

# MOSQUITOES OF THE TENNESSEE VALLEY

S. G. Breeland, W. E. Snow, And Eugene Pickard Vector Control Branch, Division of Health and Safety Tennessee Valley Authority, Wilson Dam, Alabama

TABLE OF CONTENTS	PAGE
INTRODUCTION	250
SYSTEMATICS	253
List of the Species	
Illustrated Keys to the Adults	
Illustrated Keys to the Larvae	
ECOLOGICAL ASPECTS OF THE MOSQUITOES OF THE TENNESSEE VALLEY	267
THE EFFECT OF WATER LEVEL OPERATIONS OF THE TVA ON THE PRODUCTION AND CONTROL OF MOSQUITOES	271
DISCUSSION OF THE SPECIES	274
Anopheles barberi Coquillett	274
A. crucians Wiedemann	275
A. punctipennis (Say)	276
A. quadrimaculatus Say	278
A. walkeri Theobald	281
Aedes aegypti (Linnaeus)	
Ae. atlanticus Dyar and Knab	
Ae. atropalpus (Coquillett)	
Ae. canadensis (Teobald)	
Ae. dupreei (Coquillett)	
Ae. fulvus pallens Ross	
Ae. infirmatus Dyar and Knab	
Ae. mitchellae (Dyar)	
Ae. sollicitans (Walker)	
Ae. sticticus (Meigen)	
Ae. thibaulti Dyar and Knab	
Ae. tormentor Dyar and Knab	
Ae. triseriatus (Say)	
Ae. trivittatus (Coquillett)	
Ae. vexans (Meigen)	
C. peccator Dyar and Knab	
C. pipiens pipiens Linnaeus	
C. pipiens quinquefasciatus Say	
C. restuans Theobald	
C. salinarius Coquillett	
C. tarsalis Coquillett	
C. territans Walker	302

Culiseta inornata (Williston)	302
C. melanura (Coquillett)	
Mansonia perturbans (Walker)	
Orthopodomyia alba Baker	
O. signifera (Coquillett)	306
Psorophora ciliata (Fabricius)	307
P. confinnis (Lynch Arribalzaga)	
P. cyanescens (Coquillett)	
P. discolor (Coquillett)	310
P. ferox (Humboldt)	311
P. horrida (Dyar and Knab)	
P. howardii (Coquillett)	
P. signipennis (Coquillett)	
P. varipes (Coquillett)	
Toxorhynchites rutilus septentrionalis (Dyar and Knab)	314
Uranotaenia sapphirina (Osten-Sacken)	
NON-BITING MIDGES	316
SUMMARY	317
LITERATURE CITED	317

#### INTRODUCTION

The Tennessee Valley Authority was created in 1933 by Act of the Congress of the United States of America. Its purpose is to provide the necessary tools for the total development of the natural resources of the Tennessee River Valley.

When TVA undertook its job of developing the natural resources of the Tennessee Valley in 1933, over 30 per cent of the people living along the Tennessee River in north Alabama had malaria. This meant chills and fever for a large number of people, ill-afforded loss of time from work, never feeling quite "good." Occasionally, it meant death.

TVA recognized that the existing prevalence of malaria in the region might be intensified by construction of dams and reservoirs unless proper control measures were devised and put into effect. To meet this problem, TVA established a staff of medical malariologists, entomologists, biologists, and engineers and went to work to control malaria primarily through controlling the production of *Anopheles quadrimaculatus*, the mosquito vector of malaria. With valuable consulting assistance of specialists from the Rockefeller Foundation, U.S. Public Health Service, U.S. Department of Agriculture, health departments of the Valley states, and others, the TVA staff developed control techniques that are now in common use on large impoundments throughout the world. Malaria steadily declined around TVA

reservoirs, and in 1949 no cases of malaria of local origin were reported nor has there been a single indigenous case traceable to TVA reservoirs since that time.

In recent years health agencies have become increasingly concerned over nuisance and annoyance effects of mosquitoes as contrasted to demonstrable hazards of disease transmission. The public is developing a broader concept of environmental health, and man is no longer content to allow so-called pest mosquitoes to cause him pain and discomfort by taking his blood or to cause discomfort and weight loss to his livestock.

As a preventive public health measure, TVA continues, even in the absence of malaria, to control the production of *A. quadrimaculatus* mosquitoes. In addition, the program has been broadened to include the control of other mosquitoes of potential public health significance associated with TVA reservoirs.

The TVA mosquito control program places emphasis on naturalistic control methods. Its aim is to provide an environment unsuitable for mosquito propagation. This means a clean water surface unbroken by vegetation or flotage. Manipulation of the water itself is the principal mosquito control measure employed by TVA. The chart (Fig. 1) shows graphically the various features of water level management for mosquito control. Other measures carried out by TVA to create an unfavorable environment for mosquito production in its reservoirs include diking and dewatering, shoreline alteration through deepening and filling, plant growth control, and drainage. Chemical control by helicopter applications of DDT larvicide supplements these measures as needed.

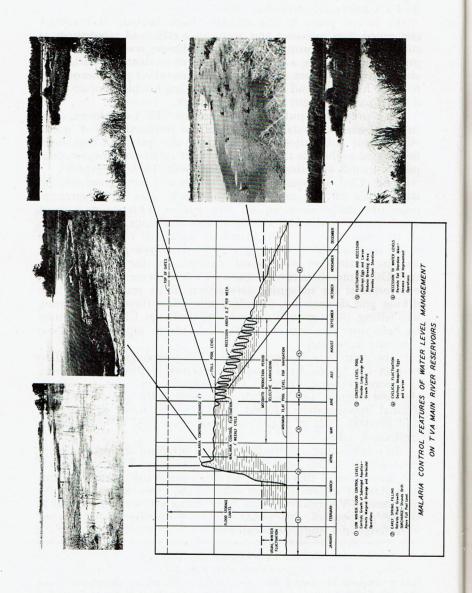
The control of mosquitoes on TVA reservoirs is designed to protect the public from potential vectors of disease, but there is a bonus benefit. Freedom from annoying mosquitoes permits the development, use, and full enjoyment of the unlimited recreational opportunities offered by the 10,000 miles of shoreline and 600,000 acres of water that make up the TVA system of freshwater lakes.

In establishing an effective control program against A. quadrimaculatus, it has been necessary to conduct basic studies on the bionomics of this species. In this connection, a vast amount of collateral information on other mosquitoes which breed in and near TVA reservoirs has been collected over the years. It is the purpose of this paper to bring together this body of knowledge in a single publication.

#### News of Tennessee Science (Continued from Page 247)

into a cooperative project with several other University departments and the Oak Ridge National Laboratory, and in 1955 the Institute of Radiation Biology was established. More than forty people are now associated with the program, which has produced nine graduates with Ph.D. degrees and fourteen with M.S. degrees.

(Continued on Page 319)



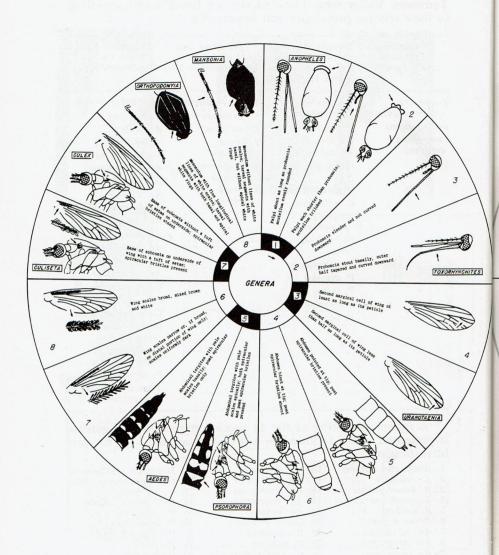
#### SYSTEMATICS

Forty-four species of mosquitoes have been found in the Tennessee Valley area. These species are listed below according to their relative prevalence and importance.

Perennially Prevalent and Important	Locally Abundan (Seasonally and/o Geographically) and Important	Relatively Rare in the Tennessee Valley
Anopheles quadrimaculatus Aedes vexans Psorophora confinnis	Anopheles punctipennis Aedes sticticus Ae. triseriatus Ae. trivittatus Culex pipiens C. quinquefasciatus C. salinarius Mansonia perturbans Psorophora ciliata P. cyanescens P. discolor P. ferox P. horrida P. varipes	Anopheles barberi A. crucians A. walkeri A. edes aegypti Ae. atlanticus Ae. atropalpus Ae. canadensis Ae. dupreei Ae. fulvus pallens Ae. infirmatus Ae. mitchellae Ae. sollicitans Ae. thibaulti Ae. tormentor Culex peccator C. tarsalis Culiseta melanura Orthopodomyia alba Psorophora howardii P. signipennis Toxorhynchites septentrionalis

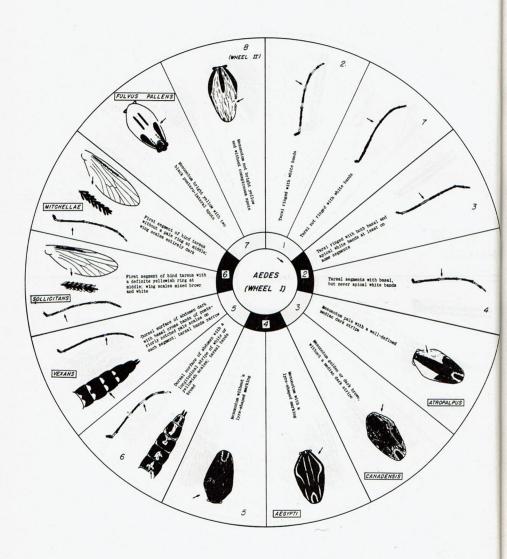
A systematic listing of the 44 species, representing 9 genera, is presented below followed by a set of illustrated keys to their identification.

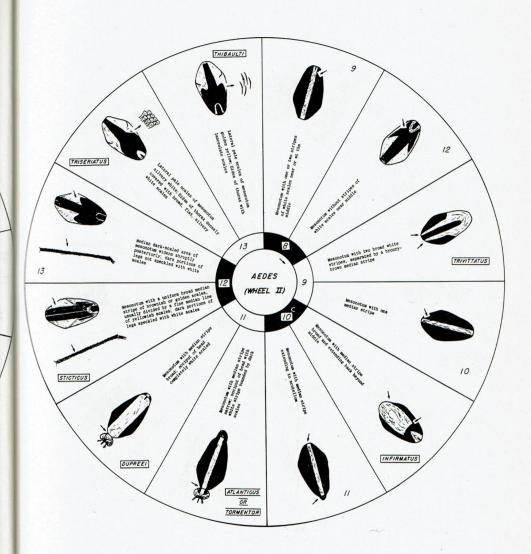
1. Anopheles barberi	16. Ae. thibaulti	31. Mansonia perturbans
2. A. crucians	17. Ae. tormentor	32. Orthopodomyia alba
3. A. punctipennis	18. Ae. triseriatus	33. O. signifera
4. A. quadrimaculatus	19. Ae. trivittatus	34. Psorophora ciliata
5. A. walkeri	20. Ae. vexans	35. P. confinnis
6. Aedes aegypti	21. Culex erraticus	36. P. cyanescens
7. Ae. atlanticus	22. C. peccator	37. P. discolor
8. Ae. atropalpus	23. C. pipiens	38. P. ferox
9. Ae. canadensis	24. C. quinquefasciatus	39. P. horrida
10. Ae. dupreei	25. C. restuans	40. P. howardii
11. Ae. fulvus pallens	26. C. salinarius	41. P. signipennis
12. Ae. infirmatus	27. C. tarsalis	42. P. varipes
13. Ae. mitchellae	28. C. territans	43. Toxorhynchites
14. Ae. sollicitans	29. Culiseta inornata	septentrionalis
15. Ae. sticticus	30. C. melanura	44. Uranotaenia
		sapphirina

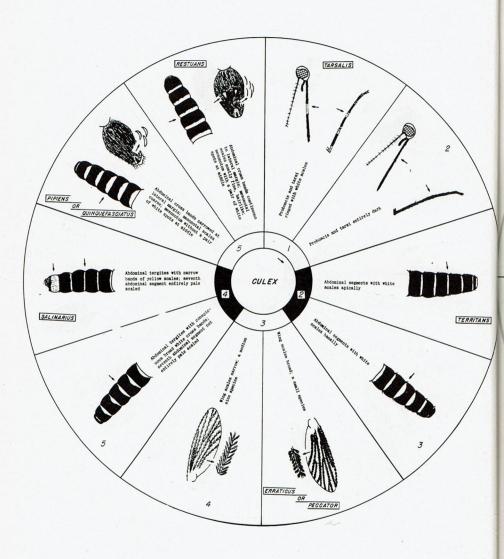


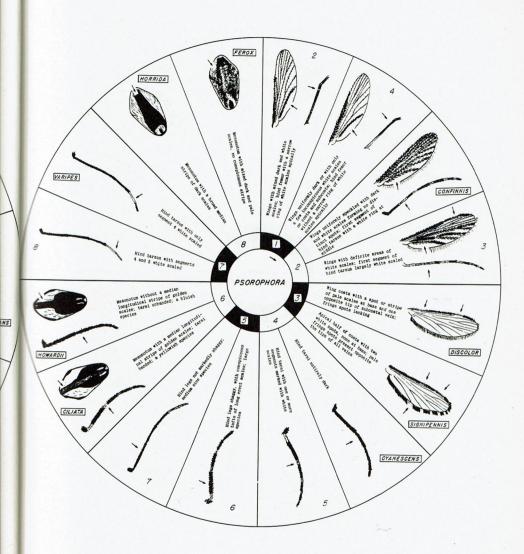
These keys may be obtained in larger size from Tennessee Valley Authority, Wilson Dam, Alabama.

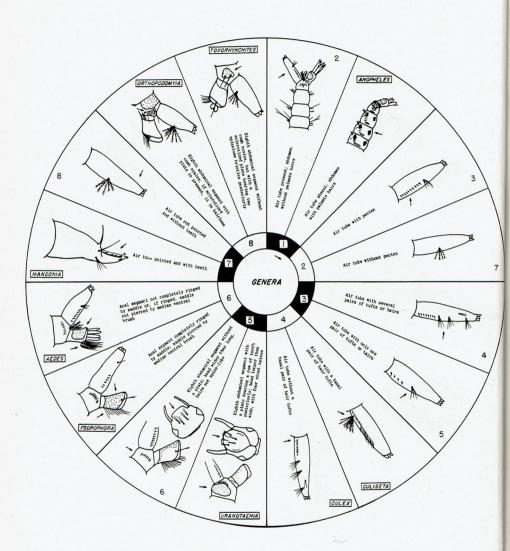


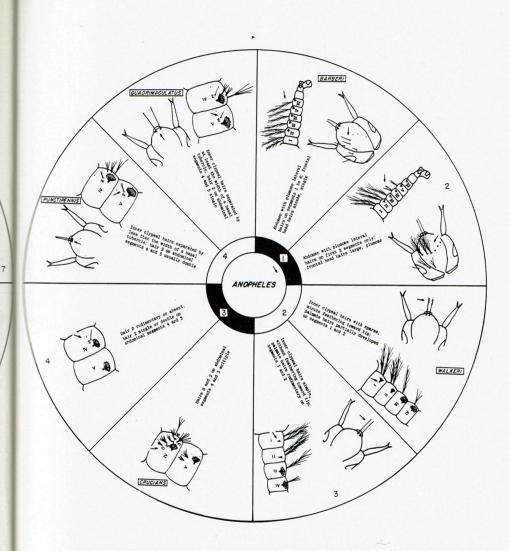


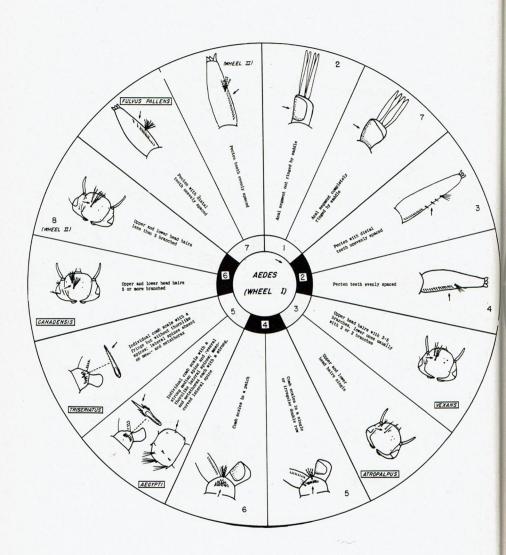


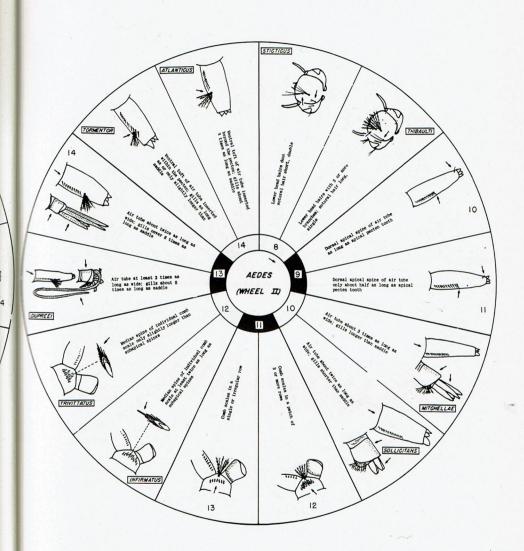


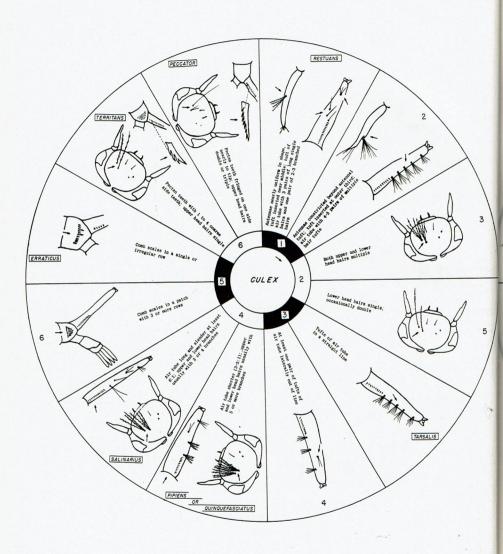


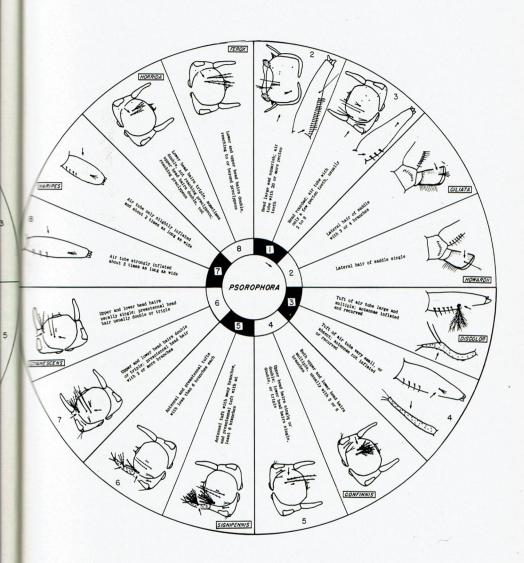


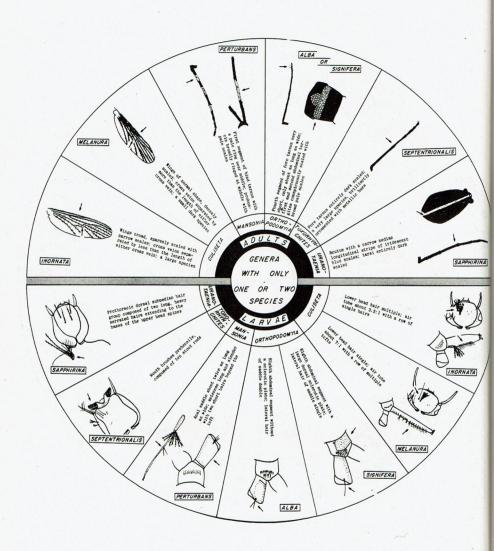












# ECOLOGICAL ASPECTS OF THE MOSQUITOES OF THE TENNESSEE VALLEY

The physical and chemical nature of the watered areas in the region offers mosquitoes a wide variety of habitats which include impounded reservoirs, swamps, sloughs, intermittently flooded bottoms, wooded pools, sluggish streams, limesink ponds, rock pools, spring seepage areas, ditches, borrow pits, wheel ruts, hoofprints, tree holes, and domestic containers such as flower pots, tubs, troughs, rainbarrels, automobile tires, etc.

For practical purposes, the species of mosquitoes found in TVA reservoir areas may be grouped on the basis of their larval habitat. These are: (1) the permanent pool group, (2) the floodwater or rainpool group, and (3) the natural, artificial, or domestic container group.

