient cumulative hatch. In larval surveys, sod sampling delineates breeding areas, especially when sampling is done during times when larvae are not present.

Egg Separation
Egg separation machines can be used for separating mosquito eggs from soil and debris by mechanical agitation, washing, screening, or sedimentation of debris and flotation of the eggs in a saturated salt solution. Sod or soil samples are cut in the field with a sharp trowel around a 6-inch-square template, placed in plastic bags and stored (sometimes for months) in a cool room.

The various species and densities of Aedes, Ochlerotatus and Psorophora can be identified by microscopic examination of live or preserved eggs using taxonomic keys for mosquito eggs.

Mosquito traps recreate warm moist CO_2 (human breath), primarily with dry ice but other traps use propane, and some traps add the irresistible attraction of octenol to trap mosquitoes. Some traps will contain a suction fan and a light bulb to trap and attract the female mosquito. Several mosquito traps will operate quietly and will eliminate hundreds of mosquitoes in a few hours at dusk and dawn.

Several government agencies will place the daily quarry of mosquitoes into plastic bags for counting and determining the mosquito species. The captured mosquitoes are often sent to a laboratory for further analysis.

Oviposition Trap
Collections of mosquito eggs in oviposition traps are used to detect and monitor container-breeding mosquitoes such as Oc. triseriatus, Ae. aegypti and Ae. albopictus. The oviposition trap can easily be made out of food cans (3-pound coffee cans) or pint jars painted black inside and outside. The traps are placed in shaded areas at a height no greater than 1.2 m and filled with water and a few dried leaves placed at the bottom of the container. An oviposition substrate made of a strip of various materials (seed germination paper, muslin, formica, balsa wood, wooden tongue depressor, etc.) is then placed vertically inside the container with the water covering about half of it.

Gravid females use this substrate to lay eggs just above the water level. Traps are checked every 10 to 14 days to prevent them from becoming breeding sources. If larvae are found in the trap, then the water should be dumped and the trap reset. The ovipositional substrate is periodically collected and returned to the laboratory in a plastic bag. Samples are kept cool and moist during transportation, taking care to avoid too much moisture, which could cause eggs to begin hatching. Eggs or the resulting 4th instar larvae are then identified.

Larval and Pupal Surveillance
Before beginning a survey, obtain information about the general breeding behavior and habitats of the species known or suspected to be in the area. An experienced person may be able to spot the probable mosquito breeding places in a specific area by rapid reconnaissance. These areas are carefully numbered and marked on the map. Determining the specific breeding sites and establishing permanent larval sampling stations requires a more detailed inspection. Larval surveys to determine the exact areas in which the mosquitoes breed and their relative abundance are of special value in control operations.

Equipment
A white enameled or plastic dipper about 4 inches in diameter (1 pint or 350 ml capacity) is frequently used for collecting mosquito larvae. The handle of the dipper may be lengthened by inserting a suitable piece of wood dowel or PVC pipe. Specially designed dippers can be created so that their capacity can be directly related to the amount of water surface examined. Thus, the number of larvae per square foot or meter can be computed with reasonable accuracy.

Dip Procedure
Mosquito larvae of some species are usually found near surface vegetation or debris. In larger ponds or bodies of water, these larvae are ordinarily confined to the shoreline areas where it is necessary to proceed slowly and carefully in searching for mosquito larvae as disturbance of the water or shadows may cause the larvae to dive to the bottom.

Anopheline larvae are collected by a skimming movement of the dipper with one side pressed just below the surface. The stroke is ended just before the dipper is full because larvae will be lost if the dipper is filled to the point that it runs over. Where clumps of erect vegetation are present, it is best to press the dipper into a clump with one edge depressed so that the water flows from the vegetation into the dipper. Culicine larvae such as Ae. vexans or Oc. sollicitans or species of Psorophora require a quicker chopping motion of the dipper as they are more likely to dive below the surface when disturbed.

The inspector records the number of dips made and the number of larvae found, by instar if warranted, and transfers representative sample specimens by pipette into small vials of alcohol for later identification. With most species, it is possible to get a rough idea of the breeding activity by computing the average number of larvae of each species per dip.

The number of dips required will depend on the size of the area and the relative larval density, but for convenience is often in multiples of 10. Inspection should be made at weekly or biweekly intervals during the mosquito breeding season, as areas that are entirely negative at one time may rapidly become heavily infested. Inspections for certain species require variations in the procedure described above.

For example, Coquillettidia larvae remain below the surface throughout much of their development attached by the siphon to the stems of emergent vegetation. These larvae are found by pulling up aquatic plants (cattail, sedges, pickerelweed, etc.), washing or shaking them in a pan of water, and searching the bottom muck and debris.

Inspection for Oc. triseriatus, Oc. sierrensis, etc., breeding involves searching tree holes and artificial containers such as tires. These containers are often too small for an ordinary dipper, but water can be transferred with a turkey baster or siphoned into a dipper or pan where the larvae can be seen.

Topic 2 – Mosquito Identification Section Post Quiz

1. The black-tailed mosquito, *Culiseta melanura*, belongs to the family Culicidae. This species of mosquito is considered unusual because it overwinters as larvae while most mosquito species overwinter as either?

2. Culiseta melanura is important because of its role in the transmission cycle of?

3. Adult female *Culiseta melanura* primarily take blood meals from birds such as the?

4. Anopheles quadrimaculatus Say is historically not a vector of malaria in the eastern United States.
True of False

5. Malaria was never a serious plague in the United States.
True or False

6. Culex pipiens, the Northern House Mosquito has a distribution range along the Pacific coast extends into northern California and then east on a relatively straight line to North Carolina.
True or False

7. Culex pipiens females pass the winter in diapause and do not become active during periods of warm winter weather. Hibernating females are common in basements, outbuildings, and subterranean enclosures.
True or False

St. Louis Encephalitis
8. House Sparrows, an introduced species, circulate exceptionally high levels of SLE when they become infected. Culex pipiens that bite infected birds acquire the virus and are capable of passing it on to humans.
True or False

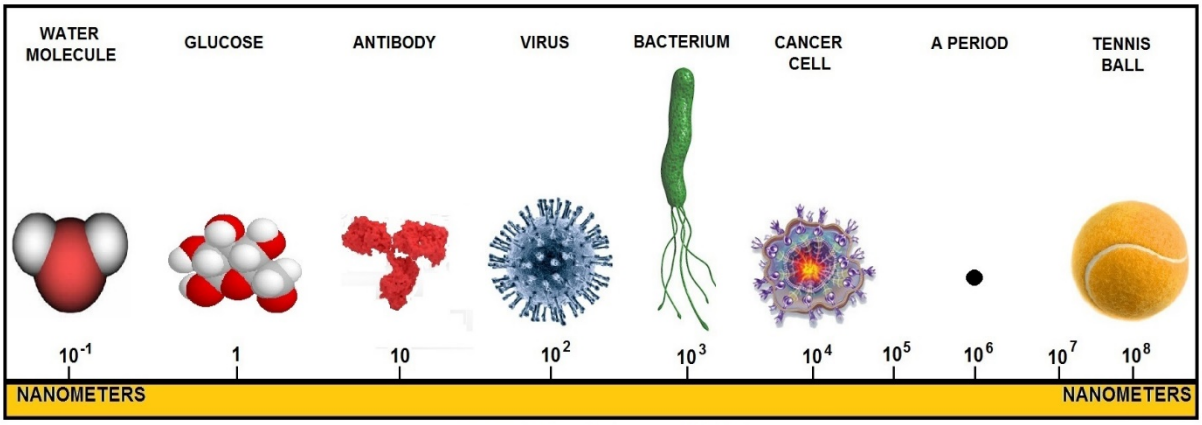
9. As mosquitoes go, the Western Encephalitis Mosquito is one of the more difficult to recognizable, because of its undistinctive scale patterns.
True or False

10. Species in the genus *Culex* are known as “standing-water” mosquitoes. Unlike their “floodwater” relatives (such as *Aedes vexans*) that lay eggs above the water line, standing-water mosquitoes must lay their eggs directly on the water’s surface.
True or False

Topic 3– Mosquito-Borne Diseases Section

Topic 3 - Section Focus: You will learn the basics of mosquito-borne diseases. At the end of this section, you will be able to understand and describe primary mosquito-borne diseases. You will learn about the mosquito family class, genera, life cycle and related subjects. There is a post quiz at the end of this section to review your comprehension and a final examination in the Assignment for your contact hours.

Topic 3– Scope/Background: Mosquitoes are highly developed blood-sucking insects and are the most formidable transmitters of disease in the animal kingdom. Mosquito-borne diseases are caused by human parasites that have a life stage that happens to begin in the human blood stream. Successful mosquito management requires intervening at some point during the mosquito's life cycle before they bite and infect a human.



SIZE COMPARISON
HOW SMALL IS SMALL ?

Mosquito-Borne Diseases

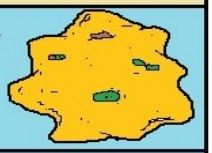
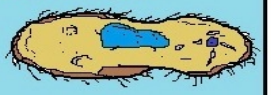
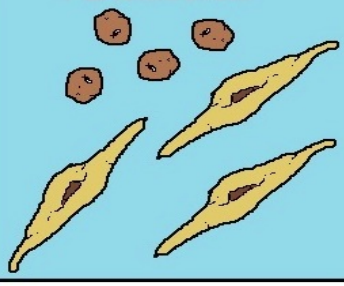
Mosquito-borne diseases affect millions of people worldwide each year. In the United States, some species of mosquitoes can transmit diseases such as West Nile, Encephalitis, Dengue fever, and Malaria to humans, and a variety of diseases to wildlife and domestic animals. To combat mosquitoes and the public health hazards they present, many states and localities have established mosquito control programs. These programs, which are based on surveillance, can include non-chemical forms of prevention and control, as well as ground and aerial application of chemical and biological pesticides.

Can Mosquitoes Carry Diseases?

Any insect that feeds on blood has the potential of transmitting disease organisms from human to human. Mosquitoes are highly developed blood-sucking insects and are the most formidable transmitters of disease in the animal kingdom. Mosquito-borne diseases are caused by human parasites that have a life stage that happens to begin in the human blood stream.

The female mosquito picks up the blood stage of the parasite when she imbibes blood to develop her eggs.

The parasites generally use the mosquito to complete a portion of their own life cycle and either multiply, change in form inside the mosquito or do both. After the mosquito lays her eggs, she seeks a second blood meal and transmits the fully developed parasites to the next unwitting host.

PHYLUM	COMMON NAME	LOCOMOTION	EXAMPLES
SARCODINA	SARCODINES	PSEUDOPODIA	AMOEBA 
CILIOPHORA	CILIATES	CILIA	PARAMECIUM 
SARCO-MASTIGOPHORA (ZOOMASTIGINA)	ZOOFLAGELLATES	FLAGELLA	TRYPANOSMA  GIARDIA
APICOMPLEXA (SPOROZOA)	SPOROZOANS	NONE IN ADULT FORM	PLASMODIUM 

PROTOZOA CLASSIFICATION DIAGRAM

Malaria is a parasitic protozoan that infects the blood cells of humans and is transmitted from one human to the next by *Anopheles* mosquitoes.

There nine major diseases that mosquitoes carry. Seven of these affect humans; one of them affects dogs and the other horses.

Mosquito-Borne Diseases Introduction
(We will cover these in greater detail later)

Zika
Zika virus disease is caused by Zika virus, which is spread to people primarily through the bite of an infected mosquito (Aedes aegypti and Aedes albopictus). Zika virus infection during pregnancy can cause a serious birth defect called microcephaly and other severe brain defects. Other problems have been detected among fetuses and infants infected with Zika virus before birth, such as defects of the eye, hearing deficits, and impaired growth. There have also been increased reports of Guillain-Barre syndrome, an uncommon sickness of the nervous system, in adults living in areas affected by Zika.

- Zika is spread mostly by the bite of an infected Aedes species mosquito (Ae. aegypti and Ae. albopictus). These mosquitoes bite during the day and night.
- Zika can be passed from a pregnant woman to her fetus. Infection during pregnancy can cause certain birth defects.
- There is no vaccine or medicine for Zika.

Yellow Fever
Yellow fever is a viral disease carried by certain mosquitoes. The virus damages many body tissues, but especially the liver. The Aedes Aegypti mosquito carries the yellow fever virus from one person to another. When the mosquito bites an infected person or animal, the virus enters the insect's body, where it develops rapidly. Yellow fever is found in jungle areas, especially in South America. The disease can now be prevented by a vaccine.

Yellow fever is a virus infection of monkeys that can either be transmitted from monkey to human or from human to human in tropical areas of the world.

Encephalitis
Encephalitis is an untreatable, sometimes deadly, and serious disease carried by mosquitoes. Its symptoms are severe headache, fever, vomiting, disorientation, chills, muscle aches and pains. It usually occurs in warm wet weather.

Encephalitis is a virus of the central nervous system that is passed from infected birds to humans by mosquitoes that accept birds as blood meal hosts in addition to humans.

Malaria
Malaria is a dangerous parasitic disease common in tropical and subtropical areas. It is transmitted by the female Anopheles mosquito. Victims of malaria suffer chills and fever, and millions of people die of the disease each year. There are four types of malaria. Most malaria can be healed by two different types of drugs.

Dengue Fever
Dengue Fever is also called Breakbone Fever. The disease causes fever, headaches, eye aches, pain in the muscles and joints. It may also cause a runny nose, sore throat, and skin rash. Dengue fever is caused by viruses that are carried by mosquitoes. Symptoms appear three to six days after the person is bit by a mosquito. Dengue fever is mostly found in the tropics.

Chikungunya
Chikungunya virus is spread to people by the bite of an infected mosquito. The most common symptoms of infection are fever and joint pain. Other symptoms may include headache, muscle pain, joint swelling, or rash. Outbreaks have occurred in countries in Africa, Asia, Europe, and the Indian and Pacific Oceans.

In late 2013, chikungunya virus was found for the first time in the Americas on islands in the Caribbean. There is a risk that the virus will be imported to new areas by infected travelers. There is no vaccine to prevent or medicine to treat chikungunya virus infection. Travelers can protect themselves by preventing mosquito bites. When traveling to countries with chikungunya virus, use insect repellent, wear long sleeves and pants, and stay in places with air conditioning or that use window and door screens.

Chikungunya usually doesn't cause death, but the symptoms can be severe and debilitating. The most common symptoms are joint aches and pains. The disease can also cause:

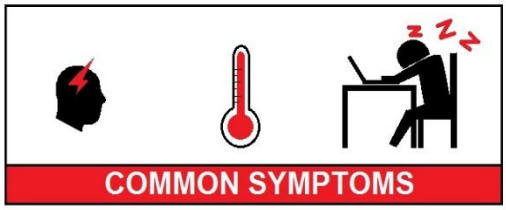
- a fever
- depression
- fatigue
- a headache
- muscle pain
- a rash

HIV AIDS
The HIV virus that produces AIDS in humans does not develop in mosquitoes. If HIV infected blood is taken up by a mosquito the virus is treated like food and digested along with the blood meal. If the mosquito takes a partial blood meal from an HIV positive person and resumes feeding on a non-infected individual, insufficient particles are transferred to initiate a new infection.

If a fully engorged mosquito with HIV positive blood is squashed on the skin, there would be insufficient transfer of virus to produce infection. The virus diseases that use insects as agents of transfer produce tremendously high levels of parasites in the blood. The levels of HIV that circulate in human blood are so low that HIV antibody is used as the primary diagnosis for infection.

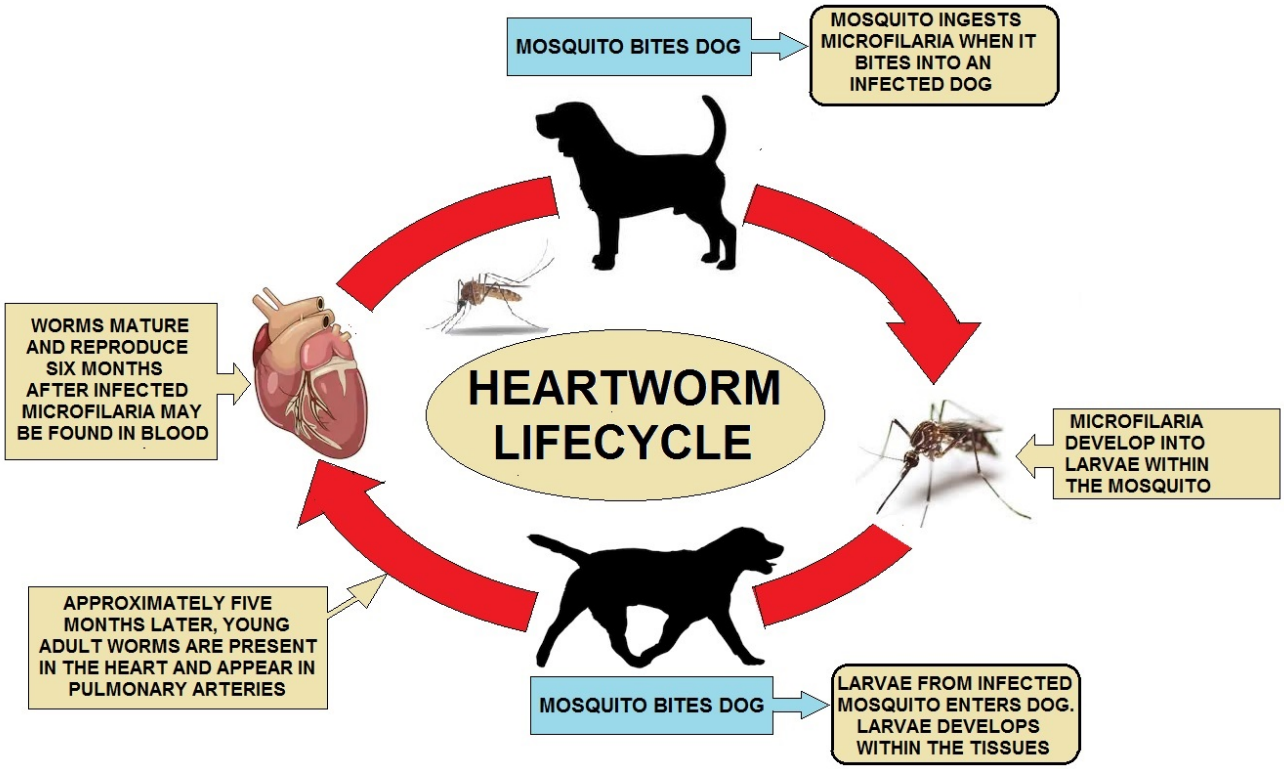
Canine Heartworm
The heartworm may cause serious illness or even death. Adult heartworms live in a dog's heart, but young forms of the worm are found in their blood. Mosquitoes transmit the infection when they feed on the blood of an infected dog.

Dog heartworm is a large filarial worm that lives in the heart of dogs, but produces a blood stage small enough to develop in a mosquito. The dog heartworm parasite does not develop properly in humans and is not regarded as a human health problem. A closely related parasite, however, produces human elephantiasis in some tropical areas of the world, a debilitating mosquito-borne affliction that results in grossly swollen arms, legs, and genitals.



COMBINED WITH:	DISEASE
RASH + SEVERE JOINT PAIN + JOINT SWELLING	CHIKUNGUNYA
BACK PAIN + NAUSEA / VOMITING + BODY ACHES	WEST NILE VIRUS
CONFUSION + LETHARGY + STIFF NECK	ARBORVIRAL ENCEPHALITUDES
CHILLS + DISCOMFORT / UNEASINESS + SWEATING WHILE BODY TEMP. FALLS	MALARIA
PAIN BEHIND EYES + MUSCLE / BONE / JOINT PAIN + BLEEDING GUMS (Rare)	DENGUE FEVER
CHILLS + NAUSEA / VOMITING + BACK & KNEE PAIN + SENSITIVITY TO LIGHT + RED EYES / FACE TONGUE	YELLOW FEVER

SYMPTOMS OF MOSQUITO BORNE DISEASES



Technical Learning College

LIFECYCLE OF HEARTWORM IN DOGS

Heartworms are not directly contagious to other dogs since the parasites transmit through **mosquito** bites.

Here's how it works: A **mosquito** bites an infected animal and picks up microscopic heartworm larvae, called microfilariae. When this **mosquito** bites another animal, it passes the microfilariae into the bloodstream of the new host.

West Nile Virus (WNV)

West Nile virus is a mosquito-borne virus that can cause encephalitis (inflammation of the brain) or meningitis (inflammation of the lining of the brain and spinal cord). This virus is named after the West Nile region of Uganda, where the virus was first isolated in 1937. West Nile virus is most commonly found in the U.S. Africa, West Asia, and the Middle East.

West Nile virus is spread to humans by the bite of an infected mosquito. A mosquito becomes infected by biting a bird that carries the virus.

You cannot get West Nile virus from a person who has the disease. West Nile virus is not spread by person-to-person contact such as touching, kissing, or caring for someone who is infected.

West Nile virus is not spread directly from birds to persons. However, you should always avoid bare-handed contact when handling dead animals or birds. Use gloves or double plastic bags to place the carcass in a garbage can.

What are the Symptoms of West Nile Virus?
Most people who are infected with the West Nile virus have no symptoms or may experience mild illness such as a fever, headache, and body aches before fully recovering.

Some persons also develop a mild rash or swollen lymph glands. In some individuals, particularly the elderly, West Nile virus can cause serious disease that affects brain tissue. At its most serious, it can cause permanent neurological damage and can be fatal. Encephalitis (*inflammation of the brain)* symptoms include the rapid onset of severe headache, high fever, stiff neck, confusion, loss of consciousness (coma), muscle weakness, or possibly death.

How long does it take to get sick after being bitten by an infected mosquito?
West Nile virus symptoms generally occur 5 to 15 days after being bitten by an infected mosquito.

Who is at risk of contracting West Nile virus?
Anyone can become infected with the virus. However, the very old are more likely to become ill and develop serious symptoms (*such as encephalitis*) when infected.

If I live in an area where birds or mosquitoes with West Nile virus have been reported, and I am bitten by a mosquito, am I likely to get sick?
No. Even in areas where mosquitoes do carry the virus, very few mosquitoes -- less than 1% -- are infected. The chances that any one bite will be from an infected mosquito are very small.

I've gotten a mosquito bite. Should I be tested for West Nile virus?
No. Most mosquitoes are not infected with the West Nile virus. Illnesses related to mosquito bites are rare. However, you should see a doctor immediately if you develop symptoms such as high fever, confusion, muscle weakness, severe headaches, stiff neck, or if your eyes become sensitive to light. Patients with mild symptoms should recover completely, and do not require any specific medication or laboratory testing.

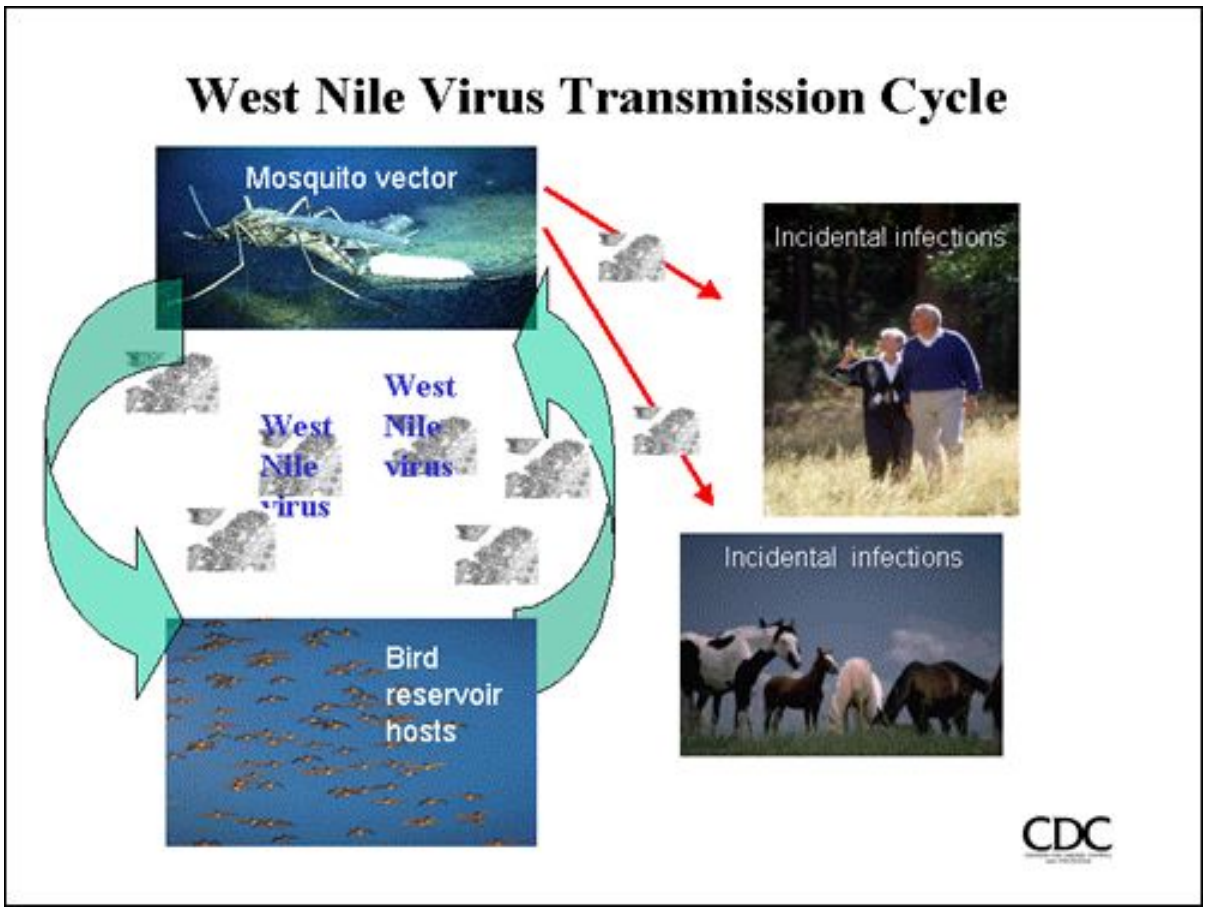
Is there treatment for West Nile virus?
Although there is no specific treatment, medication or cure, the symptoms and complications of the disease can be treated. Most people who get this illness recover from it.
Is there a vaccine for West Nile virus?
No. A vaccine for West Nile virus does not exist.

West Nile Virus Mosquito Transmission Cycle

The West Nile virus (**WNV**) is maintained in nature when an arthropod vector transmits the virus between vertebrate hosts. The primary vector for WNV in the United States is the ***Culex pipiens*** mosquito that commonly breeds in urban areas and prefers to feed on birds. To date, 11 mosquito species in the U.S., including other ***Culex, Aedes***, ***Anopheles***, and ***Psorophora*** mosquito species, have tested positive for WNV. Mosquitoes acquire WNV when feeding on infected birds.

The virus is then stored in the mosquito's salivary glands and transmitted to humans and other incidental hosts when the mosquito takes a blood meal (view transmission cycle). The virus has been detected in many wild bird species, including the American crow.

Humans and other domestic animals are considered "***dead-end***" hosts, as they do not contribute to the transmission cycle but can develop an illness as a result of infection.



West Nile Virus Activity in the United States
(as reported to CDC)*

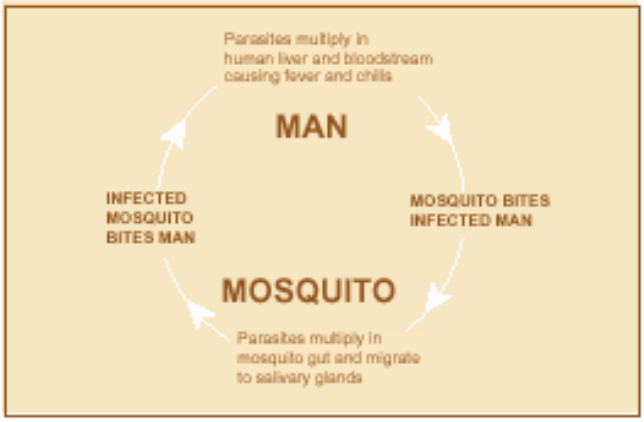
North American Mosquito Species producing West Nile Virus positives (source: CDC)		
1	**Aedes**	*Aedes aegypti*
2		*Aedes albopictus*
3		*Aedes cinereus*
4		*Aedes vexans*
5	**Anopheles**	*Anopheles atropos*
6		*Anopheles barberi*
7		*Anopheles crucians/bradleyi*
8		*Anopheles franciscanus*
9		*Anopheles freeborni*
10		*Anopheles hermsi*
11		*Anopheles punctipennis*
12		*Anopheles quadrimaculatus*
13		*Anopheles walkeri*
14	**Coquillettidia**	*Coquillettidia perturbans*
15	**Culex**	*Culex coronator*
16		*Culex erraticus*
17		*Culex erythrothorax*
18		*Culex nigripalpus*
19		*Culex pipiens*
20		*Culex quinquefasciatus*
21		*Culex restuans*
22		*Culex salinarius*
23		*Culex stigmatosoma*
24		*Culex tarsalis*
25		*Culex territans*
26		*Culex thriambus*
27	**Culiseta**	*Culiseta impatiens*
28		*Culiseta inornata*
29		*Culiseta melanura*
30		*Culiseta morsitans*
31	**Deinocerites**	*Deinocerites cancer*
32	**Mansonia**	*Mansonia tittilans*
33	**Ochlerotatus**	*Ochlerotatus atlanticus/tormentor*
34		*Ochlerotatus atropalpus*
35		*Ochlerotatus canadensis*
36		*Ochlerotatus cantator*
37		*Ochlerotatus condolescens**
38		*Ochlerotatus dorsalis*
39		*Ochlerotatus dupreei*
40		*Ochlerotatus fitchii*
41		*Ochlerotatus fulvus pallens*
42		*Ochlerotatus grossbecki*

43		*Ochlerotatus infirmatus*
44		*Ochlerotatus japonicus*
45		*Ochlerotatus melanimon*
46		*Ochlerotatus nigromaculis*
47		*Ochlerotatus provocans*
48		*Ochlerotatus sollicitans*
49		*Ochlerotatus squamiger*
50		*Ochlerotatus sticticus*
51		*Ochlerotatus stimulans*
52		*Ochlerotatus taeniorhynchus*
53		*Ochlerotatus triseriatus*
54		*Ochlerotatus trivittatus*
55	**Orthopodomyia**	*Orthopodomyia signifera*
56	**Psorophora**	*Psorophora ciliata*
57		*Psorophora columbiae*
58		*Psorophora ferox*
59		*Psorophora howardii*
60	**Uranotaenia**	*Uranotaenia sapphirina*
*detected in Monroe County, FL 2003, not in ArboNET		

Anopheles crucians

Malaria Section

Malaria is a life-threatening parasitic disease transmitted by mosquitoes. It was once thought that the disease came from fetid marshes, hence the name ***mal aria***, ((bad air). In 1880, scientists discovered the real cause of malaria, a one-cell parasite called plasmodium. Later they discovered that the parasite is transmitted from person to person through the bite of a female Anopheles mosquito, which requires blood to nurture her eggs.



Man and mosquito play complementary roles in the malaria cycle.

Today approximately 40% of the world's population, mostly those living in the world's poorest countries, are at risk of malaria. The disease was once more widespread, but it was successfully eliminated from many countries with temperate climates during the mid-20th century. Today malaria is found throughout the tropical and sub-tropical regions of the world and causes more than 300 million acute illnesses and at least one million deaths annually.

90% of deaths due to malaria occur in Africa south of the Sahara, mostly among young children. Malaria kills an African child every 30 seconds. Many children who survive an episode of severe malaria may suffer from learning impairments or brain damage. Pregnant women and their unborn children are also particularly vulnerable to malaria, which is a major cause of prenatal mortality, low birth weight, and maternal anemia.

There are four types of human malaria Plasmodium vivax
P. malariae, P. ovale and *P. falciparum. P. vivax* and *P. falciparum* are the most common and falciparum the deadliest type of malaria infection. *Plasmodium falciparum* malaria is most common in Africa, south of the Sahara, accounting in large part for the extremely high mortality in this region. There are also worrying indications of the spread of *P. falciparum* malaria into new regions of the world and its reappearance in areas where it had been eliminated. The malaria parasite enters the human host when an infected Anopheles mosquito takes a blood meal. Inside the human host, the parasite undergoes a series of changes as part of its complex lifecycle. Its various stages allow plasmodia to evade the immune system, infect the liver and red blood cells, and finally develop into a form that is able to infect a mosquito again when it bites an infected person. Inside the mosquito, the parasite matures until it reaches the sexual stage, where it can again infect a human host when the mosquito takes her next blood meal, 10 to 14 days later.

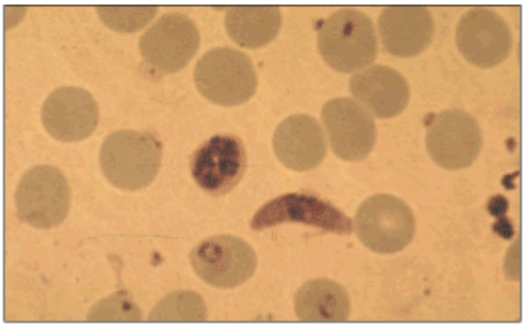
Malaria Symptoms
Malaria symptoms appear about 9 to 14 days after the infectious mosquito bite, although this varies with different plasmodium species. Typically, malaria produces fever, headache, vomiting, and other flu-like symptoms. If drugs are not available for treatment or the parasites are resistant to them, the infection can progress rapidly to become life-threatening. Malaria can kill by infecting and destroying red blood cells (anemia) and by clogging the capillaries that carry blood to the brain (cerebral malaria) or other vital organs.

Malaria, together with HIV/AIDS and TB, is one of the major public health challenges undermining development in the poorest countries in the world.

Malaria Parasites

Malaria parasites are developing unacceptable levels of resistance to one drug after another, and many insecticides are no longer useful against mosquitoes transmitting the disease. Years of vaccine research have produced few hopeful candidates, and although scientists are redoubling the search, an effective vaccine is, at best, years away.

Above: Anopheles mosquito in characteristic biting and resting position. Below: Microscopist's view of Plasmodium Falciparum.

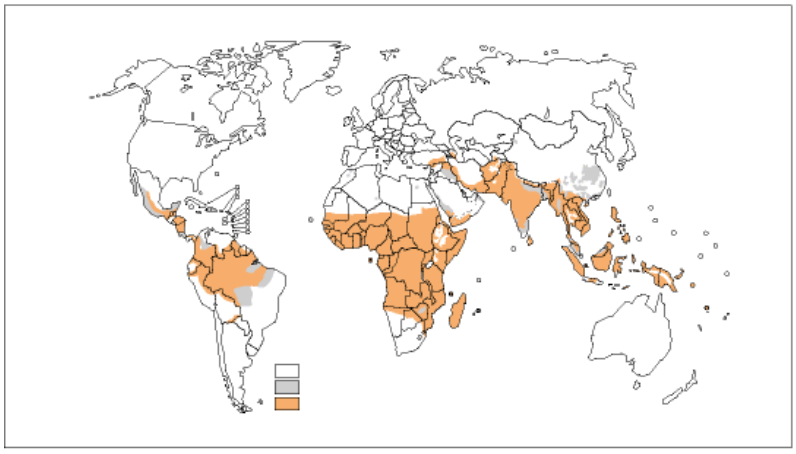


Pictures: WHO/TDR, WHO/Pylot

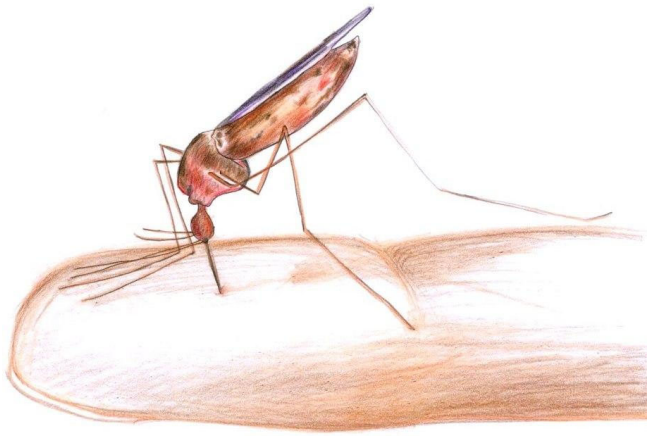
Science still has no magic bullet for malaria, and many doubt that such a single solution will ever exist. Nevertheless, effective low-cost strategies are available for its treatment, prevention, and control and the Roll Back Malaria global partnership is vigorously promoting them in Africa and other malaria-endemic regions of the world. Mosquito nets treated with insecticide reduce malaria transmission and child deaths.

Prevention

Prevention of malaria in pregnant women, through measures such as Intermittent Preventive Treatment and the use of insecticide-treated nets (ITNs), results in improvement in maternal health, infant health, and survival. Prompt access to treatment with effective up-to-date medicines, such as artemisinin-based combination therapies (ACTs), saves lives. If countries can apply these and other measures on a wide scale and monitor them, then the burden of malaria will be significantly reduced.



Above: World malaria situation. Malaria is endemic to tropical and subtropical regions.

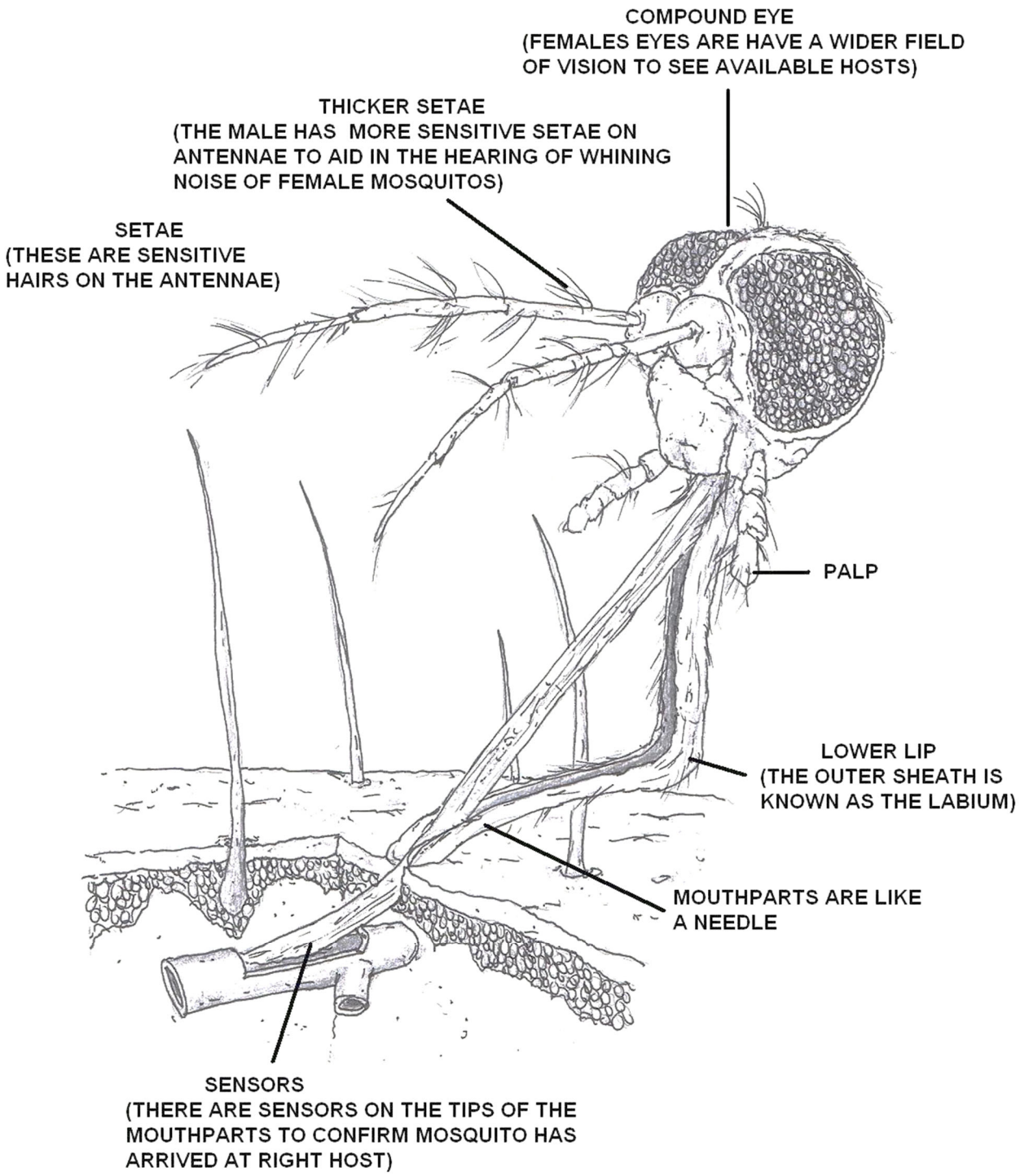


Female of the malaria vector mosquito, *Anopheles gambiae* taking a blood meal.

Mosquitoes were already feeding on blood during the days of the dinosaurs. Many viruses, bacteria, protozoans, worms, and other parasitic organisms have spent years adapting their own life cycles to the intimate relationships between biting arthropods and their hosts. In a kind of lottery-of-life, every successful agent has evolved and fine-tuned each detail of its existence to the ecology and natural history of its two very different kinds of hosts.

Vector-borne diseases that affect agriculture, like equine encephalitis, canine heartworm, or bluetongue of sheep, have received a lot of attention by scientists. The vast majority affect only wildlife populations, and still very little is known about these insects. Some bacterial and viral agents have only recently been discovered, when new diagnostic tools identified a previously unrecorded organism in a human patient.

The normal vertebrate hosts of most vector-borne diseases of man (malaria is now almost an exception) are wild or domestic animals. Humans usually become infected only when they step into an already existing natural or "*enzootic*" cycle. Diseases caused by organisms currently exploring these newly opened transmission routes to man have been called "*emerging infectious diseases.”*



ANATOMY OF THE FEMALE MOSQUITO BITE DIAGRAM

Viral Encephalitis Section

An arbovirus (**ar**thropod-**bo**rne **virus**) natural cycle includes periods in two hosts: a blood feeding arthropod and a population of wild vertebrates. The virus is picked up during a blood meal. It multiplies and eventually lodges in the arthropod's salivary glands, ready to be injected during any subsequent feeding. The arthropod can remain infective for life, without being harmed. There are no preventive vaccines for man, so adequate vector control is the only front-line defense against these viruses.

Public health workers in California keep watch for three especially dangerous arboviruses: Western Equine Encephalitis **(WEE)** and Saint Louis Encephalitis **(SLE),** and the rapidly spreading West Nile virus **(WNV).** Typical vertebrate hosts are wild birds, like sparrows, finches, jays, robins, doves, and pigeons. Their seasonal north-south migrations mean that surveillance needs to be maintained throughout the state.

***Culex S*pecies**
The most important insect vector in California is the encephalitis mosquito, *Culex tarsalis*, common in both Marin and Sonoma Counties. Other *Culex* species can also serve as vectors. Encephalitis outbreaks in wild vertebrates occur during the months when mosquito density is highest, and sometimes they develop very quickly. Nevertheless, the environmental factors (like seasonal weather patterns, temperature and rainfall) that might help predict increased human exposure and risk of infection still need to be studied.

Occasional human infections with WEE have occurred in both Marin and Sonoma, and at least 13 cases have been found in horses in Sonoma County. Man and horses are accidental, dead end hosts for the virus. Transmission does not occur directly from person to person, and is unlikely from man or horses to mosquitoes, because virus levels in circulating blood remain low.

From 1945 to 1987, there were 1,307 human deaths in California due to arbovirus infection. About 3 in every 100 such infections prove fatal, while others cause long-term disability. But for every recognized case, many more go undiscovered. Surveys in areas like Kern County, where high frequency of exposure would be expected, turned up many residents with antibodies against WEE and SLE arboviruses, but with no apparent symptoms of disease.

When symptoms do appear, they can be severe, including fever, headache, and central nervous system disease with encephalitis (inflammation of the brain). Horses have a much greater exposure to migratory birds and mosquitoes. Equine cases tend to be severe, with between 25% and 30% fatalities. Recent experience in Sonoma County suggests that imported Australian emus may be extremely susceptible to the virus.

Sentinel Chicken Flocks
Several California vector control districts and the State Department of Health Services put out sentinel chicken flocks each spring to alert them of arbovirus presence in wild birds and transmission by local mosquitoes. This is how they discovered that WEE was active in Sonoma County during 1992, 1993, 1994, and 1997, and in neighboring Napa and Solano counties in 1996.

Mosquito-borne Encephalitis-Detailed Explanations

Mosquito-borne encephalitis offers a rare opportunity in public health to detect the risk of a disease before it occurs and to intervene to reduce that risk substantially. The surveillance required to detect risk is being increasingly refined by the potential utilization of these new technologies which allows for rapid identification of dangerous viruses in mosquito populations. These rapid diagnostic techniques used in threat recognition can shorten public health response time and reduce the geographic spread of infected vectors and thereby the cost of containing them. The Arbovirus Diseases Branch of NCID's Division of Vector-Borne Infectious Diseases has responsibility for CDC's programs in surveillance, diagnosis, research and control of arboviral encephalitides.

La Crosse Encephalitis
La Crosse (LAC) encephalitis was discovered in La Crosse, Wisconsin in 1963. Since then, the virus has been identified in several Midwestern and Mid-Atlantic states. During an average year, about 75 cases of LAC encephalitis are reported to the CDC. Most cases of LAC encephalitis occur in children under 16 years of age. LAC virus is a Bunyavirus and is a zoonotic pathogen cycled between the daytime-biting treehole mosquito, Aedes triseriatus, and vertebrate amplifier hosts (chipmunks, tree squirrels) in deciduous forest habitats. The virus is maintained over the winter by transovarial transmission in mosquito eggs. If the female mosquito is infected, she may lay eggs that carry the virus, and the adults coming from those eggs may be able to transmit the virus to chipmunks and to humans.

Historically, most cases of LAC encephalitis occur in the upper Midwestern states (Minnesota, Wisconsin, Iowa, Illinois, Indiana, and Ohio). Recently, more cases are being reported from states in the mid-Atlantic (West Virginia, Virginia and North Carolina) and southeastern (Alabama and Mississippi) regions of the country. It has long been suspected that LAC encephalitis has a broader distribution and a higher incidence in the eastern United States, but is under-reported because the etiologic agent is often not specifically identified.

LAC encephalitis initially presents as a nonspecific summertime illness with fever, headache, nausea, vomiting and lethargy. Severe disease occurs most commonly in children under the age of 16 and is characterized by seizures, coma, paralysis, and a variety of neurological sequelae after recovery. Death from LAC encephalitis occurs in less than 1% of clinical cases. In many clinical settings, pediatric cases presenting with CNS involvement are routinely screened for herpes or enteroviral etiologies. Since there is no specific treatment for LAC encephalitis, physicians often do not request the tests required to specifically identifying LAC virus, and the cases are reported as aseptic meningitis or viral encephalitis of unknown etiology. Also found in the United States, Jamestown Canyon and Cache Valley viruses are related to LAC, but rarely cause encephalitis.

Eastern Equine Encephalitis
Eastern equine encephalitis (EEE) is also caused by a virus transmitted to humans and equines by the bite of an infected mosquito. EEE virus is an alphavirus that was first identified in the 1930's and currently occurs in focal locations along the eastern seaboard, the Gulf Coast and some inland Midwestern locations of the United States. While small outbreaks of human disease have occurred in the United States, equine epizootics can be a common occurrence during the summer and fall.

It takes from 4-10 days after the bite of an infected mosquito for an individual to develop symptoms of EEE. These symptoms begin with a sudden onset of fever, general muscle pains, and a headache of increasing severity. Many individuals will progress to more severe symptoms such as seizures and coma. Approximately one-third of all people with clinical encephalitis caused by EEE will die from the disease and of those who recover, many will suffer permanent brain damage with many of those requiring permanent institutional care.

In addition to humans, EEE virus can produce severe disease in: horses, some birds such as pheasants, quail, ostriches and emus, and even puppies.

