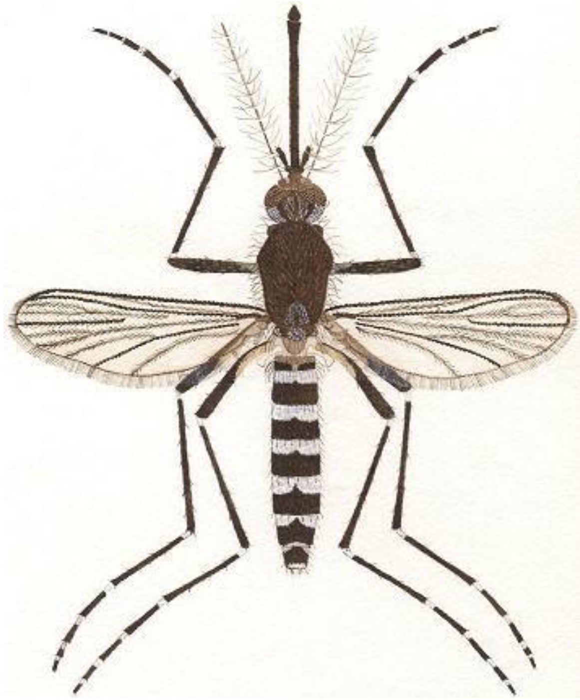
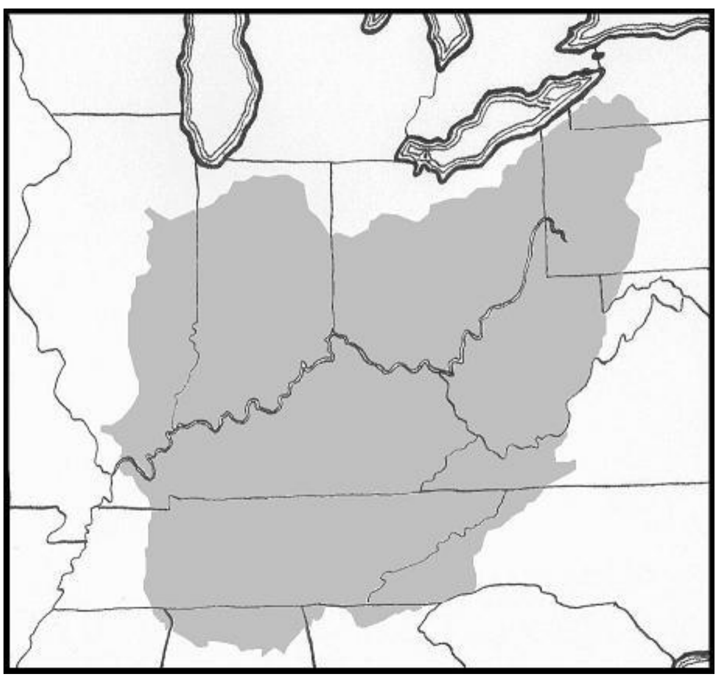


The Mosquitoes of the Ohio River Basin:

Illinois, Indiana, Kentucky, Ohio, and West Virginia



Catherine L. E. Craker and Frank H. Collins

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Introduction: How to Use This Book

This book is designed to assist the novice mosquito collector in the identification of mosquito species found in the Ohio River basin, an area roughly corresponding to the states of Illinois, Indiana, Kentucky, Ohio, and West Virginia. It contains all species of mosquitoes reported to be found within the geopolitical borders of those five states and is also applicable in large portions of several neighboring states within the boundaries of the Ohio River basin. Not all species presented in the key are common throughout this range; any given area will tend to develop its own particular species composition, and collectors will quickly become familiar with the makeup of the local population. It is not uncommon for 80-90% of a day's catch to be comprised of only one or two species which are present in vast abundance, while other species may be found only rarely, if ever.

Chapters 3-8 of this book comprise a dichotomous key which will allow the user to identify all 78 species of mosquitoes reported from this five-state region through the year 2007, including very rare species. Chapter 10 contains full-body color illustrations of 23 of the most common, medically important, or otherwise prominent species in the region, along with information on their biology, habits, and tips for identification. It should be possible to identify the majority of any catch simply by matching specimens to the illustrations in this section, though the user is strongly encouraged to master the use of the key in order to approach the identification of less common species with confidence.

How to Use the Key

The identification section is laid out in the form of a traditional dichotomous (branching) key. Each step in the identification of a specimen will offer you a choice between two descriptions (a couplet), and you will be asked to select the one that better describes your specimen. The description you choose will then direct you either to a species name, or to a second couplet, with which you will repeat the process until you arrive at a species identification. A sample couplet is shown below:

3a (2a). Wing scales mingled light and dark; abdomen mostly pale with dark patches ....***Aedes (Ochlerotatus) dorsalis***

3b. Wing scales, scutum and abdomen all or mostly dark..***4***

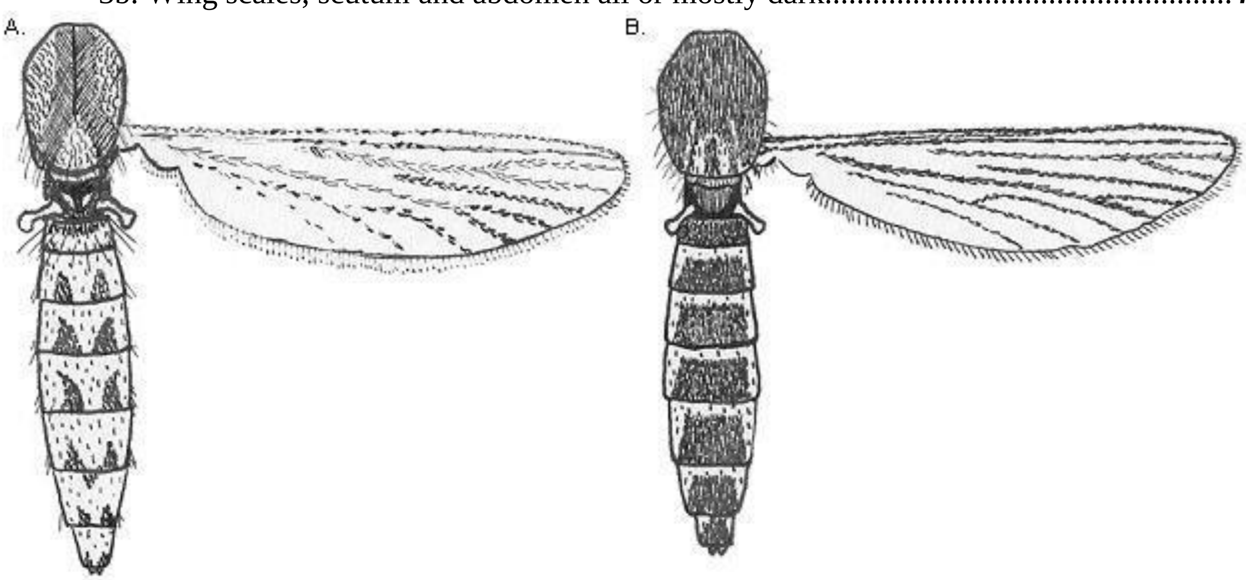

Figure 4.3 Wing, thorax, and abdomen, dorsal view, Ae. dorsalis and Ae. canadensis

This is the third couplet in the key to mosquitoes of the genus *Aedes;* therefore the two options are labeled 3a and 3b. The number (2a) in parentheses tells us that we arrived at this couplet by choosing option "a" in couplet 2; this is useful for backtracking when necessary. When keying, you may arrive at a point where you realize that neither option accurately describes your specimen; if this is the case, simply retrace your steps to a point at which you feel confident, and try again.

Returning to the couplet, carefully read both options all the way through. When a description contains two or more sections separated by a semicolon, as in option (a) above, *make sure that both sections are true for your specimen* before selecting that option. If you examine your specimen and see that there are significant numbers of both light and dark scales on the wing veins, and that more of the abdomen is covered by pale scales than by dark ones, as in the illustration, you can be reasonably confident that the specimen is *Aedes dorsalis.* If the wing scales are nearly all dark and more of the abdomen is covered by dark scales than by light ones, proceed to couplet 4. If, on the other hand, neither option really seems to fit (say, for example, the wings have large patches of both light and dark scales, but the abdomen is predominantly dark-scaled), return to couplet 2 and retrace your steps until you are confident of your identification.

If, despite your best efforts, you are unable to identify a specimen, set it aside and come back to it after identifying the rest of the catch. Sometimes individual mosquitoes may display characteristics that are unusual for the species, due either to genetic variation or to environmental influences (for example, hitting the suction fan on the way into a mosquito trap), making them difficult to identify. Chances are good that you will have captured more than one of that species, and the second one you come across may prove easier to key. It is always possible, though uncommon, that you may collect a species which is new to your area and not included in the key. If you believe this to be the case, you may wish to consult a key which covers a wider geographic area. Identification and Geographical Distribution of the Mosquitoes of North America, North of Mexico by Richard F. Darsie and Ronald A. Ward (©2004, University Press of Florida) is an excellent reference for this purpose, though with 174 species, using this key can be a lengthy process. Mosquitoes of North America by Stanley J. Carpenter and Walter J. LaCasse (©1955, University of California Press) is another excellent reference, containing detailed descriptions and full-body illustrations of each species that have never been surpassed, but several of the classifications used in this book are out of date, and a number of species which are now common in the United States were introduced after its publication and are thus not included. It is also, regrettably, currently out of print and copies may be difficult to obtain, though well worth the effort.

Chapter 1. Mosquito Biology

Few insects have a greater impact on human life, health, and well-being than the mosquito. Mosquitoes are common throughout the world; their annoying whine and irritating bites are familiar to nearly everyone who has ever spent time outdoors on a summer evening, whether in the middle of a large city, in a suburban backyard, in a rural countryside, or deep in the woods. There are over 2,500 species of mosquitoes currently known to exist in the world, roughly 200 of which are found in the United States (AMCA 2005). Members of different species do not necessarily look or act alike: each species has its own unique characteristics and habits, which influence where it lives, what it eats, when it is most active, which diseases it may transmit, and to what degree it impacts the lives of people in the area. The effects of mosquito bites may range from a minor nuisance to a devastating swarm that can render life outdoors nearly unbearable. In areas where certain types of mosquitoes have been particularly prolific, dairy cattle have been observed to produce less milk due to the stress of the constant harassment, and there have even been reports of livestock deaths from loss of blood and loss of condition due to mosquito bites.

A danger which is much more common than death by exsanguination, though perhaps less dramatic, is the ability of mosquitoes to transmit disease. The bite of a single mosquito, perhaps unnoticed by its victim, can be enough to transmit a potentially lethal infection with any number of viruses or other pathogens. Most recently, the United States has experienced a series of epidemics of West Nile virus, a mosquito-borne virus which can cause symptoms ranging in severity from a mild flulike illness to a potentially fatal encephalitis in both humans and horses, as well as other animals. Our region is also subject to occasional outbreaks of several other arboviruses (arbovirus= **ar**thropod-**bo**rne **virus**), including St. Louis encephalitis, Eastern equine encephalitis, and La Crosse encephalitis. Historically, mosquitoes have also been responsible for the spread of malaria and Yellow fever, and while these are now, thankfully, extremely rare in the United States, they remain an extremely serious problem in many parts of the world.

Despite their ubiquity and importance, however, to most people, mosquitoes remain as poorly understood as they are familiar. Here, therefore, we provide a brief introduction to the biology of the mosquito, its life history, and its habits.

Classification

Mosquitoes are flies. They are members of the order Diptera, insects which possess only two functional wings. Most insects have four wings, but in the Diptera the second pair has been highly modified to form *halteres*, small knoblike structures which assist with balance and stability during flight. These are visible just behind the primary wings (See figures 1.3 and 1.4, page 11).

Within the Diptera, mosquitoes comprise the family Culicidae, which can be distinguished from other flies by the presence of scales on the veins of the wings and by the presence of a long, slender proboscis adapted to pierce flesh and suck blood. Certain other families of flies, including the Chironomidae (midges) and Tipulidae (crane flies), superficially resemble mosquitoes, but in these families the wing veins are completely smooth and the mouthparts small and inconspicuous.

The Culicidae are further divided into three subfamilies, the Anophelinae, Culicinae, and Toxorhynchitinae. The vast majority of mosquitoes are placed in the subfamily Culicinae, including the North American genera *Aedes, Coquillettidia, Culex, Culiseta, Orthopodomyia, Psorophora, Uranotaenia,* and *Wyeomyia*. Each of the other two subfamilies is represented by a single genus in North America, the Anophelinae by *Anopheles* and the Toxorhynchitinae by *Toxorhynchites.*

Classification within the subfamily Culicinae is a subject of continual debate, and has undergone many changes through the years. The names and groupings given in this book represent, to the best of the author's knowledge, the current general consensus in the mosquito research community on these topics, but the reader should be aware that names in use today may have been different in the past and may be subject to change in the future. This topic is discussed in greater detail in the *Most Important Species* section and in the introduction to the genus *Aedes.*

Life Cycle

All mosquitoes possess a seven-part life cycle, of which at least five stages are spent entirely in an aquatic environment. Mosquito eggs are typically laid in, on, or near water and may hatch within days or may remain dormant for a period of weeks, months, or even years. The eggs of some species are resistant to drying and can survive considerable periods of drought, hatching when conditions become favorable. The newly hatched mosquito larva then passes through four developmental stages, called *instars*, molting after each one. After the fourth larval instar, the mosquito sheds its last larval skin to become a pupa. The pupae of mosquitoes are unusual in that, unlike the quiescent pupae of most metamorphosing insects, they are quite active, able to swim and dive with considerable agility, though they do not feed. All four larval instars and the pupa require an aquatic habitat in order to survive and develop.

The pupal phase typically lasts from one to a few days. When metamorphosis is complete, the pupa will rise to the surface of the water and adopt a straightened-out posture, with its tail parallel to the surface. The cuticle splits along the midline of the thorax, and the adult mosquito rises slowly out of it on a column of compressed air. Once free of the pupal casing, it comes to rest standing on the surface of the water, supported by the surface tension, until its wings harden and it is able to fly.

Within the first 24 hours after emergence, the last abdominal segments of the male, which contain the genitalia, undergo a 180° rotation relative to the rest of the body. This rotation is necessary before the males are able to mate.

Feeding

Most mosquito larvae feed on the minute particles of organic matter that float on the surface of their aquatic habitat. A few species, including *Toxorhynchites* and some of the larger *Psorophora*, are predatory in the later larval stages and will hunt, kill, and consume other small aquatic insects, including other mosquito larvae. Some species are able to store enough protein from their carnivorous larval diet to supply all of their adult protein needs. The females of these species are able to develop and lay eggs using this stored protein without requiring a meal of protein-rich vertebrate blood, and are called *autogenous.* Species in which the females require a blood meal in order to develop eggs are called *anautogenous.*

The primary food of all adult mosquitoes is flower nectar and other sugary liquids. The author has occasionally collected wild mosquitoes engorged with red syrup probably obtained from a hummingbird feeder, and colonies of mosquitoes are often maintained in the laboratory on sliced fruit or on cotton soaked with a solution of water and sugar or diluted honey or corn syrup. This sugary diet provides all of the energy required by the adult mosquito to maintain its own bodily functions, and the males consume nothing else.

As noted above, the adult females of many, though not all, mosquito species do require additional protein in their diet in order to produce eggs, and they obtain this protein by consuming vertebrate blood. Females in search of a blood meal locate hosts primarily through scent cues. Carbon dioxide (CO_2), which is exhaled in large quantities by humans and all other host species, is detected by the mosquito's antennae and serves as a strong feeding stimulus to most species. Upon sensing the presence of CO_2, the mosquito will turn and fly upwind, tracking the plume of gas to its source. At close range, additional chemical and visual cues come into play, helping the mosquito to identify the host as desirable or undesirable and, if desirable, to locate an attractive spot on which to land and attempt to bite. Many species have particular host preferences, and may or may not be willing to bite an animal of a different type if its preferred host is unavailable. *Culex restuans*, for example, is primarily ornithophilic, meaning that it feeds almost exclusively on birds, while *Psorophora columbiae* is mammalophilic and prefers to bite cattle and other large mammals, and *Aedes trivittatus* is an opportunistic feeder and will take advantage of almost any available blood source.

A mosquito's proboscis, the long, slender "snout" which projects forward from the bottom of its head, is a complex apparatus composed of seven parts. The portion visible to the naked eye is the sturdy, protective outer sheath called the *labium*, which has two tiny lobes at the tip called *labellae*. Inside the sheath of the labium is a set of four long, slender, piercing stylets derived from the paired *mandibles* and paired *maxillae*, and a two-part "drinking straw" consisting of the *labrum-epipharynx*, which is U-shaped in cross-section, and the *hypopharynx*, a straw-like tube which conducts saliva into the wound and which fits into the groove of the labrum-epipharynx to complete the hollow tube through which blood is ingested.

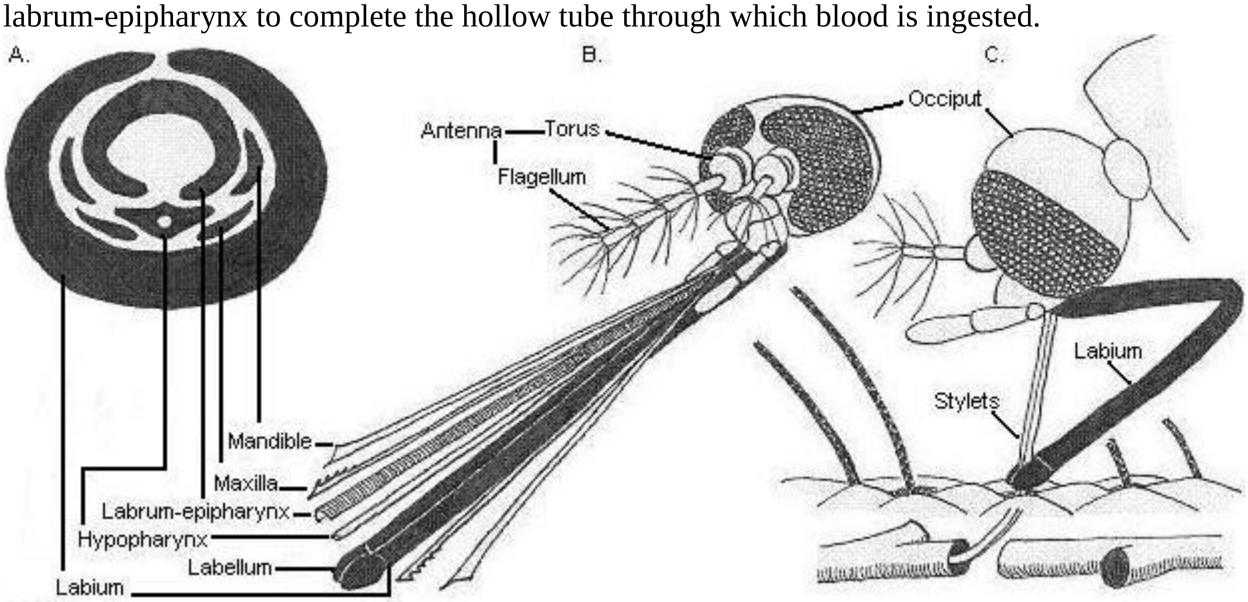

Figure 1.1 Female mosquito head showing anatomy of the proboscis. A: cross section of proboscis. B: Dissection of proboscis, showing stylets. C: Mosquito in the act of biting, with cross section of host skin and blood vessel.

When a female mosquito lands on a potential host, she "quests," brushing the tip of her proboscis back and forth across the host's skin until she locates a spot where a blood vessel runs close to the surface. Having found one, she sets the tip of the proboscis against the skin and begins to work the stylets into the host's flesh. The labium is never inserted into the skin; its tip remains in contact with the skin's surface, surrounding the bundled stylets, while the remaining length of the tube is pushed up and back toward the mosquito's head, buckling outward and out of the way. The serrated maxillae and piercing mandibles, lubricated by saliva transported by the hypopharynx, allow the mosquito to penetrate a blood vessel and suck up blood through the tube formed by the labrum-epipharynx and the hypopharynx.

Feeding usually takes about a minute. The female drinks until her entire abdomen is distended with blood, which can be clearly seen through the semi-transparent sides of the abdominal wall. In order to maximize protein uptake, females will often begin to excrete the liquid portion of the blood while continuing to drink, concentrating the cells to be digested. A careful observer will therefore sometimes find tiny droplets of clear to dark red fluid beneath the site where a mosquito has been feeding.

When she is finished, she braces herself and quickly pulls her stylets out of the host's skin, working the labium back down to surround them, sometimes adjusting it with her front legs. She then flies a short distance away, finds a sheltered place to rest, and begins the process of digestion and egg development.

The life span of an adult mosquito ranges from a few days to several months, with females typically living longer than males. In some species, including members of the genera *Culex* and *Anopheles* in the United States, adult females which emerge in the autumn will mate and then hibernate through the winter, reawakening in the spring to bite and lay eggs. Favored hibernation spots are sheltered locations in which the temperature remains above freezing, such as natural caves or treeholes or man-made structures such as culverts, sheds, outbuildings, and the undersides of bridges.

Mosquitoes as Vectors of Disease

Mosquitoes do not possess venom. Most of the irritation caused by a mosquito bite is due to a histamine response by the host's immune system to the mosquito's saliva, a small quantity of which is injected into the host's body as the mosquito inserts her stylets. Of much greater concern is the risk that, in a small percentage of cases, this saliva may also contain pathogens (viruses, bacteria, or parasites) which can cause disease.

A mosquito may become infected with a pathogen in a variety of ways. The most common is by ingestion—the mosquito consumes blood from an infected host, and the pathogen makes its way from the ingested blood into the cells of the mosquito's digestive system, spreading from there to infect other organs and tissues of the mosquito's body. It may also become infected through sexual contact with an infected partner, though it is not known how frequently this occurs in the wild. Finally, an infected mosquito may transmit the infection to its offspring, either during the development of eggs in the ovaries (transovarial transmission) or to the mature eggs during the acts of fertilization and oviposition (transovum transmission).

In order for a mosquito to transmit a pathogen to another organism, the pathogen must infect certain specific tissues within the mosquito's body; namely, the salivary glands in order to infect a vertebrate host through the mosquito's next bite, or the sexual organs in order to infect the mosquito's eggs or its mate. There are a number of barriers through which the pathogen must pass in order to achieve this. If ingested with the blood of an infected vertebrate, the pathogen must first penetrate the walls of the mosquito's midgut, in which it may or may not replicate. It must then escape from the midgut wall into the *hemolymph* (the clear fluid which circulates freely about the mosquito's body in place of blood), in which it can travel throughout the mosquito's body, creating what is called a *disseminated infection*. From the hemolymph, the pathogen must reach and penetrate the appropriate organ or tissue, then escape from the cells of that tissue into the fluid which will transport it to its next host: the saliva or the fluids of the reproductive system which surround the developing eggs.

Pathogens may be blocked at any point in this process, and different species of mosquito may offer more or less resistance to each of these transitions. A species may be highly resistant to penetration of the midgut by a particular pathogen; this species would therefore be rarely, if ever, found to be infected with this pathogen in the wild. Alternatively, a species could be quite susceptible to midgut infection, but strongly resistant to infection of the salivary glands; this species might be found to be infected with this pathogen at a very high rate, yet be unable to transmit the infection to other animals through its bite. The ability of a particular species of mosquito to become infected with and to transmit a particular pathogen is called its *vector competence* for that pathogen. Competence may vary widely for different pathogens, and a mosquito species which is an extremely competent vector for West Nile virus, for example, may have no vector competence at all for malaria.

Vector competence, which can readily be tested in the laboratory, is only one element required in order for a mosquito to be an effective vector. Environmental and behavioral traits also play a role: the species must be sufficiently abundant and active at the right time of day and the right time of year in order to encounter both infected and susceptible hosts, and must be willing and able to bite them in order to acquire and transmit the infection. It must survive long enough for the pathogen to complete its journey from the midgut to the salivary glands and undergo any changes necessary to release infective particles into the saliva, a length of time known as the *extrinsic incubation period*. The length of this period varies according to the pathogen and the vector species, and is influenced by environmental factors such as the ambient temperature; many pathogens replicate more quickly at higher temperatures, so hotter weather will often shorten extrinsic incubation periods, increasing the odds that a mosquito will survive long enough to become infectious and therefore raising transmission rates. This overall ability to transmit a particular pathogen in a particular place and time, incorporating the mosquito's inherent biological vector competence and all other contributing factors, is called its *vector capacity*. Mosquitoes with a high vector capacity for any pathogen known to affect humans or domestic animals are considered medically important. The medically important vector species known to occur in our area, along with those *anthropophagic* (human-biting) species which occur in numbers great enough to be considered significant nuisances, are discussed in greater detail individually in the "Most Important Species" chapter.

Mosquito Anatomy

The major characteristics of mosquito anatomy are frequently referred to in the physical descriptions and couplets found throughout this book. Below are the definitions of a number of the most commonly-used technical terms with which the reader will need to become familiar.

The basics

The body of a mosquito, like that of other insects, is divided into three main sections: the head, the thorax, and the abdomen. The head holds a pair of multifaceted compound eyes, the mouthparts bundled together to form a long proboscis, a pair of antennae resembling bottlebrushes, and a pair of palpi which may range in size from very short to nearly as long as the proboscis.

The thorax is the middle section of the body, to which the legs, wings, and halteres are attached. The dorsal surface of the thorax (the mosquito's "back") is called the *scutum*, and there is a small, shelflike projection from the posterior end of the scutum called the *scutellum.* The sides of the thorax are divided into a number of separate plates collectively referred to as the thoracic *pleura*, which are generally covered to a greater or lesser degree by pale whitish or cream-colored scales. At the top of each side, just below the edge of the scutum and about one-third of the way back from the mosquito's head, is a small opening called a *spiracle,* which allows air to enter and leave the mosquito's respiratory system. In *Culiseta* and *Psorophora,* there is a row of small, stiff bristles emerging along the anterior edge of the spiracle and extending posteriorly across it (See Figures 3.6 and 3.8, page 23).

The abdomen is the third and longest section of the body and consists of nine segments, numbered from "I" adjacent to the thorax to "IX" at the abdominal tip. Segments VIII and IX are usually small and may be partially or almost completely retracted inside the larger segment VII, and are therefore often difficult to see. The dorsal (upper, "back") plate of each abdominal segment is called a *tergum* or *tergite*, while the ventral (lower, underside, "tummy") plate is called a *sternum* or *sternite.* At the tip of the abdomen are the genitalia; in the male, these are readily visible as a set of elaborate claspers and copulatory apparatus, while in the female, only a set of small, slightly-protruding cerci are visible.

The legs of the mosquito are composed of nine segments. The short, somewhat oval first segment which connects the leg to the thorax is called the *coxa.* Attached to the coxa is the small *trochanter*, followed by the long, slender *femur.* Approximately equal in length to the femur is the *tibia*, which is followed by the *tarsus,* which is divided into five *tarsal segments* or *tarsomeres.* The fifth tarsal segment bears two tiny claws at its tip.

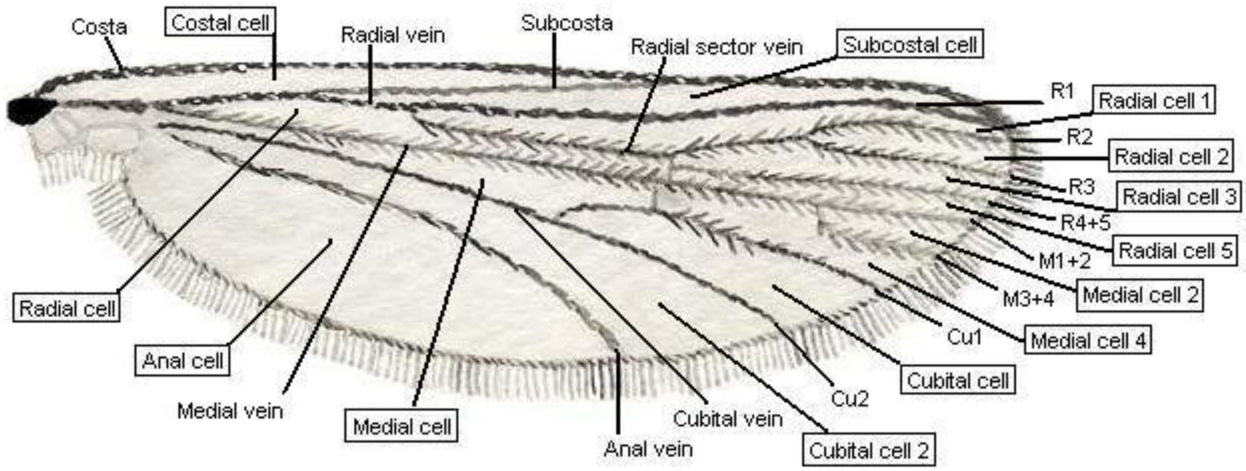

Figure 1.2 Wing of *Culiseta inornata*, showing major veins and cells

Each wing of the mosquito is strengthened by a set of six major veins which radiate outward from a point close to the mosquito's body like the ribs of a fan. The first of these veins is called the *costa*, and it forms the leading edge of the wing, running unbranched and unbroken from base to tip. It is generally large and thickly covered with scales, which may be arranged in patterns which are important in the identification of some species. The second vein, the *subcosta*, is much smaller and may be difficult to see. It runs just below the costa and joins it about two-thirds of the way to the tip of the wing. The *radial vein* is similar to the costa in size and weight and runs parallel to it for its entire length, terminating at the wingtip. The heavily-scaled radial vein often obscures a portion of the subcosta close to the thorax, as the two originate fairly close together. At a point approximately one-third to one-half of the distance to the wingtip, the radial vein gives rise to a smaller, thinner branch called the *radial sector vein.* This in turn branches into two shortly thereafter, and the upper of these two branches divides once again before reaching the edge of the wing. The radial vein therefore touches the wing's edge at four points, and these subveins are labeled, beginning with the uppermost, R_1, R_2, R_3, and R_{4+5} (an artifact of other entomological vein-labeling systems—in some insects, this subvein would also be branched, making the terminal veins R_4 and R_5).

The fourth major vein, running diagonally through roughly the center of the wing, is called the *medial vein*. It is branched only once, and the two subveins are called M_{1+2} and M_{3+4}. The fifth vein, the *cubitus*, also branches once to form Cu_1 and Cu_2. The final, unbranched vein is called the *anal vein.* The sections of translucent membrane between the veins are called *cells*, and each cell is named for the primary vein that defines its upper boundary. The relative lengths of some of these cells and veins are important in identifying some species. The edge of the wing is fringed with long scales, as are several of the interior veins.

Glossary of Specific Terms

Antenna (pl: antennae): One of a pair of long, slender, bristly sensory organs projecting forward from the mosquito's head. Each antenna emerges from the head just forward of, and partially surrounded by, the compound eye, and is composed of a narrow basal ring called a *scape* which attaches it to the head, a rounded, bulbous globe called a *torus* or *pedicel,* and a long, slender *flagellum* which is subdivided into 13 or 14 segments called *flagellomeres,* each of which bears several slender sensory bristles, giving the whole antenna the appearance of a bottlebrush or pipe cleaner. In the males, these bristles are much more numerous and elongated, making the antennae resemble tiny ostrich plumes. (Fig. 1.1, 1.4)

Antepronotum (or *anterior pronotal lobe*; pl: antepronota): One of a pair of bulbous lobes located on either side of the thorax, just behind the head. (Fig. 1.3, 1.4)

Cercus (pl: cerci): One of a pair of small, fingerlike appendages projecting from the tip of the abdomen. These are much more readily visible in some genera than in others. (Fig. 1.4)

Corneal Facet: Any one of the many “lenses” that make up the compound eyes.

Costa: The heavy, thickly-scaled vein that forms the leading edge of the wing. (Fig. 1.1)

Coxa (pl: coxae): The first segment of the leg, closest to the thorax. The forecoxae often have patches of light or dark scales which can be useful in species identification. (Fig. 1.3)

Femur (pl: femora): The long and cylindrical third segment of the leg. (Fig. 1.4)

Haltere: One of a pair of knoblike structures that project from the thorax immediately behind and below the membranous wings. The halteres are evolutionarily derived from the second pair of wings possessed by the ancestors of mosquitoes and other insects; in their present form, they assist the mosquito with balance and stability during flight. (Fig. 1.4)

Integument: The surface of the exoskeleton, which may be covered by scales or bristles.

Occiput: The scaly dorsal surface of the mosquito’s head, posterior to the compound eyes. The anterior portion of this surface is sometimes called the *vertex.* (Fig. 1.1, 1.4)

-omere: a common suffix in anatomical description, which can be effectively translated as “segment of.” For example, a palpomere is a segment of the palpus.

Palpus (pl: palpi): One of a pair of segmented, leglike appendages located on either side of the proboscis. In males of all local genera except *Wyeomyia*, the palpi are roughly the same length as the proboscis and the tips are often covered with long bristles and may be clubbed. In females, the palpi are of fairly uniform thickness, with few or no long bristles and may vary in length from shorter than the mosquito’s head to nearly as long as its proboscis. (Fig. 1.4)

Pleuron (pl: pleura): the side of a body segment. The thoracic pleura are covered by a number of hardened exoskeletal plates or sclerites, while the sides of the abdomen are covered by the *pleural membrane*, a thin, elastic tissue which connects the tergites and sternites and allows the abdomen to expand during feeding or egg development. The pleural membrane is relatively transparent, making the blood-filled midgut or the outline of developing eggs readily visible from the side under magnification. It is usually not visible in unfed, non-gravid individuals.

Postnotum (or *mesopostnotum*): A large, shiny, dome-shaped structure at the posterior end of the thorax, just below the scutellum. (Fig. 1.4)

Proboscis: The long, slender, scaly appendage projecting forward from the mosquito’s head, consisting of a bundle of mouthparts adapted for piercing and sucking. (Fig. 1.1, 1.4)

Pulvillus (pl: pulvilli): A pad at the base of the tarsal claws in some genera. (Fig. 1.7)

Sclerite: Any of the hardened plates that make up an insect’s exoskeleton.

Scutal fossa (pl: scutal fossae): One of a pair of broad, shallow depressions in the convex surface of the scutum, located toward the side of the anterior portion of the scutum, just forward of the widest point. (Fig. 1.4)

Scutellum: A small, shelflike projection from the posterior end of the scutum above the postnotum. The edge of the scutellum forms a continuous arc in *Anopheles,* but has three lobes in all other local genera. (Fig. 1.4)

Scutum: The dorsal surface of the mosquito’s thorax. (Fig. 1.3, 1.4)

Seta (pl: setae): A bristle, which may be fine and hairlike or thick and almost spine-like.

Spiracle: An opening in the integument that allows air to enter and leave the respiratory system. In the mosquito, the *mesothoracic spiracle* is the most prominent, located on the side of the thorax just below the edge of the scutum. (Fig. 1.3)

Sternum (or *sternite*; pl: sterna): the hardened ventral plate of an abdominal segment.

Suture: A line where two or more sclerites join, usually visible as a groove or furrow in the exoskeleton.

Tarsus (pl: tarsi): The terminal portion of the leg, which is divided into five slender, cylindrical segments called *tarsomeres*. Tarsomere 5 is the furthest from the body and bears a pair of claws. (Fig. 1.4)

Tergum (or *tergite*; pl: terga): the hardened dorsal plate of an abdominal segment.

Tibia (pl: tibiae): The fourth, and often longest, segment of the leg. (Fig. 1.4)

Torus (pl: tori): The second segment of the antenna, the torus (or *pedicel*) rests on the tiny, barely-visible *scape*. The torus is generally of similar length to the other segments, but is roughly spherical or doughnut-shaped. The torus may be bare and shiny or may have scales in some species. (Fig. 1.1)

Trochanter: The second segment of the leg, usually relatively small and inconspicuous.

Anatomical Directions

Anterior: Toward the front of the body.

Apical: Toward the apex of an appendage or segment, furthest from the middle of the body.

Basal: Toward the base of an appendage or segment, closest to the middle of the body.

Distal: Further from the middle of the body.

Dorsal: Toward the mosquito's "back" or upper surface.

Lateral: Toward the side, away from the midline.

Medial: Close to the midline.

Posterior: Toward the rear end of the body.

Proximal: Closer to the middle of the body.

Ventral: Toward the "belly" or underside.

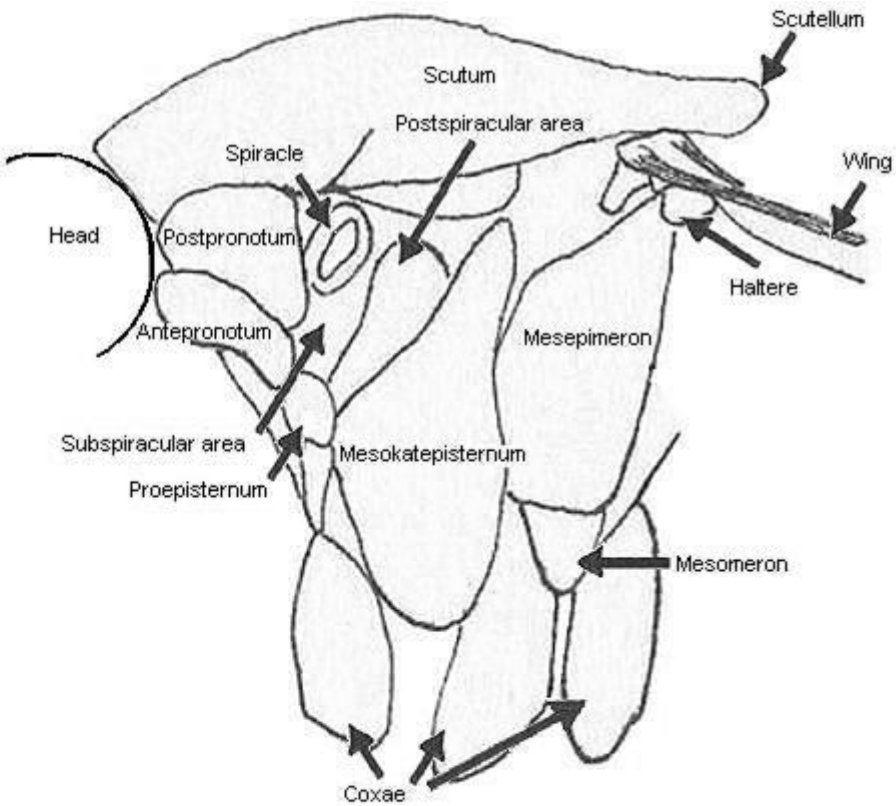

Figure 1.3 Thorax of a mosquito, side view

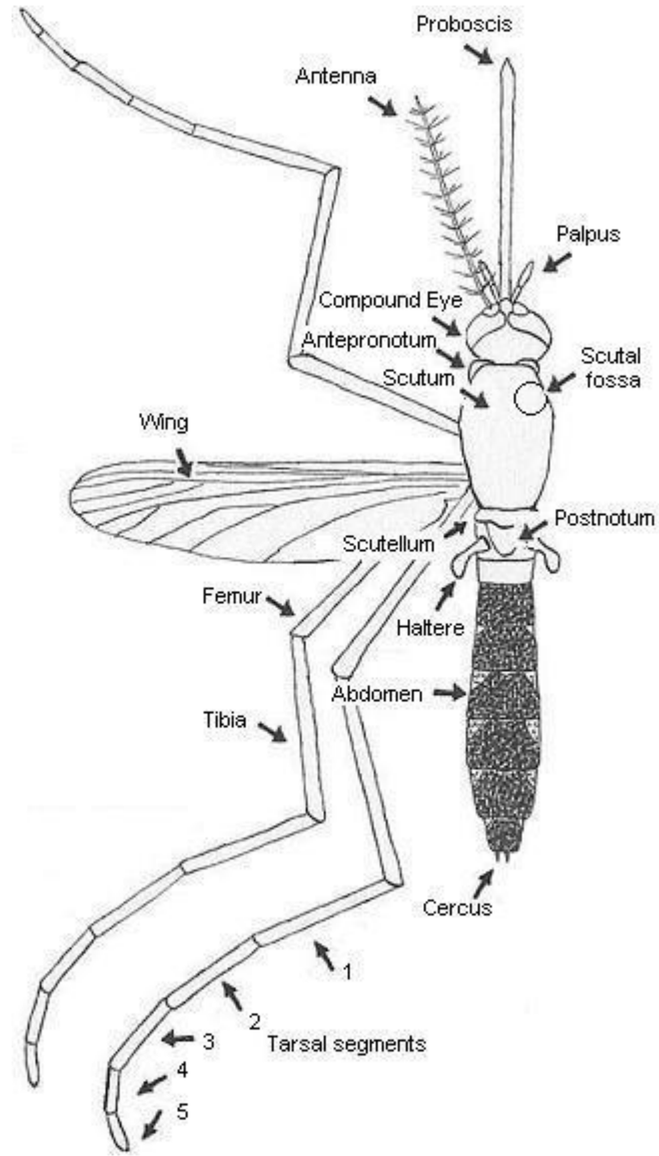

Figure 1.4 Generalized mosquito anatomy, dorsal view

Common Characteristics of Common Genera

Certain morphological characteristics are common to all members of each of the various genera of mosquitoes found in our area, and can be used as a quick reference to identify each genus. The next few pages contain diagrams of generalized representatives of each of the five genera (*Aedes, Anopheles, Culex, Culiseta,* and *Psorophora*) containing more than one species commonly found in our region, highlighting each of these identifying features. Those species which do not fall into one of these five genera (*Coquillettidia perturbans, Orthopodomyia signifera/Or. alba, Toxorhynchites rutilus septentrionalis, Uranotaenia sapphirina,* and *Wyeomyia smithii*) have been illustrated and described individually in the "Most Important Species" chapter.

Each genus also tends to have characteristic life cycle traits that are shared by many, if not all, members of the genus. For example, both *Aedes* and *Psorophora* species tend to overwinter as eggs or occasionally as larvae, while *Culex, Culiseta,* and *Anopheles* typically overwinter as inseminated adult females. The larvae of most species of *Aedes* and *Psorophora* are to be found most often in small, often temporary bodies of relatively clean water such as flooded depressions in woodlands or pastures or in containers filled with rainwater. *Culex* larvae, particularly the medically important species, often prefer larval habitats high in organic matter and may be found in storm drains, cesspools, stagnant bird baths, or flooded ditches, while *Culiseta* commonly breed in wetlands or ponds.