# The Permanent Pool Group

This group of mosquitoes is generally found in fresh, clear, quiet bodies of shallow water exposed to sunlight and containing an abundance of low vegetation and flotage. The manmade impoundages in the Tennessee Valley have provided numerous situations meeting these ideal requirements for the production of this group of mosquitoes. A typical permanent pool habitat is illustrated in Figure 2.

The following species may be grouped as permanent pool breeders based primarily on the fact that water must be present at the time of oviposition: Anopheles crucians, A. punctipennis, A. quadrimaculatus, A. walkeri, Culex erraticus, C. peccator, C. salinarius, C. territans, Mansonia perturbans, and Uranotaenia sapphirina usually found in large permanent bodies of water such as lakes, ponds, or reservoirs; and Culex p. pipiens, C. p. quinquefasciatus, C. restuans, C. tarsalis, Culiseta inornata, and C. melanura usually found in more transient bodies of quiet water.

# The Floodwater or Rainpool Group

The floodwater species of mosquitoes generally deposit their eggs on the damp soil in grassy depressions, in low shaded situations, and along vegetated shorelines that are intermittently flooded. When flooded after a period of desiccation, the eggs hatch if conditions are favorable; otherwise, the eggs may remain dormant and viable on the soil until conditions become favorable. Usually large numbers are produced at a hatching, and adults may appear as early as six days after flooding.

The floodwater species are of particular concern to human populations for the following reasons: (1) emergence of the

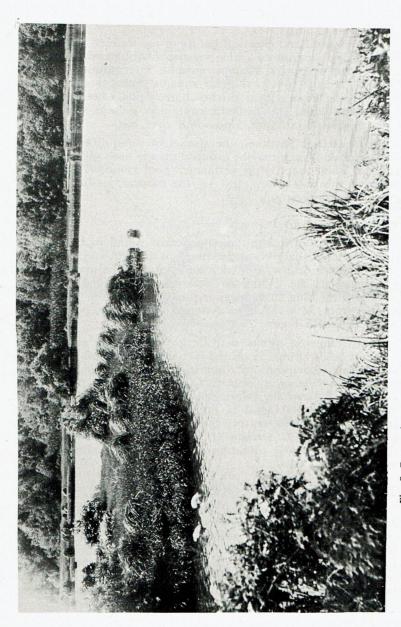


Fig. 2. Reservoir mosquito breeding habitat, permanent pool group.

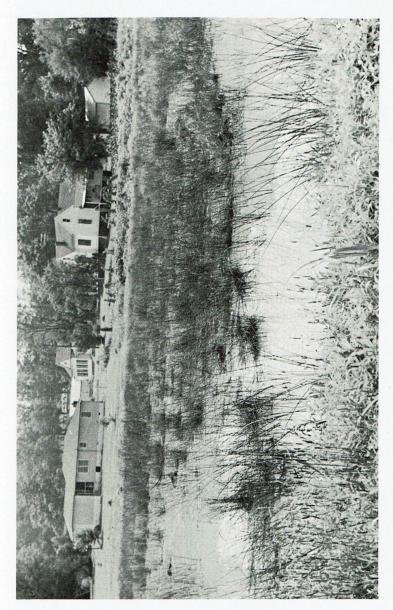


Fig. 3. Reservoir mosquito breeding habitat, floodwater group.

adult is spontaneous, and a large number of mosquitoes may appear in a very short time, (2) all floodwater species in the Tennessee Valley feed avidly on man and warm-blooded animals, (3) most species require two or three blood meals before viable eggs are laid, (4) the eggs, deposited on soil, are drought resistant and generally remain viable for several years, (5) the most abundant and pestiferous species, which include Aedes vexans, Psorophora cyanescens, P. confinnis, and P. discolor, can easily fly three to five miles from the breeding area, and (6) these adults are readily attracted to artificial light and often invade large population centers in search of blood meals.

A sufficient number of observations have been made to indicate that species of the floodwater mosquito genera (Aedes and Psorophora) are present in all main river and tributary reservoirs. The principal reservoir breeding areas are in grassy floodplain flats adjacent to the main channels. In many situations only isolated residents and livestock are affected. In a number of instances, however, if control measures were not applied, sizable concentrations of people would be annoyed and the situation could well become one of general community concern. Figure 3 illustrates a typical breeding area for floodwater mosquitoes. The following species occurring in the Valley may be classified in the floodwater group based primarily upon the fact that the eggs are deposited on moist substrate and require later inundation for hatching: Aedes atlanticus, Ae. atropalpus, Ae. canadensis, Ae. dupreei, Ae. fulvus pallens, Ae. infirmatus, Ae. mitchellae, Ae. sollicitans, Ae. sticticus, Ae. thibaulti, Ae. tormentor, Ae. trivittatus, Ae. vexans, Psorophora ciliata, P. confinnis, P. cyanescens, P. discolor, P. ferox, P. horrida, P. howardii, P. signipennis, and P. varipes.

# The Natural, Artificial, or Domestic Container Group

The species of this group are found primarily in a variety of containers having water with a fairly high organic content. Such habitats include tree cavities, rainbarrels, tire casings, septic tanks, waste pools, and open ditches of polluted water. In general, the mosquitoes belonging to this group may become abundant and locally annoying and are therefore of importance in municipal mosquito control campaigns. Rarely would members of the group be expected to be produced in reservoir waters.

Figure 4 illustrates several principal types of natural, artificial, or domestic containers which contribute to the production of this group of mosquitoes. The illustration further shows the species included in the group and their usual habitats.

# THE EFFECT OF WATER LEVEL OPERATIONS OF THE TVA ON THE PRODUCTION AND CONTROL OF MOSQUITOES

The production and control of both permanent pool and floodwater mosquitoes are affected by water level operations. A brief discussion of some of the effects is given below.

Anopheles barberi
Aedes triseriatus
Orthopodomyia alba
O. signifera
Toxorhynchites septentrionalis





Aedes aegypti
Culex pipiens pipiens
C. p. quinguefasciatus
C. restuans
Toxorhynchites septentrionalis

Aedes aegypti
Ae. triseriatus
Culex pipiens pipiens
C. p. quinquefasciatus
C. restuans
Toxorhynchites septentrionalis



Fig. 4. Some natural, artificial, and domestic container mosquito breeding habitats with species associations.

Permanent Pool Group

Current water level schedules, planned specifically for A. quadrimaculatus control on the main river system, have provided also a high degree of control of other mosquitoes of the permanent pool group. In small parts of several reservoirs where floating vegetation is present, production of A. quadrimaculatus and C. erraticus is little affected by cyclical fluctuation. In these situations, larvicidal measures are employed for control.

Floodwater Group

The water level management schedules developed by TVA are of two major types and have the dual function of managing the marginal vegetation and controlling anopheline larvae. The two general types of schedules are (1) the four-phase type used on most main river reservoirs, and (2) the seasonal recessional type employed on the tributary reservoirs. Both types affect the production and control of floodwater mosquitoes.

In the four-phase type of water level management (Fig. 1), the pool is filled (spring filling) to the surcharge zone prior to the beginning of active plant growth. Observations made over the past several years have shown that this spring filling may produce a brood of the floodwater species, Aedes vexans, when levels

reach egg beds at upper contours.

Surcharging (Fig. 1) is conducive to hatching of eggs at higher elevations. If this rise is followed by rapid recession, countless larvae are stranded and killed. Where drainage in the zone immediately above top pool elevation is poor, surcharging may provide temporary pooled situations suitable for floodwater mosqui-

to production unless control measures are applied.

During cyclical fluctuations (Fig. 1) where the rule curve has been followed, little production of floodwater species has resulted from weekly cyclical fluctuation. After seasonal recession is started no opportunity is provided for rewetting eggs deposited at top pool level unless reservoir operational requirements result in partial or complete refilling during the mosquito breeding season.

In the seasonal recessional type of schedule, the storage reservoirs are usually filled during the wet period from late winter through spring. Drawdown is generally started at the beginning of the dry season in early summer. A recession rate of 0.2 to 0.3 ft. per week beginning July 1 is considered adequate for mosquito control. The water level operations curve occurring on Hiwassee Reservoir at Murphy, N. C., in 1954 (Fig. 5) is illustrative of this type of schedule which provides satisfactory control of both anopheline and culicine mosquitoes.

Occasionally it is necessary to hold water in storage reservoirs at elevations well within the marginal growth band for periods which permit the emergence of floodwater mosquitoes. If several weeks then intervene, during which time new egg deposition occurs, a subsequent flooding may produce sizable numbers of WATER LEVEL OPERATIONS HIWASSEE RESERVOIR

MURPHY NORTH CAROLINA

DURING THE GROWING SEASON OF 1949 & 1954

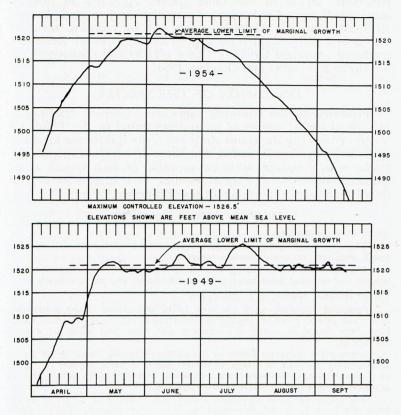


Fig. 5

mosquitoes. For example, water level operations for Hiwassee Reservoir in 1949 provided very favorable conditions for floodwater mosquito production (Fig. 5). A heavy hatch of eggs deposited in prior years occurred along channel flats between contours 1520.0 to 1521.5 ft. during the early part of May 1949 (Fig. 5). Due to incomplete drainage an initial heavy brood emerged during the latter part of May. Subsequent series of Ae. vexans appeared as higher elevations were reached in the rises of June 15-20 and July 13-23.

# The Natural, Artificial, or Domestic Container Group

Since species in this group do not breed generally in reservoir water, few observations are available on their adaptability to current water level operations. Larvae of *Culex restuans* invaded leafy, isolated pools left by receding surcharge water at Lost Creek on Hiwassee Reservoir in May, 1952. On Watauga Reservoir, larvae of the same species appeared in sawdust waste pools near Carderview, Tennessee, in July and August, 1949. At Florence, Alabama, pools left by receding reservoir waters in a polluted ditch on Cypress Creek, Pickwick Reservoir, produced abundant larvae of *Culex pipiens* and occasionally *C. tarsalis* in September and October, 1954.

#### DISCUSSION OF THE SPECIES

Presented on the following pages are condensed descriptions of each of the 44 species of mosquitoes found in the Tennessee Valley. Following the genus *Anopheles*, the species are arranged alphabetically. It is intended that these descriptions furnish the reader with a concise, accurate appraisal of each species as regards its salient morphological features, basic bionomics, and its distribution and importance in the Tennessee Valley.

# Anopheles barberi Coquillett

Recognition Characters

This is a small brown anopheline characterized by unmarked wings and palpi, and long, curved mesonotal setae.

The larva is unique among local anophelines in having minute. single frontal and occipital head hairs; glabrous antennae; and an oval black head. Larval Habitat, Habits, and Associations

Preferred breeding sites are tree holes and stump holes containing collections of water rich in organic matter. Horsfall (1955) reports that larvae have been found in artificial containers and from foul water in a barn manure pit.

Information on larval habits in the Valley is lacking. Horsfall (ibid.). in summarizing the work of others, mentions predation by A. barberi on larvae of Aedes triseriatus, Orthopodomyia signifera, and Culicoides guttipennis in addition to its reported habit of filter feeding.

The larvae are most frequently found with those of O. signifera. Other associates have been Ae. triseriatus, O. alba, and Toxorhynchites septentrionalis.

Adult Habits and Importance

The mating habits are not known. Eggs are laid singly on the water surface of the breeding receptacle. Adults rest during the day under the shelter of sheds, barns, tree holes, culverts, and bridges. Such shelters are used routinely by TVA as index stations for A. quadrimaculatus, and it is from these that A. barberi is most frequently taken, although specimens have also been collected by light traps. The flight range is considered to be short, generally within the forested area close to the breeding site. According to Thibault (1910), the species is a nervous feeder and seldom finishes a blood meal at one sitting. Observations of feeding activity on man are infrequent, only two records having been recorded in the Valley. In both instances, biting took place in a forested area, once during early dawn and once at dusk.

This tree hole mosquito occurs in only limited numbers and is of no known economic or medical importance.

Overwintering and Seasonal Development

The species overwinters in the region in all larval instars from October to February.

The first adults emerge as early as March after spending three to five days in the pupal stage. Adults have been taken during the warm season as late as September, and the species completes four or possibly five generations a year.

Distribution in the Tennessee Valley

Although restricted in habitat, this mosquito is geographically distributed throughout the area.

# Anopheles crucians Wiedemann

Recognition Characters

The adult is readily distinguished from other Valley anophelines by the white spot at the wing tip, three black spots on the anal vein of the wing, and banded palpi.

The larva is characterized by plumose hairs in positions 0 and 2 on the fourth and fifth abdominal tergites.

Larval Habitat, Habits, and Associations

The aquatic stages are found in both intermittent and permanent freshwater habitats, such as impoundments, ponds, lake margins, marshes, and swamps with or without surface vegetation. The species breeds in tupelo gum, swamp black gum, and cypress swamps, and in swamps composed of these trees in various combinations. Bands of black willow and giant cutgrass provide good breeding areas for this mosquito. A. crucians is most abundant in acid waters but tolerates alkalinity and has been taken in water with a pH up to 8.0 (Boyd. 1930).

The larvae feed upon a diversity of microorganisms, yet healthy adults have emerged from cultures of single organisms. It has been suggested that this feature of thriving on scant forms, such as desmids, might account for the tolerance of *A. crucians* to acid conditions (Frohne, 1939).

In waters approaching neutrality, the species has been taken in association with A. punctipennis, A. quadrimaculatus, A. walkeri, and Uranotaenia sapphirina. In acid waters, common companion species were Culiseta melanura, Culex territans, and C. restuans. Other associates in the Valley have been Ae. sticticus, C. salinarius, and C. melanura.

Adult Habits and Importance

The adults rest during the daytime in natural and artificial shelters, such as barns, sheds, and nail kegs and under culverts, bridges, and houses, but are seldom found inside human habitations. They feed occasionally during daylight hours but are primarily nocturnal. They are known to feed at tempera tures of 50° to 60° F., but higher temperatures around 80° to 85° F. are considered near the optimum. Both males and females are attracted by light and have been taken frequently in light traps. The adult females feed to a limited extent on man, but most of their blood meals come from other sources, such as cows, horses, pigs, sheep, dogs, and chickens. Estimates of nocturnal activity using light traps and human biting collections simultaneously during the breeding season at Reelfoot Lake, Tennessee, showed A. crucians to be very abundant in the immediate area but seldom attacking man (Show and Pickard, 1954). During one week of nocturnal collecting no females attempted to feed on man, while 107 specimens were collected in the light trap nearby. The species has been taken feeding on man in forest canopy at 30 feet but not higher (Snow, 1955). The flight range of the species has been found to be between one and two miles in central Alabama dispersion studies (Metz, 1918).

Although A. crucians is susceptible to infection with malaria parasites, it is not known to be of serious importance in the transmission of this disease. Its virus potential for eastern equine encephalitis was rated as "poor" in tests by Chamberlain et al. (1954).

Overwintering and Seasonal Development

The species overwinters mainly in the larval stage with some emergence of adults during mild winters. In 1950-1951, larvae passed the winter near

Tuscumbia, Alabama, in ponds intermittently covered with three or four inches of ice. Soil temperatures below the ice and water were never below 39° F. During the latter part of November 1950, temperatures dropped to 0° F., and the larvae retreated to the warmer soil surface during the cold period. The water temperatures reached 49° F. a week later in December and several larvae pupated. A few larvae survived a similar cold period in January and were still present in the field on March 2, 1951. Adult males emerged at temperatures between 45° and 68° F., while females emerged at a higher temperature range of 65° to 78° F.

The first generation of adults usually emerges in April. The eggs hatch in about one week when water temperatures are 51° to 70° F. The completion of the life cycle requires about three more weeks with the appearance of the second generation adults in May along the main river reservoirs. The number of generations a season is not known, but there appear to be spring and fall peaks in the population with decreased activity in the summer.

Distribution in the Tennessee Valley

This species is moderately distributed throughout the Valley except for the upper eastern region where records show scattered distribution.

### Anopheles punctipennis (Say)

Recognition Characters

Diagnostic characters of the adult are the prominent, pale golden spot on the costal margin of the wing, unmarked palpi, and the broad frosted stripe on the mesonotum.

The larva is identified by the separation of the basal tubercles of the inner clypeal hairs being less than the diameter of one tubercle and by the bifurcated hair in position 2 on abdominal tergites IV and V.

Larval Habitat, Habits, and Associations

During the hot summer months the larvae of A. punctipennis can usually be found in association with plants inhabiting cool waters, such as coontail (Ceratophyllum demersum), watercress (Nasturtium officinale), parrots feather (Myriophyllum brasiliense), smartweed (Polygonum hydropiperoides), and pondweed (Potamogeton crispus). In the cool spring and fall, breeding occurs in most all kinds of partially flooded vegetation. The larvae are more tolerant of both acid and polluted conditions than are those of A. quadrimaculatus and have been found commonly in swamps with poor drainage. A degree of tolerance for micropools is shown by their frequent occurrence in hoofprints. While the water in hoofprints is fairly well exposed to sunlight, the depth of water in the soil tends to hold water temperatures within a favorable range. The preference of A. punctipennis for cool water probably accounts for the fact that this is the only anopheline which breeds regularly at elevations above 2,000 feet in the region.

Along the grassy margins of spring-fed streams, larvae of A. punctipennis are commonly associated with Culex territans and C. restuans. Near Triana, Alabama, larvae occurred with A. crucians and A. walkeri in a spring-fed tupelo gum forest and with A. quadrimaculatus in exposed areas where the tupelo had been cut over. In flooded forests of black gum on poorly drained acid soils, A. punctipennis was collected with larvae of A. crucians, C. restuans, C. territans, and Culiseta melanura. Rainfilled hoofprints frequently contained associated larvae of Aedes vexans and C. territans. Other associates have been Ae. atropalpus. Ae. sollicitans, C. p. pipiens, C. p. quinquefasciatus, C. salinarius, C. tarsalis, Culiseta inornata, Psorophora howardii, and Toxorhynchites septentrionalis.

Adult Habits and Importance

The adults are relatively inactive during the daylight hours and may be found at rest in a variety of natural and artificial shelters. They do not frequent human habitations in numbers comparable to A. quadrimaculatus.

This robust and hardy anopheline feeds readily on man, domestic and wild animals. The peak of feeding usually occurs near dusk, but blood may be taken at other times during the day or night. In the spring and fall, feeding may occur earlier in the afternoon as evidenced by a February collection when 33 specimens were taken in a wooded barnyard from 1638 to 1730 hours with temperature ranging from 55° to 66° F. Feeding on man has been observed over a temperature range from 38° to 83° F. The females have been observed feeding during all months of the year in the Valley but are more abundant and annoying in the spring and fall.

The flight range and dispersal pattern of the species are not known. One observer (Clark, 1943) reports recovering a marked adult at light a week after its release from a point seven miles away. Adults are readily attracted to light at night and have been frequently captured in light traps and by means of a parked car with the domelight lit. Females have been taken biting up to 75 feet in a forest canopy and were more active within the forest than they were along a pastured forest margin (Snow, 1955).

This mosquito is of no known importance in the transmission of malaria in nature; however, experimentally, it shows a similar level of susceptibility to *Plasmodium* spp. as does *A. quadrimaculatus*. The species is considered a vector of *Dirofilaria immitis* which results in heartworm in dogs. Its hardy nature and adaptability to a wide variety of breeding places often make it a serious pest.

Overwintering and Seasonal Development

The species overwinters in the Tennessee Valley as inseminated females which take refuge in caves, hollow trees, houses, and other protective structures. Some observations on an overwintering cave population follow. As a general rule, the adults congregate in the "twilight zone" of caves (Ives, 1938; Hess and Crowell, 1949), and their in and out movement is apparently governed by temperature. With the onset of cold weather, they entered the cave in greatest numbers when the noonday air and cave temperatures reached equilibrium at about 50° F. In January and February, they left the cave in greatest numbers when the air temperature increased to that of the cave. Adults survived a cave temperature of 35° F. at which time the outside air temperature dropped to 12° F. During cold, windy periods or when the ceiling of the cave became excessively wet, the adults moved out of the twilight zone of the cave to the darker, drier and better protected interior. The adults emerged from the cave during any warm periods in the winter and took blood meals, particularly when the outside air temperature reached 50° F. or higher. The overwintering adults lived as long as four or five months.

The adult females emerge from overwintering quarters in large numbers in February with air temperatures mainly in the range of 60° to 70° F., take blood meals, and oviposit. Eggs may be deposited as early as February with water temperatures in the sixties and hatch within a few days. Larval development of the first spring brood is slow. requiring about three weeks in March when water temperatures are low. The duration of the pupal stage is about one week at this time of year. The adults of the first generation can usually be found about April 1 on the main river reservoirs. The second generation of adults appears about May 1. The species completes eight or nine generations during the year with peak production in the cooler portions of the season in spring and fall.