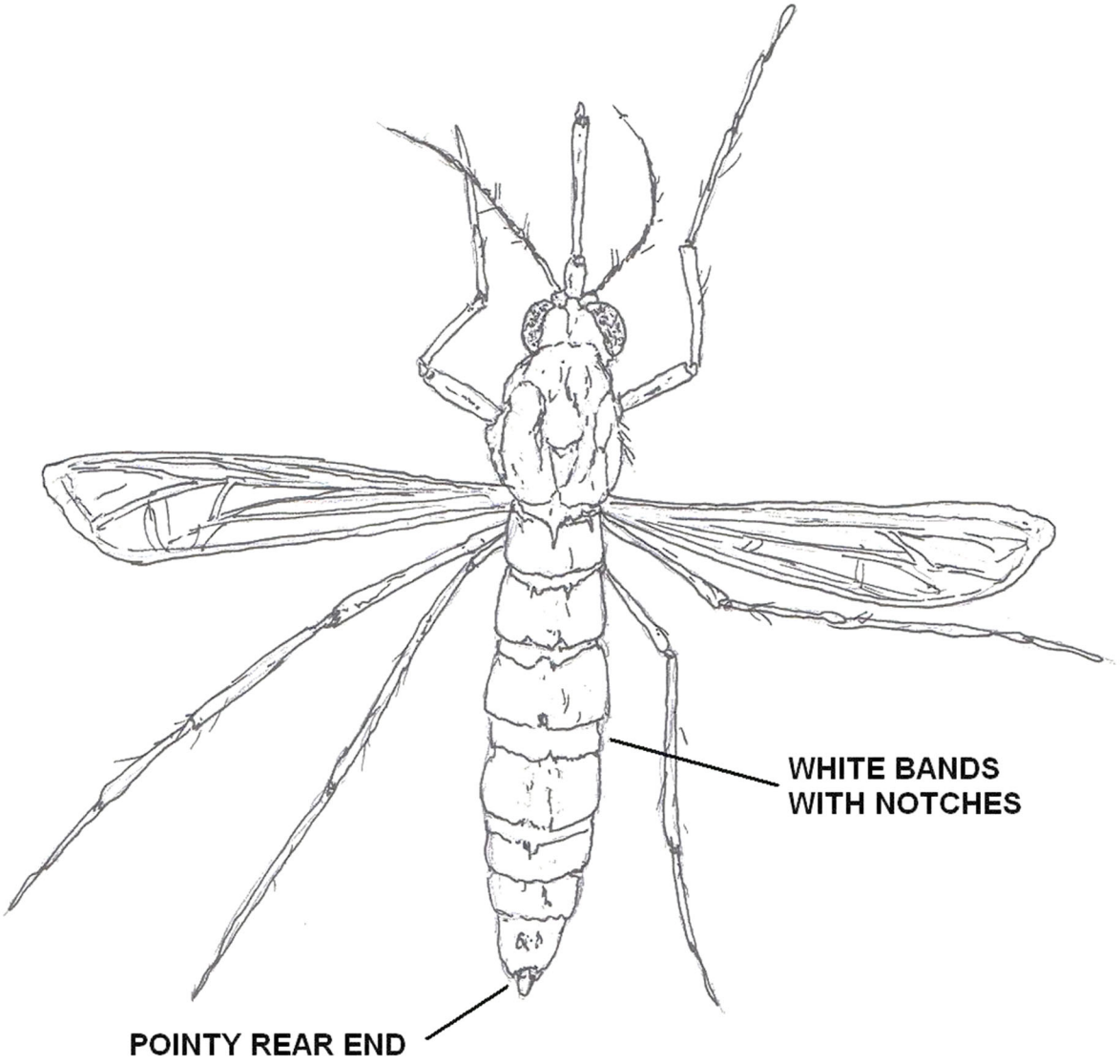
Because horses are outdoors and attract hordes of biting mosquitoes, they are at high risk of contracting EEE when the virus is present in mosquitoes. Human cases are usually preceded by those in horses and exceeded in numbers by horse cases which may be used as a surveillance tool.

EEE virus occurs in natural cycles involving birds and Culiseta melanura, in some swampy areas nearly every year during the warm months. Where the virus resides or how it survives in the winter is unknown. It may be introduced by migratory birds in the spring or it may remain dormant in some yet undiscovered part of its life cycle.

With the onset of spring, the virus reappears in the birds (native bird species do not seem to be affected by the virus) and mosquitoes of the swamp. In this usual cycle of transmission, virus does not escape from these areas because the mosquito involved prefers to feed upon birds and does not usually bite humans or other mammals.

For reasons not fully understood, the virus may escape from enzootic foci in swamp areas in birds or bridge vectors such as Coquilletidia perturbans and Aedes sollicitans. These species feed on both birds and mammals and can transmit the virus to humans, horses, and other hosts.

Other mosquito species such as Ae. vexans and Culex nigripalpus can also transmit EEE virus. When health officials maintain surveillance for EEE virus activity, this movement out of the swamp can be detected, and if the level of activity is sufficiently high, can recommend and undertake measures to reduce the risk to humans.



INLAND FLOODWATER MOSQUITO
(Aedes vexans)

Western Equine Encephalitis

The alphavirus western equine encephalitis (WEE) was first isolated in California in 1930 from the brain of a horse with encephalitis, and remains an important cause of encephalitis in horses and humans in North America, mainly in western parts of the USA and Canada. In the western United States, the enzootic cycle of WEE involves passerine birds, in which the infection is in apparent, and culicine mosquitoes, principally Cx. tarsalis, a species that is associated with irrigated agriculture and stream drainages. The virus has also been isolated from a variety of mammal species. Other important mosquito vector species include Aedes melanimon in California, Ae. dorsalis in Utah and New Mexico and Ae. campestris in New Mexico. WEE virus was isolated from field collected larvae of Ae. dorsalis, providing evidence that vertical transmission may play an important role in the maintenance cycle of an alphavirus.

Expansion of irrigated agriculture in the North Platte River Valley during the past several decades has created habitats and conditions favorable for increases in populations of granivorous birds such as the house sparrow, Passer domesticus, and mosquitoes such as Cx. tarsalis, Aedes dorsalis and Aedes melanimon. All of these species may play a role in WEE virus transmission in irrigated areas. In addition to Cx. tarsalis, Ae. dorsalis and Ae. melanimon, WEE virus also has been isolated occasionally from some other mosquito species present in the area. Two confirmed and several suspect cases of WEE were reported from Wyoming in 1994. In 1995, two strains of WEE virus were isolated from Culex tarsalis and neutralizing antibody to WEE virus was demonstrated in sera from pheasants and house sparrows. During 1997, 35 strains of WEE virus were isolated from mosquitoes collected in Scotts Bluff County, Nebraska.

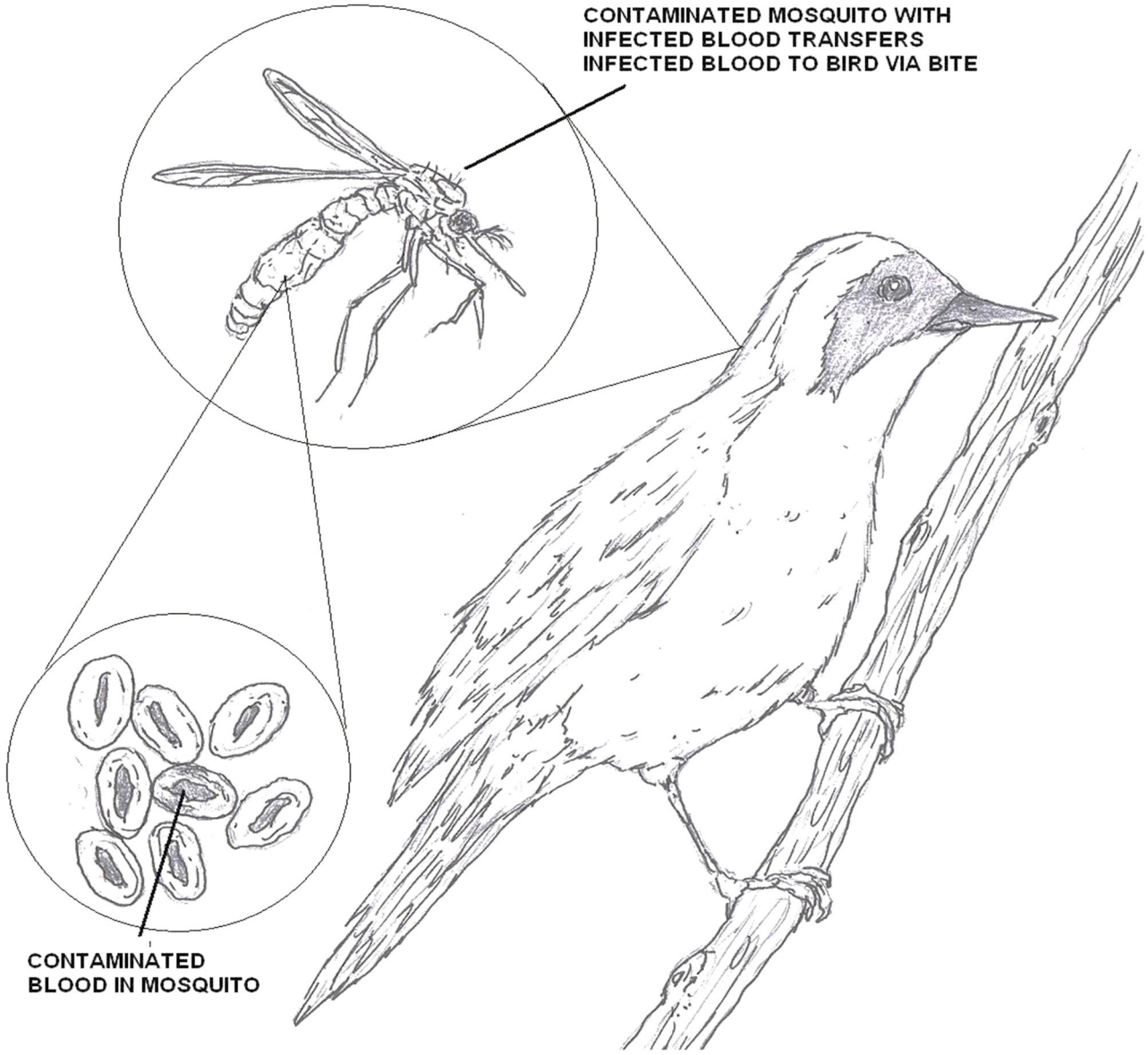
Human WEE cases are usually first seen in June or July. Most WEE infections are asymptomatic or present as mild, nonspecific illness. Patients with clinically apparent illness usually have a sudden onset with fever, headache, nausea, vomiting, anorexia and malaise, followed by altered mental status, weakness and signs of meningeal irritation. Children, especially those under 1-year-old, are affected more severely than adults and may be left with permanent sequelae, which is seen in 5 to 30% of young patients. The mortality rate is about 3%.

St. Louis Encephalitis

In the United States, the leading cause of epidemic flaviviral encephalitis is St. Louis encephalitis (SLE) virus. SLE is the most common mosquito-transmitted human pathogen in the U.S. While periodic SLE epidemics have occurred only in the Midwest and southeast, SLE virus is distributed throughout the lower 48 states. Since 1964, there have been 4,437 confirmed cases of SLE with an average of 193 cases per year (range 4 - 1,967). However, less than 1% of SLE viral infections are clinically apparent and the vast majority of infections remain undiagnosed. Illness ranges in severity from a simple febrile headache to meningoencephalitis, with an overall case-fatality ratio of 5-15 %. The disease is generally milder in children than in adults, but in those children who do have disease, there is a high rate of encephalitis. The elderly are at highest risk for severe disease and death. During the summer season, SLE virus is maintained in a mosquito-bird-mosquito cycle, with periodic amplification by peridomestic birds and Culex mosquitoes. In Florida, the principal vector is Cx. nigripalpus, in the Midwest, Cx. pipiens and Cx. p. quinquefasciatus and in the western United States, Cx. tarsalis and members of the Cx. pipiens complex.

Powassan Encephalitis

Powassan (POW) virus is a flavivirus and currently the only well documented tick-borne transmitted arbovirus occurring in the United States and Canada. Recently a Powassan-like virus was isolated from the deer tick, Ixodes scapularis. Its relationship to POW and its ability to cause human disease has not been fully elucidated. POW's range in the United States is primarily in the upper tier States. In addition to isolations from man, the virus has been recovered from ticks (Ixodes marxi, I. cookei and Dermacentor andersoni) and from the tissues of a skunk (Spiligale putorius). It is a rare cause of acute viral encephalitis. POW virus was first isolated from the brain of a 5-year-old child who died in Ontario in 1958. Patients who recover may have residual neurological problems.



AVIAN MALARIA DIAGRAM

Venezuelan Equine Encephalitis

Like EEE and WEE viruses, Venezuelan equine encephalitis (VEE) is an alphavirus and causes encephalitis in horses and humans and is an important veterinary and public health problem in Central and South America. Occasionally, large regional epizootics and epidemics can occur resulting in thousands of equine and human infections. Epizootic strains of VEE virus can infect and be transmitted by a large number of mosquito species. The natural reservoir host for the epizootic strains is not known.

A large epizootic that began in South America in 1969 reached Texas in 1971. It was estimated that over 200,000 horses died in that outbreak, which was controlled by a massive equine vaccination program using an experimental live attenuated VEE vaccine. There were several thousand human infections. A more recent VEE epidemic occurred in the fall of 1995 in Venezuela and Colombia with an estimated 90,000 human infections. Infection of man with VEE virus is less severe than with EEE and WEE viruses, and fatalities are rare. Adults usually develop only an influenza-like illness, and overt encephalitis is usually confined to children. Effective VEE virus vaccines are available for equines.

Enzootic strains of VEE virus have a wide geographic distribution in the Americas. These viruses are maintained in cycles involving forest dwelling rodents and mosquito vectors, mainly Culex (Melanoconion) species. Occasional cases or small outbreaks of human disease are associated with these viruses, the most recent outbreaks were in Venezuela in 1992, Peru in 1994 and Mexico in 1995-96.

Other Arboviral Encephalitides

Many other arboviral encephalitides occur throughout the world. Most of these diseases are problems only for those individuals traveling to countries where the viruses are endemic.

Japanese Encephalitis

Japanese encephalitis (JE) virus is a flavivirus, related to SLE, and is widespread throughout Asia. Worldwide, it is the most important cause of arboviral encephalitis with over 45,000 cases reported annually. In recent years, JE virus has expanded its geographic distribution with outbreaks in the Pacific. Epidemics occur in late summer in temperate regions, but the infection is enzootic and occurs throughout the year in many tropical areas of Asia.

The virus is maintained in a cycle involving culicine mosquitoes and water birds. The virus is transmitted to man by Culex mosquitoes, primarily Cx. tritaeniorhynchus, which breed in rice fields. Pigs are the main amplifying hosts of JE virus in peridomestic environments.

The incubation period of JE is 5 to 14 days. Onset of symptoms is usually sudden, with fever, headache and vomiting. The illness resolves in 5 to 7 days if there is no CNS involvement. The mortality in most outbreaks is less than 10%, but is higher in children and can exceed 30%. Neurologic sequelae in patients who recover are reported in up to 30% of cases. A formalin-inactivated vaccine prepared in mice is used widely in Japan, China, India, Korea, Taiwan and Thailand. This vaccine is currently available for human use in the United States, for individuals who might be traveling to endemic countries.

Tick-Borne Encephalitis

Tick-borne encephalitis (TBE) is caused by two closely related flaviviruses which are distinct biologically. The eastern subtype causes Russian spring-summer encephalitis (RSSE) and is transmitted by Ixodes persulcatus, whereas the western subtype is transmitted by Ixodes ricinus and causes Central European encephalitis (CEE). The name CEE is somewhat misleading, since the condition can occur throughout much of Europe.

Of the two subtypes, RSSE is the more severe infection, having a mortality of up to 25% in some outbreaks, whereas mortality in CEE seldom exceeds 5%. The incubation period is 7 to 14 days. Infection usually presents as a mild, influenza-type illness or as benign, aseptic meningitis, but may result in fatal meningoencephalitis. Fever is often biphasic, and there may be severe headache and neck rigidity, with transient paralysis of the limbs, shoulders or less commonly the respiratory musculature.

A few patients are left with residual paralysis. Although the great majority of TBE infections follow exposure to ticks, infection has occurred through the ingestion of infected cows' or goats' milk. An inactivated TBE vaccine is currently available in Europe and Russia.

West Nile Encephalitis

WNV is a flavivirus belonging taxonomically to the Japanese encephalitis serocomplex that includes the closely related St. Louis encephalitis (SLE) virus, Kunjin and Murray Valley encephalitis viruses, as well as others. WNV was first isolated in the West Nile Province of Uganda in 1937 (2). The first recorded epidemics occurred in Israel during 1951-1954 and in 1957. Epidemics have been reported in Europe in the Rhone delta of France in 1962 and in Romania in 1996 (3-5). The largest recorded epidemic occurred in South Africa in 1974 (6).

An outbreak of arboviral encephalitis in New York City and neighboring counties in New York state in late August and September 1999, was initially attributed to St. Louis encephalitis virus based on positive serologic findings in cerebrospinal fluid (CSF) and serum samples using a virus-specific IgM-capture enzyme-linked immunosorbent assay (ELISA).

The outbreak has been subsequently confirmed as caused by West Nile virus based on the identification of virus in human, avian, and mosquito samples. See also Outbreak of West Nile-Like Viral Encephalitis -- New York, 1999. MMWR, 1999:48(38);845-9 and Update: West Nile-Like Viral Encephalitis -- New York, 1999. MMWR, 1999:48(39);890-2. A recent outbreak WN encephalitis occurred in Bucharest, Romania in 1996.

The virus that caused the New York area outbreak has been definitively identified as a strain of WNV. The genomic sequences identified to date from human brain, virus isolates from zoo birds, dead crows, and mosquito pools are identical. SLE and West Nile viruses are antigenically related, and cross reactions are observed in most serologic tests.

The isolation of viruses and genomic sequences from birds, mosquitoes, and human brain tissue permitted the discovery of West Nile virus in North America and prompted more specific testing. The limitations of serologic assays emphasize the importance of isolating the virus from entomologic, clinical, or veterinary material.

Although it is not known when and how West Nile virus was introduced into North America, international travel of infected persons to New York or transport by imported infected birds may have played a role.

WNV can infect a wide range of vertebrates; in humans it usually produces either asymptomatic infection or mild febrile disease, but can cause severe and fatal infection in a small percentage of patients. Within its normal geographic distribution of Africa, the Middle East, western Asia, and Europe, WNV has not been documented to cause epizootics in birds; crows and other birds with antibodies to WNV are common, suggesting that asymptomatic or mild infection usually occurs among birds in those regions. Similarly, substantial bird virulence of SLE virus has not been reported.

Therefore, an epizootic producing high mortality in crows and other bird species is unusual for either WNV or SLE virus. For both viruses, migratory birds may play an important role in the natural transmission cycles and spread.

Like SLE virus, WNV is transmitted principally by Culex species mosquitoes, but also can be transmitted by Aedes, Anopheles, and other species. The predominance of urban Culex pipiens mosquitoes trapped during this outbreak suggests an important role for this species. Enhanced surveillance for early detection of virus activity in birds and mosquitoes will be crucial to guide control measures.

Arboviral Encephalitides Mosquito-borne Disease Summary

Perspectives
Arthropod-borne viruses, i.e., arboviruses, are viruses that are maintained in nature through biological transmission between susceptible vertebrate hosts by blood feeding arthropods (mosquitoes, psychodids, ceratopogonids, and ticks). Vertebrate infection occurs when the infected arthropod takes a blood meal. The term 'arbovirus' has no taxonomic significance. Arboviruses that cause human encephalitis are members of three virus families: The Togaviridae (genus Alphavirus), Flaviviridae, and Bunyaviridae.

Complex Life Cycles
All arboviral encephalitides are zoonotic, being maintained in complex life cycles involving a nonhuman primary vertebrate host and a primary arthropod vector. These cycles usually remain undetected until humans encroach on a natural focus, or the virus escapes this focus via a secondary vector or vertebrate host as the result of some ecologic change. Humans and domestic animals can develop clinical illness but usually are "dead-end" hosts because they do not produce significant viremia, and do not contribute to the transmission cycle. Many arboviruses that cause encephalitis have a variety of different vertebrate hosts and some are transmitted by more than one vector. Maintenance of the viruses in nature may be facilitated by vertical transmission (e.g., the virus is transmitted from the female through the eggs to the offspring).

Global Distribution
Arboviral encephalitides have a global distribution, but there are four main virus agents of encephalitis in the United States: eastern equine encephalitis (EEE), western equine encephalitis (WEE), St. Louis encephalitis (SLE) and La Crosse (LAC) encephalitis, all of which are transmitted by mosquitoes. Another virus, Powassan, is a minor cause of encephalitis in the northern United States, and is transmitted by ticks.

A new Powassan-like virus has recently been isolated from deer ticks. Its relatedness to Powassan virus and its ability to cause disease has not been well documented. Most cases of arboviral encephalitis occur from June through September, when arthropods are most active. In milder (i.e., warmer) parts of the country, where arthropods are active late into the year, cases can occur into the winter months.

The majority of human infections is asymptomatic or may result in a nonspecific flu-like syndrome. Onset may be insidious or sudden with fever, headache, myalgias, malaise and occasionally prostration. Infection may, however, lead to encephalitis, with a fatal outcome or permanent neurologic sequelae. Fortunately, only a small proportion of infected persons' progress to frank encephalitis.

Experimental studies have shown that invasion of the central nervous system (CNS), generally follows initial virus replication in various peripheral sites and a period of viremia. Viral transfer from the blood to the CNS through the olfactory tract has been suggested. Because the arboviral encephalitides are viral diseases, antibiotics are not effective for treatment and no effective antiviral drugs have yet been discovered. Treatment is supportive, attempting to deal with problems such as swelling of the brain, loss of the automatic breathing activity of the brain and other treatable complications like bacterial pneumonia.

No Commercially Available Human Vaccines
There are no commercially available human vaccines for these U.S. diseases. There is a Japanese encephalitis vaccine available in the U.S. A tick-borne encephalitis vaccine is available in Europe. An equine vaccine is available for EEE, WEE and Venezuelan equine encephalitis (VEE). Arboviral encephalitis can be prevented in two major ways: personal protective measures and public health measures to reduce the population of infected mosquitoes. Personal measures include reducing time outdoors particularly in early evening hours, wearing long pants and long sleeved shirts and applying mosquito repellent to exposed skin areas. Public health measures often require spraying of insecticides to kill juvenile (larvae) and adult mosquitoes.

Selection of mosquito control methods depends on what needs to be achieved; but, in most emergency situations, the preferred method to achieve maximum results over a wide area is aerial spraying. In many states aerial spraying may be available in certain locations as a means to control nuisance mosquitoes. Such resources can be redirected to areas of virus activity. When aerial spraying is not routinely used, such services are usually contracted for a given time period.

Financing of aerial spraying costs during large outbreaks is usually provided by state emergency contingency funds. Federal funding of emergency spraying is rare and almost always requires a federal disaster declaration. Such disaster declarations usually occur when the vector-borne disease has the potential to infect large numbers of people, when a large population is at risk and when the area requiring treatment is extensive. Special large planes maintained by the United States Air Force can be called upon to deliver the insecticide(s) chosen for such emergencies. Federal disaster declarations have relied heavily on risk assessment by the CDC.

Laboratory diagnosis of human arboviral encephalitis has changed greatly over the last few years. In the past, identification of antibody relied on four tests: hemagglutination-inhibition, complement fixation, plaque reduction neutralization test, and the indirect fluorescent antibody (IFA) test. Positive identification using these immunoglobulin M (IgM) - and IgG-based assays requires a four-fold increase in titer between acute and convalescent serum samples. With the advent of solid-phase antibody-binding assays, such as enzyme-linked immunosorbent assay (ELISA), the diagnostic algorithm for identification of viral activity has changed. Rapid serologic assays such as IgM-capture ELISA (MAC-ELISA) and IgG ELISA may now be employed soon after infection. Early in infection, IgM antibody is more specific, while later in infection, IgG antibody is more reactive. Inclusion of monoclonal antibodies (MAbs) with defined virus specificities in these solid phase assays has allowed for a level of standardization that was not previously possible.

Virus isolation and identification have also been useful in defining viral agents in serum, cerebrospinal fluid and mosquito vectors. While virus isolation still depends upon growth of an unknown virus in cell culture or neonatal mice, virus identification has also been greatly facilitated by the availability of virus-specific MAbs for use in IFA assays. Similarly, MAbs with avidities sufficiently high to allow for specific binding to virus antigens in a complex protein mixture (e.g., mosquito pool suspensions) have enhanced our ability to rapidly identify virus agents in situ. While polymerase chain reaction (PCR) has been developed to identify a number of viral agents, such tests have not yet been validated for routine rapid identification in the clinical setting.

Yellow Fever Section

Yellow fever is still an important disease despite scientific advances in understanding the disease and the development of an effective vaccine. The continued appearance of yellow fever epidemics and the potential for large epidemics of this disease is of real concern. The ability to reduce human suffering due to yellow fever depends on being able to use efficient and effective mosquito control coupled with a massive vaccination program. Both are extremely difficult to accomplish in many regions of the world where the risk for a yellow fever outbreak may be greatest.

Successful mosquito control against Aedes aegypti has reduced the number of yellow fever cases in many cities. However, mosquito control resources may be non-existent and delivery of vaccine insufficient. In the 1990s the worldwide annual production of yellow fever vaccine was about 15 million doses with demands on vaccine extremely unpredictable.

A vaccination program that is geared to regions in advance of an expected epidemic is cost-effective, but it is unlikely to be successful because of the time delay in identifying the epidemic and that it takes 5-7 days for the vaccine to provide any protection after inoculation. On the other hand, a campaign to vaccinate the entire population in the absence of yellow fever would be extremely costly and require a long-term commitment to vaccinate everyone.

History of Yellow Fever
Yellow fever is among the most feared of human diseases. It was one of the most devastating and important diseases in Africa and the Americas in the 17-20th centuries with periodic outbreaks of yellow fever that involved thousands of human cases. New Orleans experienced the last major yellow fever epidemic in the United States in 1905 with about 4000 human cases and 500 deaths.

Yellow fever virus is transmitted to humans through the bite of infected mosquitoes. Epidemics of yellow fever during the past 300 years show why this disease inspired dread and fear. The numbers of deaths during outbreaks are startling: 6,000 dead in Barbados in 1647; 3,500 deaths in Philadelphia in 1793; 1,500 in New York City in 1798; 29,000 deaths in Haiti in 1802; and 20,000 deaths in over 100 American towns in 1878.

It was not until 1901 that yellow fever transmission to humans was associated with the blood-feeding by the Aedes aegypti mosquito. The larval habitat for this species is primarily containers such as barrels, buckets, cisterns, and vases. Eliminating the larval habitat was instrumental in controlling yellow fever. This was accomplished by either removing the container, or modifying containers by covering the openings with screen, for example, to prevent female mosquitoes from laying eggs in the water container.

During the 20th century yellow fever has re-emerged as a cause of human suffering. Recent epidemics include 100,000 cases and 30,00 deaths in Ethiopia in 1960-62; 17,500 cases with 1,700 deaths in Upper Volta in 1983; and Cameroon had 20,000 cases with 1,000 deaths in 1990. The World Health Organization officially reported 18,735 yellow fever cases with 4,522 deaths for the period 1987 – 1991.

What is Yellow Fever?

The Disease

Yellow fever is particularly feared due to the disturbing nature of its symptoms. Symptoms may range from clinically unapparent to fatal. In some regions of Latin America as much as 90% of the population have been infected with the yellow fever virus but show no clinical symptoms. After being bitten by an infected mosquito, the incubation period in infected humans is generally 3-6 days. The onset of the disease is very sudden and devastating to the patient. There is high fever (102o – 104o F), headache, malaise, back pain, chills, prostration, nausea, slow pulse and vomiting. The virus can be found in the blood of the patient for about 4 days following the bite of the mosquito, and during this period the patient is capable of infecting more mosquitoes. Some individuals show a rapid recovery at this point and the symptoms stop. This phase can last from 3-4 days.

Severe yellow fever cases also have symptoms that can subside but then return in a day or so. This is the diphase part of the progression of the disease. Twenty to fifty percent of people who enter the second phase will die from yellow fever.

Symptoms include fever, vomiting, abdominal pain, prostration, dehydration, jaundice due to liver involvement, internal bleeding, bleeding of the nose, mouth, and gums, blood in the urine, and kidney or liver failure. The internal bleeding results in blood in the vomit, called “black vomit” due to the color, and dark stools. No virus is in the blood at this point so the patient is not infectious to mosquitoes.

Death usually occurs between the 7th and 10th day of the illness showing the quickness with which the disease can act and the reason it is so dreaded. Some very severe atypical cases of yellow fever may die as early as 3 days after the onset of symptoms. Mortality from yellow fever approaches 10% of clinical cases but has reached as high as 50% of those people developing symptoms.

There is no cure for yellow fever. Treatment is only supportive in an attempt to reduce the severity of the symptoms. However, the disease is preventable. An excellent vaccine is available to provide protection against yellow fever. It was first developed by Dr. Max Theiler in the 1930s and is called the 17D vaccine.

In 1951 Dr. Theiler received a Nobel Prize for this extraordinary contribution. This vaccine provides excellent protection against yellow fever for as long as 10 years after vaccination and some people still are protected 30-35 years after being vaccinated. People traveling to areas where yellow fever is known to cause disease should be vaccinated in advance. Current information for travelers can be found at the Centers for Disease Control website for travelers' health: http://wwwnc.cdc.gov/travel/

The Virus

Yellow fever virus is a member of the group of viruses called flaviviruses. The virus has been found in the tropical regions of the Americas, Africa, and there have been historical yellow fever incursions in parts of North America and Europe. The yellow fever virus has never been detected in Asia, Australia or the Pacific despite the presence of Aedes aegypti in these regions. The reason for this is unknown and the subject of much speculation.

Insect Transmission
Several different mosquito species transmit yellow fever virus depending on the geographic region and habitat. The most important mosquito species involved worldwide in the transmission of yellow fever to humans is Aedes aegypti, also known as “the yellow fever mosquito.” The association of yellow fever transmission to humans by Aedes aegypti was a major breakthrough in understanding this dreaded disease. In 1901, Major Walter Reed, U. S. Army, lead the studies showing the role of Aedes aegypti. The species is widely distributed throughout the tropics and subtropics of the world. Larvae of Aedes aegypti can develop in a variety of artificial containers, i.e., flower pots, tires, water jars, many commonly found around human habitats. Adult Aedes aegypti have a distinct preference for humans as a source of blood.

Chikungunya

Chikungunya is suspected when there is epidemic disease with the characteristic triad of symptoms of fever, rash and joint pain. Chikungunya can easily be confused with another mosquito-borne human pathogen called Dengue.

The definitive diagnosis of Chikungunya requires laboratory testing. The virus can be detected during the first 48 hours of disease, and may be detected as late as day 4 in some patients. Usually Chikungunya is diagnosed by detecting patient antibodies produced by the immune response to the virus and found in the blood. Antibodies to CHIKV persist in the blood in excess of 6 months.

Chikungunya is a virus that can be transmitted to humans by mosquitoes. The resulting illness is also called Chikungunya. It was originally described in the early 1950s after an outbreak in a Swahili village on the Makonde plateau that lies between Tanzania and Mozambique. The translation of Chikungunya from Makonde means “illness of the bended walker,” “that which bends up,” stooped over, walking bent over, or “bended walker.” In India, it is known as Aakyda, meaning “stiff man” and Maakyda meaning “monkey-like”. These words refer to the arthritic condition that occurs in some patients which gives rise to a stooped posture. The virus was first found in Asia, isolated in Bangkok, Thailand in 1958.

The Virus
Chikungunya virus, or CHIKV is a member of the Alphavirus genus in the family Togaviridae. CHIKV is related to other alphaviruses like Ross River, Sindbis and Venezuelan equine encephalitis viruses.

What are the Symptoms?
Reported symptoms include fever, chills, headache, rash and severe joint pain with or without swelling. Pain in the joints is a major feature of Chikungunya symptoms. The ankles and wrists are most commonly affected. Intense pain due to pressure placed on a wrist is commonly used to help diagnose the disease.

Symptoms begin to appear within 2 – 12 days after being infected from the bite of an infected female mosquito. Initial symptoms include a sudden onset of flu-like symptoms including severe headache, chills, insomnia, fever, joint pain, nausea and vomiting.

A rash may occur, first as a flush over the face and chest, followed by a rash that can have lesions. There can be mild hemorrhaging in children. Joint pain can persist for many months or even years after the other symptoms have subsided. All but a few patients recover.

How is Chikungunya Transmitted to Humans?
The cycle of transmission is from mosquito to human and back to mosquito. Transmission to humans may occur when infected female mosquitoes attempt to feed on a human host. The species of mosquitoes that may transmit the virus are Aedes aegypti and Aedes albopictus.

The eggs of these mosquitoes are laid just above the water line in water-holding containers. When the water level rises, the eggs hatch into larvae, where they continue to develop through the pupal stage, then to the adult that will fly to seek a blood meal.

During the recent outbreak, a nurse caring for an infected patient in France came down with Chikungunya fever, suggesting that transmission may also occur from person to person, without the involvement of a mosquito vector.

CDC Vector Surveillance and Control Recommendations Before Mosquito Season

• Conduct public mosquito education campaigns focusing on reducing or eliminating larval habitats for the Ae. aegypti and Ae. albopictus vectors.
• Conduct surveys to determine abundance, distribution, and type of containers; large numbers of containers may translate into high mosquito abundance and high risk.
• Initiate a community wide source reduction campaign – the goal of the campaign is to motivate the community to remove and dispose of any water-holding containers.
• Cover, dump, modify, or treat large water-holding containers with long-lasting larvicide.
• Reduce adult mosquito resting sites by keeping vegetation trimmed and tall grass cut.
• Develop mosquito education materials about Ae. aegypti and Ae. albopictus and personal protection measures. Beginning of mosquito season
• Continue public education campaigns focusing on reducing or eliminating larval habitats for Ae. aegypti and Ae. albopictus vectors.
• Continue to distribute mosquito education materials about Ae. aegypti and Ae. albopictus and personal protection measures.
• Initiate Ae. aegypti and Ae. albopictus community-wide surveys to:

- Determine presence or absence
- Estimate relative abundance
- Determine distribution
- Develop detailed vector distribution maps
- Evaluate the efficacy of source reduction and larvicide treatment.

• Continue/maintain community source reduction efforts.
• Initiate adult sampling to identify or confirm areas of high adult mosquito abundance.
• Initiate preventive adult control to reduce adult populations targeting areas of high mosquito abundance.
• Concentrate control efforts around places with high mosquito density. Single or several suspected/confirmed imported/locally acquired cases
• Begin public mosquito containment education campaigns aimed at preventing or minimizing contact between vectors and suspected or confirmed human cases, especially during the first week of illness when an infected person is viremic and can infect mosquitoes, thereby possibly triggering or contributing to a local outbreak.

- Educate the public to continually dispose of water-holding containers to eliminate larval habitats. Or, if funding allows, host a community volunteer/waste disposal program to help facilitate removal of larval habitats.
- Treat with long-lasting larvicide any water-holding containers that cannot be dumped, covered, discarded, or otherwise modified.
- Eliminate larval habitats within 100-200 yards/meters around a case's home.
- • Initiate community source reduction, adult mosquito, and case containment initiatives to minimize the spread of infected mosquitoes.

• Educate the public about reported cases of disease and urge them to use:

- Insect repellents
- Window and door screens to prevent mosquitoes from entering the house
- Air conditioning

Adult Mosquito Control

• Treat the outdoors within 100–200 yards/meters around a case's home with adulticide.
• Provide outdoor residual and spatial insecticide treatments; repeat as necessary to reduce vector abundance.
• Initiate/maintain adult sampling to estimate adult mosquito abundance and evaluate effectiveness of insecticide treatments. Outbreak; clusters of suspected or confirmed cases
• Divide the outbreak area into operational management areas where control measures can be effectively applied within a few days; repeat as needed to reduce mosquito density.
• Conduct door-to-door inspections and mosquito control in an area-wide fashion (reach >90% coverage of the control area within a week).
• Identify and treat, modify, or remove mosquito-producing containers.
• Organize area/community clean-up campaigns targeting disposable containers (source reduction), including large junk objects that accumulate water (broken washing machines, refrigerators, toilets) in buildings, public areas, etc.
• Combine outdoor spatial and residual spraying with source reduction and larviciding (including residual spraying of container surfaces and adjacent mosquito resting areas). Remember to treat storm drains, roof gutters, and other often overlooked cryptic water sources

Center for Mosquito-Borne Disease Control Summary

In the United States, mosquitoes transmit a variety of arboviruses (arthropod-borne viruses). This document is limited to arboviruses transmitted by Ae. aegypti and Ae. albopictus, the principal vectors of dengue (DENV-1, DENV-2, DENV-3, DENV-4), chikungunya (CHIKV), yellow fever (YFV), and Zika (ZIKV) viruses. Of the above seven arboviruses, ZIKV, DENV, YFV, and CHIKV have caused outbreaks within the United States and its territories in the past 110 years.

Whereas dengue viruses are endemic to Puerto Rico, in other territories including American Samoa, Guam, Northern Mariana Islands, and the U.S. Virgin Islands, only sporadic outbreaks of dengue have occurred. Most recently, focal outbreaks of locally transmitted dengue have occurred in the continental United States including Florida, Hawaii, and Texas.

In 2014, 12 cases of locally acquired CHIKV infections were reported in Florida, and in 2015, 1 case of locally acquired CHIKV was reported in Texas. YFV, once common in the United States, has not caused locally transmitted outbreaks since 1905. However, it circulates in tropical forests of Latin America and infected travelers periodically return to the United States. In 2015, ZIKV outbreaks were, for the first time, reported in the Western Hemisphere, with local transmission occurring in Central and South America, the Caribbean, and Mexico.

In 2016, local transmission of Zika virus was first reported in the United States. ZIKV transmission increased throughout the region, which increased the incidence of infection in returning travelers and contributed to local transmission in the United States. Though none of these arboviruses continuously circulate in the continental United States, local outbreaks have and will continue to occur as a result of virus importation by infected, viremic travelers.

Any viremic travelers visiting or returning to parts of the United States with established populations of Ae. aegypti or Ae. albopictus mosquitoes could initiate local virus transmission.

Prevention and Control
The prevention or reduction of transmission of DENV, ZIKV, and CHIKV (there is a safe and efficacious vaccine against YFV) is completely dependent on the control of mosquito vectors and limiting person mosquito contact. Mosquito surveillance is a key component of any local integrated vector management program. The goal of mosquito-based surveillance is to quantify human risk by determining local vector presence and abundance.

The principal functions of DENV, CHIKV, and ZIKV mosquito-based surveillance programs are to:

- Determine presence or absence of Ae. aegypti and Ae. albopictus in a geographic area.
- Identify what types of containers are producing the most mosquitoes for targeting vector control efforts.
- Develop detailed maps to track larval sites if Ae. aegypti or Ae. albopictus are detected in an area.
- Collect mosquito population data and identify geographic areas of high abundance (high-risk).
- Monitor the effectiveness of vector control efforts.
- Collect data on mosquito infection rates during outbreaks to:
    - Identify primary/secondary mosquito vectors
    - Establish thresholds at which humans get infected

Arbovirus transmission ecology varies regionally and surveillance practices vary among programs (e.g., number and type of traps, frequency of sampling, etc.) based on available funding, resources, and trained staff. However, in order to quickly identify and mitigate a mosquito-borne disease outbreak, establishing and maintaining a local vector surveillance program is critical. Whereas mosquito-based surveillance is the preferred method for monitoring or predicting West Nile virus outbreaks, it is not the preferred method for monitoring or predicting DENV, CHIKV, YFV, or ZIKV outbreaks.

For these arboviruses, it is more efficient to detect cases in people. In the United States, DENV, CHIKV, and ZIKV are nationally notifiable conditions. Healthcare providers are therefore required to report any confirmed or suspected cases to local and state health departments. In turn, health departments should immediately notify state or local vector control districts or authorities.

Timely identification and response to mosquito-borne disease outbreaks like DENV, CHIKV, YFV, and ZIKV require constant communication between healthcare providers, local and state public health departments, and vector control specialists. Effective vector-based DENV, CHIKV, YFV, and ZIKV prevention involves initiating control measures such as source reduction (container elimination) and larvicide treatments before the beginning of the mosquito season, and adult reduction measures such as adulticide treatments following detection of human arbovirus activity. Containment, a combination of procedures to prevent DENV, CHIKV, ZIKV, and YFV from spreading, may be initiated whenever a suspected/confirmed imported or locally acquired case is detected. During outbreaks a combination of containment and large-scale vector control may be used to minimize vector-human contact.

Vector Control General guidelines for the diagnosis, treatment, prevention, and control of DENV and CHIKV have been published (PAHO 2011; WHO 2009).

Control of Immature Stages
An important step in Ae. aegypti and Ae. albopictus control operations is identifying the types and abundance of containers producing mosquitoes and their productivity. Different containers require specific control measures that depend on the nature of the container and how it is used.

Five general types of containers produce Ae. aegypti and Ae. albopictus:

- Phytotelmata (treeholes, leaf axils, etc.)
- Non-essential or disposable containers (food and drink containers, tires, broken appliances)
- Useful containers (water-storage vessels, potted plants and trivets, animal drinking pans, paint trays, toys, pails, septic tanks)
- Cavities in structures (fence poles, bricks, uneven floors and roofs, roof gutters, air-conditioner trays)
- Outdoor underground structures (storms drains, water meters, public wells, septic tanks) Commonly used control methods Environmental sanitation: This is the permanent elimination of containers producing Ae. aegypti and Ae. albopictus such as establishing reliable supplies of piped water, municipal refuse recycling programs (glass, metal, and plastic), used-tire recycling operations, replacing septic tanks with sewerage, etc. Larvicides: This is the use of chemicals or biological agents to kill or prevent development of mosquito immature stages. A number of agents can be used to control mosquito production in containers:
- Biological larvicides: These include products containing Bacillus thuringiensis var. israelensis (B.t.i.), spinosad, and Insect Growth Regulators (IGR's) such as juvenile hormone analogs (methoprene, pyriproxyfen) and chitin synthesis inhibitors (Diflubenzuron, Novaluron). Biological larvicides have little or no impact on non-target organisms and do not accumulate in the environment.
- Monomolecular films and oils. These products spread on the water surface forming a thin film that causes suffocation of immature mosquitoes by preventing gas exchange.

Evaluation of the effectiveness of pre-adult mosquito control may be accomplished by comparing the presence/absence and abundance of immature stages in treated containers before and after treatment or by comparing treated and untreated areas (Chadee 2009).

Topic 3– Mosquito-Borne Diseases Section Post Quiz

1. Zika is spread mostly by the bite of an infected Aedes species mosquito (Ae. aegypti and Ae. albopictus). These mosquitoes bite during the_____ .

2. Yellow fever is a viral disease carried by certain mosquitoes. The virus damages many body tissues, but especially the _____.

3. Encephalitis is a virus of the central nervous system that is passed from infected birds to humans by mosquitoes that accept birds as blood meal hosts in addition to humans.
True or False

4. Malaria is a dangerous parasitic disease not common in tropical and subtropical areas. It is transmitted by the male Anopheles mosquito.
True or False

5. Dengue fever is mostly found in the artic.
True or False

6. Chikungunya usually causes death, but the symptoms are not severe and debilitating. The most common symptoms are joint aches and pains.
True or False

7. The dog heartworm parasite also develops properly in humans and is regarded as a human health problem.
True or False

8. LAC virus is a Bunyavirus and is a zoonotic pathogen cycled between the daytime-biting treehole mosquito, Aedes triseriatus, and vertebrate amplifier hosts (chipmunks, tree squirrels) in deciduous forest habitats.
True or False

9. In addition to humans, EEE virus can produce severe disease in: horses, some birds such as pheasants, quail, ostriches and emus, and even puppies.
True or False

Prevention and Control

10. The prevention or reduction of transmission of DENV, ZIKV, and CHIKV (there is a safe and efficacious vaccine against YFV) is completely dependent on the control of mosquito vectors and limiting person mosquito contact.
True or False

Topic 4– Mosquito Control Section

Topic 4 - Section Focus: You will learn the basics of mosquito control. At the end of this section, you will be able to understand and describe the mosquito control methods and treatments. You will learn about adulticide, larvicides, pesticides and repellants. There is a post quiz at the end of this section to review your comprehension and a final examination in the Assignment for your contact hours.

Topic 4 – Scope/Background: This training section has been prepared for use as an guidebook to control mosquitoes. Professionals from local government departments or mosquito control districts develop mosquito control plans, perform tasks to control larvae and adult mosquitoes, and evaluate the effectiveness of actions taken. A successful IPM strategy can use pesticides. IPM uses a combination of ways to control mosquito populations with decisions based on surveillance, such as keeping track or count of the numbers and types of mosquitoes in an area. Surveillance is a critical component to any successful IPM program because the results from the surveillance will help determine the appropriate response to an infestation. Extensive infestations, or those where disease is present, merit a different response than will lower levels of infestations.

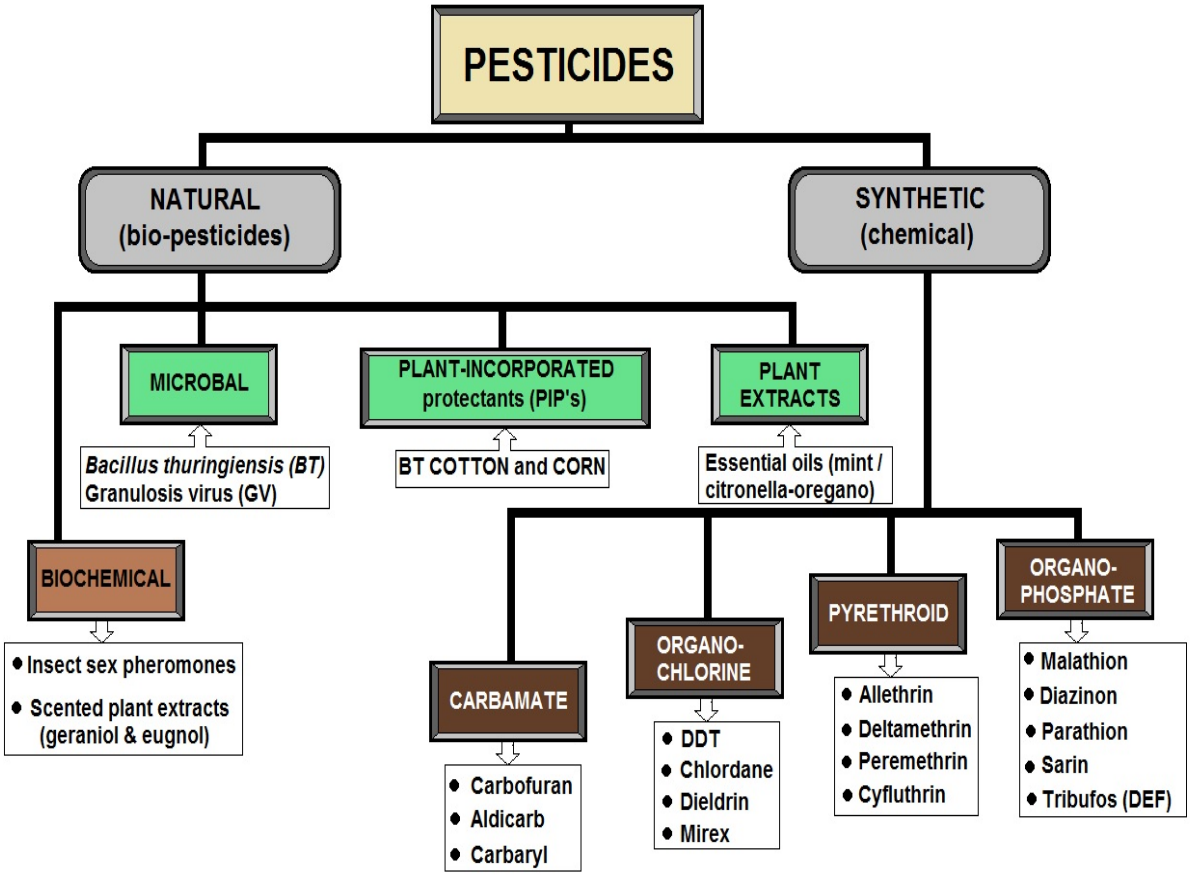
How Are Mosquitoes Controlled with Pesticides and Other Methods?

The first step in mosquito control is surveillance. Mosquito specialists conduct surveillance for diseases harbored by domestic and nonnative birds, including sentinel chickens (used as virus transmission indicators), and mosquitoes. Surveillance for larval habitats is conducted by using maps and aerial photographs, and by evaluating larval populations.

Other techniques include various light traps, biting counts, and analysis of reports from the public. Mosquito control programs also put high priority on trying to prevent a large population of adult mosquitoes from developing, so that additional controls may not be necessary.

Since mosquitoes must have water to breed, methods of prevention may include controlling water levels in lakes, marshes, ditches, or other mosquito breeding sites, eliminating small breeding sites if possible, and stocking bodies of water with fish species that feed on larvae.