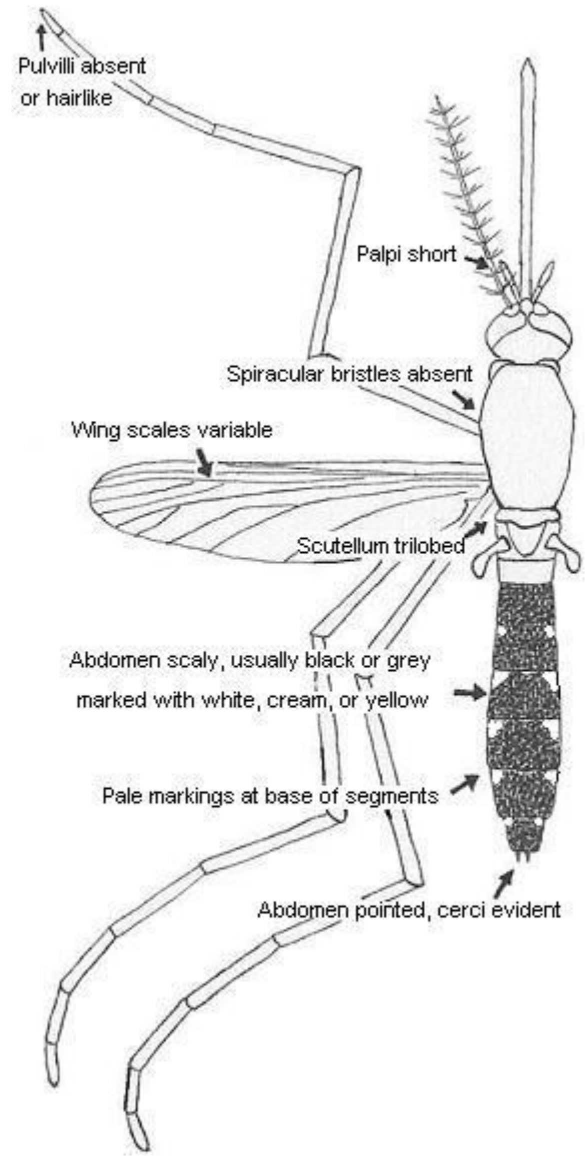

Figure 1.5 Characteristics of adult female *Aedes*

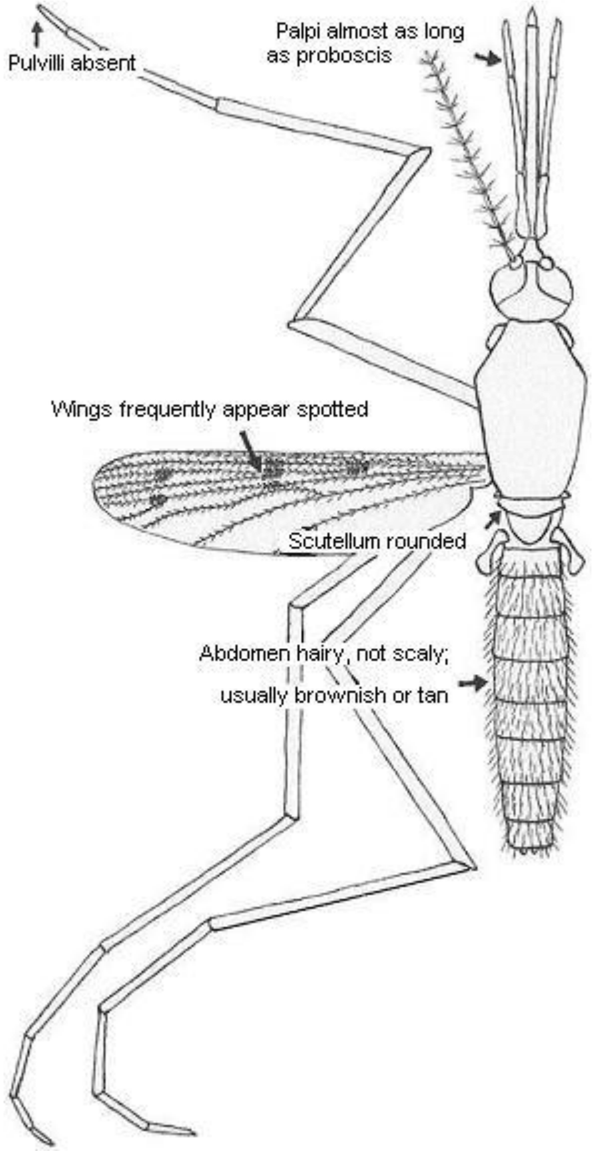

Figure 1.6 Characteristics of adult female *Anopheles*

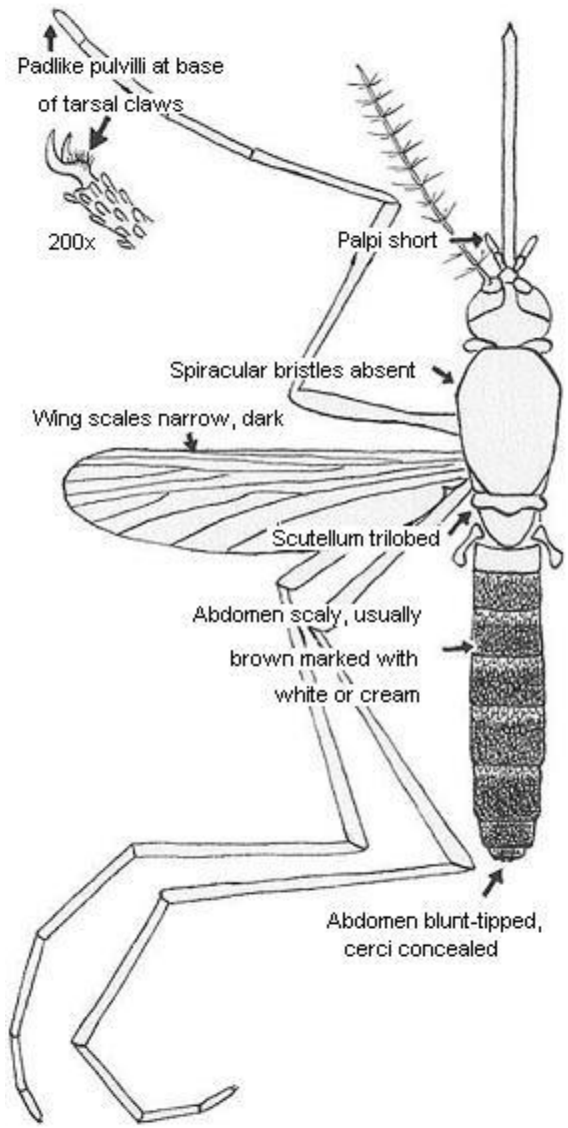

Figure 1.7 Characteristics of adult female *Culex*

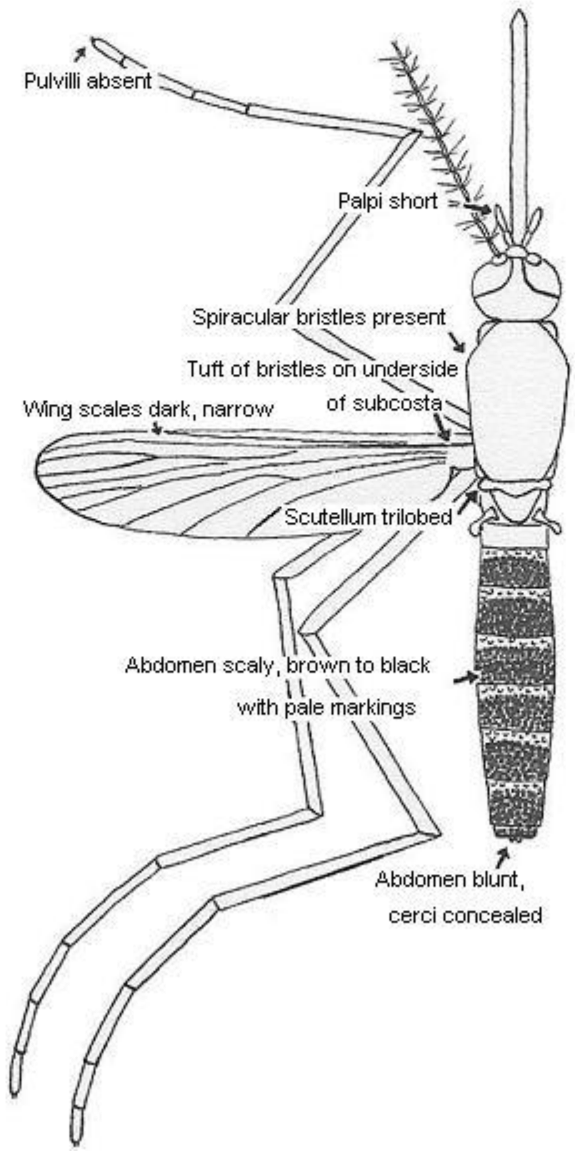

Figure 1.8 Characteristics of adult female *Culiseta*

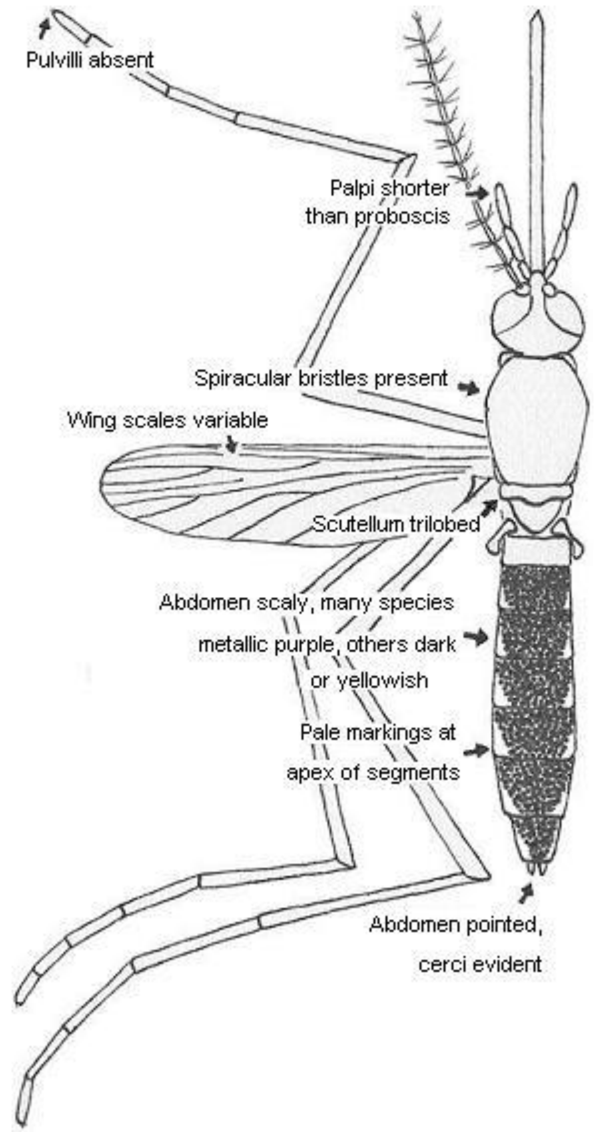

Figure 1.9 Characteristics of adult female *Psorophora*

Chapter 2. Mosquito Collecting

Many specialized techniques have been developed for collecting mosquitoes from the wild in nearly every possible life stage, condition, and habitat. Each has its own particular advantages and disadvantages, and each may be useful in certain situations. Here we will focus on a few of the most common collection techniques used in public health work and surveillance.

Habitat

All mosquitoes require water in which to breed, but the variety of ponds, puddles, bird baths, buckets, cesspools and cisterns which can be pressed into service as larval habitats is truly staggering. Virtually any body of water which is reasonably still and not too heavily saline is likely to harbor mosquito larvae, from a rain-filled bottlecap to the marshy edges of a large lake. Each species has its own characteristic habitat, though some are more particular than others. Adult mosquitoes are nearly always present in the vicinity of breeding sites, so these are good locations for adult trapping as well as for larval sampling. It should be noted, though, that many species of mosquito are capable of flying significant distances, and adults may be found several miles away from their larval habitat.

Peridomestic containers

Human houses and commercial sites are frequently surrounded by containers which will catch and hold water, often overlooked by the residents. Bird baths, decorative ponds, children's wading pools, and flowerpot saucers may be deliberately kept filled, while buckets, wheelbarrows, clogged rain gutters, discarded cans and bottles, and uncovered garbage cans are all common sites for water to collect from rain or lawn sprinklers. These small, still bodies of water are generally easily warmed by the sun and provide a perfect habitat for mosquito larvae. They often also contain organic matter such as fallen leaves, garden waste, bird or other animal droppings, or food residue, creating a rich organic brew strongly favored by *Culex* mosquitoes. Particular environments may contain unusual features which make good breeding sites. Cemeteries, for example, have occasionally been implicated as sources of mosquitoes due to the presence of numerous vases of water containing cut flowers at gravesites.

Treeholes

Many large trees contain holes or depressions which are capable of holding water, typically at the branching points between large boughs, in the hollows between the aboveground portions of roots, or in places where a branch has fallen off, leaving a wound through which decay has eaten into the trunk. These holes are the favored breeding habitat of several species of mosquitoes, including *Aedes triseriatus*, *Orthopodomyia signifera,* and *Toxorhynchites rutilus septentrionalis*.

Tires

Automobile tires which are kept outdoors without wheels or inner tubes, such as abandoned used tires, tire recycling and salvage operations, or children's tire swings without drainage holes, have a tendency to accumulate rainwater, creating sheltered puddles which are perfect breeding grounds for certain species of mosquitoes. *Aedes aegypti, Ae. albopictus, Ae. japonicus,* and *Ae. triseriatus* are all extremely common in tires. Tires are also frequently transported over long distances in large shipments for sale or salvage, and mosquito eggs or larvae may be transported with them. As all four of the above species may be considered medically important as disease vectors as well as nuisance biters, care should always be taken in the transportation and disposal of tires to prevent colonization by mosquitoes. Old tires used for swings or other secondary purposes should always be provided with drainage holes to prevent the accumulation of water. Unwanted tires intended for disposal may be slit in half to facilitate drainage. Laws governing tire disposal vary by state; contact your local waste disposal agency or the U.S. Environmental Protection Agency for specific information.

Ditches and Temporary Pools

Roadside ditches and depressions in the ground may become filled with rainwater or runoff from melting snow. These temporary puddles and pools are particularly common in the springtime, and often form in the same locations year after year. Many mosquitoes take advantage of these sites to lay their eggs; *Culex* and *Anopheles* species may colonize them opportunistically, but the definitive inhabitants of temporary pools are the floodwater *Aedes* and *Psorophora.* Members of these two genera usually pass the winter in the egg stage, and the eggs are typically at least somewhat resistant to drying. Gravid females of floodwater species, which in our area are represented primarily by *Aedes vexans, Ae. trivittatus, Ae. sticticus, Ae. canadensis, Psorophora columbiae,* and *Ps. ferox,* will lay their eggs in the soil and sod at the margins of these pools, where they lie dormant as the pools dry and shrink and hatch when the pool is refilled by rain or snow, which may be the following week or the following year. Hatching may be staggered, with only a certain percentage of a given egg batch hatching with each flooding, which increases the odds that at least some of the offspring will survive even if the rain is undependable and the pool dries too quickly for a particular batch of larvae to complete development.

Floodwater species are notorious for their incredible abundance following periods of rainy weather. A single pool may produce thousands of adult mosquitoes within a very short time, and all of the species listed above are mammalophilic feeders which will bite humans, livestock, and pets very readily and persistently. They can be an incredible nuisance, and have been known to have a measurable and significant negative economic impact on farming operations in heavily infested areas. Fortunately from a human perspective, these species are seldom effective vectors of serious human diseases found in our area, though some of them do transmit dog heartworm, *Dirofilaria immitis*, a serious and potentially lethal parasite of domestic animals, as well as a number of pathogens considered non-serious or rare.

Permanent Pools

Ponds, wetlands, and the slow-moving, reedy backwaters of streams and rivers are home to several species, including *Coquillettidia perturbans, Anopheles quadrimaculatus, Uranotaenia sapphirina,* and several species of *Culiseta.* The immature stages of *Cq. perturbans* are peculiarly adapted for life in these habitats, as the respiratory apparatus of both the larva and the pupa is modified to pierce the air-filled tissue of water plants such as cattails, from which they obtain oxygen.

Special Habitats

Certain species may make use of unusual and specific habitats, such as the pools of water that collect inside plants such as bromeliads and pitcher plants. This is more common in and around the tropics, but an example from our region is *Wyeomyia smithii*, the pitcher plant mosquito, which breeds only inside the leaves of the pitcher plant *Sarracenia purpurea.*

Collecting

Mosquitoes captured for public health work or surveillance are typically collected as adults, or occasionally as late-stage larvae or pupae. Immature stages are rarely useful in estimating infection rates for disease risk, but it is desirable to be able to recognize them in order to identify and treat breeding sites, or to obtain specimens for laboratory study. Larval identification is not addressed in this book, but various other keys are available for this purpose, or specimens collected as larvae may be permitted to complete their development and identified as adults.

Adult Traps

The two varieties of trap most often used in adult mosquito collections are the CDC-style light trap and the gravid trap. The CDC-style light trap uses light as its primary attractant, though many have attachments by which one can add chemical baits such as carbon dioxide. The trap has a small light bulb to which mosquitoes, like many insects, are attracted at night; close to this light source is a small suction fan which sends the insects into a mesh collection bag. In the author's experience, this type of trap tends to capture the greatest variety of insect species, including the greatest variety of mosquito species, though not all species are attracted equally. The addition of carbon dioxide, either through slow release from a compression tank or by placing chunks of dry ice in an insulated container attached to the trap to slowly sublimate, will tend to vastly increase the number of blood-seeking mosquitoes captured, while repelling a number of non-biting insects. Traps may be hung at various heights from any available support, and will capture a different assortment of species near ground level (placing traps approximately 1.5 meters above the ground—chest height—is common when collecting human-biting species) than if hoisted several meters up into the tree canopy, where more ornithophilic mosquito species may be hunting.

Gravid traps are designed specifically to attract gravid female *Culex* mosquitoes in search of a place to lay eggs. The bait in this case is a bucket or basin filled with foul-smelling water high in organic content: a standard recipe is to place roughly a pound of grass clippings or similar material into a thirty-gallon garbage can, fill it with tap water, and allow it to ferment for a week or so (covered, to prevent mosquitoes from gaining access to it prematurely) before using. About a gallon of this fragrant brew is used to fill the basin of the trap to within a half-inch of the opening of the suction tube. Female mosquitoes are attracted by the scent, descend to the water's surface to lay eggs, and are sucked into the collection compartment. Gravid traps can be extremely effective at collecting *Culex* and other container-breeding species, including *Aedes triseriatus* and *Aedes japonicus.*

Other types of equipment used for collecting adult mosquitoes include the New Jersey light trap, which is larger than the CDC-style light trap but operates on similar principles; commercial traps such as the Mosquito Magnet™ marketed to homeowners; and handheld suction devices which may range from a small breath-powered aspirator to a backpack-mounted vacuum. These latter are useful for collecting recently blood-fed or hibernating mosquitoes, which are rarely attracted to baits. Some specialized traps may even include compartments for housing live animals such as chickens for attracting particular types of mosquitoes.

Larval Collecting

Mosquito larvae and pupae, with a few notable exceptions such as *Coquillettidia perturbans*, spend most of their time hanging from the surface of the water by their air tubes or respiratory trumpets. If disturbed by a passing shadow or sudden movement, they will quickly dive to the bottom and hide among the debris there, remaining submerged for several seconds to about a minute before returning to the surface. The aim in collecting them, therefore, is generally to sneak up on them and scoop them off the surface of the water before they have a chance to dive.

The standard piece of equipment for collecting mosquito larvae is the long-handled mosquito dipper. This consists of a one-pint-capacity white cup, which may be plastic or enamel, affixed to the end of a four-foot-long pole. Telescoping handles are available, extending the dipper's reach to eight feet or more. Dippers may be used in any larval habitat in which one has ready access to roughly a square foot or more of the water's surface: puddles, ponds, ditches, and large, open containers. Approach the water to be sampled in such a way as to avoid casting a shadow on it, slowly extend the dipper, and quickly sweep it across the water's surface, scooping up a sample from the top 2-3" of the water. Avoid touching the bottom of the pool, as this will stir up sediment and make the larvae harder to see.

Examine your sample carefully. It often helps to rest the dipper on the ground and allow the water to become still; the water will become clearer as debris settles to the bottom, and any captured larvae or pupae should rise to the top. These may be poured off into a separate container for transport, or individual larvae may be picked up and moved to the transport container with a small plastic transfer pipette which has had its tip snipped off to enlarge the hole.

For treeholes, tires, and other small containers which cannot be sampled with a dipper, an ordinary plastic turkey baster can be used to collect the water and transfer it to a shallow basin to be examined for larvae. Again, a white background is desirable to make the larvae easier to spot, and large, shallow white plastic or enamel pans designed for aquatic insect collecting are available from biological supply companies. The author has also found that the white plastic snap-top boxes in which baby wipes are sold, and similar boxes sometimes used to ship laboratory supplies, make excellent sorting basins, and have the added advantage that one can store one's turkey baster, transfer pipettes, and other collecting gear inside to make a handy travel kit.

Raising Larvae

Larvae and pupae may be identified immediately or may be reared to adulthood before identification. Specimens should be housed in a dish or pan of chlorine-free water; if possible, keep them in the water in which they were collected. If tap water must be used, allow it to stand overnight to remove the chlorine before adding larvae. Keep the pans loosely covered to admit light and air while preventing any emerging mosquitoes from escaping, and also to prevent any additional mosquitoes from laying eggs in the pans and contaminating the sample. Pupae will not require food, and fourth-stage larvae will often pupate without requiring any nourishment beyond whatever particulate organic matter was introduced in the water sample in which they were collected. Unless the collection water is particularly rich in organic matter, however, younger larvae will probably need to be fed. Every mosquito-raising laboratory has its own preferred food, ranging from tropical fish flakes to powdered rat chow to a mixture of powdered beef liver and brewer's yeast. Whatever the food, it should be fine-textured and float on the surface of the water. Most *Culex* larvae will thrive in the rich, stinking organic brew caused by excess food, but many other species require that the water remain relatively clear, so it is best not to overfeed. The larvae of *Toxorhynchites* are predatory and will need other small aquatic insects (such as other mosquito larvae) for food.

Pupae should be transferred promptly to a small cup of water and placed inside an adult mosquito cage to emerge. A small bucket or empty ice cream tub covered tightly with netting makes a good cage, and a hole may be cut into the side and a cloth sleeve attached to allow a hand or an aspirator to be inserted into the cage without removing the netting and allowing the mosquitoes to escape. If the adult mosquitoes are to be kept alive for any length of time, they should be provided with sugar water in the form of a small slice of fruit or a piece of cotton soaked with a roughly 10-25% solution of corn syrup in water. Adult mosquitoes should generally be kept alive for at least 24 hours post-emergence in order to allow their exoskeletons to harden completely before killing them for identification and pinning.

Identification of Adult Mosquitoes

The best way to kill adult mosquitoes to be identified, whether freshly captured or raised in the lab, is by freezing. Trap nets and cages may be placed directly into the freezer, or mosquitoes may be removed from the cage via aspirator prior to freezing. The freezing time required to kill mosquitoes varies by species and temperature; most species in our area will be reliably killed by half an hour at -80°C, an hour at -40°C, or two hours at -20°C. *Culex* are generally more cold-hardy than members of other genera in the region and may "wake up" if returned to room temperature after insufficient freezing. If live specimens are desired, mosquitoes may be temporarily immobilized for identification by placing them in the freezer for a few minutes, keeping them on ice while sorting, and then placing them in a cage at room temperature to recover.

For most studies, it is generally desirable to keep killed mosquitoes as cold as possible for as much of the time before use as possible. Nets and cages should be kept in the freezer or on ice prior to sorting, and mosquitoes which will be used for further study should be returned to the freezer or otherwise preserved immediately following identification. To avoid thawing of specimens during identification, the dissecting microscope may be set up on a commercial chill table which will maintain a set surface temperature, or specimens may be examined in a Petri dish set in a larger dish of crushed ice.

All features used for identification of mosquitoes in this book should be readily visible under a standard dissecting microscope with magnifications of 10x-60x. Two pairs of fine-tipped forceps and a few sharp probes (commercially available, or make your own by fastening an insect pin to the end of a wooden applicator stick or other handle) are useful for manipulating the specimen to the desired positions for examination.

Making a Reference Collection

It is a good idea to keep a collection of identified mosquitoes on hand for reference. Freshly-caught mosquitoes can then be compared to the reference specimen in the case of difficult identifications, and an accurate record is essential if later research projects may refer back to your work. Species may be divided or reclassified, and it may be necessary to re-examine your preserved specimens to determine to which of the new categories they belong. It is also possible that, after you gain more experience, you may suddenly realize that what you have been calling Species X has in fact been Species Y all along. Keeping such a collection allows you to double-check your earlier work to maintain accuracy and consistency.

A carefully prepared and properly stored collection of pinned insects will last for decades, even centuries. To create such a collection, you will need a shallow, sturdy box with a tightly-fitting lid and a bottom lined with Styrofoam, thick cardboard, cork, or another yielding substance into which to insert the pins. Most mosquitoes are too small for traditional insect-pinning techniques and would be destroyed if speared through the body with a standard insect pin like a butterfly. Instead, two alternate techniques are commonly used.

Points

Tiny, narrow triangles (points) are cut from stiff paper. The insect pin (size 3 is the most common) is inserted through the wide end of the paper point, and the tip is bent downward and glued to the right side of the mosquito's thorax.

Minuten nadeln (double mounts)

A tiny block of soft, porous material (now usually a synthetic foam, but historically often a strip cut from a particular kind of bracket fungus) is pierced with the insect pin, and used to secure the blunt end of a tiny, extremely sharp pin called a *minuten.* The sharp end of the minuten is then used to pierce the mosquito's thorax, either from the right side or from below. This technique is slightly more complicated than using paper points, but it avoids the problem of obscuring important features with glue, and causes minimal damage to the specimen.

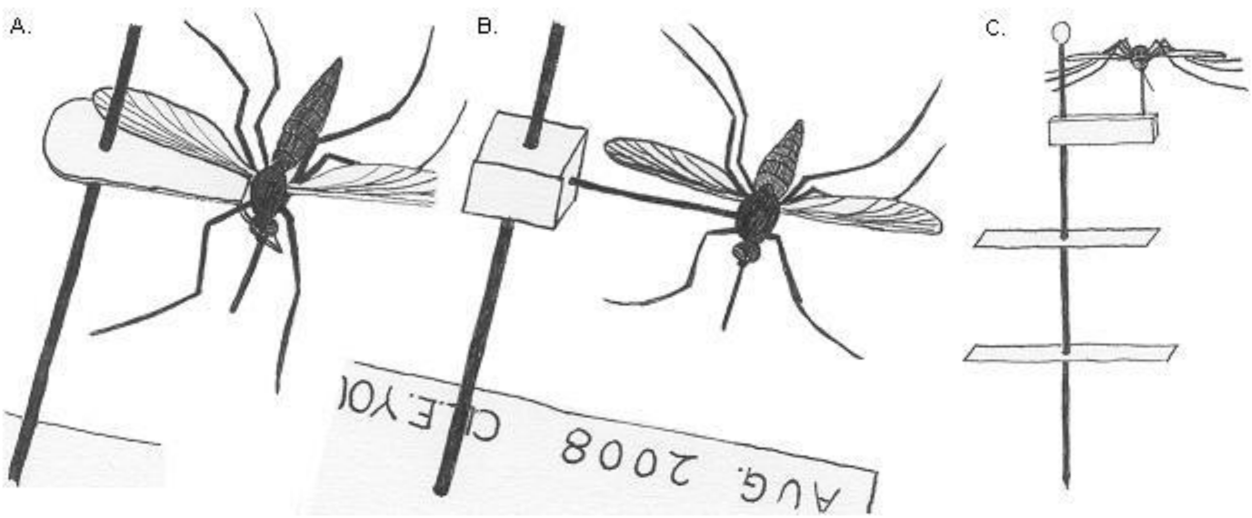

Figure 2.1 Mounting techniques. A: Paper point mount. B: Horizontal minuten mount. C: Vertical minuten mount, showing positioning of labels.

Positioning

If possible, the mosquito should then be positioned with its wings and legs spread and its body as nearly horizontal as possible. Additional pins and bits of paper or other materials may be used to prop the body parts into the desired position until the specimen is fully dried. Care must be taken in removing these, as dried mosquitoes are extremely fragile and break easily.

Labeling

To be scientifically valuable, a specimen must be properly labeled. For each mosquito, include the scientific name (genus and species; include subspecies or other information if known), the date and location of collection, and your name as the person responsible for the collection and identification. Record this information on a small slip of paper and impale it on the large pin holding the specimen. For a formal collection, labels should be uniform in appearance, and both they and the specimens should be at the same height and orientation on each pin. High-quality materials will greatly extend the life of your collection: look for "archival quality" acid-free, heavy rag paper (readily available at craft stores) and use India ink or a very sharp pencil for hand-writing labels. Pens designed for technical drawing, such as pigma micron, crowquill, or rapidograph pens, are excellent for labeling; laser printing is a good alternative if you are labeling many specimens at one time.

Preservation

Dried specimens may be stored at room temperature indefinitely, but care should be taken to protect them from moisture and from scavenging insects which prey on dried material. Boxes should always be kept tightly closed when not in use, and a mothball pinned in one corner of the box, carefully secured so that it will not roll around and damage the specimens, will repel scavengers. In humid environments, a packet of silica gel or other dessicant may help remove excess moisture.

Chapter 3: Key to Genera of Adult Female Mosquitoes

1a. Proboscis tapered, curved strongly downward in apical half; wing margin indented at apex of Cu_2 so that posterior edge appears distinctly lobed; a large species, brightly marked with blue, silver, and gold...***Toxorhynchites rutilus septentrionalis***
1b. Proboscis of nearly uniform thickness, approximately straight or only slightly curved; wing without pronounced indent at Cu_2, margin appearing smooth or only slightly waved...................***2***

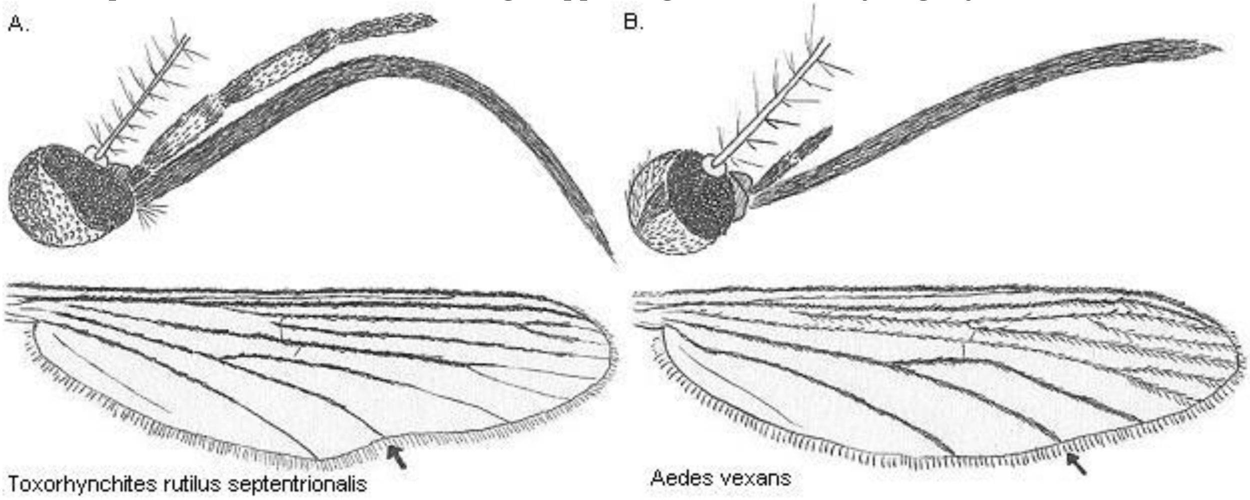

Figure 3.1 Head, side view, and wing, Tx. rutilus septentrionalis and Ae. vexans

2a (1b). A tiny species, marked with lines of iridescent blue scales on head, thorax, and wings as though decorated with glitter; second radial cell of wing (R_2) less than half as long as its stalk ....***Uranotaenia sapphirina***
2b. Glittering blue lines absent, R_2 as long as or longer than its stalk...***3***

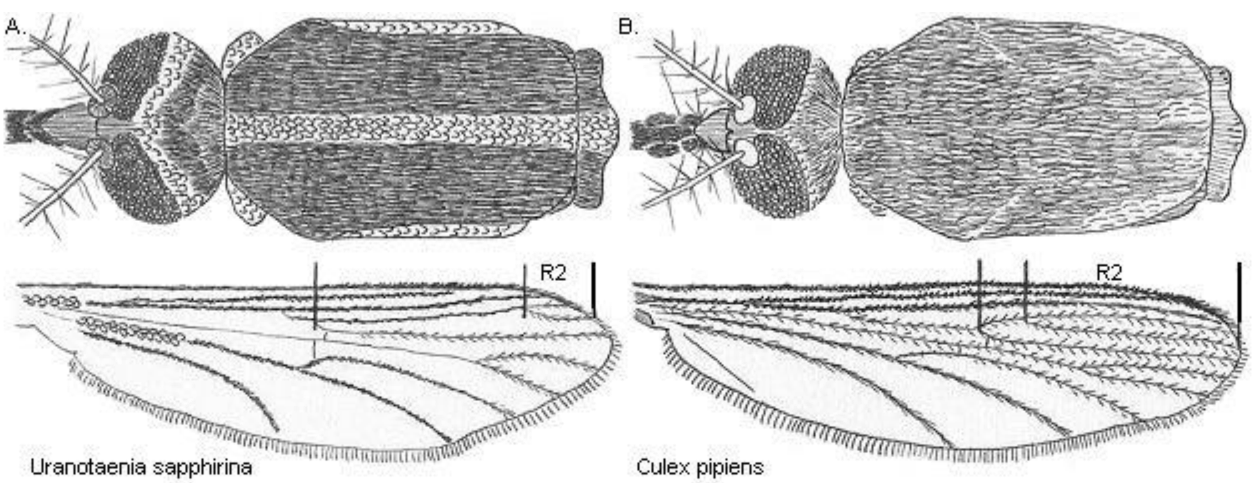

Figure 3.2 Head and thorax, dorsal view, and wing, Ur. sapphirina and Cx. pipiens

3a (2b). Maxillary palpi about as long as proboscis (and of more or less uniform appearance throughout; if ends of palpi are clubbed or fringed with long hairs and antennae are plumose, specimen is male and key will not work); scutellum rounded, with evenly distributed setae; abdomen appearing perhaps slightly hairy but with few or no scales..................**Genus *Anopheles***
3b. Palpi much shorter, less than half as long as proboscis; scutellum tri-lobed, with a tuft of setae on each; abdomen scaly..***4***

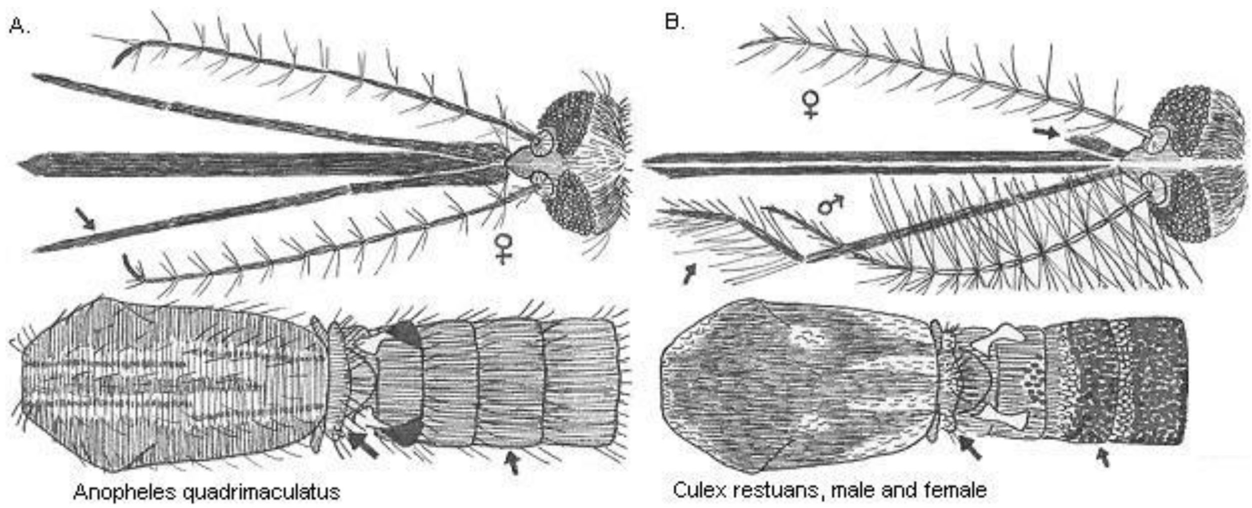

Figure 3.3 Head, thorax, and upper abdomen, dorsal view, An. quadrimaculatus and Cx. restuans

4a (3b). Postnotum with a tuft of bristles; abdomen uniformly dark above and pale below, the colors meeting in striking contrast in a nearly straight line laterally with no sign of banding; an uncommon species, found only in vicinity of pitcher plant bogs.........................***Wyeomyia smithii***
4b. Postnotum without a tuft of bristles; dorsal portion of abdomen banded or with lateral spots, not uniformly dark..***5***

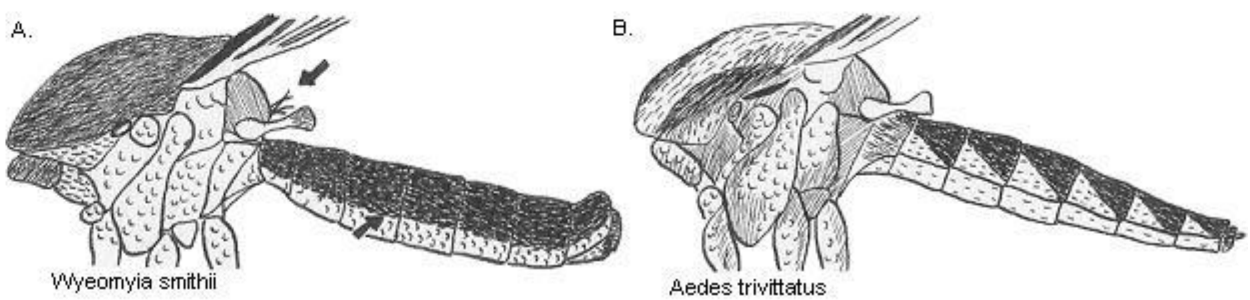

Figure 3.4 Thorax and abdomen, side view, Wy. smithii and Ae. trivittatus

5a (4b). Tip of abdomen pointed, with segment VII distinctly narrower than VI; cerci prominent..***6***
5b. Abdomen tapering only slightly throughout, tip blunt, rounded; cerci concealed or nearly so...***7***

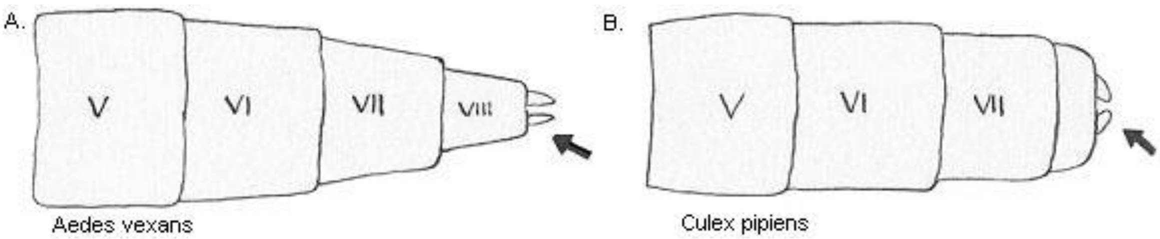

Figure 3.5 Tip of abdomen, dorsal view, Ae. vexans and Cx. pipiens

6a (5a). Abdomen with light-colored bands or lateral triangles at apex of segments; spiracular bristles present...**Genus *Psorophora***
6b. Abdomen with bands or lateral triangles at base of segments; spiracular bristles absent...**Genus *Aedes***

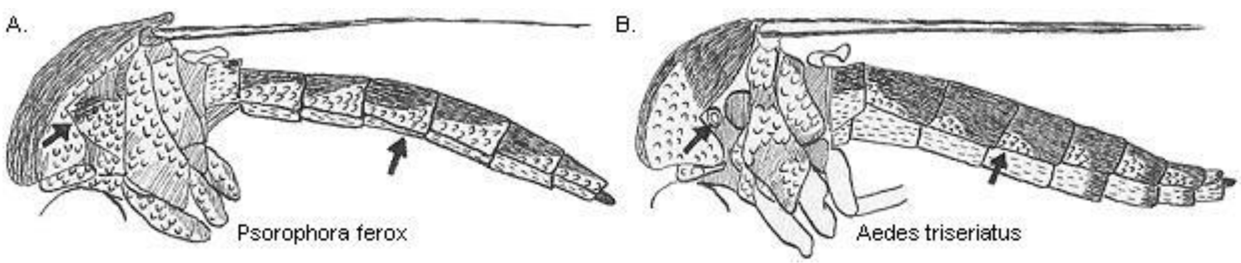

Figure 3.6 Thorax and abdomen, side view, Ps. ferox and Ae. triseriatus

7a (5b). Scales on wing veins small, narrow; mostly dark...***8***
7b. Wing scales broad; mingled dark and light, giving a salt-and-pepper effect............................***9***

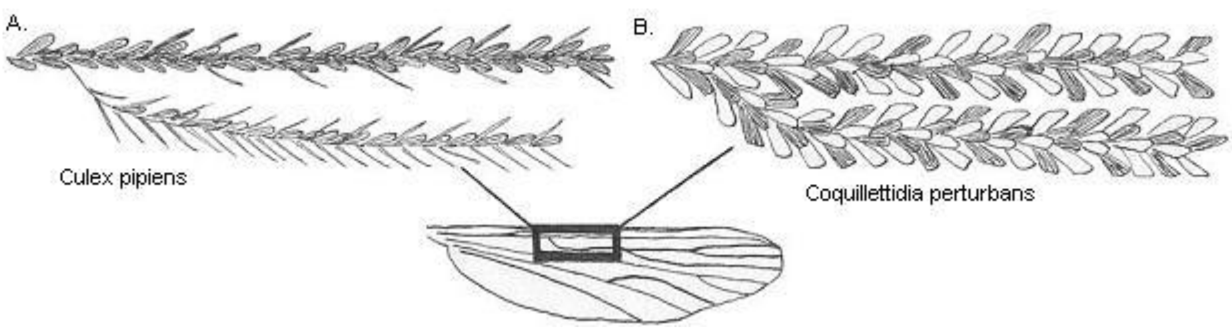

Figure 3.7 Wing scales, Cx. pipiens and Cq. perturbans

8a (7a). Bristles present on base of second vein on underside of wing and along anterior edge of thoracic spiracle..**Genus *Culiseta***
8b. Bristles absent from base of wing vein and spiracle..**Genus *Culex***

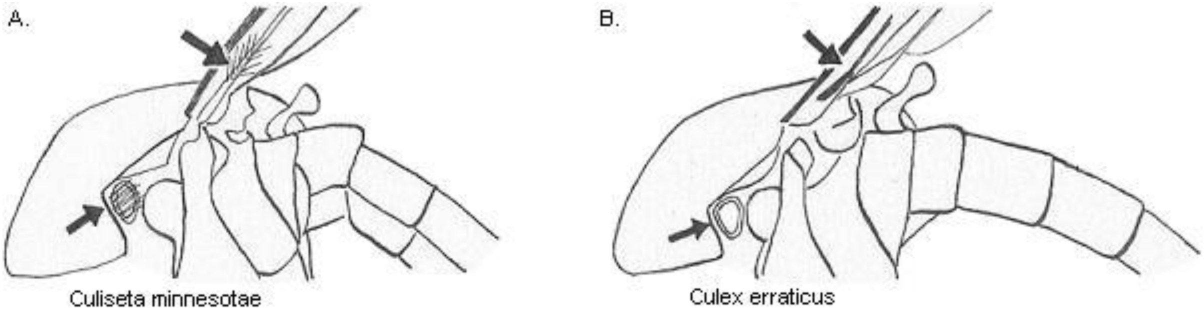

Figure 3.8 Spiracular and wing-vein bristles, Cs. minnesotae and Cx. erraticus

9a (7b). Pale rings on hind tarsi extending both above and below joints; thorax dark with very fine white longitudinal lines dorsally...***Orthopodomyia signifera***
9b. Pale rings present only immediately distal of joints, at base of hind tarsal segments; thorax with mottled pattern in grey and brown...***Coquillettidia perturbans***

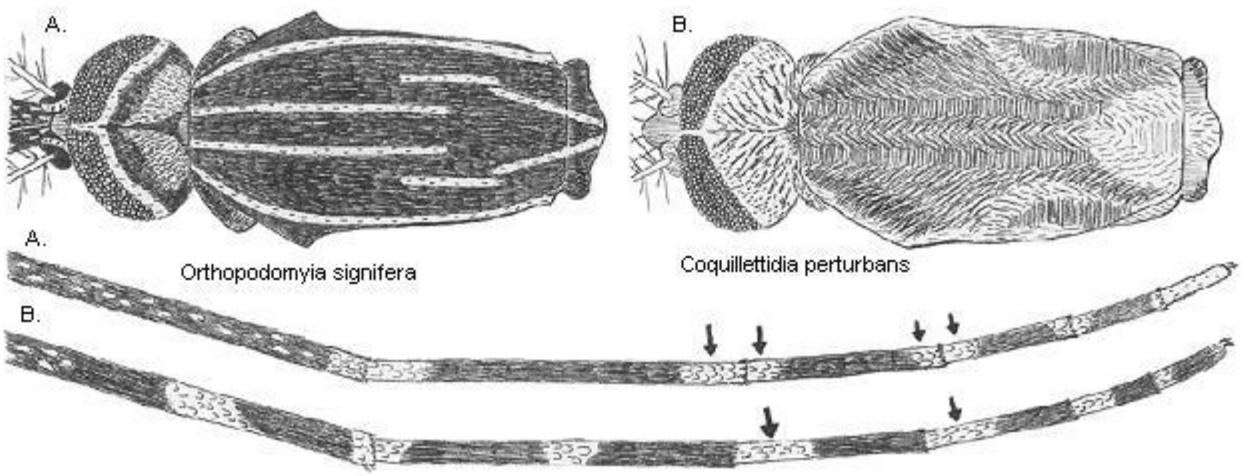

Figure 3.9 Head and thorax, dorsal view, and hind tarsus, Or. signifera and Cq. perturbans

Chapter 4: Key to Adult Female *Aedes* (includes *Ochlerotatus)*

Author's Note: The genus *Aedes*, as traditionally defined, is a massive and diverse genus containing a wide variety of species. Many prominent scientists in the field of mosquito taxonomy have suggested that it would be more useful and informative if this genus were to be subdivided into a number of smaller genera, and various alternative classification schemes have been proposed to achieve this goal. One widely accepted version (Reinert 2000) raised the existing subgenus *Ochlerotatus* to the rank of a separate genus and placed the majority of local species within it, including all members of the subgenus *Ochlerotatus* itself and members of many other subgenera of *Aedes.* As this division has received widespread support in the past few years, each species affected by the change has been noted within the text. However, visual separation of adult *Aedes* and adult *Ochlerotatus* by morphological characteristics has so far proven extremely impractical for large-scale field identification programs of the type for which this key is primarily intended. The proposed new classification system is also subject to ongoing revision (Reinert et al. 2004, 2006), and at this time no stable consensus has been reached regarding which, if any, of the proposed versions ought to be adopted. The author has therefore followed the example of the Journal of Medical Entomology (JME 2005) and others (Black 2004, Savage and Strickman 2004) in retaining use of the traditional nomenclature.

