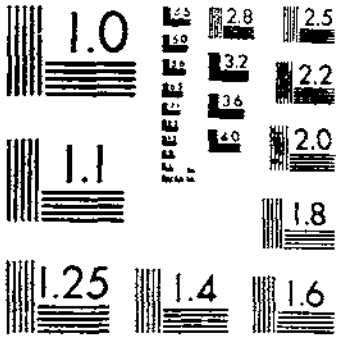
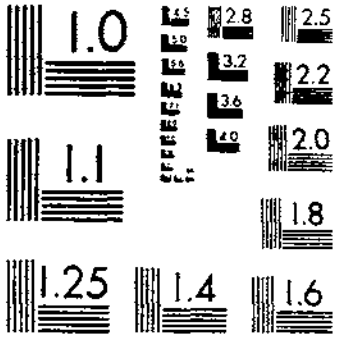
START



MICROCOPY RESOLUTION TEST CHART
NATIONAL BUREAU OF STANDARDS-1963-A



MICROCOPY RESOLUTION TEST CHART
NATIONAL BUREAU OF STANDARDS-1963-A

The TABANIDAE (DIPTERA) *of Florida*

By CALVIN M. JONES
and DARRELL W. ANTHONY

Technical Bulletin No. 1295

Agricultural Research Service
UNITED STATES DEPARTMENT OF AGRICULTURE
in cooperation with
Florida Agricultural Experiment Station

Washington, D.C. Issued July 1964

Contents

The TABANIDAE (DIPTERA) *of Florida*

By CALVIN M. JONES and DARRELL W. ANTHONY, *entomologists, Entomology Research Division, Agricultural Research Service*[1]

The family Tabanidae constitutes one of the most annoying groups of bloodsucking insects that attack livestock in the United States. Since no satisfactory method has been developed to reduce infestations or to protect livestock and man from serious attacks, this study was undertaken in 1950 to gain a better understanding of the life histories and habits of the economically important species of this family. Florida was the appropriate place to conduct such a study, because the tabanid fauna there probably includes a greater number of these species than that in any other State. Some of the most intense infestations are also found there. Large areas of permanently wet, undeveloped land and the mild climate contribute to the rich fauna.

In this bulletin are presented field studies on adult activities, distribution, and larval ecology, and laboratory rearing studies, which were made to identify larvae and to augment field observations on life histories. Keys for determining the genera and species of tabanids in Florida are also included.

[1] The authors are indebted to D. A. Sanders, head of the Department of Veterinary Science, Florida Agricultural Experiment Station, and to other members of his staff for their advice and assistance. A special note of gratitude is due Leonard E. Swanson, also of that station, who shared his parasitological research facilities. His encouragement and personal interest in the work were invaluable to the authors.

ECONOMIC IMPORTANCE

The economic loss caused by tabanids results from one or a combination of factors. No quantitative studies have been made to rate these factors in order of importance. In Florida, cattle suffer most, perhaps from constant annoyance of these biting flies. The degree of annoyance may vary from 1 fly to as many as 100 or more attacking an animal. Most animals react to the puncture of a single fly by trying to dislodge the insect with the head or tail or by stamping the feet. Even though dislodged, the fly usually persists until it has fed to satiety. Under heavy attacks animals cease grazing and seek protection by bunching together or by entering sheltered areas. A few animals may show little or no annoyance. Under these conditions they suffer greatly, and the owner in turn realizes a loss of income due to the decreased vitality and productivity of the animals.

According to Webb and Wells (1924),[2] a population of 25 to 30 horse flies containing 25 percent of *Hybomitra sonomensis phaenops* (Osten Sacken) and 75 percent of *Tabanus punctifer* Osten Sacken on a host continually for 6 hours would take on an average at least 100 cc. of blood. Philip (1931) estimated that about 100 flies in feeding to satiety would consume on an average 10 cc. of blood. He stated that an animal would lose a minimum of 300 cc. of blood in a steady attack by 50 flies at any one time throughout a 10-hour period of activity in 1 day.