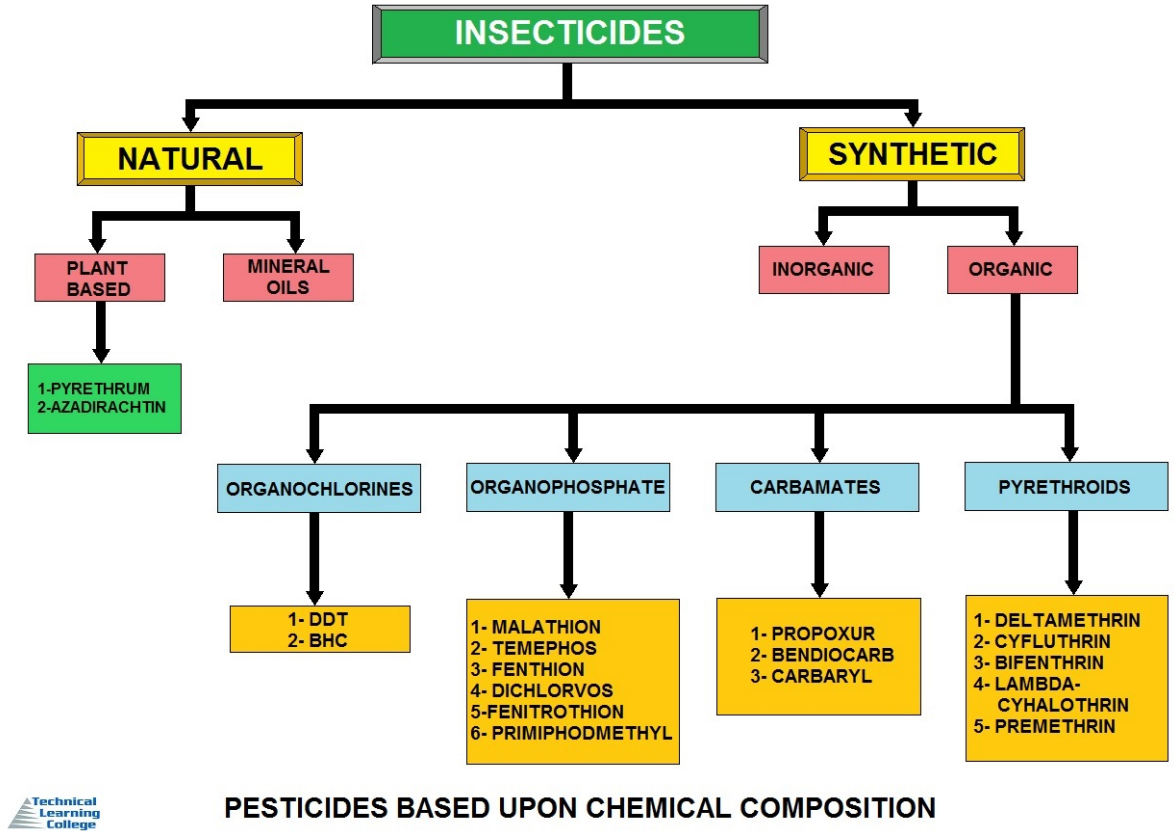
Both chemical and biological measures may be employed to kill immature mosquitoes during larval stages. *Larvicides* target larvae in the breeding habitat before they can mature into adult mosquitoes and disperse.



Technical Learning College

DIFFERENT CLASSIFICATIONS OF PESTICIDES

Basic Control Definitions



Larvicides *Always follow the pesticide label's instructions.*
Larvicides include the bacterial insecticides *Bacillus thuringiensis israelensi*s and *Bacillus sphaericus*, the insect growth inhibitor methoprene, and the organophosphate insecticide temephos. Mineral oils and other materials form a thin film on the surface of the water, which cause larvae and pupae to drown.

Liquid larvicide products are applied directly to water using backpack sprayers and truck or aircraft-mounted sprayers. Tablet, pellet, granular, and briquette formulations of larvicides are also applied by mosquito controllers to breeding areas.

Homeowners may apply Mosquito Dunks (made with Bacillus thuringiensis Berliner var. israelensis or B.t.i.) to kill mosquito larvae in the water. This natural ingredient is harmless to other living things and is biodegradable. (Summit Chemical Co. 800-227-8664.)

Larvicidal Oils *Always follow the pesticide label's instructions.*
Oils have been used for mosquito control for more than a century. The Marin / Sonoma District in California uses Golden Bear 1111, a light-viscosity oil that spreads quickly and evenly over the water surface, preventing larvae and pupae from obtaining oxygen through the surface film.

Oils have always been used as a product of last resort for the control of mosquito pupae, since this stage does not feed but does require oxygen. The only other option would be draining the source. Closer surveillance and timing of other agents and techniques can greatly reduce the need for larvicidal oils. Always follow the pesticide label's instructions.

Chemical Larvicides *Always follow the pesticide label's instructions.*
Costs and complexity of mosquito control have increased markedly since the passage of the Environmental Protection Act in 1969. The increasing number of governmental regulations and permitting bodies, rising costs of alternative chemicals, and the spreading resistance of many vector species to existing pesticides have almost completely changed or eliminated the use of chemical control agents.

Chlorinated hydrocarbons like DDT and Chlordane are very much a thing of the past, as are the use of organophosphate and carbamate insecticides. Chlorinated hydrocarbons were removed from the US market in 1964, and in 1987.

Methoprene (Altosid XR) *Always follow the pesticide label's instructions.*
Methoprene (Altosid XR) is another safe material for control of mosquito larvae. It is an insect hormone that retards the development of larvae (disrupts molting) and prevents mosquitoes from developing into adults (Clarke Mosquito Control Products, Inc. 800-323 -5727).

Altosid XR Briquettes *Always follow the pesticide label's instructions.*
Altosid XR Briquettes can be placed even on ice for season-long control. Treat swamps, ponds, and marsh areas in early spring before thawing. These extended-release briquettes will provide up to 150 days of uninterrupted mosquito control once they hit the water. They can be applied by hand and the product is labeled for use in known fish habitats.

Microbial Insecticides *Always follow the pesticide label's instructions.*
The product known as **Bti** (*Bacillus thuringiensis israelensis*) can be as effective as chemical insecticides. When the bacteria Bti encysts, it produces a protein crystal toxic to mosquito and midge larvae. Once the bacteria have been ingested, the toxin disrupts the lining of the larvae's intestine. It has no effect on a vast array of other aquatic organisms except midges in the same habitat. Bti strains are sold under the names Bactimos, Teknar and Vectobac.

Mosquito Dunks or Briquettes
Product Description: Small donut shaped and sized objects that release bacteria into water where mosquitoes are breeding. When the larvae feed on the bacteria, they die.

Target Pests: Mosquito larvae.

Areas of Use: *Anywhere*. This bacterium will not hurt pets, children, birds, or wildlife. Great for use in bird baths, ponds, lakes, swamps, rain barrels, clogged gutters, sewers that hold water, retention ponds, drainage ditches, slow moving streams, bottoms of planters and anywhere water is able to accumulate and provide mosquitoes a place to reproduce. Always follow the pesticide label's instructions.

Application: One dunk will cover about 100 sq./ft of surface area. You can break it up if treating small areas and tie it to a weight or anchor of some sort when applying it to moving water. Always follow the pesticide label's instructions.

Juvenile Hormone *Always follow the pesticide label's instructions.*
Methoprene (sold under the name Altosid) is an insect growth regulator widely used by abatement districts to control mosquito larvae.

Methoprene mimics a natural juvenile hormone, and when present in the larval habitat, it keeps immature insects from maturing into adults. Unable to metamorphose, the mosquitoes die in the pupal stage.

Vector control technicians sometimes use methoprene to reach larval sources that would otherwise be difficult or dangerous to treat. Pellets can be flushed down toilets into underground septic tanks known to be breeding house mosquitoes. The methoprene kills the mosquitoes without upsetting the septic system's bacterial digestive processes.

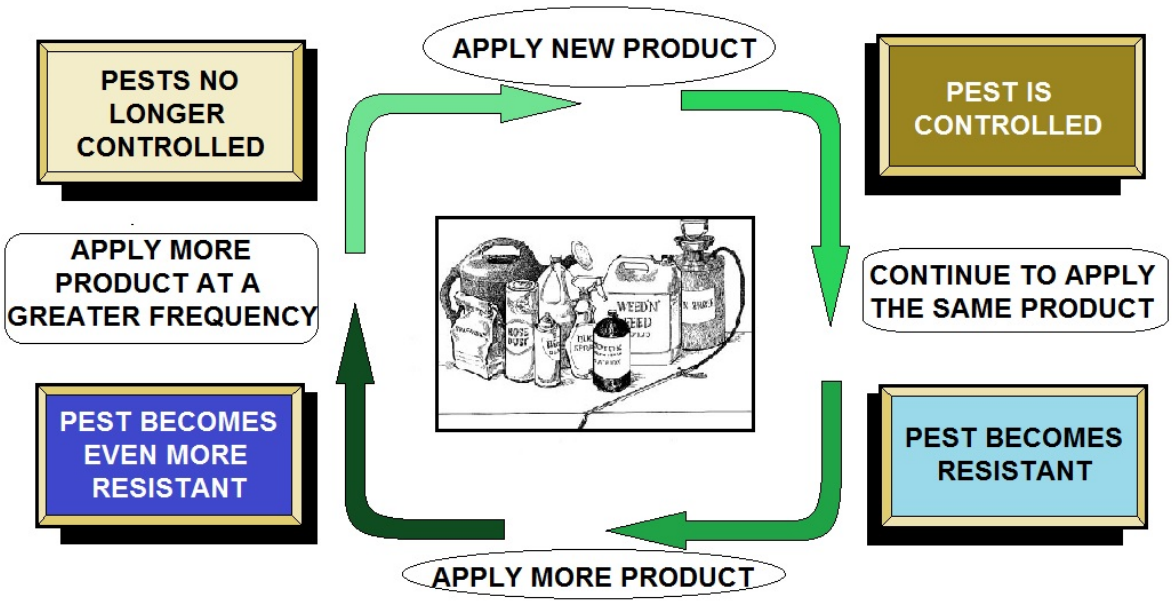
Adulticides *Always follow the pesticide label's instructions.*
Adult mosquito control may be undertaken to combat an outbreak of mosquito-borne disease or a very heavy nuisance infestation of mosquitoes in a community. Pesticides registered for this use are *adulticides* and are applied either by aircraft or on the ground, employing truck-mounted sprayers. State and local agencies commonly use the organophosphate insecticides Malathion and Naled and the synthetic pyrethroid insecticides Permethrin, Resmethrin, and Sumithrin for adult mosquito control. Always follow the pesticide label's instructions.

Mosquito adulticides are applied as ultra-low volume (**ULV**) sprays. ULV sprayers dispense very fine aerosol droplets that stay aloft and kill flying mosquitoes on contact. ULV applications involve small quantities of pesticide active ingredient in relation to the size of the area treated, typically less than 3 ounces per acre, which minimizes exposure and risks to people and the environment.

Chemical Control of Adult Mosquitoes *Always follow the pesticide label's instructions.*
Because of environmental concerns and drift, chemical pesticides are not the most popular method. But if you do use chemical pesticides, the technique used for adult mosquito control is known as ultra-low volume (**ULV**) spray.

A small quantity of the pesticide is atomized into micron-size particles and broadcast in a fog that drifts into sites where the adult mosquitoes hide. At best, control is achieved up to 300 feet away, but it does help reduce the numbers of biting mosquitoes to tolerable levels. In recent years the use of vehicle-mounted units has decreased in favor of small, hand-carried dispersal units. This allows a more precise application of the pesticide. The pesticide used for ULV spraying is pyrethrum (sold as Pyrocide), a naturally occurring substance harvested from two species of Old World chrysanthemums, or pyrethrum flowers. This material is the least toxic available for mosquito control, and it degrades into non-toxic by-products within 4 to 6 hours after spraying.

Indoor Control
Space sprays or aerosol ***"bombs,"*** containing synergized pyrethrins 0.1%, are effective against adult mosquitoes. Frequent treatments may be needed during problem periods.



PESTICIDE TREADMILL DIAGRAM

Outdoor Mosquito Control

Adulticides *Always follow the pesticide label's instructions.*
Space sprays or aerosol foggers containing pyrethrins result in rapid knockdown of adult mosquitoes. However, it is a temporary treatment with little residual effect. Residual sprays applied to tall grasses, weeds, trees, shrubs, and outbuildings, one to two days before use of the area, are effective. Use water solution or emulsions instead of oil-based formulations to prevent plant injury. Some insecticides registered for residual mosquito control include: carbaryl (**Sevin**), chlorpyrifos (**Dursban**), and Malathion. There are a number of different formulations available. Follow specific label directions when applying. Always follow the pesticide label's instructions.

Note: Malathion and carbaryl (**Sevin**) are extremely toxic to honey bees. Do not spray plants when in bloom. Mow weedy areas before treatment. Bee losses are minimized by spraying late in the afternoon when bees are gone or when temperatures are below 45°F. Malathion and methoxychlor are highly toxic to fish.

Mosquito fish (*Gambusia affinis*)
Mosquito fish can eat 100 to 500 larvae per day. They play an important role in mosquito control in ponds, canals, irrigated fields, and some other freshwater sources. The fish live two to three years; they are live-bearing and produce 3 to 4 broods each year.

Release of mosquito fish in open freshwater situations should only be carried out by certified vector technicians. Upon request, Marin / Sonoma personnel will stock ponds for residents. Mosquito fish are not a feasible control alternative for saltwater marsh mosquitoes because they cannot tolerate the changes of salinity.

Repellents
Repellents applied to the skin and clothing will prevent mosquito bites for one to five hours depending on the person, type, number of mosquitoes, and the type and percent of active ingredient in the repellent. Repellents are available as aerosol sprays, pump sprays, cream sticks, lotions, or foams.

N, N-Diethyl-m-toluamide (**DEET**) is very effective and widely used as a repellent, but it should not be used indiscriminately, as severe allergies can develop. Formulations containing high concentrations of DEET, 50% or more, should not be used on children. Formulations containing 5 to 10% DEET will work just as well as those containing 90% or more, however, they will not last as long.

Avon Skin-So-Soft has been widely used as a mosquito repellent for a number of years without being labeled. Avon Products, Inc. has recently obtained EPA approval and is now marketing some of its ***Skin-So-Soft*** products for use as a mosquito repellent.

Prevention
Since most of the mosquitoes that transmit encephalitis will not travel very far, the risk of contracting encephalitis can be minimized by controlling the mosquito breeding sites that are in close proximity to your home. Water management, to prevent mosquito breeding, is essential for control. Eggs do not hatch unless they are in water.

Remove old tires, buckets, cans, jars, broken toys, and other water-catching devices. Change water in bird baths and wading pools once or twice a week; clean out roof gutters holding stagnant water; and place tight covers over cisterns, cesspools, septic tanks, barrels, and tubs where water is stored.

Never over-apply lawn and garden irrigation; fill, drain, or treat tree holes; and drain or fill stagnant water pools, puddles, ditches, or swampy areas. Inspect water in plant containers, and water-holding stumps; keep grass mowed around bodies of water, stock ponds, and reservoirs with fish.

Window Screens
Use adequate screens with 16 x 16 or 14 x 18 mesh on windows and doors. Screen doors should open outward and close automatically.

Reducing the Number of Mosquitoes in and Around a Home
The most important step is to eliminate potential breeding habitats for mosquitoes. Get rid of any standing water around the home, including water in potted plant dishes, garbage cans, old tires, gutters, ditches, wheelbarrows, bird baths, hollow trees, and wading pools. Any standing water should be drained, including abandoned or unused swimming pools.

Mosquitoes can breed in any puddle that lasts more than 4 days. Make sure windows and screen doors are "***bug tight***." Replace outdoor lights with yellow "***bug***" lights. Wear headnets, long-sleeved shirts, and long pants if venturing into areas with high mosquito populations, such as salt marshes or wooded areas. Use mosquito repellents when necessary, always following label instructions.

Should I Take Steps to Reduce Exposure to Pesticides During Mosquito Control Spraying?
Generally, there is no need to relocate during mosquito control spraying. The pesticides have been evaluated for this use and found to pose minimal risks to human health and the environment when used according to label directions.

For example, the EPA has estimated the exposure and risks to both adults and children posed by ULV aerial and ground applications of the insecticides Malathion and Naled. For all the exposure scenarios considered, exposures ranged from 100 to 10,000 times below an amount of pesticide that might pose a health concern. These estimates assumed several spraying events over a period of weeks, and also assumed that a toddler would ingest some soil and grass in addition to dermal exposure.

Other mosquito control pesticides pose similarly low risks. (For more details on health and environmental risk considerations, visit the EPA's website and download EPA fact sheets on the specific mosquito control pesticides.)

Although mosquito control pesticides pose low risks, some people may prefer to avoid or further minimize exposure. Some common sense steps to help reduce possible exposure to pesticides include:

- Pay attention to the local media for announcements about spraying and remain indoors during applications in the immediate area.

- People who suffer from chemical sensitivities or think that spraying may aggravate a preexisting health condition, may consult their physician or local health department and take special measures to avoid exposure.
- Close windows and turn off window-unit air conditioners when spraying is taking place in the immediate area.
- Do not let children play near or behind truck-mounted applicators when they are in use.

What Doesn't Work
There have been a number of natural and man-made mosquito repellents, attractants, and predators touted as effective against mosquitoes. In truth, they don't do much good and cannot be used to effectively control mosquitoes.

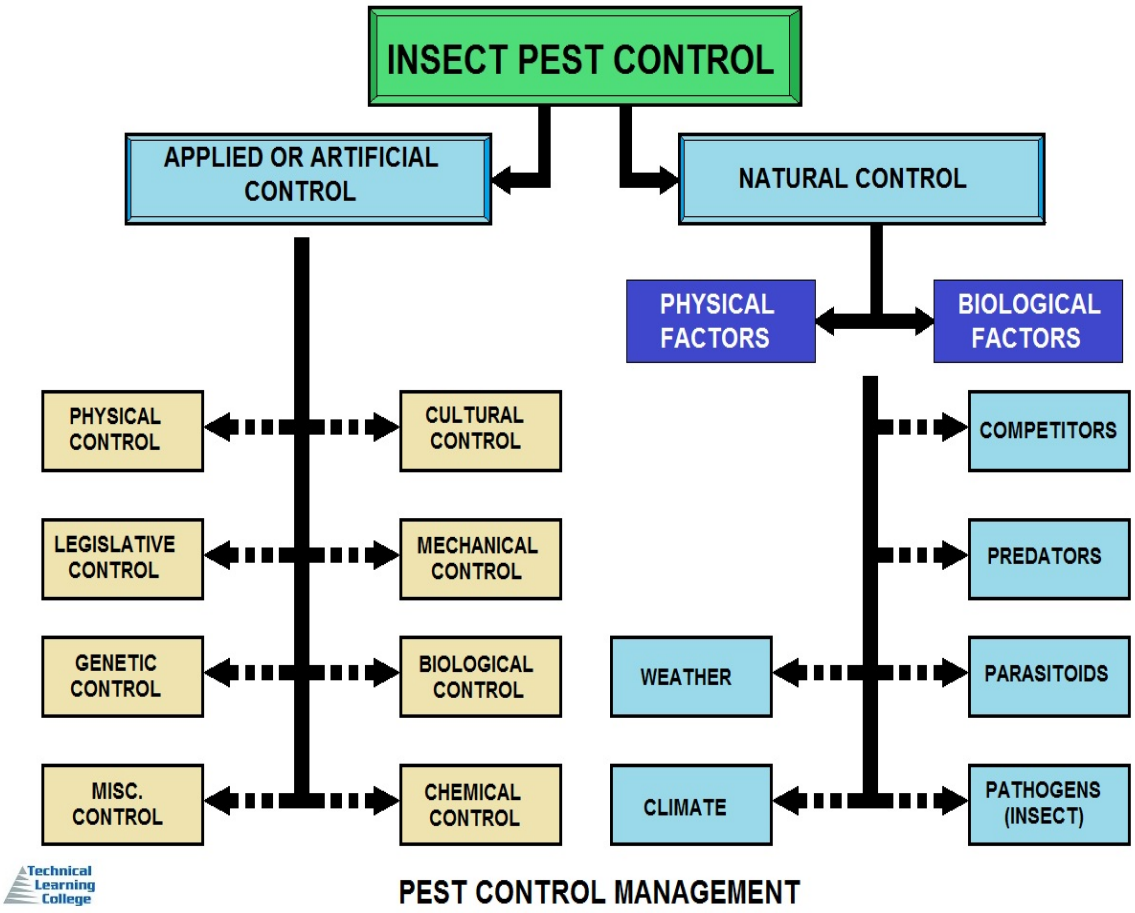
A company has been marketing a "*mosquito repellent plant*" that produces citronella and consequently repels mosquitoes. Citronella oil is produced by a number of different plants. At relatively high concentration, citronella oil is repellent to mosquitoes. Thus far, there does not appear to be adequate scientific literature to substantiate the claim that enough citronella is released by a stationary plant to repel mosquitoes. Most likely, the plant would have to be physically damaged in order to release enough citronella to repel mosquitoes, and the effect would be very short lived.

Purple Martin Diet
Dietary studies indicate that mosquitoes are insignificant in the purple martin diet. Studies of bat stomach contents show beetles as the dominant food. Ultraviolet or black lights and sonic devices indicate ineffective control.

Environmental Protection Agency
The Environmental Protection Agency (**EPA**) evaluates and registers (licenses) pesticides to ensure that they can be used safely. These pesticides include products used in the mosquito control programs that states and communities have established.

To evaluate any pesticide, the EPA assesses a wide variety of tests to determine whether a pesticide has the potential to cause adverse effects on humans, wildlife, fish, and plants, including endangered species and non-target organisms.

Pesticides and Mosquito Control Introduction



Mosquito-borne diseases affect millions of people worldwide each year. In the United States, some species of mosquitoes can transmit diseases such as encephalitis, dengue fever, and malaria to humans, and a variety of diseases to wildlife and domestic animals. To combat mosquitoes and the public health hazards they present, many states and localities have established mosquito control programs.

These programs, which are based on surveillance, can include non-chemical forms of prevention and control, as well as ground and aerial application of chemical and biological pesticides.

The mission of the Environmental Protection Agency (**EPA**) is to protect human health and the environment. The EPA reviews and approves pesticides and their labeling to ensure that the pesticides used to protect public health are applied by methods that minimize the risk of human exposure and adverse health and environmental effects. In relation to mosquito control, the Agency also serves as a source of information about pesticide and non-pesticide controls to address the concerns of the general public, news media, and the state and local agencies dealing with outbreaks of infectious diseases or heavy infestations of mosquitoes.

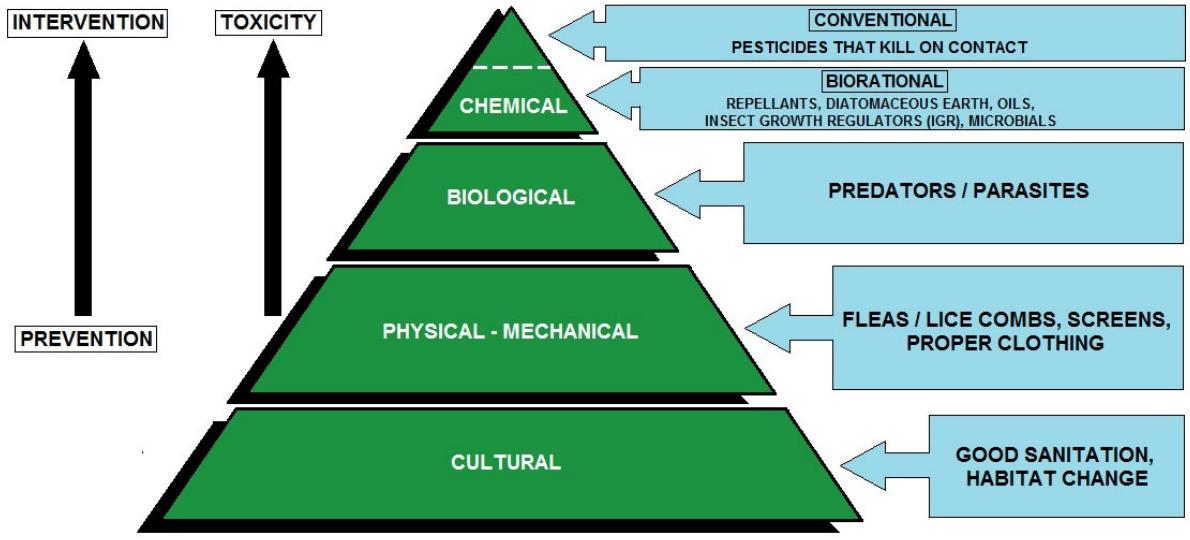
The following questions and answers provide some basic information on mosquito control, safety precautions, and information on insecticides used for mosquito control programs.

How Does EPA Ensure the Safest Possible Use of Pesticides?
The EPA must evaluate and register pesticides before they may be sold, distributed, or used in the United States. The Agency is also in the process of reassessing, and reregistering when appropriate, all older pesticides (those registered prior to 1984) to ensure that they meet current scientific standards. To evaluate a pesticide for either registration or re-registration, the EPA assesses a wide variety of potential human health and environmental effects associated with use of the product.

The producer of the pesticide must provide data from tests performed according to the EPA guidelines. These tests determine whether a pesticide has the potential to cause adverse effects on humans, wildlife, fish, and plants, including endangered species and non-target organisms.

Other tests help to assess the risks of contaminating surface water or ground water from leaching, runoff, or spray drift. If a pesticide meets the EPA requirements, the pesticide is approved for use in accordance with label directions.

However, no pesticide is 100 percent safe, and care must be exercised in the use of any pesticide.



Mosquito Non-Repellents

There have been a number of natural and man-made mosquito repellents, attractants, and predators touted as effective against mosquitoes. In truth, they don't do much good and cannot be used to effectively control mosquitoes. A company has been marketing a "mosquito repellent plant" that produces citronella and consequently repels mosquitoes. Citronella oil is produced by a number of different plants. At relatively high concentration, Citronella oil is repellent to mosquitoes. Thus far, there does not appear to be adequate scientific literature to substantiate the claim that enough Citronella is released by a stationary plant to repel mosquitoes. Most likely the plant would have to be physically damaged in order to release enough citronella to repel mosquitoes and the effect would be very short lived. Dietary studies indicate that mosquitoes are insignificant in the purple martin diet. Studies of bat stomach contents show beetles as the dominant food. Ultraviolet or black lights and sonic devices indicate ineffective control.

Mosquito control requires knowledge of the behavioral and habitat differences among species in order to plan and carry out a treatment program. The trained worker first identifies the problem species. With identity established, useful correlations are immediately available, such as the type of breeding habitat and where to search for larvae. A working knowledge of the behavior and habitats frequented by various species aids in determining the kinds of survey and control strategies best suited for the task.

While it is not possible to provide a concise, generic overview of all mosquito-control programs in the U.S., there are certain components that virtually all operational programs include as they are inherent to the principles and practices of Integrated Pest Management (IPM). Traditionally an overriding concept in organized mosquito control, the IPM acronym was not used in this sense a century ago when mosquito control was in its infancy. Typical IPM programs use a combination of resource-management techniques that include source reduction, habitat modification, biocontrol, larviciding and adulticiding, all based on surveillance data as to need and timing of application.

An important consideration in the practice of mosquito control is the advisability, whenever possible, to target control operations against immature populations. These stages are usually concentrated, relatively immobile and therefore occupy minimum acreage compared with adults, which may rapidly disperse over large areas. By targeting the immatures, it is possible to minimize the area treated and often avoid treating populated areas. Conversely, targeting adult mosquitoes may require highly visible and extensive applications of adulticides within residential and urban areas. The adulticides registered for this use are applied at levels 100 to 10,000 times below rates that would be cause for concern about exposure risk for the general public or the environment.

Nevertheless, achieving good larval control while at the same time minimizing the use of adulticides is environmentally and client friendly, and appreciated by the public. Most states have specific regulations governing the decision to apply pesticides for mosquito control. These usually involve the collection of data that substantiate the need for the application. Thus, standardized ultra-low-volume (ULV) operation on a fixed schedule is not allowed in most areas. Each application must be justified by documentation of increased mosquito activity, such as trap collections, landing or biting counts, telephone complaints, etc.

Barrier treatments, typically applied as high volume (low concentration) liquids with hand-held spray equipment using compounds with residual characteristics, are common in some U.S. locations and their use is growing. This technique is especially attractive to individual homeowners living near mosquito-producing habitats where residual chemicals applied to the vegetation along property borders can provide relief to the residents.

Portable ULV Equipment
Space sprays, generated by portable ULV equipment, often are used to provide indoor mosquito control in houses, tents, trailers, warehouses, etc. For small enclosures, commercial aerosol (bug bomb) applications are also highly effective. These applications require close review of the label to ensure the safety of inhabitants and pets when they reenter after completion of the application. This technique relies on the movement of fine droplets throughout the enclosed space in order to impinge on the mosquitoes. Alternatively, in certain circumstances residual applications of insecticides are placed on interior walls to kill mosquitoes that subsequently rest on the treated surfaces. Residual treatments, common overseas, are not routinely used in the U.S. for mosquito control, but some insecticides are labeled for this usage. Adulticides labeled for mosquito control include organophosphates, natural pyrethrins and synthetic pyrethroids. As with other pesticides, the specific attributes and methods of use for adulticides are listed on the label. It is incumbent on the pesticide applicator to perform as directed by the label.

Vertebrate Host Collection
Use mist nets, baited traps or cannon nets to capture juvenile and adult birds alive. For special studies, birds can be shot. The appropriate state and federal permits are required before collecting birds with any of these methods. Furthermore, banding permits are required if one wishes to band birds before they are released.

Mist Nets
Mist nets are perhaps the most common means of collecting wild birds. The most popular nets are about 40 feet long and 7 feet high, commonly supported by metal poles and suspended 4 to 5 feet above the ground. These nets are made of materials that are difficult to see, causing the birds to become entangled in the fibers. The mosquito control worker can then remove the birds, draw blood samples and release them at the site. Some districts band some or all of the birds prior to release.

Baited Traps
Bait traps are especially useful in trapping sparrows, grackles, doves, quail and pigeons. The bait (grain, seed or both) is scattered around the trap to attract birds. Additional bait is placed in the trap to lure the birds inside to get to the bait. Bait traps are usually equipped with large hinged openings so that the trapped birds can be removed easily. Elevated bait traps, which may be more attractive to some species of birds, are used where cats or other predators pose a threat.

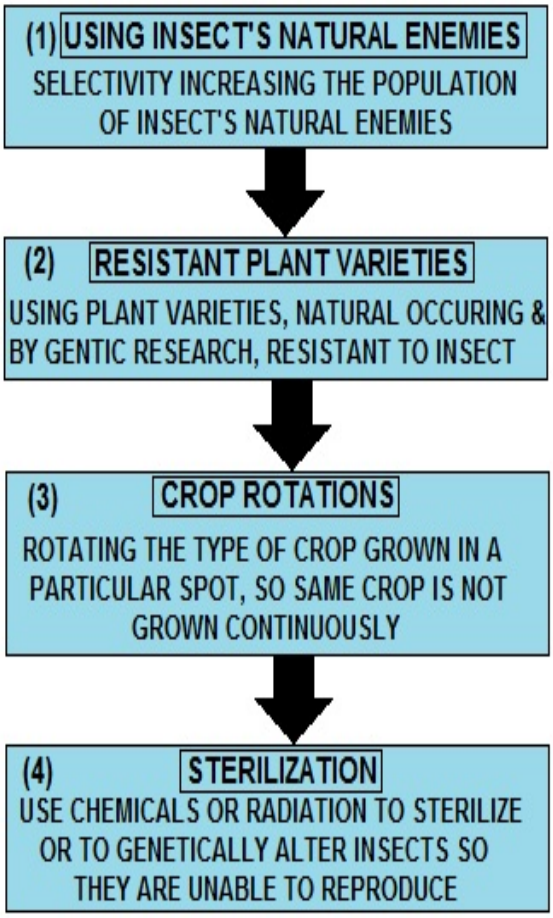
Cannon Nets
These devices are used to collect large numbers of blackbirds, pigeons, ducks, cowbirds and other birds that travel and feed in large flocks. They are the only realistic way to capture some species alive. The cannon net is designed so that one edge is anchored to the ground and the other is attached to rocket projectiles that carry the net over feeding birds. Because cannon nets are expensive and require several people to remove birds quickly to avoid injuring them, this is probably the least- used trap method.

Shooting
This expensive and time-consuming method is available when other methods are inadequate. The collector must purchase the appropriate hunting licenses. Furthermore, all game laws must be obeyed and collections can only be made during regular hunting seasons. In addition, since the birds (usually waterfowl) are killed, nonspecific blood reactions could interfere with antibody testing. Although this technique may yield valuable information, especially on the overwintering of viruses, it is used sparingly.

Sentinel Flocks
Chickens, quail, pheasant or other birds are retained in outdoor cages in specific sampling areas and bled periodically to monitor arbovirus activity. These sentinel birds are raised in a mosquito- free environment and tested prior to placement to ensure that they have not been exposed to arboviral activity elsewhere. If the sentinel bird tests positive after being placed in an area, it is a sure sign of arbovirus activity in the area. A supply of unexposed birds should be readily available to replace those that become infected. To adequately sample large areas requires numerous sentinel flocks, so this method can be costly.

BIOLOGICAL CONTROL METHODS

FOUR AREAS OF BIOLOGICAL PEST CONTROL



Specific Mosquito Adulticides Section

Malathion (Fyfanon)

Malathion is an organophosphate parasympathomimetic which binds irreversibly to cholinesterase. Malathion is an insecticide of relatively low human toxicity; however recent studies have shown that children with higher levels of malathion in their urine seem to be at an increased risk of attention deficit hyperactivity disorder. Malathion is a pesticide that is widely used in agriculture, residential landscaping, public recreation areas, and in public health pest control programs such as mosquito eradication. In the US, it is the most commonly used organophosphate insecticide.

Malathion was used in the 1980s in California to combat the Mediterranean Fruit Fly. This was accomplished on a wide scale by the near weekly aerial spraying of suburban communities for a period of several months. Formations of three or four agricultural helicopters would overfly suburban portions of Alameda County, San Bernardino County, San Mateo County, Santa Clara County, San Joaquin County, Stanislaus County, and Merced County releasing a mixture of malathion and corn syrup, the corn syrup being a bait for the fruit flies. Malathion has also been used to combat the Mediterranean fruit fly in Australia.

Malathion was sprayed in many cities to combat West Nile virus. In the Fall of 1999 and the Spring of 2000, Long Island and the five boroughs of New York City were sprayed with several pesticides, one of which was malathion. While it was claimed by some anti-pesticide groups that use of these pesticides caused a lobster die-off in Long Island Sound, there is as of yet no conclusive evidence to support this. Malathion is also used in conjunction with diesel fuel to fog an area where there is an infestation of mosquitoes. By diluting the mixture, it becomes much weaker. It is possible to dilute the mixture to the point where mosquitoes are not killed, but become more resistant to the mixture, making it less effective in subsequent foggings.

Malathion itself is of low toxicity; however, absorption or ingestion into the human body readily results in its metabolism to malaoxon, which is substantially more toxic. Chronic exposure to low levels of malathion have been hypothesized to impair memory, but this is disputed. According to the United States Environmental Protection Agency there is currently no reliable information on adverse health effects of chronic exposure to malathion.

Always follow label instructions and take steps to avoid exposure. If any exposures occur, be sure to follow the First Aid instructions on the product label carefully. For additional treatment advice, contact the Poison Control Center at 1-800-222-1222. If you wish to report a pesticide problem, please call 1-800-858-7378.

NOTE: When pesticides are used, it is the applicator’s legal responsibility to read and follow directions on the product label. Not following label directions, even if they conflict with information provided herein, is a violation of federal law.

This publication contains pesticide recommendations that are subject to change at any time. These recommendations are provided only as a guide. It is always the pesticide applicator's responsibility, by law, to read and follow all current label directions for the specific pesticide being used. Due to constantly changing labels and product registration, some of the recommendations given in this writing may no longer be legal by the time you read them. If any information in these recommendations disagrees with the label, the recommendation must

be disregarded. No endorsement is intended for products mentioned, nor is criticism meant for products not mentioned. The author and Technical Learning College (TLC) assume no liability resulting from the use of these recommendations.

Acute Exposure
Acute exposure to extremely high levels of malathion will cause body-wide symptoms whose intensity will be dependent on the severity of exposure. Possible symptoms include skin and eye irritation, cramps, nausea, diarrhea, excessive sweating, seizures and even death.
Most symptoms tend to resolve within several weeks. Malathion present in untreated water is converted to malaoxon during the chlorination phase of water treatment, so malathion should not be used in waters that may be used as a source for drinking water, or any upstream waters.

In 1981, B. T. Collins, Director of the California Conservation Corps, publicly swallowed and survived a mouthful of dilute Malathion solution. This was an attempt to demonstrate Malathion's safety following an outbreak of Mediterranean fruit flies in California. Malathion was sprayed over a 1,400 sq. miles area to control the flies.

In 1976, numerous malaria workers in Pakistan were poisoned by isomalathion, a contaminant that may be present in some preparations of malathion. It is capable of inhibiting carboxyesterase enzymes in those exposed to it. It was discovered that poor work practices had resulted in excessive direct skin contact with isomalathion contained in the malathion solutions. Implementation of good work practices, and the cessation of use of malathion contaminated with isomalathion led to the cessation of poisoning cases.

Malaoxon
Malathion breaks down into Malaoxon. In studies of the effects of long-term exposure to oral ingestion of malaoxon in rats, malaoxon has been shown to be 61 times more toxic than malathion. If malathion is used in an indoor, or other poorly ventilated environment, it can seriously poison the occupants living or working in this environment. A possible concern is that malathion being used in an outdoor environment, could enter a house or other building; however, studies by the EPA have conservatively estimated that possible exposure by this route is well below the toxic dose of malathion. Regardless of this fact, in jurisdictions which spray malathion for pest control, it is often recommended to keep windows closed and air conditioners turned off while spraying is taking place, in an attempt to minimize entry of malathion into the closed environment of residential homes.

Although current EPA regulations do not require amphibian testing, a 2008 study done by the University of Pittsburgh found that "cocktails of contaminants", which are frequently found in nature, were lethal to leopard frog tadpoles. They found that a combination of five widely used insecticides (carbaryl, chlorpyrifos, diazinon, endosulfan, and malathion) in concentrations far below the limits set by the EPA killed 99% of leopard frog tadpoles.

A May 2010 study found that in a representative sample of US children, those with higher levels of organophosphate pesticide metabolites in their urine were more likely to have attention-deficit/hyperactivity disorder. Each 10-fold increase in urinary concentration of organophosphate metabolites was associated with a 55% to 72% increase in the odds of ADHD. The study was the first investigation on children's neurodevelopment to be conducted in a group with no particular pesticide exposure

NOTE: When pesticides are used, it is the applicator's legal responsibility to read and follow directions on the product label. Not following label directions, even if they conflict with information provided herein, is a violation of federal law.

Methiocarb

Methiocarb is a chemical mainly used as a bird repellent, as an insecticide and as molluscicide. It is toxic to humans, not listed as a carcinogen, is toxic to reproductive organs, and a potent neurotoxin. Methiocarb can also cause acute toxicity in humans if anyone is exposed to it for long periods of time. Methiocarb is also a known poison to water organisms.

Methidathion

Methidathion is an organophosphate insecticide.
Always follow label instructions and take steps to avoid exposure. If any exposures occur, be sure to follow the First Aid instructions on the product label carefully. For additional treatment advice, contact the Poison Control Center at 1-800-222-1222. If you wish to report a pesticide problem, please call 1-800-858-7378.

NOTE: When pesticides are used, it is the applicator's legal responsibility to read and follow directions on the product label. Not following label directions, even if they conflict with information provided herein, is a violation of federal law.

This publication contains pesticide recommendations that are subject to change at any time. These recommendations are provided only as a guide. It is always the pesticide applicator's responsibility, by law, to read and follow all current label directions for the specific pesticide being used. Due to constantly changing labels and product registration, some of the recommendations given in this writing may no longer be legal by the time you read them. If any information in these recommendations disagrees with the label, the recommendation must be disregarded. No endorsement is intended for products mentioned, nor is criticism meant for products not mentioned. The author and Technical Learning College (TLC) assume no liability resulting from the use of these recommendations.

NOTE: When pesticides are used, it is the applicator's legal responsibility to read and follow directions on the product label. Not following label directions, even if they conflict with information provided herein, is a violation of federal law.

Fenthion (Baytex)

Fenthion is an organothiophosphate insecticide, avicide, and acaricide. Like most other organophosphates, its mode of action is via cholinesterase inhibition. Due to its relatively low toxicity towards humans and mammals, fenthion is listed as moderately toxic compound in U.S. Environmental Protection Agency and World Health Organization toxicity class

Fenthion is a contact and stomach insecticide used against many sucking, biting pests. It is particularly effective against fruit flies, leaf hoppers, cereal bugs, stem borers, mosquitoes, animal parasites, mites, aphids, codling moths, and weaver birds. It has been widely used in sugar cane, rice, field corn, beets, pome and stone fruit, citrus fruits, pistachio, cotton, olives, coffee, cocoa, vegetables, and vines. Based on its high toxicity on birds, fenthion has been used to control weaver birds and other pest-birds in many parts of the world. Fenthion is also used in cattle, swine, and dogs to control lice, fleas, ticks, flies, and other external parasites.

Amid concerns of harmful effects on environment, especially birds, Food and Drug Administration no longer approves uses of fenthion. However, fenthion has been extensively used to control adult mosquitoes. After preliminary risk assessments on human health and environment in 1998 and its revision in 1999, USEPA issued an Interim Reregistration Eligibility Decision (IRED) for fenthion in January 2001. The EPA has classified fenthion as Restricted Use Pesticide (RUP), and warrants special handling because of its toxicity.

Some common trade names for fenthion are Avigel, Avigrease, Entex, Baytex, Baycid, Dalf, DMPT, Mercaptophos, Prentox, Fenthion 4E, Queletox, and Lebaycid. Fenthion is available in dust, emulsifiable concentrate, granular, liquid concentrate, spray concentrate, ULV, and wettable powder formulations.

This course contains EPA's federal rule requirements. Please be aware that each state implements pesticide regulations that may be more stringent than EPA's regulations and these frequently are changed. Check with your state environmental/pesticide agency for more information.

Fenitrothion

Fenitrothion (IUPAC name: O,O-Dimethyl O-(3-methyl-4-nitrophenyl) phosphorothioate) is a phosphorothioate (organophosphate) insecticide. In experiments fenitrothion at sublethal doses affected the motor movement of marsupials, and at acute dose levels it reduced the energy of birds.

In chronic (low) dose tests, unexpectedly only the lowest concentration (0.011 microgram/liter) of fenitrothion depressed the growth of an algae, though all of the chronic dose levels used were toxic in other ways to the algae. Just half of fenitrothion's minimally effective dose altered the thyroid structure of a freshwater Morrel (the snakehead fish).

Fenvalerate

Fenvalerate is an insecticide. It is a mixture of four optical isomers which have different insecticidal activities. The 2-S alpha (or SS) configuration is the most insecticidally active isomer. Fenvalerate consists of about 23% of this isomer.

Fenvalerate is an insecticide of moderate mammalian toxicity. In laboratory animals, central nervous system toxicity is observed following acute or long-term exposure. Fenvalerate has applications against a wide range of pests. Residue levels are minimized by low application rates. Fenvalerate is most toxic to bees and fish. It is found in some emulsifiable concentrates, ULV, wettable powders, slow release formulations, insecticidal fogs, and granules. It is most commonly used to control insects in food, feed, and cotton products, and for the control of flies and ticks in barns and stables. Fenvalerate does not affect plants, but is active for an extended period of time. Fenvalerate may irritate the skin and eyes on contact, and is also harmful if swallowed

Always follow label instructions and take steps to avoid exposure. If any exposures occur, be sure to follow the First Aid instructions on the product label carefully. For additional treatment advice, contact the Poison Control Center at 1-800-222-1222. If you wish to report a pesticide problem, please call 1-800-858-7378.

NOTE: When pesticides are used, it is the applicator’s legal responsibility to read and follow directions on the product label. Not following label directions, even if they conflict with information provided herein, is a violation of federal law.

This publication contains pesticide recommendations that are subject to change at any time. These recommendations are provided only as a guide. It is always the pesticide applicator's responsibility, by law, to read and follow all current label directions for the specific pesticide being used. Due to constantly changing labels and product registration, some of the recommendations given in this writing may no longer be legal by the time you read them. If any information in these recommendations disagrees with the label, the recommendation must be disregarded. No endorsement is intended for products mentioned, nor is criticism meant for products not mentioned. The author and Technical Learning College (TLC) assume no liability resulting from the use of these recommendations.

Pyrethroids

To mimic the insecticidal activity of the natural compound pyrethrum another class of pesticides, pyrethroid pesticides, has been developed. These are non-persistent, which are sodium channel modulators, and are much less acutely toxic than organophosphates and carbamates. Compounds in this group are often applied against household pests.

The pyrethroids are a large family of modern synthetic insecticides similar to the naturally derived botanical pyrethrins. They are highly repellent to MOST INSECTS AND ESPECIALLY termites, which may contribute to the effectiveness of the termiticide barrier. They have been modified to increase their stability in the natural environment. They are widely used in agriculture, homes, and gardens. Some examples are bifenthrin, cyfluthrin, cypermethrin, deltamethrin, and permethrin. They may be applied alone or in combination with other insecticides. Pyrethroids are formulated as emusifiable concentrates (EC), wettable powders (WP), granulars (G), and aerosols. Certain pyrethroids exhibit striking neurotoxicity in laboratory animals when administered by intravenous injection, and some are toxic by the oral route. Systemic toxicity by inhalation and dermal absorption are low, however—there have been very few systemic poisonings of humans by pyrethroids. Though limited absorption may account for the low toxicity of some pyrethroids, rapid biodegradation by mammalian liver enzymes (ester hydrolysis and oxidation) is probably the major factor responsible. This course contains pesticide recommendations that are subject to change at any time. These recommendations are provided only as a guide. It is always the pesticide applicator's responsibility, by law, to read and follow all current label directions for the specific pesticide being used. Due to constantly changing labels and product registration, some of the recommendations given in this writing may no longer be legal by the time you read them. If any information in these recommendations disagrees with the label, the recommendation must be disregarded. No endorsement is intended for products mentioned, nor is criticism meant for products not mentioned. The author and Technical Learning College (TLC) assume no liability resulting from the use of these recommendations.

Most pyrethroid metabolites are promptly excreted, at least in part, by the kidney. In response to dermal exposure, some persons may experience a skin sensitivity called paresthesia. The symptoms are similar to sunburn sensation of the face and especially the eyelids.

Sweating, exposure to sun or heat, and application of water aggravate the disagreeable sensations. This is a temporary effect that dissipates within 24 hours. For first aid, wash with soap and water to remove as much residue as possible, and then apply a vitamin E oil preparation or cream to the affected area.

Paresthesia is caused more by pyrethroids whose chemical makeup includes cyano- groups: fenvalerate, cypermethrin, and fluvalinate. In addition to protecting themselves from future exposure, persons who have experienced paresthesia should choose a pyrethroid with a different active ingredient, as well as a wettable powder or microencapsulated formulation.

About These Pesticides
Pyrethrins and pyrethroids are insecticides included in over 3,500 registered products, many of which are used widely in and around households, including on pets, in mosquito control, and in agriculture. The use of pyrethrins and pyrethroids has increased during the past decade with the declining use of organophosphate pesticides, which are more acutely toxic to birds and mammals than the pyrethroids. This change to less acutely toxic pesticides, while generally beneficial, has introduced certain new issues. For example, residential uses of pyrethrins and pyrethroids may result in urban runoff, potentially exposing aquatic life to harmful levels in water and sediment.

Pyrethrins are botanical insecticides derived from chrysanthemum flowers most commonly found in Australia and Africa. They work by altering nerve function, which causes paralysis in target insect pests, eventually resulting in death.

Pyrethroids are synthetic chemical insecticides whose chemical structures are adapted from the chemical structures of the pyrethrins and act in a similar manner to pyrethrins. Pyrethroids are modified to increase their stability in sunlight.

Most pyrethrins and some pyrethroid products are formulated with synergists, such as piperonyl butoxide and MGK-264, to enhance the pesticidal properties of the product. These synergists have no pesticidal effects of their own but enhance the effectiveness of other chemicals.

Pyrethrins, a single pesticide active ingredient, contain six components that have insecticidal activity:
pyrethrin 1, pyrethrin 2, cinerin 1, cinerin 2, jasmolin 1, and jasmolin 2

Pyrethroids include:
Allethrin stereoisomers, Bifenthrin, Beta-Cyfluthrin, Cyfluthrin, Cypermethrin, Cyphenothrin, Deltamethrin, Esfenvalerate, Fenpropathrin, Tau-Fluvalinate, Lambda-Cyhalothrin, Gamma Cyhalothrin, Imiprothrin, 1RS cis-Permethrin, Permethrin, Prallethrin, Resmethrin, Sumithrin (d-phenothrin), Tefluthrin, Tetramethrin, Tralomethrin, and Zeta-Cypermethrin

Synergists include:
MGK-264 and Piperonyl butoxide

Always follow label instructions and take steps to avoid exposure. If any exposures occur, be sure to follow the First Aid instructions on the product label carefully. For additional treatment

advice, contact the Poison Control Center at 1-800-222-1222. If you wish to report a pesticide problem, please call 1-800-858-7378.

NOTE: When pesticides are used, it is the applicator’s legal responsibility to read and follow directions on the product label. Not following label directions, even if they conflict with information provided herein, is a violation of federal law.

This publication contains pesticide recommendations that are subject to change at any time. These recommendations are provided only as a guide. It is always the pesticide applicator's responsibility, by law, to read and follow all current label directions for the specific pesticide being used. Due to constantly changing labels and product registration, some of the recommendations given in this writing may no longer be legal by the time you read them.

If any information in these recommendations disagrees with the label, the recommendation must be disregarded. No endorsement is intended for products mentioned, nor is criticism meant for products not mentioned. The author and Technical Learning College (TLC) assume no liability resulting from the use of these recommendations.

NOTE: When pesticides are used, it is the applicator’s legal responsibility to read and follow directions on the product label. Not following label directions, even if they conflict with information provided herein, is a violation of federal law.

Permethrin

General Information

Permethrin is a broad-spectrum pyrethroid insecticide. It is available in dusts, emulsifiable concentrates, smokes, ULV concentrates, and wettable-powder formulations.

The historical development of the synthetic pesticides called pyrethroids is based on the pyrethrins, which are derived from chrysanthemums. Pyrethrins are a "natural" environmental product that is of low toxicity to mammals. They are highly photolabile and degrade quickly in sunlight, and the cost of reapplying them has limited their widespread agricultural use. Pyrethroids have been synthesized to be similar to pyrethrins yet more stable in the environment. Evidence suggests that they have a very large margin of safety when used as directed by the label (Aldridge, 1990; Chen et al., 1991; Snodgrass, 1992).