Distribution in the Tennessee Valley

It is well distributed throughout the area and is the dominant anopheline in the upper one-third of the Valley where cooler waters prevail.

# Anopheles quadrimaculatus Say

Recognition Characters

This anopheline is dark brown with four conspicuous dark spots on the wing, unbanded palpi, and dark halteres. The inner clypeal hairs of the larva are separated at the base by a distance equal to at least the diameter of one tubercle, and hair 2 on abdominal tergites IV and V is single.

Larval Habitat, Habits, and Associations

The larvae of A. quadrimaculatus are found principally in fresh, warm, quiet water where vegetation or flotage intersects the water surface for long periods during the breeding season. Examples of common breeding sites include ponds, lakes, borrow pits, roadside pools, sloughs, bayous, and similar situations where the water is relatively permanent and has a slightly acid to alkaline reaction. As a general rule, the intensity of production is directly related to the amount of food and to plant life and flotage breaking the water surface and is usually greater in areas exposed

to full or partial sunlight.

A study of the breeding potentials of a number of species of plants in the Tennessee Valley has led to the classification of the plants into ecological types by Hess and Hall (1945). The importance of a plant in relation to anophelism is indicated by the absolute larval density coupled with the total area of colonization by the offending plant species. Significant production of A. quadrimaculatus in the Valley has been found in bladderworts (Utricularia spp.), muskgrasses (Chara spp.), duckweeds (Lemna spp.), pondweeds (Potamogeton spp.), and buttonball (Cephalanthus occidentalis). Anophelism is rarely associated with such plants as watershield (Brasenia schreberi) and white waterlily (Nymphaea odorata). Breeding of A. quadrimaculatus seldom occurs where Euglena and bluegreen algae are abundant since these organisms reflect the presence of stagnant or heavily polluted waters.

The larvae are indiscriminate feeders, partaking almost anything at the water surface small enough to be ingested. Green algae, diatoms, flagellated protozoans, and related microscopic organisms are usually abundant in waters favorable for the larvae. These types of organisms are considered the main sources of food for this species. Common predators of the larvae are surface fish, such as Gambusia, and several orders of predatory insects,

principally Hemiptera and Odonata.

Under optimum conditions of abundant flotage or vegetation, high water temperature, and near neutral waters, A. quadrimaculatus larvae have been most commonly associated with those of Uranotaenia sapphirina and Culex erraticus. In the cooler months of spring and fall, common associates include A. punctipennis. A. crucians. C. restuans, and C. salinarius. Other associates are C. p. pipiens, C. p. quinquefasciatus, and C. tarsalis.

Adult Habits and Importance

Males and females emerge from a given brood in about equal numbers, but the males tend to precede the females. The females are apparently capable of mating any time following emergence; however, the males require the passage of a short postemergence period for rotation of the inverted genitalia and for the erection of the antennal fibrillae. These antennal structures are extended by the male to receive sound vibrations sent out by the female and are of importance in the male finding his mate. Males are cyclically active to mating.

Copulation in this species takes place while on the wing and may occur effectively either before or after the female's first blood meal. The fore tarsi of the males are modified for seizing, and, with these, the female is grasped while flying. While in flight, the genitalia are brought together and maintained so by the claspers and associated structures of the male. The female is then released from the tarsal grip, and the mating pair with bodies extended in a straight line along a common axis gradually descends to the substrata and remains attached for an addition 10 or 15 seconds. Under insectary conditions mating occurs most frequently within the first hours after sunset. In nature, mating occurs near sundown at which time swarming flights of males may be observed.

According to Keener (1945), a female may mate a number of times, although apparently only one insemination is necessary for her to remain fertile during her entire life.

The adult female requires a blood meal for egg development to take place. She ingests about 2.0 cu. mm. of blood at a feeding and takes a maximum of 25 to 30 blood meals over her life span. Eggs are usually deposited two to three days following a blood meal. Egglaying takes place at night and occurs mainly during the first two hours after the onset of darkness (Keener, 1945). The pearly white eggs are deposited singly on the water surface and turn a glossy black about 45 minutes after deposition. The number of eggs deposited following a given blood meal varies from 100 to 300. A single female may oviposit as many as 12 times, thus laying more than 3,000 eggs during her life span.

Females show peak feeding at dusk and dawn over the 24-hour period. Feeding is maintained at a low level during the night, and, at times, it also occurs in shady situations during the day. The wave of adult females seeking a blood meal at dusk can be readily observed by sitting in a parked car with domelight on and with windows and doors open in the vicinity of a prolific breeding area (Smith, 1948). Adults have been collected while attempting to feed on man at temperatures which range from 48° to 85° F. Temperatures above 60° F. appear to be more favorable for females seeking blood meals.

The female feeds on a number of different kinds of hosts. These include man, horses, cows, pigs, dogs, cats, and chickens. Host preference studies indicate that A. quadrimaculatus does not show a preference for man as a source of blood meals (Darling, 1925). The degree of human host feeding may be strongly influenced by the number and variety of domesticated animals in the vicinity of dwellings and the degree of accessibility of human hosts. Nevertheless, the species seems to make a persistent effort to enter houses and feed even though domestic animals are nearby as sources of blood.

Movement of the adult mosquito is motivated by requirements for food, mating, oviposition, and other activities. Short flights appear to be the main pattern of dispersion. A. quadrimaculatus appears to avoid crossing open water but under certain conditions may do so. Flights up to one-half mile across open water have been recorded.

The flight range of A. quadrimaculatus is influenced greatly by its population densities and the location of available blood supplies. Its effective range (for sanitary control) is about one mile from the breeding area with the majority staying within the first half-mile zone. The females disperse rather widely in all directions, but the males tend to remain close to the point of emergence. Adult females have been noted to migrate up a tributary stream approximately three miles from the breeding area in Kentucky Reservoir. The conditions under which these long flight distances were observed suggest the possibility of prehibernation flights and also that distant dispersion may be the result of one or more secondary flights after an initial blood meal (Gartrell and Orgain, 1946).

The adult females of this species have been transported from one area to another by airplanes, trains, automobiles, and wagons. In automobiles, they have been observed to be carried in large numbers under the dashboard for 100 miles or more.

In forested areas there is a limited vertical movement into forest canopy at dusk, some individuals readily ascending into the tree tops where they feed and may participate in swarming activities above the forest canopy (Snow, 1955). This upward movement appears correlated with a decrease in light intensity to 0-foot candle. Feeding on man in the canopy (75') at dusk began 15 to 25 minutes later than at ground level. During the night females were found resting in the canopy, although occasional feeding was recorded. At daybreak the mosquitoes passing the night in the canopy experienced a second peak of feeding activity followed

by descent to the ground level where diurnal resting sites were sought. Activity at ground level often continued several hours after it had ceased in the canopy. Generally, by the time the sun's rays penetrated to the ground level area, the majority of A. quadrimaculatus had already found a sheltered resting site for the day. Males and females have been taken in airplane traps at elevations up to 1,000 feet (Glick, 1939). These extensive vertical movements were attributed to ascending air currents, but the species has been taken as high as 200 feet in calm weather.

Adults seek a variety of natural shelters (i.e., interior of houses, privies, barns, sheds; under porches, bridges, culverts; hollow trees, etc.) in which to spend the day. Cool, dark, protected situations are desirable features of a good resting station. A single structure, properly located near a heavy breeding area, may be used by several hundred adults as a diurnal resting place. In addition to natural resting places, various types of artificial structures have been studied. Such structures include animal-baited traps, nail kegs, privy-type traps, and various boxes (Smith, 1942; Goodwin, Jr., 1942; Snow, 1949). From these studies, it was learned that the location of the structure in relation to light was a controlling factor in the movement of the mosquitoes into the shelters.

The use of data from different traps or resting stations has serious limitations for comparing production in two or more breeding areas due to variables such as extent of breeding area, prevailing winds, topography, animal attractants, type and location of structures, etc. Although this species responds to artificial illumination, light traps have not been satisfactory for measuring its density. Populations have also been estimated by recovering marked mosquitoes and calculating the total population. So far, a satisfactory and practical method for estimating adult densities for direct comparative purposes in different areas has not been produced.

This mosquito is the important vector of malaria in the southeastern United States, and it has had a significant effect on the economy of the Tennessee Valley. Although the last evidence of indigenous malaria transmission in the region was recorded in 1949, this species is still abundant and is an annoying pest in reservoir areas. Until malaria is completely eradicated from the world, its great potential as a malaria vector remains.

Overwintering and Seasonal Development

The species overwinters as inseminated females in the twilight zones of caves, cellars, hollow trees, barns, and other protected situations (Ives, 1938). The movement of adult females in and out of caves appears to be a function of temperature as observed for A. punctipennis. Adult females were found to enter caves in greater numbers with the onset of winter when noonday air temperatures coincided with cave temperatures which occurred at a temperature slightly above 50° F. (Hess and Crowell, 1949). Likewise, they left the cave in January and February when outside air temperatures increased and again coincided with the cave temperature. During winters with a sustained cold period, the adults remained in the caves from November to February without obtaining a blood meal. However, in milder winters, they have been observed to emerge from caves during warm periods and take blood meals every month. These wintertime blood meals were taken with air temperatures mainly in the range of 65° to 75° F., but some feeding has been recorded at temperatures as low as 48° F. These winter blood meals are used for maintenance of fat production rather than for the development of eggs.

Overwintering females live as long as four or five months. The adults leave their overwintering sites in early February and take blood meals. After a two- or three-week period during which ovarian development is completed, eggs are deposited for the first spring brood. The eggs hatch in one to two weeks and larvae develop slowly so that pupation does not occur usually until near mid-April. The pupal period lasts about one week, and adults of this first brood generally appear during the last half of April. Under outdoor conditions, it appears that about two months is

required to complete development from egg to adult of the first spring brood, and during spring and fall with relatively cool water temperatures a month or more may be required to complete development of other broods. Under optimum conditions during midsummer, development from egg to adult usually requires about two weeks. Larvae generally do not appear in significant numbers until the afternoon water surface temperatures reach 65° to 75° F. and do not become dominant in collections until the water temperature reaches 90° to 95° F. Considering time for ovarian development, it is estimated that the species completes nine or ten generations annually in north Alabama. Larvae occur in the field in this area from March through November. Peak production on the lower main river reservoirs occurs from mid-June to mid-August, whereas on the upper main rivers reservoirs it occurs generally between mid-July and mid-August. On upstream storage reservoirs, the peak production is delayed until the latter part of August or September. Decreased production in the latter part of the season appears to coincide with a decrease in rainfall and a reduction in reservoir habitats due to water level recession rather than lower fall temperatures.

#### Distribution in the Tennessee Valley

This species is well distributed throughout the Valley and is the most abundant anopheline except in the upper eastern portion where cooler temperatures prevail.

## Anopheles walkeri Theobald

Recognition Characters

This slender, dark, sooty anopheline has four dark spots on the wing, narrowly banded palpi, and golden halter knobs.

The larva has finely barbed inner clypeal hairs and fan-shaped outer clypeals with no evident basal stalk.

Larval Habitat, Habits, and Associations

The larvae are generally confined to relatively permanent bodies of fresh water containing good colonial species of emergent aquatic plants which provide good shade. The species has not been found in the Valley in areas exposed to full sunlight. Common breeding areas consist of good stands of cattail, lizard tail, giant cutgrass, and waterwillow. They also occur in association with the adventitious roots of hempvine and marsh smartweed. They may be found in alkaline to slightly acid waters. According to Peters (1943), larvae of this species are unable to survive fluctuating water level. In the Valley areas it is found more consistently in heavily vegetated bogs formed by silt-blocking streams and where springs maintain water surface permanently.

If the larvae are disturbed, they dive and remained submerged longer than most anophelines, a factor which might result in failure to detect them even though they may be abundant. The larvae in nature are dark brown, but specimens reared on dog chow in the insectary may be either green, gray, or somewhat transparent. The pupae, when confined, have the unusual habit of pushing themselves up above the level of the water surface.

A. walkeri larvae have been found associated with those of A. crucians and A. punctipennis.

#### Adult Habits and Importance

The adults are classed as a cool weather species and have been found to be active and abundant even after the first killing frost. At Blackwell Swamp on Wheeler Reservoir in 1948, one collection from late afternoon until dark in a parked car on October 29 yielded 1,898 female A. valkeri, and another collection at the same site on December 14 produced 22 females (Snow and Smith, 1957). The females feed readily on man with air temperatures within the low range of 50° to 65° F.

Common sources of blood meals are man, cattle, horses, mules,

swine, and chickens. The adults have a major peak of feeding near dusk, a minor peak at dawn, with intermittent feeding during the hours of darkness (Snow, 1955). At times, they also actively seek blood meals in full sunlight. At night, they are known to enter lighted houses and feed.

During the daytime, the adults rest on stems of emergent vegetation, such as lizard tail, waterwillow, and giant cutgrass, just a few inches above the waterline or moist soil (Bang et al., 1943; Smith, 1948). Hollow stumps of emergent tupelo gum are also occasionally used as diurnal resting sites. Artificial structures appear to be generally avoided by this species. In a special study around Blackwell Swamp, approximately 40,000 adult anopheline mosquitoes were collected in nail kegs with only one specimen of A. walkeri being detected, although this species constituted about 30 per cent of the anophelines taken in night biting collections in the same area (Smith, ibid.). In 26 years of routine mosquito station inspections (188,640 collections) from artificial and natural resting places in the Valley, over one million A. quadrimaculatus adults have been counted, and not one specimen of A. walkeri has been recorded from these collections.

The adults make short flights in the afternoon from plant to plant, and the species is dispersed about the swamps in this manner. During the daytime practically all flights are restricted to the confines of the breeding area. Toward dusk the females may leave the breeding site in large numbers and range into the surrounding countryside. Usually they retreat to vegetational resting sites in the swamp about dawn. In late fall engorged females have been found to linger in barns over half a mile from the breeding area during the day, possibly due to cooler weather, as they did not behave thus in the summer months.

Dispersal over open marsh and water has been noted on several occasions with light as an attractant (Snow and Smith, ibid.). Approximately 1,400 A. walkeri were dyed with rhodamine B, released, and captured the same night on the opposite side of a swamp. Captures the following evening and six days later in a parked car at the original collecting site showed 120 or 8 per cent of those originally released to have crossed 1,000 feet of water surface broken by lizard tail, lotus, and tupelo stumps. In another parked car collection, 29 female A. walkeri were taken in the dusk-dark period at Cane Landing which was about 1,100 feet across the open water of the Tennessee River from Blackwell Swamp, the nearest known breeding ground. Its favorable response to light may account for its appearance at night in appreciable numbers in communities as much as two miles from a breeding site in west Tennessee (Bang et al., ibid.)

The adults show a strong tendency to remain close to the ground. During nocturnal observations in bottomland forest, females were commonly found feeding on man near the forest floor and occasionally at 30 feet, but no specimens were detected biting in the forest canopy at heights of 50 and 75 feet (Snow, *ibid.*). Light trap collections on the ground yielded large numbers of adults, but simultaneous trap collections on a 100-foot bluff yielded only a few adults (Bang *et al.*, *ibid.*).

Since this species is very seldom recovered in typical anopheline diurnal resting shelters, special sampling techniques are employed to get a more accurate measure of its prevalence. By far, the best method used for measuring feeding activity of A. walkeri in the Tennessee Valley has been the parked car technique (Smith, ibid.). A sedan car is driven to the vicinity of the breeding area at twilight, the doors opened, and the dome and headlights turned on. The mosquitoes are attracted by the light and readily enter the car where they can be captured while resting on the interior or while attempting to bite the collector.

Probably because of their diurnal resting habits, this species has never been incriminated in the natural transmission of malaria, but this does not preclude its potential importance as a disease vector. Females have been infected experimentally with malaria parasites. One wild-caught specimen has been collected near Bondurant, Kentucky, with sporo-

zoites similar to those found in artificially infected A. quadrimaculatus (Bang et al., 1940).

Overwintering and Seasonal Development

The species overwinters in the egg stage, the overwintering eggs being different from summer eggs both in structure and physiology. In early fall some eggs may hatch, but others remain dormant until the following spring (Hurlbut, 1938). The overwintering eggs hatch in April when water temperatures are still in the 40's. The first generation of adults has been detected in the Tennessee Vally as early as the middle of May. These adults mate and oviposit and the summer type eggs hatch in about three days with temperatures of about 70° F. Five or possibly six generations are passed in the breeding season with adults being found in the field from May to December.

Distribution in the Tennessee Valley

This species has been recorded from Annie-Winnie Pond near Florence, Alabama; upper Beaver Dam Creek near Bel Mina, Alabama; Vale Pond near Bruceton, Tennessee; Live Oak Pond near Paris, Tennessee; and over wide areas in the Kentucky and Wheeler Reservoir areas.

# Aedes aegypti (Linnaeus)

Recognition Characters

The adult is readily recognized by the silvery lyre-shaped pattern on the mesonotum; the three light spots on the scutellum; and the banded legs.

The larva is short and robust with single upper and lower head hairs and has sausage-shaped anal papillae.

Larval Habitat, Habits, and Associations

This mosquito breeds almost exclusively in manmade water-retaining receptacles around the home. Common breeding sites of this domesticated species include water barrels, cisterns, tanks, troughs, bottles, tin cans, and old tires. Flower vases inside houses or in cemeteries are favored breeding sites for this mosquito. Occasionally the larvae can be found in tree holes, particularly if they are close to human habitation.

The inseminated females deposit eggs singly on the wall of the breeding container just above the existing waterline or at the edge of the water. The eggs withstand drying for long periods and may remain viable for at least a year (LeVan, 1940). Thus containers emptied, turned over, and dried out may harbor dormant eggs for a long period of time. The eggs will hatch at any season if wetted by water of favorable temperatures (77° to 85° F.), such wetting resulting from rising water levels in the container due to rains or to activities of man. With high water temperatures, the eggs hatch within eight days, and larval life is completed in six to ten days. When larval life is prolonged over 30 days, adult survival is very poor (Hatchett, 1946). The pupal stage is completed in about two days in summer and about eight days during mild winters.

The larvae respond rapidly to noise or shadows and, when so disturbed, dart to the bottom of the breeding receptacle and remain pressed against it. This habit enables the larvae to remain in water containers which are frequently emptied and refilled since they often escape being poured out. Containers with organic matter in the bottom provide protection to larvae during unusually cold periods.

The larvae have been found associated only with those of the Culex pipiens complex in the Valley (Shlaifer and Harding, 1946).

Adult Habits and Importance

Males copulate at any time during the day and over their life span when stimulated by vibrations of flying females. They may copulate with the same female repeatedly or with different females. The males will also attempt to mate with females of other species when flight vibrations are within the range of their receptors.

The inseminated female seeks the necessary blood meal which is usually followed by egg deposition several days later. Usually the eggs are laid at intervals after successive blood meals. The female deposits from 50 to 100 eggs during her lifetime.

Adults rest mainly in or near human dwellings. Feeding activity peaks occur in the morning and evening, but females may actively seek blood during the day and have been reported to feed after dark in lighted dwellings. The females are persistent biters although very stealthy in their attacks. They appear to make an effort to keep out of sight, generally approaching from behind to feed on the back of the neck or about the ankles and under coat sleeves. The bite is often imperceptible and causes little irritation at the time of feeding, but severe pain and itching may develop after the mosquito leaves. The males may cause some irritation by lapping perspiration from the surface of the skin but are unable to suck blood. The female is almost entirely restricted to human blood which may explain to some degree its limited flight range from human habitations. The flight range is considered to be very short and does not generally exceed the breeding sites (artificial containers around dwellings) by much more than 300 feet.

This species is an important vector of yellow fever and dengue. It is experimentally capable of transmitting all three common strains of encephalomyelitis. Historically, this mosquito is one of the most important in the Southeastern United States. Probably more studies have been made of its bionomics than any other species. It was abundant in the Tennessee Valley and was responsible for many deaths in Decatur, Alabama, during the yellow fever epidemic years, but during the past fifteen years it has practically disappeared and its now taken only on very rare occasions. The reasons for its present rarity are only conjectural, but are attributed to the widespread household use of DDT and other modern insecticides, better practices of premises sanitation, inability of the mosquito to resort to natural cavity breeding sites, and its restricted dispersal.

## Overwintering and Seasonal Development

This species is quite susceptible to cold and overwinters mainly south of the 68° F. isotherm. The mosquito is not a common resident in our area but apparently overwinters in milder climes and is brought to the Valley by car, railroads, or other forms of transportation during the warmer months.

Under optimum conditions the majority of newly laid Ae. aegypti eggs hatch within a week. Development is usually in two or three weeks after egg hatching. The number of generations per year varies considerably, but under favorable conditions a new generation occurs every two or three weeks, and breeding may continue throughout the year. Distribution in the Tennessee Valley

The only record in the Tennessee Valley since 1946 consists of one female collected in a junkyard shed at Chattanooga, Tennessee, on August 16, 1956. None have been reported in north Alabama since 1930. Attempts to locate larvae of Ae. aegypti in tires and other containers during the summers of 1952 and 1953 at Sheffield, Alabama, were negative.