Tashiro and Schwardt (1949) determined that the average amount of blood consumed by one *Tabanus quinquevittatus*[3] and one *sulcifrons* was 0.074 and 0.359 cc., respectively. They reported that it was not uncommon for 720 *T. quinquevittatus* or 320 *sulcifrons* flies to feed on a single animal for 8 hours, and that probably the amount of blood taken by these flies could be doubled because of the combined activities of all species present and the loss of blood from the wounds after the flies left. There is no estimate of the amount of blood that exudes from punctures made by the flies. The hair on animals exposed to extremely heavy infestations of 100 or more flies per animal at all times may become crusted with blood (fig. 1).

FIGURE 1.—*Tabanus trijunctus* feeding on the leg of a horse. Loss of blood from feeding punctures is evident.

[2] References to Literature Cited (p. 78) are herein indicated by the name of the author or authors followed by the year of publication.

[3] The names of describers of tabanids that occur in Florida are given in Biologies of the Species (p. 14) and in the Index to Species (p. 83).

Occasionally the authors of this bulletin observed an estimated 75 to 100 cc. of blood oozing from a single puncture made by *Tabanus atratus*. This unusual loss probably resulted from a physiological condition in the animal rather than from an anticoagulating substance injected by the fly.

The extent to which diseases of livestock are transmitted by tabanids is not known. Experimental transmission studies by several workers showed that tabanids can mechanically transmit some diseases and are suspected of being vectors of others. The interrupted feeding of the flies on one animal and the immediate attack on another may very likely cause the direct transfer of blood-inhabiting pathogenic organisms. Sanborn et al. (1932), Morris (1918), Knowlton and Rowe (1937), Scott (1920), and Francis and Mayne (1921) implicated tabanids as vectors of anaplasmosis, anthrax, equine encephalomyelitis, equine infectious anemia, and tularemia, respectively. A comprehensive review of the major diseases transmitted by tabanids was made by Anthony (1962).

Economic loss also results from interrupted grazing caused by large numbers of tabanids that livestock cannot tolerate. Ranchers in the Big Cypress Swamp and Everglades areas of Florida stated that horse flies actually aid in the roundup of cattle in the spring. The flies cause the cattle to come to open areas and bunch together.

Dove and Parman (1935) suggested that horse flies can be a predisposing cause of attack by the screw-worm (*Cochliomyia hominivorax* (Coquerel)) in animals. Fresh blood oozing from a puncture appears to be attractive to the screw-worm adult. Although it is conceivable, no direct evidence has been obtained that young larvae could become established in such a small wound.

Annoyance to man is not normally evaluated as an economic loss. However, *Diachlorus ferrugatus* and several species of *Chrysops* constitute a serious problem, especially in recreational areas and in work areas, such as where timber is harvested.

ECONOMICALLY IMPORTANT SPECIES AND THEIR SEASONAL OCCURRENCE

Approximately 35 species of tabanids in Florida occur in sufficient numbers and throughout a prolonged period to be classed as economically important. Too little is known about them as vectors of diseases to use this criterion in determining the economic species. Most of the other 83 species, subspecies, and varieties attack livestock but are never abundant. A few species apparently never seek a blood meal.

Determining the density of infestations of individual species from one season to another is rather difficult. Population survey methods have not been established by which one person can correctly interpret another's observations. Observations made at a given location are usually sporadic, and collections under similar weather conditions are often impractical. The time of day and weather conditions affect the feeding activities of the flies. The extent of annoyance they cause man and animals was the major consideration in determining their eco-