Commercial pyrethroid products commonly use petroleum distillates as carriers. Some commercial products also contain OP or carbamate insecticides because the rapid paralytic effect of pyrethrins on insects ("quick knockdown") is not always lethal (Cheremisinoff and King, 1994). Pyrethroids are formulated as emulsifiable concentrates, wettable powders, granules, and concentrates for ULV application.

Always follow label instructions and take steps to avoid exposure. If any exposures occur, be sure to follow the First Aid instructions on the product label carefully. For additional treatment advice, contact the Poison Control Center at 1-800-222-1222. If you wish to report a pesticide problem, please call 1-800-858-7378.

NOTE: When pesticides are used, it is the applicator’s legal responsibility to read and follow directions on the product label. Not following label directions, even if they conflict with information provided herein, is a violation of federal law.

This publication contains pesticide recommendations that are subject to change at any time. These recommendations are provided only as a guide. It is always the pesticide applicator's responsibility, by law, to read and follow all current label directions for the specific pesticide being used. Due to constantly changing labels and product registration, some of the recommendations given in this writing may no longer be legal by the time you read them. If any information in these recommendations disagrees with the label, the recommendation must be disregarded. No endorsement is intended for products mentioned, nor is criticism meant for products not mentioned. The author and Technical Learning College (TLC) assume no liability resulting from the use of these recommendations.

NOTE: When pesticides are used, it is the applicator’s legal responsibility to read and follow directions on the product label. Not following label directions, even if they conflict with information provided herein, is a violation of federal law.

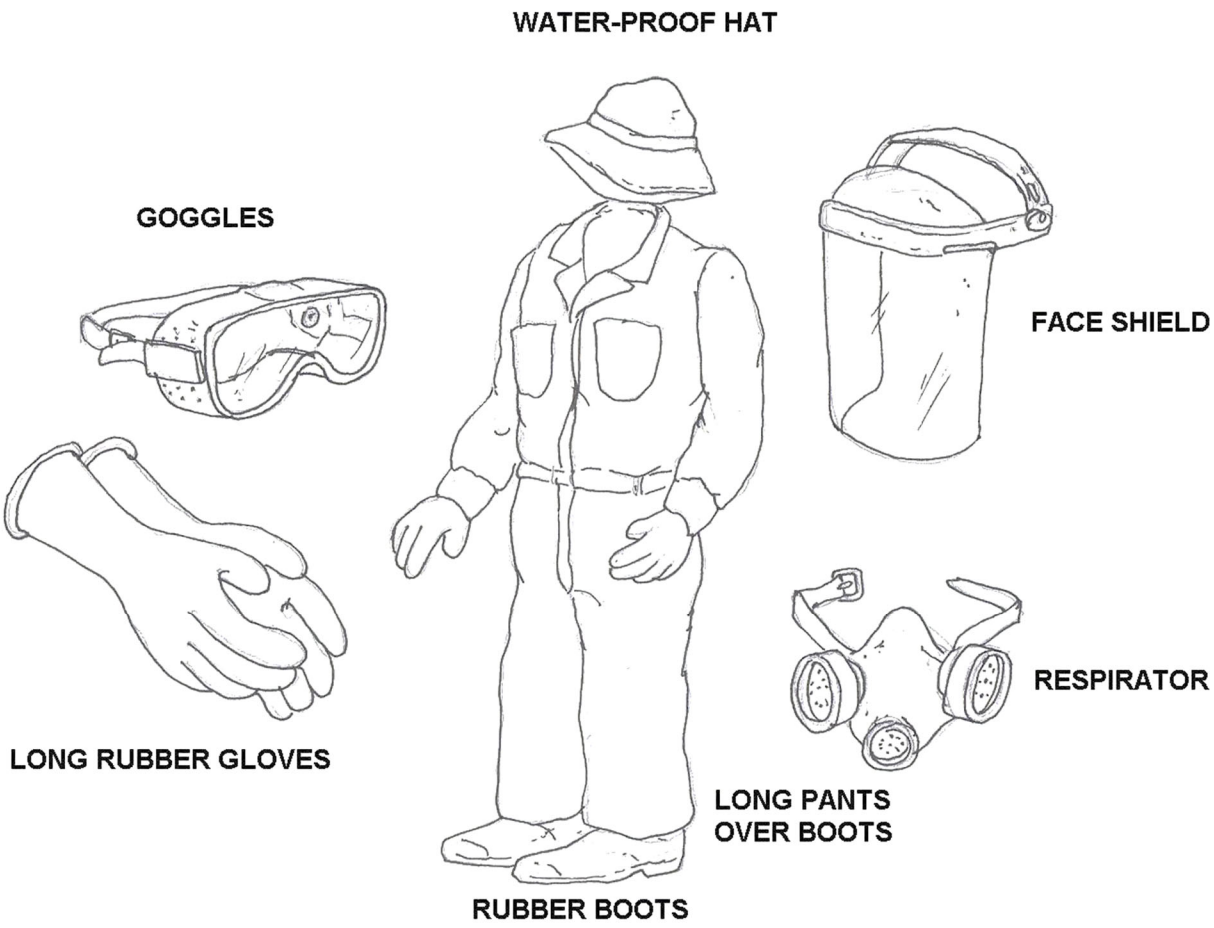
Resmethrin

Resmethrin is a pyrethroid insecticide with many uses, including control of the adult mosquito population. The resmethrin molecule has four stereoisomers determined by cis-trans orientation around a carbon triangle and chirality. Technical resmethrin is a mixture of (1R, trans)-, (1R, cis)-, (1S, trans)-, (1S, cis)- isomers, typically in a ratio of 4:1:4:1. The 1R isomers (both trans and cis) show strong insecticidal activity, while the 1S isomers do not. The (1R, trans)- isomer is also known as Bioresmethrin, (+)-trans-Resmethrin, or d-trans-Resmethrin; although bioresmethrin has been used alone as a pesticide active ingredient, it is not now registered as a separate Active Ingredient (AI) by the U.S. EPA. The (1R, cis)- isomer is known as Cismethrin, but this is also not registered in the U.S. for use alone as a pesticide AI. Commercial trade names for products that contain resmethrin are Chrysron, Crossfire, Pynosect, Raid Flying Insect Killer, Scourge, Sun-Bugger #4, SPB-1382, Synthrin, Syntox, Vectrin and Whitmire PT-110

Always follow label instructions and take steps to avoid exposure. If any exposures occur, be sure to follow the First Aid instructions on the product label carefully. For additional treatment advice, contact the Poison Control Center at 1-800-222-1222. If you wish to report a pesticide problem, please call 1-800-858-7378.

NOTE: When pesticides are used, it is the applicator’s legal responsibility to read and follow directions on the product label. Not following label directions, even if they conflict with information provided herein, is a violation of federal law.

This publication contains pesticide recommendations that are subject to change at any time. These recommendations are provided only as a guide. It is always the pesticide applicator's responsibility, by law, to read and follow all current label directions for the specific pesticide being used. Due to constantly changing labels and product registration, some of the recommendations given in this writing may no longer be legal by the time you read them. If any information in these recommendations disagrees with the label, the recommendation must be disregarded. No endorsement is intended for products mentioned, nor is criticism meant for products not mentioned. The author and Technical Learning College (TLC) assume no liability resulting from the use of these recommendations.



PESTICIDE PROTECTIVE EQUIPMENT DIAGRAM #1

Skin contact is the most common cause of pesticide poisoning for applicators and some pesticides enter the body through the skin quite readily. At the time of mixing, pesticides are more concentrated and the likelihood of injury is increased during this time. Some parts of the body absorb pesticides extremely fast (within a few minutes) and need extra protection. Two such areas are the head and body area between the navel and about mid-thigh. If any pesticide is spilled in this area, wash it off immediately and change clothing. It is best to avoid direct contact with pesticides by wearing the proper Personal Protective Equipment (PPE) as specified on the label of the pesticide you intend to use.

PESTICIDE PROTECTIVE EQUIPMENT DIAGRAM #2

Label Signal Words

One of four words are required on a pesticide label to indicate the relative toxicity of the pesticide:

Danger-Poison or Danger - Toxicity category I - Highly toxic (fatal if ingested)

Danger- Toxicity category I - Highly corrosive to eyes and skin

Warning- Toxicity category II - Moderately toxic

Caution- Toxicity category III and IV - Least toxic

Malathion for Mosquito Control Summary

Officials responsible for mosquito control programs make decisions to use pesticides based on an evaluation of the risks to the general public from diseases transmitted by mosquitoes or on an evaluation of the nuisance level that communities can tolerate from a mosquito infestation. Based on surveillance and monitoring, mosquito control officials select specific pesticides and other control measures that best suit local conditions in order to achieve effective control of mosquitoes with the least impact on human health and the environment. It is especially important to conduct effective mosquito prevention programs by eliminating breeding habitats or applying pesticides to control the early life stages of the mosquito.

Prevention programs, such as elimination of any standing water that could serve as a breeding site, help reduce the adult mosquito population and the need to apply other pesticides for adult mosquito control. Since no pesticide can be considered 100 percent safe, pesticide applicators and the general public should always exercise care and follow specified safety precautions during use to reduce risks.

What is Malathion?
Malathion is an organophosphate (**OP**) insecticide that has been registered for use in the United States since 1956. It is used in agriculture, residential gardens, public recreation areas, and in public health pest control programs.

When applied in accordance with the rate of application and safety precautions specified on the label, Malathion can be used to kill mosquitoes without posing unreasonable risks to human health or the environment.

How is Malathion Used in Mosquito Control?
The mosquito goes through four distinct stages during its life cycle: egg, larva, pupa, and adult. Malathion is an ***adulticide***, used to kill adult mosquitoes. In mosquito control programs conducted by state or local authorities, Malathion is applied by truck-mounted or aircraft-mounted sprayers.

Malathion is applied as an ultra-low volume (**ULV**) spray. ULV sprayers dispense very fine aerosol droplets that stay aloft and kill mosquitoes on contact. ULV applications involve small quantities of pesticide active ingredient in relation to the size of the area treated. For mosquito control, Malathion is applied at a maximum rate of 0.23 pounds (or about 2.5 fluid ounces) of active ingredient per acre, which minimizes exposure and risks to people and the environment.

Malathion can be used for public health mosquito control programs without posing unreasonable risks to the general population when applied according to the label. The EPA has estimated the exposure and risks to both adults and children posed by ULV aerial and ground applications of Malathion.

Because of the very small amount of active ingredient released per acre of ground, the estimates found that for all scenarios considered, exposures were hundreds or even thousands of times below an amount that might pose a health concern. These estimates assumed several spraying events over a period of weeks, and also assumed that a toddler would ingest some soil and grass in addition to skin and inhalation exposure.

However, at high doses, Malathion, like other organophosphates, can over stimulate the nervous system, causing nausea, dizziness, or confusion. Severe high-dose poisoning with any organophosphate can cause convulsions, respiratory paralysis, and death.

Does Malathion Pose Risks to Wildlife or the Environment?
Malathion used in mosquito control programs does not pose unreasonable risks to wildlife or the environment. Malathion degrades rapidly in the environment, especially in moist soil, and it displays low toxicity to birds and mammals. Malathion is highly toxic to insects, including beneficial insects such as honeybees. For that reason, the EPA has established specific precautions on the label to reduce such risks. Always follow the pesticide label's instructions.

What is the Current Regulatory Status of Malathion?
As part of its responsibility to re-assess all older pesticides registered before 1984, the EPA is currently reviewing Malathion as part of its reregistration process. The review of Malathion was scheduled for completion in 2002. A risk assessment covering all uses of Malathion is currently available to the public for review at http://www.epa.gov/oppsrrd1/op/Malathion.htm.

Visit the EPA Web site for the most current information on Malathion.

Larvicides for Mosquito Control

The Environmental Protection Agency (**EPA**) evaluates and registers (**licenses**) pesticides to ensure that they can be used safely. These pesticides include products used in the mosquito control programs that states and communities have established. To evaluate any pesticide, the EPA assesses a wide variety of tests to determine whether a pesticide has the potential to cause adverse effects on humans, wildlife, fish and plants, including endangered species and non-target organisms.

Officials responsible for mosquito control programs make decisions to use pesticides based on an evaluation of the risks to the general public from diseases transmitted by mosquitoes or on an evaluation of the nuisance level that communities can tolerate from a mosquito infestation.

Based on surveillance and monitoring, mosquito control officials select specific pesticides and other control measures that best suit local conditions in order to achieve effective control of mosquitoes with the least impact on human health and the environment. It is especially important to conduct effective mosquito prevention programs by eliminating breeding habitats or applying pesticides to control the early life stages of the mosquito.

Prevention programs, such as the elimination of any standing water that could serve as a breeding site, help reduce the adult mosquito population and the need to apply other pesticides for adult mosquito control.

Since no pesticide can be considered 100 percent safe, pesticide applicators and the general public should always exercise care and follow specified safety precautions during use to reduce risks. The next section will provide basic information on larvicides, a type of pesticide used in mosquito control programs. Visit the EPA Web site for the most current information on Malathion.

Larvicide Introduction

Larvicides kill mosquito larvae. Larvicides include biological insecticides, such as the microbial larvicides ***Bacillus sphaericus*** and ***Bacillus thuringiensis israelensis***. Larvicides include other pesticides, such as temephos, methoprene, oils, and monomolecular films. Larvicide treatment of breeding habitats help reduce the adult mosquito population in nearby areas. Always follow the pesticide label's instructions.

How are Larvicides Used in Mosquito Control?
State and local agencies in charge of mosquito control typically employ a variety of techniques in an Integrated Pest Management (**IPM**) program. An IPM approach includes *surveillance, source reduction*, *larviciding*, and *adulticiding* to control mosquito populations.

Since mosquitoes must have water to breed, source reduction can be as simple as turning over trapped water in a container to undertaking large-scale engineering and management of marsh water levels. Larviciding involves applying pesticides to breeding habitats to kill mosquito larvae. Larviciding can reduce overall pesticide usage in a control program.

Killing mosquito larvae before they emerge as adults can reduce or eliminate the need for ground or aerial application of pesticides to kill adult mosquitoes.

What are Microbial Larvicides?
Microbial larvicides are bacteria that are registered as pesticides for control of mosquito larvae in outdoor areas such as irrigation ditches, flood water, standing ponds, woodland pools, pastures, tidal water, fresh or saltwater marshes, and storm water retention areas.

Duration of effectiveness depends primarily on the mosquito species, the environmental conditions, the formulation of the product, and water quality.

Microbial larvicides may be used along with other mosquito control measures in an IPM program. The microbial larvicides used for mosquito control are *Bacillus thuringiensis israelensis (Bti)* and *Bacillus sphaericus (B. sphaericus)*.

Bacillus thuringiensis israelensis is a naturally occurring soil bacterium registered for control of mosquito larvae. *Bti* was first registered by the EPA as an insecticide in 1983. Mosquito larvae eat the *Bti* product that is made up of the dormant spore form of the bacterium and an associated pure toxin. The toxin disrupts the gut in the mosquito by binding to receptor cells present in insects, but not in mammals. There are 26 Bti products registered for use in the United States. Aquabac, Teknar, Vectobac, and LarvX are examples of common trade names for the mosquito control products.

Bacillus sphaericus is a naturally occurring bacterium that is found throughout the world. *B. sphaericus* was initially registered by the EPA in 1991 for use against various kinds of mosquito larvae. Mosquito larvae ingest the bacteria, and as with *Bti*, the toxin disrupts the gut in the mosquito by binding to receptor cells present in insects but not in mammals.

VectoLex CG and WDG are registered *B. sphaericus* products and are effective for approximately one to four weeks after application. Always follow the pesticide label's instructions.

Do Microbial Larvicides Pose Risks to Human Health?
The microbial pesticides have undergone extensive testing prior to registration. They are essentially nontoxic to humans, so there are no concerns for human health effects with *Bti* or *B. sphaericus* when they are used according to label directions.

Do Microbial Larvicides Pose Risks to Wildlife or the Environment?
Extensive testing shows that microbial larvicides do not pose risks to wildlife, nontarget species, or the environment, when used according to label directions.

What is Methoprene?
Methoprene is a compound first registered by the EPA in 1975 that mimics the action of an insect growth-regulating hormone and prevents the normal maturation of insect larvae. It is applied to water to kill mosquito larvae, and it may be used along with other mosquito control measures in an IPM program. Altosid is the name of the methoprene product used in mosquito control and is applied as briquettes (similar in form to charcoal briquettes), pellets, sand granules, and liquids. The liquid and pelletized formulations can be applied by helicopter and fixed-wing aircraft.

Does Methoprene Pose Risks to Human Health?
Methoprene, used for mosquito control according to its label directions, does not pose unreasonable risks to human health. In addition to posing low toxicity to mammals, there is little opportunity for human exposure, since the material is applied directly to ditches, ponds, marshes, or flooded areas that are not drinking water sources.

Does Methoprene Pose Risks to Wildlife or the Environment?
Methoprene used in mosquito control programs does not pose unreasonable risks to wildlife or the environment. Toxicity of methoprene to birds and fish is low, and it is nontoxic to bees.

Methoprene breaks down quickly in water and soil and will not leach into ground water. Methoprene mosquito control products present minimal acute and chronic risk to freshwater fish, freshwater invertebrates, and estuarine species.

What is Temephos?
Temephos is an organophosphate (**OP**) pesticide registered by the EPA in 1965 to control mosquito larvae, and it is the only organophosphate with larvicidal use. It is an important resistance management tool for mosquito control programs; its use helps prevent mosquitoes from developing resistance to the bacterial larvicides.

Temephos is used in areas of standing water, shallow ponds, swamps, marshes, and intertidal zones. It may be used along with other mosquito control measures in an IPM program. Abate is the trade name of the temephos product used for mosquito control. Temephos is applied most commonly by helicopter, but can be applied by backpack sprayers, fixed-wing aircraft, and right-of-way sprayers in either liquid or granular form.

Does Temephos Pose Risks to Human Health?
Temephos, applied according to the label for mosquito control, does not pose unreasonable risks to human health. It is applied to water, and the amount of temephos is very small in relation to the area covered, less than 1 ounce of active ingredient per acre for the liquid and 8 ounces per acre for the granular formulations.

Temephos breaks down within a few days in water, and post-application exposure is minimal. However, at high dosages, temephos, like other OPs, can over stimulate the nervous system causing nausea, dizziness, and confusion.

Does Temephos Pose Risks to Wildlife or the Environment?
Because temephos is applied directly to water, it is not expected to have a direct impact on terrestrial animals or birds. Current mosquito larviciding techniques pose some risk to nontarget aquatic species and the aquatic ecosystem. Although temephos presents relatively low risk to birds and terrestrial species, available information suggests that it is more toxic to aquatic invertebrates than alternative larvicides.

For this reason, the EPA is limiting temephos use to areas where less-hazardous alternatives would not be effective, specifying intervals between applications, and limiting the use of high application rates.

What is the Current Regulatory Status of Temephos?
As part of its responsibility to reassess all older pesticides registered before 1984, the EPA completed its revised risk assessments for temephos in July 2001, and has issued risk management decisions in the final reregistration eligibility decision (**RED**).
The RED document is available on the EPA Web site at:
www.epa.gov/oppsrrd1/REDs/temephos_red.htm.

What are Monomolecular Films?
Monomolecular films are low-toxicity pesticides that spread a thin film on the surface of the water that makes it difficult for mosquito larvae, pupae, and emerging adults to attach to the water's surface, causing them to drown. Films may remain active typically for 10-14 days on standing water, and have been used in the United States in floodwaters, brackish waters, and ponds. They may be used along with other mosquito control measures in an IPM program. They are also known under the trade names Arosurf MSF and Agnique MMF.

Do Monomolecular Films Pose Risks to Human Health?
Monomolecular films, used according to label directions for larva and pupa control, do not pose a risk to human health. In addition to low toxicity, there is little opportunity for human exposure, since the material is applied directly to ditches, ponds, marshes, or flooded areas that are not drinking water sources.

Do Films Pose Risks to Wildlife or the Environment?
Monomolecular films, used according to label directions for larva and pupa control, pose minimal risks to the environment. They do not last very long in the environment, and are usually applied only to standing water, such as roadside ditches, woodland pools, or containers that contain few nontarget organisms.

What are Oils?
Oils, like films, are pesticides used to form a coating on top of water to drown larvae, pupae, and emerging adult mosquitoes. They are specially derived from petroleum distillates and have been used for many years in the United States to kill aphids on crops and orchard trees, and to control mosquitoes. They may be used along with other mosquito control measures in an IPM program.

Trade names for oils used in mosquito control are Bonide, BVA2, and Golden Bear-1111, (GB-1111). Always follow the pesticide label's instructions.

Do Oils Pose Risks to Human Health?
Oils, used according to label directions for larva and pupa control, do not pose a risk to human health. In addition to low toxicity, there is little opportunity for human exposure, since the material is applied directly to ditches, ponds, marshes, or flooded areas that are not drinking water sources.

Do Oils Pose Risks to Wildlife or the Environment?
Oils, if misapplied, may be toxic to fish and other aquatic organisms. For that reason, the EPA has established specific precautions on the label to reduce such risks.

Naled for Mosquito Control

The Environmental Protection Agency (**EPA**) evaluates and registers (**licenses**) pesticides to ensure that they can be used safely. These pesticides include products used in the mosquito control programs that states and communities have established. To evaluate any pesticide, the EPA assesses a wide variety of tests to determine whether a pesticide has the potential to cause adverse effects on humans, wildlife, fish and plants, including endangered species and non-target organisms.

Officials responsible for mosquito control programs make decisions to use pesticides based on an evaluation of the risks to the general public from diseases transmitted by mosquitoes or on an evaluation of the nuisance level that communities can tolerate from a mosquito infestation.

Based on surveillance and monitoring, mosquito control officials select specific pesticides and other control measures that best suit local conditions in order to achieve effective control of mosquitoes with the least impact on human health and the environment.

It is especially important to conduct effective mosquito prevention programs by eliminating breeding habitats or applying pesticides to control the early life stages of the mosquito. Prevention programs, such as elimination of any standing water that could serve as a breeding site, help reduce the adult mosquito population and the need to apply other pesticides for adult mosquito control.

Since no pesticide can be considered 100 percent safe, pesticide applicators and the general public should always exercise care and follow specified safety precautions during use to reduce risks.

Naled Introduction

Naled is an organophosphate (**OP**) insecticide that has been registered since 1959 for use in the United States. It is used primarily for controlling adult mosquitoes, but Naled is also used on food and feed crops, and in greenhouses. When applied in accordance with the rate of application and the safety precautions specified on the label, Naled can be used to kill mosquitoes without posing unreasonable risks to human health or the environment.

How is Naled Used in Mosquito Control?
Naled is an *adulticide* used to kill adult mosquitoes. In mosquito control programs conducted by state or local authorities, Naled is applied by truck-mounted or aircraft-mounted sprayers.

Naled is applied as an ultra-low volume (**ULV**) spray. ULV sprayers dispense very fine aerosol droplets that stay aloft and kill mosquitoes on contact. ULV applications involve small quantities of pesticide active ingredient in relation to the size of the area treated.

For mosquito control, Naled is applied at a maximum rate of 0.05 pounds (0.8 ounce) of active ingredient per acre for aerial application and 0.1 pounds (0.33 ounce) per acre for ground application, which minimizes exposure and risks to people and the environment.

Does Naled Pose Risks to Human Health?
Naled can be used for public health mosquito control programs without posing unreasonable risks to the general population when applied according to the label. The EPA has estimated the exposure and risks to both adults and children posed by ULV aerial and ground applications of Naled. Because of the very small amount of active ingredient released per acre of ground, the estimates found that for all scenarios considered, exposures were hundreds or even thousands of times below an amount that might pose a health concern.

These estimates assumed several spraying events over a period of weeks, and also assumed that a toddler would ingest some soil and grass in addition to skin and inhalation exposure. However, at high doses, Naled like other organophosphates, can over stimulate the nervous system causing nausea, dizziness, or confusion. Severe high-dose poisoning with any organophosphate can cause convulsions, respiratory paralysis, and death.

Does Naled Pose Risks to Wildlife or the Environment?
Naled used in mosquito control programs does not pose unreasonable risks to wildlife or the environment. Always follow the pesticide label's instructions.

Naled degrades rapidly in the environment, and it displays low toxicity to birds and mammals. Acute and chronic risk to fish is not expected, but there is potential for risks to invertebrates from the repeated use of Naled. Naled is highly toxic to insects, including beneficial insects such as honeybees. For that reason, the EPA has established specific precautions on the label to reduce such risk.

What is the Current Regulatory Status of Naled?
As part of its responsibility to reassess all older pesticides registered before 1984, the EPA reviewed Naled as part of its reregistration process. The review of Naled was completed in 2002. A risk assessment covering all uses of Naled is available to the public on the EPA Web site at http://www.epa.gov/oppsrrd1/op/Naled.htm

Synthetic Pyrethroids for Mosquito Control

The Environmental Protection Agency (**EPA**) evaluates and registers (**licenses**) pesticides to ensure that they can be used safely. These pesticides include products used in the mosquito control programs that states and communities have established.

To evaluate any pesticide, EPA assesses a wide variety of tests to determine whether a pesticide has the potential to cause adverse effects on humans, wildlife, fish and plants, including endangered species and non-target organisms.

Officials responsible for mosquito control programs make decisions to use pesticides based on an evaluation of the risks to the general public from diseases transmitted by mosquitoes or on an evaluation of the nuisance level that communities can tolerate from a mosquito infestation.

Based on surveillance and monitoring, mosquito control officials select specific pesticides and other control measures that best suit local conditions in order to achieve effective control of mosquitoes with the least impact on human health and the environment. It is especially important to conduct effective mosquito prevention programs by eliminating breeding habitats or applying pesticides to control the early life stages of the mosquito.

Prevention programs, such as elimination of any standing water that could serve as a breeding site, help reduce the adult mosquito population and the need to apply other pesticides for adult mosquito control. Since no pesticide can be considered 100 percent safe, pesticide applicators and the general public should always exercise care and follow specified safety precautions during use to reduce risks. This fact sheet provides basic information on larvicides, a type of pesticide used in mosquito control programs.

What are Synthetic Pyrethroids?
Pyrethroids are synthetic chemical insecticides that act in a similar manner to pyrethrins, which are derived from chrysanthemum flowers. Pyrethroids are widely used for controlling various insects. **Permethrin, resmethrin,** and **sumithrin** are synthetic pyrethroids commonly used in mosquito control programs to kill **adult mosquitoes**.

- **Permethrin** has been registered by the EPA since 1977. It is currently registered and sold in a number of products such as household insect foggers and sprays, tick and flea sprays for yards, flea dips and sprays for cats and dogs, termite treatments, agricultural and livestock products, and mosquito abatement products.
- **Resmethrin** has been registered by the EPA since 1971 and is used to control flying and crawling insects in the home, lawn, garden, and industrial sites. It can also be used to control insects on ornamental plants (outdoor and greenhouse use), on pets and horses, and as a mosquitocide. Because of its toxicity to fish, resmethrin is a Restricted Use Pesticide (**RUP**) that is available for use only by certified pesticide applicators or persons under their direct supervision.
- **Sumithrin** has been registered by the EPA since 1975 and is used to control adult mosquitoes and as an insecticide in transport vehicles such as aircraft, ships, railroad cars, and truck trailers. It is also used as an insecticide and miticide in commercial, industrial, and institutional nonfood areas, in homes and gardens, in greenhouses, in pet quarters, and on pets.

How are Synthetic Pyrethroids Used in Adult Mosquito Control?

Most pyrethroid mosquito control products can be applied only by public health officials and trained personnel of mosquito control districts. Mosquito control professionals apply pyrethroids as an ultra-low volume (**ULV**) spray. ULV sprayers dispense very fine aerosol droplets that stay aloft and kill adult mosquitoes on contact.

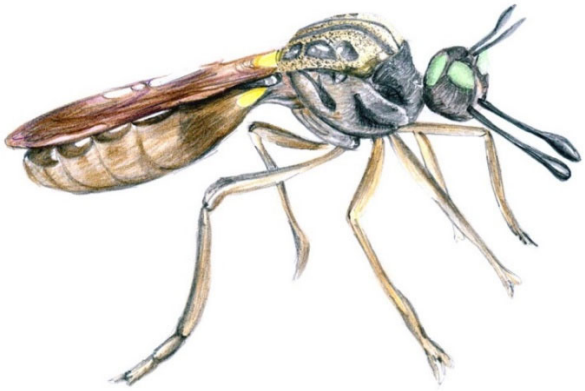
Pyrethroids used in mosquito control are typically mixed with a synergist compound, such as piperonyl butoxide, which enhances the effectiveness of the active ingredient. The product is often diluted in water or oil and applied at rates less than 1/100th of a pound of active ingredient or less than 4 fluid ounces of mixed formulation per acre.

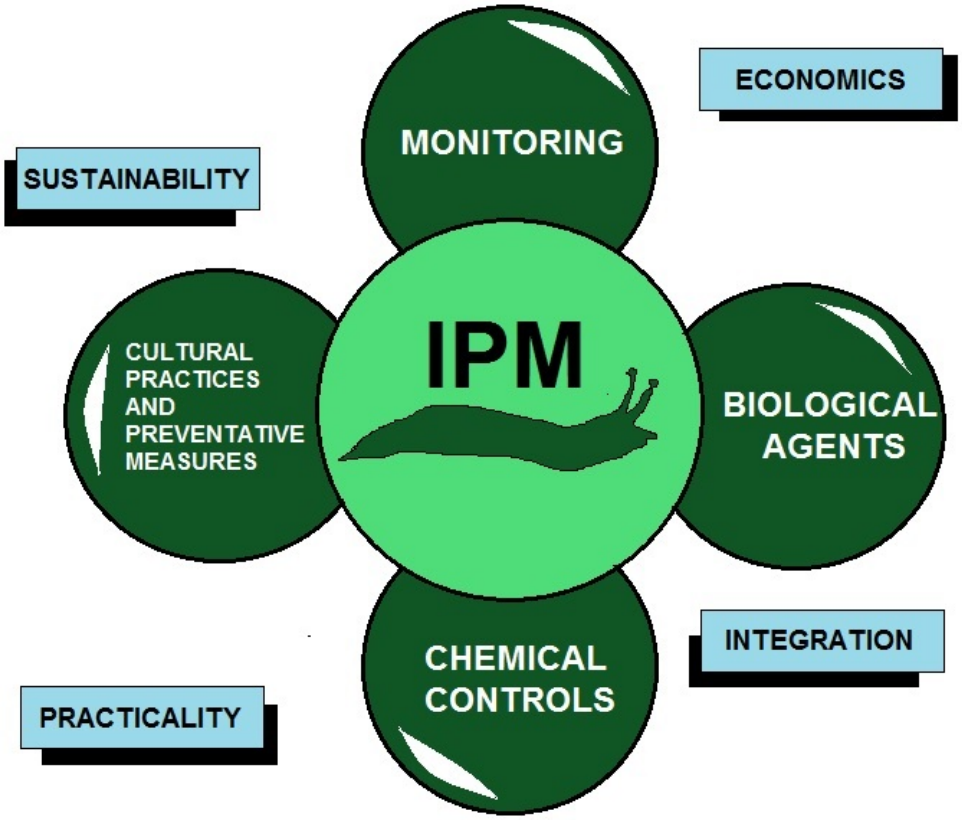
Do Pyrethroids Pose Risks to Human Health?
Pyrethroids can be used for public health mosquito control programs without posing unreasonable risks to human health when applied according to the label. Pyrethroids are considered to pose slight risks of acute toxicity to humans, but at high doses, pyrethroids can affect the nervous system.

Do Pyrethroids Pose Risks to Wildlife or the Environment?
Pyrethroids used in mosquito control programs do not pose unreasonable risks to wildlife or the environment. Pyrethroids, when applied at mosquito control rates, are low in toxicity to mammals, and are practically nontoxic to birds.

Mosquito control formulations of permethrin break down in the environment, and high temperatures and sunlight accelerate this process. However, pyrethroids are toxic to fish and to bees. For this reason, the EPA has established specific precautions on the label to reduce such risks, including restrictions that prohibit the direct application of products to open water or within 100 feet of lakes, streams, rivers, or bays.

What is The Current Regulatory Status of Pyrethroids?
As part of its responsibility to reassess all pesticides registered before 1984, the EPA has given highest priority to reviewing more acutely toxic pesticides, such as organophosphates and carbamates. Organophosphates are currently under review.





INTEGRATED PEST MANAGEMENT (IPM)

Aquatic Herbicides- Destroying Mosquito Habitat

Aqua-Kleen
Aqua-Kleen is a granular formulation of 2,4-D which has been used for years for selective control of noxious aquatic plants, including water milfoil. This aquatic herbicide can also be used to manage aquatic plants such as coontail, water stargrass, spatterdock, and water lilies when considered nuisance. Aqua-Kleen does not affect most plants considered beneficial by water resource and fisheries managers; therefore, this herbicide works very well for spot treatments without impacting untreated areas of the water body. Suspension of water use for irrigation and domestic use based on testing for residual.

DISCLAIMER: The information in this profile does not in any way replace or supersede the information on the pesticide product labeling or other regulatory requirements. Please refer to the pesticide product labeling.

Aqua-Pro
A concentrated systemic type herbicide infective against a variety of emergent aquatic and terrestrial grasses, broadleaf weeds, brush, and cattails in and around aquatic sites, including lakes, rivers, streams, ponds, seeps, irrigation and drainage ditches, canals, and reservoirs. There is no restriction on the use of water for irrigation, recreation, or domestic purposes following application as described on the label. This product must be used with a non-ionic surfactant approved for the application site. We use Cide Kick II or Silenergy.

DISCLAIMER: The information in this profile does not in any way replace or supersede the information on the pesticide product labeling or other regulatory requirements. Please refer to the pesticide product labeling.

Diquat dibromide
This is a contact herbicide that will control some, but not all, species of filamentous algae. It is applied by pouring directly from the container or by diluting with water and injecting below the water surface. For best results, it should be applied before algae growth reaches the surface. Diquat dibromide should not be used in muddy water. There are water-use restrictions associated with this material. Read the label.

DISCLAIMER: The information in this profile does not in any way replace or supersede the information on the pesticide product labeling or other regulatory requirements. Please refer to the pesticide product labeling.

Aquathol K
A liquid concentrate soluble in water which is effective against a broad range of aquatic plants with a wide margin of safety to fish and other aquatic life. This product may be used in irrigation and drainage canals, ponds, and lakes. Aquathol K is a contact herbicide; consequently, do not apply before weeds are present. For best results water temperature should be at least 65°F. Restrictions on water usage following application are: livestock water, irrigation, and domestic use- 7 to 14 days; fish consumption - 3 days. Application rates range from 0.3 to 3.2 gallons/acre foot of water treated.

DISCLAIMER: The information in this profile does not in any way replace or supersede the information on the pesticide product labeling or other regulatory requirements. Please refer to the pesticide product labeling.

Aquathol Super K
A concentrated granular herbicide effective against a broad range of aquatic plants with a wide margin of safety to fish and other aquatic life. The Super K pellets are manufactured in a manner which provides an essentially dust free material for easier application. The more concentrated formulation reduces the amount of material needed. Restrictions on water usage following application are: livestock water, irrigation, and domestic use - 7 days; fish consumption – 3 days. Application rates range from 2.2 to 22 pounds/acre foot of water treated.

DISCLAIMER: The information in this profile does not in any way replace or supersede the information on the pesticide product labeling or other regulatory requirements. Please refer to the pesticide product labeling.

Endothall
The amine salt formulation of endothall (sold as Hydrothol 191) is labeled for algae control. It is available as a liquid or granular material. Endothall is a contact herbicide and is most effective in waters 65° F and above. Fish are extremely sensitive to this material. Read the label for water-use restrictions.

DISCLAIMER: The information in this profile does not in any way replace or supersede the information on the pesticide product labeling or other regulatory requirements. Please refer to the pesticide product labeling.

DMA 4 IVM
An amine formulation of 2,4-D containing 46.3%(3.8 lb.) active ingredient per gallon. DMA*4 IVM provides general aquatic weed control for susceptible emergent species, primarily broad-leaved plants and also controls brush and bulrushes. DMA*4 IVM is labeled for the control of water milfoil. Mix 2 to 4 quarts of DMA*4 IVM plus aquatic surfactant and drift control agent with 50-100 gallons of water per surface acre of foliage. For small areas use 2 ounces per gallon of water in sprayer. Available in 2.5 gallon containers.

DISCLAIMER: The information in this profile does not in any way replace or supersede the information on the pesticide product labeling or other regulatory requirements. Please refer to the pesticide product labeling.

Nautique
Nautique is an effective copper based aquatic herbicide that is used to control hydrilla, naiads, Brazilian elodea, widgeon grass, milfoil, sago pondweed, and horned pondweed. Nautique aquatic herbicide may be used in lakes, ponds, potable water reservoirs, ornamental ponds, golf course water hazards, fire ponds, and industrial retention basins. Water may be used immediately after treatment for swimming, fishing, livestock watering, and irrigation. Application rates range from 1.8 to 3.0 gallons per acre foot of water treated.

DISCLAIMER: The information in this profile does not in any way replace or supersede the information on the pesticide product labeling or other regulatory requirements. Please refer to the pesticide product labeling.

Navigate
A granular formulation of 2,4-D which is effective on water milfoil, water stargrass, coontail, spatterdock, water lilies, and watershield. It is very effective in control of Eurasian watermilfoil, an aggressive, exotic species found throughout the U.S. This product is not for use in waters used for irrigation, agricultural sprays, watering dairy animals, or domestic water supplies. Recommended restrictions after application include no swimming for 1 day and no use of fish from treated waters for 3 days. Application rates vary from 100 pounds per acre for milfoil to a maximum of 200 pounds per acre for resistant plants such as spatterdock and watershield.

DISCLAIMER: The information in this profile does not in any way replace or supersede the information on the pesticide product labeling or other regulatory requirements. Please refer to the pesticide product labeling.

Renovate 3
A systemic aquatic herbicide used for control of certain submersed, floating, and emergent aquatic plant species, including woody plants, in ponds, lakes, reservoirs, and marshes. Additional treatment sites include adjacent banks, shores, canal banks, and on non-irrigation canals which have little or no continuous outflow. Renovate 3 is an effective herbicide for water milfoil, purple loosestrife, and other "broadleaved" aquatic species. Renovate 3 will not harm "monocot" species such as cattails and grasses. Available in 2.5 gallon containers.

DISCLAIMER: The information in this profile does not in any way replace or supersede the information on the pesticide product labeling or other regulatory requirements. Please refer to the pesticide product labeling.

Reward
A concentrated liquid aquatic herbicide effective against a wide variety of submersed, emergent, and floating aquatic plants including duckweed, naiads, and cattails. Reward poses virtually no environmental risk in aquatic applications because the herbicide concentration rapidly decreases as it is absorbed onto soil, vegetation, and organic matter. Restrictions on water usage following application: livestock consumption - 1 day; irrigation of food crops - 5 days; irrigation of turf and non-food crops- 1-3 days; human drinking - 1-3 days. The product of choice when fishing restrictions are not tolerable. Application rates: 1 to 2 gallons per surface acre.

DISCLAIMER: The information in this profile does not in any way replace or supersede the information on the pesticide product labeling or other regulatory requirements. Please refer to the pesticide product labeling.

Sonar
An aquatic herbicide effective against a variety of submersed, emergent, and floating aquatic plants (including duckweed and watermeal). Provides excellent season-long control with an early spring application prior to or just after plant growth begins. Available in liquid and pelleted formulations. No restrictions on water use for fishing, swimming, or domestic use following application according to label instructions. Fourteen to thirty-day restriction on use of treated water for irrigation following application. Application rates: Liquid: ponds - 0.16 to 1.5 quarts per acre; lakes - 0.11 to 4 quarts per acre. Pellets: ponds - 3.2 to 25 pounds per acre- lakes - 4 to 80 pounds per acre.

DISCLAIMER: The information in this profile does not in any way replace or supersede the information on the pesticide product labeling or other regulatory requirements. Please refer to the pesticide product labeling.

Weedtrine D
A non-volatile herbicide for use in controlling submersed and floating aquatic weeds. It is also recommended for top kill of shoreline emergent weeds and as a grass and broadleaf weed growth killer in non-crop or non-planted areas. Absorption and herbicidal action of Weedtrine D is usually quite rapid with effects visible in a few days. Application rates are 5-10 gallons per surface acre. Water should not be used for irrigation or domestic use for 5 days following treatment.

DISCLAIMER: The information in this profile does not in any way replace or supersede the information on the pesticide product labeling or other regulatory requirements. Please refer to the pesticide product labeling.

Acknowledgement for use of the herbicide information and for more information, please contact:

Aquatic Control
P.O. Box 100
Seymour, IN 47274
812.497.2410 800.753.LAKE
Email: sales@aquaticcontrol.com

Kentucky

National Aquatics Division
P.O. Box 32492
Louisville, KY 40232-2492
502.744.6497

Missouri
4025 Old Highway 94 South, Suite S
St. Peters, MO 63304
636.447.7446 800.568.LAKE

Northern Indiana
3001 Cascade Drive
Valparaiso, IN 46383
219.476.7663

Inert Dyes

Inert dyes can be used to control algae. The color they turn the water, usually blue, reduces sunlight penetration, which in turn reduces growth of algae and submerged weeds. These dyes are not effective in water less than 2 feet deep or if the alga is floating on the water surface. Most inert dyes are labeled for all water uses except domestic drinking water supplies. Check the label.

Table 1. Aquatic Herbicides for Filamentous Algae Control (except Pithophora)

Labeled Herbicides		Waiting Period Before Water Used For:					
Trade Name	Chemical Name	Human			Animal	Irrigation	
		Drinking	Swimming	Fishing	Drinking	Turf	Food Crops
AlgaePro	Copper chelate	0 days	0 days	0 days	0 days	0 days	0 days
Aquashade, Aquashadow	(Inert dye)	Not permitted	24 hours (note 1)	0 days	0 days	0 days	0 days
Copper sulfate	Copper sulfate	0 days (note 2)	0 days (note 2)	0 days	0 days (note 2)	0 days	0 days
Cutrine Plus (liquid and granular)	Copper chelate	0 days	0 days	0 days	0 days	0 days	0 days
Diquat/ Reward (note 3)	Diquat dibromide	14 days	24 hours	0 days	14 days	14 days	14 days
Hydrothol 191	Endothall	7-14 days (note 4)	24 hours	3 days	7-14 days (note 4)	Not permitted	7-14 days (note 4)

Notes to Table 1: 1 - Wait for complete dispersal before swimming.
2 - No required waiting period. 24-hour waiting period recommended to allow for dissipation of metallic odor.
3 - Controls some species of algae: *Spirogyra* and *Pithophora*.
4 - Varies by application rate used.
5 - Copper is toxic to fish eggs and fish fry.
6 - Production of this material has been terminated, but it may be purchased and used until supplies are exhausted.

Table 1. (Continued) Aquatic Herbicides for Filamentous Algae Control (except Pithophora)					
Labeled Herbicides		**Characteristics**			
Trade Name	**Chemical Name**	**Min/Max Water Temp.**	**Biodegradable**	**Fish Toxicity at Recommended Rates**	**Observable Effects**
AlgaePro	Copper chelate	60 F/None	Partial	note 5	7-10 days
Aquashade, Aquashadow	(Inert dye)	None	Yes	No	Varies
Copper sulfate	Copper sulfate	60 F/None	No	note 5	3-5 days
Cutrine Plus (liquid and granular)	Copper chelate	60 F/None	Partial	note 5	7-10 days
Diquat/ Reward (note 3)	Diquat dibromide	60 F/None	Adheres to soil	No	7 days
Hydrothol 191	Endothall	65 F/None	Yes	Yes	3-14 days
Notes to Table 1: 1 - Wait for complete dispersal before swimming. 2 - No required waiting period. 24-hour waiting period recommended to allow for dissipation of metallic odor. 3 - Controls some species of algae: *Spirogyra* and *Pithophora*. 4 - Varies by application rate used. 5 - Copper is toxic to fish eggs and fish fry. 6 - Production of this material has been terminated, but it may be purchased and used until supplies are exhausted.					

2017 Changes to EPA's Farm Worker Protection Standard

In late 2015 the Environmental Protection Agency issued the long awaited revision to the Worker Protection Standard (WPS). This law it is now technically active and it will be enforced. Please keep in mind that the WPS covers both restricted use AND general use pesticides. This course is not for worker and/or handler training. Always follow the label and your State Pesticide Agency rules.

This course contains EPA's federal rule requirements. Please be aware that each state implements pesticide regulations may be more stringent than EPA's regulations. Check with your state environmental/pesticide agency for more information.

Copper-Resistant Algae

One form of filamentous algae, Pithophora, can be especially troublesome because it is resistant to normal applications of copper compounds. Although it is not widespread, scattered reports of Pithophora in ponds are received every year. If, after a normal treatment with copper sulfate, there is algae remaining that does not appear to be affected, it may be Pithophora.

Pithophora is extremely difficult to control. Its unique cell wall structure and the tight clumping of filaments inhibit the penetration by copper. Additionally, large numbers of resilient spore-like bodies, called akinetes, germinate and provide a continuous source of new plants. Partial, short term control can usually be achieved with either of the following herbicide mixtures:

	Ratio	Application Rate of Mixture
Cutrine Plus Liquid and Diquat/Reward	1:1	2 gallons per acre-foot
Cutrine Plus Liquid and Hydrothol 191 Liquid	2:1	1 gallon per acre-foot

Additionally, Cide-Kick, a nonionic spray adjuvant, should be added to the mixture at the rate of 1-2 gallons per surface-acre. This material acts as a cell wall penetrant to increase the effectiveness of the herbicides.

Special Precautions
Fish are extremely sensitive to Hydrothol 191. To reduce the hazard of a fish kill, start application at the shoreline and move outward so that fish can escape from treated areas. Select another product if fish toxicity is a concern.

Copper sulfate is corrosive to galvanized containers. Therefore, the solution should be mixed in wooden, earthenware, plastic, stainless steel or copper-lined containers. If a sprayer is not available, you may broadcast the solution with a plastic watering can or bucket and dipper.

If the algae are so abundant that it covers more than half of the total pond surface, a complete treatment may result in an oxygen depletion and fish kill. This hazard is greatest during very hot, overcast weather. When these conditions exist, treat only half the pond and wait 10-14 days before treating the other half.

Copper compounds applied at the recommended rates are lethal to fish eggs and some species of newly hatched fish. These materials should not be applied during spawning periods, unless it is desirable to destroy the eggs and the new hatch. Bass will begin to construct shallow depressions in the pond bottom when the water reaches 60°F. Eggs are deposited by the female and guarded by the male for 3-14 days.

Within a couple of weeks after the bass have spawned and when the water temperature reaches 70°F, bluegill and red-ear sunfish will be seen building nests in the shallow areas. As with the bass, the male guards the nest after the eggs have been deposited.

These eggs will hatch in a few days. Bass will only spawn once in the spring, but forage fish (bluegill, red-ear sunfish and minnows) will spawn throughout much of the summer and some individuals may spawn several times in a single season. To avoid the application of copper compounds during the spawning season, monitor the water temperature and look for active nests in the shallow areas of the pond.

DISCLAIMER: The information in this profile does not in any way replace or supersede the information on the pesticide product labeling or other regulatory requirements. Please refer to the pesticide product labeling.

The Right Chemical

Will the chemical achieve the results desired? This question may seem too obvious, but it is one that is often overlooked by pond owners. For example, no single aquatic herbicide is capable of controlling all kinds of weeds that are potential pond management problems. Most chemicals used to control weeds, diseases, and other aquatic pests are expensive and are effective only on certain pest organisms. For this reason, it is important to accurately identify the aquatic pest or the water quality problem before purchasing and applying a chemical to a pond. Your county extension agent or state fisheries biologist can assist you in identifying the pest or the water quality problem.

Once you have accurately identified the problem, then select the most effective control measure. This does not mean that a chemical can or should be used to correct every pond management problem. The best approach is to consider preventive measures first. If they are not practical or do not produce the desired results, then other control methods should be considered. It is always easier and more economical to prevent a problem than to cure one. Even when preventive measures are only partially successful, they quite often facilitate the effectiveness of other control measures. Preventive measures may or may not include the use of chemicals.

Matching the management problem with an effective chemical is not enough. You must also consider the effect that chemicals may have on non-target organisms.

For example, some chemicals used to treat diseases in fish are also toxic to plants. Use of these chemicals during the summer months may cause oxygen depletion. Also, the water chemistry and its effect on the chemical may need to be considered. Some chemicals break down rapidly in the presence of sunlight, high pH, and high temperature and are less likely to be effective during the hot summer months. Be sure to consider other water uses and effects the chemical may have on them. For example, aquatic herbicides applied to a pond used for irrigation may have a disastrous effect upon the irrigated crops. Also, consider the effects the chemical may have downstream from your pond.