# Aedes atlanticus Dyar and Knab

Recognition Characters

The adult has a narrow silvery white to pale yellow median longitudinal stripe extending the full length of the scutum and covering the middle lobe of the scutellum. While the female is indistinguishable from that of Ae. tormentor, the males of these two species can be separated on differences in the genitalia.

The larva shows unusual coloration in that the first six abdominal

tergites are darkly pigmented, while those of the thorax and distal segments are translucid with the silver sheen of the tracheal reservoir showing through the integument. In the larval stage they can be separated from Ae. tormentor by the placement of the subventral hair tuft of the siphon. In Ae. atlanticus, the subventral tuft is located beyond the pecten, whereas in Ae. tormentor the tuft is within the pecten.

Larval Habitat, Habits, and Associations

The larvae have been collected in the Valley from temporary grass pools and from flooded woodland bottoms.

In the grass pool situations, they have been found associated with larvae of Ae. vexans, Psorophora confinnis, and P. cyanescens. In flooded woodlands, they have been found with Ae. dupreei, Ae. infirmatus, Ae. trivittatus, Ae. vexans, P. ferox, P. horrida, and P. varipes.

Adult Habits and Importance

The females are active during portions of both day and night and may seek blood either in bright sunlight or in darkness. The peak feeding period was observed to be at dawn and dusk. This species appears eager to feed with little preliminary maneuvering. In northern Alabama, feeding has been recorded over a temperature range of 69° to 80° F. The adults appear to have a longevity of two or more weeks in the area.

The species is of no known economic or medical importance in the Valley but may be a component of the pest species complex.

Overwintering and Seasonal Development

The species overwinters in the egg stage. Reservoir water during the surcharge phase of water level operations in spring annually provokes hatching of overwintering eggs in April. Larval development and pupation follow in about a week with adult emergence appearing within two weeks after eclosion. Subsequent flooding above top summer pool near Pickwick Dam on Pickwick Reservoir has provided additional broods of Ae. atlanticus in May and July. In grassy depressions at Muscle Shoals, City, Alabama, broods of this species have been produced in April, June, and September by normal rainfall.

Distribution in the Tennessee Valley

Pickwick, Wheeler, Guntersville, and Hales Bar Reservoirs.

# Aedes atropalpus (Coquillett)

Recognition Characters

The adult of this species is characterized by markings of the scutum and hind tarsus. The scutum has a wide median longitudinal stripe of dark bronze scales which is margined by pale yellow to golden yellow scales. Each segment of the hind tarsus has both basal and apical white banding except the terminal segment which is entirely white.

The anal segment of the larva is not ringed by the dorsal plate, the subventral tuft of the siphon is within the pecten, and the pecten has 2 to 4 widely spaced teeth.

Larval Habitat, Habits, and Associations

The larvae occur in water pockets in rock holes or concrete. Shields (1938) reported them from an abandoned septic tank, and Hedeen (1953) collected them from tree holes in a hackberry tree. According to Trembley (1947), the larvae feed mainly on green algae.

In the Tennessee Valley the larvae have been found in rock holes in association with Anopheles punctipennis and Ae. canadennsis (Jones, 1946).

Adult Habits and Importance

Both sexes have been reported resting during the day under rock ledges in the vicinity of the larval habitats by Carpenter (1941). Resting adults have been collected on two occasions from a routine barn collecting station near Spring City, Tennessee.

Trembley (ibid.) reports the females to be autogenous. The same author observed mating in cages at twilight, the mating flight lasting about four seconds. In the Valley, small numbers have been observed feeding on man near breeding areas during daylight hours through dusk.

The flight range is short and generally does not exceed several hundred

yards from the breeding area.

This species has been experimentally infected with equine encephalomyelitis virus.

Overwintering and Seasonal Development

Under favorable conditions, they overwinter in the egg stage. Overwintering eggs hatch in February and March and give rise to the spring adults. Subsequent broods may be produced throughout the summer and fall in suitable rock pool habitats. Eggs are laid singly on the walls of rock holes above the existing water level.

Distribution in the Tennessee Valley

Watts Bar Reservoir near Spring City, Tennessee (adult resting); Fort Loudoun Reservoir near Loudoun, Tennessee (larvae); Great Falls Reservoir near Rock Island, Tennessee (larvae).

# Aedes canadensis (Theobald)

Recognition Characters

The proboscis of the adult is unmarked; the mesonotum is uniformly brown-scaled bordered by a few indistinct gray lines along the lateral margins with similar lines on or near the scutellum; and there are fairly wide basal and apical white bands on all segments of the hind tarsus except the terminal one which is entirely white.

The integument of the larva is darkly pigmented; the upper and lower head hairs are multiple; the upper lateral hairs are double on the first two abdominal segments; the anal segment is incompletely ringed; and the pecten teeth are evenly spaced.

Larval Habitat, Habits, and Associations

Larvae occur mainly in isolated, shaded, woodland rainpools. They may be found occasionally in small streams, pools, ditches, and pasture ponds adjacent to woodlands.

The larvae are commonly found in cool waters varying from 50° to 70° F. Larval development usually requires about two months, but the pupal period is complete in from two to seven days.

The larvae are usually taken in association with those of Ae. vexans, Ae. tormentor, and Psorophora ferox. They have also been taken with Ae. atropalpus.

Adult Habits and Importance

Adults are active during the daytime with increasing tempo toward dusk. They usually become inactive during the night and have been taken sparingly in light traps on TVA reservoirs. Adults rest in hollow trees and wooden shelters.

Though large populations of this mosquito have been encountered frequently in the spring, only six instances of feeding on man have been observed in the Valley. This has been noted mainly near dusk. In more northerly regions, the species has been found to be an annoying pest in woodland areas.

Ae. canadensis is of no known economic or medical importance in the Tennessee Valley.

Overwintering and Seasonal Development

This species overwinters in the egg stage. The overwintering eggs hatch when flooded by late winter and early spring rains. Its spring appearance is one of the earliest in the Valley with adults on the wing about April 1 from

eggs hatching as early as February. Observations indicate that about two months is required for the production of the first generation after the eggs hatch under average winter temperatures in north Alabama. Eggs from different broods continue to hatch during May, and larvae are usually infrequent by July. Larvae are rarely taken from main river reservoir bottoms during the summer months. The species is considered to have only one generation per year, and it is not known whether late season larvae are from eggs laid the previous year or from eggs laid earlier in the season. Distribution in the Tennessee Valley

This species, though relatively rare, is geographically distributed throughout the Valley.

# Aedes dupreei (Coquillett)

Recognition Characters

The wide silver stripe extending the length of the dark brown scutum, the dark-scaled abdomen, and the unbanded legs characterize the adult of this species.

The larva is unique in having extremely long anal gills (over twice the length of the air tube) with darkly pigmented trachea within. Larval Habitat, Habits, and Associations

The larvae occur in temporary rainfilled pools and are difficult to locate since they habitually remain hidden among leaves and debris in the bottom of the pool and do not have to come to the surface for air. They are quite transparent and are difficult to see even when confined in glass containers.

Larvae have been found in association with Ae. infirmatus, Ae. atlanticus, and Culex territans.

Adult Habits and Importance

The females have been collected biting man during daylight hours up to dark in open woods and in a tupelo gum bottom. Feeding was observed with temperatures ranging from 60° to 78° F. during October in Guntersville and Hales Bar Reservoir areas. The same population did not feed when given an opportunity after dark. Light trap collections show that they do fly after dark. They are not known to enter houses.

Small numbers of adult females have been collected on biting forays in association with those of Ae. vexans, Ae. atlanticus-tormentor, Psorophora confinnis, P. discolor, P. ferox, P. ciliata, and P. horrida.

 $Ae.\ dupreei$  is not considered to be of economic or medical importance in the Valley.

Overwintering and Seasonal Development

They overwinter in the egg stage. Larvae have been taken from April to October, appearing periodically in temporary rainpools. The adults also appear periodically from April to October. The number of generations per season is not known.

Distribution in the Tennessee Valley

Pickwick, Guntersville, and Hales Bar Reservoirs.

# Aedes fulvus pallens Ross

Recognition Characters

This species, the largest *Aedes* mosquito in the Valley, has a bright golden yellow integument except for a dark brown rectangle at each posterolateral corner of the mesonotum, irregular dark brown areas at the ends of the abdominal tergites. and blackish antennae. The black eyes are particularly noticeable against the light body.

The larva is dark brown with the upper head hairs single, the lower ones double; the pecten reaches beyond the middle of the siphon, the last tooth being widely spaced; and the subventral hair tuft of the siphon is multiple and is inserted within the pecten.

Larval Habitat, Habits, and Associations

The larvae occur in temporary pools and semipermanent sink holes. When Belkin collected the first specimen of Ae. fulvus pallens from exposed turbid pools with scant marginal grass in a low wooded area near Florence, Alabama, in 1942, Psorophora ciliata and P. howardii were taken with them. A week later more Ae. fulvus pallens were taken from the same location to the exclusion of other species. The larvae rest almost parallel to the water surface but are very wary and difficult to catch.

Adult Habits and Importance

The adults have been taken biting twelve times from ground level to 35 feet in the forest canopy. They are severe biters and in each instance biting was at dawn or dusk.

The species is of no known medical importance in the Valley and occurs too infrequently to be of economic importance.

Overwintering and Seasonal Development

The species overwinters in the egg stage. The adults have been taken from June to October. Little is known about their seasonal development. Belkin (in litt.) is of the opinion that their eggs require a long exposure to water before hatching and undoubtedly special environmental conditions which prevail only after unusually high rainfall in the summertime. It appears to develop in temporary pools after all the other Aedes and Psorophora have emerged. Belkin's collecting experience previously mentioned is a case in point.

Distribution in the Tennessee Valley

Annie-Winnie Pond near Florence, Alabama (larvae); Wheeler Reservoir near Decatur, Alabama (adults).

### Aedes infirmatus Dyar and Knab

Recognition Characters

The broad median patch of silvery scales on the anterior half of the scutum and brown scales on the sides and posterior half characterize the adult.

Salient features of the larva are the long, single, upper and lower head hairs which are distally barbed; the long siphon (about twice as long as wide); the ringed anal segment; and the apical spine of the thornlike comb scales which is 3 to 4 times as broad and about twice as long as the subapical spinules.

Larval Habitat, Habits, and Associations

The larvae occur in temporary woodland pools, at the edge of marshes, and along reservoir margins where grassy pools occur.

In a flooded woodland site at Pickwick Village, Tennessee, in late April, larvae and pupae of Ae. infirmatus were associated with those of Ae. atlanticus, Ae. dupreei, and Culex territans.

Adult Habits and Importance

These mosquitoes feed on man during the daytime in or near woods, and at night they can be found near dwellings but seldom enter houses.

The species has limited distribution in the Valley and therefore is of little economic or medical importance.

Overwintering and Seasonal Development

Ae. infirmatus passes the winter in the egg stage. Spring and summer broods are produced when conditioned eggs are flooded by rains or rising reservoir waters. At Pickwick Village, Tennessee, a brood of larvae was observed to mature during the last week in April, 1954, in connection with normal spring filling and surcharging on Pickwick Reservoir. Larvae and adults have been recorded from March to December.

Distribution in the Tennessee Valley

Pickwick and Wheeler Reservoirs.

# Aedes mitchellae (Dyar)

Recognition Characters

The adult has a wide median ring of white scales on the proboscis and broad basal white bands on each segment of the hind tarsus except the terminal one which is entirely white. (Ae. mitchellae may be separated from the closely resembling adult of Ae. sollicitans by its uniform dark wing scales and the absence of a pale median ring on the first segment of the hind tarsus.)

The lower head hairs of the larva are single, the upper ones usually single but sometimes double; the comb scales are in a patch, the single scale being thornshaped; the anal segment is completely ringed by the plate; and the gills are slightly longer than the segment and somewhat pointed. Larval Habitat, Habits, and Associations

The larvae are known to breed in temporary rainpools but have not been taken in the Valley. Information on the habits and associations of this species is lacking.

Adult Habits and Importance

These mosquitoes are considered to be rather severe biters. Numerous light trap records by the Third Army Medical Laboratory over the coastal plain indicate some nocturnal activity. No information is available on the seasonal activities of this species.

The species is of no known economic or medical importance in the Valley.

Distribution in the Tennessee Valley

Near Athens, Tennessee, July 3. 1952 (adult, light trap); Pickwick Reservoir, Sheffield, Alabama, June 9, 1959 (adult, light trap).

# Aedes sollicitans (Walker)

Recognition Characters

This mosquito is distinguished by the golden-scaled scutum; the whitebanded legs and proboscis; and the basal and medial whitish-yellow scaled bands on abdominal tergites II-VII.

The mature larva is robust with single upper and lower head hairs and short budlike anal gills.

Note: This is the common salt marsh mosquito which has been found on two occasions in the Tennessee Valley and for this reason is included here. In inland situations it may be found in water having a salinity several times the average for sea water which is 19,000 ppm of chloride. Typical inland breeding occurs in salt water sites from natural licks and coal mine or oil well drainage.

Since its known habits are associated with coastal areas well removed from the Tennessee Valley, and to avoid needless repetition, the reader is referred to the writeup of the species in A Handbook of the Mosquitoes of the Southeastern States (King et al., 1960).

Those observations made in the Valley are given below.

Larval Habitat, Habits, and Associations

Larvae and pupae of Ae. sollicitans were found with those of Culex salinarius, C. p. pipiens, and Anopheles punctipennis in a brackish cattail marsh and with those of Psorophora confinnis, P. cyanescens, P. ciliata, and Ae. vexans in a freshwater, grassy, roadside ditch.

Distribution and Importance in the Tennessee Valley

The species has been collected on only two occasions and is, therefore, of no practical significance in the Valley at this time. In 1954-55 all stages were commonly found in a brackish marsh at Saltville, Va., and on April 27, 1955, one larva was taken in a freshwater, roadside ditch near Paris, Tenn., and was reared to an adult female which is preserved in the TVA reference collection at Wilson Dam, Alabama.

### Aedes sticticus (Meigen)

Recognition Characters

This species is distinguished by having the sides of the mesonotum pale-scaled and a broad central stripe of brown scales, usually divided by a fine median line of yellowish scales.

The larva is robust with the head as wide as the thorax; the upper

head hairs are multiple, the lower ones are usually double.

Larval Habitat, Habits, and Associations

Typical breeding areas are floodwater pools in river bottoms. In laboratory studies at a constant temperature of 80° F., the larvae reached the fourth instar in three days, began pupation on the fifth day, and the adults emerged on the sixth day (Gjullin et al., 1950). In nature, development has been observed to require 10 to 21 days, depending upon prevailing temperature, and newly hatched larvae have been found only in shallow, quiet waters. Apparently, the lowering of oxygen content in the water acts as a regulating mechanism which insures egg hatching only in shallow water having an abundance of food material for the larvae. Larvae have been observed to wriggle en masse shoreward to shallow water from breeding areas suddenly flooded to extreme depths.

The larvae have been found associated with those of Ae. vexans,

Anopheles crucians, Culex territans, Psorophora varipes, and P. ferox in

north Alabama.

Adult Habits and Importance

Mating is known from caged specimens, and Gjullin et al. (ibid.) reported that the species mated in cylinders nine inches long and ten inches in diameter as well as in larger box-type cages. Inseminated females laid an average of 22 eggs each with a maximum number of 96. A single oviposition usually occurs five to ten days after a blood meal. Eggs have not been obtained from virgin females. Wild-caught females collected in August oviposited and produced viable eggs, 75 per cent of which hatched in eight to ten days.

In nature, females deposited eggs singly upon the ground, mainly in that portion of the floodplain subject to early spring flooding. Eggs are commonly deposited on loam soils with living and/or dead vegetation. Forested areas harbored about five times as many eggs per unit area than either grassland or pastured areas. In addition, eggs have been found in bryophytes growing on trees, logs, and concrete abutments within

two feet of the ground.

The adult female takes blood meals both day and night, but a reduction in feeding intensity has been observed after the onset of darkness. The species commonly feeds on man and is a fierce biter. Resting adults have been collected in demountable privy-type stations and other resting sites visited by the common malaria mosquito. The species has been collected in light traps, but such studies indicate a low nocturnal frequency from July to September. The flight range has been ascertained to be at least five miles, and observations in the Columbia River Valley indicate that the species may have a maximum flight range of 25 to 30 miles (Gjullin et al., ibid.). Vertical distribution studies in a floodplain forest showed adults to be about three times as abundant near the forest floor as compared to the 20-foot and 30-foot levels. Adults have been collected biting along with those of Ae. vexans, Ae. trivittatus, Psorophora ferox, P. horrida, and P. discolor.

The species is of no known medical importance in the Valley but may be a component of the pest species complex. Their bites in the Muscle Shoals area in April, 1961, caused several complaints.

Overwintering and Seasonal Development

The species overwinters in the egg stage. The eggs remain dormant with water temperatures below  $45^{\circ}$  to  $50^{\circ}$  F. The dormancy of the overwintering egg is broken in the spring when water temperatures approach 50° F. or higher. Eggs begin to hatch during the latter part of March in north Alabama, and larvae and adults have been collected in the field during the first week in April. Adults have been found through the summer months, and one has been collected as late as the middle of October. These observations suggest a staggering of the population of this species which is believed to have but one generation per year. Distribution in the Tennessee Valley

Kentucky, Pickwick, Wheeler, Guntersville, Chickamauga, and Chero-

kee Reservoirs.

### Aedes thibaulti Dyar and Knab

Recognition Characters

The adult has a bluish-black mesal patch on the scutum, narrow on the anterior half and markedly wider on the posterior half. The antero-lateral areas of the scutum are bright gray with long, narrow non-overlapping scales.

The larva has multiple upper and lower head hairs; the inner preclypeal spines are separated by a little more than the length of one spine; the body is slightly pigmented; and the anal segment is not completely ringed by the dorsal plate. The collection of larvae from their restricted habitat aids in the identification of this species.

Larval Habitat, Habits, and Associations

The larvae occur mainly in the basal cavities of tupelo gum, swamp black gum, sweet gum, and bald cypress which are subject to flooding or stand in semipermanent pools.

Studies of the gut contents of larvae from natural breeding areas showed them to be indiscriminate feeders. The following were found as food items of the larvae: copepods. ciliates, diatoms, flagellate protozoa, filamentous and non-filamentous green algae, blue-green algae, pollen, soil particles, fungus spores and amorphous brown matter.

Larvae of this species have been taken in association with those of Culex territans, C. restuans, and Culiseta melanura.

Adult Habits and Importance

The females feed on man during daylight hours in the shade of swamp forests when they are disturbed. The adults commonly rest in the hollow basal cavities of swamp trees and have been observed mating in hollow tree bases in April. They usually remain within a few hundred feet of the swamp margin; however, a male and a female were collected in a light trap at a distance of one-half mile from the nearest bottomland.

The species is of no known economic or medical importance in the Valley.

Overwintering and Seasonal Development

The species overwinters in the egg and larval stages in the Tennessee Valley. The eggs are attached to the inner basal wall of the hollow tree trunks. The eggs on the wall of the tree cavity hatch when they are flooded by rising waters at favorable temperatures. Hatching has been observed in the field in December in northern Alabama. When water temperatures were generally below 50° F., larval development was slow and the adults appeared in March. For eggs hatching in April, the larval period averaged 42 days and the pupal period 3 days under field conditions. The number of generations per year is not known. In some years, the eggs may not be flooded, and they have been reported to retain their viability until the following year (Horsfall, 1939).

Distribution in the Tennessee Valley

Wilson and Wheeler Reservoirs; Black Warrior National Forest near Moulton, Alabama; Henry County, Tennessee; and Reelfoot Lake, Tenn.

#### Aedes tormentor Kyar and Knab

Recognition Characters

The adult female of Ae. tormentor and Ae. atlanticus are difficult to separate. Male genitalia differ.

The larva resembles that of Ae. atlanticus, but Ae. tormentor differs in having the subventral hair tuft of the siphon inserted within the pecten.

Larval Habitat, Habits, and Associations

The larvae occur in transient woodland pools. Early instar larvae are difficult to find in the breeding areas since they are largely bottom dwellers. Later instar larvae are readily seen even in rust-colored pools due to the lack of dark pigmentation in the integument of the thorax and the eighth abdominal segment. The larvae have the interesting habit of moving forward in a series of short regular jerks.

The larvae have been taken with those of Ae. canadensis, Ae. vexans,

Psorophora ferox, and P. ciliata.

Adult Habits and Importance

They feed on man and show a preference for the upper parts of the body. They feed from late afternoon until dusk and apparently remain in forested areas near the breeding grounds. They are relatively inactive after dark and are not readily attracted to light. Night light trap collections near breeding areas in Wheeler Reservoir have given negative results.

Ae. tormentor is of no known economic or medical importance in the Valley but may be a component of the pest species complex.

Overwintering and Seasonal Development

The species overwinters in the egg stage. Overwintering eggs are known to hatch as early as April in the Wheeler Reservoir area. At this time of year when water temperatures are low, larval development requires about two weeks. Collections of recently emerged adults in May, July, and October indicate at least three broods a year.