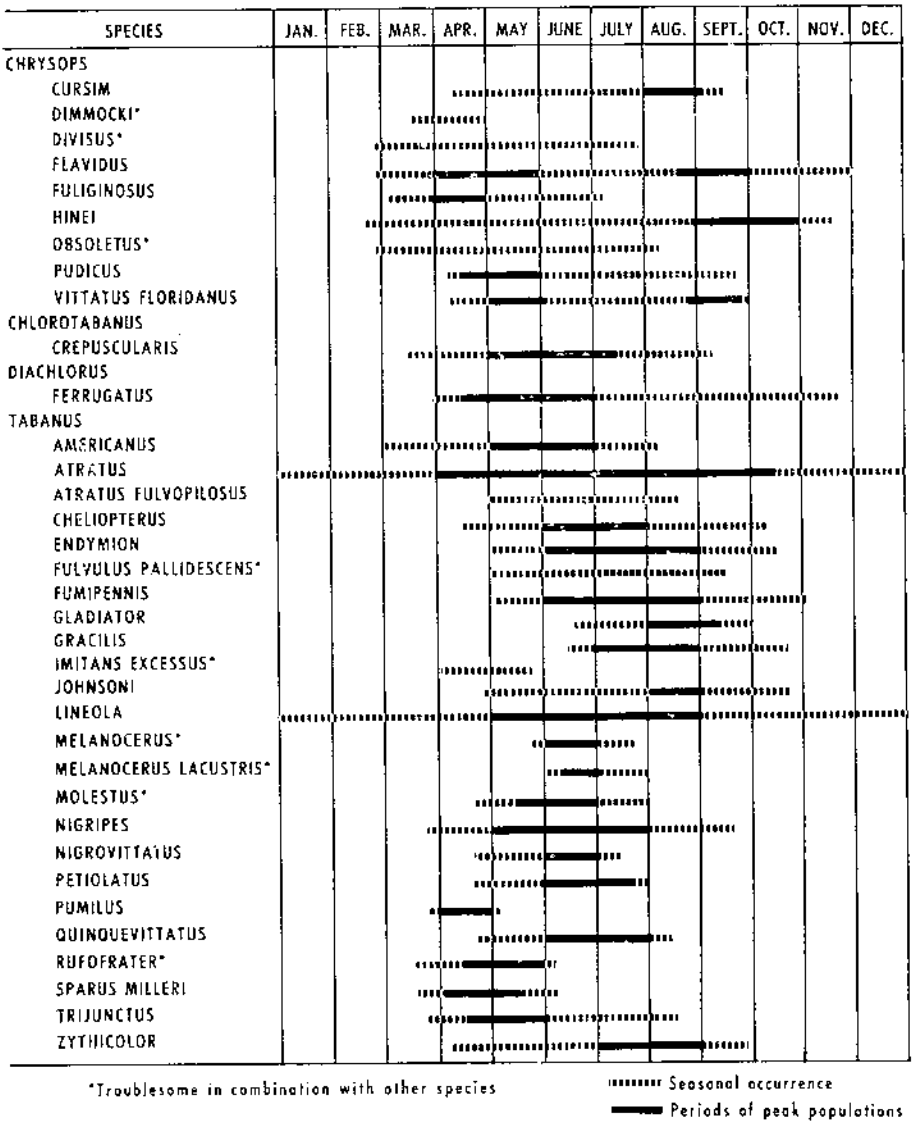


FIGURE 2.—Seasonal occurrence and periods of peak populations of economically important tabanids.

nomic importance. Obviously, the degree of annoyance depends on the intensity of the fly population, the number of animals present in a given area, and weather conditions.

The data on seasonal occurrence of the important species (fig. 2) were compiled from the authors' records and from the literature. Also indicated is the period during which each species was considered by the authors to be a serious pest.

ADULT STUDIES

Collecting Methods

Collecting flies from a host proved to be the simplest and most direct method of determining the species present and their abundance. The presence of *Chrysops* and *Diachlorus* was readily detected by walking through wooded areas. If present, large numbers of them could be collected by swinging a net about one's head.

For data on comparative abundance in various parts of the State at different times of the year, cooperators with gentle animals were located. Populations in remote areas, such as the Steinhatchee Game Reserve and the Ocala National Forest, were studied by taking a horse or mule into the areas in a stock trailer. Female and occasionally male flies were attracted to slow-moving vehicles. Large numbers of several economically important species were collected by driving a station wagon, with the rear door open, 3 to 5 miles per hour through wooded areas. Flies that entered the open door were easily trapped and collected. Specimens were frequently taken from the exterior as well as the interior of standing vehicles.