1a. Some or all tarsal segments with white bands..***2***
1b. Tarsi without white bands...***21***

Figure 4.1 Tarsi, Ae. vexans and Ae. triseriatus

2a (1a). Hind tarsi with white bands at both ends of some segments, overlapping joints...............***3***
2b. Hind tarsi with white bands at base of segments only...***6***

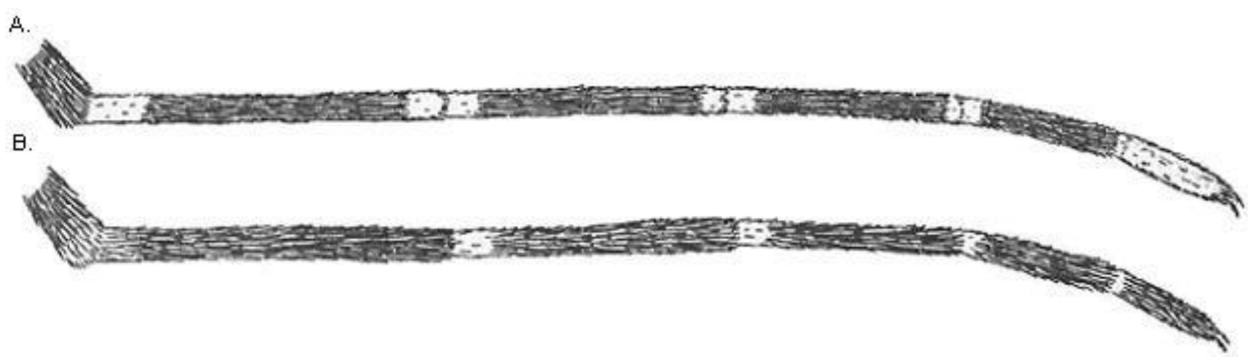

Figure 4.2 Hind tarsi, Ae. canadensis and Ae. vexans

3a (2a). Wing scales mingled light and dark; abdomen mostly pale with dark patches. ....***Aedes (Ochlerotatus) dorsalis***
3b. Wing scales, scutum and abdomen all or mostly dark...***4***

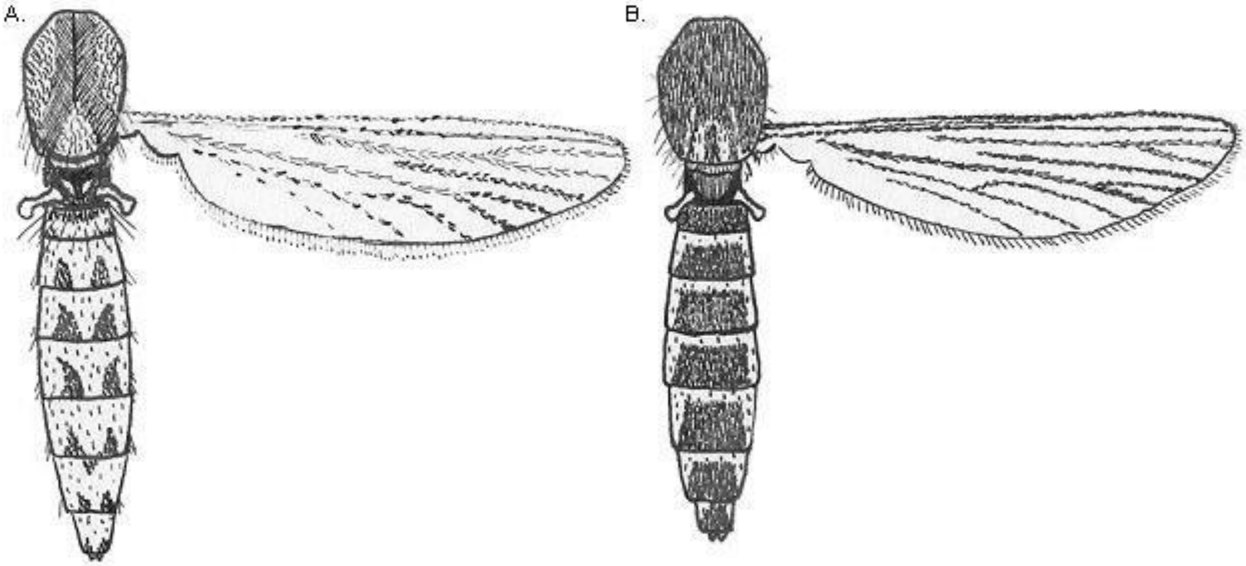

Figure 4.3 Wing, thorax, and abdomen, dorsal view, Ae. dorsalis and Ae. canadensis

4a (3b). Wing with a patch of white scales at base of costa; scutum with pale sides and a broad brown median stripe..***5***
4b. Costa uniformly dark-scaled, without a basal patch of pale scales; scutum evenly brown, not striped..***Aedes (Ochlerotatus) canadensis canadensis***

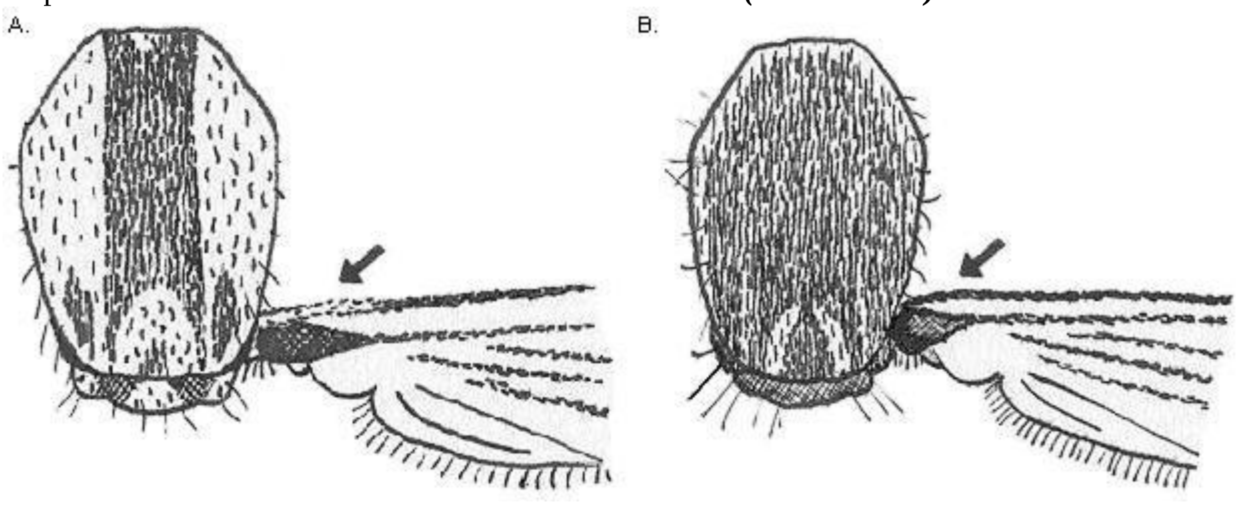

Figure 4.4 Scutal pattern and wing base, Ae. atropalpus and Ae. canadensis

5a (4a). Hind femur with dark scales extending from near base to apical pale ring; one or more prominent setae present on scutal fossa; compound eyes separated by no more than 2x diameter of one corneal facet..***Aedes (Ochlerotatus) epactius***
5b. Base of hind femur pale for at least 1/3 length; no setae on scutal fossa; eyes separated by at least 2.5x facet diameter..***Aedes (Ochlerotatus) atropalpus***

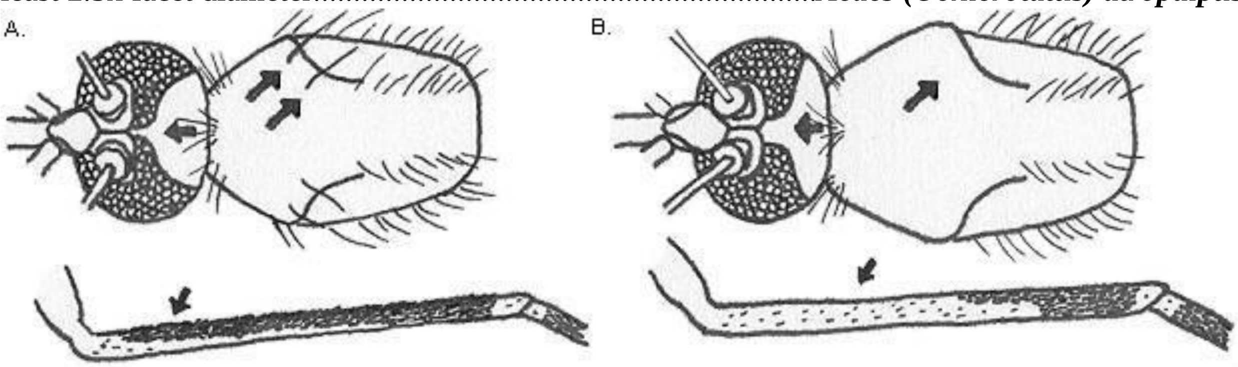

Figure 4.5 Head and scutal setae, dorsal view, and hind femur; Ae. epactius and Ae. atropalpus

6a (2b). Proboscis with a pale band near the middle...***7***
6b. Proboscis uniformly dark or with mingled dark and pale scales, without a distinct pale band..***10***

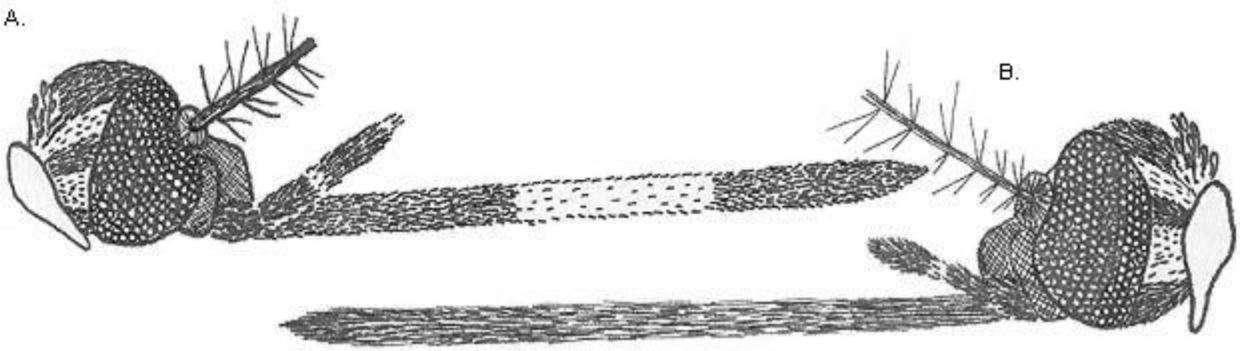

Figure 4.6 Head and proboscis, side view, Ae. mitchellae and Ae. vexans

7a (6a). Abdomen with pale bands at base of segments but lacking pale median longitudinal stripe; wing scales all dark..***Aedes (Ochlerotatus) taeniorhynchus***
7b. Abdomen with pale longitudinal stripe or row of pale spots in the middle of each segment; wing scales may be all dark or mottled dark and light..***8***

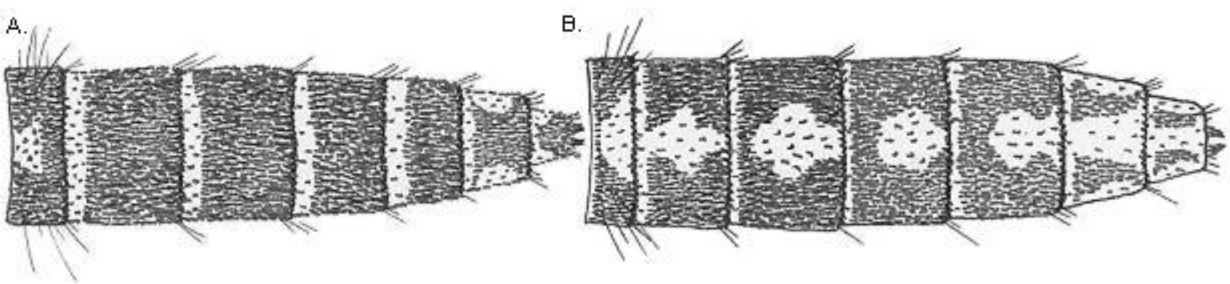

Figure 4.7 Abdomen, dorsal view, Ae. taeniorhynchus and Ae. mitchellae

8a (7b). Wing scales all dark; basal segment of hind tarsus uniformly dark-scaled except for pale basal ring covering less than 1/3 of segment...............................***Aedes (Ochlerotatus) mitchellae***
8b. Wing scales mingled dark and light; basal segment of hind tarsus variable, with pale scales extending from base to midpoint or forming a ring (see fig. 4.9)..***9***

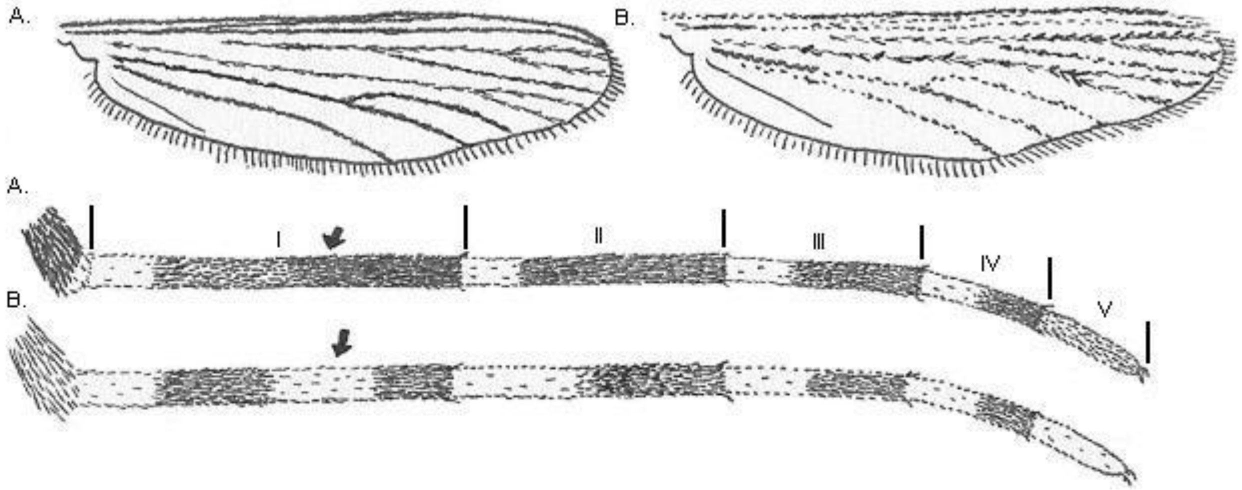

Figure 4.8 Wing and hind tarsus, Ae. mitchellae and Ae. sollicitans

9a (8b). Basal segment of hind tarsus with dark bands at apex and near base, pale at middle; apical segment of hind tarsus mostly white; pale abdominal markings white laterally and yellow dorsally ....***Aedes (Ochlerotatus) sollicitans***
9b. Basal segment of hind tarsus with dark band only at apex, at least basal half pale-scaled; apical segment of hind tarsus usually dark-tipped; all pale abdominal markings yellowish ....***Aedes (Ochlerotatus) nigromaculis***
(in part; some have proboscis unbanded; see couplet 16a)

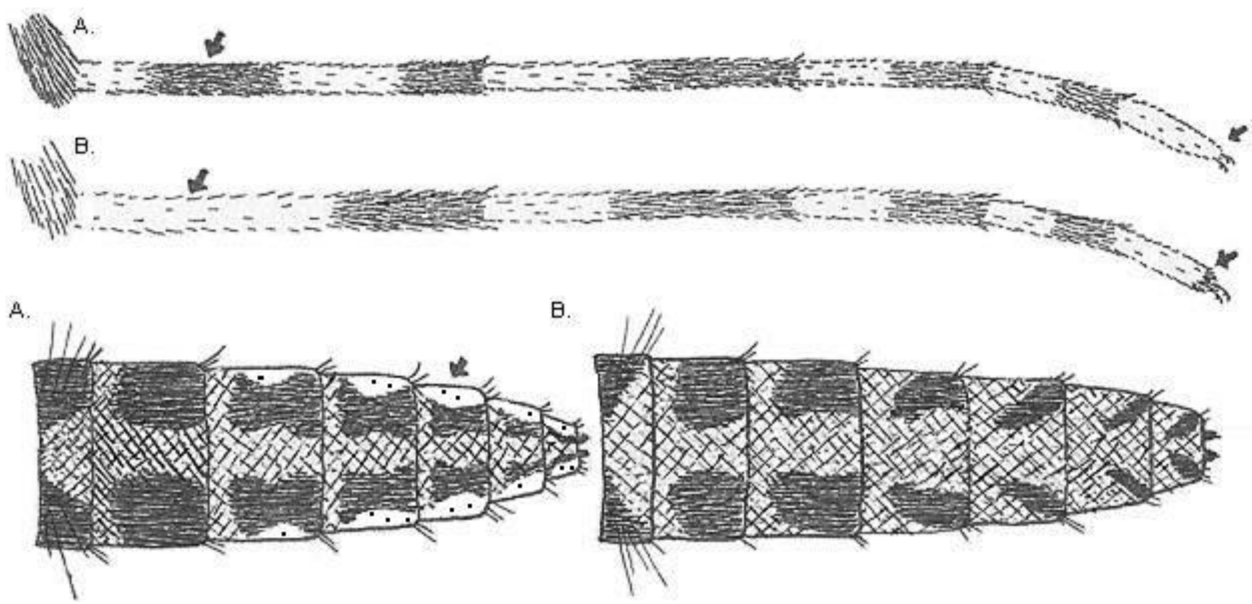

Figure 4.9 Hind tarsus and dorsal view of abdomen, Ae. sollicitans and Ae. nigromaculis

10a (6b). Scutum dark with narrow, very bright white median stripe..................***Aedes albopictus***
10b. Scutum without bright white median stripe..***11***

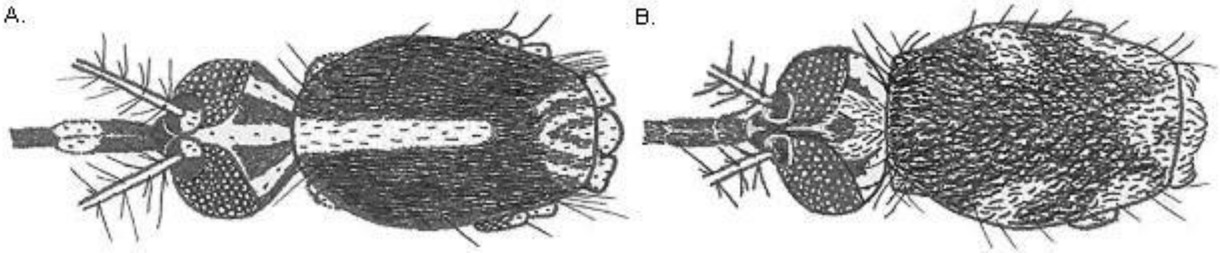

Figure 4.10 Head and thorax, dorsal view, Ae. albopictus and Ae. vexans

11a (10b). Pale tarsal bands narrow, covering much less than 1/3 of each segment....................***12***
11b. Pale tarsal bands broad, at least some covering at least 1/3 length of the segment on which they occur...***13***

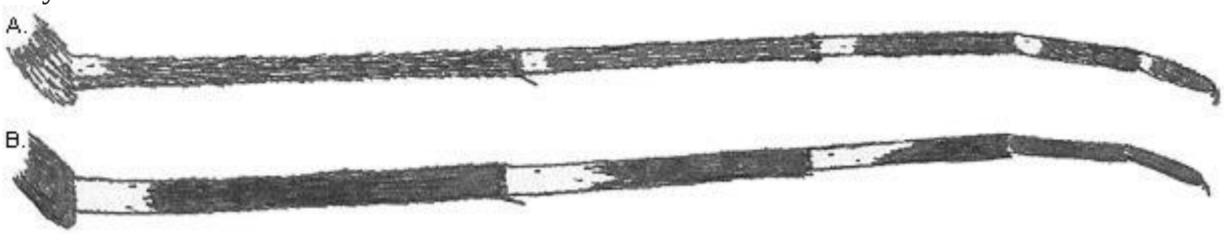

Figure 4.11 Hind tarsus, Ae. vexans and Ae. japonicus

12a (11a). At least some pale basal abdominal bands distinctly scalloped in the shape of a capital letter 'B;' tergum VII mostly dark-scaled..***Aedes vexans***
12b. Pale abdominal bands not B-shaped; tergum VII mostly pale-scaled.............................***Aedes (Ochlerotatus) cantator***

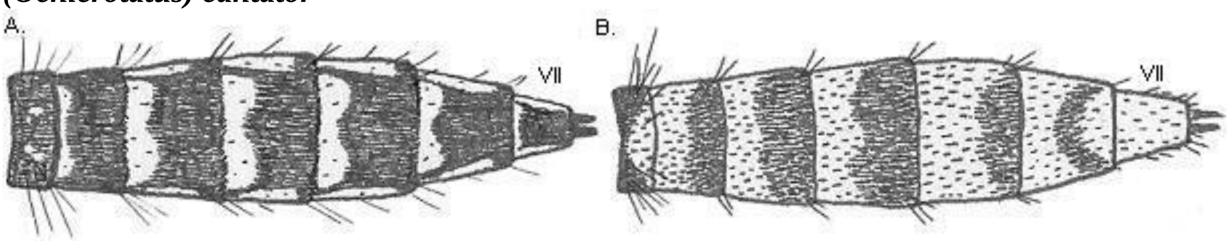

Figure 4.12 Abdomen, dorsal view, Ae. vexans and Ae. cantator

13a (11b). Scutum with white or gold, curving lateral stripes forming "lyre" pattern (see fig. 4.14)...***14***
13b. Scutum without such markings...***15***

14a (13a). Scutum with yellow stripes, including prominent median stripe; palpi dark-scaled; dorsal surface of abdomen dark-scaled, without prominent pale bands; apical segment of hind tarsi dark-scaled...***Aedes (Ochlerotatus) japonicus***
14b. Scutum with white stripes and without a median stripe; palpi white-tipped; abdominal segments with strong basal pale bands; apical segment of hind tarsi pale-scaled......***Aedes aegypti***

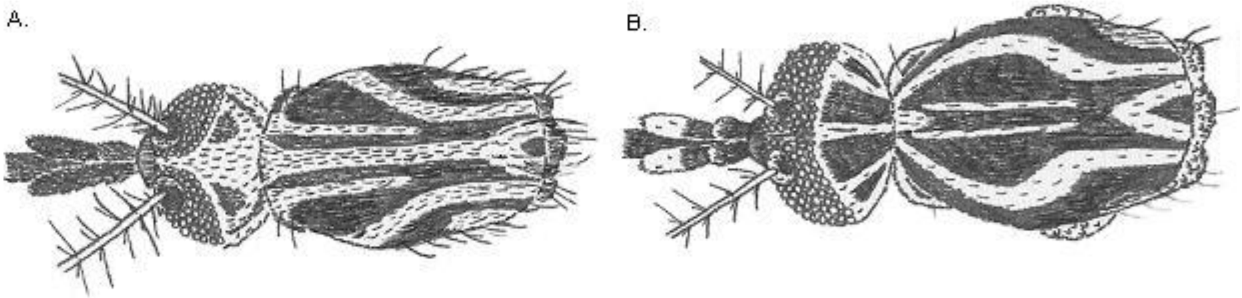

Figure 4.14 Head and thorax, dorsal view, Ae. japonicus and Ae. aegypti

15a (13b). All wing scales broad, triangular; dark and pale wing scales evenly mingled ....***Aedes (Ochlerotatus) grossbecki***
15b. At least some wing veins with scales all narrow; dark and pale scales mingled or patchy...***16***

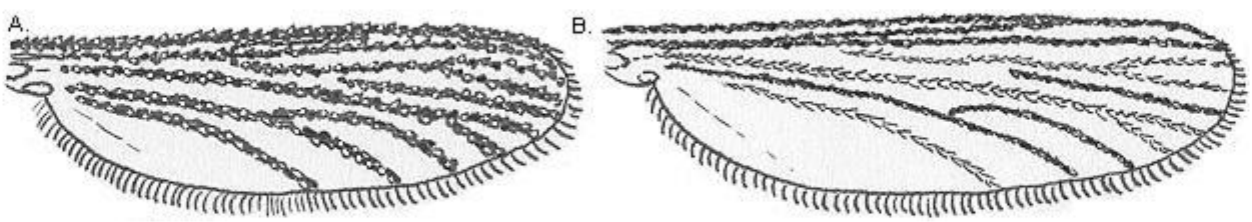

Figure 4.15 Wing, Ae. grossbecki and Ae. fitchii

16a (15b). Palpi entirely dark-scaled; abdomen with pale yellow longitudinal stripe or row of pale spots in the middle of each segment................................***Aedes (Ochlerotatus) nigromaculis*** (in part; some have proboscis banded; see couplet 9b)
16b. Palpi with some pale scales; abdomen without longitudinal median stripe...........................***17***

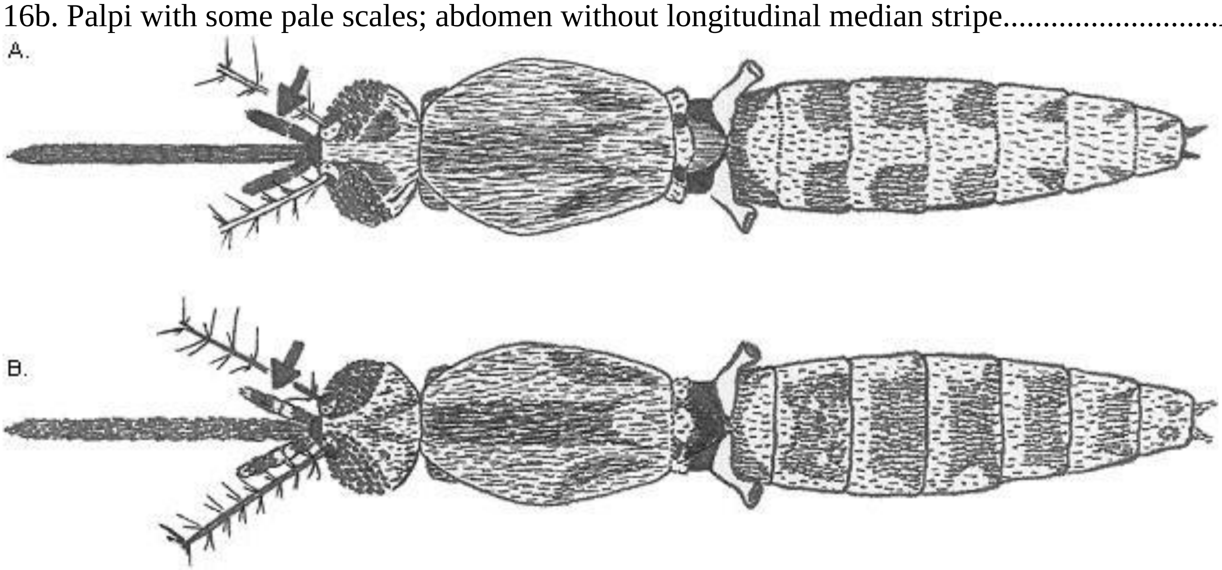

Figure 4.16 Head, thorax, and abdomen, dorsal view, Ae. nigromaculis and Ae. fitchii

17a (16b). Dorsal surface of all abdominal segments entirely yellow, without dark bands ....***Aedes (Ochlerotatus) flavescens***
17b. Dorsal surface of abdomen banded, not entirely yellow........***Aedes (Ochlerotatus) stimulans* complex, *18***

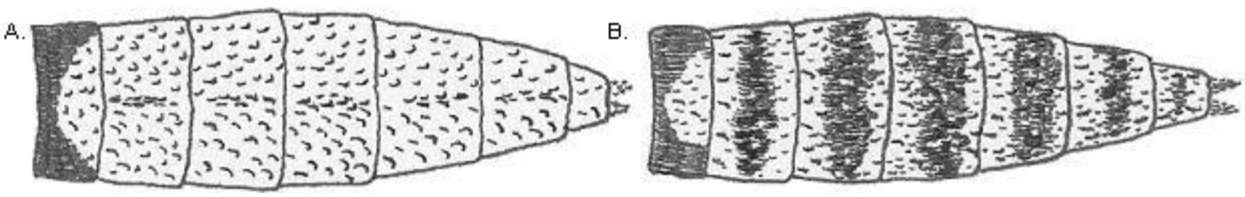

Figure 4.17 Abdomen, dorsal view, Ae. flavescens and Ae. excrucians

18a (17b). Fore and middle tarsal claws strongly bent near fork, teeth of each claw roughly parallel to one another...***Aedes (Ochlerotatus) excrucians***
18b. Claws with larger tooth curved after division from smaller, with teeth divergent, not parallel...***19***

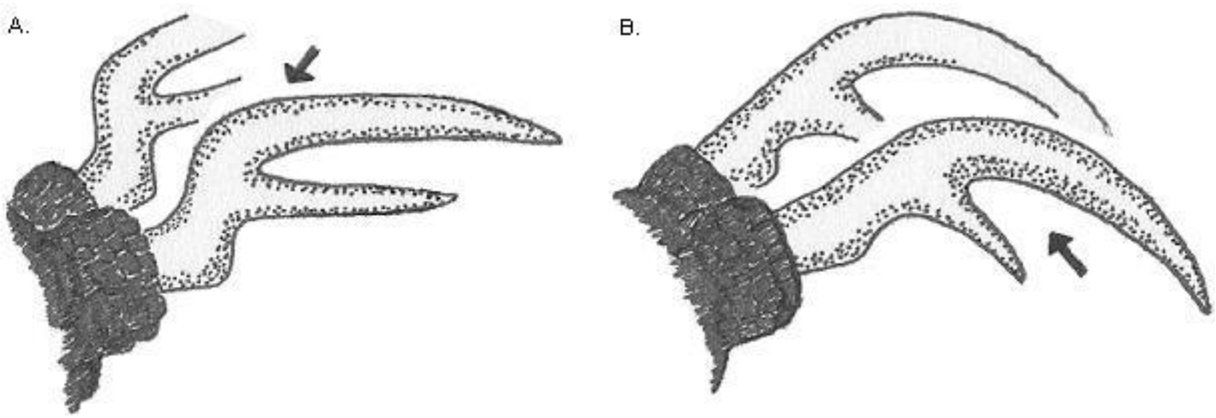

Figure 4.18 Foreclaws, Ae. excrucians and Ae. fitchii

19a (18b). Foreclaw with a short, blunt tooth, less than 1/3 as long as the primary tooth......***Aedes (Ochlerotatus) riparius***
19b. Foreclaw with a longer, thinner tooth, at least half as long as the primary tooth.................***20***

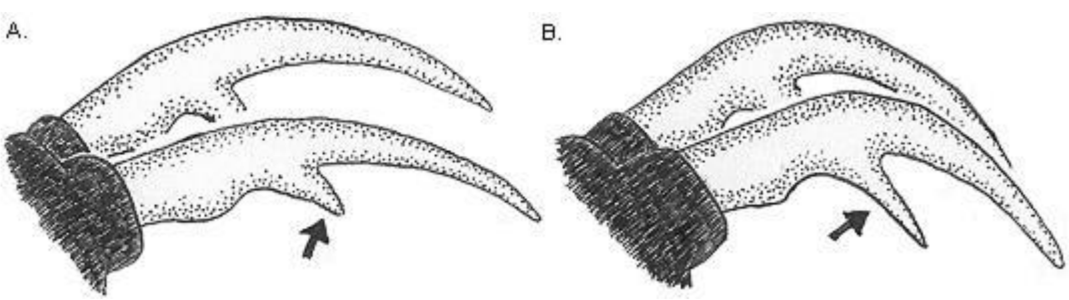

Figure 4.19 Foreclaws, Ae. riparius and Ae. fitchii

20a. Lower mesepimeral bristles 2 or fewer; tori with many white scales on inner half.........***Aedes (Ochlerotatus) fitchii***
20b. Lower mesepimeral bristles 3 or more; tori with few or no white scales........................***Aedes (Ochlerotatus) stimulans***

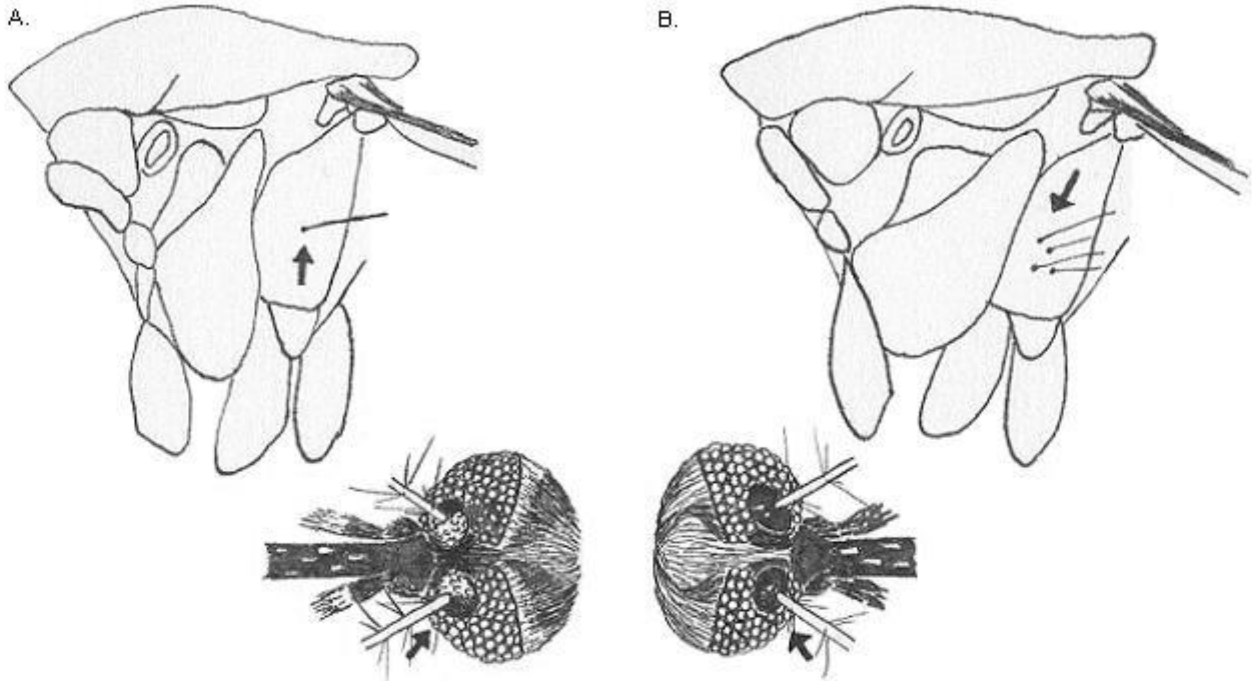

Figure 4.20 Thorax, side view, and torus, Ae. fitchii and Ae. stimulans

21a (1b). Scutum mostly yellow, except for a pair of dark brown to black spots on the posterior half...***Aedes (Ochlerotatus) fulvus pallens***
21b. Scutum not as above..***22***

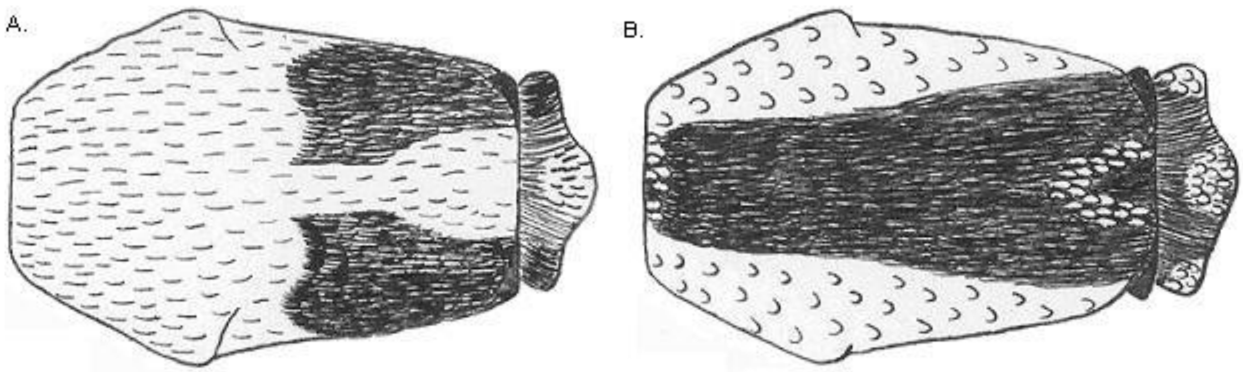

Figure 4.21 Scutal patterns, Ae. fulvus pallens and Ae. triseriatus

22a (21b). Sides of scutum covered with broad, very bright silvery-white scales, surrounding a median patch of dark brown scales...***23***
22b. Sides of scutum and thorax with narrow scales in brown, yellow, or dull white, never bright silvery-white...***24***

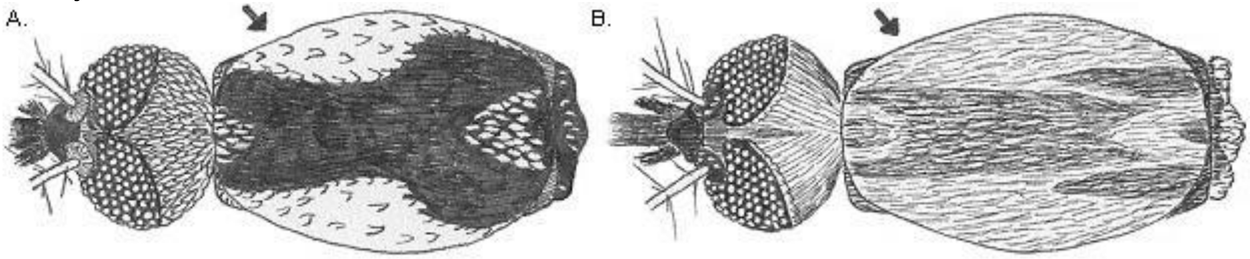

Figure 4.22 Head and thorax, dorsal view, Ae. triseriatus and Ae. sticticus

23a (22a). Most of scutum covered by broad dark median patch; anterior portion of scutum with few setae; fore and middle tarsal claws evenly curved, with shorter tooth less than 1/3 length of longer tooth...***Aedes (Ochlerotatus) triseriatus***
23b. Scutum dominated by silvery-white scales, dark median patch smaller and not reaching anterior edge of scutum; many strong setae on anterior half of scutum; claws abruptly bent, with shorter tooth 1/3 to ½ length of longer tooth..............................***Aedes (Ochlerotatus) hendersoni***

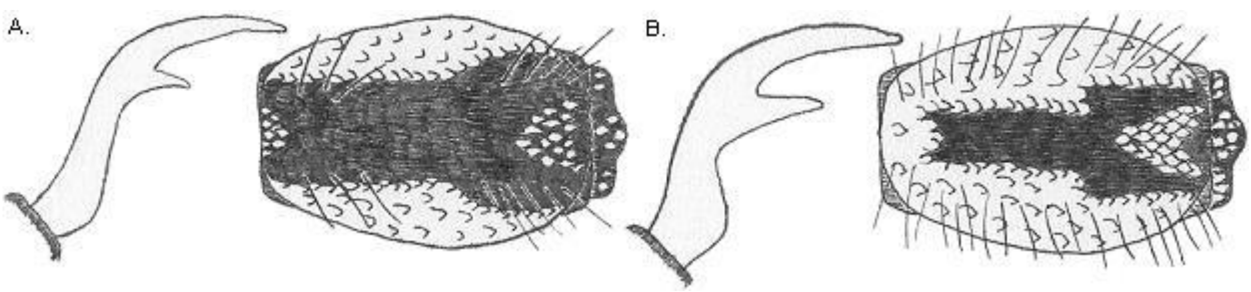

Figure 4.23 Foreclaw and scutum, Ae. triseriatus and Ae. hendersoni

24a (22b). Scutum without pale stripes, completely dark or with a poorly defined pattern of darker and lighter brown stripes...***25***
24b. Scutum with some pattern of distinct contrasting stripes...***27***

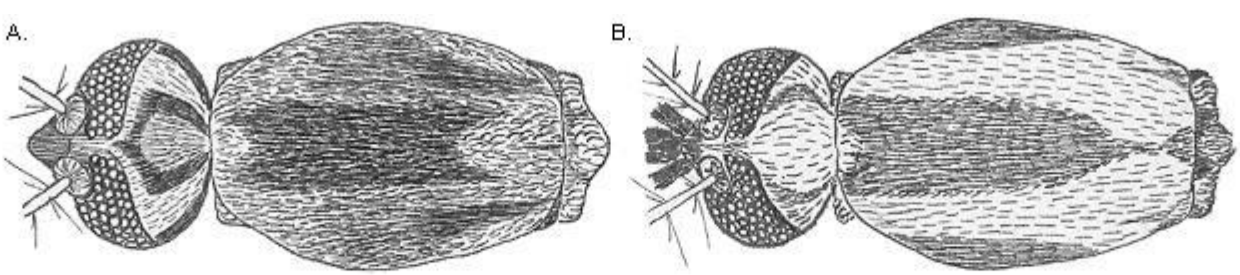

Figure 4.24 Head and thorax, dorsal view, Ae. absserratus and Ae. trivittatus

25a (24a). Sides of abdomen completely pale-scaled; fore coxa with a patch of flat dark scales; subspiracular area bare; scutum uniformly dark..***Aedes cinereus***
25b. Sides of abdomen not uniformly pale; fore coxa with a patch of pale scales; scales present on subspiracular area; scutum dark or with faint brown-on-brown stripes..................................***26***

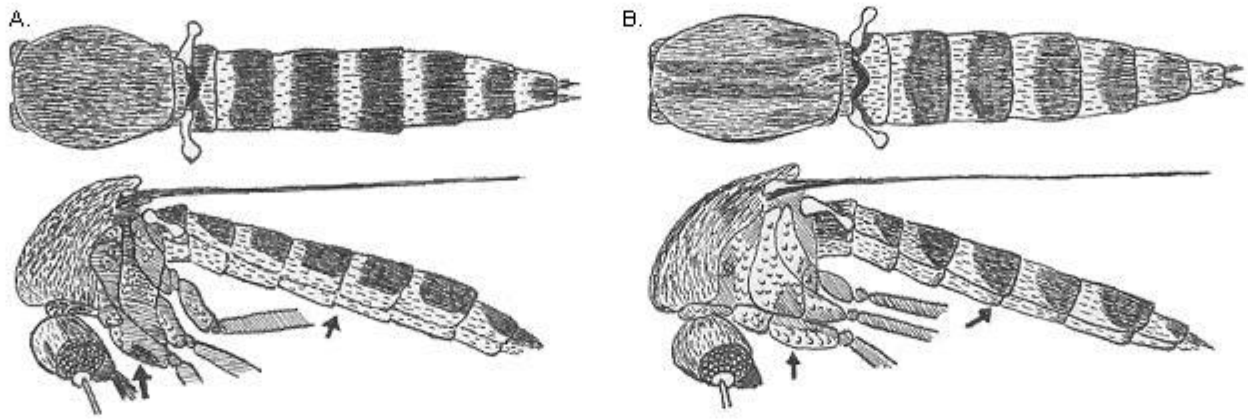

Figure 4.25 Dorsal and side views, Ae. cinereus and Ae. abserratus

26a (25b). Palpi sprinkled with grayish-white scales...................***Aedes (Ochlerotatus) intrudens***
26b. Palpi uniformly dark...***Aedes (Ochlerotatus) abserratus***

*Note: some dark-phase color variants of *Ae. (Oc.) punctor* are virtually indistinguishable from *Ae. abserratus* in the adult female. *Ae. punctor* is a primarily Canadian species which is rare in this area, but if exact identification is essential, specimens should be reared in the laboratory and the larvae or adult males examined.