Distribution in the Tennessee Valley

Pickwick, Wheeler, Guntersville, and Hales Bar Reservoirs.

## Aedes triseriatus (Say)

Recognition Characters

The mesonotum of this species bears a wide brown longitudinal stripe bordered on either side by white scales. The abdominal tergites are blueblack with conspicuous basal patches of white scales laterally.

The larva is rather slender with four small blunt anal gills which are shorter than the anal segment. The upper head hair is single and the lower one is 2 to 4 branched.

Larval Habitat, Habits, and Associations

This species breeds in still water rich in organic matter, favored breeding sites being stumps and tree holes. Larvae have been found in tree holes of many trees, e.g., the gums, yellow poplar, hackberry, pecans, beech, black willow, red maple, ironwood, hop hornbeam, ash, oaks, and elms. They are frequently found in artificial containers in or near woods, e.g., tin cans, glass jars, automobile tires, vases in cemeteries, abandoned wells, cisterns, hollow fence posts, and in debris-choked gutters on houses.

Eggs collected from tree cavities during the winter period hatch readily if placed in tap water and held a few days at room temperature of about 70° F. Larval development under field conditions requires from three to nine weeks, the duration of the developmental period being mainly a function of water temperatures (Snow, 1949). In the laboratory with water at 80° F., larval development and pupation occurred in ten days.

The larvae are active and often move in a serpentine fashion. They are negatively phototactic and do not respond to movement near them unless such movement decreases the light intensity. Under these conditions, the larvae descend to the bottom of the breeding receptacle. Frequently, the larvae burrow in the debris and can remain submerged as long as seven minutes.

Larvae have been found associated with those of Anopheles barberi, Culex restuans, Orthopodomyia alba, O. signifera, and Toxorhynchites septentrionalis in the Valley.

Adult Habits and Importance

The adult females have been observed to deposit from 100 to 150 eggs under field conditions in less than ten minutes (Snow, ibid.). The eggs are deposited singly, each being inserted on the wall of the receptacle just above the waterline. A blood meal is considered to be an essential requirement for maturation of eggs. Laboratory females provided meals of only sugar solution failed to develop mature eggs.

The females feed readily on man during the day and in the early evening hours about dusk. They attack readily if disturbed from their resting sites in woodlands. They also feed in dwellings in or near the woods. They attempt to feed mainly when air temperatures are from

60° to 80° F.

The adults may rest during the day and night on the upper wall of the breeding receptacle or on nearby vegetation. They have also been found resting during the day in routine anopheline resting stations. Both sexes have been taken in light traps, but males are particularly attracted.

On occasions, Ae. triseriatus becomes pestiferous in localized areas. In such instances, breeding is usually in discarded containers and in clogged gutters on houses. Sources of annoyance by this mosquito to residents on Ocoee and Hiwassee Reservoirs in 1953 were traced to collections of water in old tire casings on the reservoir margin and on private land. The species has also been shown experimentally capable of transmitting yellow fever and the eastern strain of encephalomyelitis.

Overwintering and Seasonal Development

The winter is passed in the egg stage on the walls of the breeding receptacle. The wetting of the overwintering eggs by rising water of favorable temperature results in their hatching in the spring. Eggs hatch as early as January in the Valley, but apparently most eggs hatch in February or thereafter. The adults are common in woodland areas mainly from May to October. Four or five broods may be produced during the season.

Distribution in the Tennessee Valley

This species is well distributed throughout the Valley.

## Aedes trivittatus (Coquillett)

Recognition Characters

The adult is marked by a distinctive pair of whitish-yellow, longitudinal, submedian stripes on the mesonotum.

The larva is recognized by the spiculate body; the slightly barbed upper and lower single head hairs; and the apical spine of the comb scale which is about twice as broad and 11/3 times as long as the subapical spinules.

Larval Habitat, Habits, and Associations

The larvae occur in shallow, rainfilled, grassy depressions, in swamps, or in bottomland forests. Abdel-Malek (1948) showed that infusions of blue grass favor hatching and considered auxins or hormones liberated from the grasses to be a controlling factor. He also induced hatching by placing eggs in aqueous solutions of plant hormones, such as alpha naphthalene acetic acid at concentrations of 10 to 20 ppm. The minimum period from hatching of eggs to the emergence of adults under laboratory conditions at 80° F. was shown by Abdel-Malek (ibid.) to be six days, with a maximum period of ten days. In nature the eggs hatch at a field water temperature of 60° to 70° F. The small larvae remain at the water surface feeding on microorganisms. The first three larval instars are completed in a total of three days, but the fourth instar requires three or more days. These fourth stage larvae are rarely seen at the surface since they spend most of their time concealed in vegetation at the bottom of the

pool. In the field, pupae tend to congregate in large clusters along the

margin of the breeding pool.

In a willow swale on Pickwick Reservoir, larvae of Ae. trivittatus were associated with those of Ae. vexans, Psorophora ferox, P. ciliata, and Ae. atlanticus.

Adult Habits and Importance

The adults usually rest during the daylight hours on the underside of leaves in low vegetation. Only one female has been collected in 26 years from anopheline resting stations in the Valley. They do not feed until approximately three days following emergence. Mature females attack man and seek blood near dusk, but they will also feed in bright sunlight if their natural resting place is invaded. Observations in the Valley indicate that they do not feed readily on man at night although the species has been taken in light traps about ½ mile from the breeding ground, indicating some nighttime activity. Abdel-Malek (ibid.) states that the female is slow in procuring a blood meal, probing the surface of the skin for one to three minutes with the tip of the proboscis before attempting to make a puncture. The mosquito first makes a shallow wound, retracts the stylets, and then, after an interval of about 30 seconds, makes a deeper wound.

The flight range is considered to be about ¼ mile in wooded areas. A retreat of 100 yards from an area where the species is pestiferous results

in relief, with most specimens remaining in their original haunts.

According to Abdel-Malek (*ibid*.) the adult female under observation laid an average of 55 eggs deposited in small batches. The females almost invariably died within a few hours after their initial oviposition under laboratory conditions and in some instances did not move from the last batch of eggs deposited. Dissection of the dead females after ovipositing showed young ova similar to those in newly emerged specimens. This suggests that a second batch of eggs might develop in nature.

suggests that a second batch of eggs might develop in nature.

This species is of no known medical importance in the Valley; however, it is well distributed, and, if man invades its woodland habitat,

it may become extremely pestiferous.

Overwintering and Seasonal Development

The species overwinters in the egg stage. The overwintering eggs on the soil hatch upon flooding generally from June to September. Observations suggest a single scattered generation per year.

Distribution in the Tennessee Valley

This species is well distributed throughout the Valley with concentrated populations being observed in Kentucky and Pickwick Reservoirs.

#### Aedes vexans (Meigen)

Recognition Characters

The mesonotum of the adult is brown-scaled except for irregular posterior and lateral patches of gray scales. The abdominal tergites are characterized by inverted V-shaped notches in the basal band of white scales. The legs and tarsi are mostly black, but each tarsal segment bears a narrow basal white band, those of the hind tarsi being the most conspicuous.

The larva is recognized by the incompletely ringed dorsal plate, the widely spaced distal teeth of the pecten, the multiple upper head hair,

and the double lower head hair.

Larval Habitat, Habits, and Associations

The larvae commonly occur in grassy rainpools, low depressions, flooded river bottoms, and roadside ditches. The eggs are long lived on moist soils as evidenced by the report of Gjullin et al. (1950) that large numbers of eggs remained viable for two years and some retained their viability as long as four years. The eggs require saturated soils or shallow flooding for hatching and do not hatch in quickly and deeply flooded areas or running water. A high percentage of hatching follows shallow spring flooding of eggs dewatered the previous winter. Periodic flooding and dewatering favors the hatching of successive broods since only a

small percentage of those continuously flooded from late winter through the spring and summer months hatch. Reduction in dissolved oxygen is thought to be the regulating mechanism of egg hatching. Some hatching occurs when the dissolved oxygen is reduced to 4 ppm, but lower oxygen levels are required for complete hatching. Hatching of eggs has been induced by lowering the oxygen tension by means of yeasts, by lowering the atmospheric pressure, and by bubbling hydrogen through a sterile solution batching the eggs. In nature, auxins released from plants might be of significance in inducing hatching of the eggs. Hatching of eggs is impeded by covering them with silt. Embryonic development is generally completed within ten days after which hatching is possible.

When field water temperatures approximate 80° F., the larval stages may be completed within five days with adult emergence on the seventh day after a two-day pupal period. Under less optimum conditions, complete development may require 10 to 20 days with the pupal stage lasting as long as seven days. In the winter season, complete development may require 60 or more days with the pupae surviving even though frozen in ice for several days. Larvae appear capable of surviving for short periods in pools free of surface water between intermittent rains, and pupae have emerged on moist filter paper for approximately a three-day period after being taken from water. Thus, the emergence of adults might be expected in nature from breeding areas no longer containing free surface water.

In nature from breeding areas no longer containing free surface water.

Larvae of this species have been taken in grassy pools with those of Ae. canadensis and Ae. atlanticus early in the spring and with Psorophora cyanescens, P. confinnis, P. ferox, P. ciliata, Ae. atlanticus, Ae. sticticus, and Ae. trivittatus during the warmer parts of the breeding season. In hoofprints, they are frequently found with larvae of Anopheles punctipennis. Overwintering eggs of this species have been recovered from soil samples with those of Ae. trivittatus, Ae. sticticus, Ae. atlanticus, P. ciliata, P. confinnis, P. cyanescens, P. discolor, P. ferox, and P. varipes. Other associates have been Ae. sollicitans, Ae. tormentor, P. horrida, and P. howardii.

#### Adult Habits and Importance

Gjullin et al. (ibid.) reported mating from confined specimens which occurred in a cage measuring 34" x 34" x 36". The females were provided blood meals from a rabbit, and low egg production resulted. Wild-caught inseminated females given blood meals in the laboratory showed good egg production under caged conditions. These females deposited an average of 43 eggs, with one specimen depositing a total of 144 eggs. Eggs were usually deposited five to ten days after the blood meal, and, under laboratory conditions, some hatched within three to five days after deposition. The females produced from two to four batches of viable eggs each.

In nature females deposit eggs singly upon the ground mainly in the floodplain subject to early spring flooding. The females oviposit almost exclusively on shaded sites, either under forested areas or under herbaceous vegetation. The eggs are usually deposited in relatively flat areas, and where oviposition occurs on a relatively steep shoreline eggs are found to be distributed in a very narrow band just above the waterline.

The adult female feeds readily on man and takes blood meals both day and night. Darkness or temperature changes over a range of 59° to 83° F. do not hinder feeding activities. The adults commonly rest in grass near the breeding area. Both sexes enter cars in large numbers in the daytime if they are disturbed from their resting site. Engorged females may also rest in the daytime in sheds, barns, culverts, and other similar protective shelters.

Marked specimens have been recovered three miles from the point of liberation, but further study will be required to establish its maximum flight range. Vertical distribution studies showed the species to be active and annoying at ground level, but it could not be found at the 20- to 30-foot level of the forest. In light traps operated simultaneously at ground level and on 100-foot towers, only nine per cent of the catch of this species occurred in the trap at 100 feet.

Ae. vexans, making up approximately 85 per cent of the pest species complex, is the most important pest species of mosquito breeding near the artificial lakes in the Tennessee Valley. At times, it has been annoying to man on portions of Fort Loudoun, Watts Bar, Hiwassee, Chicamauga, Hales Bar, Guntersville, Wheeler, Pickwick, and Kentucky Reservoirs. The largest populations have been observed at Murphy, North Carolina. with other high populations at Florence, Alabama, and Chattanooga and Dayton, Tennessee. Rapid embryonic and larval development, long viability of eggs in relatively dry situations, and an extensive flight range in the adult stage give this species a prominent place in intermittently flooded habitats along reservoir margins. Cyclical fluctuation below top summer pool at weekly intervals aids in the prevention of its development to a nuisance level. Hayes et al. (1961) present evidence that Ae. vexans was the primary epizootic vector of eastern encephalitis in the New Jersey outbreak of 1959, and may have been responsible for some of the transmission to humans.

Overwintering and Seasonal Development

The species overwinters in the egg stage, the eggs remaining dormant at water temperatures below 45° to 50° F. During the period November-February 1950-51, three winter broods of Ae. vexans were produced at Muscle Shoals, Alabama, during favorable warm periods. Eggs which hatched November 2-3 gave rise to one brood of adults in late November; eggs which hatched November 15 produced a second brood which pupated in January; and eggs which hatched in February 1951 gave rise to a third brood of adults in March. The larvae survived low water temperatures under ice for several days when air temperatures were as low as 2° F. During cold periods with water below 40° F., the larvae became rather inactive and remained on the bottom or hidden in the submerged bases of grass clumps except for occasional surfacing for air. Ground temperatures under the ice and water were not recorded below 39.5° F. even when the ice was several inches thick above the six- or seven-inch layer of water. The first spring brood of larvae appears in March or early April followed by the first spring adults in late April. In the normal spring filling of Kentucky and Picwick Reservoirs, hatching of Ae. vexans in the grassy margins near top pool elevation annually occurs in April, and the pupal stage is usually reached by the first week in May. Adults are common in the area from April to November. The species has a number of broods during the warm season, and apparently some eggs hatch throughout this period whenever rains or floodwaters form shallow temporary pools.

Distribution in the Tennessee Valley

This species is well distributed throughout the Valley and is the most important pest species therein.

# Culex erraticus (Dyar and Knab)

Recognition Characters

This species has short, wide scales on wing veins R<sub>2</sub> and R<sub>3</sub>. The occiput bears a large mesal triangle of narrow scales, while the area between this triangle and the eyes is covered with wide, overlapping scales.

The larva has long, single lower head hairs and short, multiple upper head hairs consisting of four or more branches. The comb scales are long and thorn shaped, arranged in a curved or irregular single or double row.

Larval Habitat, Habits, and Associations

The species breeds in marginal areas of permanent pools, lakes, ponds, limesinks, sloughs, and streams where there is an abundance of emergent vegetation. Egg rafts have been observed attached to leaf margins of many kinds of floating plants, particularly duckweed (Lemna) and lotus (Nelumbo). Larval development is favored by water temperatures in the mid-80's and their occurrence and development parallel that of Anopheles quadrimaculatus. The larvae are commonly found with those of A. quad-

rimaculatus and Uranotaenia sapphirina, and have been taken with C. salinarius.

Adult Habits and Importance

While man is frequently a host, the adults appear to have a preference for blood of fowl and have been found in abundance in chicken houses. They are commonly taken in diurnal shelters associated with anophelines. The females are active primarily at night with a major peak at dusk and renewed feeding at daybreak. With a decrease in light intensity at dusk, this species moved into a forest canopy and fed on man at 75-foot level (Snow, 1955).

C. erraticus is of limited importance as a pest species.

Overwintering and Seasonal Development

The species overwinters as inseminated females which retreat to caves the species overwinters as inscriminated temales which retreat to caves and hollow trees during the cold season. They usually enter caves with the onset of cool weather in November. Overwintering adults leave the caves in February, take blood meals for maturation of the ova, and subsequently oviposit. Larvae occur in the field as early as April with the first adults emerging generally in May. Several generations are produced during the season with larval development being sharply curtailed by low temperatures in October. by low temperatures in October.

Distribution in the Tennessee Valley

This species is well distributed throughout the Valley.

## Culex peccator Dyar and Knab

Recognition Characters

The adult has wide wing scales on veins  $R_2$  and  $R_3$  similar to C. erraticus. It differs from C. erraticus in having the occiput entirely covered with wide overlapping scales except for an occasional narrow mesal line of narrow scales.

The larva has long, single lower head hairs and double or triple upper head hairs. The comb scales are arranged in a patch.

Larval Habitat, Habits, and Association

The larvae are found in grassy pools and in marshy areas with emergent vegetation. They have been found in association with C. territans along reservoir margins.

Adult Habits and Importance

The adults rest during the day in natural and artificial shelters, particularly in damp situations. They are taken occasionally in light traps. Information on their feeding habits is lacking.

This species is of no known economic or medical importance here.

Overwintering and Seasonal Development

The species probably overwinters in the Tennessee Valley as inseminated females in caves and other shelters. The first larvae of the season appear in May, and larvae have been found through September but not thereafter. Adults have been collected from June to October. The number of generations produced during the breeding season is not known.

Distribution in the Tennessee Valley

Pickwick and Wheeler Reservoirs (larvae); Henry and Coffee Counties, Tennessee (adults).

# Culex pipiens pipiens Linnaeus

This species is commonly known as the northern house mosquito. Current workers in the field consider that two forms are present in the eastern United States, a northern form designated as Culex pipiens pipiens, and a southern form, Culex pipiens quinquefasciatus, known by earlier workers as Culex fatigans. Because these forms hybridize in nature and under controlled laboratory conditions, a subspecific relationship is indicated (Barr, 1960). The stability of the hybrid or intermediate population is

unknown. In general pipiens occurs north of latitude 39° N. lat. and quinquefasciatus south of 36° N. lat. Collections from between these two latitudes are quite variable and contain pipiens, quinquefasciatus, intergrades, or combinations of these three (Barr, ibid.). Much of the Tennes-

see Valley is within the zone of intergradation.

The females and larvae of pipiens and quinquefasciatus are too similar for separation; however, the males may be separated by characters of the arms of the phallosome in the genitalia (Sundararaman, 1949). Because the majority of specimens collected in the Tennessee Valley have been taken in the indistinguishable larval and female stages, our biological information applies to the pipiens complex; however. in some instances, the subspecific identity of males has been determined and is included in separate paragraphs under distribution records.

Recognition Characters

The adult female has coarse, golden lanceolate scales on the scutum, and conspicuous transverse basal bands and lateral patches of white scales on the abdominal tergites.

The larva has multiple upper and lower head hairs and has the subapical subventral tuft of the siphon out of line with the other subventral

Larval Habitat, Habits, and Associations

The larvae occur in practically all types of permanent pool habitats produced by man's activities. Common breeding sites include water barrels, street gutters, buckets, tubs, tin cans, clogged drains, cesspools, catch basins, open septic tanks, polluted refuse pits, paper mill log ponds, waste settling basins, and other artificial containers as well as polluted ground pools.

They occur over a wide temperature range but are retarded by low temperatures and do not survive freezing. Older larvae are more resistant to low temperatures than are the early instars. Larvae of pipiens show a great tolerance of polluted conditions and thrive in waters with a high content of

organic solids. They occur in water with a pH range of 4.2 to 9.0.

In the Valley, larvae of the *C. pipiens* complex are most frequently associated with those of C. restuans in container type habitats. In waste basins they occur with C. salinarius. In borrow pits, they are found with C. tarsalis, Culiseta inornata, Anopheles punctipennis, and A. quadrimaculatus. They have also been found with Aedes aegypti, Ae. sollicitans, and Toxorhynchites septentrionalis.

Adult Habits and Importance

The females show a preference for avian blood, but man is also attacked. Feeding is usually restricted to nocturnal hours and occurs either inside or outside of dwellings. The species shows two major peaks of activity, one at dusk and the other at dawn during the hours of changing light intensity. At these times, large swarms of adults have been observed either over or to the leeward side of some prominent object such as a chimney or hedge. Under natural conditions, mating is believed to occur on the wing during the dusk activity.

The adults rest during daylight hours under porches and in dwellings, barns, sheds, and chicken coops. The body of the resting adult is relatively

parallel with the resting surface.

While the effective flight range of this domestic species is considered to be short, stained females and males have been collected approximately 14 miles from the point of liberation one day after release (Clark, 1943).

The adults are attracted by moderately high temperatures. A joint of stove pipe heated by an alcohol lamp was found to be about as attractive to adults as human bait (Crumb, 1922).

The species is a known intermediate host of Wuchereria bancrofti in China, Japan, and Egypt and is readily infected in the United States. In this country, it is a vector of Dirofilaria immitis which results in heartworms in dogs. It has also been incriminated in the transmission of both Western and St. Louis encephalitis and has been shown capable of transmitting bird malaria.

Overwintering and Seasonal Development

The species overwinters as inseminated females in culverts, cellars, sheds, stables, and similar structures where dark, moist sheltered conditions prevail. Although they are generally inactive during this period, overwintering females occasionally invade the warmer rooms of dwellings and seek blood meals.

The adults usually emerge from the overwintering site and oviposit in April or May depending upon weather conditions. Each female lays from 100 to 400 eggs in a boat-shaped mass on the surface of the water. The entire life cycle from egg to adult ranges from 10 to 14 days with the pupal stage lasting two or three days. Breeding continues through the summer, and all aquatic stages can be found simultaneously in a given breeding receptacle. A large number of generations are produced each season. Larvae have been found from May to January.

Distribution in the Tennessee Valley

The C. pipiens complex is well distributed throughout the Valley; however, since much of the Valley is in the zone of intergradation, there is considerable overlap of pipiens and quinquefasciatus. From specimens sent to A. R. Barr for study, the following results were recorded (in litt.): Florence, Ala. (78 specimens collected October 12, 1954)—72 quinquefasciatus, 2 pipiens, and 4 intermediates; and Sheffield, Ala. (12 specimens collected November 18, 1953)—all quinquefasciatus.