There have been some indications that traps can be used as survey aids. Light traps as a means of sampling populations have been used by several investigators. These studies were reviewed by Anthony (1960). Although it is possible to collect small numbers of tabanids, traps alone cannot be relied upon to give an accurate index of a population.

That tabanids show a strong tendency to concentrate in enclosures that accumulate heat during daylight suggested to Thorsteinson (1958) that a "heat" trap would be effective in capturing flies. He constructed a transparent plastic cone, beneath which he hung a black funnel leading to a killing jar. The accumulated solar heat attracted the flies beneath the cone, where, as a result of thermal stress and exhaustion, they succumbed and dropped through the funnel. He reported that this apparatus was effective in trapping flies.

Roth and Lindquist (1948) noted that *Chrysops discalis* Williston in the vicinity of Summer Lake, Oreg., readily oviposited on stakes in the lake. This observation suggested to them that the insects could be trapped with adhesives applied to stakes or other objects. They reported that in 2 days as many as 16,872 flies were trapped on a board 6 inches wide and 12 feet high.

Roth and Lindquist (1952) used a rotating trap similar to that described by Chamberlin and Lawson (1940) to sample the tabanid population in Oregon. They stated that the collections very likely represented a sample of the insects flying only in the immediate vicinity of the trap.

Conical fly traps baited with beef liver, moistened dried figs, peaches and citrus pulp, or a mixture of blackstrap molasses and water were used in Florida in attempts to trap tabanids. Almost 1,000 *Diachlorus* females were taken in a liver-baited trap in one 6-day period. Very few male and female *Tabanus americanus, atratus,* and *fumipennis* specimens were taken from traps with the sweet baits. The authors do not believe that these baits at-

tract a representative sample of the existing population.

Because the different species vary in their habits of attacking and biting, the exact incidence on livestock is most difficult to determine. The animals fight the flies and make every effort to dislodge them. Some species when disturbed immediately return and renew their attack. Others fly away, apparently to rest or seek another host.

Populations were evaluated by counting the number of landings on a horse or cow during a 15-minute period, and by counting the total number of flies on five or more animals three times at 10-minute intervals. Determination of landing rates proved rather valuable in assessing annoyance caused by a given population. As only one animal was observed at a time, this method gave an opportunity to collect for determining the species present. It is believed that counts of the females feeding at 10-minute intervals gave a more accurate index of the population. However, since there was no opportunity for collecting, the species present could not always be correctly determined.

Feeding Habits of Females

PERIODS OF ACTIVITY

The feeding habits of the blood-sucking tabanid females are generally considered diurnal. Most of the Florida species are principally daytime feeders. However, at least 15 species feed regularly at dusk and 7 of these were collected after the point of complete darkness and as late as 10:30 p.m. These species are listed in table 1.

Three important species that attack livestock between sunset and sunrise are *Chlorotabanus crepuscularis*, *Tabanus cheliopterus*, and *T. johnsoni*. *C. crepuscularis*, as the name implies, attacks livestock principally at

TABLE 1.—*Tabanids collected at dusk and after dark and their preferred feeding periods*

Species collected	Observed feeding periods			Preferred feeding period
	Daylight	Dusk	Dark	
Chlorotabanus crepuscularis	.....	X	X	Dusk.
Chrysops—				
flavidus	X	X	X	Daylight.
obsoletus	X	X	.....	Do.
Leucotabanus annulatus	X	X	.....	Do.
Tabanus—				
aar	X	X	X	Unknown.
cheliopterus	X	X	X	Dusk.
gracilis	X	X	.....	Daylight.
johnsoni	.....	X	X	Dusk.
lineola	X	X	X	Daylight.
melanocerus	X	X	.....	Do.
molestus	X	X	X	Dusk.
nigripes	X	X	.....	Daylight
nigrovittatus	X	X	.....	Do.
pumilus	X	X	.....	Do.
spurus milleri	X	X	.....	Do.

dawn and dusk. This species becomes active about an hour before daybreak and ceases feeding an hour or two after complete darkness. *T. johnsoni* could almost be classed as a nocturnal feeder. It becomes active at dusk and continues to feed for 2 to 3 hours after complete darkness. Horses seem to be the preferred host, although cattle are also severely attacked. These three economically important species are rarely active between sunrise and sunset.