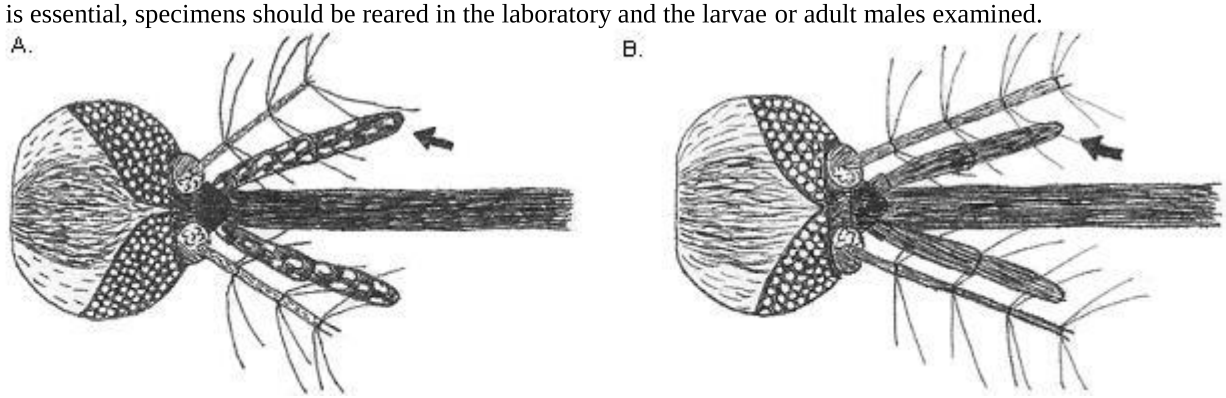

Figure 4.26 Head, dorsal view, Ae. intrudens and Ae. abserratus

27a (24b). Scutum with dark sides and dark median stripe, two pale stripes forming "V" or "U" pattern..***Aedes (Ochlerotatus) trivittatus***
27b. Scutum without pale V...***28***

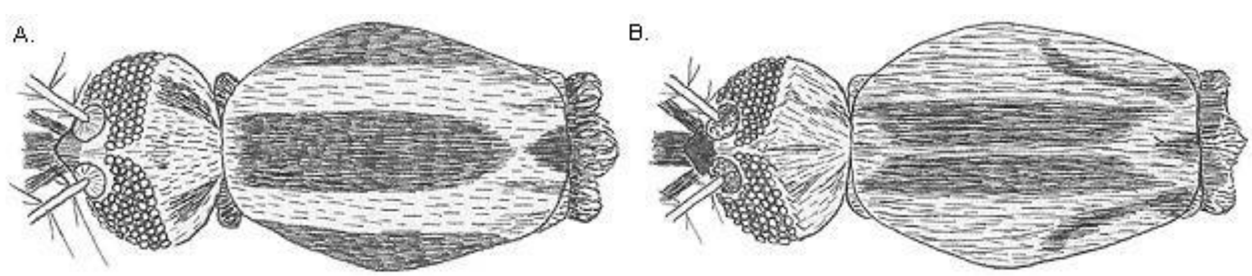

Figure 4.27 Head and thorax, dorsal view, Ae. trivittatus and Ae. sticticus

28a (27b). Most abdominal segments with prominent pale basal bands dorsally.........................***29***
28b. Abdomen mostly dark, unbanded or with prominent pale dorsal bands on fewer than half of segments (pale lateral triangles or very weak bands may be present in some specimens)...........***34***

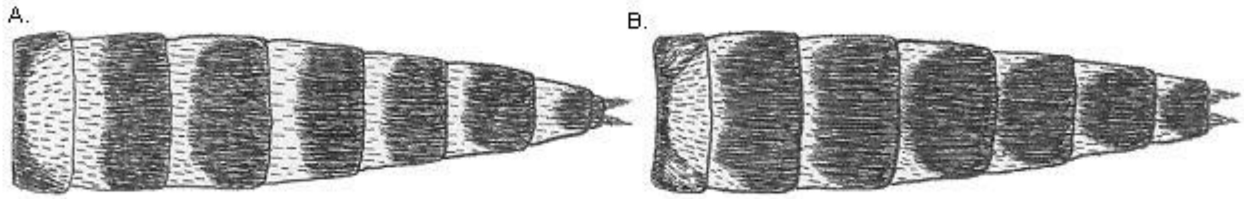

Figure 4.28 Abdomen, dorsal view, Ae. punctor and Ae. thibaulti

29a (28a). Abdomen with a broad, pale dorsal median stripe; some wing veins covered primarily with pale scales...***Aedes (Ochlerotatus) spencerii spencerii***
29b. Abdomen without a pale median stripe; wing scales mostly dark, with at most a few pale scales at base of costa..***30***

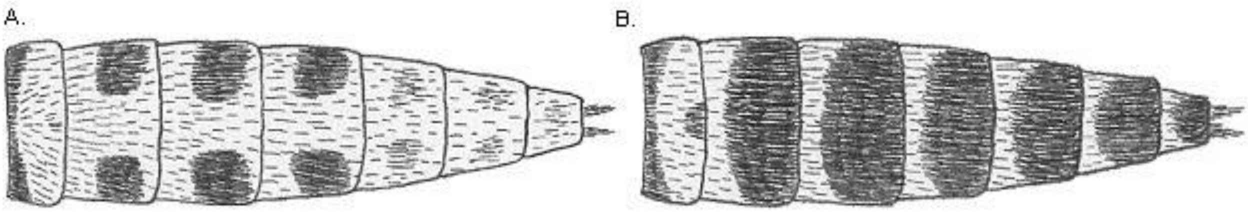

Figure 4.29 Abdomen, dorsal view, Ae. spencerii and Ae. sticticus

30a (29b). Thorax with a patch of scales immediately below spiracle (species found primarily in Canada and the northern USA, rare in most of the Ohio River basin)..***31***
30b. No scales present in area immediately below spiracle (range variable)...............................***32***

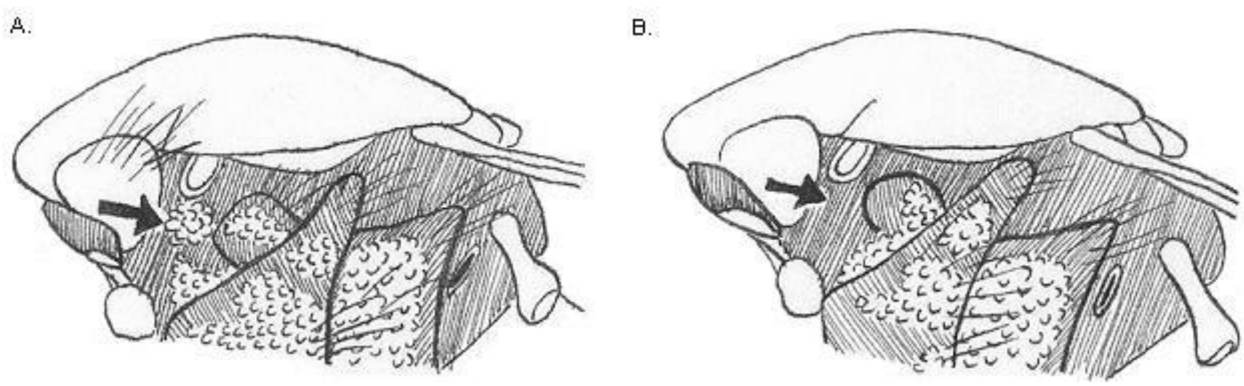

Figure 4.30 Thorax, side view, Ae. implicatus and Ae. diantaeus

31a (30a). All femora with pale knee spots; scales on mesokatepisternum clearly divided into discrete patches and not extending to anterior angle....................***Aedes (Ochlerotatus) implicatus***
31b. Tips of femora dark, without pale knee spots; scales on mesokatepisternum all more or less contiguous, extending to tip of anterior angle..............................***Aedes (Ochlerotatus) provocans***

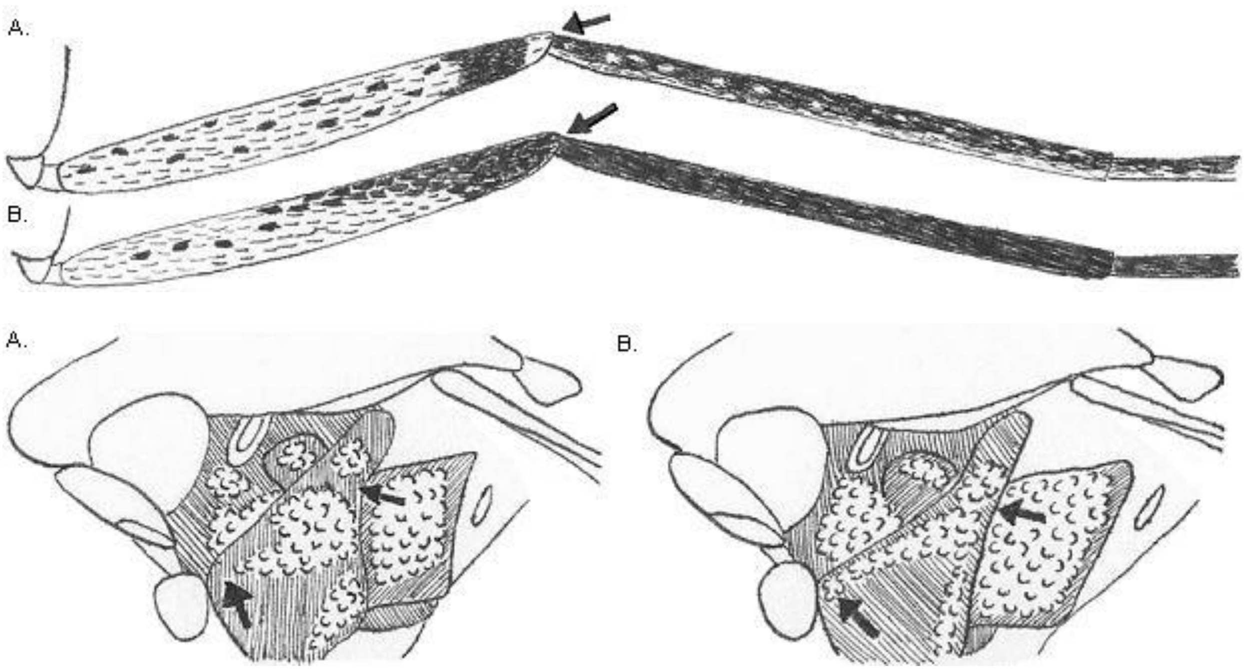

Figure 4.31 Femur and side of thorax, Ae. implicatus and Ae. provocans

32a (30b). Palpi with a few pale scales mingled with dark ones; scutellum with pale scales and dark setae...***Aedes (Ochlerotatus) communis***
32b. Palpi uniformly dark-scaled; scutellum with pale yellow to yellowish-brown scales and yellowish-brown to brown setae..***33***

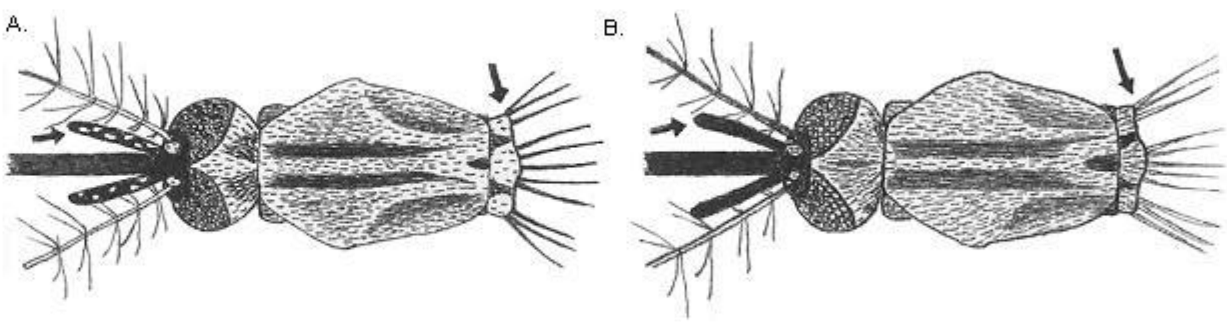

Figure 4.32 Head and thorax, dorsal view, Ae. communis and Ae. sticticus

33a (32b). Post-coxal area with pale scales; sides of scutum light brown surrounding an indistinct, darker brown median stripe. Common in Canada and the extreme northern USA, rare in most of our region..***Aedes (Ochlerotatus) punctor***
33b. Post-coxal area without pale scales; sides of scutum cream to pale brown, in distinct contrast with dark median stripe. Common throughout region.......***Aedes (Ochlerotatus) sticticus***

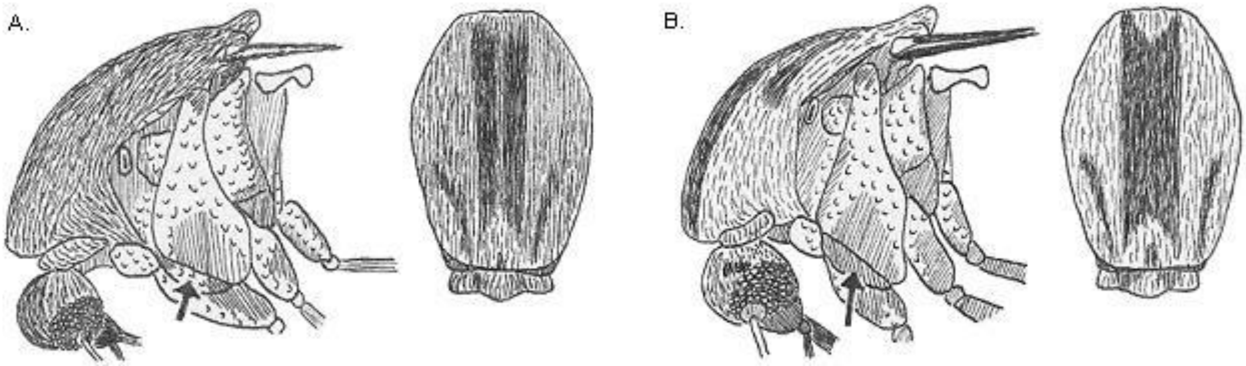

Figure 4.33 Thorax, side and dorsal views, Ae. punctor and Ae. sticticus

34a (28b). Scutum pale golden-brown with a pair of narrow dark longitudinal stripes, usually separated by a narrow median stripe of pale gold..........................***Aedes (Ochlerotatus) diantaeus***
34b. Scutum with a single median stripe, which may be either darker or lighter than the surrounding scales..***35***

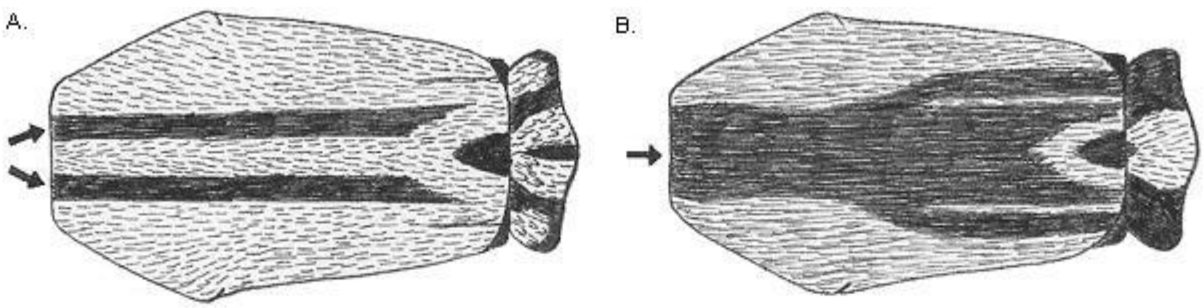

Figure 4.34 Scutal patterns, Ae. diantaeus and Ae. aurifer

35a. Scutum with pale sides and dark median stripe..***36***
35b. Scutum with dark sides and pale median stripe..***37***

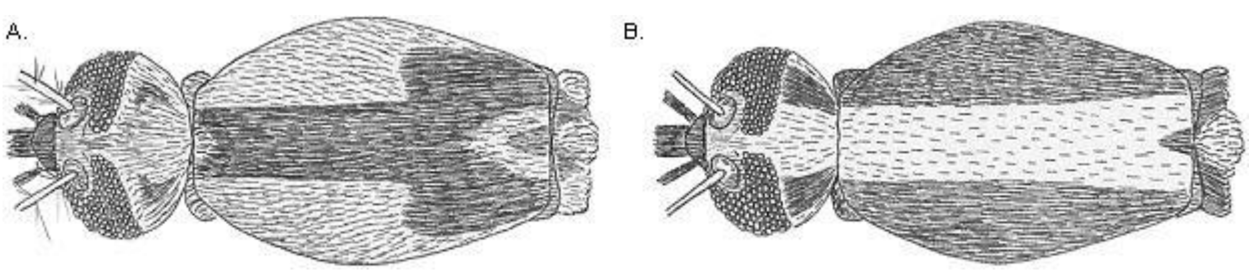

Figure 4.35 Scutal patterns, Ae. thibaulti and Ae. atlanticus

36a (35a). Dark median scutal stripe widening abruptly in posterior half; at least some abdominal segments with dark apical markings ventrally; all scales on forecoxa pale............................***Aedes (Ochlerotatus) thibaulti***
36b. Scutal stripe widening gradually; abdomen entirely pale-scaled ventrally; forecoxa with some brown scales...***Aedes (Ochlerotatus) aurifer***

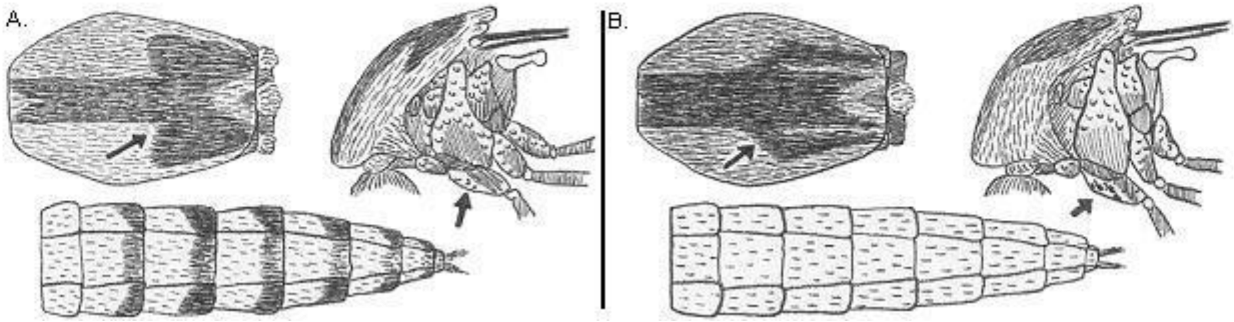

Figure 4.36 Dorsal and side views of thorax, ventral view of abdomen; Ae. thibaulti and Ae. aurifer

37a (35b). Pale median scutal stripe interrupted by dark patches in posterior half, stripe much broader than lateral dark-scaled areas..***Aedes (Ochlerotatus) infirmatus***
37b. Pale stripe extending unbroken to scutellum except for small dark posterior triangle, width variable..***38***

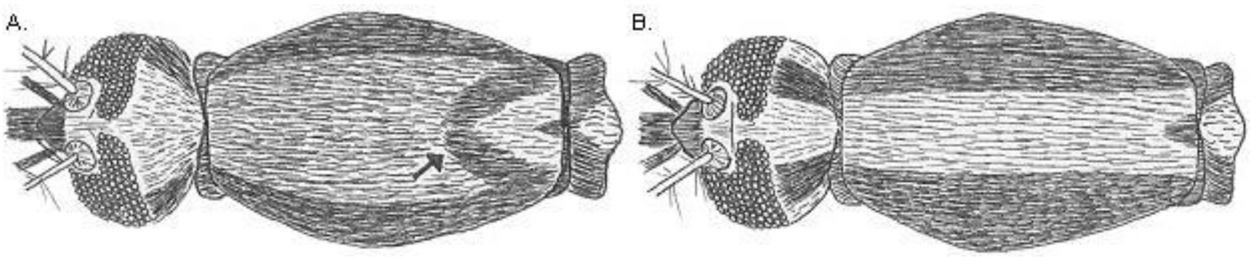

Figure 4.37 Head and thorax, dorsal view, Ae. infirmatus and Ae. atlanticus

38a (37b). Occiput of head with lateral dark scales surrounding a median white stripe; pale median scutal stripe narrow; a medium-sized species, wing length ~3-4mm..........................***Aedes (Ochlerotatus) atlanticus/tormentor***

*Note: *Ae. atlanticus* and *Ae. tormentor* are inseparable in the adult female and must be identified as larvae.

38b. Occiput completely pale-scaled; median scutal stripe variable; a small species, wing length ~2.5mm...***Aedes (Ochlerotatus) dupreei***

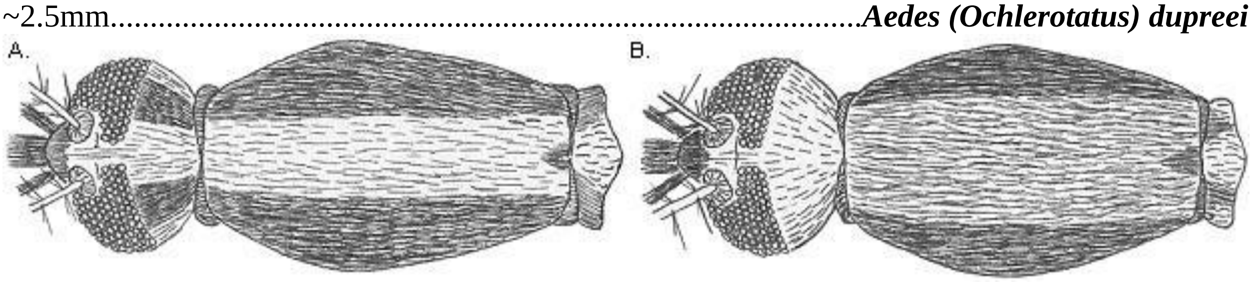

Figure 4.38 Head and thorax, dorsal view, Ae. atlanticus and Ae. dupreei

Chapter 5: Key to Adult Female *Anopheles*

1a. Wings all dark-scaled, without spots; scutum with bristles at least half as long as width of scutum; a very small species...***Anopheles barberi***
1b. Wings spotted with both dark and light scales; scutal bristles short...***2***

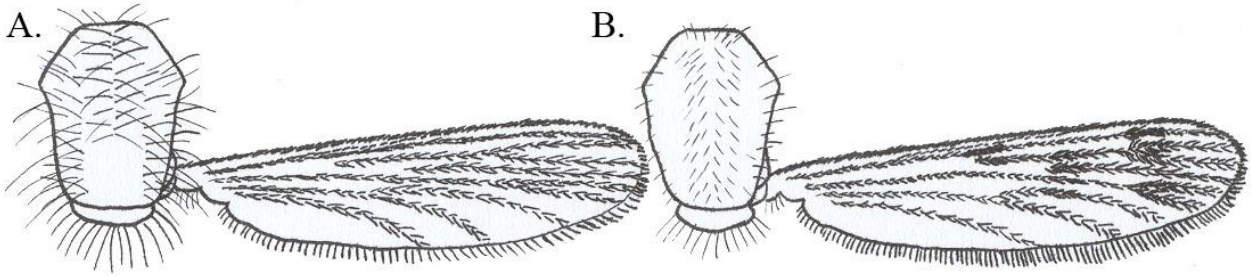

Figure 5.1 Wing and scutum, An. barberi and An. quadrimaculatus

2a (1b). Palpi with white bands...***3***
2b. Palpi uniformly dark, not banded..***4***

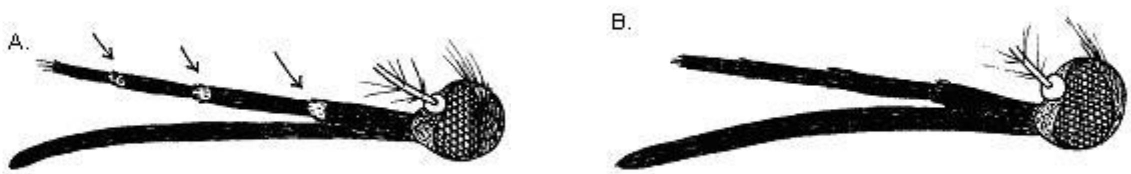

Figure 5.2 Palpi, An. walkeri and An. punctipennis

3a (2a). Wing scales dark with light patches, patch of pale marginal fringe scales at tip of wing, margin otherwise dark-scaled...***Anopheles crucians***
3b. Wings each with four indistinct dark patches, margin uniformly colored....***Anopheles walkeri***

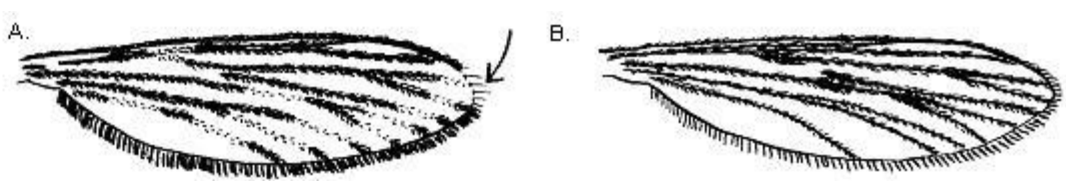

Figure 5.3 Wing, An. crucians and An. walkeri

4a (2b). Wing scales dark with several yellowish or white patches, two pale spots on anterior wing margin...***5***
4b. Wing scales grey-brown with darker patches...***6***

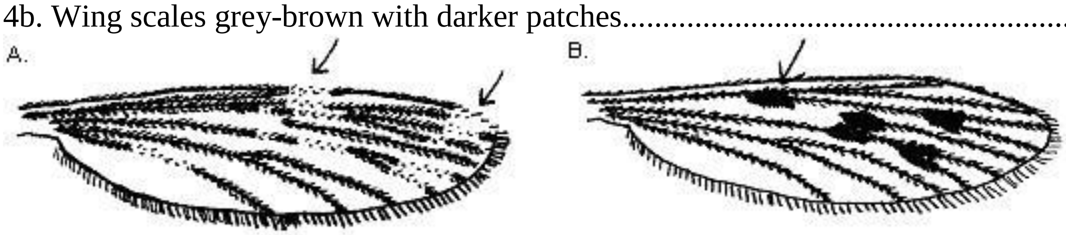

Figure 5.4 Wing, An. punctipennis and An. quadrimaculatus

5a (4a). Subcostal pale spot broad, at least half the width of the dark area between marginal pale spots...***Anopheles punctipennis***
5b. Subcostal spot narrow, 1/3 width of dark area...***Anopheles perplexens***

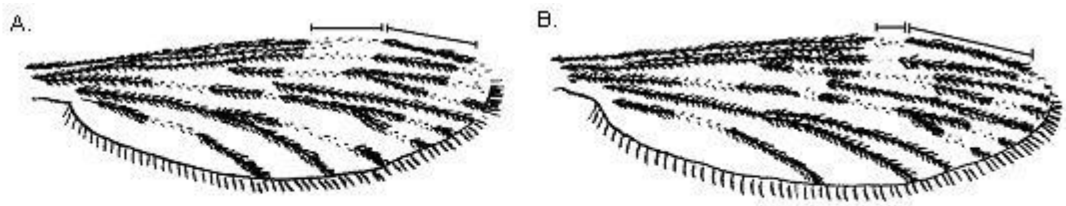

Figure 5.5 Wing, An. punctipennis and An. perplexens

6a (4b). Tip of wing with a patch of light or copper-colored fringe scales on margin.....***Anopheles earlei***
6b. Margin uniformly colored, without copper fringe.........................***Anopheles quadrimaculatus***

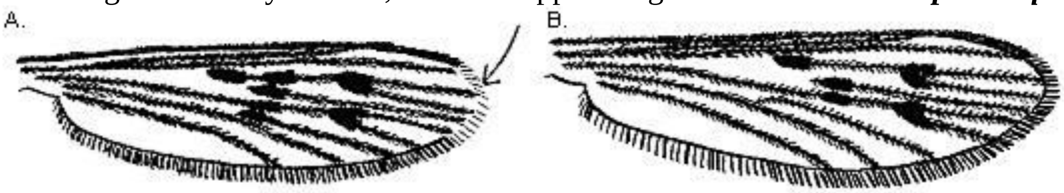

Figure 5.6 Wing, An. earlei and An. quadrimaculatus

Chapter 6: Key to Adult Female *Culex*

1a. Proboscis and hind tarsi with distinct white bands; scutum with narrow pale longitudinal stripes on posterior half..***Culex tarsalis***
1b. Proboscis and tarsi entirely dark; scutum without such lines..***2***

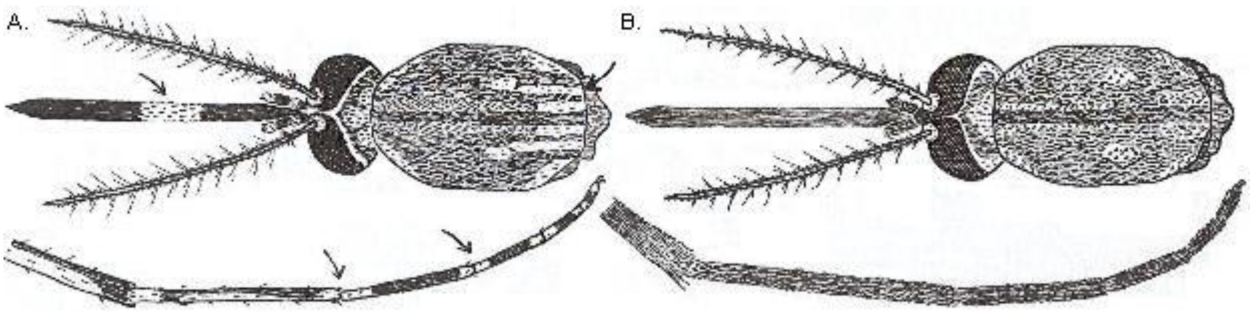

Figure 6.1 Head and thorax, dorsal view, and hind tarsus, Cx. tarsalis and Cx. pipiens

2a (1b). Abdomen with pale bands at apex of segments..***Culex territans***
2b. Abdomen with pale bands at base of segments, or without bands..***3***

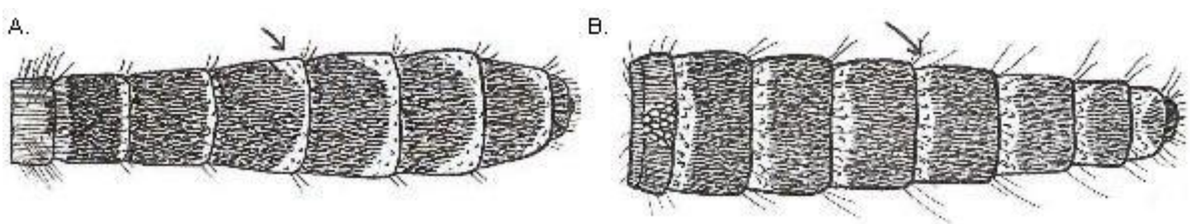

Figure 6.2 Abdomen, dorsal view, Cx. territans and Cx. pipiens

3a (2b). Broad, flattened scales present on wing vein R_2 and on back of head..............................***4***
3b. Scales on R_2 and head all uniformly narrow..***5***

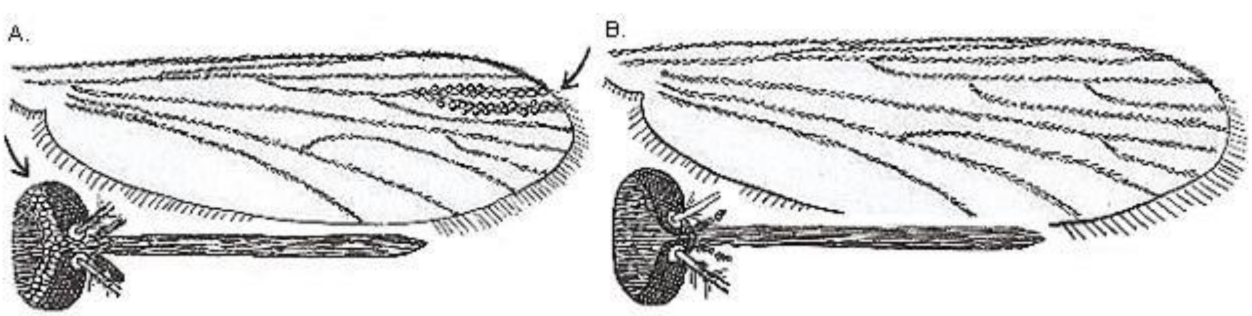

Figure 6.3 Wing and head, dorsal view, Cx. erraticus and Cx. pipiens

4a (3a). Ventral side of abdominal segments dark apically with pale basal bands; mesanepimeron with several broad, pale scales...***Culex erraticus***
4b. Ventral side of abdominal segments mostly pale, with some darker scales near apical margin; mesanepimeron without broad, pale scales..***Culex peccator***

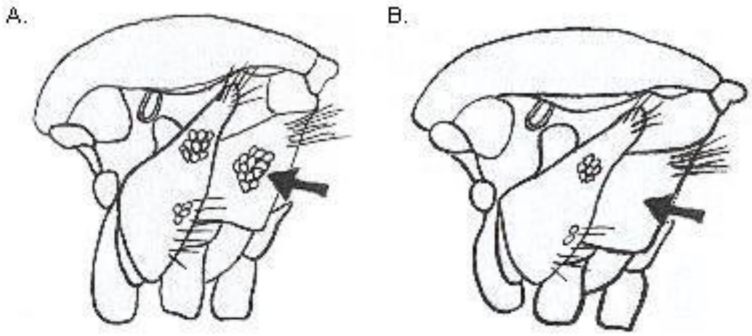

Figure 6.4 Thorax, side view, Cx. erraticus and Cx. peccator

5a (3b). Abdomen unbanded or with only narrow pale bands at the base of each segment; patch of dark scales on middle lobe of scutellum...***6***
5b. Abdomen with prominent whitish or cream-colored bands at the base of each segment; patch of pale scales on middle lobe of scutellum..***7***

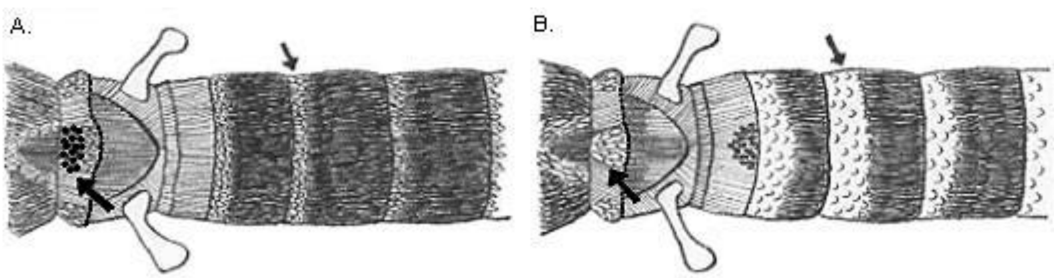

Figure 6.5 Scutellum and upper abdomen, dorsal view, Cx. salinarius and Cx. pipiens

6a (5a). Dorsal abdominal bands usually narrow or inconspicuous, consisting of yellowish scales; segment VII entirely or mostly pale yellow..***Culex salinarius***
6b. Dorsal abdominal bands usually lacking entirely, narrow and white if present; segment VII mostly dark-scaled, similar to other segments. A species found primarily in the southern USA, rare in most of our region...***Culex nigripalpus***

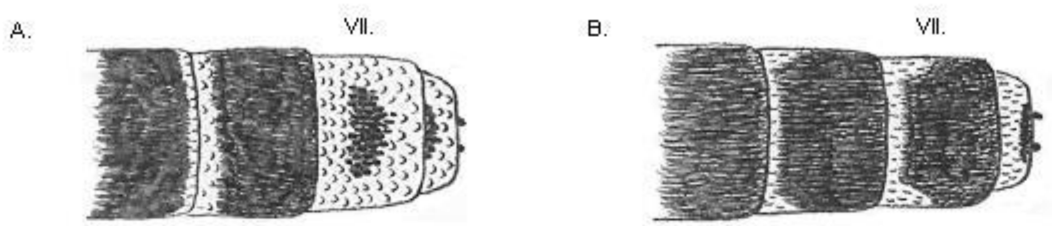

Figure 6.6 Tip of abdomen, dorsal view, Cx. salinarius and Cx. nigripalpus

7a (5b). Scutal scales coarse and curved, scutum evenly golden brown, without pale spots; dorsal abdominal bands with rounded posterior margins, strongly constricted laterally.......***Culex pipiens***
7b. Scutal scales fine and hairlike, scutum reddish brown with a pair of pale spots near middle (often missing in rubbed specimens); pale dorsal abdominal bands usually with nearly straight posterior margins...***Culex restuans***

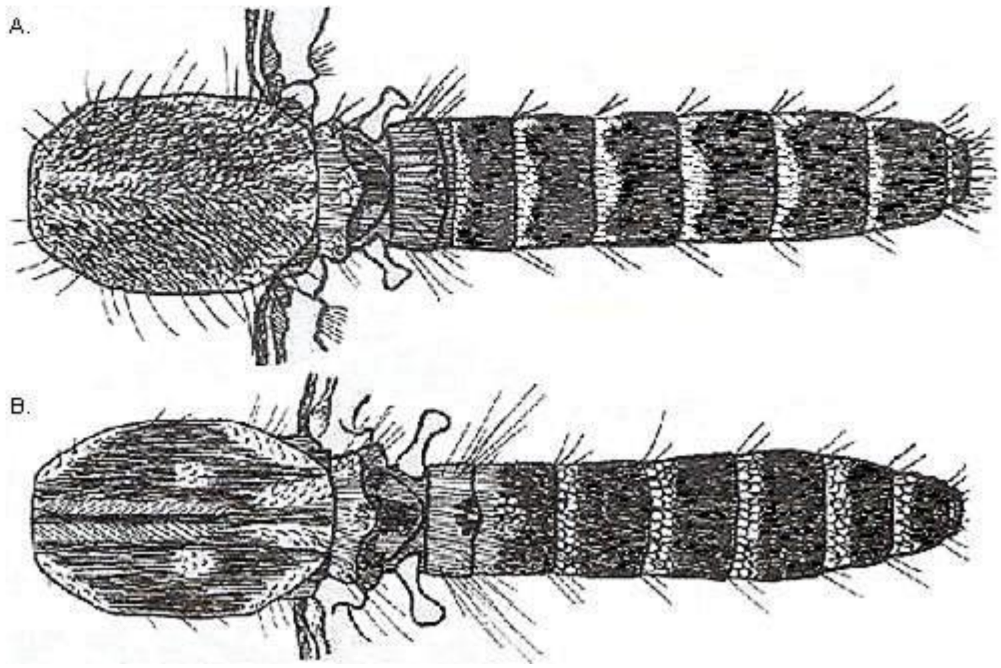

Figure 6.7 Thorax and abdomen, dorsal view, Cx. pipiens and Cx. restuans

Chapter 7: Key to Adult Female *Culiseta*

1a. Dorsal surface of abdomen uniformly dark, not banded..............................***Culiseta melanura***
1b. Dorsal surface of abdomen with distinct pale bands..***2***

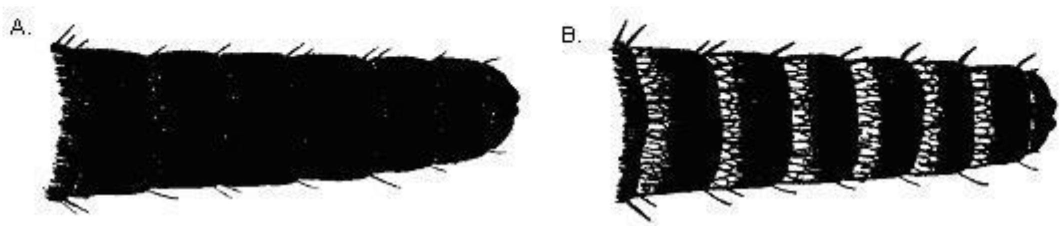

Figure 7.1 Abdomen, dorsal view, Cs. melanura and Cs. inornata

2a (1b). Hind tarsi without pale bands...***3***
2b. Pale bands present on at least some segments of hind tarsi..***4***

Figure 7.2 Hind tarsus, Cs. inornata and Cs. morsitans

3a (2a). Mingled dark and light scales present on anterior wing veins (this is most prominent near the base of the costa) and on hind tarsomeres 1 and 2..***Culiseta inornata***
3b. Wing veins and hind tarsi dark, without pale scales....................................***Culiseta impatiens***

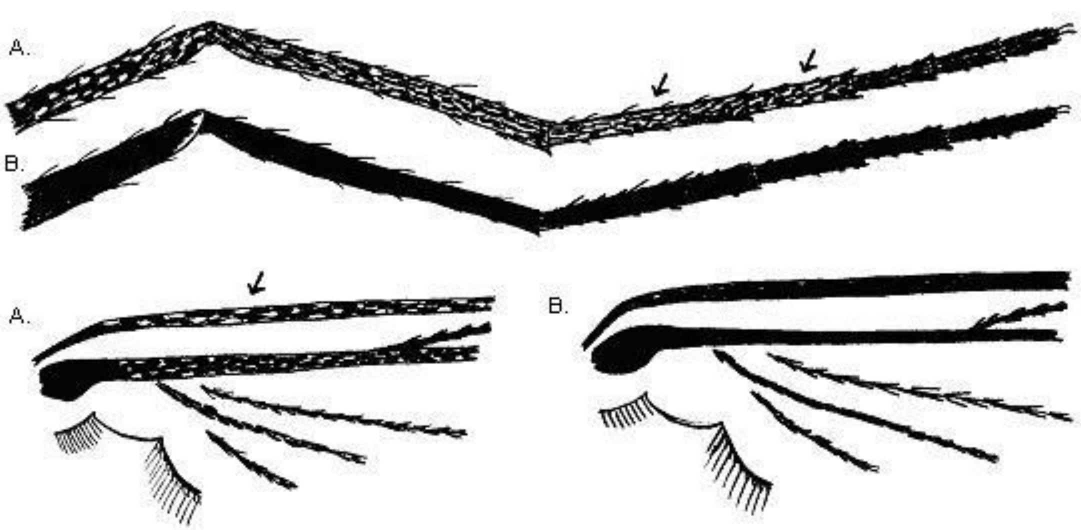

Figure 7.3 Hind tarsus and base of wing, Cs. inornata and Cs. impatiens

4a (2b). Abdomen with pale, brownish-white bands at both base and apex of each segment. ....***Culiseta minnesotae***
4b. Abdomen with whitish bands only at base of each segment, apices dark.....***Culiseta morsitans***