## Culex pipiens quinquefasciatus Say

Recognition Characters

The adult is so difficult to separate from C. p. pipiens that most specialists rely on genitalia characters for identification. The rods of the inner mesosomal plates of the male genitalia are convergent and U-shaped in C. p. quinquefasciatus and are divergent and V-shaped in C. p. pipiens. In much of the earlier literature, this mosquito has been referred to as C. fatigans Wied.

The larva is not separable from that of C. p. pipiens.

Larval Habitat, Habits, and Associations See discussion under C. p. pipiens.

Adult Habits and Importance

The adult females feed readily on man and show a greater preference for human blood than *C. pipiens*. Feeding activities are usually confined to the nocturnal period commencing at dusk and continuing until dawn. Although they enter houses readily, adults can be found resting during the daytime in many additional situations such as culverts, sheds, barns, outhouses, and other structures having a dark, moist, sheltered interior.

houses, and other structures having a dark, moist, sheltered interior.

The flight range of the adults is usually restricted to populated areas

near the breeding grounds.

Overwintering and Seasonal Development

The adults overwinter as inseminated females in caves and other structures which afford protection from subfreezing temperatures. The seasonal development as given for C. p. pipiens is applicable to this species.

Distribution in the Tennessee Valley

See discussion under C. p. pipiens.

#### Culex restuans Theobald

Recognition Characters

This mosquito is characterized by the almost straight posterior borders of the basal abdominal bands which are broadly joined to the lateral patches, and usually by a pair of small pale-scaled submedian spots on the scutum.

The larva has from 4 to 6 long, single, irregularly placed hairs on the scutum. The larva has from 4 to 6 long, single, irregularly placed hairs on the siphon, and the antennal hair tuft inserted near the middle of the antennal shaft.

Larval Habitat, Habits, and Associations

The larvae commonly occur in ground pools, ditches, and borrow pits.

They may be found in artificial containers, such as barrels, usually those containing decaying organic matter. They seem to prefer foul water, especially that containing decaying grass and leaves. The larvae occur mainly in cool

water and can be found in the warm summer in spring-fed areas.

Larvae of C. restuans were associated with those of C. territans in the coffee-colored waters of a spruce bog in North Carolina atop Clingman's Dome at an elevation of 6,643 feet. In acid waters of a black gum swamp, C. restuans tended to favor the open bases of black gum trees where it was frequently associated with larvae of C. territans, Culiseta melanura, and Anopheles punctipennis. In a polluted refuse pit, the larvae have been found associated with those of C. p. pipiens and C. p. quinquefasciatus. Other associates are A. crucians, A. quadrimaculatus, Aedes thibaulti, Aetriseriatus, C. tarsalis, Culiseta mornata, Orthopodomyia alba, O. signifera, and Toxorhynchites septentrionalis.

Adult Habits and Importance

The adults feed upon man occasionally, particularly out-of-doors. Normally adult feeding activities commence at dusk and continue sporadically throughout the night. Occasionally they have been observed feeding in the afternoon along shaded stream banks and in the interior of old tupelo gum forests.

A swarm of about 200 males was observed dancing individually above a low bush in the twilight period near Camp Shelby, Mississippi, in October. The swarm was about two feet in diameter and four to six feet in height with its lowest parts about five feet above ground. The mosquitoes quickly reassembled after being disturbed by slight air movement. Several females were seen flying horizontally but did not pass through the swarm (Michener, 1947).

1947).

The adults rest during the daytime in sheds, barns, privies, hollow trees, and other wooden structures commonly used by A. punctipennis. They have

been collected frequently in light traps.

The species is of no known economic or medical importance in the Valley. However, Hayes et al. (1960) report the isolation of eastern encephalitis virus from C. restuans collected in New Jersey during the encephalitis outbreak of 1959.

Overwintering and Seasonal Development

The inseminated females overwinter in caves or hollow trees. They emerge from their winter quarters and oviposit early in the spring. The first brood of larvae may be found in the field as early as March with the first generation of adults appearing in April. Activity of this species is somewhat limited by warm temperatures during the summer. With the onset of cool fall weather, it reinvades many of the pools forsaken in the summer and is frequently found until freezing weather in November or December. Distribution in the Tennessee Valley

This species is well distributed throughout the Valley.

# Culex salinarius Coquillett

Recognition Characters

The abdomen of the adult has poorly defined, dingy-yellow lateral basal patches connected by narrow, dingy-yellow basal bands dorsally.

Recognition features of the larva are multiple upper and lower head hairs, a slender air tube from 6 to 8 times as long as the basal width, scattered and weak tufts on the air tube, and a glabrous thorax.

Larval Habitat, Habits, and Associations

The larvae have been found in grassy pools, marshes, swamps, flooded ditches, cattle tracks, stump holes, and occasionally in rainwater barrels. They are known only from fresh water areas in the Valley, but occur also in brackish water in coastal regions.

During summer months, larvae have been associated in swamps and marshy areas with those of *C. erraticus, Anopheles quadrimaculatus,* and *Uranotaenia sapphirina*. In a flooded cornfield in November and December,

common associates included Culiseta inornata, A. crucians, and A. punctipennis. Other associates have been Aedes sollicitans, C. p. pipiens, and Toxorhynchites septentrionalis.

Adult Habits and Importance

The adults rest during the daytime in sheds, barns, culverts, hollow trees, and other protective sites. The females feed readily on man. In field collections near reservoirs, C. salinarius has been the most pestiferous mosquito of the genus. Feeding activity begins at dusk and is most heavy in the first hour of darkness but extends well into the night as determined by the parked car sampling method (Snow, 1955). Falling temperatures do not inhibit their attempts at feeding until the low 50's are reached. This species appears to be an outdoor feeder.

Adults have been collected off the eastern coast in light traps at a distance of 8.4 miles from the nearest shoreline (MacCreary, 1941). Other than this record, little is known of their flight range. The species has been collected in light traps near the ground and at elevations of 100 feet above the surrounding terrain. In forested areas, some adults rise into the forest canopy at dusk to feed and remain until dawn. Specimens were observed feeding sporadically through the night (Snow, ibid.).

C. salinarius is an abundant and annoying pest mosquito in the Valley.

Overwintering and Seasonal Development

The species overwinters as inseminated females in caves and similar sheltered situations. The overwintering females usually emerge in February and generally oviposit in March. Adults of the first generation appear in April and May. Breeding continues in the field until September or October. In exceptionally mild fall seasons, larvae have been found in the field near the middle of December. The number of generations per season has not heen determined.

Distribution in the Tennessee Valley

This species is well distributed throughout the Valley, becoming more scattered in the upper eastern areas.

# Culex tarsalis Coquillett

Recognition Characters

This mosquito is recognized by the median band of white scales on the proboscis; basal and apical white bands on the hind tarsus; and a conspicuous

white streak on the femur, tibia, and metatarsus.

The larva can be identified by characters of the air tube which is about six times as long as wide with the subventral tufts in a straight line near its

ventral margin.

Larval Habitat, Habits, and Associations

The larvae appear to have a very wide range of tolerance in habitats ranging from irrigation ditches to polluted wastes from a sulfuric acid plant. They have been found particularly abundant in marshes, irrigation water, waste and seepage water, and roadside ditches.

Near Florence, Alabama, larvae of C. tarsalis were found with those of Anopheles quadrimaculatus, A. punctipennis, and C. p. pipiens in a construction borrow pit and with those of Culiseta inornata, C. restuans, C. p.

pipiens, and A. punctipennis in backwater on Cypress Creek.

Adult Habits and Importance

Considerable research has been done on this mosquito in California and in the midwestern states where it has been found infected with the viruses

of western equine encephalitis and St. Louis encephalitis.

The females are fierce biters and attack man and avian hosts readily. They enter houses freely and usually feed at dusk and during the hours of darkness. The adults rest during the day in sheds, chicken houses, pump houses, outdoor privies, garages, and under porches and bridges.

Its flight range has been found to be 2.5 miles with most recoveries in

the 1-mile zone and upwind from the point of release (Reeves et al. 1948). All records show that C. tarsalis occurs in the Valley only during the late summer or fall months. A single light trap at Hustburg, Tennessee, where Duck River broadly joins the Tennessee, collected 67 females and 4 males, September 15, 1953, with 7 additional specimens being captured during the ensuing two weeks. Another trap in operation at the same time at Dayton, Tennessee, across the Cumberland Mountain from Hustburg, collected six female C. tarsalis on September 14-16. No others were taken during the year. This strange phenomenon may suggest a seasonal step-by-step migration from the West where they are more abundant throughout the year.

The vector relationships of C. tarsalis in the Tennessee Valley are un-

known.

Overwintering and Seasonal Development

This species has not been found overwintering in the Valley, but elsewhere it overwinters as inseminated females in caves, basements, and in similar protective situations. Rush et al. (1958) reported observations on a population of C. tarsalis in a state of true hibernation in a natural site (loose rock at bases of volcanic outcrops) in the Columbia Basin. The adults leave the overwintering site in early spring and oviposit. In areas where C. tarsalis is common, breeding continues from spring until the first freezing temperatures in the fall. At least two fall generations have been determined for C. tarsalis on Cypress Creek near Florence, Alabama.

Distribution in the Tennessee Valley

Kentucky (larvae and adults), Pickwick (larvae and adults), Wheeler (larvae), Chickamauga (adults), and Fort Loudoun (larvae and adults) Reservoirs; Christian County, Kentucky.

#### Culex territans Walker

Recognition Characters

The adult is recognized by the distinct apical triangular patches of white scales on both sides of abdominal tergites II to VII, usually joined by a

narrow dorso-apical band of similar scales.

The larva is recognized in the field by its unusually long air tube (about 7 times as long as the basal width). The upper and lower head hairs are long and single, and the head is much wider than long.

Larval Habitat, Habits, and Associations

The larvae breed in permanent and semipermanent pools. streams, open marshes, bogs, swamp forests, hoofprints, and occasionally in tree holes. They are found in cool waters that are either alkaline or acid in reaction. The larvae occur over a wide range of areas and have been collected from elevations ranging from the valley floor (300 ft. above m.s.l.) to the highest point in the Great Smoky Mountains (over 6,600 ft. above m.s.l.)

The larvae are most frequently associated with other cool water species such as C. restuans and Anopheles punctipennis. They have been found with A. crucians, Aedes dupreei, Ae. infirmatus, Ae. thibaulti, C. peccator, Ae.

sticticus, and Culiseta melanura.

Adult Habits and Importance

During daylight hours, the adults rest in situations usually frequented by the common anopheline mosquitoes of the Valley, e.g., sheds, barns, culverts, etc. In Mississippi, they have been recorded resting on vegetated and shaded earthbanks or walls of pits (Michener, 1947). The adults show a peak of activity near dusk but are infrequently recovered in light trap collections at night. They are not known to feed on warm-blooded animals. Their source of blood is probably from cold-blooded vertebrates.

They are of no known economic or medical importance in the Valley.

Overwintering and Seasonal Development

The species overwinters as inseminated females which take refuge in caves and similar sheltered situations during the cold season. Overwintering females take wing and oviposit presumably in February. The eggs are laid in rafts on the water surface. Larvae are found in the field in March, but the first spring generation of adults does not appear until early April. The species prefers cool water for breeding, thus it is abundant in the spring and fall and infrequent during the hot summer. During the warm period, some production may occur in heavily shaded, cool, spring-fed situations. The number of annual broods has not been determined.

Distribution in the Tennessee Valley It is well distributed throughout the Valley.

# Culiseta inornata (Williston)

Recognition Characters

This mosquito has very broad, sparsely scaled wings, the costa having mixed dark and white scales; the distance between cross veins arising from vein 4 is less than the length of either cross vein; and spiracular bristles number more than six.

The robust larva can be identified by the long, multiple upper and lower head hairs; an even row of long hairs beyond the pecten; and the comb consisting of many scales arranged in a patch.

Larval Habitat, Habits, and Associations

Larval Habitat, Habits, and Associations

The larvae occur in pools, ditches, sink holes, stump holes, marshes, artificial ponds, and occasionally in rainbarrels. They are capable of surviving near freezing temperatures and have occasionally been collected from beneath ice in December and January in Alabama. They have not been found during the hot summer months in the Tennessee Valley.

In Pickwick Reservoir, larvae and pupae of C. inornata were present on an arm of Cypress Creek with Culex restuans, C. p. pipiens, C. tarsalis, and Anopheles punctipennis during November. During the winter they have been found in a borrow pit near Tuscumbia, Alabama, with A. crucians and Culex salinarius.

crucians and Culex salinarius.

Adult Habits and Importance

The adults generally rest in vegetation and sheltered situations during the day though they often move about. The males tend to swarm about low vegetation at dusk. Females feed primarily during the early evening hours on livestock and occasionally on man. The species is readily attracted to light and is often found in light trap collections during cool weather when no other nocturnal insects have been captured.

They enter dwellings readily.

This species is of little known importance in the Valley, but elsewhere it has been found naturally infected with the virus of western equine

encephalitis.

Overwintering and Seasonal Development

C. inornata is the predominant cool weather species in the Tennessee Valley. Unlike the other mosquitoes in the region, it is generally active during the winter months and is inactive during the summer. It has been taken during the winter months at temperatures as low as 40° F. The largest field populations are found in the fall (September-October) and spring (March-April), though fair numbers may be collected in the field during the early evening hours in winter when temperatures are above 50° F. Distribution in the Tennessee Valley

Records on this species show a scattered distribution throughout the Valley.

# Culiseta melanura (Coquillett)

Recognition Characters

This mosquito has densely scaled wings, the costa being entirely dark-scaled; the distance between cross veins is more than the length of either cross vein; and spiracular bristles number five or less.

The larva can be identified by the short, multiple upper head hairs and long, single, lower head hairs; a row of subequal tufts beyond the pecten; and the comb consisting of about 25 barlike scales in a single row. Larval Habitat, Habits, and Associations

In the Valley, the larvae are found most frequently in tupelo gum and black gum swamps usually in the shaded but open basal cavities of gum trees rather than in the open water of the swamp.

In gum swamps, the larvae have been collected with those of Culex territans, C. restuans, Anopheles punctipennis, A. crucians, and Aedes thibaulti.

Adult Habits and Importance

Adults commonly rest during the day in the moist hollow cavities of gum trees and in tree holes of swamp species and have been frequently found resting in privy-type experimental catching stations placed on the

margin of a swamp (Snow, 1949).

They are attracted by light and have been collected in considerable numbers in light traps in other regions. They have never been observed attempting to feed in the Valley and are of no known importance. In Louisiana and New Jersey, wild-caught specimens have been found harboring the virus of eastern equine encephalitis.

Overwintering and Seasonal Development

The species overwinters in both the larval and adult stages. The wintertime populations are relatively small. The larvae develop slowly during the winter months, and several months is required for the development of the spring generation of adults. Presumably the species has a spring and fall generation, but this has not been verified.

Distribution in the Tennessee Valley

Wilson and Wheeler Reservoirs; Black Warrior National Forest near Moulton, Alabama; Henry and Coffee Counties, Tennessee.

## Mansonia perturbans (Walker)

Recognition Characters

This mosquito is recognized by the broad ring of pale scales on the middle of the proboscis, the basal bands of white scales on the tarsi, and the mixture of very broad dark and white scales on the wings.

The larva is recognized by the long slender antennae with a pair of short, stout setae inserted at the middle; and a short, pointed siphon without a pecten modified to form a sawlike structure which is used for piercing and attaching to the underwater parts of aquatic plants.

Larval Habitat, Habits, and Associations

The larva is found only in those areas where surface water is maintained in aquatic vegetation practically all year. Watered areas having muck bottoms offer a better habitat than those with sandy or hard clay bottoms. Breeding sites in the Valley are limited mainly to spring-fed areas with a permanent flow, permanent seepage areas, or to impoundments with a relatively constant pool level. The presence of surface water over most of the annual cycle is important because the larval life of M. perturbans is long, and dewatering for significant periods is fatal to the larvae; however, they can survive short periods in the moist muck in the absence of surface water.

Special collecting techniques must be employed in order to secure a larval specimen. They attach themselves to underwater portions of vascular plants by means of the siphon, and the pupae attach themselves by means of their respiratory trumpets. These structures may penetrate either roots, stems, or leaves. The respiratory organs are inserted into plant tissues containing air spaces, and, in this manner, the aquatic stages of the mosquito obtain oxygen from the internal atmosphere of the host plant. As a result, the larvae and pupae are unique among mosquitoes in that they do not come to the water surface periodically to renew their oxygen supply. Also, the larval food supply is limited to organic matter transported to them by water currents, passing food particles being swept in by the mouth brushes. The larvae can detach and reattach themselves to the host plant. The recently formed pupae have the ability to attach themselves to plants by the trumpets; however, if they once become detached from the plant, they apparently do not possess the ability to reattach themselves. The larval period is long, lasting three months and more. Normally, the pupae detach themselves in from five to nine days and rise to the water surface where eclosion takes place.

In the Tennessee Valley, larvae have been found associated with parrots feather (Myriophyllum brasiliense). Although larvae have not been collected extensively in the Valley, swamp loosestrife (Decodon verticilatus) is undoubtedly involved since the most productive area in the Valley is dominated by this plant. Elsewhere known host plants include the common pickerel weed (Pontederia cordata), swamp loosestrife (D. verticilatus), two species of arrowhead (Sagittaria lancifolia and S. montevidensis), water hyacinth (Eichhornia crassipes), spatterdock (Nymphaea macrophylla), and both species of cattail (Typha latifolia and T. angustifolia).

#### Adult Habits and Importance

The adults rest during the daytime, probably in vegetation near the breeding area. At dusk, they become active and move out seeking blood meals. A sharp feeding peak occurs with the onset of darkness and tapers off during the night hours with a secondary peak at dawn. Adults disturbed from their resting sites may feed sporadically in the daylight hours. Livestock near the breeding area appears to be the principal source of blood meals. Nevertheless, man is frequently attacked by this vicious, robust, aggressive, and strong-flying mosquito, and under certain conditions this species may show a preference for human blood. Near a 400-acre beaverdam swamp in north Alabama, this species makes up about 85 per cent of the total mosquito population that enters houses readily and causes great annoyance to a sizable human population. They literally "needle" the people into using large quantities of "Flit" inside the houses so that they can sleep at night. This daily use of insecticide also contributes to the control of the malaria vector, Anopheles quadrimaculatus, and may be partially responsible for the decline of malaria in this once highly endemic area. Great relief from all adult mosquitoes is experienced when cotton crop dusting starts.

The adults are known to have a flight range of at least two miles, but this has not been adequately studied. The vertical flight of the species is known to be at least 75 feet (Snow, 1955), many adults moving into the forest canopy at dusk. At dusk, the adults may be collected in large numbers using a parked car near the breeding area. More than 2,200 specimens were collected in a 45-minute period using this method. The species may also be collected by means of light traps.

The species is of considerable economic importance in local springfed swamp areas where surface water persists in vegetation throughout the year. The adult females in these areas are pestiferous to man and livestock.

The adults have been found naturally infected with eastern equine encephalitis in Georgia and Alabama.

### Overwintering and Seasonal Development

The species overwinters in the larval stages attached by the siphon to submerged portions of aquatic plants. In the spring, the overwintering larvae mature and some pupate. The pupa attaches itself to aquatic plants by its respiratory trumpets for a period of five to nine days. Then it detaches itself, rises to the surface. and the adults emerge. The emergence of the first brood of adults usually occurs in the latter part of May and the early part of June. The peak of emergence for the second brood of adults occurs in the latter part of September and early October. This has been observed during relatively mild fall seasons, but in years of early cold weather there is apparently no fall brood.

The adults emerge in large numbers in the spring, and the males swarm over emergent vegetation in the breeding area. Mating and oviposition follow, the eggs being laid in boat-shaped rafts on the water surface under the protective cover of emergent plants (Hagmann, 1952). The eggs hatch after several days and the larvae descend to the bottom. They attach themselves to roots or stems of plants on which they remain until the following spring. It may be that the fall brood of adults produces another generation of larvae in favorable seasons since females collected in October oviposited in the laboratory.

Distribution in the Tennessee Valley

Kentucky, Pickwick, Wilson, Wheeler, and Watts Bar Reservoirs; and near Athens, Tennessee.

### Orthopodomyia alba Baker

Recognition Characters

This mosquito has palpi about one-third as long as the proboscis and a dark scutum except for six narrow lines of white scales. Segment 5 of the hind tarsus is entirely white on one side; all other segments are ringed with white, apically and basally.

The larva can be recognized by its white to straw-colored appearance

and the absence of a sclerotic plate on the eighth abdominal segment.

Larval Habitat, Habits, and Associations

The larvae are most frequently collected in water-retaining tree holes but have also been taken from other receptacles containing water, such as flower pots. The larvae feed on organic matter in the breeding container. They are capable of surviving at least 24 hours on the moist substratum of the tree hole if the water surface evaporates completely.