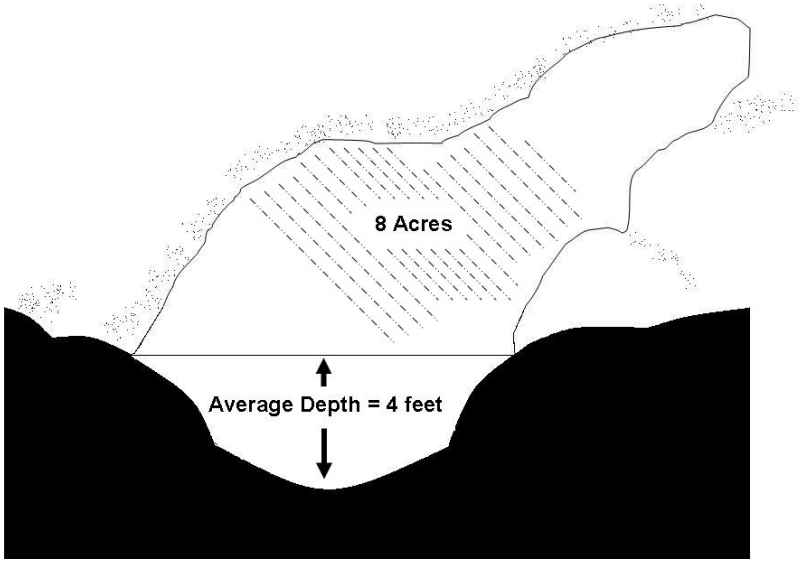
Whenever you use a chemical in a pond, it must be applied properly and all warnings and precautions concerning use must be understood and observed. Fortunately, all of this information is on the label for most chemicals approved for use in ponds. Anyone who uses a chemical in a pond should *always thoroughly read and understand the chemical label* before purchasing and applying it.

Obviously the effectiveness of some chemical treatments can be quite variable. If you are not certain of the identification of the aquatic pest or the best control method, consult your county extension agent or state fisheries biologist. Assuming you have selected the most effective chemical for use, the following information should be used to determine the proper amount to apply and to determine the best and safest way to apply it.

Calculation of Chemical Treatments Applied to Pond Water
The following information is essential in computing the amount of chemical to apply to a pond: the pond water volume, the chemical formulation, and the effective concentration of the chemical needed in the pond water to correct the problem.

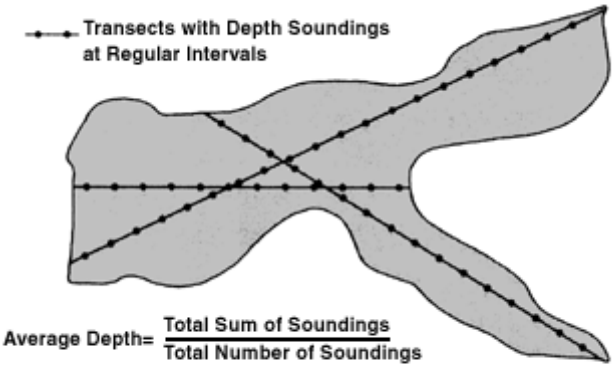
Pond Water Volume

Every pond owner should know the water volume of his pond. Volume can be expressed as cubic feet, cubic meters, gallons, liters, etc. However, because of the rather large numbers involved with these units, the common measure used for pond water volume is acre-feet. For example, a pond of eight surface acres with an average depth of four feet would contain 10,432,000 gallons of water. This equals 32 acre-feet of water.



An acre-foot is one surface acre one foot deep. Acre-feet are computed by multiplying the area (in acres) by the average depth (in feet). In the example above, eight surface acres times the average depth of four feet equals 32 acre-feet of water.

Most county Natural Resources Conservation Service offices can assist pond owners in determining the water volume of their ponds. The surface acreage of most ponds can also be determined by county Farm Service offices. Assuming the surface acreage of a pond is known, the following method can be used to determine the average depth of a pond. Average depth can be determined by use of a sounding line at regular intervals along several transects of the pond. Both deep and shallow area of the pond should be included in the transects.



$$\text{Average Depth} = \frac{\text{Total Sum of Soundings}}{\text{Total Number of Soundings}}$$

$$\text{Example: } 3.5' = \frac{1' + 2.5' + 4' + 4.5' + 4.5' + 4' + 6' + 4' + 4' + 4' + 2.5' + 1'}{12}$$

Average depth is computed by adding all of the depth measurements and dividing by the number of measurements to get the average. The average depth multiplied by the surface area should give an accurate estimate of the pond water volume.

Know the water volume of your pond before a treatment is needed. You can lose valuable time if the determination must be made after a problem has arisen. Table 1 can be used to convert acre feet into other measures of water volume.

Table 1. Equivalents of 1-acre foot of water

1 acre-foot	= 43,560 cubic feet
	= 4,840 cubic yards
	= 326,000 gallons (approximately)
	= 2,780,000 pounds (approximately)

Chemical Formulations

Chemical formulations vary in the amount of active ingredients present. The active ingredients are the chemicals which actually kill the pest or correct the undesirable water quality problem. Inert ingredients are added to improve the convenience, safety and handling of the chemical.

For a particular chemical, the application rate is based upon the amount of active ingredient in the chemical formulation. Fortunately, the amount of active ingredients contained in the chemical formulation and the application rate are printed on most product labels. This is one reason why it is important to read the information printed on the label.

Effective Chemical Concentration

In treating a pond, chemicals are added to the water to produce an effective concentration of active ingredients that will eliminate the pest or correct the water quality problem. Desired concentrations are usually expressed as parts per million, usually written as ppm.

One part per million is equivalent to the ratio of one pound of chemical to 999,999 pounds of water or one gram of chemical to 999,999 grams of water. In other words, one part per million equals one pound or one gram in one million pounds or grams of a solution or mixture, respectively.

Notice that parts per million is a weight-to-weight relation. Units of volume cannot be used directly. This is because an equal volume of two different chemicals may have considerably different weights. For example, one cubic-foot of lead weighs much more than one cubic-foot of water.

Calculation of Pond Water Treatments

The following formula can be used to determine the amount of chemical needed to treat a pond:

Amount of Chemical = Volume x CF x ECC x AI Needed

Where:

Volume = Volume of water to be treated. Although the unit of measure can be in gallons, liters, cubic feet, cubic yards, etc., when treating ponds, the more common and easier to use expression of volume is acre-feet.

CF = Conversion factor, a figure that equals the weight of a chemical to be used to give one part per million (ppm) in a given unit volume of water. Table 2 lists conversion factors (CF) for various measures of volume. For example, select the CF that corresponds to the unit of measure used for pond volume. For example, if the pond volume is measured in acre-feet, the appropriate CF is 2.72 if the chemical weight is measured in pounds or 1,233 if weight is measured in grams.

Table 2. Conversion Factors (CF) - Weight of Chemical in One Unit Volume of Water to Give One Part Per Million ppm.

2.72 pounds per acre-foot	= 1 ppm
1,233 grams per acre-foot	= 1 ppm
0.0283 grams per cubic foot	= 1 ppm
0.0000624 pounds per cubic foot	= 1 ppm
0.0038 grams per gallon	= 1 ppm
0.0584 grains per gallon	= 1 ppm
1 milligram per liter	= 1 ppm
0.001 gram per liter	= 1 ppm
8.34 pounds per million gallons of water	= 1 ppm

ECC = Effective chemical concentration of active ingredients needed in the pond water to eliminate the pest or correct a water quality problem. This unit of measure must be in ppm. AI = The total amount of active and inert ingredients divided by the amount of active ingredients. Products, which are liquid formulations, usually list the amount of active ingredients as pounds active per gallon. For such products AI = 1 gallon divided by the pounds per gallon of active ingredients. A few chemicals are liquids in their pure form and their specific gravity must be known to calculate AI. See Example 4 to calculate AI using specific gravity.

Non-liquid formulations usually list active ingredients as a percentage of the total formulation. For non-liquid formulations, AI = 100% divided by the percentage of active ingredients.

The following examples illustrate how the equation previously mentioned can be used in calculating pond water treatments.

Example 1. How much Chemical A is needed to treat a pond that has 4 surface acres and an average depth of 3 feet with 2 ppm active ingredient? Chemical A is 100% active.

Volume	= 4 acres x 3 feet
CF	= 12 acre-feet
ECC	= 2.72 pounds (from Table 2)
AI	= 2 ppm (active ingredient needed in the water)
	= 100%

100% (Chemical A is 100% active)

The amount of Chemical A needed is found by substituting the above values in the formula:

Volume x CF x ECC x AI

Thus: (12 acre-feet x 2.72 pounds x 2 ppm x 100) / 100 = 65.3 pounds of Chemical A are needed to treat the pond.

Example 2. How much Chemical B (80 percent active) is needed to treat a pond measuring 1,000 feet long by 500 feet wide by 5 feet deep with a concentration of 0.25 ppm active ingredient?

Volume	= 100 feet x 50 feet x 5 feet
	= 25,000 cubic feet
CF	= 0.0000624 pounds/cubic foot (from Table 2)
ECC	= 0.25 ppm (active ingredient needed in the water)
AI	= 100%
	80%

The amount of Chemical B needed is found by substituting the above values in the formula.

Volume x CF x ECC x AI

Thus: (25,000 cu. ft. x 0.0000624 pounds/cu.ft. x 0.25 ppm x 100) / 80 = 0.49 pounds of Chemical B (80 percent) are needed to treat the pond.

Example 3. How much Chemical C (2 pounds active per gallon) is needed to treat a pond that has 6 surface acres and an average depth of 4 feet with 0.5 ppm active ingredient?

Volume	= 6 acres x 4 feet
	= 24 acre-feet
CF	= 2.72 pounds/acre-foot (From Table 2)
ECC	= 0.5 ppm (active ingredient needed in water)
AI	= 1 gal.
	2 lbs.

The amount of Chemical C needed is found by substituting the above values in the formula:

Volume x CF x ECC x AI

Thus: (24 acre-feet x 2.72 pounds/acre-foot x 0.5 ppm x 1 gal) / 2 lbs. = 16.3 gallons of Chemical C (2 lbs. active/gallon) are needed to treat the pond.

Example 4. How much Chemical D is needed to treat a pond measuring 180 feet long by 90 feet wide by 4 feet deep with a concentration of 25 ppm active ingredient. Chemical D is a liquid and is 100 percent active.

Volume	= 180 feet x 90 feet x 5 feet
	= 81, 000 cubic feet
CF	= 0.0000624 pounds per cubic foot
ECC	= 25 ppm
AI	= 100%
	100%

The amount of Chemical D needed is found by substituting the above values in the formula:

Volume x CF x ECC x AI

Thus: (81,000 cu. ft. x 0.0000624 pounds/cu.ft. x 25 ppm x 100) / 100 =126.4 pounds of Chemical D

However, Chemical D is a liquid and 126.4 pounds must be converted to a unit of volume. Since (ppm) parts per million is a weight-to-weight relation, it is necessary to know how Chemical D compares in weight with water. Chemical D is heavier than water, thus a smaller amount of Chemical D is needed to equal 250 ppm in water on a Chemical D to water weight-to-weight ratio. Chemical D weighs about 9 pounds per gallon and water 8.34 pounds per gallon; or Chemical D is 1.08 times as heavy as water (9 divided by 8.34). This figure is called the specific gravity (SG) of Chemical D. If the weight of Chemical D is computed in grams, the weight divided by the specific gravity equals the number of cubic centimeters required. If the weight (as in this example = 126.4 pounds) is computed in pounds, divide by 8.34 times the specific gravity to convert it to gallons. In this example the amount of Chemical D needed is:

(126.4 pounds) / (8.34 lbs/gal x 1.08 SG) = 140 gallons

Treatment Methods

Selection of the best treatment method depends upon the specific situation and the chemical used in treatment. The following treatment methods can be used.

Treatments Applied to Pond Water

1. **Surface - applied treatments**
   Contact pesticides, inorganic fertilizers, lime, and a few other water quality control chemicals are applied to ponds at a rate based upon the surface acreage of the pond - not the pond's water volume. Generally, these chemicals are either sprayed or broadcasted over the pond surface.
2. **Total water column water treatments**
   This is the most common technique of chemical treatment used in a pond. The whole volume of water (water column) in the pond is treated. The pond water volume is calculated and the chemical is added to reach a specific dilution in the water column. An alternative is to calculate the entire volume and then treat only one-fourth or one-third of the total water column, based on surface area, confining the treatment to selected sections of the pond where the pest infestation may be more intense. Specific application techniques include injection

directly into the water with undiluted chemical, or some dilution of the chemical sprayed or cast upon the surface of the water. With either method, further dispersal throughout the water column is dependent upon water currents.

3. **Bottom acre-foot treatments**
   This is a specialized application technique which is intended primarily for control of submersed aquatic vegetation. A boat carrying application equipment drags a hose or boom over and just above the pond bottom. The chemical is dispersed through nozzles, and the specific gravity of the chemical causes the treatment to remain near the bottom and in proximity of the rooted submersed weeds.

Specialized Treatments
Generally, the treatment methods described below require either the fish to be removed from the culture area being treated and then returned, or instead of treating the culture water to remove a pest, the fish themselves are treated with a chemical, usually incorporated into their feed.

1. **Dip Method**
   This involves exposure of the fish to a strong solution of chemical for a short period of time. Fish are usually netted and dipped into a chemical and returned to the culture area.

2. **Flush Method**
   This method is only applicable in tanks, raceways, or egg incubators. A stock solution of a chemical is applied in the upper end of the unit and allowed to flush throughout the system. The chemical must flush through the system in a predetermined time.

3. **Bath Treatments**
   Bath treatments involve application of a chemical directly to the culture area and after a specified time, flushing it from the rearing unit. Bath treatments may be commonly used in culture tanks but are difficult to apply in ponds because most managers do not have an adequate water supply to flush the pond after treatment.

4. **Feeding Method**
   Feeding involves the incorporation of a drug or medication in a feed, or in some other way introduces the chemical into the stomach of the fish. This treatment is the most common method used in treating bacterial infections and internal parasites of fish.

5. **Injection Method**
   Some medications and drugs can be injected into fish for effective control of a disease. It is generally not practical in pond or intensive culture systems unless the fish have a high economic value.

Conversions

Table 3. Conversions for Units of Volume

	milliliter (ml)	liter (L)	pint (pt) [US liquid]	quart (qt) [US liquid]	gallon (gal) [US liquid]	barrel (bbl) [US liquid]
1 milliliter (ml)	1	0.001	0.002	0.001	0.00026	0.0000083864143605761
1 liter (L)	1000	1	2.11	1.05	0.264	0.0083864143605761
1 cubic meter (m^3)	1000000	1000	2113.37	1056.68	264.172	8.3864143605761
1 cubic inch (in^3)	16.387064	0.016387064	0.03	0.017	0.0043	0.00013742870885728
1 cubic foot/feet (ft^3)	28316.846592	28.316846592	59.8	29.92	7.4805	0.23747680890538
1 pint (pt) [US liquid]	473.176473	0.473176473	1	0.5	0.125	0.003968253968254
1 quart (qt) [US liquid]	946.352946	0.946352946	2	1	0.25	0.0079365079365079
1 gallon (gal) [US liquid]	3785.411784	3.785411784	8	4	1	0.031746031746032
1 barrel (bbl) [US liquid]	119240.471196	119.240471196	252	126	31.5	1

Table 4. Conversions for Units of Length

From	To				
	cm	m	in.	ft.	yd
cm	1	0.01	0.3937	0.0328	0.0109
m	100	1	39.37	3.281	1.0936
in.	2.54	0.0254	1	0.0833	0.0278
ft.	30.48	0.3048	12	1	0.3333
yd.	91.44	0.9144	36	3	1

Table 6. Miscellaneous Conversion Factors

1 acre-foot	43,560	cubic feet
1 acre-foot	325,580	gallons
1 acre-foot of water	2,718,144	pounds
1 cubic-foot of water	62.4	pounds
1 gallon of water	8.34	pounds
1 gallon of water	3,785	grams
1 liter of water	1,000	grams
1 fluid ounce	29.57	grams

Helpful Formulas for Determining Volume

1. Volume of a square or rectangle container = length x width x depth
2. Volume of a circular container = 3.14 x radius^2 x depth
3. Volume of a pond = surface acres x average depth = acre-feet

Abbreviations

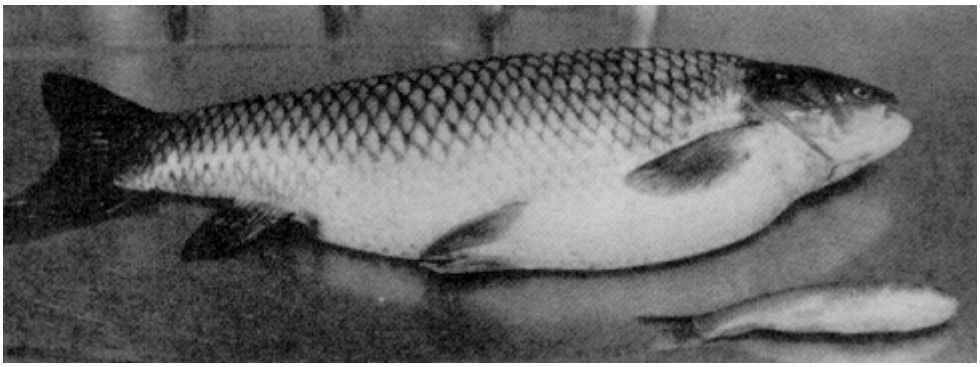
cm	=	centimeter
cm^3	=^{3}	cubic centimeter^3
fl oz	=	fluid ounce
fl pt	=	fluid pint
fl qt	=	fluid quart
ft	=	foot
ft^3	=^{3}	cubic foot ^{3}
gal	=	gallon
g	=	gram
gr	=	grain
in	=	inch
in^3	=^{3}	cubic inch ^{3}
kg	=	kilogram
lb.	=	pound
m	=	meter
m^3	=^{3}	cubic meter^3
oz	=	ounce
yd	=	yard

Attention! Pesticide Precautions

1. Observe all directions, restrictions and precautions on pesticide labels. It is dangerous, wasteful, and illegal to do otherwise.
2. Store all pesticides in original containers with labels intact and behind locked doors. KEEP PESTICIDES OUT OF THE REACH OF CHILDREN.
3. Use pesticides at correct label dosages and intervals to avoid illegal residues or injury to plants and animals.
4. Apply pesticides carefully to avoid drift or contamination of non-target areas.
5. Surplus pesticides and containers should be disposed of in accordance with label instructions so contamination of water and other hazards will not result.
6. Follow directions on the pesticide label regarding restrictions as required by state and federal laws and regulations.
7. Avoid any action that may threaten an endangered species or its habitat. Your county extension agent can inform you of endangered species in your area, help you identify them and through the Fish and Wildlife Service Field Office, identify actions that may threaten endangered species or their habitats.

Grass Carp for Weed Control-Mosquito Habitat

Aquatic weeds are a serious problem for pond owners throughout the U.S. They restrict access to fishing areas, reduce fish harvest and decrease the usefulness, attractiveness and value of a pond. Herbicides, mechanical removal, water level changes, dyes, fertilization, proper pond construction, pond renovation and biological methods successfully control unwanted aquatic weed growth. The physical and chemical characteristics of the pond and the pond owner's objectives dictate which method is most appropriate. Pond owners are familiar with the traditional methods of aquatic weed control but not with the recently available option of biological control by using sterile triploid grass carp (Figure 1).



Nine-inch triploid grass carp stocked in a central Georgia pond with a heavy weed infestation grew to lengths of 29 inches and weighs of almost 20 pounds in 16 months.

The grass carp (*Cteno pharyngodon idella*) occurs naturally in large rivers of the eastern USSR and China. It was introduced into the United States in 1963 by the United States Bureau of Sport Fisheries and Wildlife in cooperation with Auburn University. The feeding habits of the grass carp were well known and it was thought to have great potential as a biological weed control agent.

However, there was concern that the grass carp could reproduce in the wild and become an environmental nuisance, destroying valuable areas such as wetlands, swamps and waterfowl feeding grounds.

Because of these environmental concerns, early research focused on developing sterile populations. Attempts included producing single-gender populations, creating sterile hybrids and removing gonads. Success was limited because these methods were seldom 100% effective and verification of sterility was difficult. In the early 1980s researchers and commercial producers began treating eggs with heat, cold, or pressure to inhibit the second maturation division in the fertilized egg. This produced fish with abnormal chromosome numbers.

The normal diploid grass carp has a chromosome number (2N) of 48, while the triploid grass carp has a chromosome number (3N) of 72. The extra chromosomes result in sterility.

Unfortunately, not all treated eggs develop into fish with abnormal chromosome numbers. A technique using an electronic particle size analyzer was developed in the early 1980s which identifies carp as triploids or diploids.

Feeding Habits

Triploid and diploid grass carp appear to consume similar quantities of aquatic plants and to have similar feeding habits, preferring succulent young plants. Table 1 lists some common aquatic plants and rates them by grass carp feeding preferences. Grass carp will not control all types of aquatic weeds. Because of selective feeding habits, they can eliminate one plant species and make room for the expansion of others.

Table 1. Feeding preferences of grass carp on some common aquatic plants.

High	Moderate	Low
Musk-grass	Duckweeds	Eel grass
Naiads	Pondweeds	Watermeal
Hydrilla	Bladderwort	Cattail
American elodea	Fanwort	Milfoil
	Water pennywort	Parrot feather
	Coontail	Reeds
	Water primrose	Sedges
	Filamentous algae	Water hyacinth
		Alligator weed
		Spatterdock
		Yellow cowlily
		Maidencane
		Torpedo grass
		Watershield Waterlily

Stocking

If the grass carp is the preferred weed control option, stocking proper numbers is important. Stocking rates of five to over 200 fish per acre have been used depending on plant species, plant density and distribution, the size and age of the fish and the pond owner's objectives. There are computer models that determine the appropriate stocking density by considering additional factors such as the amount of human activity around the pond, the desired level of control, and grass carp feeding preferences. The numbers recommended are designed to provide a 75 to 90 percent reduction in target plant species in three to four years. In most situations complete removal of aquatic vegetation is undesirable because the vegetation provides cover for small fish and attachment surfaces for fish food organisms.

Grass carp stocking densities are based on the maximum expected weed coverage and the feeding preference rating of the weeds. Stock 10, 15, or 20 fish per acre depending on whether the target weed species is high, moderate or low on the feeding preference list, respectively. This stocking concept is best illustrated using a few examples:

Example 1: A 10-acre pond is examined in March and found to have five acres of naiads growing in it. However, three of the remaining five acres are shallow and the naiads are expected to spread to this area later in the growing season. Base the stocking rate on the maximum expected weed coverage (eight acres). Because naiads are high on the feeding preference list, stock a total of 80 fish (eight acres times 10 fish per acre).

Example 2: A 10-acre pond is examined in March and found to have five acres covered in watermeal. Because watermeal is a floating plant, pond depth does not matter. The maximum expected weed coverage would be the entire 10 acres. Stock two hundred fish (10 acres times 20 fish per acre).

Example 3: A 10-acre pond is examined in March and found to have a one-acre infestation of water primrose. Because water primrose grows only in shallow water (less than two feet deep), base the stocking rate on the area of the pond less than two feet deep. If two acres of the pond are less than two feet deep, stock 30 fish (two acres times 15 fish per acre).

Grass carp could be stocked in weed-free ponds at low rates (five fish per acre) to prevent weeds from becoming established. However, the effectiveness of preventive stocking has not been determined.

Generally, no fewer than 10 fish should ever be stocked, regardless of the pond size, because the loss of even a few fish could result in ineffective weed control.

The number of fish and the time required to achieve weed control can be reduced by using grass carp with other aquatic weed control options. For example, herbicides or mechanical removal can be used prior to fish introductions. If the established aquatic vegetation is removed, the tender new growth can be controlled by fewer fish.

Time of stocking affects the initial degree of weed control. Fish are cold-blooded animals whose feeding rates and metabolism are influenced by water temperature. Grass carp feeding is greatest when the water temperature is between 70 and 80°F and negligible when it is less than 50°F. Mortality associated with handling stress is less likely when the water temperature is cooler; therefore, fish stocked in late winter or early spring are more likely to survive. They will not begin feeding heavily until late spring or early summer, which is when most aquatic weeds begin growing.

Because grass carp are attracted to currents, ponds with water flowing over spillways or through drains are not suitable without renovation. Cover horizontal drains with a fence or bars that allow free flow of water but prevent passage of grass carp. If barriers are placed over any drain structures, make sure they do not become clogged or blocked. Water could flow over emergency spillways and possibly wash out the spillway or dam.

Predatory Fish

Predatory fish, such as largemouth bass, eat grass carp. If used with existing fish populations, grass carp should be large enough to avoid being eaten by the average size predator. A largemouth bass 12 to 14 inches long can swallow a grass carp approximately nine inches long.

Even if predation is not a problem, the pond owner should consider using larger carp if they are available because they tend to survive handling and stocking better. Grass carp stocked with existing fish populations should be at least 8-10 inches in length.

Grass carp do not reproduce in ponds and periodic restocking is required. It has been reported that the lifespan of the grass carp is between 10 and 15 years; however, triploid grass carp will provide effective vegetation control for 8-10 years.

Grass carp grow rapidly in ponds that have preferred plant species. Nine to 11-inch fish stocked in the early spring can reach lengths of 25 inches or more and weights of seven to 10 pounds by the end of the first year.

If appropriate numbers of grass carp are stocked, they will eventually reduce the vegetation to the point that new plant growth is eaten as it becomes available. The grass carp will survive and remain healthy but will not increase in size. Once stocked, grass carp are difficult to remove from a pond. They are almost impossible to remove by seining or angling. The only options are draining the pond or using toxicants such as rotenone.

Permit Requirements
Only certain producers are authorized to sell grass carp in most States because they must confirm that each fish is a triploid.

Most State agencies periodically examine shipments of grass carp to verify triploidy. If diploid fish are found, the person possessing or selling the fish is subject to serious legal action, including large fines and imprisonment, as well as having the stock destroyed.

Depending upon your State Agency, the pond owner must meet the following criteria to have Grass Carp:

1. Sterile triploid grass carp are purchased from sources authorized by State Agency. A list of currently approved dealers is available from your Game and Fish or Pesticide Agencies.
2. The pond owner retains the bill of sale as proof of legal purchase.
3. The pond is privately owned, that is, a body of water which is clearly and entirely within the title of one owner.
4. Fish cannot travel upstream or downstream directly into a body of water not owned by the pond owner.

Trade and brand names are used only for information. Technical Learning College does not guarantee nor warrant published standards on any product mentioned; neither does the use of a trade or brand name imply approval of any product to the exclusion of others which may also be suitable.

Common Carp

Cyprinus carpio

Family: Cyprinidae (Minnows or carps)

Order: Cypriniformes (carps)

Class: Actinopterygii (ray-finned fishes)

Max. size: 120 cm SL (male/unsexed; Ref. 2847); max. published weight: 37.3 kg (Ref. 40637); max. reported age: 47 years

Environment: benthopelagic; non-migratory; freshwater; brackish; pH range: 7.0 - 7.5; pH. range: 10.0 - 15.0.

Climate: temperate; 3 - 32°C; 60°N - 40°N

Global Importance: fisheries: highly commercial; aquaculture: commercial; gamefish: yes; aquarium: public aquariums.

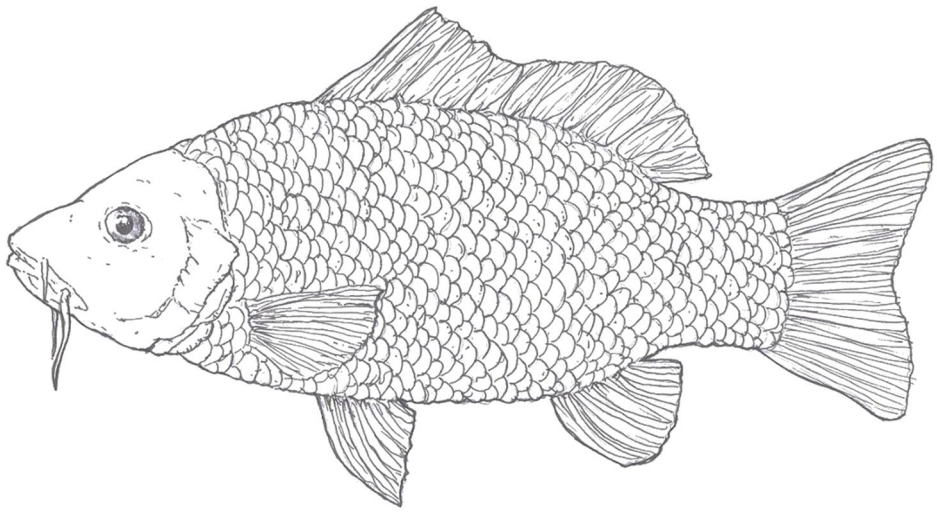
Resilience: Low, minimum population doubling time 4.5 - 14 years (K=0.11-0.17; tm=1-5; tmax=47; Fec=36,000-2,000,000)

Distribution: Western Europe throughout Eurasia to China, and South-East Asia, Siberia and India. One of the first species to be introduced into other countries and now attains global distribution. Inland aquaculture and capture fisheries contributions proved to be very significant.

A reophilic wild population in the Danube is assumed to be the origin of the European species; this population is now under threat (Ref. 13696). Several countries report adverse ecological impact after introduction.

Diagnosis: Dorsal spines (total): 3-4; Dorsal soft rays (total): 17-23; Anal spines: 2-3; Anal soft rays: 5-6; Vertebrae: 36-37. Pharyngeal teeth 1, 1, 3:3, 1,1, robust, molar-like with crown flattened or somewhat furrowed. Scales large and thick.

`Wild carp ' is generally distinguished by its less stocky build with height of body 1:3.2-4.8 in standard length. Very variable in form, proportions, squamation, development of fins, and color. Caudal fin with 3 spines and 17-19 rays (Ref. 2196). Last simple anal ray bony and serrated posteriorly; 4 barbels; 17-20 branched dorsal rays; body grey to bronze (Ref. 43281). Also Ref. 3398, 3410.



CARP ***(Carpio cyprinus)***

Biology: Occur at a temperature range of 3-35°C. Hardy and tolerant of a wide variety of conditions but generally favor large water bodies with slow flowing or standing water and soft bottom sediments.

Common carp thrive in large turbid rivers. They are omnivorous, feeding mainly on aquatic insects, crustaceans, annelids, mollusks, weed and tree seeds, wild rice, aquatic plants and algae; mainly by grubbing in sediments (Ref. 1998). Spawn in spring and summer, laying sticky eggs in shallow vegetation (Ref. 7248). A female 47 cm in length produces about 300,000 eggs (Ref. 6885).

Young are probably preyed upon by northern pike, muskellunge, and largemouth bass.
Adults uproot and destroy submerged aquatic vegetation and therefore may be detrimental to duck and native fish populations (Ref. 1998). Utilized fresh and frozen (Ref. 9987)

Topic 4– Mosquito Control Section Post Quiz

1. Methoprene (Altosid XR) is an insect hormone that retards the development of larvae (disrupts molting) and prevents mosquitoes from developing into_____.

2. Altosid XR Briquettes can be placed even on _____for season-long control.

3. When the bacteria Bti encysts, it produces a _____to mosquito and midge larvae. Once the bacteria have been ingested, the toxin disrupts the lining of the larvae's intestine.

4. _____include the bacterial insecticides *Bacillus thuringiensis israelensi*s and *Bacillus sphaericus*, the insect growth inhibitor methoprene, and the organophosphate insecticide temephos.

Chemical Larvicides.
5. _____like DDT and Chlordane are very much a thing of the past, as are the use of organophosphate and carbamate insecticides.

Juvenile Hormone
6. Methoprene mimics a natural juvenile hormone, and when present in the larval habitat, it keeps immature insects from maturing into adults. Unable to metamorphose, the mosquitoes die in the_____.

Adulticides
7. Mosquito adulticides are applied as_____.

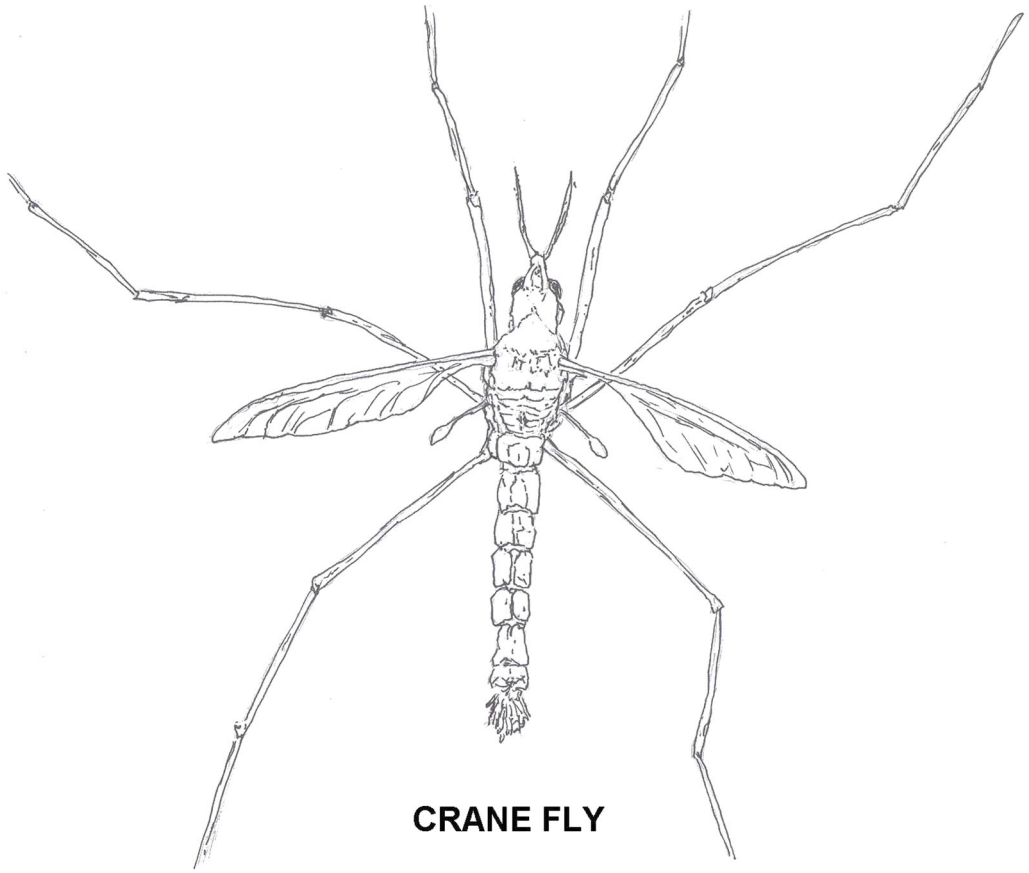
Indoor Control
8. Space sprays or aerosol *"bombs,"* containing synergized _____0.1%, are effective against adult mosquitoes. Frequent treatments may be needed during problem periods.

9. Malathion is an organophosphate parasympathomimetic which binds irreversibly to_____.

10. Based on surveillance and monitoring, mosquito control officials select specific pesticides and other control measures that best suit local conditions in order to achieve effective control of mosquitoes with the least impact on_____.

Topic 5- Insects Commonly Mistaken for Mosquitoes

Topic 5 - Section Focus: You will learn the basics of mosquito-like biting insects and control. At the end of this section, you the student will be able to understand and describe the mosquito-like insects, control methods and treatments. There is a post quiz at the end of this section to review your comprehension and a final examination in the Assignment for your contact hours.
Topic 5 – Scope/Background: This training section has been prepared for use as an guidebook to control mosquito-like insects. Like with ants and termites being difficult for many to differentiate, the same is true for mosquitoes and several biting and non-biting insects like Midges. Many of these mosquito –like creatures are beneficial to the ecosystem. We as professional pest control applicators must clearly identify and specifically control that target.



CRANE FLY

Introduction to Mosquito-like Insects

Crane Flies Looks like Giant Mosquitoes

Crane Flies are long, gangly insects that commonly resemble mosquitoes with their slender, jointed legs and elongated thorax. They are delicate insects ranging in size from 1/4 inch up to 1 1/2 inches. These insects do not bite, and contrary to popular belief, they do not eat mosquitoes. Some species of crane flies emerge from aquatic sources and others from terrestrial or decaying vegetation sources. This insect does not bite humans, and they don't carry disease. But these species still can be annoying to homeowners. To keep these pests away, consider turning out your porch or patio light since these flying insects are attracted to outdoor lights. You can also use repellent candles when outside.

Chiggers (Eutrombicula alfreddugesi) Bites like Mosquito

Larvae of chiggers, commonly called redbugs, attack humans and dogs during the larval stage. These mites are distributed over approximately the eastern half of the country. They are most common in the southern states where breeding may be continuous but frequently are abundant during the summer in the more northern states with one to three generations per year. They infest a variety of areas ranging from overgrown brush to well-kept lawns.

Adults overwinter in earthen cells in the soil, scavenge on decaying matter and emerge from the soil in the spring to lay their eggs. These hatch into tiny, oval, orange-colored larvae that normally feed on snakes, turtles, rabbits, birds and other wildlife. These larvae, barely visible to the naked eye, are very active. When humans come in contact with infested vegetation, the larvae swarm over the entire body and it might be several hours before they settle down to feed. Their attack seems to be concentrated at points where the clothing is pressed against the skin, such as under belts or garters.

Dance Flies (Empididae) Looks like Mosquitoes

Empididae is a family of flies with over 3,000 described species occurring worldwide, but the majority are found in the Holarctic. They are mainly predatory flies like most of their relatives in the Empidoidea, and exhibit a wide range of forms but are generally small to medium sized, non-metallic and rather bristly. Common names for members of this family are dagger flies (referring to the sharp piercing mouthparts of some species) and balloon flies. The term "dance flies" is sometimes used for this family too, but the dance flies proper, formerly included herein, are now considered a separate family Hybotidae. Some Empididae, such as the European species Hilara maura, have an elaborate courtship ritual in which the male wraps a prey item in silk and presents it to the female to stimulate copulation. Empidid larvae are also largely predatory (although some are scavengers) and occupy a wide range of habitats, both aquatic and terrestrial.

Appear like Mosquitoes

Dance Flies appear like mosquitoes by the way they swarm in sunlit areas in backyards and other sheltered situations. The vertical movement of the swarming adults gives them their common name. Several of the Empis species are "balloon makers." That is, the male flies capture an insect and enclose it in a frothy bag that they carry as a lure to entice the female to mate. Some species dispense with the froth, capturing and displaying live flies in front of females as a preface to courtship. Others trick their intended with an empty ball of silk. Larvae are usually found in rich, moist soil, decaying vegetable matter and in aquatic associations, or under the bark of trees.

Dixid Midges (Dixidae) Looks like Mosquitoes

Dixid Midges are common around moist areas where vegetation is abundant and may be seen swarming at dusk along the edges of streams and lakes. The adults are short lived, usually being active less than a week. The larvae are found in slow moving water, at the surface, and swim in a characteristic "U" shape. These midges lack a proboscis and scales on the wings. Periodically, dixids can produce staggeringly large emergences, but only in local and certain ecological situations. This insect does not bite humans, and they don’t carry disease. But these species still can be annoying to homeowners.

To keep these pests away, consider turning out your porch or patio light since these flying insects are attracted to outdoor lights. You can also use repellent candles when outside.

Applications of insecticides targeting the adult stage are not efficient. While this type of application may kill biting midges active on a given night, they are continually dispersing from the larval habitat and entering areas of human activity. It would require insecticide applications on a daily basis in some areas, and this is not efficient or environmentally sound.

Many government agencies that provide mosquito control services receive complaint calls about biting midges. However, most of the programs are not mandated or allowed to respond by providing control measures. Area sprays are fi ne mists of insecticide that rely on contact with the adult biting midge to kill it. They must be applied daily and do not last long in the environment; this makes them costly and less efficient. In some areas, removal trapping can be done using carbon dioxide as an attractant.

Fleas Bites like Mosquito

Fleas are small, dark brown insects whose bodies are hardened and compressed from side to side. Fleas do not fly, but have strong hind legs which they use to jump from host to host. Dogs and cats are at risk of getting fleas. Flea infestations usually get started in the summertime, after pets come in contact with infested pets or after they walk in areas where infested animals have spent time. In the U.S., the most common flea species carried by both cats and dogs is the cat flea, Ctenocephalides felis. Compared with other flea species, the cat flea has a very wide host range. Wild animals carrying cat fleas include raccoons, opossum, skunks and foxes.

Fungus Gnats (Sciaridae) Looks like Mosquitoes

Fungus Gnats (Sciaridae) are small (about ¼ inch long), black flies commonly found around decaying vegetation. They have large wings and long antennae, but they are weak flyers and do not move far from the breeding site. Fungus gnats occasionally become a nuisance indoors when adults emerge in large numbers as mosquito-like insects from potted plants or flower boxes containing damp soil rich in humus. Adults are attracted to lights and are often first noticed at windows. In the household, fungus gnats are usually found around potted plants, because both the adult fly and the larvae require a humid environment. The larvae can complete their development by feeding on the wet and decaying organic matter in potting soil. The lifecycle may be completed in about 10 days, and the adults may live about 2 weeks.

Biting Midges, No-See-Ums, Punkies Culicoides spp.

(Insecta: Diptera: Ceratopogonidae) Bites like Mosquito

Biting midges are extremely annoying, but none are known to transmit disease agents to humans in the U.S. They have a much greater impact on non-human animals, both as biting pests and vectors of disease agents. In North America, the most important disease agent transmitted by biting midges is Blue Tongue virus. This virus is a major cause of disease in livestock in the western U. S., but it does not infect humans. The bites of biting midges inflict a burning sensation and can cause different reactions in humans, ranging from a small reddish welt at the bite site to local allergic reactions that cause significant itching.

When numerous, biting midges have a real impact on residents and visitors of the Atlantic Coast, Gulf Coast, San Francisco Bay region, and southwestern deserts, primarily by limiting outdoor activities. Biting midge is a common name for pest species, but it is not the only one. For example, “no-see-ums” is used widely in the North America, “punkies” in the Northeast, “Five-O’s (related to biting around 5 PM) in Florida and Alabama, “pinyon gnats” in the Southwest, and “moose flies” in Canada.

Sand Fly

The common name "sand fly" at times is applied to members of the biting midge family Ceratopogonidae and the black fly family Simuliidae, but it usually is reserved for blood-sucking species in the subfamily Phlebotominae of the family Psychodidae. There are an estimated 600 species of phlebotomine sand flies in the world, including 14 species in the U. S. Only one of these species bites humans, and it is not known to be involved in the transmission of disease agents. Phlebotomine sand flies are known to be vectors of viruses, bacteria, and protozoa that cause human disease in Asia, Africa, southern Europe, and Latin America. Their most important involvement is the transmission of protozoan species in the genus Leishmania. Depending on the species and region in which they are transmitted, Leishmania parasites can cause a serious disease known as "visceral leishmaniasis" or "Kala-Azar" plus several forms of disfiguring skin diseases collectively known as "cutaneous leishmaniasis."

Applications of insecticides targeting the adult stage are not efficient. While this type of application may kill biting midges active on a given night, they are continually dispersing from the larval habitat and entering areas of human activity. It would require insecticide applications on a daily basis in some areas, and this is not efficient or environmentally sound. Many government agencies that provide mosquito control services receive complaint calls about biting midges. However, most of the programs are not mandated or allowed to respond by providing control measures. Area sprays are fi ne mists of insecticide that rely on contact with the adult biting midge to kill it. They must be applied daily and do not last long in the environment; this makes them costly and less efficient. In some areas, removal trapping can be done using carbon dioxide as an attractant.

Mayflies (Ephemeroptera) Looks like Mosquitoes

Mayflies (Ephemeroptera) can be quite abundant near creeks, flood control channels and other water sources throughout the United States. Their larvae are found in most aquatic habitats and can live in moving water.

Adult mayflies are recognized by the way they hold their wings at rest and the presence of two or three long "caudal" filaments at the tip of the abdomen. Though not even closely resembling mosquitoes, their seasonal occurrence at porch lights and on the walls of buildings near their aquatic breeding sources invariably attracts the attention of some concerned residents. The nymphs of mayflies develop in all types of aquatic habitats where they form an important part of the food chain. Adults are among the shortest lived in the insect world.

They generally survive hours to a few days after emergence in order to mate and lay eggs. Huge swarms of adult mayflies, in recent years (1995-97), have become a nuisance by their presence in some communities along the western basin of Lake Erie. Most swarming occurs in late June and early July. Mayflies accumulate around lights, making roads, streets, sidewalks, etc. slippery and dangerous. These annoying insects may fly into one's face, ears, hair, land on clothing, crawl behind eyeglasses and splatter car windshields. Along lake shores, piles of decaying bodies drift onto beaches and, if not removed, an offensive fish-like odor occurs discouraging tourists during the July 4th holidays.

Also, some people are hypersensitive, displaying symptoms of hay fever and asthma (allergies) from inhaling airborne pieces of their dead fragmented bodies. Mayflies do not bite or sting nor feed on homes, furnishings, food, etc. (Their presence is an indicator of clean water and a healthy environment.)

The chief importance lies in their value as food for fish, dragonfly nymphs and birds. Anglers imitate the adults in dry flies, referred to as "spinners" or "duns," and pattern wet flies after the nymphs (Naiads).

This insect does not bite humans, and they don't carry disease. But these species still can be annoying to homeowners. To keep these pests away, consider turning out your porch or patio light since these flying insects are attracted to outdoor lights. You can also use repellent candles when outside.

Owl Midges (Psychodidae) Looks like Mosquitoes

Owl Midges (Psychodidae) are small hairy flies that can move about very nimbly, but are weak fliers. The larvae are aquatic or semi aquatic and are very common in sewers and drains. The larvae are able to live in soapy water and are a good indicator of a leak in a shower/bath, sink, or laundry drain. This insect does not bite humans, and they don't carry disease. But these species still can be annoying to homeowners. To keep these pests away, consider turning out your porch or patio light since these flying insects are attracted to outdoor lights. You can also use repellent candles when outside. Applications of insecticides targeting the adult stage are not efficient. While this type of application may kill biting midges active on a given night, they are continually dispersing from the larval habitat and entering areas of human activity. It would require insecticide applications on a daily basis in some areas, and this is not efficient or environmentally sound. Many government agencies that provide mosquito control services receive complaint calls about biting midges. However, most of the programs are not mandated or allowed to respond by providing control measures. Area sprays are fi ne mists of insecticide that rely on contact with the adult biting midge to kill it. They must be applied daily and do not last long in the environment; this makes them costly and less efficient. In some areas, removal trapping can be done using carbon dioxide as an attractant.

Phantom Crane Flies (Ptychopteridae) Looks like a full Mosquito

Ptychopteridae, the phantom crane flies, is a small family (three extant genera) of nematocerous Diptera. Superficially similar in appearance to other "tipuloid" families, they lack the ocelli of Trichoceridae, the 5-branched radial vein of Tanyderidae, and the two anal veins that reach the wing margin of Tipulidae. They are usually allied with the Tanyderidae based on similarities of the mesonotal suture, this group being called the Ptychopteromorpha. The adults are found most often from late spring through to autumn in shaded, moist environs. It is presumed that adults feed little, if at all. There are two generations per year.

The common species of Eastern North America (Bittacomorpha clavipes) is known for the odd habit of spreading out its legs while flying, using expanded, trachea-rich tarsi to waft along on air currents. They are called "phantom" crane flies: Their legs are thin and black with white sheaths near the tips, and when they fly under a shady tree, everything disappears except the white spots, appearing and disappearing like a "phantom".

Sand Flies (Phlebotomine) Bites like Mosquito

Phlebotomine sand flies are of considerable public health importance because of their ability to transmit several viral, bacterial, and protozoal disease-causing organisms of humans and other animals. The males and females feed on nectar and other plant juices, but females require a blood meal in order to mature a second batch of eggs. The blood meal hosts include white-tailed deer, horses, donkeys, mules, cattle, swine, raccoons, rodents, birds and humans (Young and Perkins 1984, Comer et al. 1994).

Confusion with other types of biting flies is often caused because the common name "sand fly" is also used for other biting flies of genera Ceratopogon and Culicoides. There are about 700 species of phlebotomine sand flies of which about 70 are considered to transmit disease organisms to people (Adler and Theodor 1957).

Moth-like Appearance
Sand flies are characterized by their densely hairy wings, giving them a moth-like appearance. Phlebotomines are distinguished from other members of the family by the way they hold their wings erected above the body in a vertical "V", whereas members of other psychodid subfamilies hold their wings flat and near the body (Azar and Nel 2003).

This insect does not bite humans, and they don’t carry disease. But these species still can be annoying to homeowners. To keep these pests away, consider turning out your porch or patio light since these flying insects are attracted to outdoor lights. You can also use repellent candles when outside.

Applications of insecticides targeting the adult stage are not efficient. While this type of application may kill biting midges active on a given night, they are continually dispersing from the larval habitat and entering areas of human activity. It would require insecticide applications on a daily basis in some areas, and this is not efficient or environmentally sound.

Many government agencies that provide mosquito control services receive complaint calls about biting midges. However, most of the programs are not mandated or allowed to respond by providing control measures. Area sprays are fine mists of insecticide that rely on contact with the adult biting midge to kill it. They must be applied daily and do not last long in the environment; this makes them costly and less efficient. In some areas, removal trapping can be done using carbon dioxide as an attractant.

Winter Crane Flies (Trichoceridae) Looks like Mosquitoes

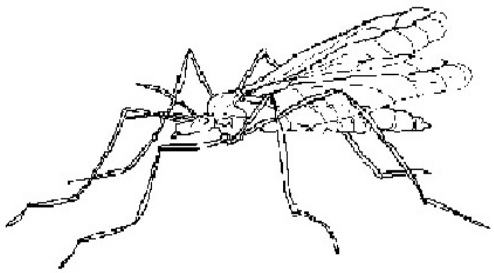
Winter Crane Flies (Trichoceridae) are often quite abundant during winter and spring. They so closely resemble mosquitoes that they are frequently mistaken for them. Their larvae are found in roots, fungi, decaying vegetation, rotting leaves, manure, and other vegetative material. The adults are readily attracted to lights.