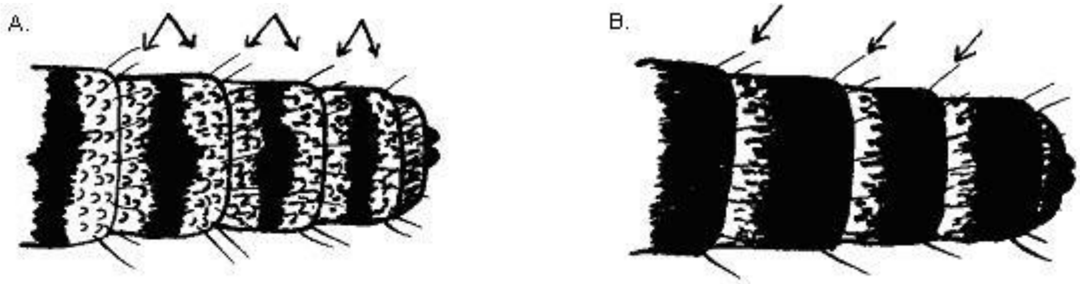

Figure 7.4 Tip of abdomen, dorsal view, Cs. minnesotae and Cs. morsitans

Chapter 8: Key to Adult Female *Psorophora*

1a. Wing with mingled dark and light scales on all veins; hind femur with narrow, pale ring below apex and separated from it by a broad band of dark or mingled dark and light scales (ring may be indistinct). ***2***
1b. Wing scales all or nearly all dark; hind femur without pale ring below apex...........................***4***

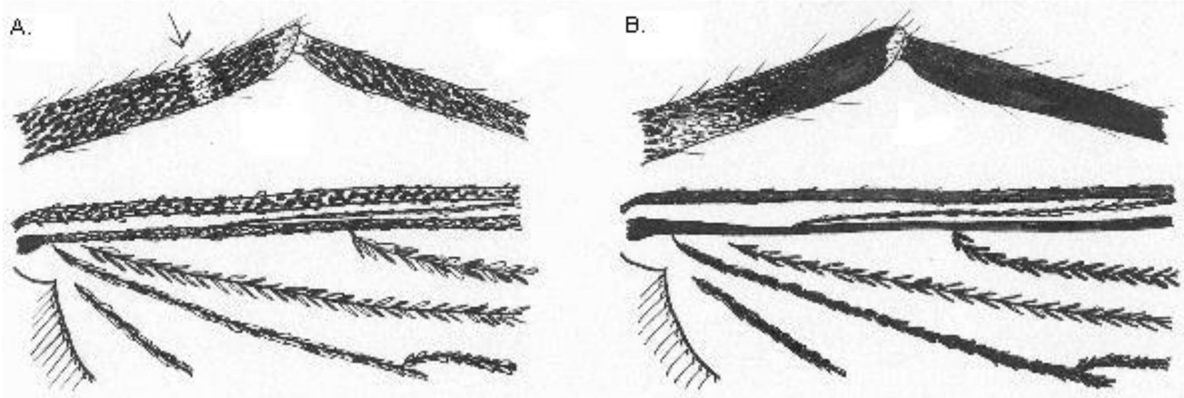

Figure 8.1 Hind femur and base of wing, Ps. columbiae and Ps. ferox

2a (1a). Hind tarsomere 1 distinctly banded, with broad dark bands at the middle and apex of the segment and pale ones at the base and just past the middle; wing with dark and light scales uniformly mingled, giving a "salt-and-pepper" effect.................................***Psorophora columbiae***
2b. Hind tarsomere 1 mostly pale-scaled; wings with patches of dark and light scales..................***3***

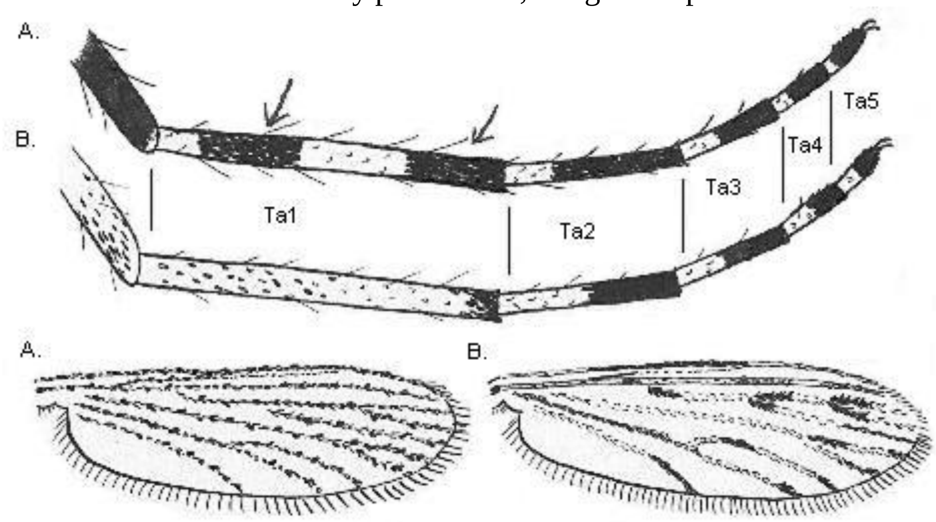

Figure 8.2 Hind tarsus and wing, Ps. columbiae and Ps. discolor

3a (2b). Wing fringe dark; distal portion of anal wing vein dark-scaled.........***Psorophora discolor***
3b. Wing fringe with alternating groups of dark and light scales; distal portion of anal wing vein light-scaled...***Psorophora signipennis***

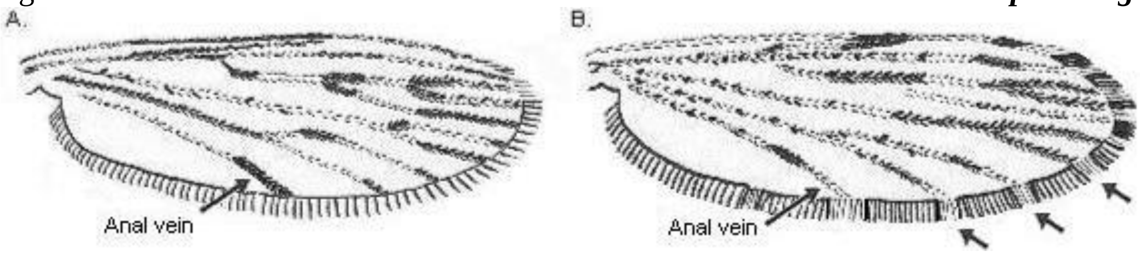

Figure 8.3 Wing, Ps. discolor and Ps. signipennis

4a (1b). Hind legs with many long, erect scales giving "spiny" appearance; last tarsomere (Ta_5) with at least some dark scales; very large species, up to 2 cm long...***5***
4b. Hind legs without prominent spiny scales, Ta_5 variable; if moderately long scales are present, then Ta_5 completely pale-scaled; small or medium-sized species, less than 1.5 cm long...............***6***

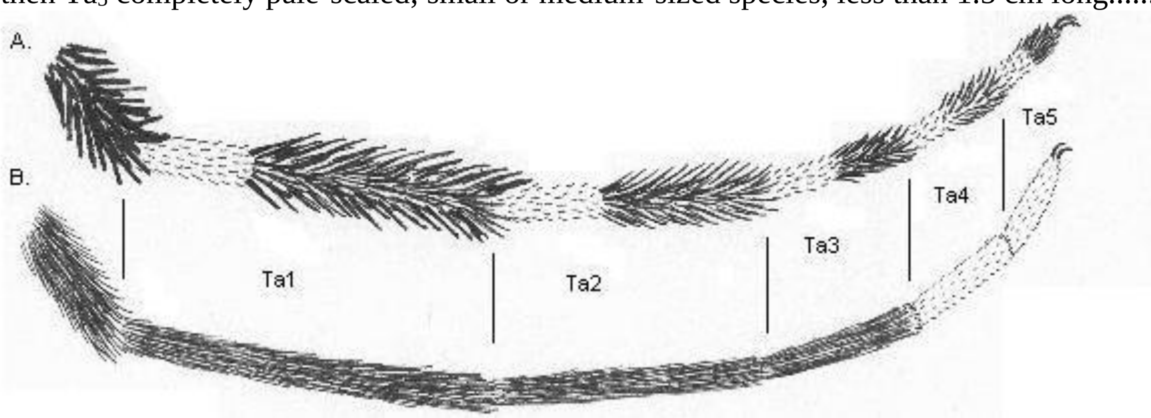

Figure 8.4 Hind tarsus, Ps. ciliata and Ps. ferox

5a (4a). Scutum with a median stripe of golden scales; distal half of proboscis yellow-scaled; overall coloration yellowish-brown..***Psorophora ciliata***
5b. Scutum without golden median stripe; proboscis dark throughout; overall coloration blue, shading into purple or green..***Psorophora howardii***

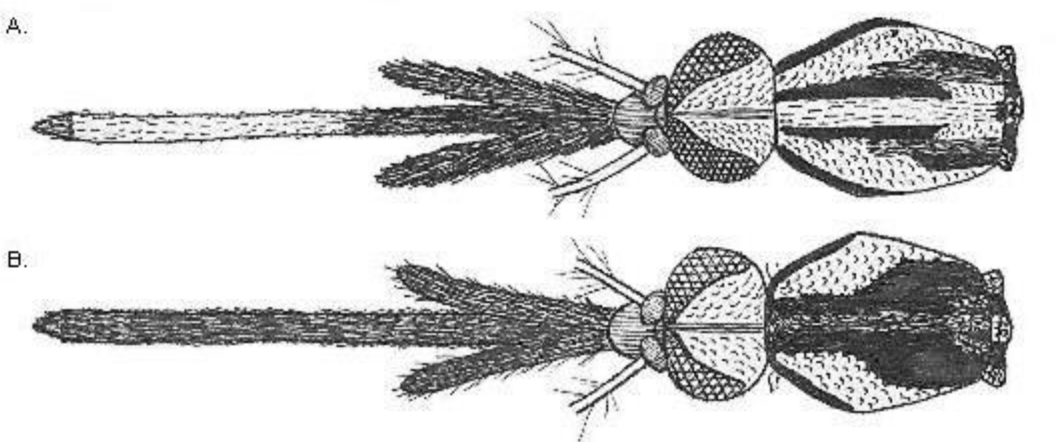

Figure 8.5 Head and thorax, dorsal view, Ps. ciliata and Ps. howardii

6a (4b). Hind tarsi dark; dorsal surface of abdomen with prominent golden patches at apex of segments...***Psorophora cyanescens***
6b. Hind tarsi with one or more pale segments; abdominal golden patches absent or restricted to apicolateral corners or margin...***7***

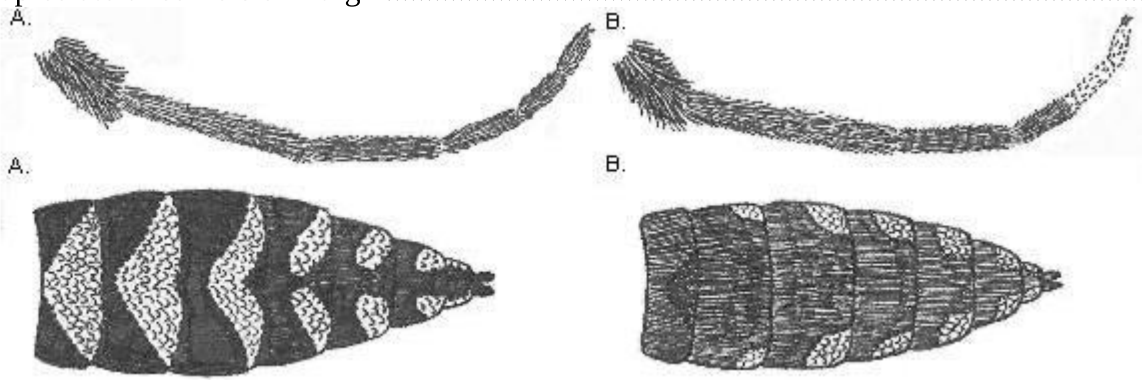

Figure 8.6 Hind tarsus and abdomen, dorsal view, Ps. cyanescens and Ps. ferox

7a (6b). Ta_5 of hind tarsi dark, only Ta_4 with pale scales...***8***
7b. Both Ta_4 and Ta_5, and sometimes apex of Ta_3, pale-scaled..***9***

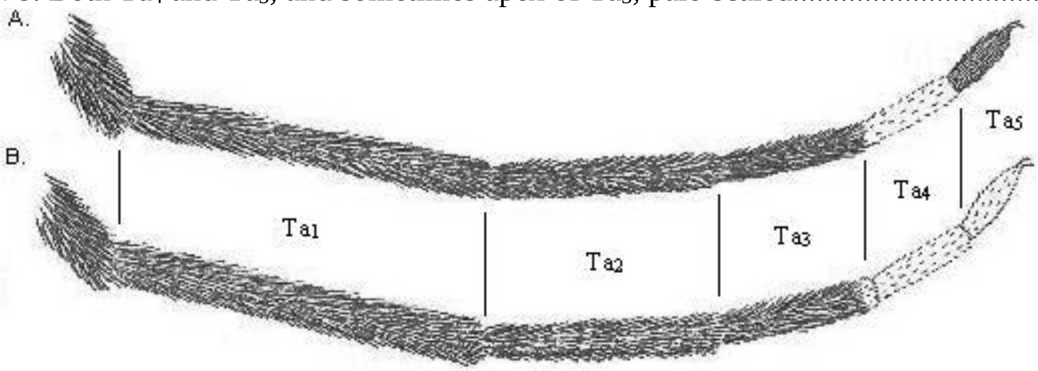

Figure 8.7 Hind tarsus, Ps. mathesoni and Ps. ferox

8a (7a). Subspiracular area of thoracic pleuron with few or no scales.........***Psorophora mathesoni***
8b. Several scales present in subspiracular area...***Psorophora varipes***

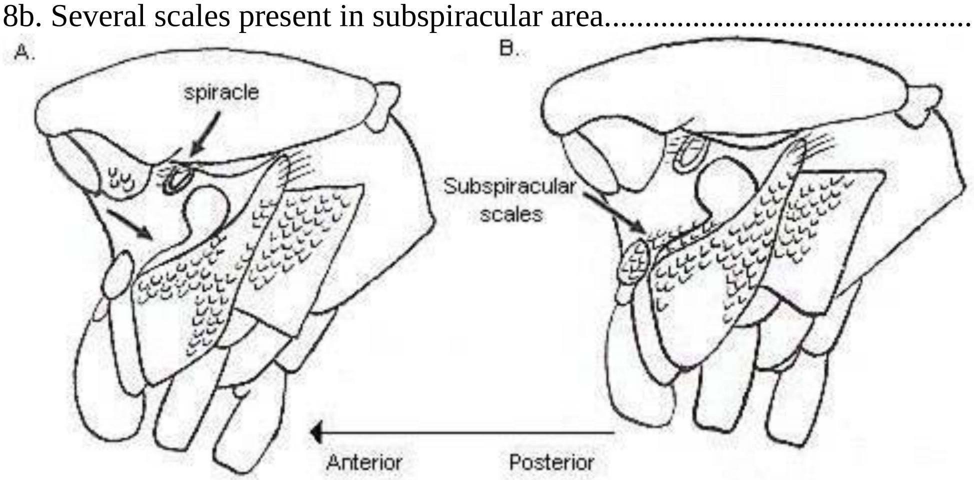

Figure 8.8 Thorax, side view, Ps. mathesoni and Ps. varipes

9a (7b). Scutum with dark scales forming a broad median stripe with pale yellowish or greyish scales laterally; first abdominal segment with dorsal median patch of pale scales......................***10***
9b. Scutum with mingled dark and golden scales, without distinct stripes; first abdominal segment with median patch of purplish scales..***Psorophora ferox***

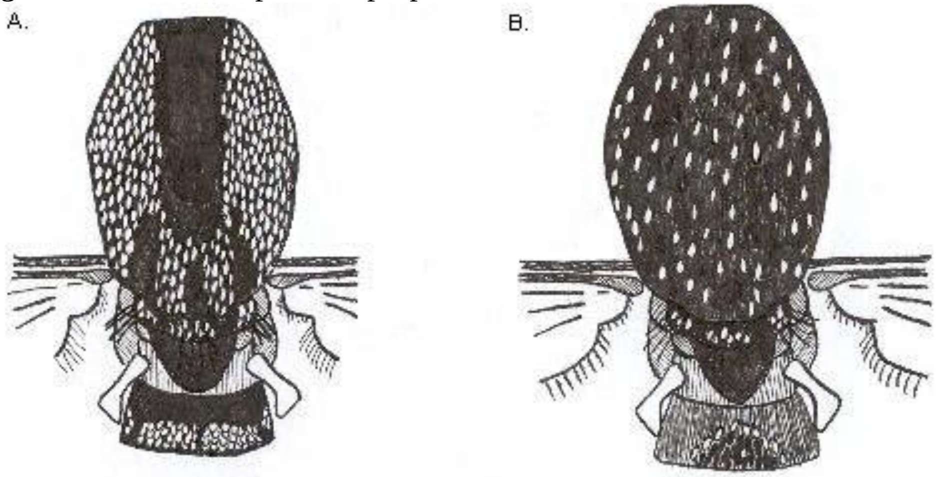

Figure 8.9 Thorax, dorsal view, Ps. horrida and Ps. ferox

10a (9a). Pale knee spot at apex of each femur; palpus less than ¼ length of proboscis ....***Psorophora horrida***
10b. Apex of femur dark-scaled, without pale knee spot; palpus about 1/3 length of proboscis ....***Psorophora longipalpus***

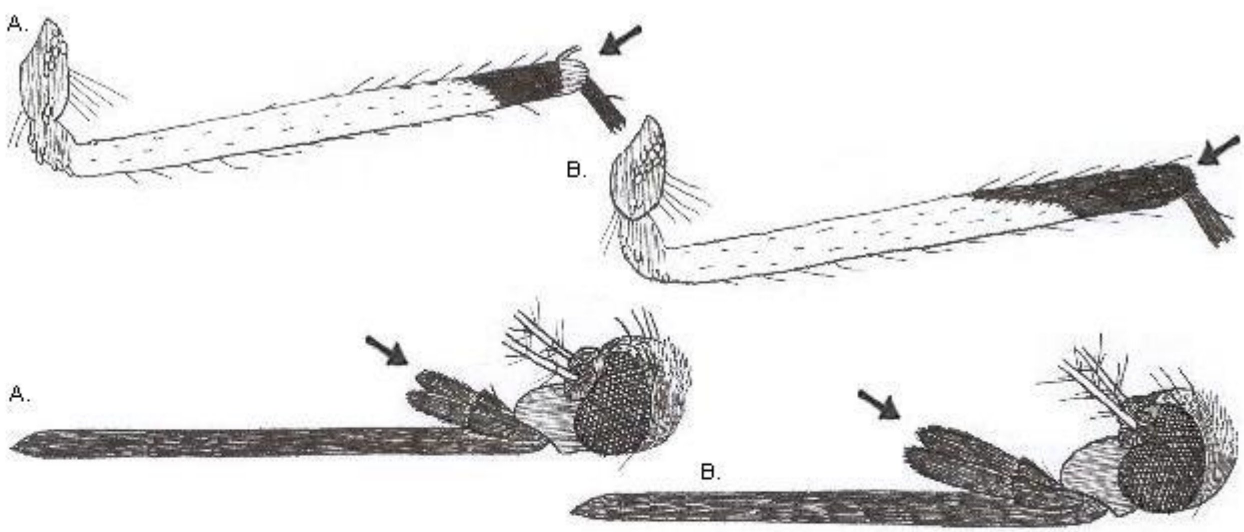

Figure 8.10 Femur and head, side view, Ps. horrida and Ps. longipalpus

Chapter 9. Most Important Species

Many of the mosquito species known to occur in our area are of little interest to most people, including researchers and health workers, because these species occur in low numbers, rarely or never bite humans, or have no known role in the spread of disease. Most of the species described and illustrated on the following pages are those considered to be of particular importance due to their regional abundance, their fondness for human blood, their roles as vectors of disease, or some combination of the three. At least one representative species from each genus found in our region, including those with no known public health importance, has been included as a matter of scientific interest and as an aid to proper identification of these genera in the key.

While this book is concerned mainly with the identification of adult female mosquitoes, the markings of the two sexes are usually quite similar, and males are easily matched to the correct females once the latter are identified. Color plate # 24 shows an adult male *Aedes vexans,* one of the most commonly collected species; comparison to color plate #8 illustrates the conservation of the characteristic markings of the species despite the significant anatomical differences between the sexes in most genera.

It should be noted that the classification of mosquitoes is a dynamic process and subject to continual change. Most recently, the proposed elevation of *Ochlerotatus* and *Stegomyia* to generic level and their subsequent reinstatement as subgenera of the genus *Aedes* have made waves in the mosquito literature. Numerous publications have made use of both nomenclatures, and a final consensus has yet to be reached. Species names may also be disputed; in some cases, a single species may have been "discovered," described, and named by several different collectors, sometimes more than once by the same, particularly enthusiastic collector (for example, in the early 20th century, the French medical entomologist Emile Roubaud described the species now known as *Culex pipiens* under at least five different names). In such cases, the original name is generally considered to have priority, and later names are relegated to the status of disused synonyms, though occasionally justification is found for resurrecting a more recent synonym as a distinct species. In some cases, modern molecular and genetic tools have revealed that some supposed "species" were in fact cryptic species complexes, composed of two or more visually identical but biologically distinct species deserving of individual names.

All of this can be very confusing to the researcher, as information about a species of interest may be published under many different names. An effort has been made for the species discussed in the following pages to include a list of any alternate names by which the mosquito in question may appear in the published literature, but the reader should bear in mind that these lists are by no means complete. A great deal of useful information about mosquito classification can be obtained from the Walter Reed Biosystematics Unit's Systematic Catalog of Culicidae, available online at http://www.mosquitocatalog.org/main.asp.

How to Read a Scientific Name

There are several elements in the scientific name of a species. The full scientific name of the Asian tiger mosquito, for example, is properly written as ***Aedes (Stegomyia) albopictus* (Skuse).** The first name, *Aedes*, is the name of the genus, and *albopictus* is the specific epithet. The second name, *Stegomyia*, is the subgenus, and its use is optional. It is always placed in parentheses if included. The genus, species, and any subgenus or subspecies names are always written in italics. The final name, Skuse, which is not italicized, refers to the taxonomist who originally described the species. Placing this name in parentheses, as it is here, indicates that this taxonomist described the species in a different genus, and that it was transferred to its current genus in a later taxonomic revision. In this case, the mosquito was originally described by Skuse as *Culex albopictus,* and later reclassified as *Aedes.* The Latin endings of the genus and species must always agree with one another in gender, so taxonomic revisions sometimes require grammatical revisions as well. For example, if one adopts the proposal by Reinert et al. (2004) to subdivide the genus *Aedes* (masculine) and elevate the subgenus *Stegomyia* (feminine) to generic rank, the specific epithet would be altered accordingly, making this species *Stegomyia albopicta.*

<u>Species included in this section</u>

Page numbers refer to descriptive text and ***color plate***

***Aedes (Stegomyia) aegypti* (Linnaeus)** Color plate 1, p. 74

Alternate names: *Culex aegypti* Linnaeus, *Culex argenteus* Poiret, *Cx. fasciatus* Fabricius, *Cx. calopus* Meigen, *Cx. frater* Robineau-Desvoidy, *Cx. mosquito* Robineau-Desvoidy, *Cx. sugens* Wiedemann, *Cx. taeniatus* Wiedemann, *Cx. kounoupi* Brulle, *Cx. toxorhynchus* Macquart, *Cx. annulitarsis* Macquart, *Cx. viridifrons* Walker, *Cx. excitans* Walker, *Cx. inexorabilis* Walker, *Cx. exagitans* Walker, *Cx. insatiabilis* Bigot, *Cx. bancrofti* Skuse, *Cx. elegans* Ficalbi, *Cx. rossii* Giles, *Stegomyia nigeria* Theobald, *St. lamberti* Ventrillon, *Cx. albopalposus* Becker, *Cx. anguste-alatus* Becker, *Duttonia alboannulis* Ludlow, *Mimeteomyia pulcherrima* Taylor

Identifying features: *Ae. aegypti* is easily recognized by the distinctive white "lyre" pattern on its thorax. Most of the body is covered with dark brown to black scales, though in certain populations of this extremely widespread species these scales are a relatively light cocoa brown. The frame of the "lyre," the lateral spots on the abdominal segments, and the light bands on the legs and palpi are all composed of very bright white scales, while the basal abdominal bands and the narrow stripes that form the "strings" of the lyre are pale yellow or cream-colored.

Look-alikes: *Ae. japonicus* has similar markings and breeds in similar habitats, but its scutal stripes are deep golden yellow, not white. *Ae. aegypti* has white bands on its palpi and on the last two segments of the hind tarsi, all of which are completely dark-scaled in *Ae. japonicus.*

Habitat: This species is strongly associated with human habitation, and is most often found in and around homes or in areas frequented by people. The larvae breed in containers and small pools of relatively clean, still water. The eggs are glued to the sides of these containers or to objects projecting out of the water, generally in a line just above the water's surface. They are extremely resistant to drying and can survive for months, hatching within minutes when the eggs finally become submerged. This makes them very easy to transport, and accidental introductions, especially inside used automobile tires, are not uncommon. The usual range of this species is restricted to the southern United States, extending roughly to the southern border of Tennessee, but specimens introduced into northern states may form temporary breeding colonies in warm weather and may even survive the winter given a suitably sheltered habitat (Christensen and Harmston 1944).

Seasonality: Found only when introduced. *Ae. aegypti* are sensitive to cold and will be killed by frost, but imported specimens may be active at any time during warm weather.

Feeding preference: Humans are the preferred blood host for this species, though it will also feed on other mammals and on birds (Christophers 1960). It is most active during the day.

Medical importance: *Ae. aegypti* is probably one of the most medically important mosquitoes in the world, as it is the primary vector of Yellow fever, Dengue, and Chikungunya viruses worldwide. Specimens captured in the United States have tested positive for West Nile virus (CDC 2005), but as of this writing, it is not believed to play a major role in viral transmission. Fortunately, the scarcity of this species in our region makes it unlikely to have any significant impact on disease transmission in the area.

***Aedes (Stegomyia) albopictus* (Skuse)** Color plate 2, p. 75
Alternate names: *Culex albopictus* Skuse, *Stegomyia scutellaris samarensis* Ludlow, *St. nigritia* Ludlow, *St. quasinigritia* Ludlow

Identifying features: The narrow, brilliantly white stripe along the midline of the thorax, combined with white-banded legs, is distinctive.

Look-alikes: None. Both *Ae. atlanticus* and *Ae. tormentor* also have a pale stripe along the thoracic midline, but the legs of these species are completely dark, without the white tarsal bands of *Ae. albopictus.*

Habitat: Like *Ae. aegypti*, the larvae of *Ae. albopictus* are most often found in pools of fresh rainwater which collect in treeholes, leaf axils, or a wide variety of man-made containers. Abandoned tires are frequently used for breeding purposes, and as with *Ae. aegypti*, the used tire trade provides a convenient means of long-distance transportation for the eggs, which are resistant to drying and will hatch when resubmerged in water, producing adults within days (Knudsen 1995).

Seasonality: Overwintering is in the egg stage. Eggs are attached to the sides of a container or to partially submerged material just above the waterline, and hatch when flooded by spring rains. Tropical strains of this species are sensitive to cold, but strains which have adapted to our temperate climate are quite capable of entering diapause and surviving our cold winters (Hanson and Craig 1995).

Feeding preference: *Ae. albopictus* is an opportunistic feeder and will take advantage of a variety of available hosts, and while the majority of blood meals appear to be derived from mammals, blood hosts of wild-caught specimens have also included birds and turtles (Niebylski et al. 1994, Knudsen 1995, Gingrich and Williams 2005).

Medical importance: This species is the second most important vector of dengue worldwide, surpassed only by *Ae. aegypti* (Knudsen 1995). It is also a competent vector of many other arboviruses, some of which are common in our area, including La Crosse encephalitis virus (Cully et al. 1991), West Nile virus, Cache Valley virus, and the viruses of both Eastern and Western equine encephalitis. Specimens infected with Eastern equine encephalitis virus and with Cache Valley virus have been collected in the wild (Moore and Mitchell 1997). It is also a competent vector of Japanese encephalitis virus and naturally-infected specimens have been collected in other parts of its worldwide range, though this virus is not known to occur in the United States at this time (Moore and Mitchell 1997).

***Aedes (Ochlerotatus) canadensis* (Theobald)** Color plate 3, p. 76
Alternate names: *Culex canadensis* Theobald, *Cx. nivitarsis* Coquillett

Identifying features: The thorax is a light golden to reddish brown which is uncommon in *Aedes* in our area.

Look-alikes: This species closely resembles some of the *Culex* species, including *Cx. pipiens*, in overall coloration, but the pointed abdomen with prominent cerci should distinguish *Ae. canadensis.*

Habitat: While typically associated with forest pools, *Ae. canadensis* is opportunistic and will breed in almost any available body of fresh water, including ditches, wheel ruts, rock pools, and ponds. Adults are generally to be found in wooded areas.

Seasonality: This is one of the spring floodwater mosquitoes, common early in the season after the snow melts and the spring rains have left temporary pools in woodland depressions. Larvae have been collected in early spring from pools completely covered with a layer of ice in which holes had to be chopped to allow the introduction of collecting equipment (Smith 1904). Overwintering is in the egg stage, and most eggs do not hatch the year that they are laid, though a small percentage will (Barr 1958). The result is a large population in the spring and early summer, with much lower levels present throughout the summer.

Feeding preference: This species has been reported to feed on both warm and cold-blooded animals, including turtles (DeFoliart 1967) and humans (Siverly 1972).

Medical importance: A pest species during its spring population peak, *Ae. canadensis* may also serve as a vector of LaCrosse encephalitis in some areas. One study found a higher frequency of isolations of this virus from *Ae. canadensis* than from *Ae. triseriatus* in northeastern Ohio (Berry et al. 1986), and isolations were made at similar rates from the two species in West Virginia (Nasci et al. 2000). Wild-caught specimens of *Ae. canadensis* have also been found to be infected with Highlands J virus (Andreadis et al. 1998). It has also been shown to transmit Jamestown Canyon virus under laboratory conditions (Heard et al. 1991), and was found to have a very high vector competence for Rift Valley Fever virus (Gargan et al. 1988), though this virus is not currently known to occur in the United States.

***Aedes (Finlaya) japonicus* (Theobald)** Color plate 4, p. 77
Alternate names: *Culex japonicus* Theobald, *Ae. eucleptes* Dyar, *Ae. tokushimaensis* Tanimura, *Ae. bisanensis* Suzuki, Tanimura, Miyagawa and Murata

Identifying features: The overall coloration of these mosquitoes is a deep, rich black with bright white markings on abdomen and legs. The underside of the abdomen is primarily dark, with a narrow white band at the base of each segment. The white bands on the legs are narrower than those of most other local species, with the exception of *Aedes vexans.* The golden-yellow “tiger stripes” on the upper surface of the thorax are highly distinctive.

Look-alikes: *Ae. aegypti* has similar markings, but the lyre-shaped markings on its thorax are bright white instead of yellow. *Ae. aegypti* also has white tips on the palpi and white stripes on the last two segments of the hind tarsi, all of which are completely dark-scaled in *Ae. japonicus*.

Habitat: *Ae. japonicus* is most often found in our area in containers such as discarded tires and flowerpot saucers, usually in water which is relatively clear or tea-like, containing fallen leaves or woody debris. They have often been found in company with *Aedes triseriatus* and other rock or treehole species.

Seasonality: Active first-instar larvae of this species have been collected by the author in St. Joseph County on the northern border of Indiana as early as March 9, and adults remain active well into October. Overwintering appears to be in the egg stage, though larvae have been collected beneath thick layers of ice in winter. There are multiple generations per year.

Feeding preference: Bloodmeal analysis of wild-caught *Ae. japonicus* in New Jersey indicated that primary hosts in that area are humans and white-tailed deer (Scott 2003), and members of this species have been observed feeding on humans outdoors in Indiana.

Medical importance: Experiments under laboratory conditions indicate that *Ae. japonicus* is a competent vector of West Nile (Turell et al. 2001), Eastern equine encephalitis (Sardelis et al. 2002), and St. Louis encephalitis viruses (Sardelis et al. 2003), three of the most significant arboviruses affecting our area, and specimens have been found to be infected with WNV in the wild (Fonseca et al. 2001, Scott 2003). In its native range in Southeast Asia, *Ae. japonicus* has also been shown to transmit Japanese encephalitis, a flavivirus related to West Nile and St. Louis encephalitis, vertically to its offspring at a minimum infection rate of 0.7% (Takashima and Rosen 1989). While the precise role played by this species in disease transmission in the United States has yet to be determined, these factors indicate that it is likely to be of some importance as a bridge vector or, potentially, a winter reservoir for one or more of these arboviruses.

Notes: This species is a new addition to the mosquito fauna of North America. It was first collected in New York and New Jersey in 1998 (Peyton et al. 1999), and has been spreading westward ever since, reaching West Virginia in 2002 (Joy 2004), Kentucky in 2003 (Saenz et al. 2006) Indiana in 2004 (Young et al. 2004, Moberly et al. 2005) and Illinois in 2006 (Morris et al. 2007). Knowledge of its distribution and behavior is therefore limited at this time, and much remains to be discovered.

***Aedes (Ochlerotatus) sticticus* (Meigen)** Color plate 5, p. 78
Alternate names: *Culex sticticus* Meigen, *Cx. concinnus* Stephens, *Cx. hirsuteron* Theobald, *Cx. aestivalis* Dyar, *Cx. pretans* Grossbeck, *Ae. aldrichi* Dyar and Knab, *Ae. gonimus* Dyar and Knab, *Ae. vinnipegensis* Dyar and Knab, *Ochlerotatus lesnei* Seguy, *Ae. paradiantaeus* Apfelbeck

Identifying features: A rather plain-looking *Aedes*, this species is best identified by the yellowish-grey patches which extend all the way to the sides of the scutum and which do not touch each other at the midline.

Look-alikes: *Aedes sticticus* may be easily confused with either *Ae. triseriatus* or *Ae. trivittatus.* The white markings of *Ae. triseriatus*, however, are far brighter than the dingy yellow-grey of *Ae. sticticus,* and the lateral white patches on the dorsal surface of the abdomen are more rounded or rectangular in shape, while those of *Ae. sticticus* are distinctly triangular. *Ae. trivittatus* shares the coloration of *Ae. sticticus*, but the pale stripes on its scutum form a V-shape, touching briefly at the midline and bordered by dark brown scales on the outer edges. In most specimens, the pale lateral triangles on the abdomen of *Ae. sticticus* extend all the way to the midpoint of the dorsal surface of the abdomen, joining to form a narrow basal band, while the lateral triangles of *Ae. trivittatus* are separate, with the basal band absent or represented only by a small pale patch at the midline. These characteristics are variable, however, and may overlap in a minority of specimens, so abdominal morphology should be used only as secondary confirmation in the separation of these two species. Variability among populations of *Ae. sticticus* may be significant; various forms were once recognized as separate, coexistant species (Dyar 1922, Mail 1934).

Habitat: Larvae are most often to be found in temporary woodland pools formed by spring rains and snowmelt. Adults are generally associated with wooded or brushy areas, but can fly significant distances; migrations of up to 15 miles have been recorded, with a general infestation of adults in fair abundance everywhere within a roughly ten-mile radius of good breeding sites (Hearle 1926).

Seasonality: Overwintering is in the egg stage. Eggs hatch when flooded in the spring; subsequent batches of eggs will hatch shortly after being laid if water is available, producing multiple generations each year. Adults are most common in late spring and early summer, but abundance is dependent on rainfall.

Feeding preference: Livestock and other mammals, including humans. This species may be a significant pest of both humans and domestic animals in some areas, being both abundant and vicious biters (Hearle 1926, Twinn 1926, Siverly 1972, Riha et al. 1979). They will invade houses, and have been known to squeeze through window screens (Hearle 1926). They feed primarily at dusk, and to a lesser extent during the day.

Medical importance: This species is important primarily as a nuisance rather than as a vector of disease; however, the impact of nuisance biting should not be underestimated. Riha et al. (1979) found that nuisance biting by large numbers of *Ae. sticticus,* together with *Ae. vexans, Ae. cinereus,* and *Ae. punctor*, had a dramatic negative influence on dairy production by affected cattle, a phenomenon also noted by dairy farmers in British Columbia (Hearle 1926), where *Ae. sticticus* (then known as *Ae. aldrichi*) and *Ae. vexans* were the primary species.

A study in Alabama found *Ae. sticticus* to be a vector of dog heartworm, *Dirofilaria immitis* (Buxton and Mullen 1980). A small number of wild-caught specimens in the United States have been found to be infected with West Nile virus, but this species is not believed to play a significant role in WNV transmission (Andreadis et al. 2004). Interestingly, a small percentage of *Ae. sticticus* collected in the Czech Republic were found to contain spirochetes related to the causative agent of Lyme disease (Hubalek et al. 1998), but despite circumstantial evidence (Hard 1966, Doby et al. 1987), transmission of *Borrelia* by this or any species of mosquito has not yet been conclusively demonstrated and is considered unlikely to occur to any great extent in nature.

***Aedes (Protomacleaya) triseriatus* (Say)** Color plate 6, p. 79
Alternate names: *Culex triseriatus* Say, *Finlaya nigra* Ludlow

Identifying features: The very bright, silvery-white patches of broad, flat scales on the sides of the scutum are very distinctive and usually easy to identify even in rubbed specimens.

Look-alikes: *Aedes hendersoni* is a closely related species and looks very much like *Ae. triseriatus*, but the dark stripe down the midline of the scutum is much narrower, making the scutum of *Ae. hendersoni* more white than dark, while that of *Ae. triseriatus* has approximately equal amounts of each color, or else more dark than white. *Ae. sticticus* has markings similar to those of both species, but its light-colored patches are a dirty yellowish-grey rather than brilliant silvery-white.

Habitat: Typically found in wooded or park-like areas with at least a few good-sized trees, both *Ae. triseriatus* and its sibling species *Ae. hendersoni* prefer to breed in treeholes or sheltered containers such as old tires.

Seasonality: Fairly common throughout the summer, from early June to late September in northern Indiana. Overwintering is in the egg stage, with multiple generations per year.

Feeding preference: *Ae. triseriatus* feeds primarily on mammals. Females will bite readily if disturbed during the day by humans venturing into wooded areas where they are resting, but prefer to hunt in the evening and have been known to enter houses in search of a meal.

Medical importance: *Ae. triseriatus* is the primary vector of La Crosse virus, which it maintains in an enzootic cycle among small woodland mammals, mainly squirrels and chipmunks. It is also extremely efficient at transmitting this virus vertically to its offspring, so that in some areas infection rates among these mosquitoes may reach 70-90% (Chandler et al. 1998, Woodring et al. 1998). *Ae. triseriatus* is a competent vector for other arboviruses found in our area as well, including West Nile virus, and may be considered a threat to human health. A laboratory study by Gargan et al. (1988) found that this species had moderate vector potential for the transmission of Rift Valley Fever, though this virus is not currently known to occur in the United States.

***Aedes (Ochlerotatus) trivittatus* (Coquillett)** Color plate 7, p. 80
Alternate names: *Culex trivittatus* Coquillett, *Cx. inconspicuus* Grossbeck

Identifying features: The thorax of this species is marked with two broad, pale stripes of dirty yellowish or grayish white which form a “V”or “U” shape against a dark background. These stripes touch briefly at the posterior midline of the thorax and do not extend all the way to the sides at the anterior end, leaving the mosquito’s “shoulders” dark. When lying on its side, the white triangles at the corners of each abdominal segment form a neat, continuous jagged line which is easily spotted in the midst of the daily catch.

Look-alikes: Rubbed specimens may be difficult to distinguish from *Aedes sticticus*, but in the latter species, the pale scutal stripes do not meet in the middle and do reach the sides of the scutum. Abdominal markings are similar in the two species and one may occasionally take on the characteristic form of the other, but in the great majority of specimens, the pale lateral triangles of *Ae. sticticus* meet in the middle to form a narrow band at the base of each abdominal segment, while those of *Ae. trivittatus* are typically separate, with the basal pale band absent or represented only by a small pale spot at the midline.

Habitat: *Ae. trivittatus* is a "floodwater" mosquito and thrives in temporary pools in wooded areas flooded by heavy rains or snowmelt.

Seasonality: Overwintering in this species is in the egg stage, and there are multiple generations per year, beginning with the advent of warm weather and standing water in the spring. This species is prone to massive population explosions if conditions are favorable, and I have found that my light traps in St. Joseph County in northern Indiana are usually inundated with them from late June through September, sometimes in excess of a thousand individuals per trap in a single night.

Feeding preference: *Ae. trivittatus* will bite humans very readily and can be a significant pest. It has also been observed to bite cottontail rabbits, other mammals, and birds (Pinger and Rowley 1975, Ritchie and Rowley 1981, Nasci 1984, Tiawsirisup et al. 2004).

Medical importance: Aside from its importance as a major nuisance biter, *Ae. trivittatus* may serve as a significant vector of canine heartworm (Christensen and Andrew 1976, Pinger 1985) and is capable of transmitting several arboviruses, including trivittatus virus (Watts et al. 1976) and West Nile virus (Tiawsirisup et al. 2004), though it is not considered to play a significant role in the transmission of West Nile virus in the wild at this time.

***Aedes (Aedimorphus) vexans* (Meigen)** Color plate 8, p. 81 (Male: Color plate 24, p. 97)
Alternate names: *Culex vexans* Meigen, *Cx. parvus* Macquart, *Cx. articulatus* Rondani, *Cx. malariae* Grassi, *Cx. sylvestris* Theobald, *Cx. montcalmi* Blanchard, *Culicada minuta* Theobald, *Culicada eruthrosops* Theobald, *Ae. euochrus* Howard, Dyar, and Knab, *Cx. sudanensis* Theobald

Identifying features: The narrow white bands at the base of each tarsal segment once seen are nearly unmistakable, and mangled specimens may be identified by an experienced mosquito sorter with a reasonable degree of confidence based on this character alone. Each band covers less than one third of the segment on which it appears, and is rarely longer than the leg is wide. The white abdominal bands are also unique in their scalloped shape, resembling a capital letter "B." The thorax is uniformly dark, dusted with fine, rusty or cinnamon-brown scales.

Look-alikes: This is a very distinctive mosquito and difficult to mistake, but in older or rubbed specimens the telltale markings may begin to fade. Oddly enough, I have most often seen this species misidentified as *Culex restuans* or *Cx. pipiens*, but a quick glance at the tip of the abdomen (pointed in *Aedes*, bluntly rounded in *Culex*) should sort these.

Habitat: *Ae. vexans* is a floodwater mosquito and will breed in virtually any standing water, from temporary woodland pools to flooded roadside ditches, generally in fairly open areas. It is capable of traveling a considerable distance from its breeding sites, and adults can easily cover a distance of ten miles or more (Hearle 1926).

Seasonality: Like most *Aedes*, winter survival is in the egg stage. Eggs are resistant to drying, and hatch when flooded the following year. Only a certain portion of the eggs will hatch at a time; Hearle (1926) reports that as many as four cycles of drying and flooding may be necessary to induce hatching in the entire egg batch. This gives the impression of the production of multiple generations per year, but Mail (1934) found that freezing is necessary to stimulate eggs to hatch. Moderate numbers of larvae and adults are usually present throughout the warm months, but like *Ae. trivittatus*, *Ae. vexans* is prone to population explosions and under favorable conditions may attain vast abundance, numbering in the thousands per light trap per night. Males form mating swarms at dusk.

Feeding preference: Mammals, preferably large ones such as deer, livestock, or dogs (Magnarelli 1977, Burkot and DeFoliart 1982, Nasci 1984), though a minority of blood meals may be derived from smaller mammals or birds (Molaei and Andreadis 2006). They will bite humans given the opportunity, and can become a significant nuisance. Females bite primarily around dawn and dusk, but will bite during the day if disturbed. Both sexes are strongly attracted to light traps, with or without carbon dioxide.

Medical importance: *Ae. vexans* is a prominent vector of canine heartworm (*Dirofilaria immitis*) in some areas (Hendrix et al. 1980, Tolbert and Johnson 1982). It has been observed to carry Eastern equine encephalomyelitis virus at a minimum infection rate (MIR) of up to 2.2 per thousand (Cupp et al. 2003), and has also been found to be infected with Cache Valley virus at low rates in the wild (Iversen et al. 1979). Estimates of its vector competence for West Nile virus range from poor (Turell et al. 2001) to moderate (Tiawsirisup et al. 2008), but given its abundance, transmission by even a very small percentage of the population may have an impact. It is also one of the primary pest mosquitoes in our area, reducing quality of life for both humans and domestic animals.