LOCATION ON HOST

The different species vary widely in their preference of feeding location on the host. *Chrysops* spp. attack man principally about the head, neck, and shoulders. Their preferred feeding areas on livestock are similar. Other important species of tabanids that feed at these locations are *Tabanus pumilus, sparus milleri,* and *nigripes*. The last species feeds mainly on the face. All of them occasionally attack the legs.

Large species such as *Tabanus americanus, atratus,* and *fumipennis* nearly always attempt to feed on the sides, back, and shoulders of livestock. However, *T. americanus* will feed at any location where it will not be unduly disturbed. *T. fumipennis* appears unerringly to select a site on the back, sides, or neck, where neither the tail nor the head of the host can disturb it.

The "striped horse fly complex" —as *Tabanus lineola, nigrovittatus,* and *quinquevittatus*—and *T. petiolatus* feed principally on the lower legs and the belly of livestock. Some of the species of this group frequently feed on the face and neck. The inner surfaces of the hindlegs are preferred feeding locations for *Tabanus gracilis* and *zythicolor*.

Observations on Males

Except for occasional specimens seen resting on vegetation or visiting flowers, the males are seldom observed. Bailey (1949) reviewed the literature on their hovering and mating activities. Blickle (1959) observed the hovering and mating of *Tabanus bishoppi* in Indian River County, Fla.

Copulation was observed only once during these studies. In the first 2 weeks of August 1950 the male population of *Tabanus fumipennis* at Alice Lake, Gainesville, Fla., reached a peak not seen at any other time for this species. On August 7 a male and female were seen copulating on the ground near the larval habitat. The tips of their abdomens were in contact and their heads were in opposite directions. The pair was captured and taken to the laboratory, where they were held in the same cage. No further mating was noted before death occurred 4 days later.

An unusually large population of *Tabanus trijunctus* males was seen on May 1, 1952, in the extreme northeast corner of Monroe County, Fla. These flies were resting in the trees, shrubs, and palmettoes for about 50 yards along the edge of an abandoned field. As many as 24 adults, a male-female ratio of 9 to 1, were counted in a distance of 6 feet on a tree branch. The only activity noted was a few flies of both sexes visiting blossoms of *Eugenia dicrana*, a shrub commonly known as twinberry eugenia. The surrounding wooded area was very dense and the soil was extremely dry to a depth of 1 foot. About

200 yards from the woods was a drainage ditch containing a small amount of water. No larvae could be found there or in the woods.

One week later a large population of *T. trijunctus* at the Big Cypress Seminole Indian Reservation in Hendry County, Fla., was studied. An occasional male was observed resting on trees and shrubs and in cypress heads, and a few males, as well as females, were visiting palmetto blossoms.

Noticeable numbers of *Tabanus fumipennis* males were observed in Alachua County, Fla., during August 7–18, 1950. On an average, six to eight per day were noted on grass and weeds between 9 and 9:30 a.m. A few visited *Crotalaria intermedia* blossoms approximately 300 yards from the breeding area. No noticeable increase in the female population occurred. A few *Tabanus atratus* males were in the area. Three alighted on a vehicle, one visited flowers, and others rested on vegetation.

Oviposition

The oviposition habits of most of the economically important species are not known. Many hours were spent in areas where adults were abundant, as well as around larval habitats. The attempt to locate egg masses or ovipositing females was disappointing. Only five species were observed ovipositing in nature —*Tabanus atratus, fumipennis, lineola, Chrysops callidus,* and *Merycomyia brunnea.* With the exception of the last species, they rested with heads downward and deposited their eggs in masses on vertical objects, such as grass and weeds growing in water or near the edge of water. *M. brunnea* assumed a position with the head up while ovipositing.