This insect does not bite humans, and they don’t carry disease. But these species still can be annoying to homeowners. To keep these pests away, consider turning out your porch or patio light since these flying insects are attracted to outdoor lights. You can also use repellent candles when outside.

WOOD GNAT

Wood Gnats (Anisopodidae) Looks like Mosquitoes
Wood Gnats (Anisopodidae) are some of the better known gnats, for they are attracted to light and can be found near windows, especially in spring time. The adults can be found all year long, though.

The larvae live in rotting plants and rotting plant parts, fermenting sap, animal manure, tree trunks, mud and sometimes sewage. Adults are found on foliage in or near damp places, some are found around flowing sap. They are sometimes seen in small swarms. Adults appear in two variations: grayish black or reddish.



(Drawn to scale)

CRANE FLY

- **LOCAL GENUS:** Tipula ultima
- **SIZE:** 3/8 to 2 1/2 inch
- **HABITAT:** Humid Areas
- **HARMLESS TO HUMANS**
- **ADULTS ARE A FAVORITE FOOD OF MANY BIRDS AND SMALL MAMMALS**

MOSQUITO

- **LOCAL GENUS:** Culex pipiens
- **SIZE:** 1/8 to 1/4 inch
- **HABITAT:** Any still water
- **CAN BE HARMFUL TO HUMANS AS THEY MAY CARRY VARIOUS TYPES OF DISEASES**

Technical Learning College

CRANE FLY / MOSQUITO COMPARISON

Detailed Sections

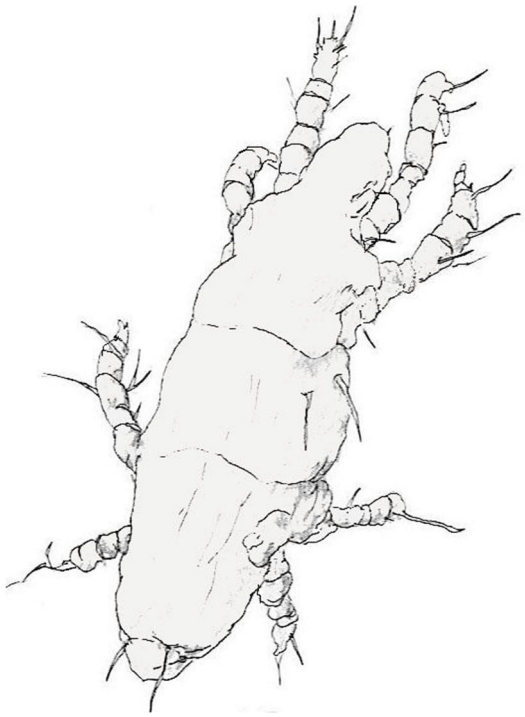
Chiggers (*Eutrombicula alfreddugesi)*

Larvae of chiggers, commonly called redbugs, attack humans and dogs during the larval stage. These mites are distributed over approximately the eastern half of the country. They are most common in the southern states where breeding may be continuous but frequently are abundant during the summer in the more northern states with one to three generations per year. They infest a variety of areas ranging from overgrown brush to well-kept lawns. Adults overwinter in earthen cells in the soil, scavenge on decaying matter and emerge from the soil in the spring to lay their eggs. These hatch into tiny, oval, orange-colored larvae that normally feed on snakes, turtles, rabbits, birds and other wildlife. These larvae, barely visible to the naked eye, are very active. When humans come in contact with infested vegetation, the larvae swarm over the entire body and it might be several hours before they settle down to feed. Their attack seems to be concentrated at points where the clothing is pressed against the skin, such as under belts or garters.

They attach, frequently near a hair follicle, by their mouthparts and first pair of appendages. The mites inject a fluid that liquefies the immediately adjacent tissues, which are then ingested. The surrounding tissues become hardened and, as feeding progresses, form a tiny tube through which further liquefied tissue may be withdrawn.

The larvae become fully fed in four to six days when they drop off the host, leaving behind the tubes that have developed from the feeding activity. The digestive fluid of the mites causes a severe itching and a definite dermatitis. Itching may last for a week or more. Scratching these areas may lead to secondary infection. After leaving the host, the larvae transform into nymphs and later into adults.

Neither of these forms attacks humans or other animals. Both feed on vegetable matter. Chiggers are not associated with disease transmission in the U.S.
Order: Acari
Family: Trombiculidae
Scientific Name: Trombicula



Itch Mite (*Sarcoptes scabiei*).
This mite causes scabies or itch in humans and is parasitic on dogs, pigs, horses and sheep. There are several closely related forms on animals that may sometimes transfer to humans, but usually close contact is required. Favored sites are in the skin between the fingers, the folds at the wrists, at the bend of the elbow or knee, and under the breasts.

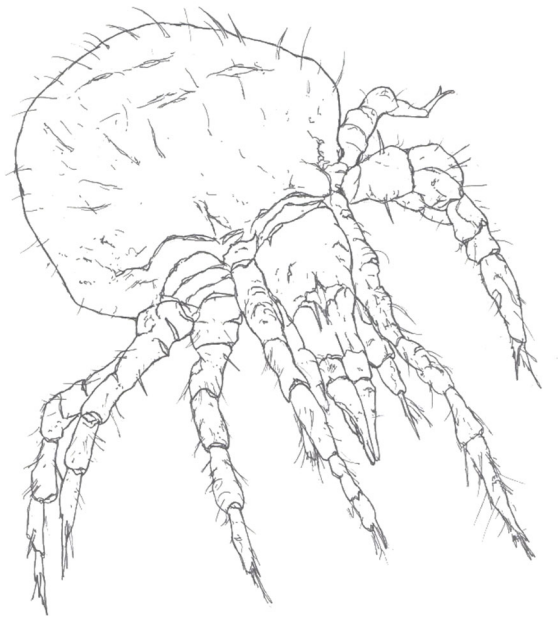
Crowded conditions encourage the spread of scabies infestations. The female mite cuts into the skin, makes a burrow under the skin and lays eggs.

The larvae return to the surface of the skin to molt, and the nymphal and adult stages then live on the surface. Unnoticed at first in newly infested people, sensitivity and itching build up at the end of the first month of infestation.

Follicle mite (*Demodex folliculorum*).
This mite is found in the skin pores of humans, especially around the nose and eyelids. It is likely that most people harbor this species. The mite is entirely parasitic, spending the entire life cycle on the host.

House Dust Mite (*Dermatophagoides* spp.).

House dust mites can be a problem in any building occupied on a regular basis. They are generally found in mattresses, pillows, overstuffed furniture, rugs, floors or other protected places where people sleep or sit for long periods. They require a damp environment and are often found in floors where moist air may enter a room. Eggs are laid singly and the life cycle takes about a month. Adults live for one to three months, feeding on a variety of foods including dog food, cereals, yeast and especially the scaling of the skin of humans and their pets. In some sensitive people, they cause an allergic reaction.



Detection. Survey methods vary with the habits of the species being investigated. Various household **ectoparasites** can generally be found in structures.

To survey for chigger mites, use 12-inch squares of black or white paper placed on the ground for one to five minutes at intervals of 100 feet, perhaps, throughout the area, or in 400x400-foot grids. Count and record the number of mites aggregating at the upper edge of the squares.

Collect the mites with a fine-pointed brush and vials of alcohol for later identification. Use Berlese funnels to collect flour and grain mites and other free-ranging species, such as bird mites in nesting material.

Estimates of chigger, bird, and rodent mite population densities can be based on data gathered by stunning or killing the ectoparasites (with ether or chloroform) on dead or trapped animals, and combing (or beating) the parasites into a white enameled pan or picking them off with forceps.

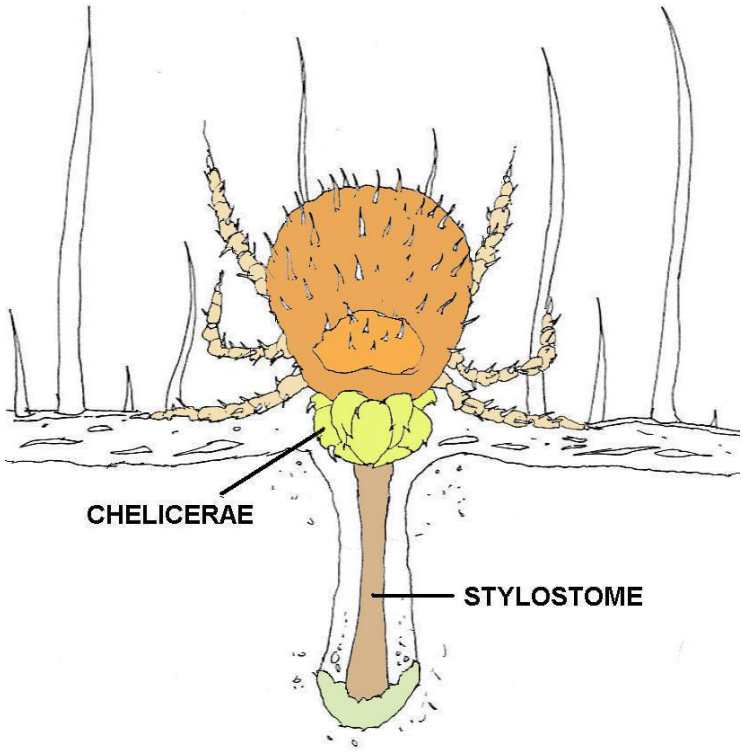
Alternatively, live hosts in cages with hardware cloth bottoms can be placed so that mites will drop into a pan of water after engorging, or the ectoparasites can be floated from a dead animal by immersion in water containing detergent and then collected on filter paper.

Scabies mites are detected by making skin scrapings for microscopic examination.

Control
Do not attempt control for the scabies (human itch) mite. This pest is controlled by laundering bedding and underwear and use of pesticide ointments prescribed by a physician. These may be recommended for application from the neck down for all family members.

For mites that migrate from bird nests or coops, remove the nests or caulk to exclude mite movement into dwellings. Wear protective clothing (gloves, eyeglasses, etc.) to prevent mites and nest debris from contaminating workers.

Apply approved pesticide sprays or dusts indoors to cracks and crevices near or leading to mite sources, and outside at nest areas. Habitat alteration to remove birds from nest areas coupled with pesticide application should immediately eliminate the problem.



CHIGGER FEEDING DIAGRAM

Chigger Mites
For chigger mites, avoid infested locations or use repellents on pants legs and shoes and tuck trousers into boots. When possible, keep vegetation cut low. Not only does this remove chigger **harborage**, it also eliminates harborage for rodents and other animals that serve as wild hosts. These sanitation practices are especially important for chigger management in fields, vacant lots, recreational areas and parks.

Chiggers can also be controlled in lawns and other infested areas by careful and thorough treatment with granules or sprays of residual pesticides that are effective against mites. The miticides will work best if applied after the infested area has been mowed.

Chigger Bite Example

Chigger Control

Chiggers, also known as “redbugs or jiggers,” are the immature stages of the common red harvest mite. It is only the first (larval) stage of the mite that feeds on people and other passing animals. Chigger mites attach themselves to the clothing of people or the fur of passing animals. They prefer constricted locations like sock tops, or waist bands. They do not burrow into the skin or suck blood as many people believe. Instead they crawl into a hair follicle, inject a salivary fluid which dissolves the hosts’ cells, then suck up the liquefied tissues. Within a few hours after feeding begins, small, reddish, intensely-itching welts begin to appear.

A chigger is the parasitic larval stage of a common mite in the genus Trombicula. Several species of chiggers exist in the United States, but Trombicula alfreddugesi is most commonly encountered. The adult stage is not parasitic and is often seen in lawns and moving across pavement. The adult stage spends its winter in the soil and the females will deposit eggs during the first warm days of spring. Eggs hatch into chiggers that are only about 1/150 inch in diameter. It is this stage that attacks humans and causes so much discomfort.

Chiggers crawl about on vegetation, waiting to attach to a host. Rodents, birds, livestock, snakes, toads and other animals serve as natural hosts. Humans are an accidental host. Two to three generations of chiggers are produced each year, so the threat of being attacked exists from May until the first killing frost.

In general, chiggers are more common in damp areas with low-growing shrubs, tall grass, weeds and similar foliage. Within favorable habitats, the distribution of chiggers is usually patchy. Individuals are often concentrated in certain areas of the habitat and virtually absent from other areas of apparently equal quality. The unfortunate person sitting in an area with a high concentration of chiggers will be attacked, while someone sitting only a few yards away may not be bitten at all.

Avoidance
The best defense against chiggers is to avoid them. Avoid wearing shorts, sleeveless shirts and sandals when going into chigger habitats. Tightly woven fabrics reduce the threat of chiggers penetrating clothing. Tuck pant legs inside boots, and button cuffs and collars tightly to keep chiggers on the outside of clothing. This increases the time that chiggers are exposed to any repellents you have applied to your clothes. Remove clothing as soon as possible after exposure to chigger habitats, and launder it before wearing it again. A warm shower with a vigorous skin massage, taken within an hour or two after exposure, greatly reduces the number of irritating bites. If itching has already started, however, it is probably too late for bathing to do much good.

Repellents
If you must enter chigger-infested areas, chemical repellents can be used with good results.

- Any insect repellent containing DEET (diethyl toluamide) or picaradin will be effective. Apply it to clothing from the feet up, and reapply every two to three hours to maintain its effectiveness.
- Sulfur powder is also effective when applied to clothing but has a strong odor that makes it less desirable.

- Permanone, also sold as Coulston's Permethrin Tick Repellent, contains the pyrethroid insecticide permethrin and should be sprayed on clothing and allowed to dry before the clothing is worn.
- These products are generally available at sporting goods stores and outdoor-clothing outlets.

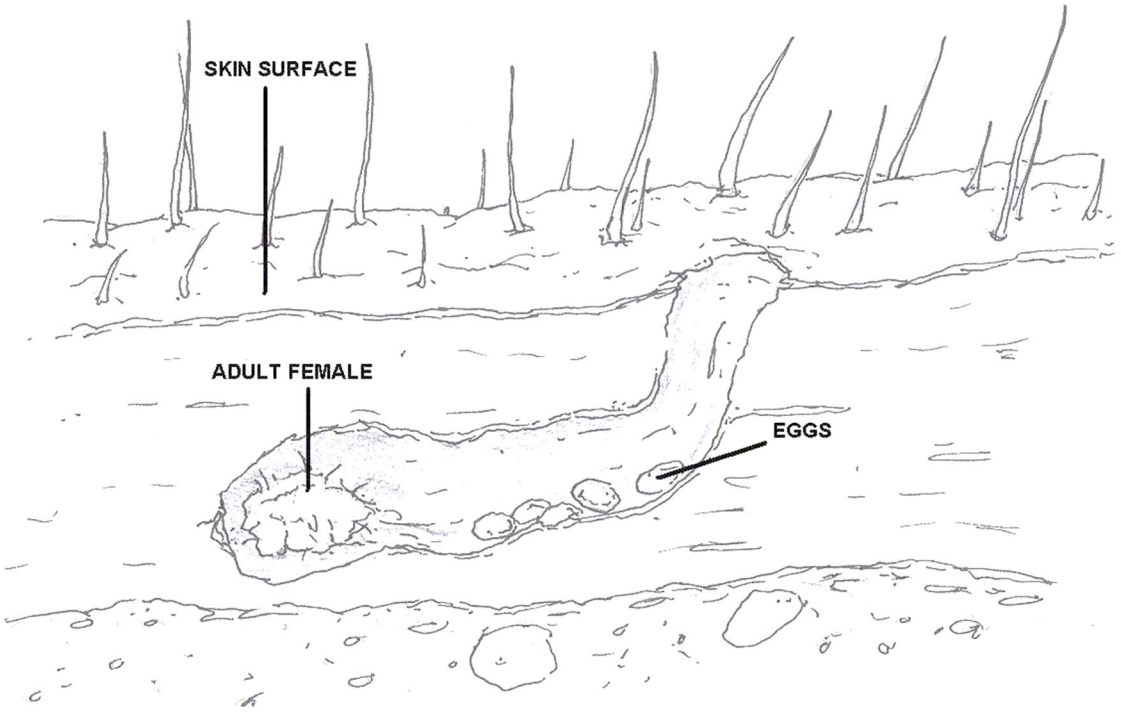
Area Control
Mowing lawns and removing unnecessary shrubs or weeds will decrease suitable chigger habitats and is the most effective form of area control.

Controlling chigger populations by spraying infested areas has limited effectiveness and gives temporary control of only a few days or weeks, depending on environmental conditions. A variety of over-the-counter products are labeled for chigger control. The active ingredients in these products all end with the suffix -thrin and are similar in effectiveness.

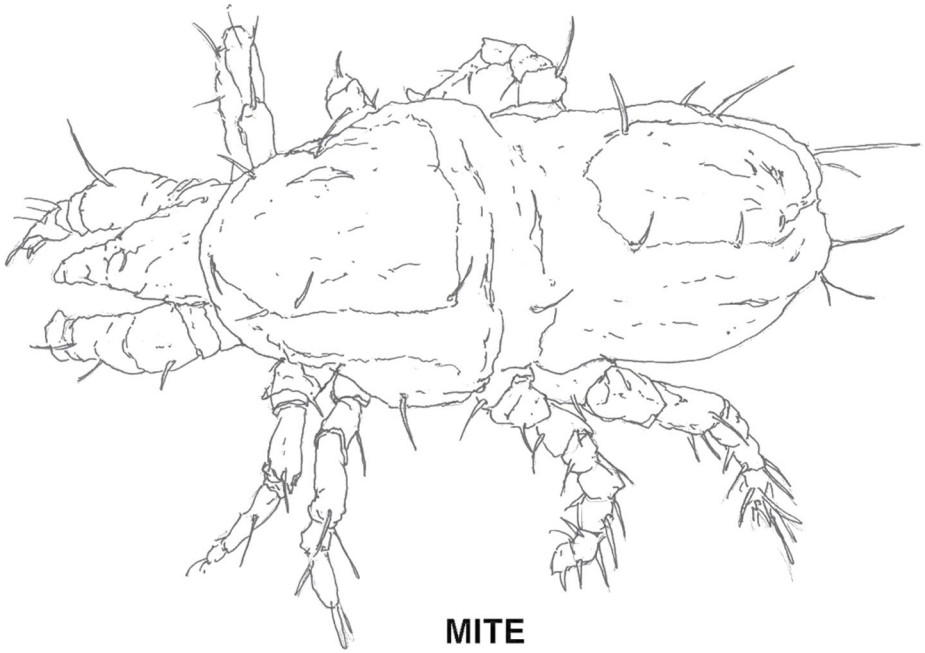
If you decide to treat, a single application during Late-April through mid-June is best. Treating the entire lawn is of little benefit because chiggers avoid direct sunlight and normally will not infest areas that are mowed or otherwise well maintained. Focus treatment on the unkempt areas of the lawn and lawn edge.

Chigger Prevention/Control
Spraying or dusting a yard or similar area with a pesticide (cyfluthrin) is the primary way to kill chiggers. Repeated applications of this pest control agent in your yard and adjacent wild areas will control chiggers for a season. This pesticide is available locally or on the internet and is an effective chigger remedy.

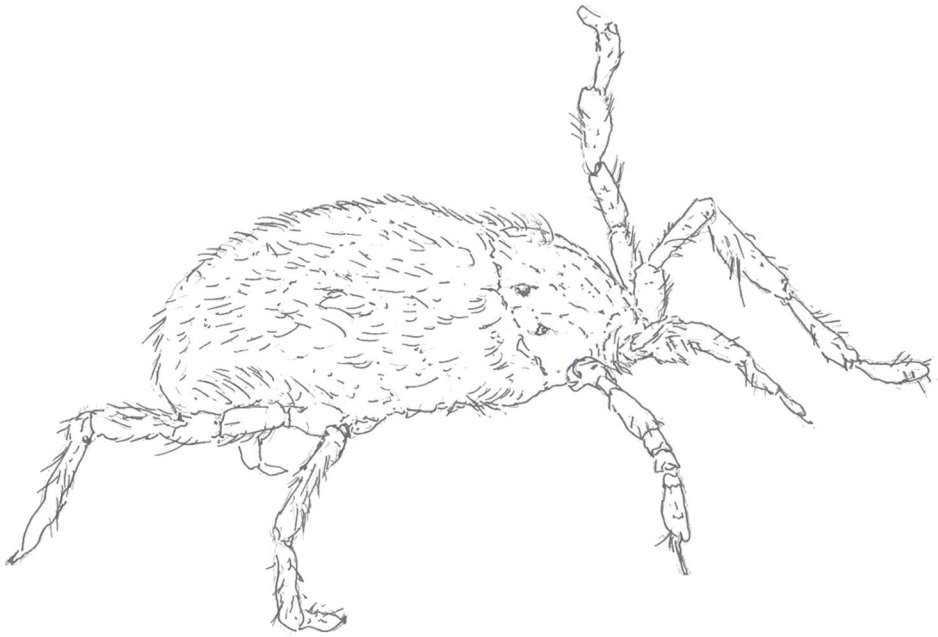
Spreading sulfur around the yard sends the chiggers away. Also beneficial nematodes will help you get rid of chiggers.
- Fire ants also eat chiggers but it is your choice as to which pest you want hanging around.
- Cedar granules have also been reported as an effective natural pest control agent for chiggers.



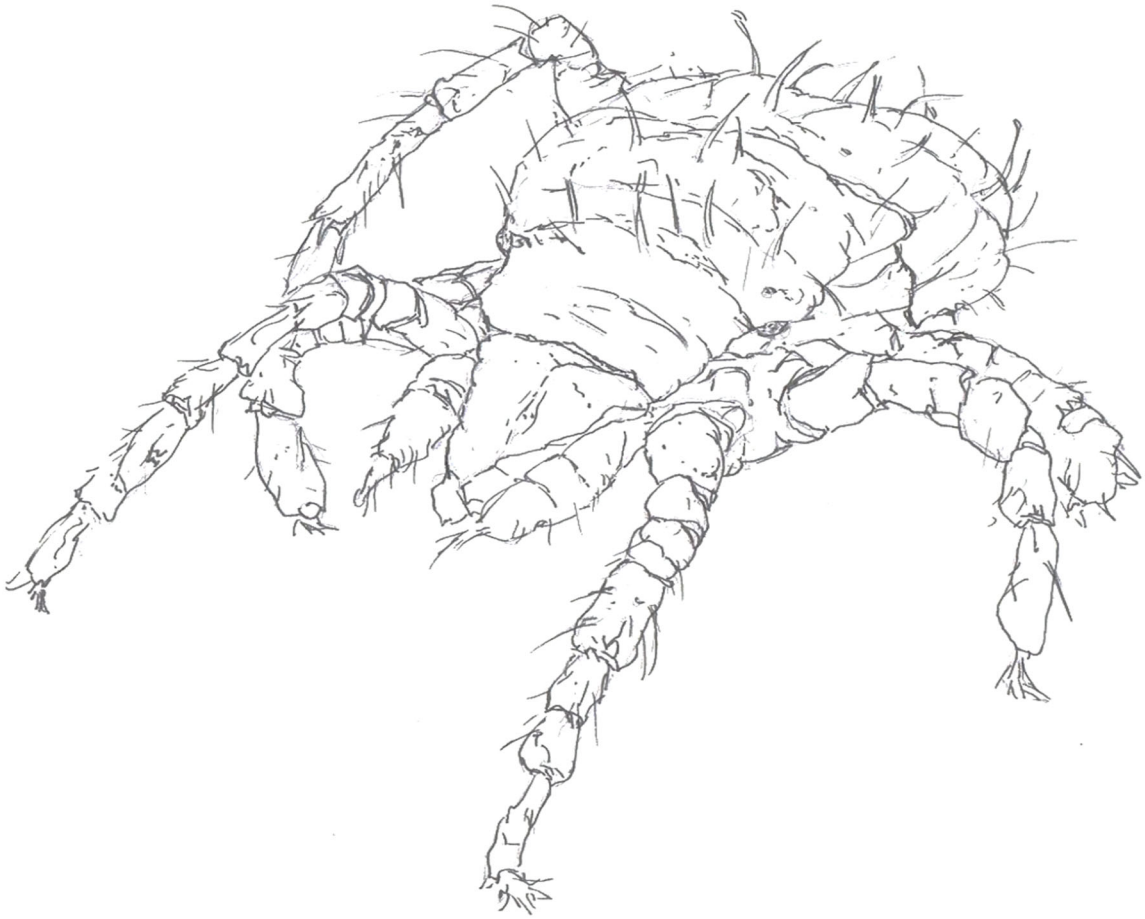
SARCOPTES SCABEI BURROWING AND LAYING EGGS IN TUNNEL



MITE



HARVEST MITE



CHIGGER

Chigger Chemical Treatments

Cyfluthrin

Cyfluthrin is a synthetic pyrethroid derivative that is used as an insecticide. Like most pyrethroids, it is highly toxic to fish. It is generally supplied as a 10-25% liquid concentrate for commercial use and is diluted prior to spraying onto agricultural crops and outbuildings. Excessive exposure can cause nausea, headache, muscle weakness, salivation, shortness of breath and seizures. In humans, it is deactivated by enzymatic hydrolysis to several carboxylic acid metabolites, whose urinary excretion half-lives are in a range of 5–7 hours. Worker exposure to the chemical can be monitored by measurement of the urinary metabolites, while severe overdosage may be confirmed by quantification of cyfluthrin in blood or plasma.

Cyfluthrin is a skin and eye irritant in humans, but overall poisonings from pyrethroid chemicals are rare. In humans pyrethroids are rapidly broken down by the liver proteins. In addition, pyrethroids are not absorbed into the bloodstream very well. Cyfluthrin may cause itching, burning, or stinging if it comes in contact with human skin which may last up to 24 hours. The onset of these symptoms can take 1 or 2 days to appear after initial exposure but may also occur at the time of the exposure. Sweating and/or exposure to sun/heat may exacerbate skin irritation.

Cyfluthrin is the active ingredient in many insecticide products including Baythroid, Baythroid H, Attatox, Contur, Laser, Responsar, Solfac, Tempo and Tempo H. Combination products include Baythroid TM (+ methamidophos) and Aztec (+ tebupirimphos).

This course contains pesticide recommendations that are subject to change at any time. These recommendations are provided only as a guide. It is always the pesticide applicator's responsibility, by law, to read and follow all current label directions for the specific pesticide being used. Due to constantly changing labels and product registration, some of the recommendations given in this writing may no longer be legal by the time you read them. If any information in these recommendations disagrees with the label, the recommendation must be disregarded.

Always follow label instructions and take steps to avoid exposure. If any exposures occur, be sure to follow the First Aid instructions on the product label carefully. For additional treatment advice, contact the Poison Control Center at 1-800-222-1222. If you wish to report a pesticide problem, please call 1-800-858-7378.

Pyrethroids

To mimic the insecticidal activity of the natural compound pyrethrum another class of pesticides, pyrethroid pesticides, has been developed. These are non-persistent, which are sodium channel modulators, and are much less acutely toxic than organophosphates and carbamates. Compounds in this group are often applied against household pests. The pyrethroids are a large family of modern synthetic insecticides similar to the naturally derived botanical pyrethrins. They are widely used in agriculture, homes, and gardens. Some examples are bifenthrin, cyfluthrin, cypermethrin, deltamethrin, and permethrin. They may be applied alone or in combination with other insecticides. Pyrethroids are formulated as emusifiable concentrates (EC), wettable powders (WP), granulars (G), and aerosols.

Certain pyrethroids exhibit striking neurotoxicity in laboratory animals when administered by intravenous injection, and some are toxic by the oral route.

Systemic toxicity by inhalation and dermal absorption are low, however—there have been very few systemic poisonings of humans by pyrethroids. Though limited absorption may account for the low toxicity of some pyrethroids, rapid biodegradation by mammalian liver enzymes (ester hydrolysis and oxidation) is probably the major factor responsible. This course contains pesticide recommendations that are subject to change at any time.

These recommendations are provided only as a guide. It is always the pesticide applicator's responsibility, by law, to read and follow all current label directions for the specific pesticide being used. Due to constantly changing labels and product registration, some of the recommendations given in this writing may no longer be legal by the time you read them. If any information in these recommendations disagrees with the label, the recommendation must be disregarded. No endorsement is intended for products mentioned, nor is criticism meant for products not mentioned. The author and Technical Learning College (TLC) assume no liability resulting from the use of these recommendations.

Most pyrethroid metabolites are promptly excreted, at least in part, by the kidney. In response to dermal exposure, some persons may experience a skin sensitivity called paresthesia. The symptoms are similar to sunburn sensation of the face and especially the eyelids. Sweating, exposure to sun or heat, and application of water aggravate the disagreeable sensations. This is a temporary effect that dissipates within 24 hours.

For first aid, wash with soap and water to remove as much residue as possible, and then apply a vitamin E oil preparation or cream to the affected area. Paresthesia is caused more by pyrethroids whose chemical makeup includes cyano- groups: fenvalerate, cypermethrin, and fluvalinate. In addition to protecting themselves from future exposure, persons who have experienced paresthesia should choose a pyrethroid with a different active ingredient, as well as a wettable powder or microencapsulated formulation.

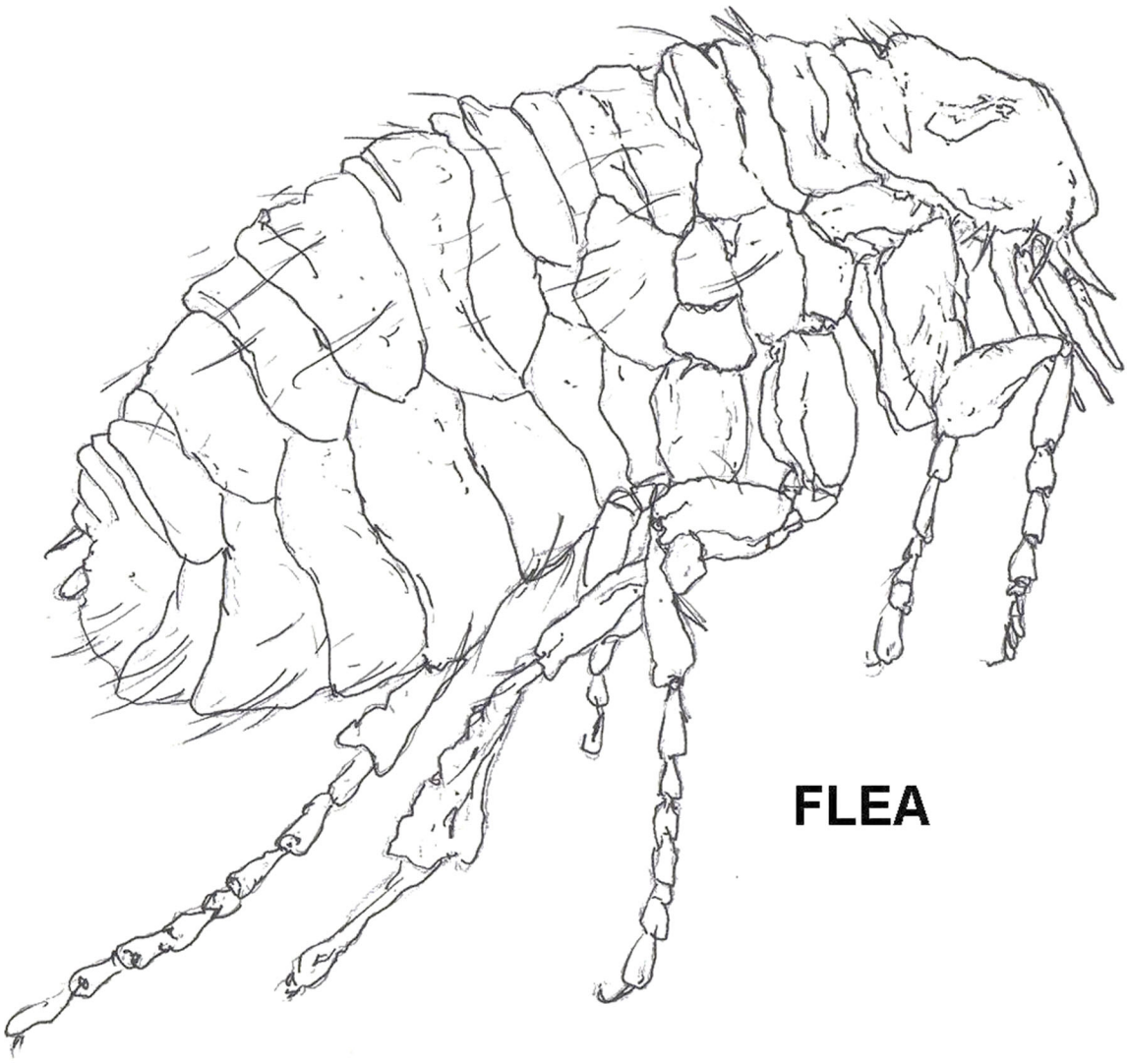
About These Pesticides

Pyrethrins and pyrethroids are insecticides included in over 3,500 registered products, many of which are used widely in and around households, including on pets, in mosquito control, and in agriculture. The use of pyrethrins and pyrethroids has increased during the past decade with the declining use of organophosphate pesticides, which are more acutely toxic to birds and mammals than the pyrethroids. This change to less acutely toxic pesticides, while generally beneficial, has introduced certain new issues. For example, residential uses of pyrethrins and pyrethroids may result in urban runoff, potentially exposing aquatic life to harmful levels in water and sediment.

Pyrethrins are botanical insecticides derived from chrysanthemum flowers most commonly found in Australia and Africa. They work by altering nerve function, which causes paralysis in target insect pests, eventually resulting in death. Pyrethroids are synthetic chemical insecticides whose chemical structures are adapted from the chemical structures of the pyrethrins and act in a similar manner to pyrethrins. Pyrethroids are modified to increase their stability in sunlight.

Most pyrethrins and some pyrethroid products are formulated with synergists, such as piperonyl butoxide and MGK-264, to enhance the pesticidal properties of the product. These synergists have no pesticidal effects of their own but enhance the effectiveness of other chemicals.

Fleas

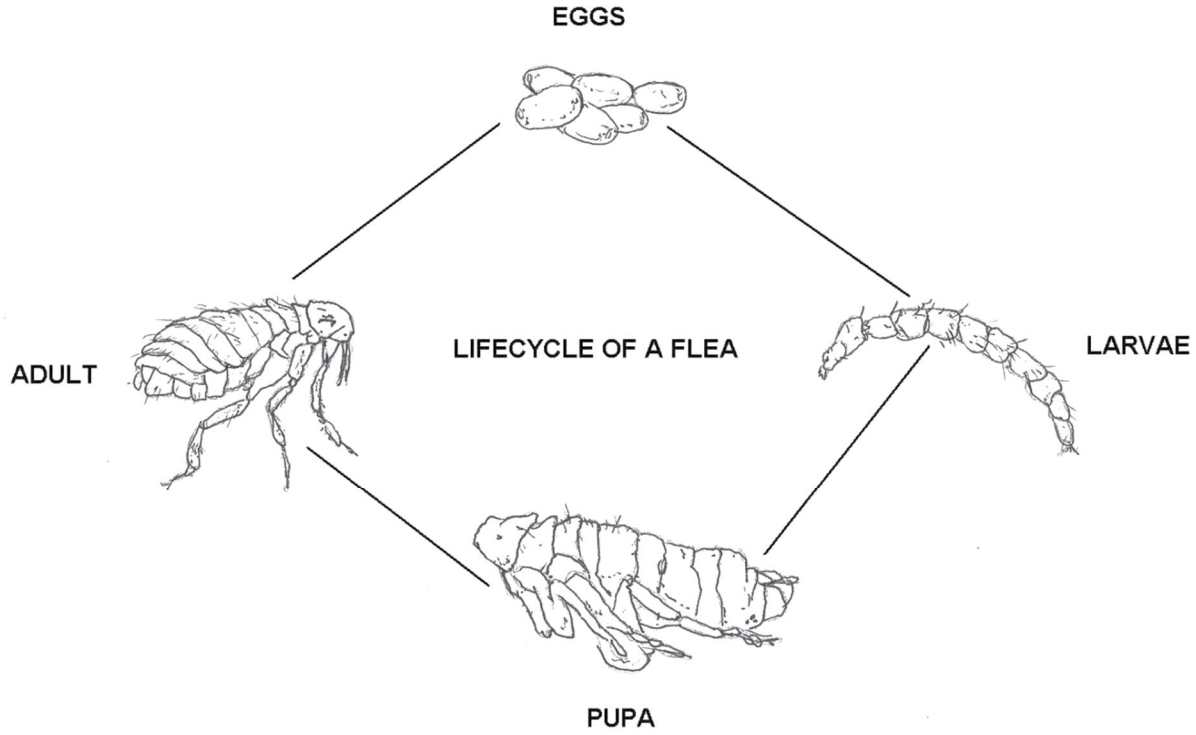


Fleas are small, dark brown insects whose bodies are hardened and compressed from side to side. Fleas do not fly, but have strong hind legs which they use to jump from host to host. Dogs and cats are at risk of getting fleas. Flea infestations usually get started in the summertime, after pets come in contact with infested pets or after they walk in areas where infested animals have spent time.

In the U.S., the most common flea species carried by both cats and dogs is the cat flea, Ctenocephalides felis. Compared with other flea species, the cat flea has a very wide host range. Wild animals carrying cat fleas include raccoons, opossum, skunks and foxes.

Essential Facts About Fleas

- Adult fleas (the biting stage seen by pet owners) spend most of their time on the animal, not in the carpet. This is why treatment of the pet in conjunction with the pet's environment is an essential step in ridding a home of fleas.
- Adult fleas lay all of their eggs (up to 50 per day) on the pet. However, the eggs soon fall off the animal into carpeting, beneath the cushions of furniture, and wherever else the pet rests, sleeps or spends most of its time. This is where homeowners should focus control measures.
- After hatching, flea eggs develop into tiny, worm-like larvae. Larvae remain hidden deep in carpet fibers, beneath furniture cushions and in other protected areas. The larvae feed mainly on adult flea feces (dried blood) which accumulates, along with the eggs, in pet resting and activity areas.
- Before becoming adult fleas, the larvae transform into pupae within a silk-like cocoon. Pupae remain inside the cocoon for 2 to 4 weeks, sometimes longer. The cocoon is resistant to insecticides and this is why some adult fleas are seen for an extended period, even after the home and pet are treated.



Pupae Stage

Sometimes petless families have to deal with fleas after a visit to the pet store or after the kids have played with a neighborhood dog or cat. A flea infestation may result, after a flea infested wild animal, like a raccoon takes up residence in a chimney or crawlspace. The problem fleas will be the ones in their pupae stage. These can stay in this stage for months (even years) and only come out when they need to come out. A vacant room will not cause them to come out so that means if you left fleas developing when you vacated the room or house, they'll be primed and ready to pop in 1-2 months. Worse yet for anyone moving in there, getting rid of the infestation will be nightmare with no pet around to absorb the hatching adults.

Flea bites are extremely irritating to pets. Large infestations or extreme sensitivity may result in intense itching and weight loss. Fleas have been known to transmit diseases.

Fleas on cats and dogs are the intermediate host for Dipylidium caninum, better known as the double-pore tapeworm, which infests dogs, cats and sometimes, humans. Because fleas do not spend their entire life on their host animal, they are nearly always associated with animals that regularly return to the same nesting sites.

Life Cycle
In order to understand all the steps needed to eliminate a flea infestation, it is important to understand the flea life cycle. Adult female and male fleas need a blood meal before mating. The female flea lays 30–50 eggs on the animal each day. She may live 4-25 days. The eggs are not attached to the animal and fall off wherever the animal sleeps or walks. The eggs fall into the carpet, pet bedding or yard.

Indoors, eggs hatch into tiny, light-colored wormlike larvae which live deep among the carpet fibers, in cracks and crevices or pet bedding. Outdoors, flea larvae are most likely found in shady locations, often where animals spend time. Larvae feed on organic matter. After several larval stages, the larva spins a tiny silken cocoon and pupates within it. Adult emergence from the pupa is stimulated by vibration and an increase in carbon dioxide, which indicates a host is present. The newly emerged adult immediately jumps on the host and begins feeding.

Flea Control
Fleas are very difficult as with Bed Bugs to kill flea pupae and the primary way to get rid of them is to vacuum and/or wait for all of them to hatch. The good news is hardwood floors are easy to vacuum and clean which will effectively remove all the flea eggs, larvae and pupae. This will help tremendously. But I also suggest you set out 2-4 flea traps to help speed the process by getting any pupae left behind to hatch sooner rather than later.

Lastly, there is usually no need to treat when one only has hardwood floors so no need to change that approach now. Adding to the list of reasons not to treat is the fact that you're pregnant so as I see it, a good vacuuming and some Flea Traps will be your best solution.

Treatment of Premises
If you neglect to treat the pet's environment (the premises), you will miss more than 90% of the developing flea population -- the eggs, larvae and pupae. If the pet spends time indoors, the interior of the home should also be treated. Before treatment, the pet owner should:
1. Remove all toys, clothing, and stored items from floors, under beds, and in closets. This step is essential so that all areas will be accessible for treatment.
2. Remove pet food and water dishes, cover fish tanks, and disconnect their aerators.
3. Wash, dry-clean or destroy all pet bedding.
4. Vacuum! -- vacuuming removes many of the eggs, larvae and pupae developing within the home. Vacuuming also stimulates pre-adult fleas to emerge sooner from their insecticide-resistant cocoons, thus hastening their contact with insecticide residues in the carpet. By raising the nap of the carpet, vacuuming improves the insecticide's penetration down to the base of the carpet fibers where the developing fleas live. Vacuum thoroughly, especially in areas where pets rest or sleep. Don't forget to vacuum along edges of rooms and beneath furniture, cushions, beds, and throw rugs. After vacuuming, seal the vacuum bag in a garbage bag and discard it in an outdoor trash container.

Wash It

- Take all pet bedding, your bedding, clothes and cloth that has been on the floor, and wash it, all of it. The wash cycle will not kill the fleas, but it may eject some of the eggs through the drain. The dry cycle, on HOT for over 30 minutes, will kill the eggs and any fleas remaining on the clothes and cloth materials. Do this all at the same time, removing everything at once and wrapping it in tied up sheets. Keep your clean clothes coming out of the dryer wrapped in clean sheets or garbage bags (you can re-use the garbage bags later, this is to prevent residual fleas on the floor from crawling onto your "clean" materials.
- Keep your animals inside for 30 days.
- If your animal must go outside, try to stay away from long grasses, fallen leaves, gravel areas, sandy areas. If you have a dog and you need to walk the dog, try to stick to pavement for this first month. While your dog or cat is toxic to fleas jumping on them, you are trying to eliminate a nasty infestation - you don't want to be introducing more when you are trying to kill them all. Remember, if they jump on your animal and then fall off in your house, that's one more flea to kill.

Treatment of Pet

It is important that the pet be treated in conjunction with the premises, preferably on the same day. Adult fleas spend virtually their entire life on the animal -- not in the carpet. Untreated pets will continue to be bothered by fleas. They may also transport fleas in from outdoors, eventually overcoming the effectiveness of the insecticide applied inside the home.

Pets can be treated either by a veterinarian or the pet owner. A variety of on-animal formulations are available that may be prescribed by veterinarians. Many provide only short-term relief against biting adults (a few hours to a few weeks); however, two new veterinarian-supplied products, Advantage and Frontline, control adult fleas on pets for 1 and 3 months, respectively. Some products also contain an insect growth regulator (IGR) to prevent eggs from hatching as they are laid on the animal (e.g., Raid Flea Killer Plus, Ovitrol Plus(R), Bio Spot(TM)). Convenient, long-term prevention of egg hatch can be accomplished either with the Ovitrol(R) Flea Egg Collar, or Program(R), administered orally to pets as a tablet. Both of these products are available through veterinarians.

Pet owners should always read the product label. Certain products can be used only on dogs, and some list specific treatment procedures for puppies and kittens. Do not treat pets with the same products used to treat carpeting or the yard. As previously mentioned, it is important that pets be kept off treated carpets and surfaces until the spray has completely dried.

To re-cap, "de-fleaing" the pet is an essential step in ridding a home of fleas. However, pet owners must also treat the pet's environment, the home. Having your pet dipped will not, in itself, eliminate fleas in an infested home.

1. Frontline Flea and Tick Medication

Frontline is one of the most popular brands for flea medication on the market today and for good reason. Frontline will kill almost 100% of fleas and ticks within three days of use. The Medication works using Fipronil which is absorbed into the skin. Once the Medication is absorbed it will travel to the glands of the animal. This will cause the drug to be systemic within your pet. When the fleas come into contact with the drug they will die within 24 hours.

One of the best parts about frontline flea control is that once it is absorbed it will stay in your pets' oil glands for 30 days. It will not wash off or come off on any of your family members' hands. It should be reapplied after 30 days, and is safe for both cats and dogs. Frontline also has very few side effects, though sometimes it can cause irritation at the site of application. If this occurs stop treatment and immediately ask your Veterinarian for further instructions. Remember that Frontline comes in a few different weights for animals of all sorts of different sizes, so know your pets weight before purchasing.

2. Advantage Flea Treatment

Advantage is another popular medication, made by Bayer, the same folks that brought us Aspirin. Advantage is fantastic at eliminating fleas on dogs and cats. It comes in different doses depending on your animal. IT is very important when using Advantage that you use the correct dosage for your animal. Too much Advantage can cause side effects that can be dangerous for your pet. It is very important when using advantage that you speak to a veterinarian before deciding on treatment. Advantage is made with Imidacloprid, which acts on the fleas' nervous system causing death. The only drawback to Advantage is that if it does have side effects, which is quite rare, the side effects can be quite dangerous to your pet, especially if the animal is on to high of a dosage.

These problems include respiratory problems, and or rashes. This medication is considered to be quite safe if used intelligently and correctly. Advantage Flea Control does not work on Ticks!!

3. Advantix

Advantix is also a very popular medication for fleas; it also works on tics which is great! The medication uses Imidacloprid and Permethrin to kill both tics and fleas. This medication is not systemic, it stays on the skin, so once applied be very careful not to wash it off during bathing. Also it is imperative much like advantage that the correct dosage is used. Imidacloprid can have some very dangerous effects if not used correctly. Advantix works almost exactly like Advantage but be careful,

DO NOT USE ADVANTIX ON CATS!! This medication is very dangerous to felines, and can cause seizures and possibly death. So dogs only please!! Also as with anything it is important to consult your veterinarian before deciding what the best treatment is for your pet.

Natural Treatments

There are also Natural Treatments available for your cats and dogs. Just be sure to consult your veterinarian regarding them. Most of the times your vet is going to say use frontline or advantage, they are after all extremely effective and very safe if used responsibly.

Borax Flea Control

Borax flea control is a good way to help take out a flea infestation once it has started. By using a mixture of borax and water on your carpets and letting it soak, then thoroughly cleansing your carpets after it has had time to set, you can defeat fleas in a fairly short period of time.

However, there are some downsides to Borax flea control that you should keep in mind. First and foremost, Borax is a toxic chemical that should be treated with respect. If you have children, you will want to be wary about how you treat your carpets with Borax.

A child that likes to play on carpets, or is prone to putting their fingers in their mouth, should be kept from suite being treated from Borax. If it is not possible to keep a child from the room, Borax should not be used.

When using a Borax flea control regime, you will want to do some other things to make certain that the treatment is being as effective as possible. While Borax is very effective at the removal of fleas, it will only help control an infestation when used in conjunction with other remedies. These can be natural or unreal remedies. Common ones used with Borax include Pennyroyal, Citronella, Lemongrass, Cedar and flea foggers.

For long term use, Borax flea control can be effective, but dangerous. You should be cautious about Using Borax for a long period of time, as it is a chemical, and it can be harmful. If you need a long term solution, but still want to use Borax, there are several things you can do.

First, you can mix your Borax treatments with Advantage, Front Line or similar products. This allows you to use your pet as a flea killer, and quicken the process of killing fleas by Using Borax. The combination of these two treatments can be highly effective at preventing fleas from being able to breed.

When you use Borax flea control with pet medications, you need to make certain you vacuum your carpets frequently, as well as take care to entirely get rid of the Borax when you are not actively treating your carpet with it. Vacuuming can help remove flea larvae, as well as keep safe levels of chemicals in the carpeting.

Once you vacuum, you should make certain to throw away of the vacuum bag immediately, as larvae may still be able to hatch inside of them. The key to Borax flea control is to never miss a scheduled time to dose your carpets. Consistency is key to making certain the infestation is removed and prevented from occurring again.

Flea Insecticide Application

Once fleas become established in a home, insecticides are almost always needed to control them. Always read and follow label directions on the insecticide container. Other than the person performing the application, people and pets should be out of the house during treatment.

People and pets should also remain off treated surfaces until the spray has dried. This may take several hours, depending on carpet type, ventilation and method of application. Opening windows and running the fan or air conditioner after treatment will enhance drying and minimize odor.

Many different products are available for home treatment. The most effective formulations contain both an adulticide (e.g., permethrin) effective against the biting adult stage, and an insect growth regulator (methoprene or pyriproxyfen), necessary to provide long-term suppression of the eggs, larvae and pupae. Pet owners will need to carefully read the “active ingredients” panel on the product label to determine if these ingredients are present. Examples include Raid Flea Killer Plus(R), Siphotrol Plus(R), Bio Flea Halt(TM), and Fleatrol(R). Most homeowners will find aerosol formulations easier to apply than liquids.