***Anopheles (Anopheles) punctipennis* (Say)** Color plate 9, p. 82
Alternate names: *Culex punctipennis* Say, *Cx. hyemalis* Fitch, *An. stonei* Vargas

Identifying features: This is one of only two recognized species of anophelines in our area with distinct patches of pale scales on the leading edge of each wing. These two species may be distinguished from one another on the basis of the comparative sizes of these spots: in *An. punctipennis*, the pale spot closer to the base of the wing is broad, at least half the width of the dark-scaled area that separates it from the pale spot at the tip of the wing. The other species, *An. perplexens*, has a much narrower proximal patch of pale scales, less than 1/3 the width of the dark area between the pale spots.

Look-alikes: As described above, *An. perplexens* looks very similar to *An. punctipennis.* Interestingly, *An. punctipennis* itself is believed by some researchers to be in fact a cryptic species complex comprised of at least two distinct species which are physically nearly identical and can at present be separated only by genetic or chromosomal analysis. Little has been published regarding these forms or species and their distribution, but specimens collected in St.

Joseph County, Indiana in 2006 were found to be of the Eastern type (Porter and Collins 1996, Young et al. 2008)

Habitat: Larvae may be found in many types of water, from artificial containers to the backwaters of slow-moving streams (Barr 1958). Herrick (1901) noted a vast abundance of *An. punctipennis* larvae in a construction ditch filled with stagnant water, in company with larvae of *Cx. pipiens.*

Seasonality: Adult females hibernate in sheltered locations, including human houses, and lay eggs in spring. Larval development lasts 12-14 days under average conditions (Herrick 1901). Barr (1958) notes that Minnesota adult populations tend to be highest in late spring and early fall, with a dip in adult collections in midsummer.

Feeding preference: *An. punctipennis* will readily bite humans if given the opportunity. Biting takes place mainly around dusk and into the night, but females will bite during daylight if disturbed, and have been known to enter houses to seek a blood meal (Carpenter and LaCasse 1955).

Medical importance: The chief medical threat from this species is the transmission of dog heartworm, *Dirofilaria immitis* (Christensen and Andrew 1976, Tolbert and Johnson 1982). *An. punctipennis* is capable of transmitting human malaria, but it is believed to have been a vector of only minor importance when malaria was endemic in the United States. One wild-caught female of this species was found to be infected with the malaria parasite during an outbreak in Virginia in 2002-3 (Robert et al. 2005). Multiple isolations of Potosi virus have been made from *An. punctipennis* (Mitchell et al. 1996, Armstrong et al. 2005). Occasional specimens have been found to be infected with Eastern equine encephalomyelitis virus (Wozniak et al. 2001), but this species is not believed to play a significant role in EEE transmission in nature (Moncayo and Edman 1999).

***Anopheles (Anopheles) quadrimaculatus* Say** Color plate 10, p. 83
Alternate names: *An. annulimanus* Van der Wulp

Identifying features: All of the wing scales are various shades of brownish grey, without any of the bright yellowish-cream or coppery patches found in some other *Anopheles* species. The species name comes from the four spots of dark scales found on each wing, which are its most distinctive feature.

Look-alikes: *An. walkeri* and *An. earlei* are both similar in appearance to *An. quadrimaculatus*, and all three species share the same pattern of four dark spots on an otherwise brownish-grey-scaled wing. The wing of *An. earlei*, however, has a broad patch of copper-colored fringe scales along the apical margin, while the fringe of the other two species is uniformly colored. *An. walkeri* is distinguished by white bands at the tip of each segment of the palpi, which are uniformly dark in *An. earlei* and *An. quadrimaculatus,* and the wing spots are generally less well defined in this species than in the others.

An. quadrimaculatus s.l. is actually a complex of five cryptic species: *An. quadrimaculatus* s.s., *An. diluvialis, An. inundatus, An. maverlius,* and *An. smaragdinus* (Porter and Collins 1996, Reinert et al. 1997). These species are virtually identical in appearance and are best separated by molecular techniques (Porter and Collins 1996). The latter four species, recently described by Reinert (1997), have so far been reported only from the Southeast and are not believed to occur in significant numbers in the Ohio River basin (Darsie and Ward 2004, Levine et al. 2004).

Habitat: Breeding generally takes place in permanent bodies of fresh water such as ponds, though temporary pools are sometimes used. Like other anophelines, eggs are laid singly on the surface of the water, so concentrations of larvae are generally lower than those of *Aedes* or *Culex* species in which eggs are laid in large clusters.

Seasonality: Multiple generations are produced each year, and overwintering is in the adult stage, so this species is present to some degree throughout the warm seasons of the year. Inseminated adult females hibernate in sheltered areas, including human buildings, and may become active during brief spring thaws.

Feeding preference: Usually mammals, including man and domestic animals (Gingrich and Williams 2005); a study in Mississippi found that the majority of bloodmeals in wild-caught specimens were derived from white-tailed deer (Apperson and Lanzaro 1991). Biting is heaviest just after dusk and continues throughout the night. Females usually seek shelter around dawn and rest during the day, though they may hunt during daylight on cloudy days or inside dark buildings (Carpenter and LaCasse 1955).

Medical importance: *An. quadrimaculatus* is believed to have been the primary vector of human malaria in the United States before the malaria parasite was eradicated from the country in the 1950's (Levine et al. 2004). It is a common and widespread species and remains fully capable of transmitting malaria if the parasite is introduced under favorable conditions; most recently, several wild-captured individuals of this species tested positive for the parasite in a localized outbreak involving three locally-acquired human cases of malaria in a neighborhood in Virginia in 2002-3 (Robert et al. 2005).

***Coquillettidia (Coquillettidia) perturbans* (Walker)** Color plate 11, p. 84
Alternate names: *Culex perturbans* Walker, *Cx. testaceus* Van der Wulp, *Cx. ochropus* Dyar and Knab, *Mansonia perturbans* (Walker), *Taeniorhynchus perturbans* Walker

Identifying features: This species is larger than most, and the broad salt-and-pepper scales on the wings and prominent banding on the legs and proboscis make it stand out in a catch even to the naked eye.

Look-alikes: None. At first glance, the body size and shape may resemble *Or. signifera* or some of the larger *Culiseta*, and the color pattern is superficially similar to *Culex tarsalis*, but under adequate magnification or with close observation, *Cq. perturbans* is unique.

Habitat: This is one species which prefers to breed in permanent bodies of fresh water, such as ponds, wetlands, and the reedy backwaters of slow-moving rivers, always in association with emergent vegetation such as cattails. Eggs are laid in rafts on the surface of the water (McNeel

1932), and the aquatic stages attach themselves to the roots and stems of such vegetation by inserting modified respiratory structures (the siphon in the larval instars and the respiratory trumpets in the pupal phase) into the aerenchyma tissue of these plants, from which they obtain enough oxygen to remain submerged until shortly before emergence as winged adults (Gillett 1946, Carpenter and LaCasse 1955, Bosak and Crans 2002). This makes larval collection a challenge, as these aquatic stages are inaccessible to standard larval dippers; various special techniques have been developed for harvesting sections of likely host plants together with their substrate and examining these for the attached larvae (McNeel 1932, Morris et al. 1985, Batzer 1993). Control strategies must also take these habits into consideration: as the larvae are often partially or wholly buried in sediment, they may be sheltered to some extent from conventional larvicides. Some studies have shown that methoprene is effective against these larvae, but neither temephos nor *Bacillus thuringiensis* var. *israelensis* (Bti) have been shown to significantly reduce larval populations (Sjogren et al. 1986, Walker 1987, Ranta et al. 1994).

Seasonality: There is believed to be only one generation per year, but emergence is staggered so that adults of this species are present throughout most of the summer and early fall, with the highest densities occurring in the late spring or early summer (Carpenter and LaCasse 1955, Nasci et al. 1993). Overwintering is in the larval stages.

Feeding preference: This species has been observed to feed readily on both birds and mammals, including man, and some studies have found a relatively high frequency of multiple feeding (the taking of partial blood meals from multiple hosts in a short period of time) in wild-caught *Cq. perturbans* (Downe 1962, Gingrich and Williams 2005).

Medical importance: *Cq. perturbans* is considered to be one of the primary epizootic vectors of Eastern equine encephalomyelitis virus in the United States (Crans and Schulze 1986, Morris 1988, Nasci et al. 1993). It can also be a significant nuisance biter in areas close to the sort of still, reedy water favored for breeding. Biting is said to be worst after dusk (Anderson et al. 2007), and McNeel (McNeel 1932) reports a peak in activity around midnight, but females will bite readily if disturbed during the daytime (Siverly 1972). The bites are said to be more painful than those of many other common pest species (Hearle 1926, Downe 1962). Smith (1904) actually assigned this species the unofficial common name "The Irritating Mosquito" in his book on the mosquitoes of New Jersey, which gives the reader some idea of its effects. Laboratory tests of vector competence have shown this species to be an inefficient vector for West Nile virus (Sardelis et al. 2001).

***Culex (Culex) pipiens* Linnaeus** Color plate 12, p. 85

Alternate names: *Cx. bifurcatus* Linnaeus, *Cx. fasciatus* Mueller, *Cx. molestus* Forskal, *Cx. trifurcatus* Fabricius, *Cx. luteus* Meigen, *Cx. domesticus* Germar, *Cx. rufus* Meigen, *Cx. bicolor* Meigen, *Cx. marginalis* Stephens, *Cx. meridionalis* Leach, *Cx. consobrinus* Robineau-Desvoidy, *Cx. calcitrans* Robineau-Desvoidy, *Cx. thoracicus* Robineau-Desvoidy, *Cx. pallipes* Waltl, *Cx. unistriatus* Curtis, *Cx. pallipes* Macquart, *Cx. rufinus* Bigot, *Cx. agilis* Bigot, *Cx. phytophagus* Ficalbi, *Cx. haematophagus* Ficalbi, *Cx. melanorhinus* Giles, *Cx. varioannulatus* Theobald, *Cx. azoriensis* Theobald, *Cx. longefurcatus* Becker, *Cx. quasimodestus* Theobald, *Cx. doliorum* Edwards, *Cx. autogenicus* Roubaud, *Cx. berbericus* Roubaud, *Cx. sternopallidus* Roubaud, *Cx. sternopunctatus* Roubaud, *Cx. disjunctus* Roubaud, *Cx. calloti* Rioux and Pech, *Cx. erectus*

Iglisch, *Cx. torridus* Iglisch, *Cx. osakaensis* Theobald, *Cx. dipseticus* Dyar and Knab, *Cx. comitatus* Dyar and Knab

Identifying features: This is a medium-sized, relatively drab brown mosquito. The scutum is caramel brown, evenly clothed with rather rough-looking golden-brown scales. The dorsal side of the abdomen is mostly dark-scaled, with cream-colored bands at the base of each segment. These bands are usually prominent, and are very often slightly rounded, with the band forming a half-moon shape which may be completely separate from or only narrowly joined to the pale lateral spots. The author has observed that the markings on the underside of the abdomen may also sometimes be of use in identification of populations in northern Indiana: the underside of each segment is generally covered with cream-colored scales, but in many specimens is also marked with a single narrow, dark longitudinal line at the midline. The most common look-alike species, *Cx. restuans*, may also have an unmarked pale underside, but its dark markings, when present, are triangular or heart-shaped.

Look-alikes: The three subspecies of *Cx. pipiens* common in our area, *Cx. p. pipiens*, *Cx. p. quinquefasciatus*, and *Cx. p. molestus*, are very difficult or impossible to reliably distinguish in the adult female. In general, *Cx. p. pipiens* is more common in the north and *Cx. p. quinquefasciatus* in the south, but there is considerable overlap. The pale dorsal abdominal bands are generally connected to the lateral spots in *Cx. p. pipiens* and distinctly separated in *Cx. p. quinquefasciatus*. *Cx. p. molestus*, the most anthropophilic of the three, is virtually identical to *Cx. p. pipiens* and is best identified by behavior: it is autogenous and will lay its first batch of eggs without need for a blood meal, while both of the other two subspecies require a blood meal for egg development.

Cx. restuans looks very much like *Cx. pipiens*, and rubbed or otherwise damaged specimens may be indistinguishable. In good specimens, the two may be separated by any of several characteristics: the scutum of *Cx. restuans* is generally marked with two prominent cream-colored spots, no trace of which ever appears on *Cx. pipiens*. The brown scales on the scutum of *Cx. pipiens* are stout, curved, golden-brown, and rather rough-looking, while those of *Cx. restuans* are narrow, hairlike, smooth, and a more rusty or cinnamon brown. The dorsal pale bands on the abdominal segments are generally rounded in *Cx. pipiens* and straight-edged in *Cx. restuans*, while the ventral abdominal markings differ as described above.

Cx. salinarius also resembles both of the above species, but its dorsal abdominal bands are much narrower and less distinct, and of a mustardy yellow color instead of cream. *Cx. salinarius* may also have a small patch of dark scales on the middle scutellar lobe, where both *Cx. pipiens* and *Cx. restuans* have only cream-colored scales (Apperson et al. 2002).

Habitat: This species is strongly associated with stagnant water high in organic matter, and is often found breeding in cesspools, storm drains, clogged rain gutters, flowerpot saucers, and similar small bodies of water. Eggs are laid in rafts on the surface of the water and generally hatch within a few days of being laid.

Seasonality: Inseminated females hibernate in sheltered areas like sheds, outhouses, culverts, and the undersides of bridges and may become active during periods of warm weather even in winter. Breeding is continuous throughout the warm months, with large adult populations present from midsummer through autumn. Adults are relatively cold-hardy and will survive the first mild frosts of fall. A few females continue to appear in CO_2 traps in northern Indiana through the end of October in most years. This cold-hardiness also has implications for the would-be mosquito sorter if freezing is used to kill the catch, as *Culex* have a disconcerting tendency to "wake up" under the microscope when removed from the freezer after periods sufficient to reliably kill most *Aedes*. Collectors should remain alert for signs of life and adjust freezing times accordingly.

Feeding preference: Birds are the blood host of choice, but females will feed on mammals when birds are unavailable (Gingrich and Williams 2005, Molaei et al. 2006), and were taken with some frequency in human-landing collections by Gingrich and Casillas (2004). Some investigators have observed a shift in host preference from birds, particularly American robins, in spring and early summer to humans in late summer and early autumn (Kilpatrick et al. 2006), a phenomenon which increases the risk of transmission of avian zoonoses such as West Nile virus to humans. The common name for this species is the "northern house mosquito," as it often breeds near houses and will readily fly indoors to feed if houses are not adequately screened and sealed against insects.

Medical importance: This is probably the most medically important mosquito in our area at this time. It is considered to be the primary vector of both West Nile virus and St. Louis encephalitis (Molaei et al. 2006, Sanogo et al. 2007). Infected females are capable of transmitting West Nile virus vertically to their offspring, which may serve as a reservoir for winter survival of the virus (Anderson and Main 2006).

***Culex (Culex) restuans* Theobald** Color plate 13, p. 86
Alternate names: *Cx. brehmei* Knab

Identifying features: Undamaged specimens are easily identified by the two cream-colored spots on the cinnamon-brown scutum.

Look-alikes: *Cx. pipiens, Cx. salinarius,* and *Cx. tarsalis* all look rather similar and rubbed specimens may be very difficult or impossible to distinguish, though the pale band on the proboscis readily separates *Cx. tarsalis* from the other three. Since neither *Cx. pipiens* nor *Cx. salinarius* has any trace of pale spots on the scutum, even a few lingering pale scales in the appropriate area on a rubbed specimen is a good indication of *Cx. restuans.* The cinnamon-brown scales of the surrounding scutum are much finer and more hairlike than the rough, curved golden-brown scales of *Cx. pipiens,* and the pale dorsal abdominal bands are straighter, while *Cx. salinarius* is marked with narrow, indistinct bands of mustard yellow instead of creamy white.

Habitat: Breeding may occur in almost any available body of water, from ponds to ditches to abandoned tires. Like other *Culex,* females seem to prefer to lay their egg rafts on the surface of water with high organic content and are readily attracted to gravid traps baited with infusions of hay or similar materials.

Seasonality: Adults spend the winter in hibernation in sheltered areas and may become active during periods of warm weather. Eggs are laid in spring and summer, and several overlapping generations may be produced each year. Adults are most common during the late spring and early summer, but moderate numbers may be found throughout the year.

Feeding preference: Most studies indicate that *Cx. restuans* feeds primarily on birds (Magnarelli 1977, Apperson et al. 2002, Gingrich and Williams 2005, Molaei et al. 2006), but Gingrich and Williams (2005) found that most blood meals taken by a small sample (n=9) of this species in their area were derived from mammals, particularly horses and rabbits. They are seldom taken in landing collections on humans, even when they are collected in other types of traps at the same time and location (Gingrich and Casillas 2004, Gingrich and Williams 2005).

Medical importance: As *Cx. restuans* rarely bites humans, it is unlikely to pose any direct threat to human health. It may, however, play a role in enzootic transmission of pathogens among birds, and is believed to be involved in the spring amplification cycle of West Nile virus (Ebel et al. 2005, Molaei et al. 2006), for which it is a competent vector under laboratory conditions (Sardelis et al. 2001). Wild-caught specimens have been found to be infected with Eastern equine encephalomyelitis virus (Cupp et al. 2004a).

***Culex (Culex) salinarius* Coquillett** Color plate 14, p. 87
Alternate names: none

Identifying features: A brown mosquito with dingy mustard-yellow banding on the abdomen. The seventh and eighth abdominal segments are often completely covered with yellowish scales, or will have only a scattering of darker brown scales. Apperson et al. (2002) report that specimens in their New York study area can be reliably identified by the presence of a small patch of dark scales on the middle lobe of the scutellum, where *Cx. pipiens* and *Cx. restuans* possess only pale scales.

Look-alikes: Both *Cx. pipiens* and *Cx. restuans* are very similar in general appearance to *Cx. salinarius*, but in both of these species the abdominal banding is much more prominent and cream-colored rather than yellowish, and in both the seventh and eighth abdominal segments are mostly dark-scaled.

Habitat: As the species name implies, *Cx. salinarius* larvae can tolerate brackish water and may be found in salt marshes as well as freshwater pools, ponds, and containers (Wallis and Spielman 1953).

Seasonality: Adults survive the winter in hibernation and lay eggs beginning in late spring; breeding appears to be continuous through the warm season, with populations reaching their greatest peak in late summer (Siverly 1972).

Feeding preference: This species has been observed to feed readily on both mammals and birds (Gingrich and Williams 2005, Molaei et al. 2006), and Gingrich and Williams (2005) found that the majority of mammalian blood meals taken by *Cx. salinarius* in their study area in Delaware were derived from rabbits and horses. It is also known to bite humans, and was taken frequently in human-landing collections (Gingrich and Casillas 2004, Molaei et al. 2006).

Medical importance: Wild-caught specimens were found to be infected with Venezuelan equine encephalomyelitis virus during an outbreak in Texas in 1971 (Sudia and Newhouse 1971). It is a competent laboratory vector of West Nile virus (Sardelis et al. 2001), and is believed to be a possible bridge vector of WNV to humans (Molaei et al. 2006). *Cx. salinarius* has also been implicated as a potential epidemic vector of Eastern equine encephalomyelitis virus in Massachusetts (Vaidyanathan et al. 1997), and displays moderate laboratory competence as a vector of Rift Valley Fever (Gargan et al. 1988).

***Culex (Culex) tarsalis* Coquillett** Color plate 15, p. 88
Alternate names: *Cx. willistoni* Giles, *Cx. kelloggii* Theobald

Identifying features: Unlike any other *Culex* in our area, the proboscis has a wide band of pale scales in the middle, and prominent white bands are visible at both the proximal and distal ends of the tarsal segments, overlapping the joints.

Look-alikes: *Coquillettidia perturbans* has a rather similar color pattern, but its broad, flat, salt-and-pepper wing scales are very different from the narrow, dark scales on the wings of *Cx. tarsalis.* The pale markings on the scutum may resemble the two pale spots of *Cx. restuans*, particularly in rubbed specimens, but *Cx. restuans* has a uniformly dark proboscis and pale bands only at the bases of each tarsal segment, not overlapping the joints.

Habitat: Favored breeding sites include flooded ditches and irrigation trenches, but larvae may also be found in marshes, woodland pools, ornamental ponds, and containers, in water ranging from clean to very foul. Geographically, the species is very common in the West, but relatively rare east of the Mississippi River.

Seasonality: Adult females hibernate in a variety of natural and artificial shelters during the winter, and breeding is continuous from late spring through early fall, with populations peaking in late summer (Carpenter and LaCasse 1955).

Feeding preference: Passerine birds are the primary blood hosts for this species, though they will occasionally feed on mammals as well; one study found a peak in mammal feeding by *Cx. tarsalis* in California in the late summer, possibly as a result of birds leaving nesting sites and thereby becoming less readily available (Tempelis et al. 1965).

Medical importance: In areas where it is common, *Cx. tarsalis* is one of the most important vectors of several arboviruses, including St. Louis encephalitis, Western equine encephalitis, and West Nile virus. It has also demonstrated high vector competence for Rift Valley Fever under laboratory conditions (Gargan et al. 1988).

***Culiseta (Culiseta) inornata* (Williston)** Color plate 16, p. 89
Alternate names: *Culex inornatus* Williston, *Cx. magnipennis* Felt, *Theobaldia inornata* Williston

Identifying features: A medium-sized to moderately large mosquito with broad, pale yellowish-brown markings.

Look-alikes: *Cs. impatiens* looks very similar, but the wing scales are uniformly dark, without the scattering of pale scales found in *Cs. inornata.* It should be noted that the males of *Cs. inornata* have few or no pale scales on the wings and legs. *Culiseta* in general are easily confused with *Culex* in general, as the prespiracular and under-wing bristles which distinguish *Culiseta* are often difficult to see, particularly for the beginner.

Habitat: Larvae may be found in temporary snowmelt pools in early spring, but in summer are more often associated with semipermanent or permanent bodies of water, which may be clean or foul.

Seasonality: Adult females hibernate in the winter and in some areas may also estivate in the summer, leading to two major population peaks per year, one each in early summer and early fall (Barr 1958). Breeding begins very early in the year, and adults may be active even when snow is on the ground.

Feeding preference: Preferred hosts are large mammals, including horses, cows, and occasionally humans (Anderson and Gallaway 1987). Females are capable of autogenous reproduction, producing small batches of eggs without taking a blood meal (Fox 1994). Biting takes place primarily during the day in the shade and at twilight (Owen 1937).

Medical importance: *Cs. inornata* is a competent vector of several arboviruses, including West Nile virus, St. Louis encephalitis, and Western equine encephalitis (Goddard et al. 2002). It is also capable of vertical transmission of Snowshoe Hare and LaCrosse encephalitis viruses (Schopen et al. 1991). It is considered a primary vector of Cache Valley encephalitis in some areas (Hayles and Lversen 1980).

***Orthopodomyia signifera* (Coquillett)** Color plate 17, p. 90
Alternate names: *Or. californica* Bohart

Identifying features: This is a very striking-looking mosquito, with brilliant white-on-black markings and strongly patterned wings with broad scales.

Look-alikes: The related species *Or. alba* is very difficult to distinguish from *Or. signifera* in the adult stage, although good specimens can be identified with a reasonable degree of certainty by examining the scales at the base of wing vein R_{4+5} just below its branch point with the radial sector vein. *Or. signifera* usually has a small patch of white scales at the base of this vein, while the basal portion of the vein is entirely dark-scaled in *Or. alba*. The larvae, however, are easily separated: the larva of *Or. signifera* is pink, while that of *Or. alba* is white or yellowish.

Habitat: Preferred breeding sites are deep rotholes in trees (Copeland and Craig 1990), though they will use artificial containers on occasion, and larvae have been collected from large trash cans containing rainwater and garden waste (Hanson et al. 1995).

Seasonality: Overwintering is apparently in the larval stages (Barr 1958), but all stages are sensitive to cold and larvae are seldom found in the northern parts of our region before midsummer, suggesting that these areas are repopulated annually by adults spreading northward from warmer southern areas (Copeland and Craig 1990).

Feeding preference: Unknown

Medical importance: This species has been shown to be a competent vector of the viruses of both Eastern and Western equine encephalitis (Chamberlain et al. 1954), and may play a role in enzootic transmission of these pathogens. However, since very little is known of the feeding habits and biology of *Or. signifera* in the wild, it is difficult to estimate its importance.

Psorophora (Psorophora) ciliata **(Fabricius)** Color plate 18, p. 91
Alternate names: *Culex ciliata* Fabricius, *Cx. cyanopennis* Von Humboldt, *Cx. molestus* Wiedemann, *Cx. rubidus* Robineau-Desvoidy, *Cx. tibialis* Robineau-Desvoidy, *Cx. boscii* Robineau-Desvoidy, *Cx. conterrens* Walker, *Ps. lynchi* Brethes, *Ps. ctites* Dyar

Identifying features: Size alone makes this species distinctive. With an average body length close to 2 centimeters from proboscis tip to abdominal cerci, this massive mosquito is difficult to mistake for any other in our region. Its color pattern of mustard yellow and deep brown to black is also uncommon, and the long, spiky scales on the hind legs stand out even to the naked eye.

Look-alikes: None. Once seen, *Ps. ciliata* is difficult to confuse with any other mosquito species. However, novice mosquito sorters have occasionally been known to overlook them when sorting out the contents of a trap, on the assumption that "anything that large cannot possibly be a mosquito."

Habitat: Larvae develop in open, sunlit pools, typically flooded ditches or depressions in pastures or the margins of woodlands (Siverly 1972). Eggs are laid in cracks in the ground and hatch when flooded the following year by rain or agricultural runoff (Schwardt 1939).

Seasonality: Overwintering is in the egg stage, and while hatching and development occur throughout the warm months from late spring through early fall, eggs do not appear to hatch in the same year that they are laid. Larvae develop rapidly, reaching full size (a length of approximately 12 mm) and pupating about 4-6 days after hatching (Schwardt 1939).

Feeding preference: *Ps. ciliata* has been observed to feed primarily on mammals, including rabbits (Almiron and Brewer 1995), livestock, and humans (Siverly 1972). Biting may occur at any time, with activity peaking around sunset. Larvae are predatory, feeding mostly on other mosquito larvae, including others of their own species (Siverly 1972).

Medical importance: The actual medical impact of this species is relatively limited. While some wild specimens have been found to be infected with West Nile virus (CDC 2005) and with Tensaw virus (Wozniak et al. 2001), a minor arbovirus not known to cause human illness, *Ps. ciliata* has not been implicated as a significant vector of any pathogen. It also seldom attains the vast abundance necessary to be considered a true nuisance pest, though it may be common in some areas. However, vector control programs often receive calls from the public regarding these "giant mosquitoes" simply because their size is alarming and their bites can be painful.

They are persistent biters (Matheson (Matheson 1929) calls them "vicious"), and may be troublesome to campers, agricultural workers, and others who spend time outdoors near breeding sites.

***Psorophora (Grabhamia) columbiae* (Dyar and Knab)** Color plate 19, p. 92
Alternate names: *Janthinosoma columbiae* Dyar and Knab, *Ps. confinnis* (Lynch Arribálzaga), *Jan. texanum* Dyar and Knab, *Jan. floridense* Dyar and Knab, *Jan. toltecum* Dyar and Knab

Identifying features: This is one of the larger species of mosquitoes, though not in the same size class as its cousin, the 2-centimeter-long *Ps. ciliata*. *Ps. columbiae* is speckled with dark and light scales in an elaborate and fairly distinctive pattern; the rows of bright white spots along the tibiae are particularly unusual.

Look-alikes: None.

Habitat: Temporary pools, often in pastures or similar overgrown grassy habitats, or in flooded ditches with overhanging vegetation. This is a very common mosquito in rice fields in the southern United States, and is usually found in rural areas in association with livestock, though it may also breed in residential areas, making use of artificial containers.

Seasonality: Overwintering is in the egg stage, and there are two or more generations per year. Development is rapid, with the larval period usually requiring 4-10 days (Carpenter and LaCasse 1955).

Feeding preference: Large mammals. A study of feeding habits in Texas ricefields found that *Ps. columbiae* fed preferentially on cattle, with horses as a second choice (Kuntz et al. 1982).

Medical importance: This species can be an incredible nuisance to both man and livestock; in some areas of the South where *Ps. columbiae* is particularly abundant, there have even been reports of livestock deaths due to blood loss from these bites (Carpenter and LaCasse 1955). This species (classified as *Ps. confinnis* at the time) was implicated as an important vector of Venezuelan equine encephalitis during an outbreak in southern Texas and northern Mexico in 1971 (Olson and Grimes 1974), and a laboratory study found that specimens fed on viremic horses had high infection and transmission rates (28% and 33%, respectively) for this virus under experimental conditions (Sudia et al. 1971).

***Psorophora (Janthinosoma) ferox* (Von Humboldt)** Color plate 20, p. 93
Alternate names: *Culex ferox* Von Humboldt, *Cx. posticatus* Wiedemann, *Cx. musicus* Say, *Janthinosoma musica* Say, *Jan. echinata* Grabham, *Jan. sayi* Dyar and Knab, *Jan. terminalis* Coquillett, *Jan. vanhalli* Dyar and Knab, *Jan. coquillettii* Theobald, *Jan. sayi* Theobald, *Jan. jamaicensis* Theobald, *Aedes pazosi* Pazos, *Jan. centrale* Brethes

Identifying features: A fairly large species with a distinctive metallic-purple abdomen and bright white "socks" on its hind tarsi. The thorax is dark-scaled, with a fairly even sprinkling of bright gold scales across the entire upper surface.

Look-alikes: *Psorophora horrida* has almost the same markings, but while *Ps. ferox* has its golden scales scattered more or less evenly across the surface of the thorax, *Ps. horrida* has a broad stripe of uninterrupted dark scales running down the midline. Specimens should be checked very carefully to ensure that these dark scales are actually present; thoracic scales are often knocked off by collection equipment, and the resulting broad, dark, bare stripe can render a damaged *Ps. ferox* almost identical to *Ps. horrida.* Other characteristics useful for distinguishing these two species include the small patch of scales at the center of the first abdominal tergite, which are purple in *Ps. ferox* and creamy white in *Ps. horrida,* the presence of a large patch of grayish-white scales on the median side of the torus in *Ps. horrida* which is absent or limited to a few tiny scales in *Ps. ferox*, and the presence of a large patch of white scales below the spiracle in *Ps. ferox* which is absent in *Ps. horrida* (Harrison and Whitt 1996).

Habitat: Larval development usually takes place in temporary pools such as flooded woodland depressions and roadside ditches, generally in somewhat wooded areas (Siverly 1972, Guimaraes et al. 2000b). The author has encountered numerous blood-seeking adults of this species while investigating a pile of old automobile tires in deciduous woodland in northern Indiana. No larvae of *Ps. ferox* were recovered from the tire samples on this occasion, but this species is notorious for evading capture by hiding under leaves and other debris at the bottom of pools (Siverly 1972).

Seasonality: Overwintering is in the egg stage, and there are multiple generations per year, with abundance varying with rainfall.

Feeding preference: Large mammals (Cupp et al. 2004a), including humans, though a small percentage of blood meals in wild-caught engorged specimens were derived from passeriform birds (Magnarelli 1977). Females of this species bite primarily during the day (Guimaraes et al. 2000a) and are extremely persistent pests (Smith 1904).

Medical importance: This species is often a major nuisance, but a minor vector. Wild-caught *Ps. ferox* have occasionally been found to be infected with West Nile virus, but the species is not believed to play a significant role in WNV transmission (Kulasekera et al. 2001, Andreadis et al. 2004). It is also a competent vector of Eastern equine encephalomyelitis virus (Chamberlain et al. 1954), and has been found to be infected with this virus at very low rates in the wild (Cupp et al. 2004a), but it is not believed to be a significant natural vector of this virus, either.

Ps. ferox has a large geographic range, and foreign populations of this species have been found to be infected with pathogens not currently known to occur in the United States, including Rocio virus in Brazil (de Souza Lopes et al. 1981) and Ilheus virus in Peru (Turell et al. 2005). It has also been shown to be capable of transmitting Venezuelan equine encephalomyelitis virus under laboratory conditions (Chamberlain et al. 1956).

In Central America, *Ps. ferox* is a major vector of the human botfly, *Dermatobia hominis* (Bates 1943), which glues its eggs to the bodies of mosquitoes and similar insects for transport to suitable warm-blooded hosts. The eggs hatch when stimulated by the body heat of the host when the mosquito takes a blood meal, and the larvae burrow under the host's skin and remain there during development, feeding on the subcutaneous tissues. The vast majority of human botfly infestations in the United States are found in travelers returning from endemic countries (Massey and Rodriguez 2002, Lane et al. 2005, Boruk et al. 2006, Bhandari et al. 2007, Garvin and Singh

2007), but a recent report of a *D. hominis* larva found in a child in Florida with no travel history (Price et al. 2007) suggests that the insect's range may be expanding.

***Toxorhynchites (Lynchiella) rutilus septentrionalis* (Dyar and Knab)** Color plate 21, p. 94
Alternate names: *Megarhinus rutilus* Coquillett, *M. herrickii* Theobald

Identifying features: This large species is arguably one of our most beautiful mosquitoes, with brilliant metallic colors rivaled only by some members of the genus *Psorophora.* The abdomen is metallic green, shading to blue at the tip, with golden-yellow half-moon-shaped lateral spots on each segment. The thorax, head, and legs are primarily purplish marked with white or pale gold; the pale markings on the thorax are iridescent and reflect various shades of green. The proboscis is much more tapered than in any other genus, and is usually strongly curved downward by approximately 90°. The rear margin of the wing is strongly indented, giving it a lobed appearance distinct from the smooth curve of most species.

Look-alikes: Several species in the genus *Psorophora* are similarly large and colorful mosquitoes with similar markings, but none of these possess the tapered, curved proboscis or lobed wing of *Toxorhynchites.*

Habitat: Larvae are typically found in small bodies of water in treeholes, bromeliads or manmade containers. Eggs are laid singly on the surface of the water, and only a small number will be deposited in any given site. Larval cannibalism further reduces the population, so a collector may often find only one larva per pool. Adults are similarly uncommon throughout their range, which includes primarily the southern United States, and are most often found sunning themselves or feeding on flower nectar in wooded areas near their larval habitat.

Seasonality: Overwintering appears to be either in the adult or late larval stages. Due to the scarcity of this species, little has been published regarding its seasonal distribution.

Feeding preference: *Toxorhynchites* is a strict vegetarian in the adult stage and feeds only on nectar. The larvae are predators and will eat small aquatic invertebrates, including other mosquito larvae, and have also been observed to capture and eat adult *Drosophila* which had landed on the water's surface (Breland 1949). This carnivorous diet allows the larvae to store enough protein for the adult females to develop eggs without taking a blood meal.

Medical importance: If anything, *Toxorhynchites* is a species of positive medical benefit through its habit of eating the larvae of other, potentially harmful mosquito species. Due to its scarcity, however, its impact is probably negligible. The adults have no known medical importance.

***Uranotaenia (Uranotaenia) sapphirina* (Osten Sacken)** Color plate 22, p. 95
Alternate names: *Aedes sapphirina* Osten Sacken, *Ur. coquilletti* Dyar and Knab

Identifying features: This is a very small mosquito which may be overlooked when sorting through the contents of a trap. Once spotted and placed under a magnifying lens, it is easily identified by the presence of lines of brilliant sapphire-blue scales on the midline of the thorax, the back of the head, and the bases of the wings.

Look-alikes: None. Size alone will distinguish this species from almost all others found in our area, and the sapphire scales are unique.

Habitat: *Ur. sapphirina* larvae are usually to be found in wetlands and swamps, among the vegetation close to the shores of permanent and semi-permanent bodies of water. Adults rest during the day in moist, sheltered areas such as rotting logs, treeholes, and culverts, taking flight around dusk.

Seasonality: Adult females hibernate through the winter in shelters such as caves, emerging in spring to lay egg rafts on the surface of the water. There are multiple generations per year, with populations building to a peak in late summer.

Feeding preference: Unknown. It has been speculated that, like other *Uranotaenia*, this species may feed primarily on reptiles and amphibians, but attempts at bloodmeal identification in wild-caught specimens have generally had a low success rate. Only two blood meals out of 35 were successfully identified for this species in an Alabama study; both were derived from bullfrogs, *Rana catesbeiana* (Cupp et al. 2004b). Two others, from an attempted 120 captured in North Carolina, were identified as being derived from an unknown species of reptile (Irby and Apperson 1988).

Medical importance: Also unknown. Since it rarely, if ever, bites humans or domestic animals, its direct influence on human health and quality of life is probably negligible. It is possible, however, that *Ur. sapphirina* may be involved in enzootic transmission of pathogens of human interest. A surveillance project in Alabama found individuals of this species to be infected with Eastern equine encephalitis virus in each of the three years of the study, at minimum field infection rates ranging from 0.44 to 9.3 per thousand (Cupp et al. 2004b). It has also been found to be infected with West Nile virus in the wild (Andreadis et al. 2004).

***Wyeomyia (Wyeomyia) smithii* (Coquillett)** Color plate 23, p. 96
Alternate names: *Aedes smithii* Coquillett, *Wy. haynei* Dodge

Identifying features: The dark dorsal surface of the abdomen meets the pale scaling of the ventral surface in a nearly straight line, with no banding or spotting. This small mosquito is primarily clothed in dark brown scales with a slight metallic reflection, except for the silvery pronotal lobes on the anterior thorax, which reflect a violet iridescence, and the silvery or yellowish-white underside. Live adults assume an unusual posture when resting, with the hind tarsi curved up and forward over the back as though practicing yoga. Habitat is also an important clue to identification of this species, which is the only mosquito in our region known to breed exclusively in the water-filled leaves of pitcher plants.

Look-alikes: There is some confusion over the classification of this species. For many years, the temperate American species of *Wyeomyia* were divided into two: *Wy. smithii* in the north, including all of the region covered by this book, and *Wy. haynei* in the southern United States.

More recent studies have suggested that all of the *Wyeomyia* in the USA comprise a single species, *Wy. smithii*, which simply displays different physical and behavioral characteristics in different parts of its range (Bradshaw and Lounibos 1977, Bradshaw and Holzapfel 1983, Mahmood and Crans 1999). The southern populations traditionally classified as *Wy. haynei* have a patch of silvery scales on the scutellum, which is uniformly dark in northern populations of *Wy. smithii*.

Sexes are more difficult to differentiate in this than in other genera, as all adult *Wyeomyia* of both sexes possess short palpi and moderately plumose antennae. The genitalia are, however, readily differentiated under magnification.

Habitat: Eggs are laid inside the leaves of the pitcher plant, *Sarracenia purpurea*, and the larvae develop in the small pools of water that form in these leaves (Carpenter and LaCasse 1955). Adults, therefore, are generally to be found only in the vicinity of bogs and wetlands where pitcher plants grow.

Seasonality: Overwintering is in the third larval stage; as temperatures rise in spring, these larvae molt to the fourth instar, which may then undergo a second diapause until the days become long enough to support active growth and pupation (Lounibos and Bradshaw 1975). Third-instar larvae can survive freezing as long as temperatures do not drop below approximately -14°C (Owen 1937) and may become active during the day in leaves thawed by winter sunlight (Haufe 1952, Carpenter and LaCasse 1955). Winter larvae begin to pupate in late spring, and breeding is continuous throughout the summer, producing several overlapping generations.

Feeding preference: Females in our region are autogenous and do not require a blood meal to develop and lay multiple clutches of eggs (O'Meara 1981). There have been no reports of feeding on humans or any other animal in the wild; researchers who have worked with this species in the laboratory report that it very rarely attempts to bite, and that these attempts, when they do occur, are very weak and ineffectual (B. St. Laurent, personal communication). Females of the southern type once classified as *Wy. haynei*, however, produce a single batch of eggs autogenously and then require blood in order to produce subsequent batches. Among these populations, which range from the Carolinas through the Gulf Coast states, feeding has been observed on humans and on an eastern box turtle, *Terrepene carolina* (Bradshaw 1980).

Medical importance: None known. As *Wy. smithii* does not feed on blood in our area, it can have no direct impact on human health, and it is unlikely that this species plays any role in enzootic transmission of pathogens. It is possible that the southern populations which do feed on blood may be capable of serving as vectors, but the relative infrequency of biting combined with the highly specialized habitat of these mosquitoes makes this risk minimal. *Wy. smithii* is currently regarded primarily as a subject of scientific curiosity rather than of medical concern.