Holes in the following trees have produced these mosquitoes: pecan, sweet gum, silver maple, and American and other elms.

Larvae of O. alba are nearly always associated with those of O. signifera; frequently with Anopheles barberi, Aedes triseriatus, and Toxorhynchites septentrionalis; and occasionally with Culex restuans.

Adult Habits and Importance

The feeding habits of the adults are unknown. Since Orthopodomyia has never been seen taking blood from man, either in the field or laboratory. it appears that man may not be a suitable host for this species. In recent laboratory experiments females engorged overnight on chicken blood, but no subsequent oviposition occurred (Sudia and Gogel, 1953).

This species is of no known economic or medical importance in the

Valley.

Overwintering and Seasonal Development

O. alba overwinters in the larval stage. Larval development in the winter appears to be delayed or retarded even during mild years and may last for seven or eight months. The pupal stage varies from 3 to 18 days depending upon the temperature. The first generation of adults usually appears in June. The adults mate and oviposit, and at least one generation is produced during the summer. Larval development during the summer is also slow, about two months being required. Adult emergence in the Valley occurs mainly from June to September.

Distribution in the Tennessee Valley

Kentucky and Pickwick Reservoirs; Knoxville, Tennessee.

## Orthopodomyia signifera (Coquillett)

Recognition Characters

The adult is similar to O. alba but differs in having complete black scaling apically on the second abdominal tergite and in having a whitescaled pattern on the radial sector of the wing.

The larva can be recognized by its pink to dark brown color and by the presence of a sclerotic plate on the eighth abdominal segment.

Larval Habitat, Habits, and Associations

The larvae occur typically in water-retaining tree holes and hollow stumps. Occasionally they may be found in water barrels, mash barrels, wooden containers, cistern, tin cans, and automobile tires, especially if these receptacles occur in wooded areas and contain fallen leaves and rotting wood. The larvae have been taken from cavities in a variety of trees including willow, hickory, beech, oak, elm, maple, sycamore, hackberry, and gum.

The larvae are killed if they are frozen in solid ice. In this respect, they differ from O. alba which survives solid freezing (Baker, 1936). These relationships might help account for the fact that O. signifera generally does not occur as far north as does O. alba. The larvae feed on rotifers and other microscopic organisms such as Vorticella, Paramecium, and Hypotrichia.

Larvae of O. signifera were most often collected with those of Aedes triseriatus, Anopheles barberi, O. alba, Toxorhynchites septentrionalis, and occasionally with Culex restuans.

Adult Habits and Importance

Males and females have been observed resting as well as flying about both day and night. Nevertheless, they appear to have a peak of activity just after dusk as observed by collections from a parked car and from a

rotary cone trap operated at a height of six feet.

The feeding habits of the adults are unknown. Man, rabbits, hamsters, chickens, frogs, and turtles have been provided to adult females of this species as possible sources for blood meals. Since all these tests have given negative results, its feeding habits remain unsolved. This leads one to suspect that it may be a vegetarian.

Its flight range is also unknown. Observations suggest that it remains close to the breeding area and dispersal is limited mainly to within the

forested areas.

This species is of no known economic or medical importance in the Valley.

Overwintering and Seasonal Development

It overwinters in the larval stage. The overwintering larvae develop slowly and persist for as long as six or seven months. Pupation usually occurs in May and June with the pupal stage lasting from 3 to 15 days depending upon the temperature.

The first generation of adults appears in either May or June. These adults mate and oviposit singly or in small vertical groups on the wall of the tree hole at the meniscus formed by the surface water film. These eggs give rise to the first summer generation, the life cycle being completed in about six weeks. Adults are found in the field from May to November. On this basis there appear to be about three or four generations during the warm season.

Distribution in the Tennessee Valley

This species is moderately distributed throughout the Valley.

# Psorophora ciliata (Fabricius)

Recognition Characters

This species, known as the gallinipper, is the largest blood-sucking mosquito commonly encountered in the Tennessee Valley. It is characterized by leg bands consisting of shaggy clusters of dark scales, and a single

median longitudinal band of yellow scales on the mesonotum.

The mature larva is about twice the size of other members of the genus except for the closely related *P. howardii*. It is characterized by a quadrate head, longer than wide, and sharp comblike prehensile mouth brushes. The lateral hair of the anal segment is 3 or 4 branched, while that of P. howardii is single or forked.

Larval Habitat, Habits, and Associations

The larvae occur most frequently in intermittently flooded grassy pools, ditches, and other depressions associated with open fields or marginal woodland areas. The larval and pupal stages develop rapidly in the summertime, the former lasting only four or five days, the latter usually less than two days. The larvae are predaceous and commonly feed upon those of associated species, such as *P. confinnis* and *Aedes vexans*. In feeding, the larva hangs almost vertically from the water surface and makes a grab for the smaller larva, grasping it with its mouth parts. A full grown *P. ciliata* larva consumes three to four smaller larvae per day. These

large larvae have been seen feeding on tadpoles near Florence, Alabama.

In grassy pools, larvae of P. ciliata have been found with those of Ae. vexans, P. confinnis, P. cyanescens, P. discolor, and P. howardii. In

willow swales, they are generally taken with Ae. vexans, Ae. trivittatus, and P. ferox. Other associates have been Ae. fulvus pallens, Ae. sollicitans, Ae. tormentor, and P. horrida.

Adult Habits and Importance

The adults rest in the daytime mainly under vegetative cover in the general vicinity of their breeding area. Although the females appear eager to feed at any time during either day or night, particularly if disturbed in their native haunts, there is a feeding activity peak in the early evening hours near dusk. They feed primarily on livestock, but man is also frequently attacked. They are persistent and severe biters. Disturbed females have been known to follow a potential host for over a quarter of a mile in quest of a blood meal. Because of their large size, they can successfully obtain blood meals through heavy clothing.

The adults are attracted by light and can be collected at dusk near a breeding area by using the parked car technique. The specimens within range are attracted to the car mainly within the first ten minutes after the headlights are turned on, and only a few additional specimens are generally caught by extending the collecting period. They attempt to feed on the occupants or rest on the car ceiling. The adults have also been

collected in small numbers by means of light traps.

At times, the species may be of economic importance in rural areas where its severe biting habits cause a real annoyance to man. Its size attracts considerable attention and provokes numerous comical comments.

Overwintering and Seasonal Development

P. ciliata overwinters in the egg stage, the eggs having been deposited a previous summer on moist ground. The overwintering eggs hatch in the Valley from April to October following rains. During the summer the developmental cycle is rather rapid, requiring only about one week from the time of hatching to the emergence of the adult. A number of broods are produced each season, depending upon rain distribution.

Distribution in the Tennessee Valley

This species is well distributed throughout the Valley.

Psorophora confinnis (Lynch Arribalzaga)

Recognition Characters

The adult has a distinct pale band on the middle of the proboscis and on the middle of the first segment of the hind tarsus. The wings are clothed with uniformly mixed black and white scales, and the legs and thorax are speckled with white scales.

The larva is bluish with a very plump abdomen, a short ovoid dorsal

siphon, and multiple upper and lower head hairs.

Larval Habitat, Habits, and Associations

The larvae occur in temporary rainpools of pastures and farm yards, in irrigation water, and in seepage. They occur more commonly in open

grassy areas than in forested bottoms.

The larva hangs almost vertically from the water surface. Development is rapid, being completed in a period as short as four days with optimum water temperatures of 85° to 95° F. In this temperature range the pupal stage lasts only one or two days, and adult emergence is common on the sixth day after hatching of the eggs. The males emerge several hours or even a day before most of the females in a given breeding area.

Larvae of P. confinnis have been found in association with those of Aedes atlanticus, Ae. sollicitans, Ae. vexans, P. discolor, P. cyanescens, and

P. ciliata.

Adult Habits and Importance

The newly emerged adults cling to emergent vegetation near the water surface, both sexes being found in large numbers from 36 to 48 hours after emergence. Presumably, mating takes place during this interval because thereafter the females migrate from the area in search of blood meals. According to Horsfall (1942), the females require more than one blood meal to produce the first batch of eggs. Females with only one blood meal lived

only five days or less and did not oviposit. Those provided with two blood meals laid an average of 72 eggs; with three blood meals, 100 eggs; and with an opportunity for daily feeding, 322 eggs. The first blood meal was sought about 36 hours after emergence and subsequent ones were taken at about three-day intervals. The mean preoviposition period at 80° F. varied from eight to nine days. Adults under natural conditions live up to about three weeks, but caged specimens kept under more constant conditions survived as long as nine weeks.

The adults rest during the day mainly on vegetation and occasionally in resting places used by the malaria mosquito. They take to the air at dusk and remain active through the night. Horsfall (*ibid*.) stated the maximum flight range of the species as determined by the recovery of marked specimens was approximately nine miles. Eight times as many specimens were retrieved within a radius of five miles as were recovered beyond the five-mile zone. One specimen migrated about six miles in

two days.

The adults live in open areas and tend to avoid forests. Efforts to locate the species near the forest floor and in the forest canopy have yielded negative results. Both sexes fly close to the ground, and the males

are usually found within 1,000 feet of the breeding area.

Females attack man readily and often, though livestock is considered to be the principal source of blood meals. Feeding characteristically begins at dusk and continues throughout the night; however, day feeding can easily be provoked by disturbing resting females. Adults have been taken feeding from May 16 to October 28 over a temperature range of 52° to 85° F. There is also some evidence which suggests that a bottomland field used for livestock grazing one year might be expected to produce large populations of this species the following year.

The adults are strongly responsive to light and are attracted in large

The adults are strongly responsive to light and are attracted in large numbers to light traps. They have also been taken in the Valley by the parked car technique resulting in a biting rate as high as 600 specimens

per hour on man.

This species causes serious annoyance to man and livestock. When unusually abundant, they cause considerable economic loss and have been known to kill livestock.

Overwintering and Seasonal Development

They overwinter in the egg stage, the eggs having been deposited a previous season on the soil under either rank or low-growing vegetation. The overwintering eggs begin to hatch in May. The developmental cycle is rather rapid requiring as few as six days from eggs to adult with summer-time temperatures. Hatching of the first brood from overwintering eggs is often erratic and may take up to three or more days. Eggs laid during the summer usually hatch within several minutes following inundation. The number of broods produced per season has not been determined. Distribution in the Tennessee Valley

This species is well distributed throughout the Valley.

# Psorophora cyanescens (Coquillett)

Recognition Characters

This mosquito is characterized by the pale-scaled occiput and mesono-

tum, and the unbanded metallic purple legs.

The robust larva is recognized by the conspicuous, short, and swollen air tube and the single upper and lower head hairs.

Larval Habitat, Habits, and Associations

The larvae occur mainly in temporary pools in grassy fields and occasionally in similar woodland situations. Eggs deposited by wild-caught females were stored dry in the laboratory through the winter. The following spring efforts to induce hatching with tap water at favorable temperatures failed. After a month the eggs were placed in a freshly prepared medium of canned corn and tap water. In this medium, the eggs began hatching within several hours. The optimum solution was found to be 1

part of creamed corn to 400 parts of water. The corn medium may have activated hatching directly by action of hormones or indirectly by lowering the dissolved oxygen.

At a constant temperature of 70° F, the larval stages may be completed as few as five days and the pupal period in only one or two days.

in as few as five days and the pupal period in only one or two days.

Larvae have been taken in grassy pools near Paris, Tennessee, with those of P. confinnis, P. discolor, and P. ciliata. In McFarland Bottom near Florence, Alabama, fall flooding of grassy depressions produced larvae of P. cyanescens and Aedes vexans. Other associates have been Ae. atlanticus, Ae. sollicitans, and P. horrida.

Adult Habits and Importance

The adults rest in the daytime mainly on vegetation near the breeding area and occasionally in shelters commonly used by the malaria mosquito. The females feed at any time during the day or night but are most active at dusk and dawn. Daytime feeding has been frequently observed, usually after the adults were disturbed from their resting places. The females are rapid fliers and can be heard from several yards distant. They are persistent and vicious biters, usually attempting to feed wherever they land on the body, whether on exposed skin or on clothing. The females bend with the wind rather than dislodge themselves once they have started to take a blood meal. They are known to be transported for miles on horses and cattle while feeding. Some specimens were reported to remain in the same position on the host for several hours. They feed in full sunlight, and feeding has been observed over the temperature range of 64° to 93° F. Feeding rates as high at 33 bites per minute have been recorded near Wilson Dam, Alabama, during the daylight hours. During a 15-minute afternoon period, nearly 400 female *P. cyanescens* entered a parked car to feed after being disturbed from their daytime resting positions by the approach of the car. Males were also noted in the car. Females have been captured feeding on man in the forest canopy during midday hours at heights of 30 and 50 feet, but they have not been found in forests at or near ground level (Snow, 1955). After a heavy outbreak of *P. cyanescens* at Florence, Alabama, in June 1949, females were found to have dispersed approximately two miles from the source of production.

This mosquito is an important pest in localized areas of the Tennessee

Valley.

Overwintering and Seasonal Development

P. cyanescens overwinters in the egg stage, the eggs having been deposited on the ground during a previous season. The overwintering eggs require a conditioning period in the spring before hatching occurs. Water temperatures favorable for hatching of Ae. vexans in March (60° to 70° F.) have not provoked hatching of P. cyanescens. Hatching occurs later in the season following flooding when temperatures are higher. In McFarland Bottom on Pickwick Reservoir, eggs have hatched in nature with natural and artificial flooding from early April through October. The developmental period from hatching until adult emergence is seven days when water temperatures are in the range of 67° to 76° F. The species produces several broods over the warm season, the number depending upon the amount and frequency of rainfall. In northern Alabama, a brood of P. cyanescens may remain troublesome for about three weeks and then disappear.

Distribution in the Tennessee Valley

This species is moderately distributed throughout the Valley.

## Psorophora discolor (Coquillett)

Recognition Characters

The adult female is yellowish brown with definite areas of white and dark scales on the wings, the white spots being especially conspicuous on the fringe at the tip of the veins.

The larva has a slender abdomen with very long anal gills, usually three or four times as long as the anal segment. The antennae are promi-

nent, inflated subapically, and conspicuously elbowed.

Larval Habitat, Habits, and Associations

The larvae occur in temporary ground pools and grassy ditches and have the unusual habit of living upside down on the bottom of the breeding pool. Respiration is mainly cuticular even though they have very long anal gills. The larvae rarely surface until a few hours before pupation. The larval and pupal stages persist almost twice as long as those of other *Psorophora* species.

Larvae of P. discolor are most often associated with those of P. confinnis, P. ciliata, and Aedes vexans. They have also been found with those of P. cyanescens and P. horrida.

Adult Habits and Importance

The adults rest in the daytime in vegetation near the breeding areas. On rare occasions they rest in diurnal shelters commonly used by Anopheles quadrimaculatus. The flight range is considered to be about nine miles (Horsfall, 1942). The adults occur mainly in open grassy areas and have not been found in adjoining forests. They also have the habit of living close to the ground with the flying females occurring mostly in a zone four to six feet above soil level.

The adults typically begin feeding about dusk and continue to feed throughout the night but may also feed in the daytime if disturbed from their resting sites. The species may be readily collected at night by the parked car technique near a breeding area. The females are wary, often hovering about the car for 20 to 30 minutes before entering, and then they remain on the wing for another 10 or 15 minutes before settling down to feed. They commonly bite about the hands and legs after circling about their potential victim. Although they feed on man, livestock appears to be their principal source of blood meals. Females have been observed to take blood meals over a temperature range of 60° to 80° F. The adults are attracted to light and have been collected frequently by means of light traps.

This species is of considerable annoyance to livestock and man in local

situations.

Overwintering and Seasonal Development

The species overwinters in the egg stage, the eggs having been deposited on the ground during a previous breeding season. The overwintering eggs hatch in the spring and summer months after being flooded under suitable conditions. Egg hatching occurs from May to September. Larval and pupal development is relatively slow as compared to other species of the genus, requiring from 10 to 14 days under favorable summertime conditions. The species produces a number of broods over the warm season with adults being collected in the field from May to October.

Distribution in the Tennessee Valley

This species is moderately distributed throughout the Valley.

# Psorophora ferox (Humboldt)

Recognition Characters

The adult has a mixture of dark brown and whitish yellow scales on the mesonotum, and the legs are dark except for hind tarsal segments 4 and 5 which are entirely white-scaled.

The larva has the lower and upper head hairs double, and the siphon is rather long and strongly inflated.

Larval Habitat, Habits, and Associations

Larvae occur in temporary rainpools in woodlands and occasionally in potholes in stream beds. The larvae are easily disturbed and conceal themselves in leaves on the bottom of woodland pools. The darkly pigmented body blends well with soil and leaves making them difficult to see.

Larvae have been found associated with those of Aedes canadensis, Ae. atlanticus, Ae. sticticus, Ae. trivittatus, Ae. vexans, Ae. tormentor, P. ciliata,

P. varipes, and P. horrida.

Adult Habits and Importance

The adult is relatively inactive at night as evidenced by its scarcity in light traps and night-biting collections. Resting sites include low-growing vegetation, hollow trees, and sheds.

In seeking blood, the females begin at dawn and stop abruptly at dark, with a feeding peak during the afternoon hours. They are persistent biters and attack man readily. It is likely that carbon dioxide and/or perspiration serve as attractants for this species as has been shown for certain species of Aedes and Culex.

While much of the daily activity occurs near ground level, females of *P. ferox* are frequently encountered in forest canopy. The adults are more or less confined to the forest proper but venture several hundred feet into grassland, particularly during late afternoon hours (Snow, 1955).

The females are very annoying to man in forested areas.

Overwintering and Seasonal Development

The winters are passed in the egg stage, the eggs having been deposited on the ground during a previous breeding season. The overwintering eggs hatch in the spring and summer when woodland depressions are filled with water. The eggs hatch as early as April and as late as October or during the period when water temperatures are generally above 50° F. In cool waters, larval development requires as much as ten days, but in warmer waters this development requires only about five days. The pupal period is usually short, lasting one or two days. The species produces a number of broods during the season depending upon the frequency of rains and duration of surface water. Adults can usually be found in wooded bottomland at any time from mid-April to mid-October. Adult females are known to live at least two weeks in nature.

Distribution in the Tennessee Valley

This species is well distributed throughout the Valley.

### Psorophora horrida (Dyar and Knab)

Recognition Characters

The mesonotum bears a broad, median, bronze stripe bordered by white to yellowish scales. The legs are dark except for hind tarsal segments 4 and 5 which are white-scaled.

The larva has triple upper head hairs and double lower head hairs, and

the siphon is strongly inflated.

Larval Habitat, Habits, and Associations

The larvae occur in temporary pools in shaded woodland bottoms. Larvae of P. horrida have been found associated with those of P. cyanescens, P. ciliata, P. discolor, P. ferox, Aedes vexans, and Ae. atlanticus.

Adult Habits and Importance

The adults generally rest at night and are active during daylight periods. They commonly rest on low-growing vegetation and in hollow trees. The females are fierce biters and apparently range about one mile from the breeding grounds in search of blood meals. They feed both in forested and open areas during daylight hours. However, in August 1953, during a heavy outbreak at Chattanooga, Tennessee, feeding activity was observed at night in residential areas. Females have been taken feeding on man in the forest canopy at a height of 30 feet during daylight hours.

This species is very pestiferous in local wooded situations.

Overwintering and Seasonal Development

This mosquito overwinters in the egg stage, the eggs having been deposited on the soil during a previous breeding season. The overwintering eggs usually hatch in April or May, and the first brood of adults appears in May or June. Successive rains during the summer may cause other eggs to hatch, but adults have not been found beyond August in the Valley. The longevity of adults appears to be less than two weeks, and they seldom occur in large numbers.

Distribution in the Tennessee Valley

This species has a scattered distribution in the Valley.

# Psorophora howardii Coquillett

Recognition Characters

This is a large mosquito morphologically similar to P. ciliata from

which it can be distinguished by the presence of a black median stripe on the mesonotum and the yellow moderately bushy-scaled hind tibiae and tarsi.

The larva of *P. howardii* is very large and differs from *P. ciliata* in having the lateral hair of the anal segment single or merely forked beyond the middle rather than being 3 or 4 branched.

Larval Habitat, Habits, and Associations

The larvae occur mainly in temporary rainfilled pools. Being predaceous and cannibalistic like *P. ciliata*, they feed upon the larvae of associated mosquitoes and other aquatic invertebrates present in the breeding pool. Larvae of this species have been collected in association with those of Anopheles punctipennis, Aedes fulvus pallens, Ae. vexans. and P. ciliata. Adult Habits and Importance

The adults rest in vegetation during the daytime; however, they attack man readily if their haunts are invaded. At Reelfoot Lake, Tennessee, females were taken biting man in the early evening hours in grassland, but were not found to penetrate the forest or ascend into the canopy (Snow, 1955). They are readily attracted to light.

The species is of little or no known economic or medical importance

in the Valley.

Overwintering and Seasonal Development

The species overwinters in the egg stage, the eggs having been deposited on the ground during a previous season. The overwintering eggs hatch from spring to fall following rains, and larval development is rapid. The adults are seen much less frequently than those of *P. ciliata*.