Moreover, aerosol products which can be dispensed by hand -- and thus directed under and behind beds, furniture, etc. -- tend to be more effective than “foggers” or “bug bombs” which are indiscriminately set off in the center of a room. It is essential that the application be thorough and includes all likely areas of flea development.

Carpets, throw rugs, under and behind beds and furniture, and beneath cushions on which pets sleep should all be treated. Pay particular attention to areas where pets spend time or sleep, as these will be the areas where most flea eggs, larvae and pupae will be concentrated. For example, if the family cat sleeps within a closet, or hides under the bed, these areas must be treated or the problem will continue. Hardwood and tile floors generally do not require treatment, but should be thoroughly vacuumed.

These recommendations are provided only as a guide. It is always the pesticide applicator's responsibility, by law, to read and follow all current label directions for the specific pesticide being used. Due to constantly changing labels and product registration, some of the recommendations given in this writing may no longer be legal by the time you read them. If any information in these recommendations disagrees with the label, the recommendation must be disregarded.

No endorsement is intended for products mentioned, nor is criticism meant for products not mentioned. The author and Technical Learning College (TLC) assume no liability resulting from the use of these recommendations.

Expect to see some fleas for 2 weeks or longer following treatment. Provided all infested areas were treated initially, these "survivors" are probably newly emerged adults which have not yet succumbed to the insecticide. Instead of retreating the premises immediately, continue to vacuum. As noted earlier, vacuuming stimulates the insecticide-resistant pupae to hatch, bringing the newly emerged adults into contact with the insecticide sooner.

Flea traps, such as those utilizing a light and glue board to attract and capture adult fleas, can be helpful but will not eliminate a flea infestation unless used in combination with other methods. If adult fleas continue to be seen beyond 2-4 weeks, retreatment of the premises (and pet) may be necessary.

Common Flea Treatment Pesticides

Permethrin

General Information

Permethrin is a broad-spectrum pyrethroid insecticide. It is available in dusts, emulsifiable concentrates, smokes, ULV concentrates, and wettable-powder formulations. The historical development of the synthetic pesticides called pyrethroids is based on the pyrethrins, which are derived from chrysanthemums. Pyrethrins are a "natural" environmental product that is of low toxicity to mammals. They are highly photolabile and degrade quickly in sunlight, and the cost of reapplying them has limited their widespread agricultural use. Pyrethroids have been synthesized to be similar to pyrethrins yet more stable in the environment. Evidence suggests that they have a very large margin of safety when used as directed by the label (Aldridge, 1990; Chen et al., 1991; Snodgrass, 1992).

Commercial pyrethroid products commonly use petroleum distillates as carriers. Some commercial products also contain OP or carbamate insecticides because the rapid paralytic effect of pyrethrins on insects ("quick knockdown") is not always lethal (Cheremisinoff and King, 1994). Pyrethroids are formulated as emulsifiable concentrates, wettable powders, granules, and concentrates for ULV application.

Always follow label instructions and take steps to avoid exposure. If any exposures occur, be sure to follow the First Aid instructions on the product label carefully. For additional treatment advice, contact the Poison Control Center at 1-800-222-1222. If you wish to report a pesticide problem, please call 1-800-858-7378.

NOTE: When pesticides are used, it is the applicator’s legal responsibility to read and follow directions on the product label. Not following label directions, even if they conflict with information provided herein, is a violation of federal law.

Propoxur

Propoxur (Baygon®) is a carbamate insecticide and was introduced in 1959. Propoxur is a non-systemic insecticide with a fast knockdown and long residual effect used against turf, forestry, and household pests and fleas. It is also used in pest control for other domestic animals, Anopheles mosquitoes, ants, gypsy moths, and other agricultural pests. It can also be used as a molluscicide.

Several US states have petitioned the Environmental Protection Agency (EPA) to use propoxur against bedbug infestations, but EPA been reluctant to approve indoor use because of its potential toxicity to children after chronic exposure.

Always follow label instructions and take steps to avoid exposure. If any exposures occur, be sure to follow the First Aid instructions on the product label carefully. For additional treatment advice, contact the Poison Control Center at 1-800-222-1222. If you wish to report a pesticide problem, please call 1-800-858-7378.

Methoprene IGR Treatment
Methoprene is a juvenile hormone (JH) analog which can be used as an insecticide that acts as a growth regulator. Methoprene is an amber-colored liquid with a faint fruity odor which is essentially nontoxic to humans when ingested or inhaled. It is used in drinking water cisterns to control mosquitoes which spread malaria.

Methoprene is an insect growth regulator (IGR) with activity against a variety of insect species including horn flies, mosquitoes, beetles, tobacco moths, sciarid flies, fleas (eggs and larvae), fire ants, pharaoh ants, midge flies and Indian meal moths. Controlling some of these insects, methoprene is used in the production of a number of foods including meat, milk, mushrooms, peanuts, rice and cereals. It also has several uses on domestic animals (pets) for controlling fleas.

Methoprene products are sold under a number of trade names including Altosid, Precor, Kaba, Pharorid, Dianex, Apex, Fleatrol, Ovitrol, Extinguish and Diacon. Methoprene is considered a biochemical pesticide because rather than controlling target pests through direct toxicity, Methoprene interferes with an insect's life cycle and prevents it from reaching maturity or reproducing.

The Methoprene products used by professional pest control operators are sold under the brand name of Precor. When cockroaches are exposed to Gentrol (any form or type), people usually report seeing crippled, deformed, or otherwise odd looking roaches. These deformities are to be expected. Young roaches (also called cockroach nymphs) have an exoskeleton or outer shell. (Mammals have an internal skeleton or bone structure.) As roaches in their nymphal stage grow, their exoskeleton, or outer shell becomes too small to contain the insect. As they reach the limits of their exoskeleton a new, flexible exoskeleton forms beneath the old one, and the old "shell" splits open to allow the nymphs to molt. This transition denotes what is called a different instar or stage of development.

Pyrethroids
To mimic the insecticidal activity of the natural compound pyrethrum another class of pesticides, pyrethroid pesticides, has been developed. These are non-persistent, which are sodium channel modulators, and are much less acutely toxic than organophosphates and carbamates. Compounds in this group are often applied against household pests.

The pyrethroids are a large family of modern synthetic insecticides similar to the naturally derived botanical pyrethrins. They are widely used in agriculture, homes, and gardens. Some examples are bifenthrin, cyfluthrin, cypermethrin, deltamethrin, and permethrin. They may be applied alone or in combination with other insecticides. Pyrethroids are formulated as emusifiable concentrates (EC), wettable powders (WP), granulars (G), and aerosols. Certain pyrethroids exhibit striking neurotoxicity in laboratory animals when administered by intravenous injection, and some are toxic by the oral route. Systemic toxicity by inhalation and dermal absorption are low, however—there have been very few systemic poisonings of humans by pyrethroids. Though limited absorption may account for the low toxicity of some pyrethroids, rapid biodegradation by mammalian liver enzymes (ester hydrolysis and oxidation) is probably the major factor responsible. This course contains pesticide recommendations that are subject to change at any time. These recommendations are provided only as a guide. It is always the pesticide applicator's responsibility, by law, to read and follow all current label directions for the specific pesticide being used.

Due to constantly changing labels and product registration, some of the recommendations given in this writing may no longer be legal by the time you read them. If any information in these recommendations disagrees with the label, the recommendation must be disregarded.
Most pyrethroid metabolites are promptly excreted, at least in part, by the kidney. In response to dermal exposure, some persons may experience a skin sensitivity called paresthesia. The symptoms are similar to sunburn sensation of the face and especially the eyelids. Sweating, exposure to sun or heat, and application of water aggravate the disagreeable sensations. This is a temporary effect that dissipates within 24 hours. For first aid, wash with soap and water to remove as much residue as possible, and then apply a vitamin E oil preparation or cream to the affected area. Paresthesia is caused more by pyrethroids whose chemical makeup includes cyano- groups: fenvalerate, cypermethrin, and fluvalinate. In addition to protecting themselves from future exposure, persons who have experienced paresthesia should choose a pyrethroid with a different active ingredient, as well as a wettable powder or microencapsulated formulation.

Always follow label instructions and take steps to avoid exposure. If any exposures occur, be sure to follow the First Aid instructions on the product label carefully. For additional treatment advice, contact the Poison Control Center at 1-800-222-1222. If you wish to report a pesticide problem, please call 1-800-858-7378.

NOTE: When pesticides are used, it is the applicator's legal responsibility to read and follow directions on the product label. Not following label directions, even if they conflict with information provided herein, is a violation of federal law.

Cyfluthrin

Cyfluthrin is a synthetic pyrethroid derivative that is used as an insecticide. Like most pyrethroids, it is highly toxic to fish. It is generally supplied as a 10-25% liquid concentrate for commercial use and is diluted prior to spraying onto agricultural crops and outbuildings.

Excessive exposure can cause nausea, headache, muscle weakness, salivation, shortness of breath and seizures. In humans, it is deactivated by enzymatic hydrolysis to several carboxylic acid metabolites, whose urinary excretion half-lives are in a range of 5–7 hours. Worker exposure to the chemical can be monitored by measurement of the urinary metabolites, while severe overdosage may be confirmed by quantification of cyfluthrin in blood or plasma.

Cyfluthrin is a skin and eye irritant in humans, but overall poisonings from pyrethroid chemicals are rare. In humans pyrethroids are rapidly broken down by the liver proteins. In addition, pyrethroids are not absorbed into the bloodstream very well. Cyfluthrin may cause itching, burning, or stinging if it comes in contact with human skin which may last up to 24 hours. The onset of these symptoms can take 1 or 2 days to appear after initial exposure but may also occur at the time of the exposure. Sweating and/or exposure to sun/heat may exacerbate skin irritation.

Cyfluthrin is the active ingredient in many insecticide products including Baythroid, Baythroid H, Attatox, Contur, Laser, Responsar, Solfac, Tempo and Tempo H. Combination products include Baythroid TM (+ methamidophos) and Aztec (+ tebupirimphos).

About These Pesticides
Pyrethrins and pyrethroids are insecticides included in over 3,500 registered products, many of which are used widely in and around households, including on pets, in mosquito control, and in agriculture. The use of pyrethrins and pyrethroids has increased during the past decade with the declining use of organophosphate pesticides, which are more acutely toxic to birds and mammals than the pyrethroids. This change to less acutely toxic pesticides, while generally beneficial, has introduced certain new issues.

For example, residential uses of pyrethrins and pyrethroids may result in urban runoff, potentially exposing aquatic life to harmful levels in water and sediment.

Pyrethrins are botanical insecticides derived from chrysanthemum flowers most commonly found in Australia and Africa. They work by altering nerve function, which causes paralysis in target insect pests, eventually resulting in death.

Pyrethroids are synthetic chemical insecticides whose chemical structures are adapted from the chemical structures of the pyrethrins and act in a similar manner to pyrethrins. Pyrethroids are modified to increase their stability in sunlight. Most pyrethrins and some pyrethroid products are formulated with synergists, such as piperonyl butoxide and MGK-264, to enhance the pesticidal properties of the product. These synergists have no pesticidal effects of their own but enhance the effectiveness of other chemicals.

Pyrethrins, a single pesticide active ingredient, contain six components that have insecticidal activity:
pyrethrin 1, pyrethrin 2, cinerin 1, cinerin 2, jasmolin 1, and jasmolin 2

Pyrethroids include:
Allethrin stereoisomers, Bifenthrin, Beta-Cyfluthrin, Cyfluthrin, Cypermethrin, Cyphenothrin, Deltamethrin, Esfenvalerate, Fenpropathrin, Tau-Fluvalinate, Lambda-Cyhalothrin, Gamma Cyhalothrin, Imiprothrin, 1RS cis-Permethrin, Permethrin, Prallethrin, Resmethrin, Sumithrin (d-phenothrin), Tefluthrin, Tetramethrin, Tralomethrin, and Zeta-Cypermethrin

Synergists include:
MGK-264 and Piperonyl butoxide

Always follow label instructions and take steps to avoid exposure. If any exposures occur, be sure to follow the First Aid instructions on the product label carefully. For additional treatment advice, contact the Poison Control Center at 1-800-222-1222. If you wish to report a pesticide problem, please call 1-800-858-7378.

NOTE: When pesticides are used, it is the applicator’s legal responsibility to read and follow directions on the product label. Not following label directions, even if they conflict with information provided herein, is a violation of federal law.

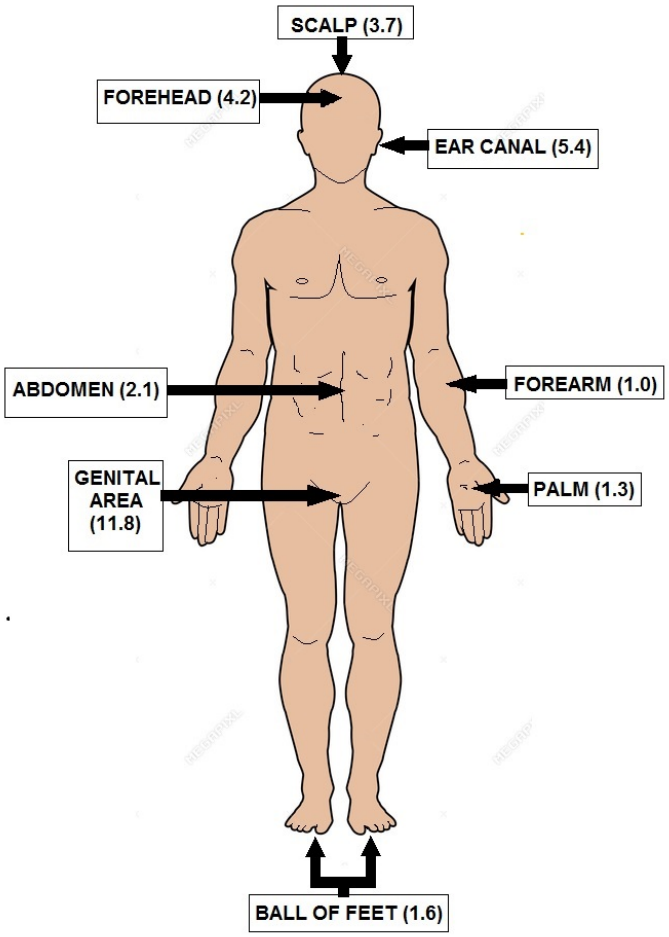
Pyriproxyfen

Pyriproxyfen is a pyridine based pesticide which is found to be effective against a variety of arthropoda. It was introduced to the US in 1996 to protect cotton crops against whitefly. It has also found useful for protecting other crops. It is also being used as a prevention for fleas on household pets. Pyriproxyfen is a juvenile hormone analogue, preventing larvae from developing into adulthood and thus rendering them unable to reproduce. In the US pyriproxyfen is often marketed under the trade name Nylar. In Europe pyriproxyfen is known under the brand names Cyclio (Virbac) and Exil Flea Free TwinSpot (Emax).

Always follow label instructions and take steps to avoid exposure. If any exposures occur, be sure to follow the First Aid instructions on the product label carefully. For additional treatment advice, contact the Poison Control Center at 1-800-222-1222. If you wish to report a pesticide problem, please call 1-800-858-7378.

NOTE: When pesticides are used, it is the applicator’s legal responsibility to read and follow directions on the product label. Not following label directions, even if they conflict with information provided herein, is a violation of federal law.

These recommendations are provided only as a guide. It is always the pesticide applicator's responsibility, by law, to read and follow all current label directions for the specific pesticide being used. Due to constantly changing labels and product registration, some of the recommendations given in this writing may no longer be legal by the time you read them. If any information in these recommendations disagrees with the label, the recommendation must be disregarded. No endorsement is intended for products mentioned, nor is criticism meant for products not mentioned. The author and Technical Learning College (TLC) assume no liability resulting from the use of these recommendations.



AREA OF EXPOSURE

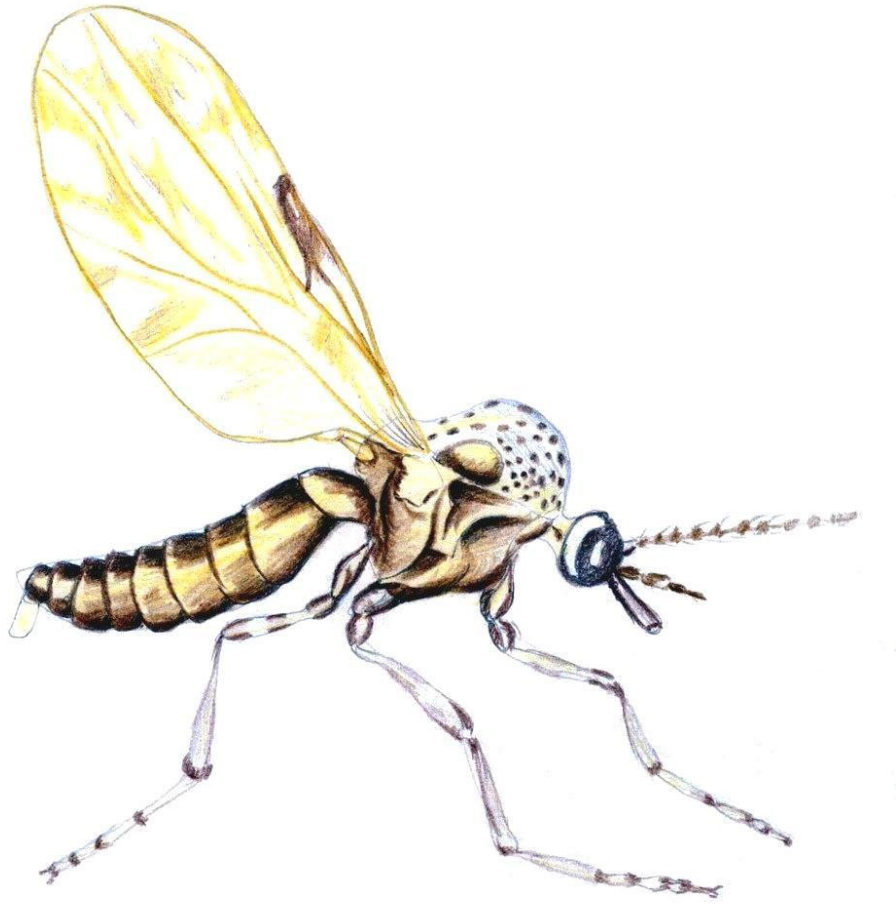
- GENITAL AREA IS HIGHEST
- ALSO THE SCALP, EAR CANAL AND THE FORHEAD

RELATIVE ABSORPTION RATES, AS COMPARED TO THE FOREARM EXPOSURE (1.0)

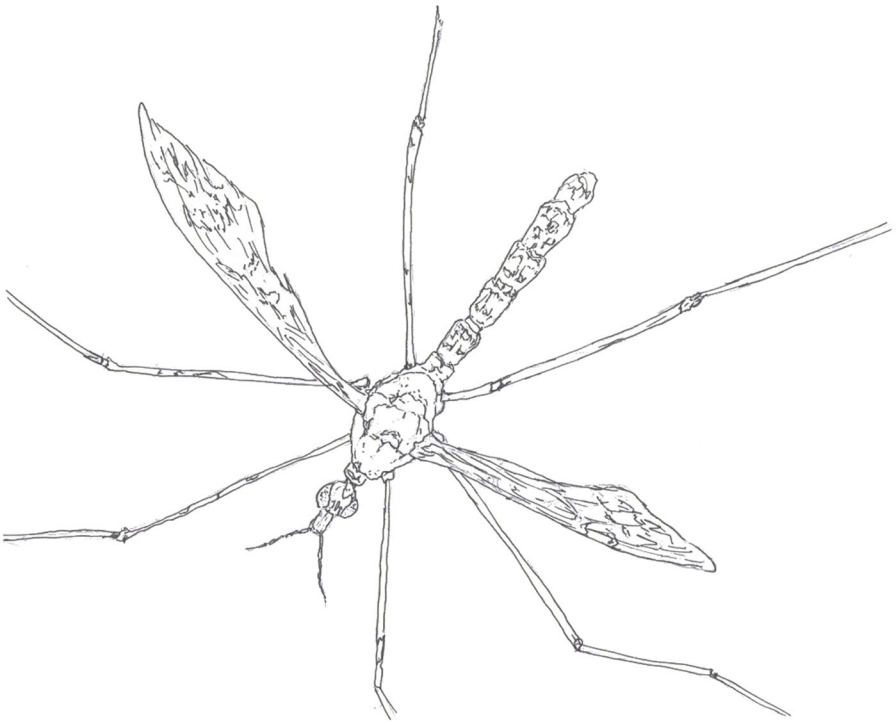
Technical Learning College

ABSORPTION RATES OF PESTICIDE EXPOSURE

Midge Section



Midges
SIZE: From 3/16 to 1/2 inch (5-12.7mm)
COLOR: Pale
DESCRIPTION: Name applies to mosquito-like flies in the family Chironomidae. They are different from mosquitoes in that female midges don't bite; males have large, bushy antennae. Adults produce a high-pitched humming sound when they swarm.
HABITAT: Adults frequently collect in large swarms in late afternoon or evening near streams, ponds, and lakes. They are often attracted to outdoor lights of houses close to these swarming sites.
LIFE CYCLE: Midges breed chiefly in water, but some develop in decaying vegetation, manure, or under the bark of trees. Because larvae occur in huge numbers in water, they are an important source of food for many species of fish. Adults emerge in the spring, frequently in large numbers.
TYPE OF DAMAGE: Although they do not bite, the adults can be a severe nuisance simply by their numbers.
CONTROL: Nearly impossible, since streams, ponds, and lakes cannot (and should not) be treated with insecticides to control these flies. Fogging for adults is not practical.
INTERESTING FACTS: Often mistaken for mosquitoes. The difference is that female mosquitoes do bite; female midges do not.



CRANE FLY

DIXIDAE MIDGE FLY

Midge Introduction

Midges are found almost everywhere and often occur in huge swarms. It is the large numbers that suddenly appear around the house or landscape that attract attention. Midges range from 1/8 to 1/2 inch and have a long, slender, delicate, mosquito-like body and feathery antennae. Midges of the type shown are harmless. (There are other species of midges, called the biting midges or no-see-ums that are annoying blood suckers.) The non-biting midges cannot bite or sting and they do not feed on field crops, landscape plants, livestock, pets, people or structures.

Biology and Identification
Most midge larvae live in water. A few occur in decaying organic matter or in very wet soil. The source of the immature stage means midges will be most numerous near lakes and streams, though swarms considerable distances from the nearest water are possible. Midge larvae are an important food item for fish.

This fly belongs to a family of small to moderately large flies. People are often alarmed by midges since they resemble mosquitoes. However, they differ from mosquitoes in that the wings are not scaled and the mouthparts are short and not adapted for biting.

Adult midges are slender, usually less than 5 mm long with long, slender legs and wings.

Midges lay their eggs on water. The larvae are usually aquatic, are found in quiet water such as lakes, ponds, reservoirs, and tanks, and are bottom feeders. Polluted water apparently favors their growth and development. In the summer, eggs will hatch in about 3 days, and larvae will reach adulthood in about 4 weeks.

During peak emergence, large numbers of midges fly into residential and industrial areas, causing annoyance and damage. They are attracted to lights at night, and thousands will rest on the outside of buildings and will enter homes through the slightest crack. They fly into people's eyes, ears, and mouths and are sometimes inhaled. Everything is contaminated by midges!

Common Name	Scientific Name
Non-biting midge	*Chironomus plumosus* (Linnaeus)
	Chironomus attenuatus Walker
Biting midges, punkies or no-see-ums	*Culicoides furens* (Poey)
Crane flies	*Tipula* spp.

Occasionally during April, May, and June, homeowners become alarmed by large swarms of gnat-like insects sometimes confused with mosquitoes. These non-biting midges are found near lakes, ponds, or streams and may "dance" in swarms over the water, inciting fish to jump.

Most occur in huge swarms or small compact mating swarms, and a *"humming"* can be heard over a considerable distance. After sunset, adults become active and fly to night-lights, entering structures through the slightest of openings.

Piles of eight to twelve inches of dead midges may accumulate in unwanted places. A stench similar to dead fish may be observed.

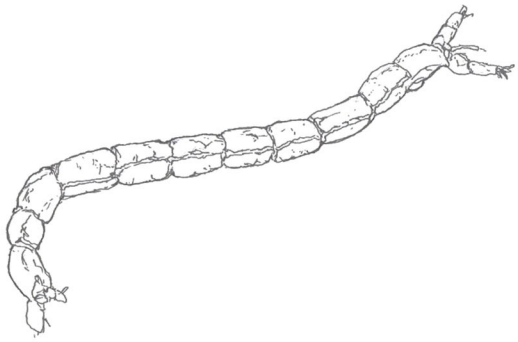
No See Ums

There are also biting midges, which are very tiny insects (sometimes called "*no-see-ums*"), that suck blood from humans, mammals, reptiles, and other insects. Bites can cause itching and, in sensitive individuals, welts and lesions that can persist for several days. Other species transmit diseases. Crane flies (some resembling overgrown or *"giant"* mosquitoes) are small to large size with extremely long legs (similar to *"daddy-long-legs"*) that break off easily. Many have patterned wings. They are non-biting or stinging, but may cause alarm by their presence on sides of homes and elsewhere.

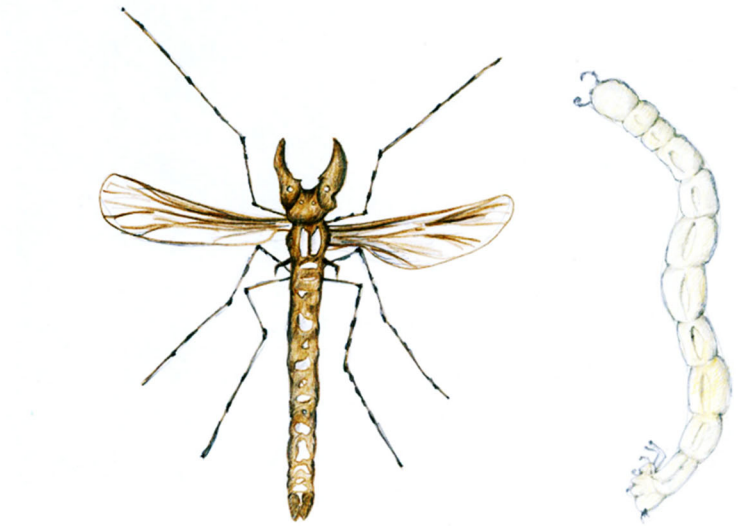
Identification

Non-biting midges are small (1/8-inch to 1/2-inch long), delicate, mosquito-like, but lack scales on their wings. Adults are humpbacked, brown, black, orange, or gray, lack a long beak (proboscis), and males have very feathery antennae. Larvae are often whitish, cylindrical-like, elongate or wormlike (up to 1/2-inch to 3/4-inch long) usually with paired prolegs, respiratory tubes absent on the prothorax, and have a dark head. Some are known as *"bloodworms"* or *"red worms"* due to the presence of hemoglobin in the blood.

Others have a greenish color. Most live in fresh water while others are found in very moist soil, in wet moss, and under damp bark. Most larvae feed on algae or small aquatic plants.

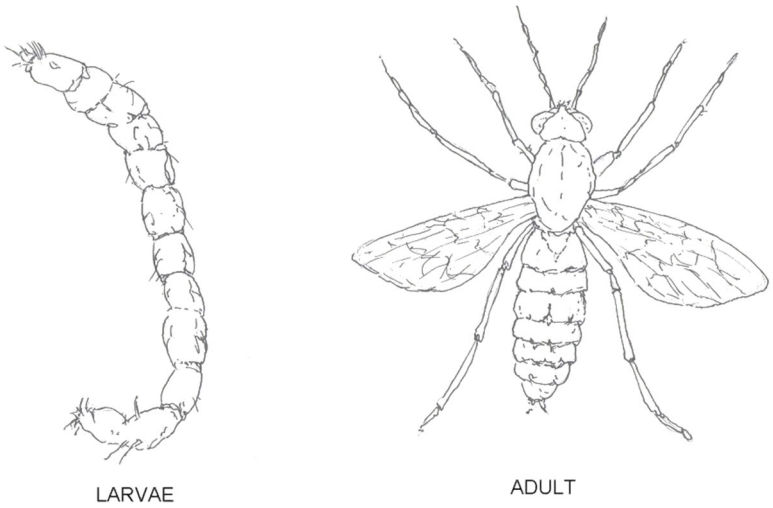


BLOODWORM



Biting Midges

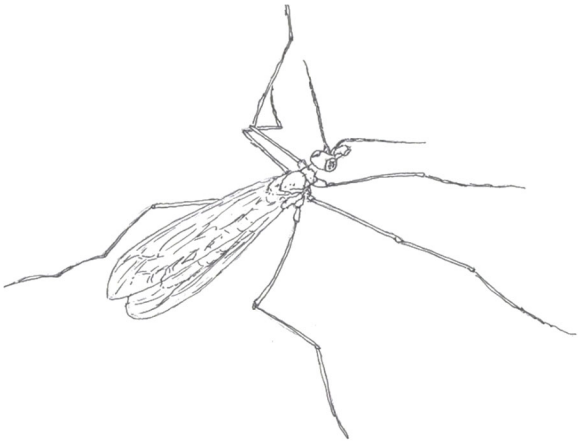
Biting midges, punkies, or no-see-ums are very tiny (less than 1/4-inch long), slender gnat-like flies. Some have narrow spotted or clear wings. Larvae are tiny, whitish, elongate, or wormlike, and are found in sand, mud, decaying vegetation, and water in tree holes.



BITING MIDGES

Compared with Crane Flies

Crane flies are small to large (3/16-inch to just under an inch long) long-legged, slender-bodied with a V-shaped suture across the thorax. Legs of all species break off easily so that perfect specimens are difficult to maintain in an insect collection. Many have patterned wings and resemble mosquitoes. The larvae, called *"leatherjackets,"* develop a tough skin and can usually be found in damp soil feeding on decaying vegetable matter. Maggots are legless, have poorly developed heads, and are about one inch long when mature. They are usually associated with poorly-drained soils and sometimes occur in large, concentrated numbers. They are sometimes mistaken as cutworms.



WINTER CRANE FLY

Life Cycle and Habits
During peak emergence, extremely large populations of non-biting midges may create much annoyance simply by accumulating in freshly applied paints, hanging onto outdoor laundry, clustering on screens, etc. Summer resorts along lakes and other water frontage may have houses and buildings covered with these midges that enter around vent openings, air conditioning units, windows, doors, etc. The following day, these midges are found dead on window sills throughout the building. Their presence causes concern to homeowners and others. Sometimes, midges invade factories and contaminate fabrics, plastics, packed materials, etc. Other times, thick swarms can cause allergic reactions in susceptible individuals and even cause traffic hazards. Even economic losses occur when customers go elsewhere from certain motels and restaurants to avoid nuisance midges that are attracted to night-lights on their premises.

Eggs
Female midges lay eggs in masses over open water or attach to vegetation. Eggs hatch in about 72 hours, and the young larvae drop to the bottom of the lake, stream, etc., feeding as scavengers on organic debris (silty ooze, algae, and plankton). The larval stage takes about four weeks, followed by pupation, lasting usually 48 hours. Pupa emerge from their pupal skin, rising to the water surface like a mosquito.

Adults do not eat and have a short life span of five to ten days. Males swarm at dusk, with mating occurring after females enter the swarm. Midges overwinter in the larval stage. They are beneficial as an important item of food for many freshwater fish and other aquatic animals.

Biting midges, punkies, or no-see-ums are found especially along the seashore and the shores of rivers or lakes. Their small size is responsible for the name "*no-see-ums,*" and their bite is far out of proportion to their size. Larvae are aquatic or semi-aquatic, found in moist sand, mud, decaying vegetation of salt and freshwater marshes, ponds and streams. They are believed to be scavengers.

Crane flies occur chiefly in damp situations with abundant vegetation. Larvae are aquatic or semi-aquatic, feeding on decaying vegetative matter. Others feed on living plants and may cause damage specially to turf and pasture. Some feed on flowers, certain vegetables, and small fruits. Others are predaceous. Little is known of the adult feeding habits, but some possess a long slender proboscis and feed on plant nectar. Crane flies do not bite or sting humans.

Control Measures
No control measures for midges are entirely satisfactory when large bodies of water are nearby. Locating the source of breeding is best. If possible and practical, locate standing water on your premises and eliminate it. Midges may fly as far as a quarter of a mile from the breeding site, such as a lagoon, drainage ditch, standing water, lake, or pond. They can also develop in and around buildings in well-watered soils and occasionally in standing water from air-conditioning units on building roofs. Check stagnant, polluted water accumulating in bird baths, clogged rain gutters, water-holding tree stumps, flower pots, old tires, etc. Sometimes, it is often best to wait out the one-to two-week emergence period for a particular species, hoping that additional emergence periods will not occur. However, several species emerging at different times may occur in the same locality, lasting six to eight weeks or longer at 75°F to 80°F during hot, muggy weather.

Midge Prevention

Houses and buildings with outside lighting will attract large numbers of non-biting midges. Move light away from sensitive areas such as doorways, windows, patios, etc. Avoid the use of unnecessary lights until 45 minutes after sundown, since 90 percent or more of flight activity takes place before that time.

Sometimes, eggs are laid on surfaces around lights and on buildings. These egg masses can become unsightly and smear when wet.

By replacing a 100-Watt mercury vapor light (ultraviolet energy) with a 50-Watt high-pressure sodium vapor light, midge concentrations are significantly reduced. (Lights least attractive to insects are sodium vapor or halogen with pink, yellow, or orange tints and dichrom yellow bulbs.) Blacklight traps (bug zappers) will kill midges, but unfortunately, often attract more midges into the area than are killed. Larvae have been controlled in small bodies of water by stocking with carp and goldfish at the rate of 150 to 500 pounds of fish per acre.

Biting midges apparently do not travel far from the place where larvae develop, and one may often avoid punkie attacks by simply moving a few yards away.

Insecticides
Small bodies of landlocked water may be treated with insecticides, but these bodies of water may or may not be the source of nuisance midges. Several of the commercial insecticides labeled for midge control are for application only by public health officials, trained personnel of Mosquito Abatement Districts, and licensed pesticide applicators.

For control of midge larvae, one can apply temephos (***Skeeter Abate***) two percent or five percent, in standing water, shallow ponds, lakes, woodland pools, tidal water, marshes, swamps, and waters high in organic content (highly polluted water). For adult control, one can apply permethrin (***Biomist***) ULV, using any standard ULV ground applicator capable of producing a non-thermal, aerosol spray with droplets ranging in size from 5 to 30 microns.

Also, labeled for adult control is chlorpyrifos + permethrin (***ULV Mosquito Master***). Permethrin 6.92 to 10 percent EC is a broad spectrum multiuse insecticide, providing quick knockdown.

Certain formulations of pyrethrins are labeled for outdoor adult midge control. Some licensed pest control operators use total release of aerosols and fog (**ULV**) for adult control. Granular pesticides have been used in barrier treatments around structures.

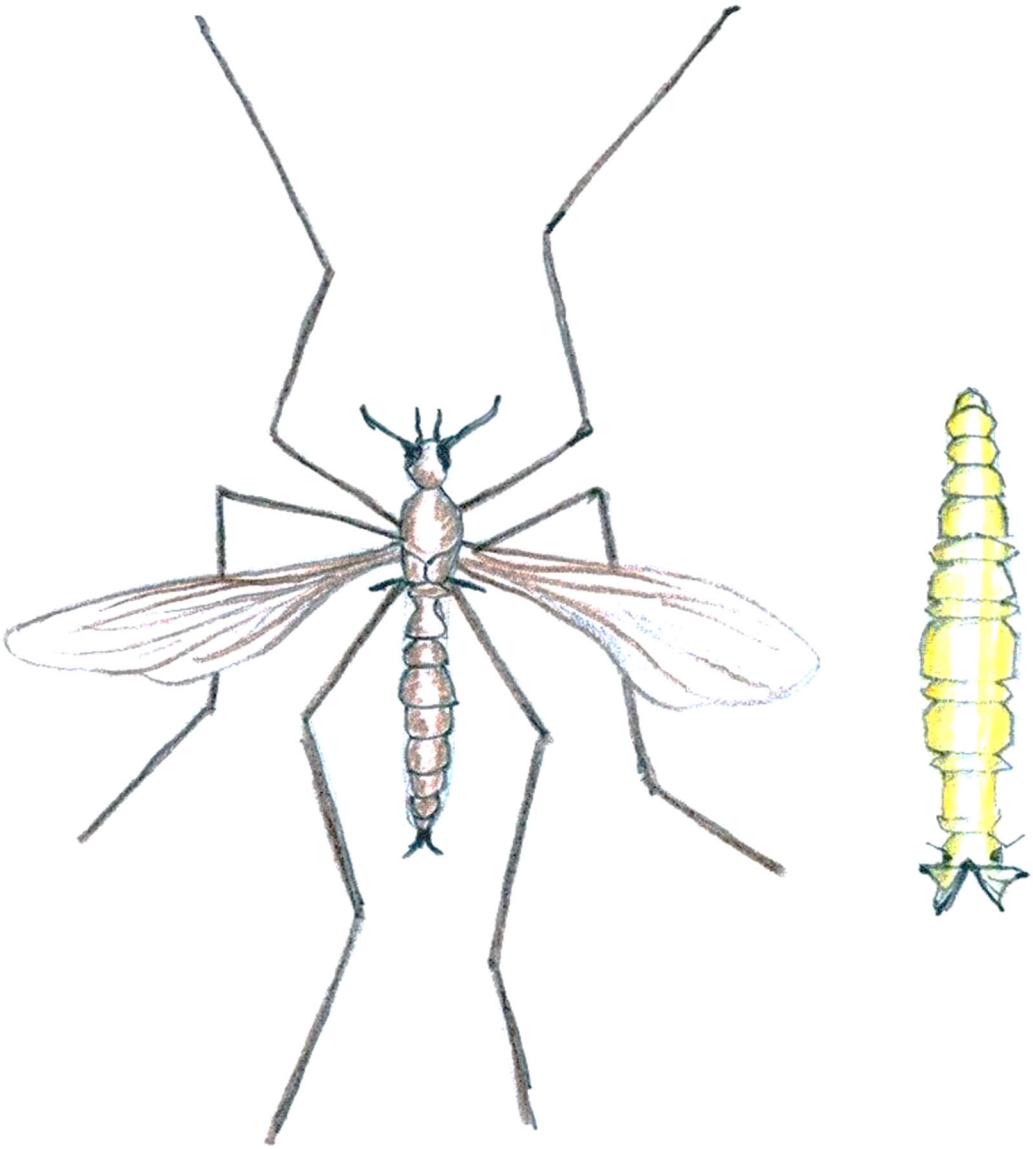
Eliminating Midges
Midge invasions may be abated by avoiding the use of outdoor lighting to the greatest possible extent, especially during early evening hours. For those midges that are still able to find their way indoors, the residual and space treatments described for the house fly will provide some degree of relief. Midges are rarely a problem in a well-balanced aquatic community. Pollution of water, where algae growth provides food for midge larvae to feed, results in excessive midge populations.

Certain insecticides can be applied to the water to kill midge larvae, but if the food supply that will support future midge outbreaks is not removed, the source of the problem remains.

Midges have been controlled in small bodies of water by stocking them with carp and goldfish at the rate of 150 to 500 pounds per acre of water surface.

When water management techniques are not practical and the treatment of larval breeding waters is not feasible, fogging for adult flies may provide temporary relief.

Malathion and synergized pyrethrins are examples of insecticides that have been used to control adult midges. Fogging provides limited results unless the entire residential area is treated.



CRANE FLY (ADULT AND LARVAE)

Sand Flies (Phlebotomine)

Phlebotomine sand flies are of considerable public health importance because of their ability to transmit several viral, bacterial, and protozoal disease-causing organisms of humans and other animals. The males and females feed on nectar and other plant juices, but females require a blood meal in order to mature a second batch of eggs. The blood meal hosts include white-tailed deer, horses, donkeys, mules, cattle, swine, raccoons, rodents, birds and humans (Young and Perkins 1984, Comer et al. 1994).

Confusion with other types of biting flies is often caused because the common name "sand fly" is also used for other biting flies of genera Ceratopogon and Culicoides. There are about 700 species of phlebotomine sand flies of which about 70 are considered to transmit disease organisms to people (Adler and Theodor 1957).

Moth-like Appearance
Sand flies are characterized by their densely hairy wings, giving them a moth-like appearance. Phlebotomines are distinguished from other members of the family by the way they hold their wings erected above the body in a vertical "V", whereas members of other psychodid subfamilies hold their wings flat and near the body (Azar and Nel 2003).

Visceral Leishmaniasis and Sand Fly Fever
Lutzomyia shannoni Dyar is a proven vector of vesicular stomatitis virus and a suspected vector of visceral leishmaniasis and sand fly fever. It is one of the more thoroughly studied species of phlebotomine sand flies in North America.

Sand flies occur in a wide range of habitats and individual species often have very specific habitat requirements. Lutzomyia shannoni is distributed from Argentina to the United States, including Brazil, Columbia, Panama and Costa Rica. Its distribution is highly spread within the range, depending on locally occurring environmental factors such as frequency of precipitation, temperature, physical barriers, habitat availability, and the distribution and abundance of vertebrate hosts (Young and Arias 1992).

In the United States, it has been found through the southern states from Florida to Louisiana plus Arkansas, Tennessee, South and North Carolina. This species has been found as far north as Maryland and Delaware. Lutzomyia shannoni is associated with live oak (Quercus viginiana Miller) forests and to a lesser extent, mixed hardwood forests where an abundance of tree holes provides diurnal resting sites for adults. Three other species of Phlebotomine sand flies, L. cubensis (Fairchild and Hertig), L. vexator (Coquillett) and L. cruciata (Coquillett).

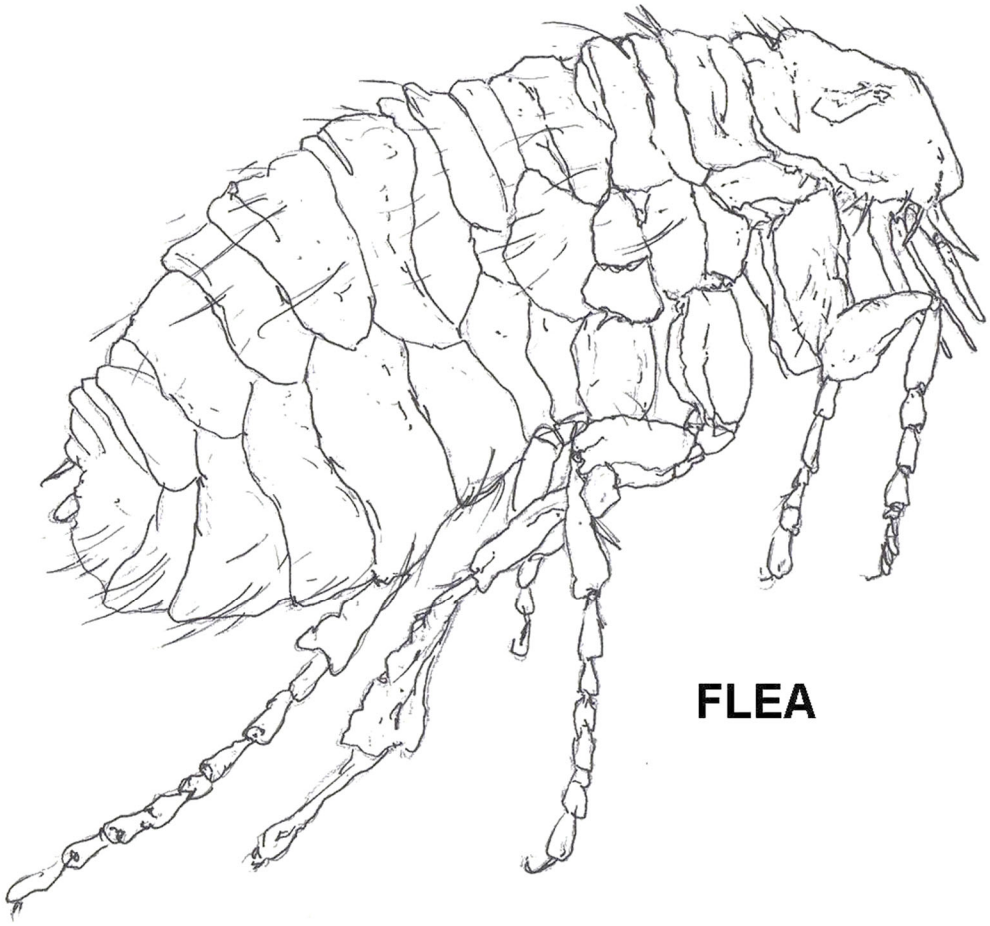
Use of Insecticides
Measures to control adult sand flies (Lutzomyia and Phlebotomus) include the use of insecticides (currently mostly pyrethroids) for residual spraying of dwellings and animal shelters, space-spraying, insecticide-treated nets, impregnated dog-collars and personal protection through application of repellents/insecticides to skin or fabrics.

Residual Insecticides
Spraying of residual insecticides on surfaces in the home has been the primary method for control of sand flies but is obviously ineffective for those species which bite away from residences.

This control technique has also been used for killing Anopheles mosquitoes that transmit malaria and in some regions is effective in reducing both malaria and leishmaniasis (Alexander and Maroli 2003). Certain species of mammals are important reservoirs of Leishmania and by eliminating the reservoir species living near human habitation, disease rates can sometimes be decreased. For instance, rodenticides have been used against the great gerbil, Rhombomys opimus, in Central Asia. Insecticide spraying of larval habitat is usually normally not possible because very little is known about where the larvae occur (Ashford 1999).

Leishmaniasis

Leishmaniasis is a disease caused by parasitic protozoans of the genus Leishmania that are transmitted to humans by sandflies of the subfamily Phlebotominae. Old World forms of Leishmania are transmitted by sandflies of the genus Phlebotomus, while New World forms mainly by sandflies of the genus Lutzomyia. Sandflies become infected by ingesting blood from infected reservoir hosts (usually small mammals) or from infected people. The disease can attack the skin, mucous membranes, liver, spleen and bone marrow. Over 20 different Leishmania species can infect humans and cause a wide spectrum of symptoms that range from self-healing skin ulcers to severe life-threatening disease.



Topic 5- Insects Commonly Mistaken for Mosquitoes Post Quiz

1. Dance flies vertical movement of swarming adults gives them their common name. Several of the Empis species are "_____."

2. Dixid Midges are common around moist areas where vegetation is abundant and may be seen swarming at _____along the edges of streams and lakes.

3. Dixid Midges does not bite humans, and they don't carry disease. But these species still can be annoying to homeowners.
True or False

4. Compared with other flea species, the dog flea has a very wide host range. Wild animals carrying dog fleas include raccoons, opossum, skunks and foxes.
True or False

5. Fungus Gnats have large wings and long antennae, and they are awesome flyers and are able to move far from the breeding site.
True or False

6. Crane Flies does not bite humans, and they don't carry disease. But these species still can be annoying to homeowners.
True or False

7. Larvae of chiggers, commonly called redbugs, attack humans and dogs during the larval stage.
True or False

8. Biting midges are extremely annoying, and are known to transmit disease agents to humans in the U.S.
True or False

9. Adult mayflies are recognized by the way they hold their wings at rest and the presence of two or three long "caudal" filaments at the tip of the abdomen.
True or False

10. Owl Midges (Psychodidae) larvae are aquatic or semi aquatic and are very common in sewers and drains.
True or False

Post Quiz Answers

Topic 1 – Mosquito Introduction Section
1. False, 2. False, 3. True, 4. True, 5. Vectors, 6. Dark and pale spots of scales, 7. True, 8. False, 9. False, 10. True

Topic 2 – Mosquito Identification Section
1. Adults or eggs 2. Eastern equine encephalitis virus and potentially West Nile virus, 3. American robin, wood thrush, and gray catbird, 4. False, 5. False, 6. True, 7. True, 8. True, 9. False, 10. True

Topic 3– Mosquito-Borne Diseases Section
1. Day and night, 2. Liver, 3. True, 4. False, 5. False, 6. False, 7. False, 8. True, 9. True, 10. True

Topic 4– Mosquito Control Section
1. Adults, 2. Ice, 3. Protein crystal toxic, 4. Larvicides, 5. Chlorinated hydrocarbons, 6. Pupal stage, 7. Ultra-low volume (ULV) sprays, 8. Pyrethrins, 9. Cholinesterase, 10. Human health and the environment

Topic 5- Insects Commonly Mistaken for Mosquitoes
1. Balloon makers, 2. Dusk, 3. True, 4. False, 5. False, 6. True, 7. True, 8. False, 9. True, 10. True

Pesticide/Insect Glossary

Acaricide: A pesticide used to control mites and ticks. Same as miticide.
Adhesive: A substance which will cause a spray material to stick to the sprayed surface, e.g., sticking agent.
Adjuvant: Any substance added to pesticide which improves the activity of the active ingredient. ***Examples***: Penetrates, spreader-stickers and wetting agents.
Adulticide: A type of pesticide used to kill adult mosquitoes.
Adventive: Located outside habitat, though a reproductive population may not be established.
Aedes Solicitans: Species of mosquito that is not known to transmit West Nile Virus; breeds in salt marshes.
Alates: Winged forms of insects.
Anthocorids: A true bug in the family Anthocoridae.
Aphid: An insect in the family Aphididae which is sometimes called plant lice.
Algaecide (Algicide): A pesticide used to kill or inhibit the growth of algae.
Alien: Same as non-native.
Altosid: Brand name of methoprene, a type of larvicide.
Anti-Transpirant: A chemical applied directly to a plant which reduces the rate of transpiration, or water loss, by the plant.
Arbovirus: A virus whose life cycle includes transmission by arthropods.
Arthropod: An invertebrate animal with jointed legs and a segmented body (includes flies, mosquitoes, ticks; also centipedes, scorpions, spiders etc.)
Aseptic Meningitis: Inflammation of the lining of the brain and spinal cord, not due to a bacterial infection.
Aspirator: A suction device used to remove liquid and other material from an area.
Autochthonous: Native to a place; not imported; used to describe a disease transmitted by vectors that became infected from a local source.
Avian Surveillance: Monitoring of the bird population for presence of a disease.
Avicide: A chemical used to kill birds.
Bacillus Sphaericus: A bacterium; type of biological pesticide used to eradicate mosquito larvae in water. (mosquito larvae die after ingesting this bacterium.)
Bacillus Thuringiensis var. Israelensis (BTI): A bacterium; type of biological pesticide used to eradicate mosquito larvae in water (mosquito larvae die after ingesting this bacteria).
Bactericide: Chemical used to kill bacteria.
Band Application: The application of a pesticide or other material to a limited area such as in or beside a crop row rather than over the entire field area.
Beneficial insect: Any insect that has a life style that is advantageous to man. Insects that preserve the balance of nature by feeding on others, pollinators, and recyclers are examples of beneficial insects.
Cephalothorax: Head (ceph) and chest (thorax) area.
Cerci: Paired appendages on the end of the abdomen of many insects which are used for sensing, defense or mating.
Chewing (mouth parts): Any mouth part that literally bites to feed; other mouth part types are sucking and rasping.
Clavus: The enlarged terminal antennal segments that form a club.
Cellophane: A tube-like structure on the underside of the first abdominal segment (folds under the body) of Collembola (e.g. springtails) which is used as a spring action for leaping.
Broad Spectrum Application: General purpose pesticides which can be used against a large number of pests on a wide range of crops.