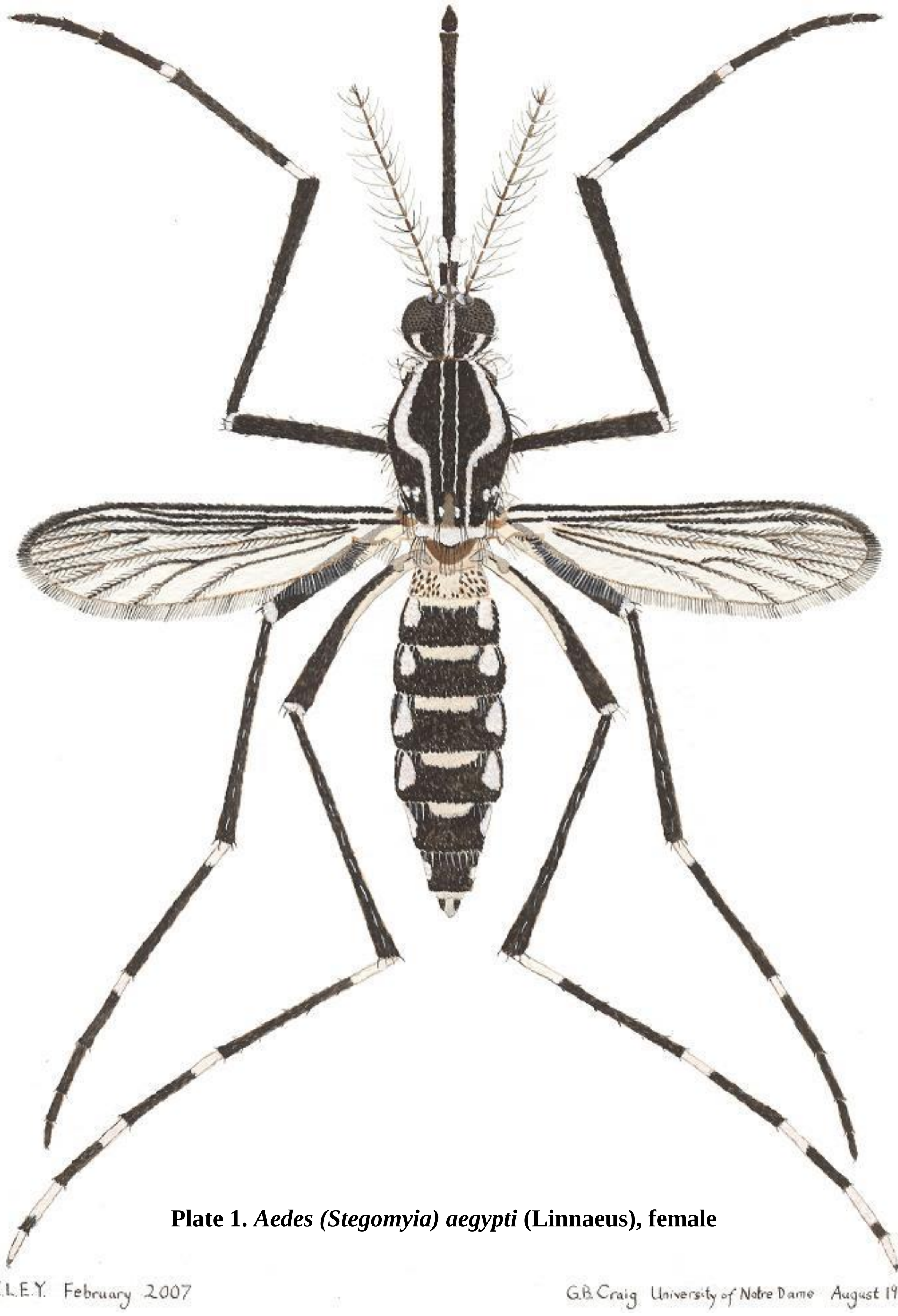

Plate 1. ***Aedes (Stegomyia) aegypti*** **(Linnaeus), female**

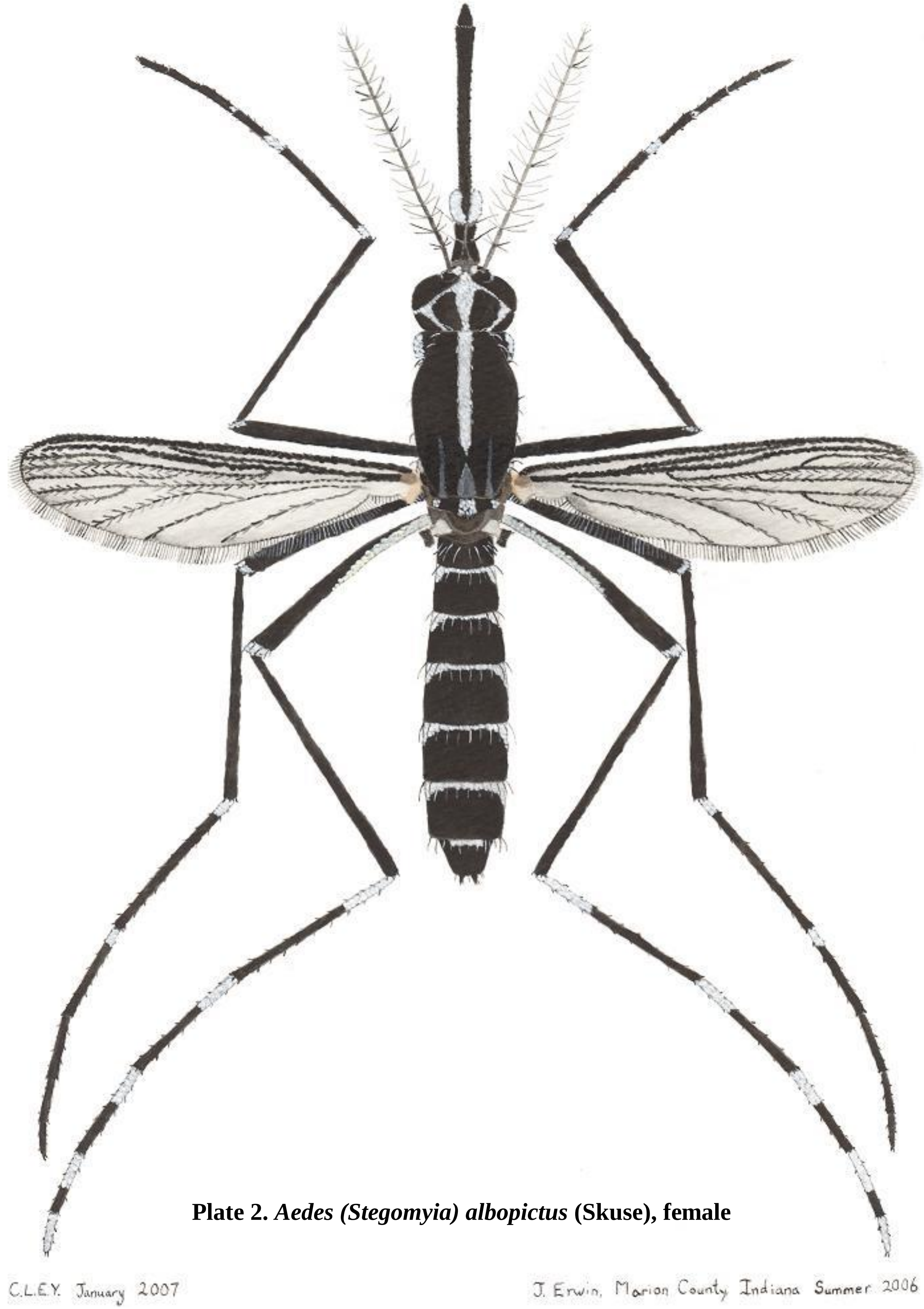

Plate 2. ***Aedes (Stegomyia) albopictus*** **(Skuse), female**

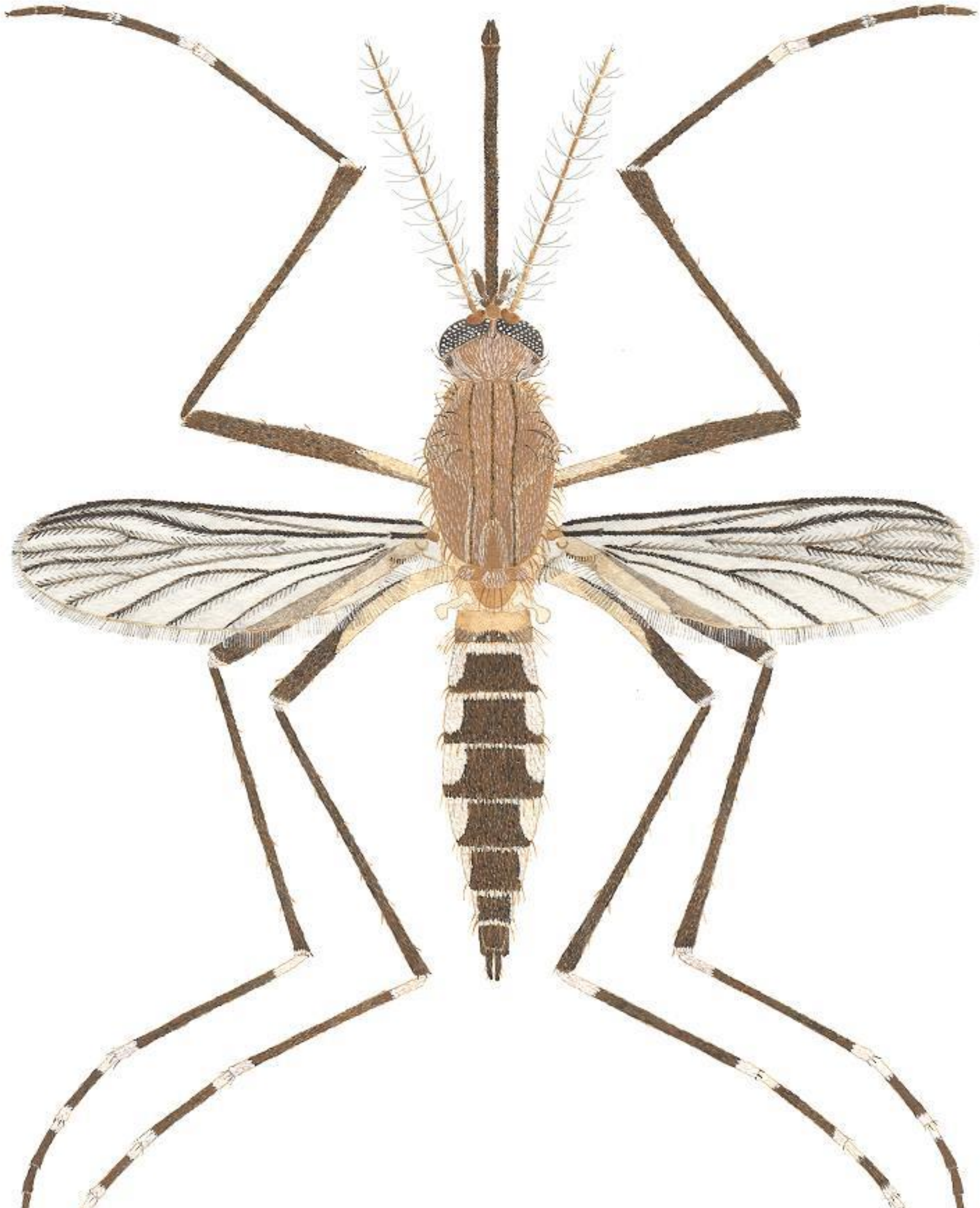

Plate 3. ***Aedes (Ochlerotatus) canadensis*** **(Theobald), female**

C.L.E.Y. April 2007

G.B. Craig, Gogebic County, Michigan, May 1974

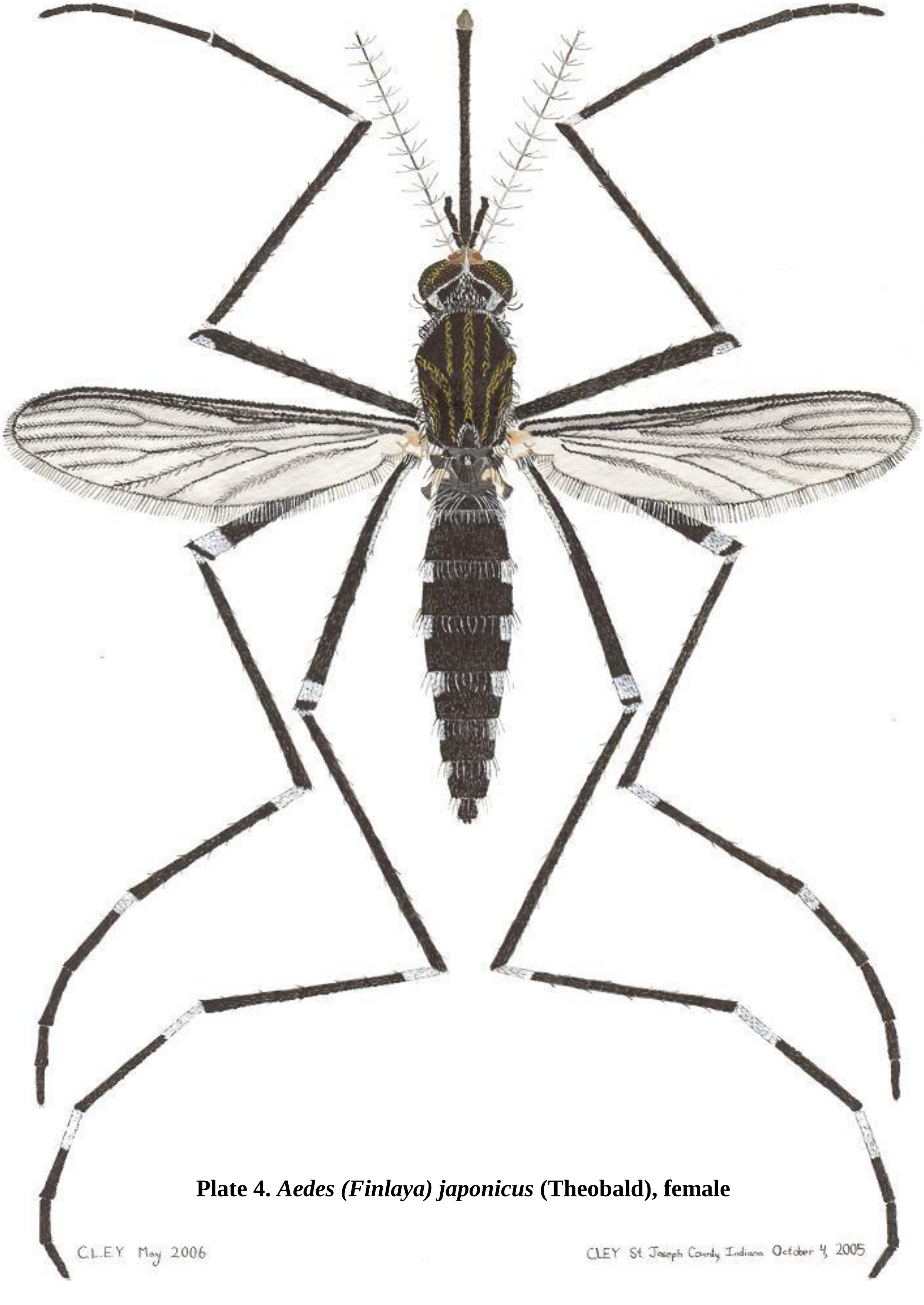

Plate 4. ***Aedes (Finlaya) japonicus*** **(Theobald), female**

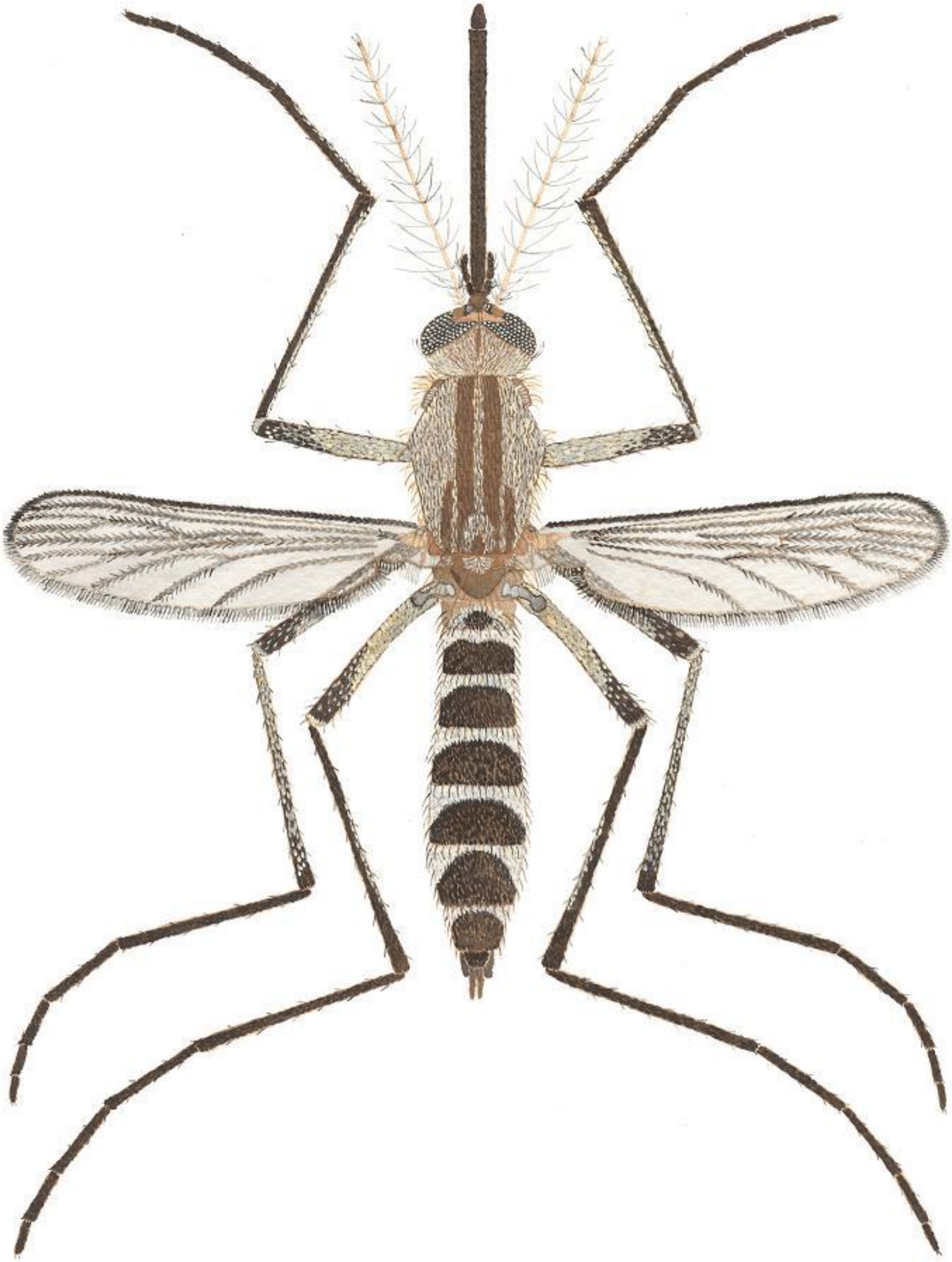

Plate 5. ***Aedes (Ochlerotatus) sticticus*** **(Meigen), female**

C.L.E.Y. May 2007

C.L.E.Y. St. Joseph County, Indiana June 17 2003

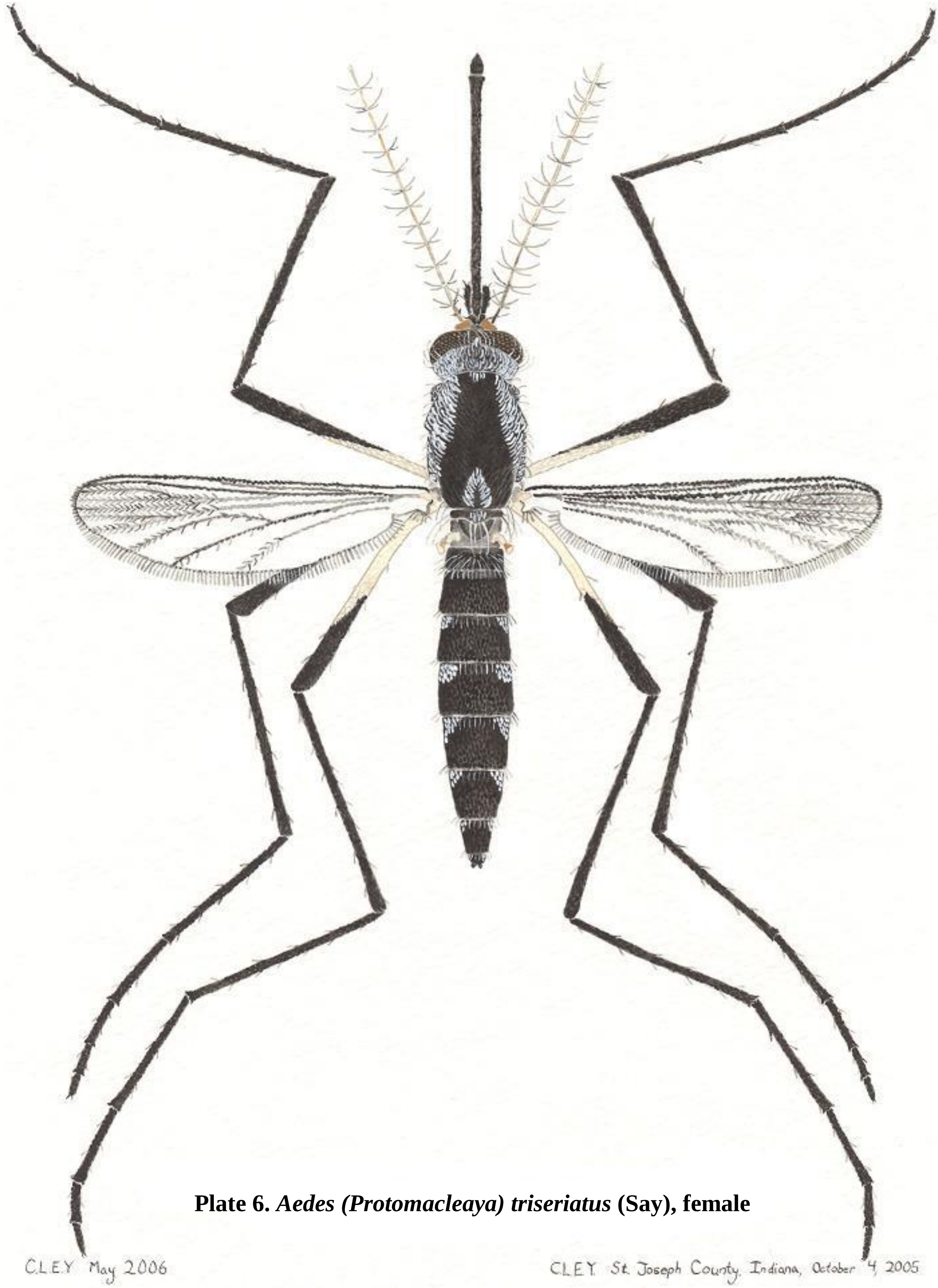

Plate 6. ***Aedes (Protomacleaya) triseriatus*** **(Say), female**

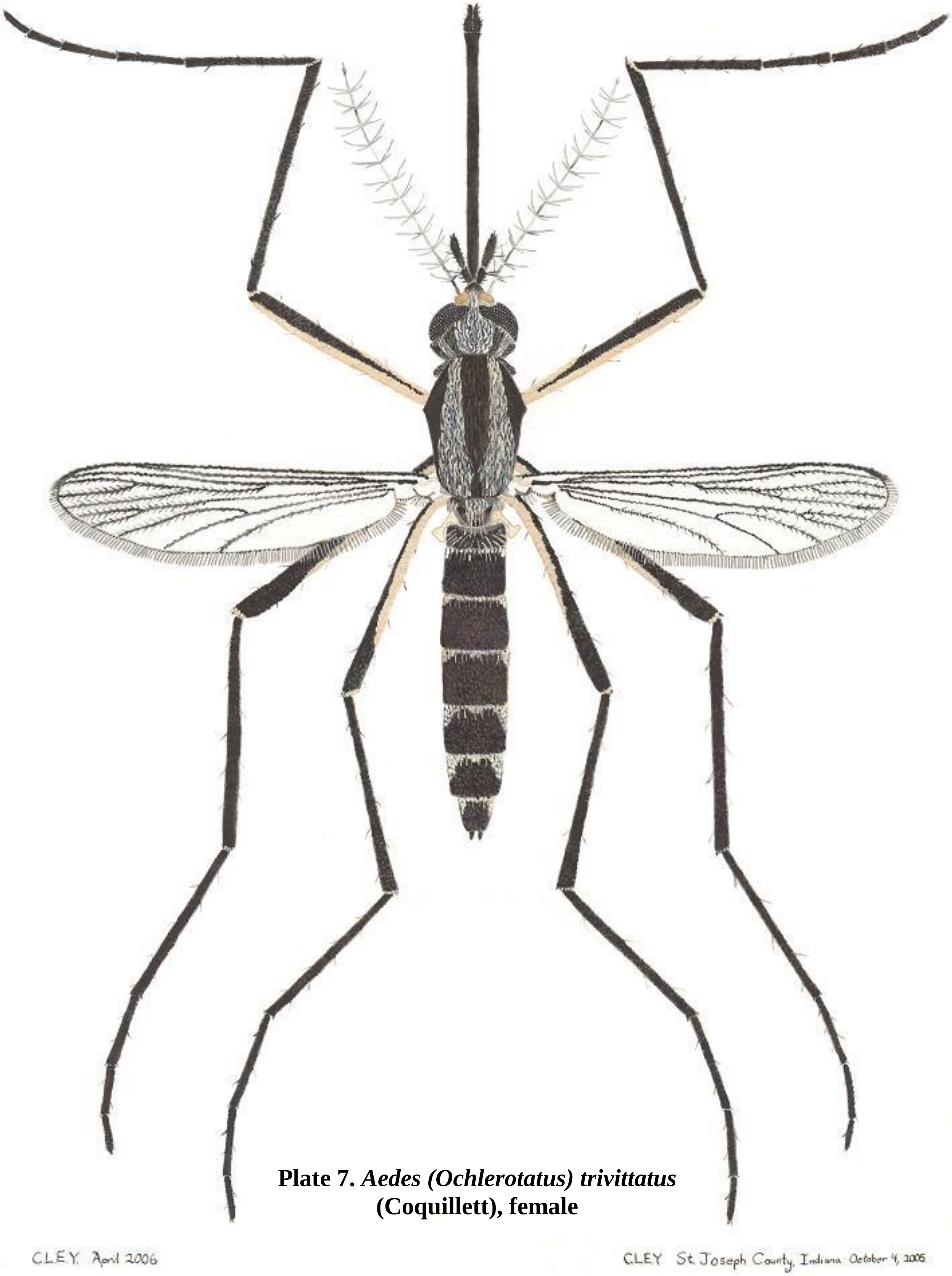

Plate 7. ***Aedes (Ochlerotatus) trivittatus***
(Coquillett), female

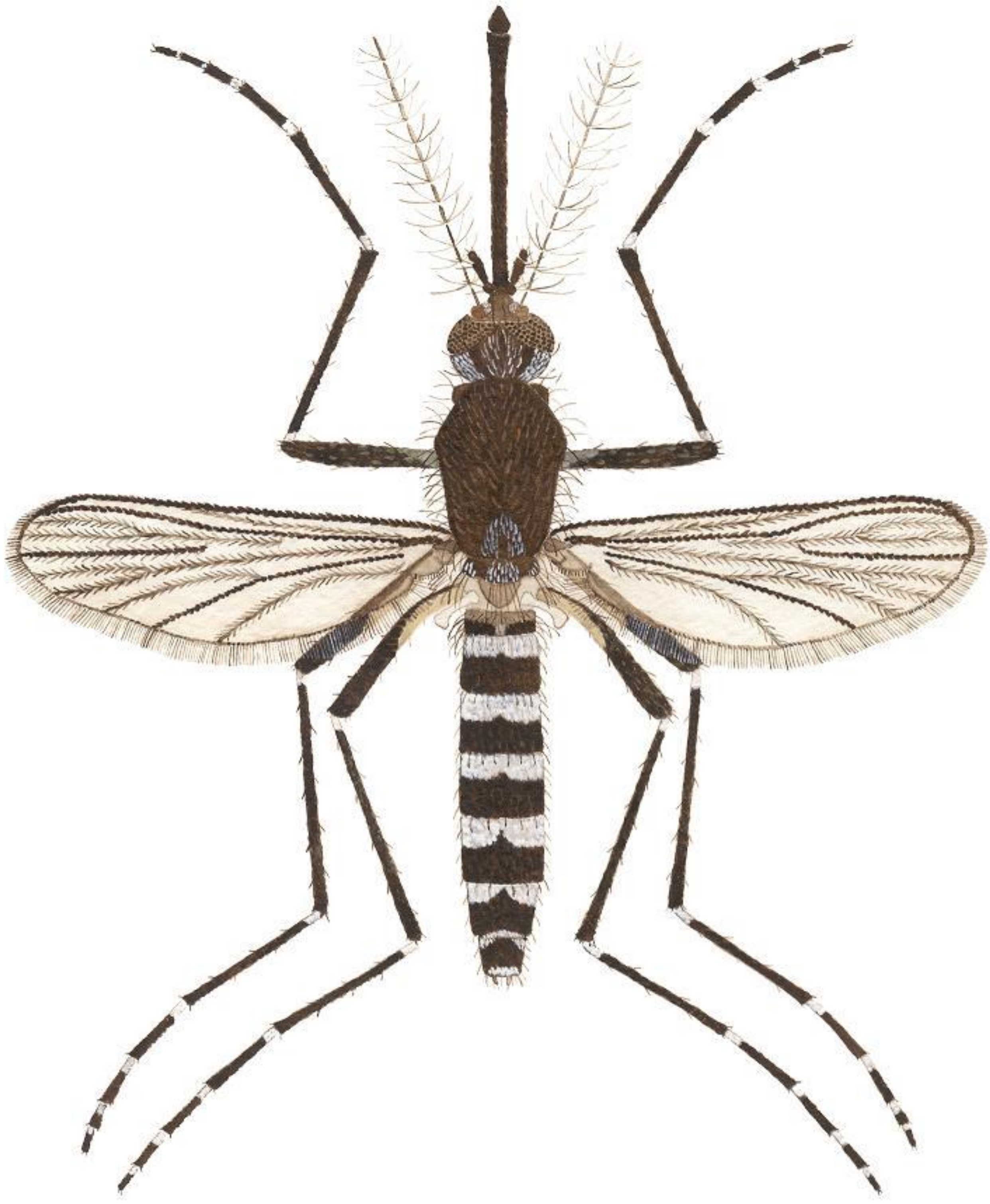

Plate 8. ***Aedes (Aedimorphus) vexans*** **(Meigen), female**

C.L.E.Y. November 2007

C.L.E.Y. St. Joseph County, Indiana September 21, 2005

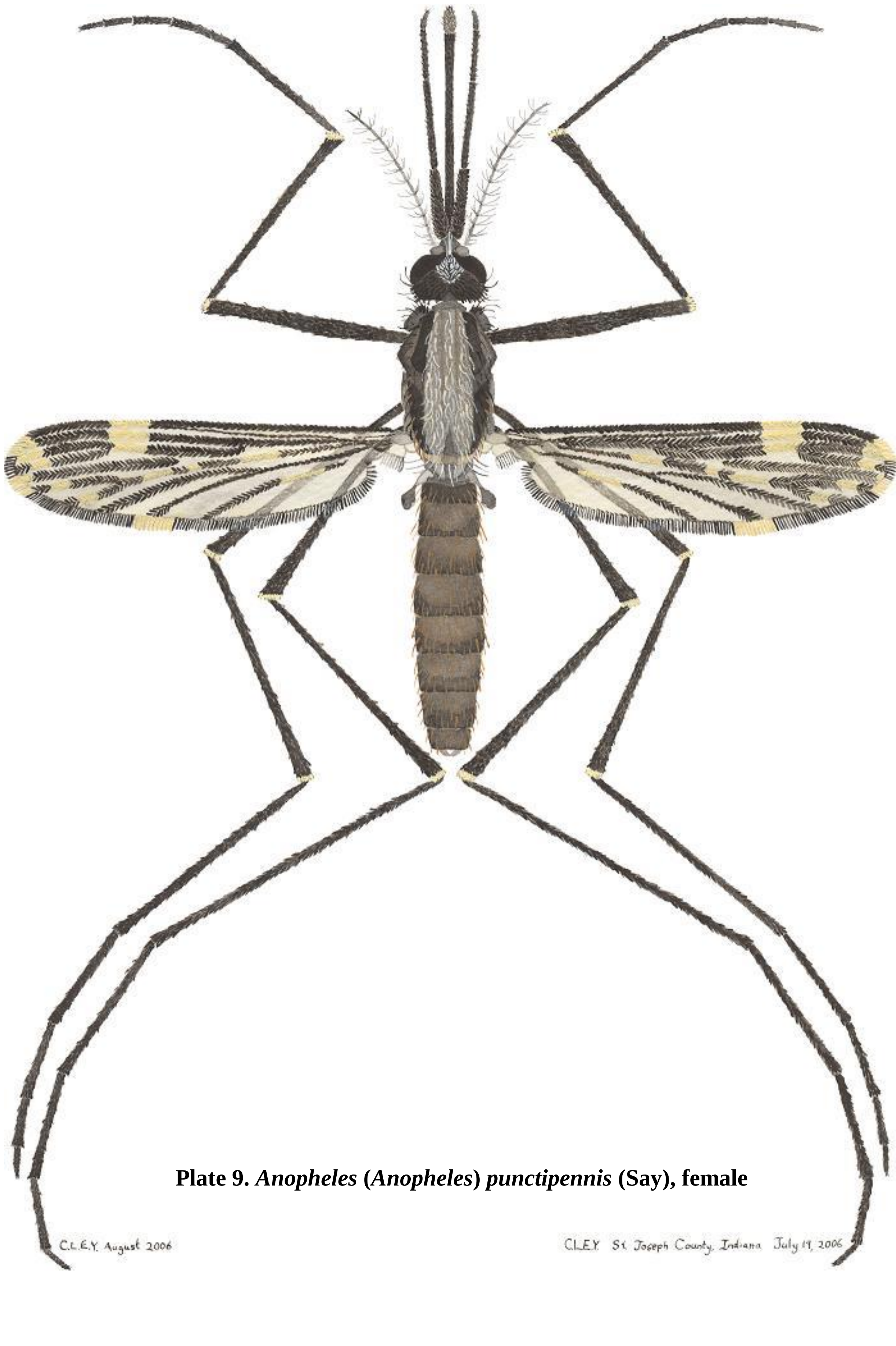

Plate 9. *Anopheles* (*Anopheles*) *punctipennis* (Say), female

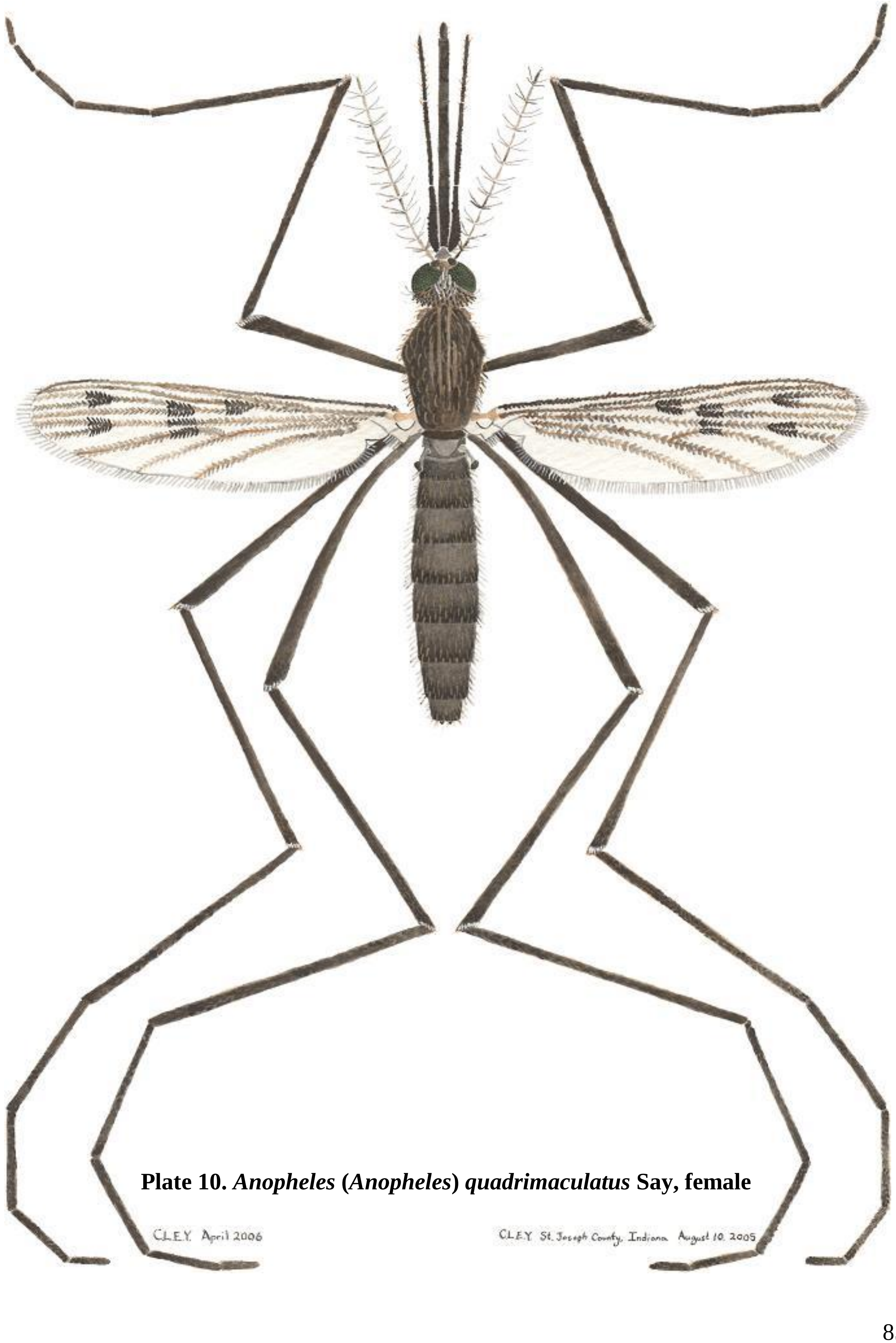

Plate 10. ***Anopheles*** **(*Anopheles*)** ***quadrimaculatus*** **Say, female**