Distribution in the Tennessee Valley

This species shows a scattered distribution in the Valley, having been collected only from Kentucky, Pickwick, and Norris Reservoirs.

### Psorophora signipennis (Coquillett)

Recognition Characters

The adult has a wide median pale band on the proboscis. The wings have two prominent black-scaled areas separated by whitish scales on the apical half fo the costa, and the fringe scales on the trailing edge of the wing are in alternating dark and light groups.

The larva has multiple antennal and preantennal tufts bearing conspicuous barbs which readily separate it from *P. cyanescens*. The upper and

lower head hairs are usually single.

Larval Habitat, Habits, and Associations

The larvae occur in temporary ground pools but have never been collected in the Valley.

Adult Habits and Importance

The adults rest on vegetation during the daylight hours and attack man readily on being disturbed from their resting sites. Adults have been captured at night in calf-baited traps at Pickwick Village along with those of *P. confinnis*.

The species is of no known economic or medical importance in the Valley.

Overwintering and Seasonal Development

The species overwinters in the egg stage, the eggs having been deposited on the ground during the previous season. The overwintering eggs hatch following spring and summer rains. During the warm summer season, the developmental period from egg to adult requires as few as five days. The number of broods per year and adult longevity are not known. Distribution in the Tennessee Valley

This species is of questionable occurrence in the Tennessee Valley, but is included here since there are two records (unsubstantiated) of its having been collected from calf-baited traps in Pickwick and Wheeler Reservoirs.

## Psorophora varipes (Coquillett)

Recognition Characters

This mosquito has a broad, dark, longitudinal stripe on the mesonotum which is bordered on either side by whitish scales. The hind tarsus is dark-scaled except for the fourth segment which is white-scaled.

The larva has the upper head hairs double, the lower ones double

or triple, and the siphon only slightly inflated.

Larval Habitat, Habits, and Associations

The larvae occur in overflow pools associated with streams and rivers in dense swamps. They move about in the flotage by means of the drawing action of the mouth brushes. The air tube of the larva is slender and is well adapted for piercing the covering mat of debris with which they are often associated. Larval development in the summertime is rapid, being completed in as few as four days with adults appearing on the sixth or seventh day after the eggs hatch.

At Morgan Creek, Tennessee, on Kentucky Reservoir, P. varipes has been consistently taken with P. ferox. Other associates have been Aedes

sticticus and Ae. vexans.

Adult Habits and Importance

The adults rest at night on vegetation and are active during portions of the daylight hours. The females are persistent feeders on man and seek blood meals from dawn to dusk with a peak of activity in the afternoon hours. Biting rates of 70 specimens per minute have been recorded near breeding areas in the daytime. Observations indicate that they remain close to the breeding area and do not take blood meals at night. The species is primarily sylvan but ventures into grassland late in the day. Observations at Morgan Creek and Reelfoot Lake, Tennessee, showed P. varipes to be active near the ground with occasional activity up to 75 feet in forest canopy during afternoon hours (Snow, 1955).

The species is an important pest mosquito in local bottomland areas

in the Valley.

Overwintering and Seasonal Development

The species overwinters in the egg stage, the eggs having been deposited on moist bottomland soil during a previous season. The overwintering eggs hatch with the formation of pooled conditions in spring, summer, and fall. The species is known to develop at least three broods of adults in the Valley per season, and adults have been found in the field from May to October.

Distribution in the Tennessee Valley

Adults of this species show a scattered distribution in the Valley. They have been collected from Kentucky, Pickwick, Wilson, Wheeler, Guntersville, Hales Bar, and Chickamauga Reservoirs.

Toxorhynchites rutilus septentrionalis (Dyar and Knab)
Recognition Characters

This unusually large and brilliantly colored mosquito may be recognized by the strong downward curvature of the distal half of the proboscis. Colorations of the adult include metallic blue, gold, silver, and other hues.

Colorations of the adult include metallic blue, gold, silver, and other hues.

The larva is the largest among our mosquito fauna, being stout. purplish, and 16 to 20 mm. long. The larva may be identified by its large quadrate head equipped with a pair of ten stout, curved, prehensile mouth brushes.

Larval Habitat, Habits, and Associations

The larvae are found in tree holes and in a variety of artificial containers which hold water and leaves, such as wooden tubs, rainbarrels, mash barrels, tin cans, stone or glass jars, and automobile tires.

The larvae are predaceous, feeding upon the larvae of other species of mosquitoes and other aquatic insects found in the breeding receptacle. At times they are also cannibalistic, feeding upon one another. In small

tree holes, only one specimen usually survives and finally emerges from the container as an adult. One fourth instar larva of this species devoured 200 larvae of Aedes vexans under laboratory conditions. In nature, Orthopodomyia signifera and Ae. triseriatus larvae are considered the principal sources of food for this species. They are not selective in feeding and strike at any small object moving near them. They will strike and eat small bits of ground meat dropped in the container. Struggling insects on the water surface are soon seized. Motion of the prey apparently is important in stimulating the strike. As a rule they remain rather motionless suspended in an angular position from the surface while awaiting prey. When in motion they generally swim backward in a jerky fashion. In the southeastern states, larvae have been taken from tree holes of sweet gum, black oak, American elm, red maple, silver maple, sandbar willow, hickory, and camphor.

Larvae of this mosquito have been associated in tree holes with those of O. signifera, O. alba, Ae. triseriatus, and Anopheles barberi. In rainbarrels, companion species were Culex restuans, C. p. pipiens, Ae. triseriatus, and A. punctipennis. In a whiskey mash barrel, O. signifera

was the only alcoholic associate found.

Adult Habits and Importance

This mosquito does not take blood meals. The adult females, as well as the males, feed mainly on nectar. The distal portion of the proboscis is

flexible and not adapted for piercing and bloodsucking.

The adults are restricted mainly to forested areas and are active principally during the daytime. Occasionally they are taken in light traps. While on the wing, the adults emit a loud humming sound. Solitary adult females are usually found resting near the breeding grounds, but males are known to swarm or gather in aggregates of about 100 specimens. Such an aggregation of males, without females, has been recorded on poison ivy growing on a hackberry tree about 100 yards from the breeding site (Thibault, 1910).

This mosquito is of no known economic or medical importance in

the Valley.

Overwintering and Seasonal Development

They overwinter in the larval stage, and pupation and emergence are delayed until spring even though the larvae appear mature much earlier. In one instance, a fourth instar larva, collected in September and maintained in the laboratory thereafter at a temperature of approximately

70° F., did not pupate and emerge until the following March.

Adults begin to emerge from the overwintering generation as early as March but do not appear in the field until about May. The adults are reported to mate while settled, and egglaying is initiated about one week following mating. The eggs are deposited singly on the water surface. The females tend to visit a series of tree holes and deposit a few eggs in each. Under normal summer conditions, the eggs hatch in about two days, and the four larval stages may be completed in three or four weeks provided the food supply is adequate. If the food supply is inadequate, the larval period may be drawn out as long as five months. Thus, the number of generations a year may vary from two to five.

Distribution in the Tennessee Valley

Although sparse in numbers, this mosquito is distributed throughout the Valley.

# Uranotaenia sapphirina (Osten-Sacken)

Recognition Characters

This small mosquito may be recognized by the narrow, median, longitudinal line of iridescent bluish scales extending nearly the full length of the mesonotum, and by the second marginal cell of the wing being much shorter than its petiole.

The small larva of *U. sapphirina* has a short siphon and may rest almost parallel with the water surface. On close examination it can be

recognized by the single spikelike upper and lower head hairs and a conspicuously black head.

Larval Habitat, Habits, and Associations

The larvae occur in permanent or semipermanent ponds, pools, limesinks, and lakes containing emergent and free-floating vegetation. They transport themselves by a rapid, jerky motion and assume a position almost horizontal to the water surface. In these respects, they resemble anopheline larvae, and without careful observations the larvae might be mistaken for anophelines, especially in the early instars.

The larvae are frequently associated with those of Anopheles quadrimaculatus and Culex erraticus in permanent, vegetated pools. Large numbers of these three species are frequently associated with floating mats of vegetation such as Potamogeton. They have also been found with

larvae of A. crucians and C. salinarius.

Adult Habits and Importance

The adults rest during the daytime in damp places such as hollow stumps, tree holes, and at the bases of emergent plants such as cattail and sawgrass. They are occasionally found resting in culverts and other common resting sites of the malaria mosquito. They have also been collected in privy-type resting stations placed near the breeding area.

The adults are most active during the early part of the night. They

are very frequently found in collections from light traps.

The feeding habits of the adult females are not known, but they apparently do not feed on man as evidenced by their failure to do so even when they were very abundant in the presence of hosts at Reelfoot Lake, Tennessee, in the cool hours of October. On occasion the females would approach and rest on an arm but failed to show further interest (Snow and Pickard, 1954). A closely related species in the southeastern states, U. lowii, has been shown to feed on amphibians, and it is probable that U. sapphirina does likewise (Remington, 1945).

The flight range has not been studied in detail, but observations

suggest that it exceeds one mile.

This species is of no known economic or medical importance in the Valley.

Overwintering and Seasonal Development

The species overwinters as inseminated females which take refuge in caves and similar protected structures. The females enter caves in the fall and leave their overwintering quarters in early spring. The spring females deposit egg rafts on the water surface of suitable breeding habitats. The larvae of the first generation appear in April with the adults emerging in May. Breeding continues throughout the summer and extends well into the fall months, the larvae frequently being found in October and occasionally in November. The number of generations has not been determined, but observations suggest as many as eight or nine generations per year.

Distribution in the Tennessee Valley

This mosquito is well distributed throughout the Valley.

#### NON-BITING MIDGES

Midges of the family Tendipedidae (Chironomidae), sometimes called "blind mosquitoes" or "fuzzy-headed gnats," are commonly mistaken for mosquitoes and cause many complaints in reservoir areas. For this reason, brief notes on this group are presented below.

Although closely related to the mosquito family (Culicidae), the midges actually bear little resemblance to mosquitoes when viewed by a trained observer and may be readily distinguished by the short proboscis, not adapted for piercing; males with long plumose antennae; a median longitudinal groove on the metanotum; absence of scales on the wings; and the length of the costa which never extends entirely around the wing.

The midge family is a very large one and comprises about two

thousand described species. They are found almost everywhere, but, since

the larvae are aquatic, the adult distribution is limited to the vicinity of water, although they may be found in large numbers at a considerable distance from any visible water supply. While they are not strong fliers, they can remain in the air for long periods of time and they often occur

in large numbers.

The larvae are scavengers and live in water everywhere, and are very important fish food. In the Valley, they breed primarily in the bottom muck of clean reservoirs and are usually very abundant around lakeshore property. The adults are attracted to light at night and rest during the day around the eaves of houses and in the weeds and shrubbery. Although they cannot bite, their numbers and close proximity may be very annoying to some people. At times a few biting mosquitoes mixed with hordes of non-biting midges may cause undue concern and panic to lakeshore residents.

#### SUMMARY

From its inception to the present time, the Tennessee Valley Authority has conducted a mosquito control program aimed at controlling *Anopheles quadrimaculatus*, the vector of malaria. Although indigenous malaria has been absent from the Valley since 1949, TVA continues to control the production of *A. quadrimaculatus* and other mosquitoes of potential public health significance.

The TVA mosquito control program places emphasis on naturalistic control methods to provide an environment unsuitable for mosquito production. The principal method is the manipulation and management of water levels in the 10,000 miles of shoreline and 600,000 acres of water that make up the

TVA system of freshwater lakes.

For the past 27 years, TVA biologists have collected and made observations on a total of 44 species of mosquitoes, representing nine genera, occurring in the Valley. Illustrated keys

are provided to aid in their identification.

Ecologically, the species of mosquitoes found in TVA reservoir areas may be grouped, on the basis of their larval habitat, in three main groups: (1) the permanent pool group, (2) the floodwater or rainpool group, and (3) the natural, artificial, or domestic container group. These groups are discussed in relation to the effects of TVA water level operations on their ecology, production, and control.

Each of the 44 species is treated in outline form under the following headings: Recognition Characters; Larval Habitat, Habits, and Associations; Adult Habits and Importance; Overwintering and Seasonal Development; and Distribution in the

Tennessee Valley.

#### LITERATURE CITED

Abdel-Malek, Albert. 1948. The biology of Aedes trivittatus. Jour. Econ. Ent. 41: 951-954.

Baker, F. C. 1936. A new species of Orthopodomyia, O. alba, sp. n. Proc. Ent. Soc. Wash. 38: 1-7.

Bang, F. B., G. E. Quinby, and T. W. Simpson. 1940. Anopheles walkeri Theobald: A wild caught specimen harboring malarial plasmodia. Public Health Reports 55: 119-120.

. 1943. Studies on Anopheles walkeri Theobald conducted at Reelfoot Lake, Tennessee, 1935-1941. Amer. Jour. Trop. Med. 23: 247-273.

Barr, A. R. 1960. A review of recent findings on the systematic status of Culex pipiens, Calif. Vector News 7: 17-21.

Boyd, Mark F. 1930. An introduction to malariology. Harvard Univ. Press, Cambridge, Mass. 437 pp.
Carpenter, S. J. 1941. The mosquitoes of Arkansas. Ark. State Bd. of Health,

Little Rock, 87 pp., rev. ed.

Chamberlain, R. W., R. K. Sikes, D. B. Nelson, and W. D. Sudia. 1954. Studies on the North American arthropod-borne encephalitides. VI. Quantitative determinations of virus-vector relationships. Amer. Jour. Hyg. 60: 278-285.

Clark, J. L. 1943. Studies on the flight range of mosquitoes. Jour. Econ. Ent. 36: 121-122.

Crumb, S E. 1922. A mosquito attractant. Science 55: 446-447.

Darling, S. T. 1925. Entomological research in malaria. Sou. Med. Jour. 18: 452-458.

Frohne, W. C. 1939. Anopheline breeding: suggested classification of ponds based on characteristic desmids. Public Health Reports 54: 1363-1387.

Gartrell, F. E., and H. Orgain. 1946. Notes on the prolific production and dispersion of Anopheles quadrimaculatus from impounded water breeding places. Jour. Nat. Mal. Soc. 5: 79-84.

Gjullin, C. M., W. W. Yates, and H. H. Stage. 1950. Studies on Aedes vexans (Meig.) and Aedes sticticus (Meig.), flood-water mosquitoes in the lower Columbia River Valley. Ann. Ent. Soc. Amer. 43: 262-275. Glick, P. A. 1939. The distribution of insects, spiders and mites in the air.

U.S. Dept. Agr. Tech. Bull. No. 673, 150 pp.

Goodwin, M. H., Jr. 1942. Studies on artificial resting places of Anopheles quadrimaculatus. Jour. Nat. Mal. Soc. 1: 93-99.

Hagmann, Lyle. 1952. Mansonia perturbans recent studies in New Jersey

Proc. N. J. Mosq. Ext. Assoc., pp. 60-66. Hatchett, S. P. 1946. Winter survival of Aedes aegypti (L.) in Houston, Texas.

Public Health Reports 61: 1234-1244. Hayes, R. O., L. C. LaMotte, L. A. White, and L. D. Beadle, 1960. Isolation

of eastern encephalitis virus from the mosquito Culex restuans collected

in New Jersey during 1959. Mosq. News 8: 190.

—, L. D. Beadle, L. C. LaMotte, A. D. Hess, Oscar Sussman, and M. J. Bonese. 1961. Entomological aspects of the 1959 outbreak of eastern encephalitis in New Jersey. Amer. Jour. Trop. Med. and Hyg. (In press). Hess, A. D., and R. L. Crowell. 1949. Seasonal history of Anopheles quad-

rimaculatus in the Tennessee Valley. Jour. Nat. Mal. Soc. 8: 159-170.—, and T. F. Hall. 1945. The relation of plants to malaria control on impounded waters with a suggested classification. Jour. Nat. Mal. Soc. 4: 20-45.

Hedeen, R. A. 1953. The biology of the mosquito Aedes atropalpus (Coquillett). Jour. Kan. Ent. Soc. 26: 1-10.

Horsfall, W. R. 1939. Habits of Aedes thibaulti Dyar and Knab (Diptera, Culicidae). Jour. Kan. Ent. Soc. 12: 70-71.

. 1942. Biology and control of mosquitoes in rice field areas. Bull. Ark. Agr. Expt. Sta. 427: 1-46

-. 1955. Mosquitoes. Their bionomics and relation to disease. The

Ronald Press. Co., New York, 723 pp.

Hurlbut, H. S. 1938. Further notes on the overwintering of the eggs of Anopheles walkeri Theobald with a description of the eggs. Jour. Pathol. 24: 521-526.

Ives, J. D. 1938. Cave hibernation of mosquitoes. Jour. Tenn. Acad. Sci. 13: 15-20.

Jones, J. W., Jr. 1946. A manual of the family Culicidae in Tennessee. M. S. thesis, Univ. of Tenn., Knoxville, 263 pp.

Keener, G. G., Jr. 1945. Detailed observations on the life history of Anopheles quadrimaculatus. Jour. Nat. Mal. Soc. 4: 263-270.

King, W. V., G. H. Bradley, C. N. Smith, and W. C. McDuffie, 1960, A handbook of the mosquitoes of the southeastern United States. U. S. Dept. Agr. Handbook No. 173: 88 pp.
LeVan, J. H. 1940. Viability of Aedes aegypti eggs. Public Health Reports 55: 900.

MacCreary, D. 1941. Comparative density of mosquitoes at ground level and at an elevation of approximately one hundred feet. Jour Econ. Ent. 34: 174-179.

Metz, C. W. 1918. Anopheles crucians: Habits of larvae and adults. Public Health Reports 33: 2156-2169.

Michener, C. D. 1947. Mosquitoes of a limited area in southern Mississippi. Amer. Midland Naturalist 37: 325-374.

Peters, H. T. 1943. Studies on the biology of Anopheles walkeri Theobald (Diptera: Culicidae). Jour. Parasit. 29: 117-122.

Reeves, W. C., B. Brookman, and W. McD. Hammon. 1948. Studies on the flight range of certain Culex mosquitoes, using a fluorescent dye marker, with notes on Culiseta and Anopheles. Mosq. News 8: 61-69.

Remington, C. L. 1945. The feeding habits of Uranotaenia lowii Theobald

(Diptera: Culicidae). Ent. News 56: 32-37.

Rush, W. A., J. M. Brennan, and C. M. Eklund. 1958. A natural hibernation site of the mosquito Culex tarsalis Coquillett in the Columbia River Basin, Washington. Mosq. News 18: 288-293.

Shields, S. E. 1938. Tennessee Valley mosquito collections. Jour. Econ. Ent.

31: 426-430.

Shlaifer, A., and D. E. Harding. 1946. The mosquitoes of Tennessee. Jour. Tenn. Acad. Sci. 21: 241-256.
Smith, G. E. 1942. The keg shelter as a diurnal resting place of Anopheles quadrimaculatus. Amer. Jour. Trop. Med. 22: 257-269.
————. 1948. The occurrence of Anopheles walkeri Theobald in the Tennessee. Valley (unpublished TMA)

nessee Valley (unpublished TVA report).

Snow, W. E. 1949. Studies on portable resting stations for Anopheles quad-

rimaculatus in the Tennessee Valley. Jour. Nat. Mal. Soc. 8: 336-343.

—. 1955. Feeding activities of some bloodsucking Diptera with reference to vertical distribution in bottomland forest. Ann. Ent. Soc. Amer. 48: 512-521.

-, and Eugene Pickard. 1954. Observations on the seasonal activity of some night-biting Diptera. Jour. Tenn. Acad. Sci. 29: 17-22.

-, and G. E. Smith. 1957. Observations on Anopheles walkeri Theobald

in the Tennessee Valley. Mosq. News 16: 294-298.
Sudia, W. D., and R. H. Gogel. 1953. The occurrence of Orthopodomyia alba Baker in Georgia. Bull. Brooklyn Ent. Soc. 48: 129-131.

Sundararaman, S. 1949. Biometrical studies on intergradation in the geni-

talia of certain populations of Culex pipiens and Culex quinquefasciatus in the United States. Amer. Jour. Hyg. 50: 307-314. Thibault, J. K. 1910. Notes on the mosquitoes of Arkansas. Proc. Ent. Soc.

Wash. 12: 13-26.

Trembley, H. L. 1947. Biological characteristics of laboratory-reared Aedes atropalpus. Jour Econ. Ent. 40: 244-250.

#### NEWS OF TENNESSEE SCIENCE

(Continued From Page 251)

Dr. R. E. McLaughlin, Department of Geology-Geography, UT, taught a course in comparative plant morphology as part of the Summer Institute of Field Biology at Stephen F. Austin State College, Nacogdoches, Texas, June 4-July 14. Dr. Harold C. Bold of the University of Texas, Austin, and formerly of Vanderbilt University was a guest lecturer at the Institute, one of several institutes for teachers of high school biology supported by The National Science Foundation.

(Continued On Page 360)