Broadcast Application: The application of a pesticide or other material over the entire field or area.
Calibrate: To determine the amount of pesticide that will be applied to the target area.
Case fatality rate: the percentage of persons diagnosed as having a specified disease that die as a result of that illness (proportion of cases that die of the total infected).
Catch Basins: Grates seen at street corners for water runoff.
Colonizing: An ant species which is successful at creating nests in new areas. While some exotic ants are successful colonizers, many colonizing species are not exotic -- and many exotics are not colonizers.
Communicable Diseases: Illnesses due to specific infectious agents or their toxic products that can be transmitted from an infected person or animal to a susceptible host; either directly or indirectly through an intermediate host.
Compound eyes: The large multi-faceted eyes of insects.
Coreids: A member of the family Coreidae, which are leaf footed bugs**.**
Corium: The elongate, thickened basal portion of the fore wing of Hemiptera.
Cornicles: Tubular structure on each side of abdominal region from which pheromones or honeydew is expelled.
Coxa (pl.=coxae): Basal portion of the leg.
Crepuscular: Having activity periods during low light levels at dawn and evening.
Cursorial: Adapted for running.
Convalescent Blood Sera: Blood serum collected from patients recently recovered from a disease, often used to test whether a person has had a specific infection.
Coverage: Spread of a pesticide chemical over a surface such as the leaves, fruit, stem, etc.
Culex Pipiens: Species of mosquito, the primary known vector for West Nile Virus, commonly found in urban areas; breeds in fresh but stagnant water.
Dactyl: Literally, a finger or fingerlike projection on an insect body part.
Dealates: Winged forms that have shed their wings, like reproductive termites or ants.
Defoliate, defoliation: Removal of foliage from plants, often by chewing insects.
Detritivore: Any organism that eats decaying organic matter.
Diapause: An insect resting stage, usually induced by environmental signals or extreme conditions like winter or summer.
Dimorphic: Having two distinct forms.
DEET: (chemical name, N, N-diethyl-meta-toluamide) is the active ingredient.
Defoliant: A chemical which causes the leaves or foliage to drop from a plant.
Desiccant: A chemical that promotes drying or loss of moisture.
Drift: The airborne movement of a pesticide spray or dust from the target area to an area not intended to be treated.
Dust: A finely ground, dry pesticide formulation usually containing a small amount of active ingredient and a large amount of inert carrier or diluent such as clay or talc.
Emulsifiable Concentrate: A pesticide formulation produced by dissolving the active ingredient and an emulsifying agent in a suitable solvent. When added to water, an emulsion (milky mixture) is produced.
Encephalitis: Inflammation of the brain, which can be caused by numerous viruses, including West Nile Virus.
Endemic: A disease naturally present in certain human or animal populations.
Endosperm: A portion of a seed which contains most of the energy reserves for germination.
Estivation (aestivation): A resting stage (quiescence) resulting from continued high temperature or xeric conditions; diapause; hibernation.
Exoskeleton: The outer portion of an insect body which may be relatively soft like a

caterpillar or hardened like many beetles.
Exotic: Same as non-native.
Enzootic: A disease naturally present in certain animal populations (sometimes used in contrast with "endemic").
Epidemic: A disease outbreak affecting certain human or animal populations.
Epizootic: A disease outbreak affecting certain animal populations (sometimes used in contrast with "epidemic").
Eradication: The complete elimination of either weeds, insects, disease organisms, or other pests from an area.
Etiologic: Agents biologic organism or chemical material that cause disease.
Femora: A segment of an insect leg; usually the largest segment.
Filiform: Linear shaped, as the antennae of ground beetles.
Flavivirus: A subset of arboviruses (transmitted by arthropods); this family of viruses includes West Nile Virus, St. Louis Encephalitis and several others.
Forbs: Any broadleaf non-woody (herbaceous) plant.
Frass: Solid larval insect excrement; plant fragments made by wood-boring insects, usually mixed with excrement.
Furculum (plural: furcula): The elongate fork-like appendage on the end of the abdomen.
Fumigant: A chemical that forms vapors (gases) which is used to destroy weeds, plant pathogens, insects or other pests.
Fungicide: A chemical that kills or inhibits fungi.
Genera: Plural of genus; A genus is a group of plants or animals with similar characteristics. Animals (insects) are classified by kingdom, phylum, class, order, family, genus, species, and author's name. For example, the honey bee is classified as Animal (kingdom), Arthropoda (phylum), Insecta or Hexapoda (class), Hymenoptera (order), Apidae (family), *Apis* (genus), *mellifera* (species), Linnaeus (author's name). The genus and species are always italicized.
Girdle, girdling: Damage of a plant that circles the stem or branch cutting off the connective plant tissue.
Gravid Traps: Type of mosquito traps designed to attract pregnant female mosquitoes.
Grigology: The study of crickets, grasshoppers and katydids.
gpm: Gallons per minute.
Hemelytron: The first wing of a true bug (Hemiptera) which has the base more thickened than the membranous outer portion.
Hopperburn: Leaf damage caused by leafhopper feeding, which is a yellowing of the leaves.
Herbicide A pesticide used for killing or preventing plant growth. A weed or grass liquid.
Host: A living organism that serves as a blood source for blood-feeding arthropods, or on which a parasite lives.
IgM: Capture enzyme immunoassay (EIA) testing. A laboratory analysis for the presence of Immunoglobulin M antibodies (antibodies that rise during the acute phase of an illness and are a sign of recent infection).
Imago: The adult stage of an insect.
Instar: An insect stage between molts; molting is growth.
Internode: The part of a plant stem between the nodes. Nodes mark the point of attachment of leaves, flowers, fruits, buds and other stems.
Indirect IgG Enzyme Immunoassay (EIA) Testing: A laboratory analysis for the presence of Immunoglobulin G antibodies (long-lasting antibodies).
Insecticide: A pesticide that is used to kill, inhibit, repel or otherwise prevent damage by pests.
Intermediate Host: The arthropod carrier of a parasitic organism.

Introduced: Same as non-native.
Invasive: A species which is spreading its geographic range into niches occupied by other species. Documentation of an invasive species requires an ecological study to demonstrate the displacement of other ants.
IPM: (**Integrated Pest Management**); A system for minimizing the impact of vectors and pests by using a variety of control procedures and decreasing the chemical input to the environment.
Larvae: Immature mosquitoes; stage which hatches from the egg, prior to adult stage.
Larval stage (larva, larvae): An immature insect, sometimes used to include all immature stages, even eggs. Usually this term refers more specifically to the feeding stages of insects with complete metamorphosis like grubs, caterpillars, and maggots.
Larvicide: A type of pesticide used to eradicate immature mosquitoes (larvae).
Maggot: In most Diptera (flies), legless larva lacking a distinct head, with cephalic (head) end pointed and caudal (rear) end blunt.
Mesophyll: Fleshy plant tissue inside a leaf or stem.
Meningitis: Inflammation of the lining of the brain and spinal cord.
Metathorax: The second section of the insect thorax which houses the second pair of legs and the first pair of wings.
Metamorphosis: **-** change in form during an insect's growth and development.

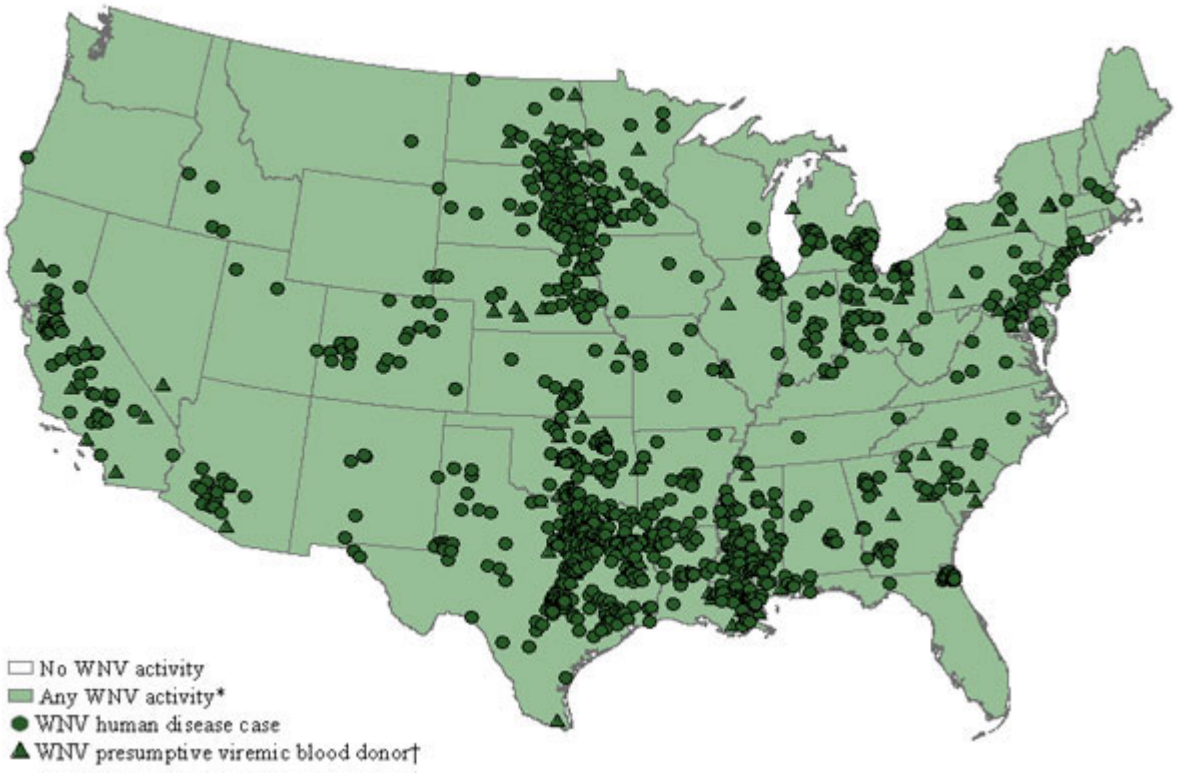
Gradual metamorphosis - incomplete metamorphosis in which there is no pupal stage and the immatures and adults look similar excluding the wings of the adults.
Incomplete metamorphosis - any metamorphosis type that does not include the pupal stage. Incomplete metamorphosis is present in Orthoptera (grasshoppers), Hemiptera (true bugs), and several other orders.
Simple metamorphosis - any metamorphosis that occurs in insect groups where they are not winged and have no pupal stage. Insect groups with simple metamorphosis include the Collembola (springtails) and Thysanura (silverfish).

Methoprene: A type of larvicide; chemical that is used to prevent mosquito larvae from emerging and developing into adult mosquitoes.
Microbial insecticide: An insecticide made of bacteria whose infection kills insects; a substance produced by bacteria that is lethal to insects.
Microbial Pesticide: Bacteria, viruses, fungi and other microorganisms used to destroy or control pests.
Migratory birds: Birds that fly south for the winter and return north in the spring.
Mite: A member of the order Acari (ticks and mites)
Miticide: See acaricide.
Molluscicide: A chemical used to kill or control snails and slugs.
Mosquito Breeding Site: A location where mosquitoes lay eggs, usually in stagnant water with organic material.
Mosquito Pools: A group of mosquitoes collected in one area and combined at the laboratory for testing for the presence of West Nile and related viruses.
Molt, molting process: In insects, as in snakes, the process of shedding the exoskeleton.
N,N-diethyl-meta-toluamide: DEET (chemical name, N,N-diethyl-meta-toluamide) is the active ingredient in many insect repellent products.
Naiad: A term for immature insects that are aquatic from the orders Plecoptera, Odonata, and Ephemeroptera. This term is becoming archaic and is now replaced by the more general term "***immature***" insect.
Native: These definitions do not necessarily define *where* a species is native. How do I define where a species is native? Sometimes the non-native status of a species is clear from

previous collections and existing knowledge from biogeography and systematics. Other times, boundaries are a lot blurrier. Is a species non-native if it has been there for 400 years?
Necrosis: Death of tissue in plants or animals.
Necropsy: Autopsy on an animal.
Nematicide: A pesticide that kills or otherwise controls nematodes.
Neurology: The study of the nervous system and its disorders.
Non-indigenous: Same as non-native.
Non-native: A species which is established outside its native habitat. With respect to ants, ants with an established reproducing colony.
Nymphs: An immature stage of hemimetabolous insects (those with incomplete metamorphosis).
Oothecae: A bean-like hardened egg capsule produced by female cockroaches.
Osmeterium (pl.=osmeteria): Scent-producing area behind the tibia.
Outbreak: An unexpected increase in frequency or distribution of a disease.
Overwinter: Time spent during the winter months. Insects are often in hibernation or at least rather immobile in the colder temperatures.
Ovipositor: The egg laying apparatus of an insect. The stinger of a bee is actually a modified ovipositor.
Palpi: The jointed feelers on each side of the mouth of some arthropods.
Parthenogenesis: Egg development without fertilization.
Pedipalps: Second pair of appendages of the cephalothorax corresponding to the mandibles of insects.
Pesticide: A chemical or other agent used to kill or otherwise control pests.
Pesticide: Substance used to kill pests such as insects, mice and rats; insecticide is a form of pesticide.
Petiole: Attachment of a leaf to stem.
Phlebotomy: Blood Drawing.
Phloem and xylem: Vascular tubes that allow fluid transport in plants. It is the way plants receive and distribute nutrients, hormones and water.
Photosynthesis: The chemical process that plants use to convert carbon dioxide and water to sugars and ultimately to energy.
Phyto- (prefix): Plant.
Phytophagous: Plant eating; an insect using plants as a food source.
Phytotoxemia: A toxic reaction in plants.
Piscicide: A chemical used to kill undesirable fish.
Poikilotherm: A cold-blooded organism.
Proboscis: A nose, or, in the case of butterflies, the coiled sucking mouthpart.
Pronotum: The plate on top of the prothorax.
Prothorax: The front part of an insect thorax which includes the attachment points for the front legs.
Protozoan: A microorganism in the kingdom Protozoa.
Pseudergates: Caste found in the lower termites (Isoptera), comprised of individuals having regressed from nymphal stages by molts eliminating the wing buds, or being derived from larvae having undergone non-differentiating molts, serving as the principle elements of the worker caste, but remaining capable of developing into other castes by further molting.
Psocids: Any insect in the order Psocoptera, which includes booklice and barklice.
Psyllid yellows: A virus disease of potatoes, tomatoes, peppers, and eggplant. See purple top.
Pupal stage (pupa): The stage in complete metamorphosis between larva and adult like the cocoon in moths.

Purple top: A purple discoloration of foliage tips caused by insect transmitted virus.
Pustulate: Pus-forming, as in spider bites.
Post-emergence: After the plants have appeared through the soil.
Proboscis: The straw-like sucking mouthparts of some blood feeding arthropods.
Protectant: A pesticide applied to a plant or animal prior to the appearance or occurrence of the pest in order to prevent infection or injury by the pest.
Repellant: A compound that keeps or drives away insects, rodents, birds or other pests from plants, domestic animals, buildings or other treated areas.
Reservoir: An animal population that normally harbors a disease-causing organism capable of being transmitted to man or other animal populations.
Resmethrin: A synthetic pyrethroid pesticide used to eradicate adult mosquitoes in the home, lawn, garden and at industrial sites; active ingredient in the product *Scourge*.
Rhopalid: An insect in the family Rhopalidae in the order Hemiptera (true bugs).
Rickettsia: A group of small bacteria that live inside tissue cells and are carried by ticks, mites, fleas or lice.
Rodenticide: A pesticide, or mixture of pesticides, used to kill or control rodents.
Rosetting: Malformation of a plant resulting in a bunched irregular growth of the leaves.
Salt Marsh: Areas of vegetation in bodies of salt water that may support the breeding of certain types of mosquitoes such as Aedes solicitans.
Scutellum: A triangular shaped section on the back of Hemiptera and some Coleoptera. It is often the identifying characteristic of Hemipterans or "***true bugs***".
Secondary reproductive: A caste of subterranean termite; also called supplemental reproductives. If these termites develop from nymphs, they are called secondary reproductives (primary reproductives are the king and queen). If they develop from pseudergates, they are called tertiary reproductives. Supplementals may be responsible for most of the egg production in the colony.
Sentinel Guard: Testing of birds and other animals as an early warning system for the presence of virus (e.g. sentinel chickens).
Serologic: Of, or relating to serum.
Seropositive: Positive laboratory result of a serum sample.
Serum: Liquid portion of the blood containing proteins, including antibodies.
Silvicide: A pesticide used to destroy woody shrubs and trees.
Smudge pot: Container used to hold a substance producing dense smoke; used to drive away insects.
Soluble Powder: A finely ground, solid material which will dissolve in water or some other liquid carrier.
Space Spray: A pesticide which is applied as a fine spray or mist to a confined area either indoors or outside.
Spinneret: A small tubular appendage from which silk threads by spiders and many larval insects are excreted.
St. Louis Encephalitis (SLE): Mosquito-borne viral disease that causes inflammation of the brain; very similar to West Nile Virus.
Stippling (leaf): A speckled appearance of a leaf, usually yellowish spots on a green leaf.
Stolon: An underground portion of a plant that grows horizontally, like a grass root.
Subgroup: A subset of a group with related characters. The term group is a general and non-specific collection of similar organisms regardless of taxonomic hierarchy.
Subimago: The first winged stage of a mayfly. This is the only group to have a winged stage that molts. The final stage is the imago, or adult.
Sumithrin: A synthetic pyrethroid pesticide used to eradicate adult mosquitoes in swamps, marshes, and recreational areas; active ingredient in the product Anvil 10 + 10.

Target: The plants, animals, structure, areas or pests to be treated with a pesticide application.
Tarsi: A foot. Insect feet are made of several segments and may have pads, hairs, or hooks.
Tegmina: Plural of tegmen, a hardened covering like the forewing of many Orthoptera and Hemiptera.
Tenaculum: A minute two-pronged structure on the underside of the third abdominal segment of Collembola (springtails) which holds the furcula (appendage used for jumping) before it is released to jump.
Tertiary reproductive termite: See secondary reproductive.
Tettigoniid: A family of Orthoptera, often called long-horned grasshoppers, which includes katydids.
Thorax: The second body segment of an insect. The thorax has all of the wings and legs attached to it.
Tip burn: A yellow or dried tip on a branch or leaf caused by insect feeding or a plant physiology disorder.
True bugs: Insects in the order Hemiptera. They are usually characterized by a scutellum, a triangular shaped section on the back.
Tramp: A widespread ant species spread by human commerce with a specific syndrome of life history characteristics: extreme polygyny, unicolonial or highly polydomous nest structure and colony reproduction by budding (sensu Passera 1994).
Transferred: Collected outside native habitat, without knowledge of established nests.
Transported: Same as transferred; often refers to animals found in quarantine inspection.
ULV: Ultra Low Volume. No water is applied with this pesticide formulation. Spray concentrates are frequently used in ULV applications.
Vectobac: Brand name for larvicide Bacillus thuringiensis var. israelensis (**BTI**).
Vectolex: Brand name for larvicide Bacillus sphaericus.
Vector Control Mechanism: Instituted to control and reduce the vector population.
Vector Control: Management of organisms that carry disease.
Vector Surveillance: Monitoring of the vector population for presence of a disease.
Vector: An arthropod carrier of a disease-producing organism. Usually used when part of the organism's natural life cycle takes place in the arthropod (= intermediate host).
Vector-borne disease: A disease carried by arthropod intermediate hosts.
Venation: The pattern of veins in the insect wing.
Viral Encephalitis: Inflammation of the brain caused by a virus.
Viral: Of, or relating, to a virus.
Wettable Powder: A solid (powder) pesticide formulation which forms a suspension when added to water.
Zoonosis: A disease of animals that may be secondarily transmitted to man.



As in this 2012 chart, you will notice that mosquitoes have indeed spread West Nile throughout the U.S. in a very short period. I will suggest that within 5 years, the mosquitoes spread across the U.S. and now West Nile is here to stay. I will update this chart as soon as the government produces a newer one.

References

"Agricultural Chemical Toxicity to Selected Aquatic Animals: Bluegill, Channel Catfish, Rainbow Trout, Crawfish, and Fresh Water Shrimp" by T.L. Wellborn, Jr., Ruth Morgan, and G.W. Guyton. Extension Wildlife and Fisheries and Extension Entomology, Mississippi State University
"Anti-inflammatory Activity of Tea Tree Oil". Rural Industries Research and Development Corporation. February 2001. http://pandora.nla.gov.au/pan/23877/20040309-0000/www.rirdc.gov.au/reports/TTO/01-10.pdf.
"Can I get HIV from mosquitoes?". CDC. October 20, 2006. http://www.cdc.gov/hiv/resources/qa/qa32.htm.
"Mosquito Information". Mda.state.md.us. 2008-04-21. http://www.mda.state.md.us/plants-pests/mosquito_control/mosquito_info/index.php.
"Mosquito". Allwords.com. 2007-03-29. http://www.allwords.com/query.php?SearchType=0&Keyword=mosquito&goquery=Find+it!&Language=ENG&v_PageSize=25.
"Mosquito". Virginia Tech. http://sites.ext.vt.edu/departments/entomology/factsheets/mosquito.html.
"Mosquito-Borne Diseases". The American Mosquito Control Association. http://www.mosquito.org/mosquito-information/mosquito-borne.aspx. Retrieved October 14, 2008. [dead link]
"Mosquito's Life Cycle". Westchester County Department of Health. http://www.westchestergov.com/HEALTH/WNVmosquito_life_cycle.htm.
"Scientists identify key smell that attracts mosquitoes to humans". US News. October 28, 2009. http://www.usnews.com/science/articles/2009/10/28/scientists-identify-key-smell-that-attracts-mosquitoes-to-humans.html?s_cid=rss:scientists-identify-key-smell-that-attracts-mosquitoes-to-humans.
"Site down for maintenance". Pestscience.com. http://www.pestscience.com/PDF/BNIra56.PDF.
*Stop the Insects' Next Generation www.westchestergov.com.
2014b. Use of the CDC Autocidal Gravid Ovitrap to Control and Prevent Outbreaks of Aedes aegypti (Diptera: Culicidae). Journal of Medical Entomology 51:145-154.
40 Code of Federal Regulations (40 CFR).
A. Borkent & D. A. Grimaldi (2004). "The earliest fossil mosquito (Diptera: Culicidae), in Mid-Cretaceous Burmese amber". Annals of the Entomological Society of America 97: 882–888. doi:10.1603/0013-8746(2004)097[0882:TEFMDC]2.0.CO;2. http://esa.publisher.ingentaconnect.com/content/esa/aesa/2004/00000097/00000005/art00004.
Appendix: Exceptions and Exemptions to the Worker Protection Standard for Agricultural Pesticides.
Applying Pesticides Correctly: A guide for Private and Commercial Applicators. U.S. EPA, USDA and Extension Service, revised 1991.
Applying Pesticides Correctly: A Supplemental Guide for Private Applicators. U.S. EPA, USDA and Extension Service, December 1993, Publication E-2474.
Barrera R, Acevedo V, Felix GE, Hemme RR, Vazquez J, Munoz JL, Amador M. 2017. Impact of autocidal gravid ovitraps on chikungunya virus incidence in Aedes aegypti (Dipter: Culicidae) in areas with and without traps. Journal of Medical Entomology Mar 1;54(2):387-395.
Beatty, R.G. 1993. The DDT Myth Triumph..... John Day Co., NY, NY.
Bhalala H, Arias JR. 2009. The Zumba mosquito trap and BG-Sentinel trap: novel surveillance tools for host-seeking mosquitoes. Journal of the American Mosquito Control Association 25:134-139.
Billingsley, P. F. & Hecker, H. (1991). "Blood digestion in the mosquito, Anopheles stephensi Liston (Diptera: Culicidae): activity and distribution of trypsin, aminopeptidase, and alpha-glucosidase in the midgut". Journal of Medical Entomology 28 (6): 865–871. PMID 1770523.
Bissonnette, E. Y., Rossignol, P. A. & Befus, A. D. (1993). "Extracts of mosquito salivary gland inhibit tumour necrosis factor alpha release from mast cells". Parasite Immunology 15 (1): 27–33. doi:10.1111/j.1365-3024.1993.tb00569.x. PMID 7679483.
Brogdon WG, McAllister JC. 1998a. Insecticide resistance and vector control. Emerging Infectious Diseases 4:605-613.
Brogdon WG, McAllister JC. 1998b. Simplification of adult mosquito bioassays through use of time-mortality determinations in glass bottles. Journal of the American Mosquito Control Association

14:159-64. Brown AWA. 1977. Worldwide surveillance of Aedes aegypti. Proceedings of Annual Conference California Mosquito Control Association; NY, USA, Academic Press. p. 20-25.
Brunhes, J.; Rhaim, A.; Geoffroy, B.; Angel, G.; Hervy, J. P. Les Moustiques de l'Afrique mediterranéenne French/English. Interactive identification guide to mosquitoes of North Africa, with database of information on morphology, ecology, epidemiology, and control. Mac/PC Numerous illustrations. IRD/IPT [12640] 2000 CD-ROM. ISBN 2-7099-1446-8
Burkhalter KL, Savage HM. 2017. Detection of Zika virus in desiccated mosquitoes by real-time reverse transcription PCR and plaque assay. Emerging Infectious Diseases 23(4):680-81.
C. Jones & E. Schreiber (1994). "The carnivores, Toxorhynchites". Wing Beats 5 (4): 4. http://www.rci.rutgers.edu/~insects/sp2.htm.
Calvo, E., Pham, V. M., Marinotti, O., Andersen, J. F. & Ribeiro, J. M. (2009). "The salivary gland transcriptome of the neotropical malaria vector Anopheles darlingi is thought to reveal accelerated evolution of genes relevant to hematophagy" (PDF). BMC Genomics 10 (1): 57. doi:10.1186/1471-2164-10-57. PMC 2644710. PMID 19178717. http://www.biomedcentral.com/content/pdf/1471-2164-10-57.pdf. Retrieved June 21, 2009.
Casas-Martinez M, Orozco-Bonilla A, Munoz-Reyes M, Ulloa-Garcia A, Bond JG, Valle-Mora J, Weber M, Rojas JC. 2013. A new tent trap for monitoring the daily activity of Aedes aegypti and Aedes albopictus. Journal of Vector Ecology 38:277-288. CDC. 2013. West Nile Virus in the United States: Guidelines for Surveillance, Prevention, and Control. 2013. 4th Edition [PDF - 69 pages; http://www.cdc.gov/westnile/resources/pdfs/wnvGuidelines.pdf].
CDC (2009). Updated Information regarding Insect Repellents. http://www.cdc.gov/ncidod/dvbid/westnile/repellentupdates.htm.
Chadee DD, Ritchie SA. 2010. Oviposition behaviour and parity rates of Aedes aegypti collected in sticky traps in Trinidad, West Indies. Acta Tropica 116:212-216.
Chadee DD. 1990. Methods for evaluating Aedes aegypti populations and insecticide treatment in a town of Trinidad, West Indies. Boletin Oficina Sanitaria Panamericana 109:350-9. Chadee DD. 2009. Impact of pre-seasonal focal treatment on population densities of the mosquito Aedes aegypti in Trinidad, West Indies: A preliminary study. Acta Tropica 109:236-240.
Chan KL, No SK, Tan KK. 1977. An autocidal ovitrap for the control and possible eradication of Aedes aegypti. Southeast Asian Journal of Tropical Medicine and Public Health 8(1): 56-62.
Chang FS, Tseng YT, Hsu PS, Chen CD, Lian IB, Chao DY. 2015. Re-assess vector indices threshold as an early warning tool for predicting dengue epidemic in a dengue non-endemic country. PLoS Neglected Tropical Diseases 9(9): e0004043. doi:10.1371/journal.pntd.0004043.
Chen CF, Shu PY, Teng HJ, Su CL, Wu JW, Wang JH, Lin TH, Huang JH, Wu HS. 2010. Screening of dengue virus in field-caught Aedes aegypti and Aedes albopictus (Diptera: Culicidae) by one-step SYBR green-based reverse transcriptase-polymerase chain reaction assay during 2004-2007 in Southern Taiwan. Vector Borne and Zoonotic Diseases 10:1017-1025.
Chien LJ, Liao TL, Shu PY, Huang JH, Gubler DJ, Chang GJ. 2006. Development of real-time reverse transcriptase PCR assays to detect and serotype dengue viruses. Journal of Clinical Microbiology 44:1295– 1304.
Chow VTK, Chan YC, Yong R, Lee KM, Lim LK, Chung YK, Lam-Phua SG, Tan BT. 1998. Monitoring of dengue viruses in field-caught Aedes aegypti and Aedes albopictus mosquitoes by a type-specific polymerase chain reaction and cycle sequencing. American Journal of Tropical Medicine and Hygiene 58:578-586.
Cilek JE. 2008. Application of insecticides to vegetation as barriers against host-seeking mosquitoes. Journal of the American Mosquito Control Association 24:172-176.
Clements, Alan (1992). The biology of mosquitoes - volume 1: Development, Nutrition and Reproduction. London: Chapman & Hall. ISBN 0-85199-374-5.
Communication and Educational Technology Services, University of Minnesota Extension Service.
Connor ME, Monroe WM. 1923. Stegomyia indices and their value in yellow fever control. American Journal of Tropical Medicine and Hygiene 3:9-19.
Cross ML, Cupp EW, Enriquez FJ (1994). "Differential modulation of murine cellular immune responses by salivary gland extract of Aedes aegypti". American Journal of Tropical Medicine and Hygiene 51 (5): 690–696. PMID 7985763.

Dash PK, Boutonnier A, Prina E, Sharma S, Reiter P. 2012. Development of a SYBR green I based RTPCR assay for yellow fever virus: application in assessment of YFV infection in Aedes aegypti. Virology Journal 9:27.
Davidson, Elizabeth W. (1981). Pathogenesis of invertebrate microbial diseases. Montclair, N. J.: Allanheld, Osmun. ISBN 0-86598-014-4.
Depinay, N., Hacini, F., Beghdadi, W., Peronet, R., Mécheri, S. (2006). "Mast cell-dependent down-regulation of antigen-specific immune responses by mosquito bites". Journal of Immunology 176 (7): 4141–4146. PMID 16547250.
Dethier, V.G. 1976. Man's Plague? Insects and Agriculture. Darwin Press, Princeton, NJ.
Devlin, Hannah (February 4, 2010). "Sweat and blood why mosquitoes pick and choose between humans". London: The Times.
http://www.timesonline.co.uk/tol/news/science/medicine/article7014046.ece.
Dr. Nigel Beebe, University of Technology, Sydney, Australia.
Eiras AE, Buhagiar TS, Ritchie SA. 2014. Development of the gravid Aedes trap for the capture of adult female container-exploiting mosquitoes (Diptera: Culicidae). Journal of Medical Entomology 51:200-209.
Elissa A. Hallem; Nicole Fox, A.; Zwiebel, Laurence J.; Carlson, John R. (2004). "Olfaction: Mosquito receptor for human-sweat odorant". Nature 427 (6971): 212–213. doi:10.1038/427212a. PMID 14724626. http://www.nature.com/nature/journal/v427/n6971/full/427212a.html?lang=en.
Fang, Janet (July 21, 2010). "Ecology: A world without mosquitoes". Nature. doi:10.1038/466432a. http://www.nature.com/news/2010/100721/full/466432a.html.
Farajollahi A, Kesavaraju B, Price DC, Williams GM, Healy SP, Gaugler R, Nelder MP. 2009. Field efficacy of BG-Sentinel and industry-standard traps for Aedes albopictus (Diptera: Culicidae) and West Nile virus surveillance. Journal of Medical Entomology 46:919-925.
Fay RW, Eliason DA. 1966. A preferred oviposition site as a surveillance method for Aedes aegypti. Mosquito News 26:531-535. Fay RW. 1968. A trap based on visual responses of adult mosquitoes. Mosquito News 28:1-7.
Fay RW, Prince WH. 1970. A modified visual trap for Aedes aegypti. Mosquito News 30:20-23.
Faye O, Faye O, Diallo D, Diallo M, Weidmann M, Sall AA. 2013. Quantitative real-time PCR detection of Zika virus and evaluation with field-caught mosquitoes. Virology Journal 10:311.
Focks DA, Brenner RJ, Hayes J, Daniels E. 2000. Transmission thresholds for dengue in terms of Aedes aegypti pupae per person with discussion of their utility in source reduction efforts. American Journal of Tropical Medicine and Hygiene 62:11-18.
Focks DA, Chadee DD. 1997. Pupal survey: An epidemiologically significant surveillance method for Aedes aegypti: An example using data from Trinidad. American Journal of Tropical Medicine and Hygiene 56:159167.
Focks DA. 2003. A Review of Entomological Sampling Methods and Indicators for Dengue Vectors. Geneva, Switzerland. Freier JE, Francy DB. 1991. A duplex cone trap for the collection of adult Aedes albopictus. Journal of the American Mosquito Control Association 7:73-79.
Fradin, M. S. (1 June 1998). "Mosquitoes and mosquito repellents: a clinician's guide". Annals of Internal Medicine 128 (11): 931–940. doi:10.1059/0003-4819-128-11-199806010-00013. PMID 9634433. http://www.annals.org/cgi/pmidlookup?view=long&pmid=9634433.
G. O. Poinar et al. (2000). "Paleoculicis minutus (Diptera: Culicidae) n. gen., n. sp., from Cretaceous Canadian amber with a summary of described fossil mosquitoes" (PDF). Acta Geologica Hispanica 35: 119–128. http://www.geologica-acta.com/pdf/aghv3501a12.pdf.
Gomes ADC, Da Silva NN, Bernal RTI, Leandro ADS, De Camargo NJ, Da Silva AM, Ferreira AC, Ogura LC, De Oliveira SJ, De Moura SM. 2007. Specificity of the Adultrap for capturing females of Aedes aegypti (Diptera: Culicidae). [Portuguese]. Revista da Sociedade Brasileira de Medicina Tropical 40:216-219. Gratz NG. 2004. Critical review of the vector status of Aedes albopictus. Medical and Veterinary Entomology 18:215-27. Hawley WA. 1988. The biology of Aedes albopictus. Journal of the American Mosquito Control Association Suppl 1:1-39.
Grossman G. L. & James, A. A. (1993). "The salivary glands of the vector mosquito, Aedes aegypti, express a novel member of the amylase gene family". Insect Molecular Biology 1 (4): 223–232. doi:10.1111/j.1365-2583.1993.tb00095.x. PMID 7505701.

Hanson, S. M. & Craig, G. B. (September 1995). "Aedes albopictus (Diptera: Culicidae) eggs: field survivorship during northern Indiana winters". Journal of Medical Entomology 32 (5): 599–604. PMID 7473614.
Harzsch, S.; Hafner, G. (2006). "Evolution of eye development in arthropods: Phylogenetic aspects". Arthropod Structure and Development 35 (4): 319–340. doi:10.1016/j.asd.2006.08.009. PMID 18089079. http://linkinghub.elsevier.com/retrieve/pii/S1467803906000570.
Hawley, W. A., Pumpuni, C. B., Brady, R. H. & Craig, G. B. (March 1989). "Overwintering survival of Aedes albopictus (Diptera: Culicidae) eggs in Indiana". Journal of Medical Entomology 26 (2): 122–129. PMID 2709388.
http://hypertextbook.com/facts/2000/DianaLeung.shtml
http://www.safari.co.uk/blog/facts-you-may-not-know-about-mosquitoes/
Jahn, G. C., Hall, D. W. & Zam, S. G. (1986). "A comparison of the life cycles of two Amblyospora (Microspora: Amblyosporidae) in the mosquitoes Culex salinarius and Culex tarsalis Coquillett". Journal of the Florida Anti-Mosquito Association 57: 24–27.
Johnson TL, Haque U, Monaghan AJ, Eisen L, Hahn MB, Hayden MH, Savage HM, McAllister J, Mutebi JP, Eisen RJ. 2017. Modeling the environmental suitability for Aedes (Stegomyia) aegypti and Aedes (Stegomyia) albopictus (Diptera: Culicidae) in the contiguous United States.
Kale, H. W., II. (1968). "The relationship of purple martins to mosquito control". The Auk 85: 654–661.
Katayama, Lisa (2008). Urawaza - Secret Everyday Tips and Tricks from Japan. California: Chronicle Books. p. 122. ISBN 978-0-8118-6215-8.
Kaufmann C, Briegel H (June 2004). "Flight performance of the malaria vectors Anopheles gambiae and Anopheles atroparvus" (PDF). Journal of Vector Ecology 29 (1): 140–153. PMID 15266751. http://www.sove.org/Journal%20PDF/June%202004/Kaufmann.pdf.
Lanciotti RS, Calisher CH, Gubler DJ, Chang GJ, Vorndam AV. 1992. Rapid detection and typing of dengue viruses from clinical samples by using reverse transcriptase-polymerase chain reaction. Journal of Clinical Microbiology. 30:545–551
Lanciotti RS, Kosoy OL, Laven JJ, Panella AJ, Velez JO, Lambert AJ, Campbell GL. 2007. Chikungunya virus in US travelers returning from India. 2006. Emerging Infectious Diseases 13: 764–767.
Lanciotti RS, Kosoy OL, Laven JJ, Velez JO, Lambert AJ, Johnson AJ, Stanfield SM, Duffy MR. 2008. Genetic and serologic properties of Zika virus associated with an epidemic, Yap State, Micronesia, 2007. 14:1232-1239.
Laurent P, Le Roux K, Grivard P, Bertil G, Naze F, Picard M, Staikowsky F, Barau G, Schuffenecker I, Michault A. 2007. Development of a sensitive real-time reverse transcriptase PCR assay with an internal control to detect and quantify chikungunya virus. Clinical Chemistry 53:1408-14.
Lorenzi OD, Major C, Acevedo V, Perez-Padilla J, Rivera A, Biggerstaff BJ, Munoz-Jordan J, Waterman S, Barrera R, Sharp TM. 2016. Reduced incidence of chikungunya virus infection in communities with ongoing Aedes aegypti mosquito trap intervention studies – Salina and Guayama, Puerto Rico, November 2015February 2016. MMWR Morbidity and Mortality Weekly Report 65(18);doi: http://dx.doi.org/10.15585/mmwr.mm6518e3.
Maciel-De-Freitas R, Eiras AE, Lourenco-De-Oliveira R. 2006. Field evaluation of effectiveness of the BGSentinel, a new trap for capturing adult Aedes aegypti (Diptera: Culicidae). Memorias do Instituto Oswaldo Cruz 101:321-325.
Marquis, D. 1940. the life and times of archy and mehitabel. Doubleday, NY, NY.
Marten, G. G. & Reid, J. W. (2007). "Cyclopoid copepods". Journal of the American Mosquito Control Association 23 (2 Suppl): 65–92. doi:10.2987/8756-971X(2007)23[65:CC]2.0.CO;2. PMID 17853599.
Minnesota Department of Agriculture
Molavi, Afshin (June 12, 2003). "Africa's Malaria Death Toll Still "Outrageously High"". National Geographic. http://news.nationalgeographic.com/news/2003/06/0612_030612_malaria.html.
Mosquito and Vector Control Association of California
Mosquito at dictionary.com.
Ohio State University Extension
Oliveira, Victor J. (Oliveira, 1991). Hired and Contract Labor in U.S. Agriculture, 1987. AER-648. U.S. Dept. Agri., Econ. Res. Serv., May 1991.

Overhults, Douglas G. Extension Agricultural Engineer, University of Kentucky, Applicator Training Manual for AERIAL APPLICATION OF PESTICIDES
R. G. Estrada-Franco & G. B. Craig (1995). Biology, disease relationship and control of Aedes albopictus. Technical Paper No. 42. Washington, D.C.: Pan American Health Organization.
Ralph Harbach (November 2, 2008). "Family Culicidae Meigen, 1818". Mosquito Taxonomic Inventory. http://mosquito-taxonomic-inventory.info/family-culicidae-meigen-1818.
Ribeiro, J. M. & Francischetti, I. M. (2003). "Role of arthropod saliva in blood feeding: sialome and post-sialome perspectives". Annual Review of Entomology 48: 73–88. doi:10.1146/annurev.ento.48.060402.102812. PMID 12194906.
Romi, R., Severini, F. & Toma, L. (March 2006). "Cold acclimation and overwintering of female Aedes albopictus in Roma". Journal of the American Mosquito Control Association 22 (1): 149–151. doi:10.2987/8756-971X(2006)22[149:CAAOOF]2.0.CO;2. PMID 16646341.
Rossignol, P. A. & Lueders, A. M. (1986). "Bacteriolytic factor in the salivary glands of Aedes aegypti". Comparative Biochemistry and Physiology B 83 (4): 819–822. doi:10.1016/0305-0491(86)90153-7. PMID 3519067.
Runyan, Jack L. (Runyan, 1992). A Summary of Federal Laws and Regulations Affecting Agricultural Employers, 1992. AIB-652. U.S. Dept. Agri., Econ. Res. Serv., August 1992.
Rutgers University
Schneider, B. S. & Higgs, S. (May 2008). "The enhancement of arbovirus transmission and disease by mosquito saliva is associated with modulation of the host immune response". Transactions of the Royal Society of Tropical Medicine and Hygiene 102 (5): 400–408. doi:10.1016/j.trstmh.2008.01.024. PMC 2561286. PMID 18342898. http://linkinghub.elsevier.com/retrieve/pii/S0035-9203(08)00053-9.
Schneider, B. S., Soong, L., Girard, Y. A., Campbell, G., Mason, P. & Higgs, S. (2006). "Potentiation of West Nile encephalitis by mosquito feeding". Viral Immunology 19 (1): 74–82. doi:10.1089/vim.2006.19.74. PMID 16553552.
Schneider, B. S., Soong, L., Zeidner, N. S. & Higgs, S. (2004). "Aedes aegypti salivary gland extracts modulate anti-viral and TH1/TH2 cytokine responses to sindbis virus infection". Viral Immunology 17 (4): 565–573. doi:10.1089/vim.2004.17.565. PMID 15671753.
Service, M.W. 1993. Mosquitoes (Culicidae). In: *Medical Insects and Arachnids* (eds R.P. Lane and R.W. Crosskey). Chapman and Hall, London, pp. 120-240.
Singh, R. K., Dhiman, R. C. & Singh, S. P. (June 2003). "Laboratory studies on the predatory potential of dragon-fly nymphs on mosquito larvae". Journal of Communicable Diseases 35 (2): 96–101. PMID 15562955.
State of New Jersey
Syed, Z.; Leal, W. S. (2008). "Mosquitoes smell and avoid the insect repellent DEET". Proceedings of the National Academy of Sciences 105 (36): 13598–13603. doi:10.1073/pnas.0805312105. PMC 2518096. PMID 18711137.
Takken, W. & Knols, B.G.J. 1999. Odor-mediated behavior of Afrotropical malaria mosquitoes. *Annual Review of Entomology* 44: 131-157.
Taylor, J. L., Schoenherr, C. & Grossberg, S. E. (1980). "Protection against Japanese encephalitis virus in mice and hamsters by treatment with carboxymethylacridanone, a potent interferon inducer". The Journal of Infectious Diseases 142 (3): 394–399. PMID 6255036.
U.S. Environmental Protection Agency (EPA, 1988). The Federal Insecticide, Fungicide, and Rodenticide Act as Amended. 1988.
U.S. Environmental Protection Agency, Office of Pesticide Programs (EPA, 1992a). Regulatory Impact Analysis of Worker Protection Standard for Agricultural Pesticides. 1992.
U.S. Environmental Protection Agency, Office of Prevention, Pesticides, and Toxic Substances (EPA, 1992b). Questions and Answers, Worker Protection Standards. 1992.
U.S. Environmental Protection Agency, Office of Prevention, Pesticides, and Toxic Substances (EPA, 1993a). The Worker Protection Standard for Agricultural Pesticides, How Soon Do You Need to Comply? March 1993.
U.S. Environmental Protection Agency, Office of Prevention, Pesticides, and Toxic Substances (EPA, 1993b). Worker Protection Standard Implementation. April 1993.
United States Environmental Protection Agency

University of California at Davis has an online publication Mosquito Management Guidelines publication, stressing integrated pest management techniques. [U.C. Agric. & Nat. Resources Publ. 7451]
Valenzuela, J. G., Pham, V. M., Garfield, M. K., Francischetti, I. M. & Ribeiro, J. M. (2002). "Toward a description of the sialome of the adult female mosquito Aedes aegypti". Insect Biochemistry and Molecular Biology 32 (9): 1101–1122. doi:10.1016/S0965-1748(02)00047-4. PMID 12213246.
Wanasen, N., Nussenzveig, R. H., Champagne, D. E., Soong, L. & Higgs, S. (2004). "Differential modulation of murine host immune response by salivary gland extracts from the mosquitoes Aedes aegypti and Culex quinquefasciatus". Medical and Veterinary Entomology 18 (2): 191–199. doi:10.1111/j.1365-2915.2004.00498.x. PMID 15189245.
Ware, G.W. 1983. Pesticides: Theory and Application. W.H. Freeman & Co. NY, NY.
Ware, G.W. 1988. Complete Guide to Pest Control. Thomson Pubs. Fresno, Ca.
Ware, G.W. 1991. Fundamentals of Pesticides. Thomson Pubs. Fresno, CA.
Ware, G.W. 1994. The Pesticide Book (4th ed.). Thomson Pubs. Fresno, CA
Wasserman, H. A., Singh, S. & Champagne, D. E. (2004). "Saliva of the Yellow Fever mosquito, Aedes aegypti, modulates murine lymphocyte function". Parasite Immunology 26 (6-7): 295–306. doi:10.1111/j.0141-9838.2004.00712.x. PMID 15541033.
Wayne J. Crans (1989). "Resting boxes as mosquito surveillance tools". Proceedings of the Eighty-Second Annual Meeting of the New Jersey Mosquito Control Association. pp. 53–57. http://www.rci.rutgers.edu/~insects/restbox.htm.
Wayne J. Crans, Mosquito Research & Control, Rutgers University
Westchester County Department of Health, Operation Mosquito S.T.I.N.G.*
Yosipovitch, Gil; Katherine Fast, Jeffrey D. Bernhard (2005). "Noxious Heat and Scratching Decrease Histamine-Induced Itch and Skin Blood Flow". Journal of Investigative Dermatology 2005 (125): 1268–1272. doi:10.1111/j.0022-202X.2005.23942.x. PMID 16354198.
http://www.nature.com/jid/journal/v125/n6/pdf/5603667a.pdf.
Zeidner, N. S., Higgs, S., Happ, C. M., Beaty, B. J. & Miller, B. R. (1999). "Mosquito feeding modulates Th1 and Th2 cytokines in flavivirus susceptible mice: an effect mimicked by injection of sialokinins, but not demonstrated in flavivirus resistant mice". Parasite Immunology 21 (1): 35–44. doi:10.1046/j.1365-3024.1999.00199.x. PMID 10081770.

We welcome you to complete the assignment in Microsoft Word. You can find the assignment at www.abctlc.com.

Once complete, just simply fax or e-mail the answer key along with the registration page to us and allow two weeks for grading.

Once we grade it, we will email a certificate of completion to you.

Call us if you need any help.

If you need your certificate back within 48 hours, you may be asked to pay a rush service fee of $50.00.

You can download the assignment in Microsoft Word from TLC's website under the Assignment Page. www.abctlc.com

You will have 90 days to successfully complete this assignment with a score of 70% or better.

If you need any assistance, please contact TLC's Student Services.