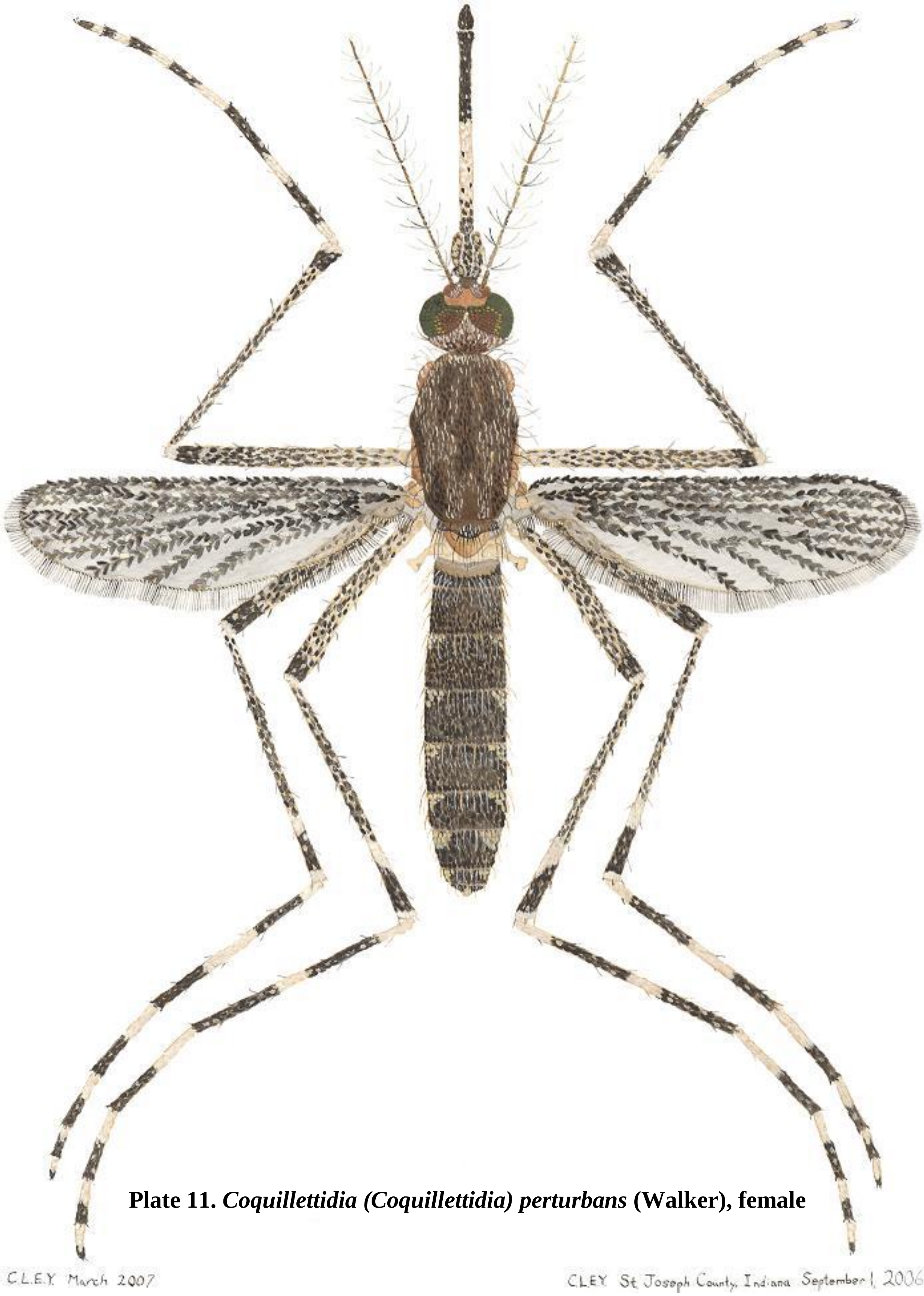

Plate 11. ***Coquillettidia (Coquillettidia) perturbans*** **(Walker), female**

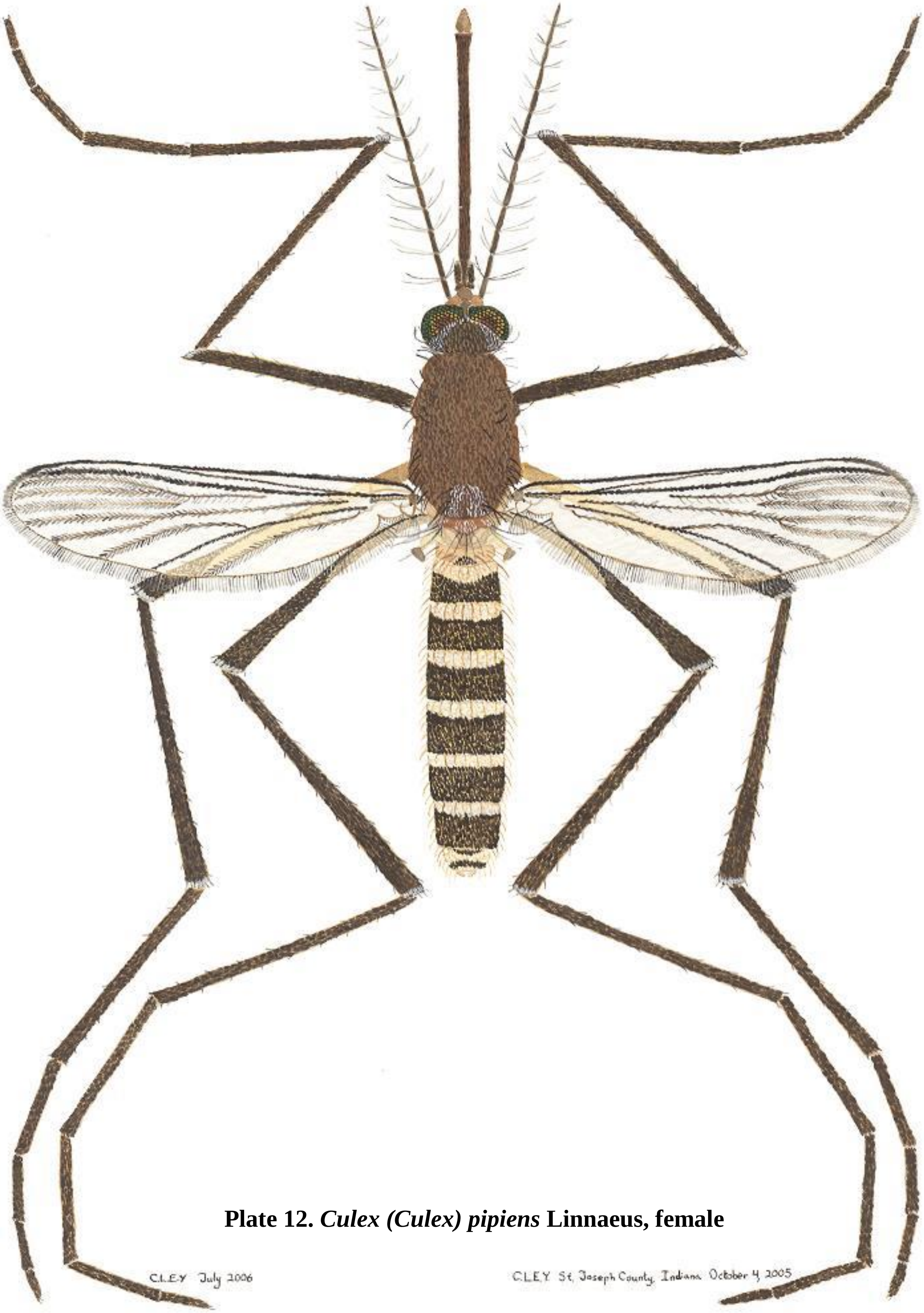

Plate 12. ***Culex (Culex) pipiens*** **Linnaeus, female**

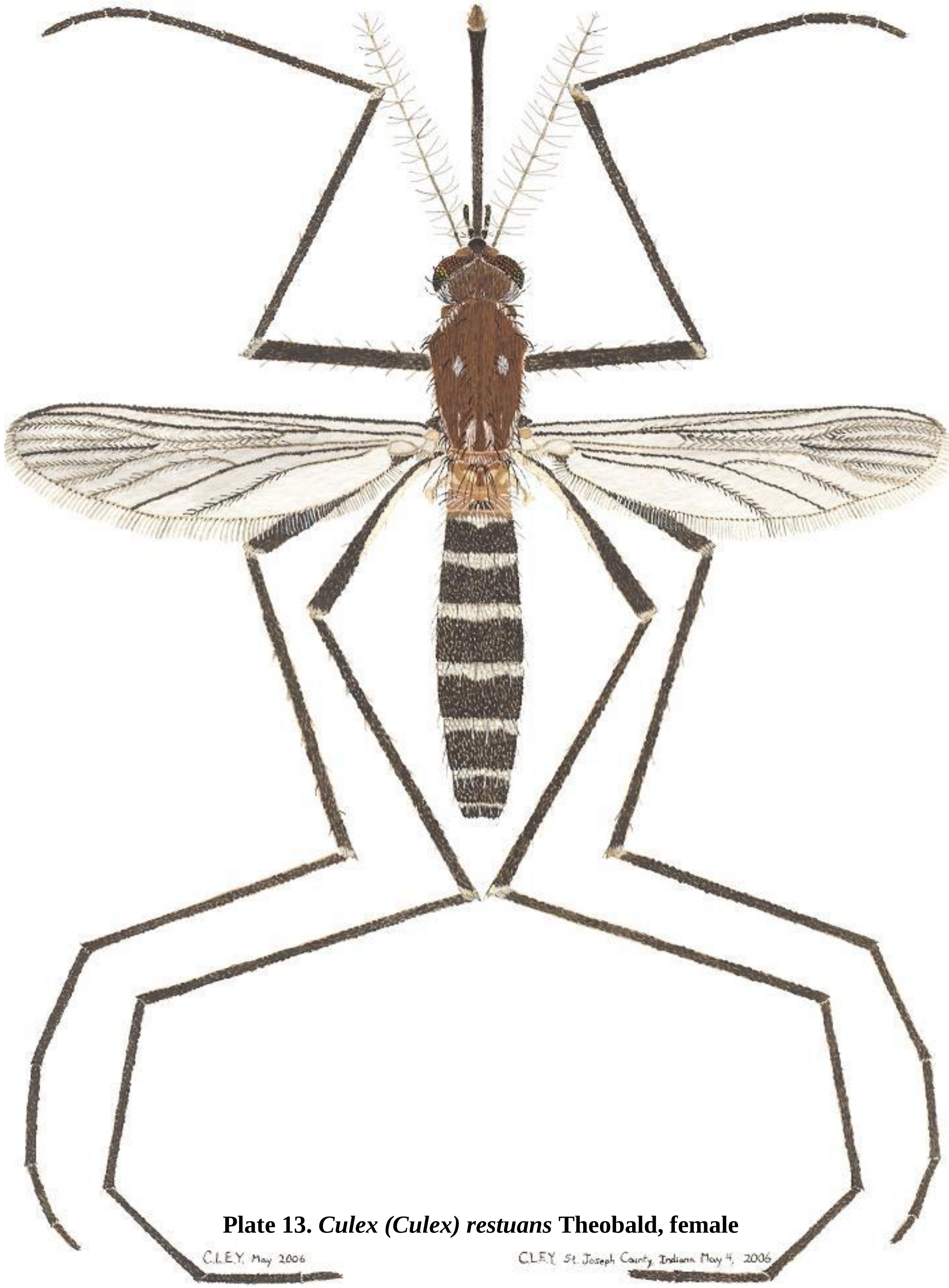

Plate 13. ***Culex (Culex) restuans*** **Theobald, female**

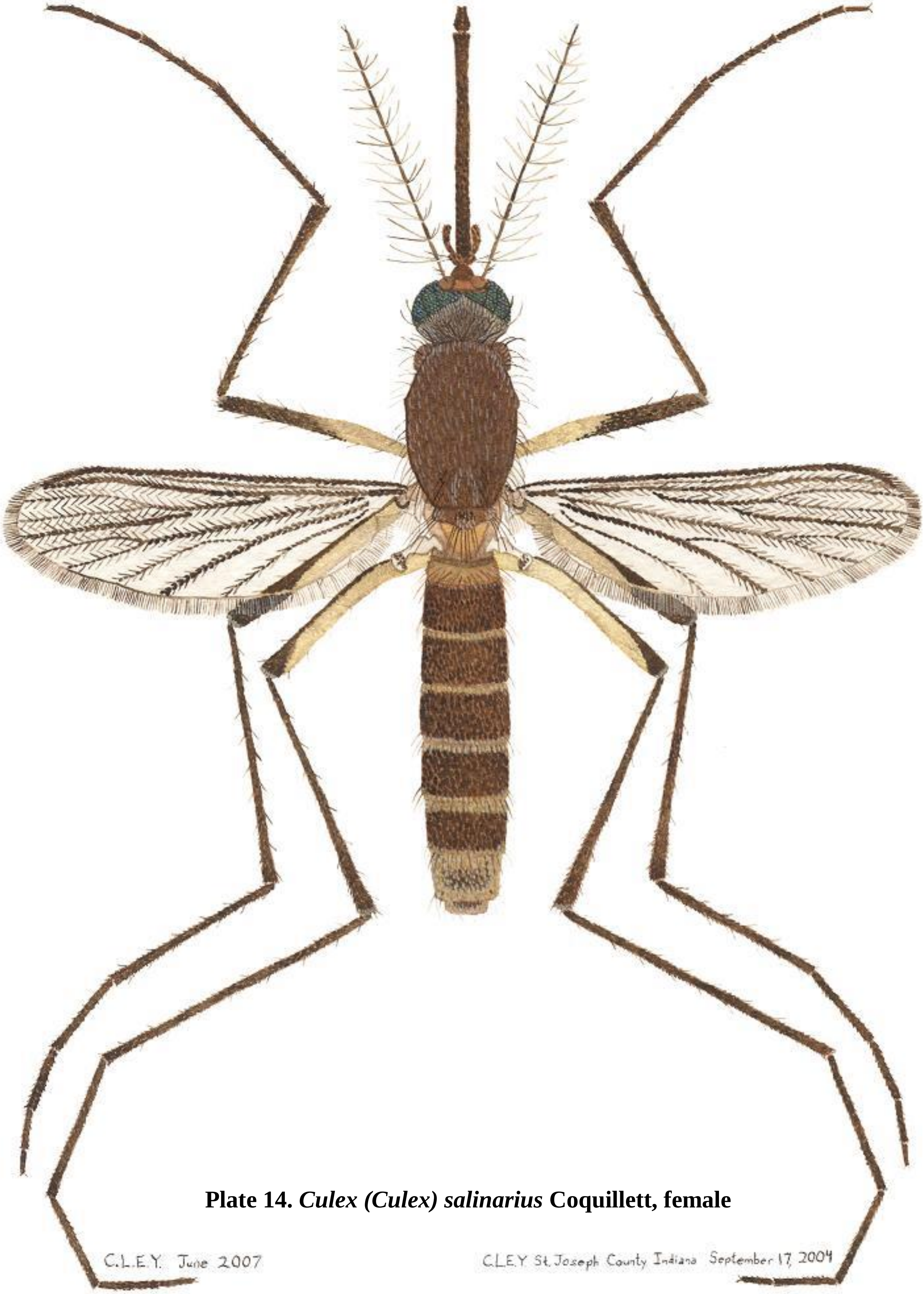

Plate 14. ***Culex (Culex) salinarius*** **Coquillett, female**

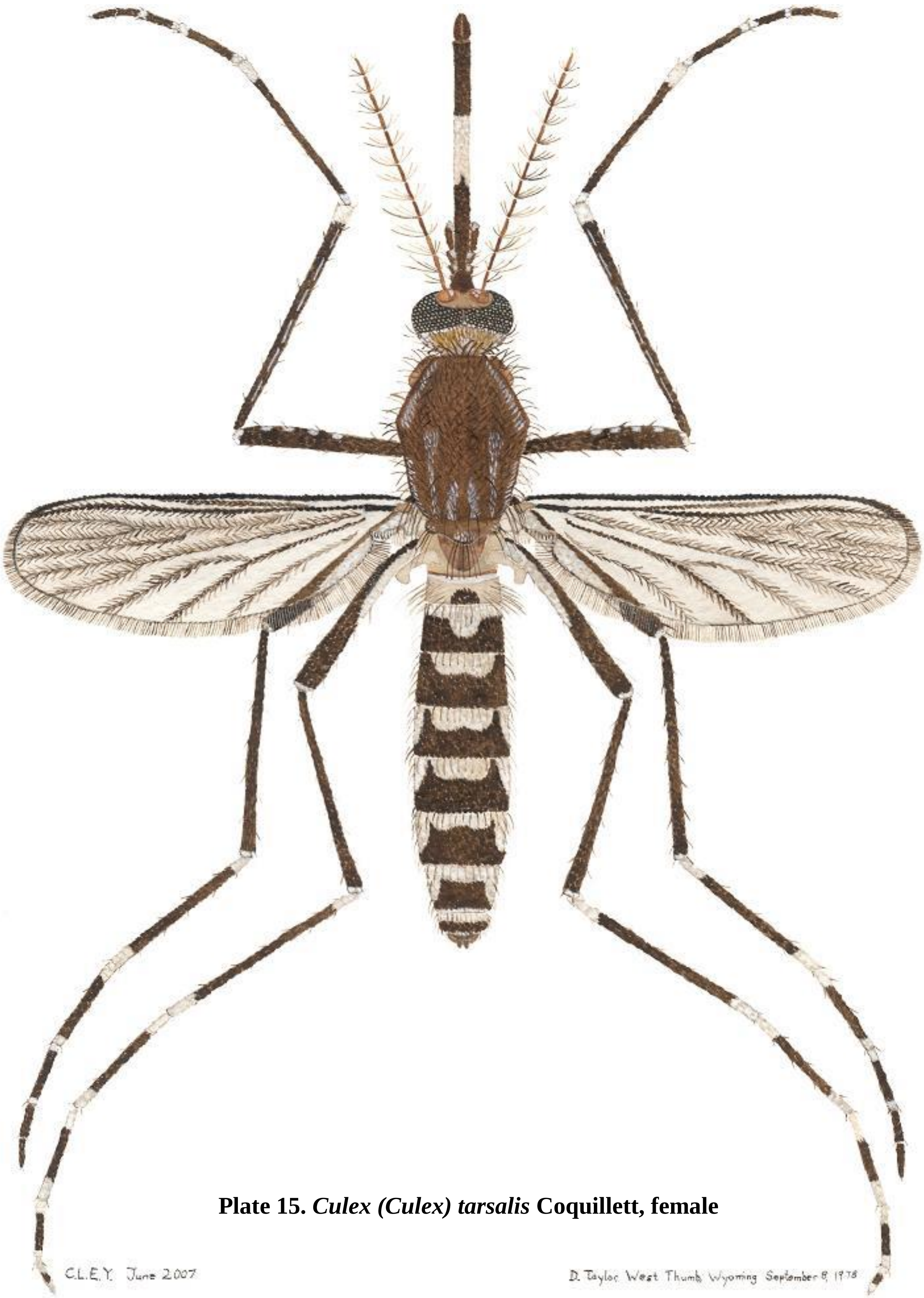

Plate 15. ***Culex (Culex) tarsalis*** **Coquillett, female**

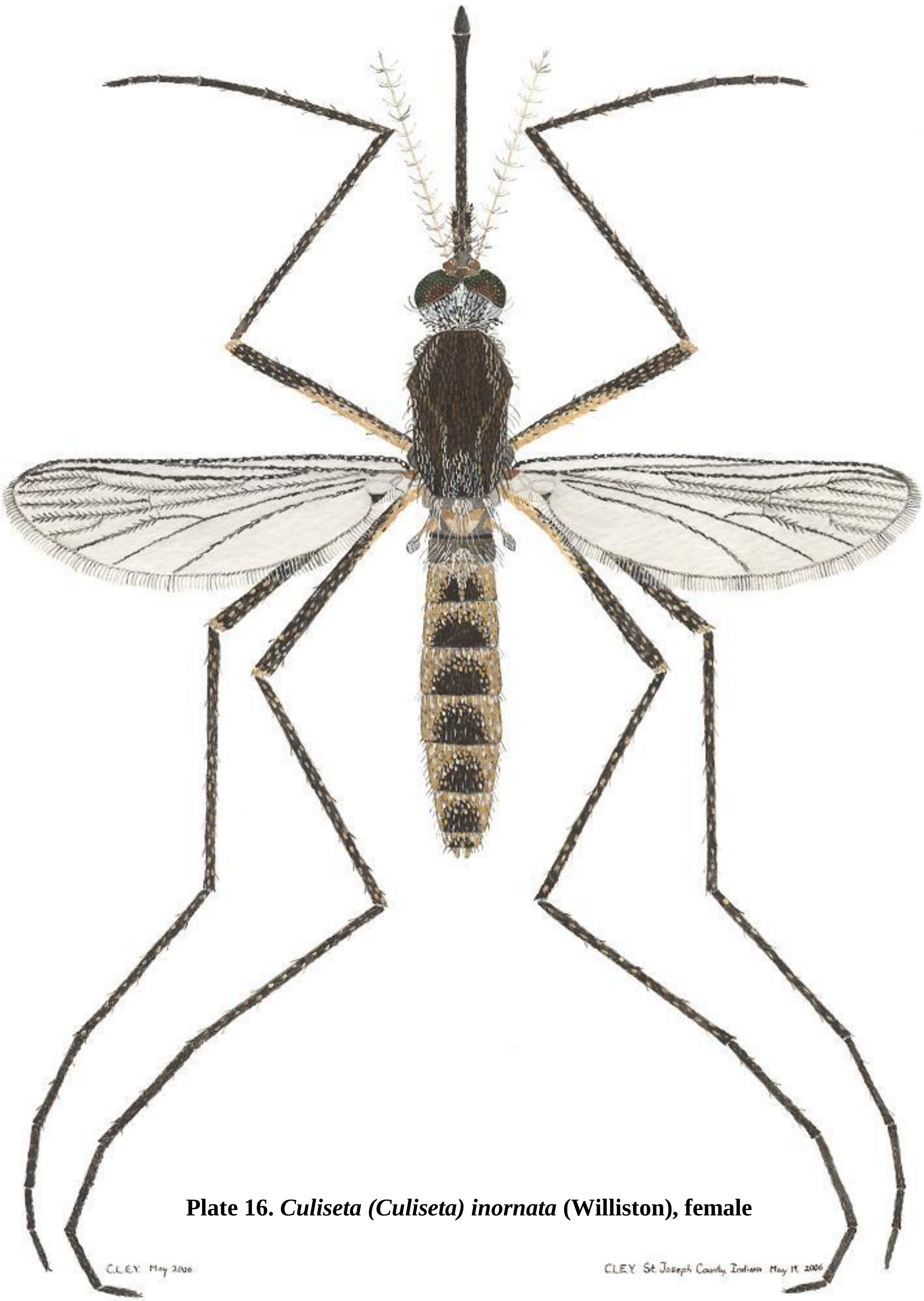

Plate 16. ***Culiseta (Culiseta) inornata*** **(Williston), female**

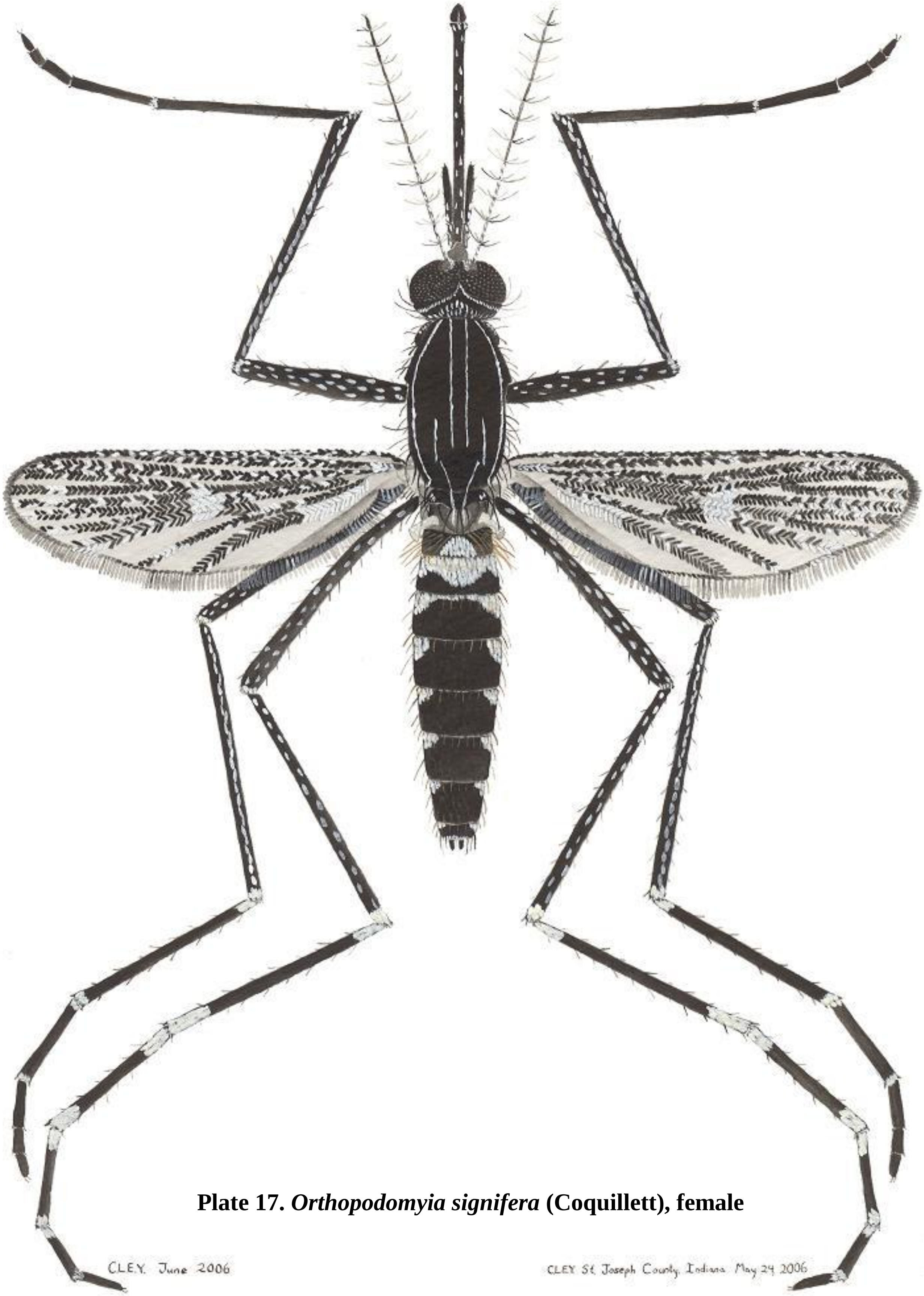

Plate 17. ***Orthopodomyia signifera*** **(Coquillett), female**

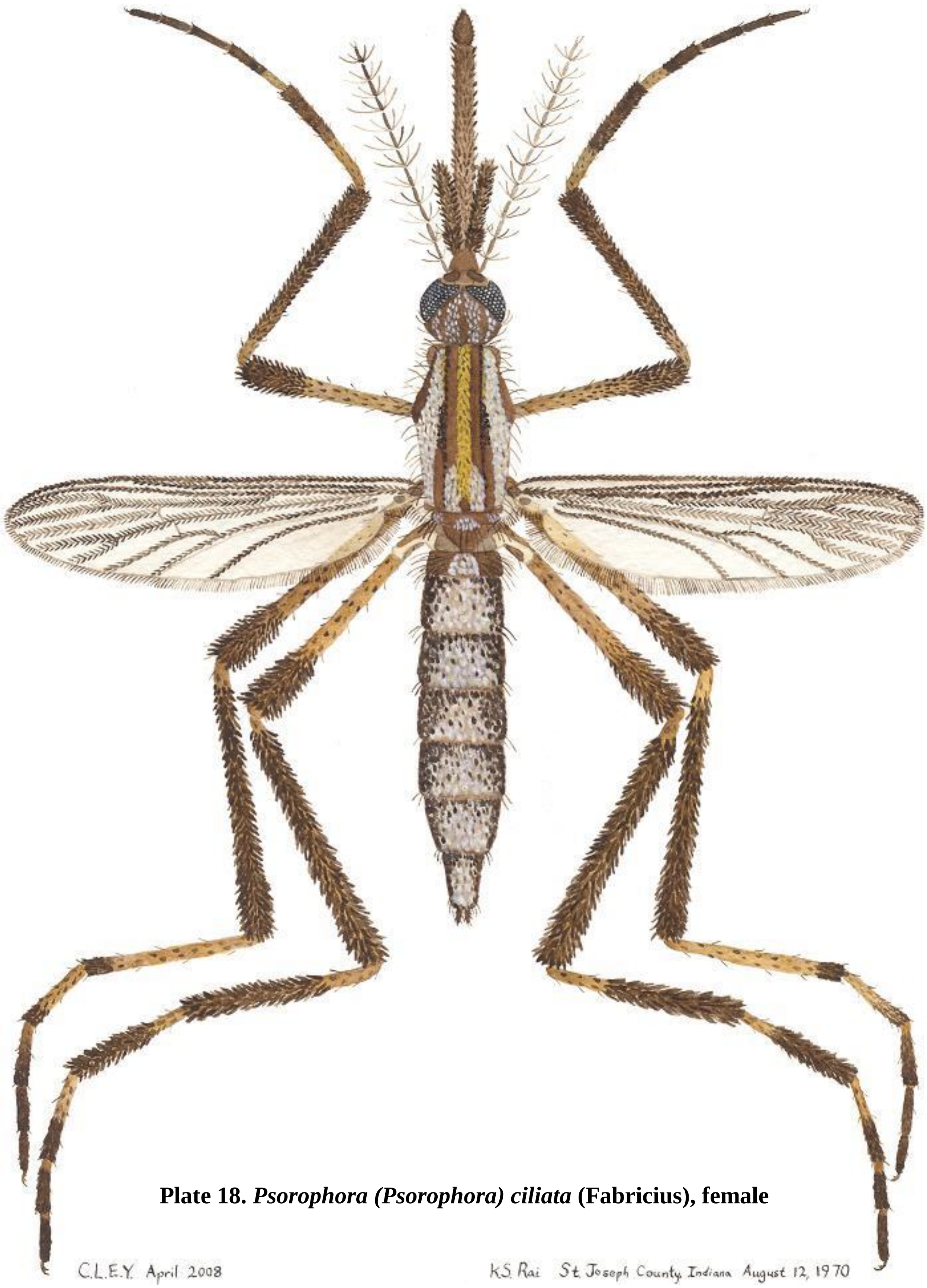

Plate 18. ***Psorophora (Psorophora) ciliata*** **(Fabricius), female**

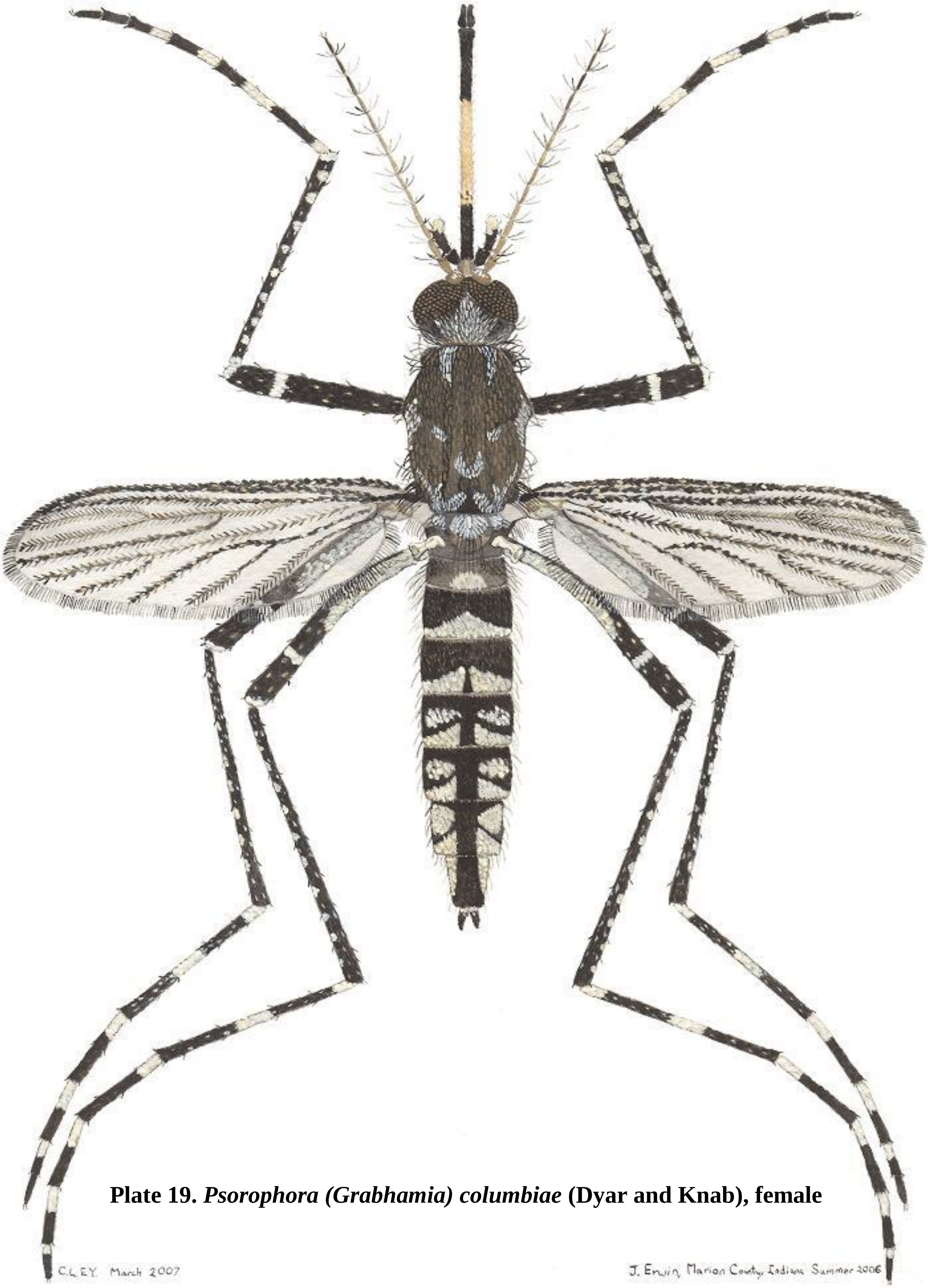

Plate 19. ***Psorophora (Grabhamia) columbiae*** **(Dyar and Knab), female**

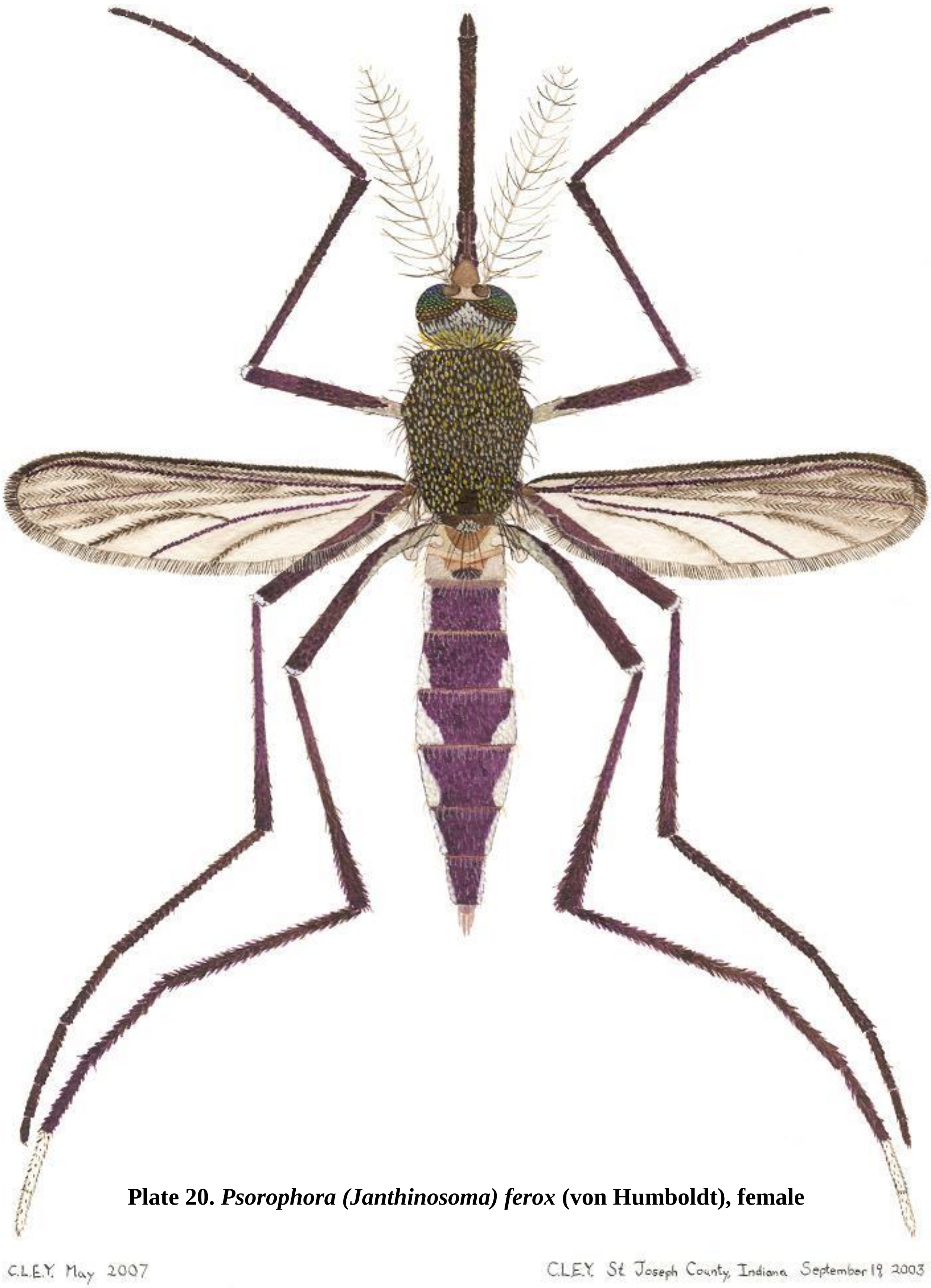

Plate 20. ***Psorophora (Janthinosoma) ferox*** **(von Humboldt), female**

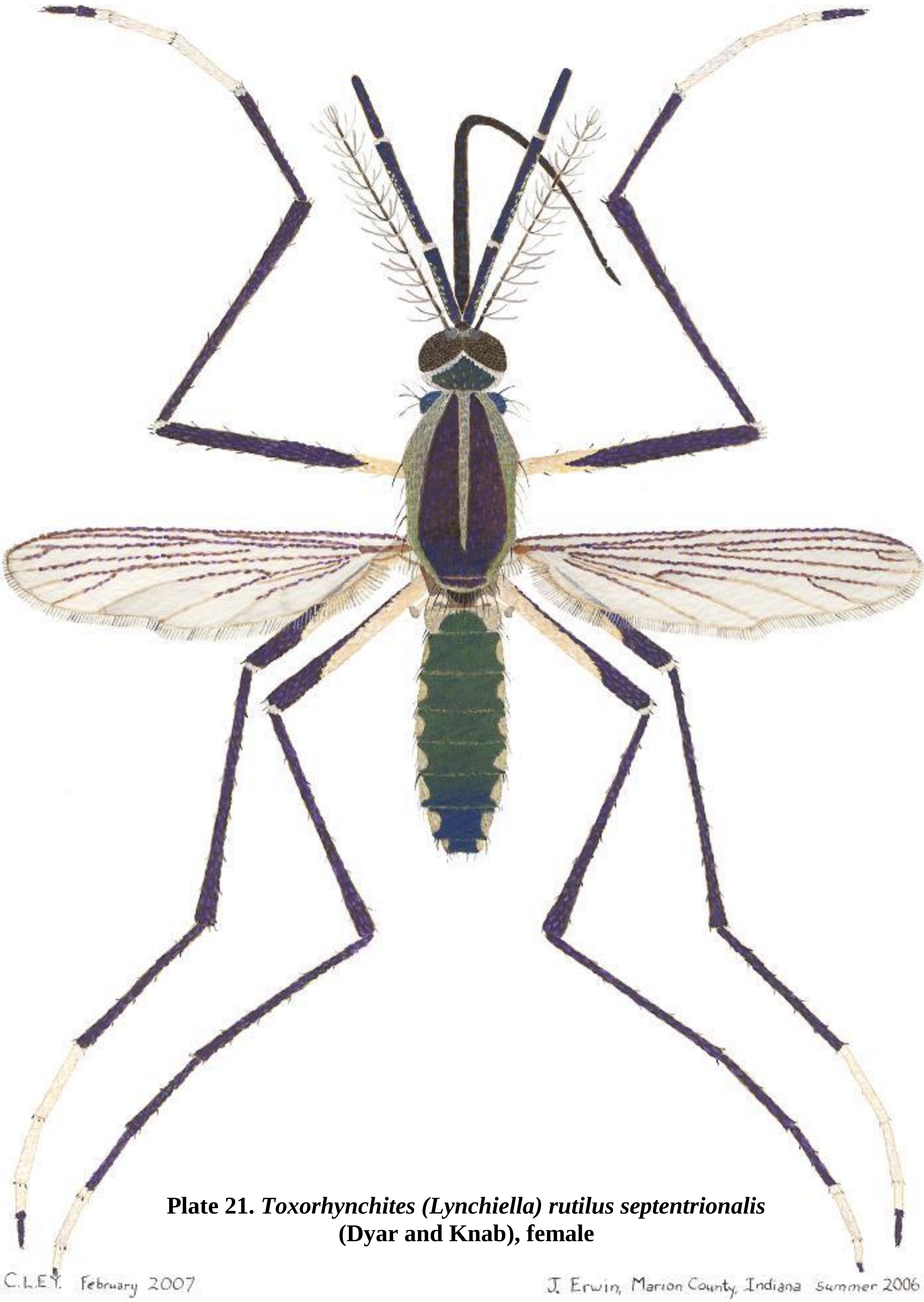

Plate 21. ***Toxorhynchites (Lynchiella) rutilus septentrionalis*** **(Dyar and Knab), female**

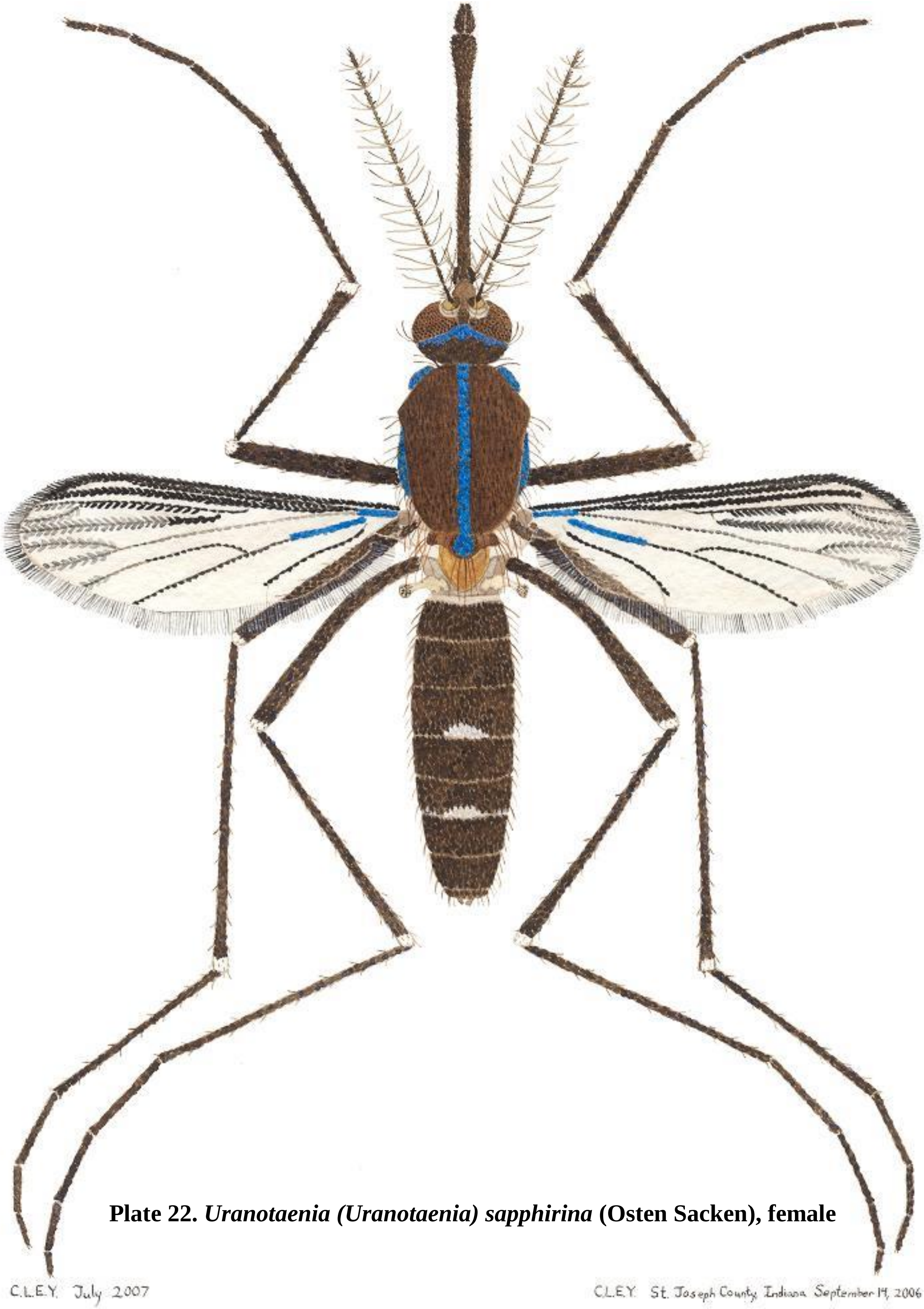

Plate 22. ***Uranotaenia (Uranotaenia) sapphirina*** **(Osten Sacken), female**

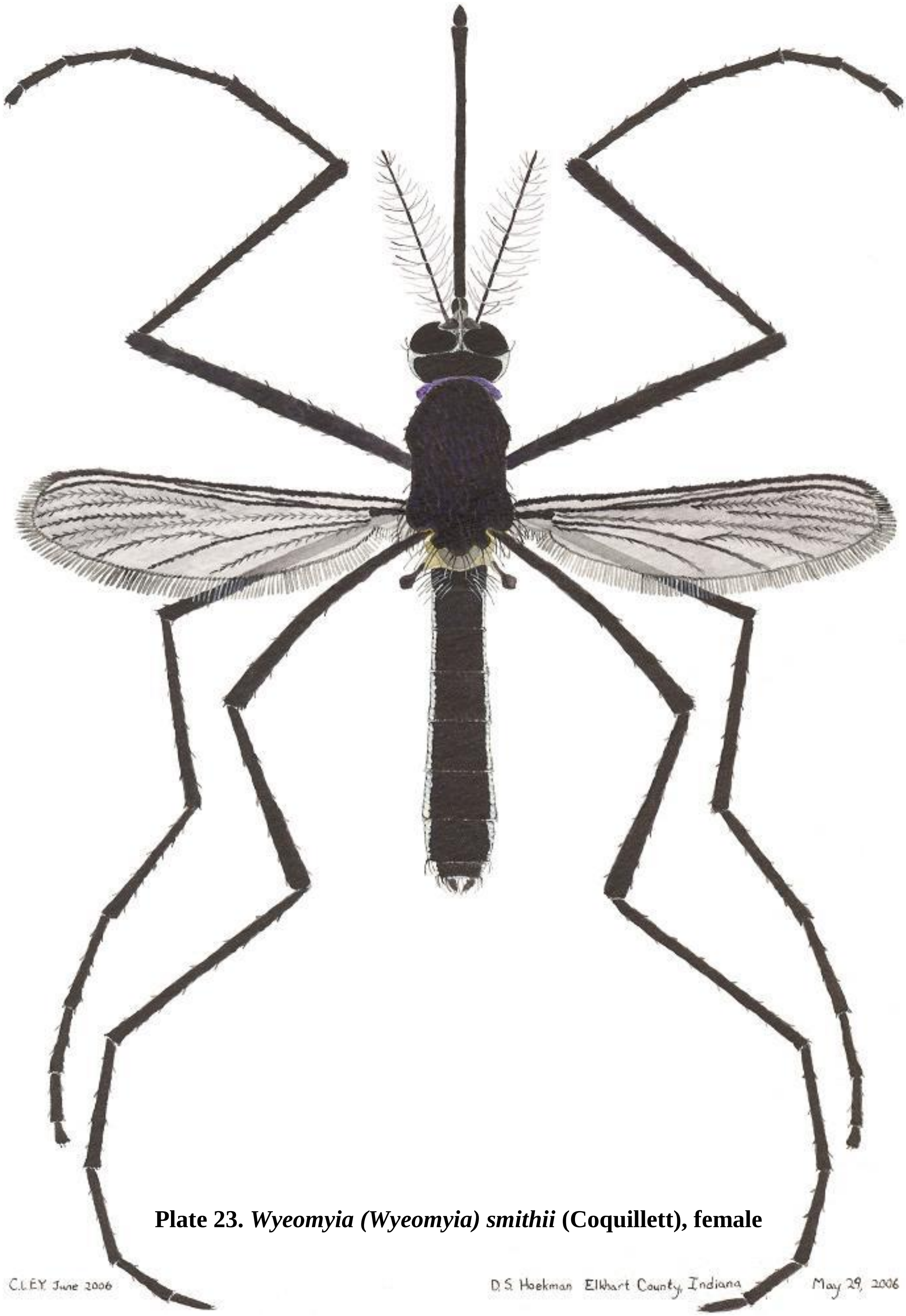

Plate 23. ***Wyeomyia (Wyeomyia) smithii*** **(Coquillett), female**

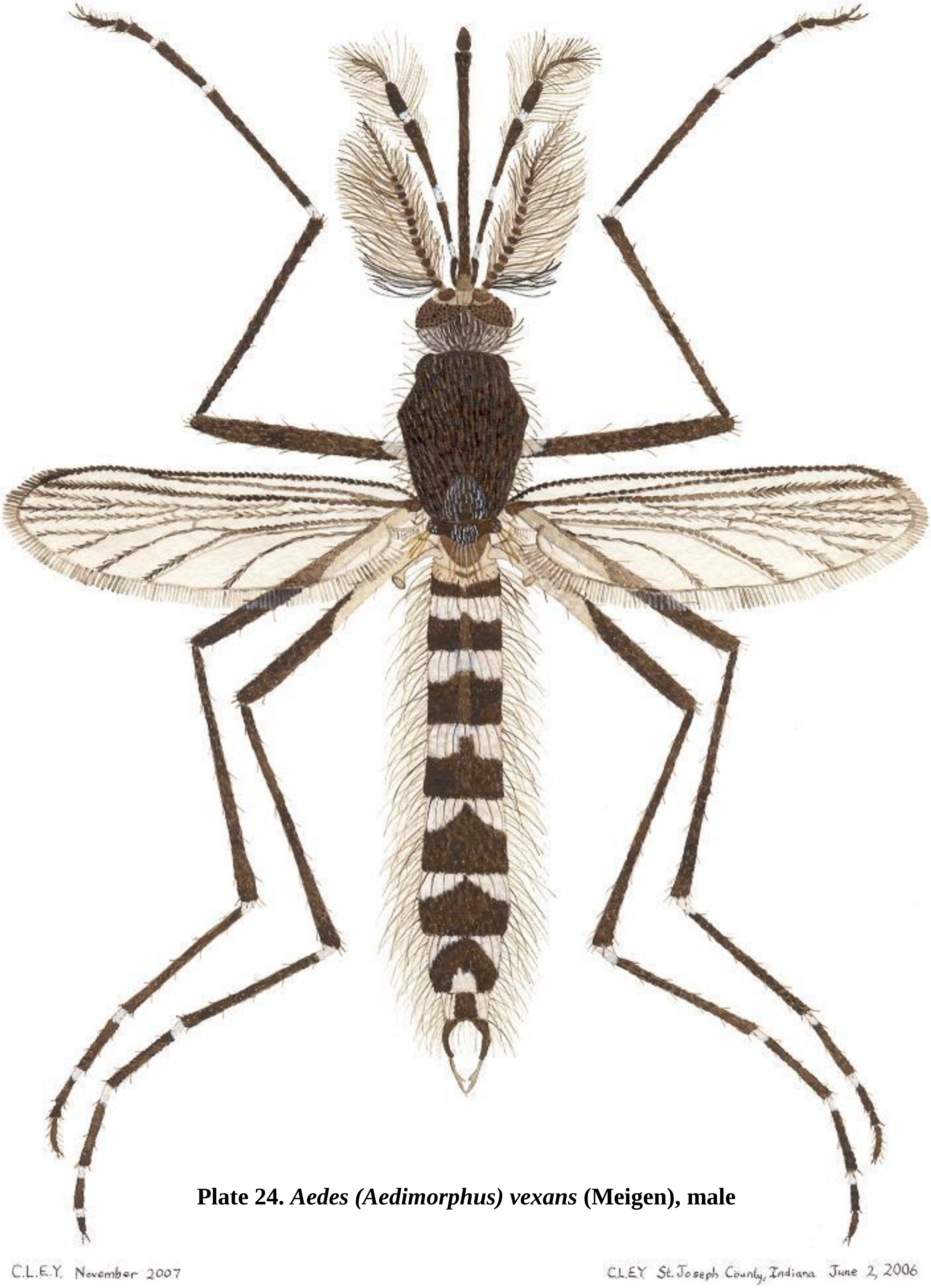

Plate 24. ***Aedes (Aedimorphus) vexans*** **(Meigen), male**

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