Figure 3 shows a typical oviposition site of *Chrysops.* Egg masses of an unidentified species can be seen on the vegetation. Drainage canals containing and surrounded by vegetation such as that shown in figure 4 provide suitable oviposition sites for sev-

FIGURE 3.—Egg masses of *Chrysops* sp. on plants a few feet from the edge of a lake.

FIGURE 4.—Vegetation in drainage canal provides ideal oviposition sites for several species of *Tabanus* and *Chrysops.*

eral species of *Tabanus* and *Chrysops*.

One egg mass, which appeared to be that of *Tabanus fumipennis*, was found overhead in a doorway between a building and a large concrete slab. A roof that was joined to the building covered the slab. It was obvious that the newly hatched larvae could not survive. Another egg mass deposited on a windowpane at the laboratory and others on various objects around the corrals were in unfavorable locations for larval development. These oviposition sites were a considerable distance from the favorable larval habitats of the species.

Many species were captured and placed in cages or jars containing wet sand to obtain egg masses. Eggs were laid by *Tabanus atratus*, *endymion*, *fumipennis*, *lineola*, *nigrovittatus*, and *rufofrater*. Caged adults, in general, were so restless that they soon became exhausted and frayed their wings beyond usefulness.

Eighteen *Tabanus atratus* females were captured from cattle, marked with nail polish, and released in a large outdoor cage. Some were engorged and others were attempting to feed when collected. A calf was taken into the cage for a 30-minute period each day, and a dead tree branch was placed over a container of water to provide oviposition sites. The flies lived to a maximum of 14 days. Twelve egg masses were deposited—9 on the branch and 3 on the cage. One fly that had just oviposited when captured engorged 2 days later. Another that was engorged when collected oviposited 2 days later. Two other flies that were engorged when caged fed 7 and 8 days later, respectively. Many tests similar to this one will have to be made before sufficient information is obtained to conclude whether a female will deposit more than one mass of eggs and at what time in her life span she oviposits.

Distended ovaries are seldom found in collected females. Many specimens of *Tabanus trijunctus* were dissected during the height of abundance in the Big Cypress Swamp, Fla. The extremely small number with enlarged ovaries was unexpected. Either the flies oviposit rather early during their life span before going afield, or they return to and remain near oviposition sites during the period when ovarian development would be noticeable in dissected specimens.

Two females of *Chrysops flavidus* that were reared from collected larvae oviposited in the rearing dishes approximately 2 days after emerging. Blood meals were not available.

Behavior and Longevity of Caged Adults

Many tabanid females were captured in nature and caged in the laboratory primarily to obtain eggs. Some flies were held in half-pint mason jars with screen lids and wet sand in the bottom; others were placed in screen cages approximately 12 inches square; and some were held outside in a large screen cage, 8 feet wide, 12 feet long, and 6 feet high, so placed as to receive partial shade from some trees.

The flies were restless in captivity. They often remained in flight against the side of the cage for short periods or darted across the cage to the opposite side with

force. The latter was more evident in large cages, where they flew at greater speed. These activities were obviously injurious to them.

Repeated efforts were unsuccessful to induce the flies held in the smaller cages to feed on drawn blood, exposed human skin, or rabbits. However, most of them readily fed on undiluted honey or on a sucrose solution. A small percentage of *Tabanus atratus* in the outside cage fed on a calf when they were very gently transferred with a stick from the sides of the cage to the animal. Less than 1 percent of captive *Chrysops* would feed on rabbits when confined in a specially constructed cage to enclose the rabbit's ear.

Large numbers of *Diachlorus ferrugatus* adults were collected and caged on several occasions for laboratory studies. The cages in which they were confined were 18 inches square and contained wet soil and plants. This species was not so restless in captivity as other species. However, the mortality was about the same. They readily fed on a 10-percent sucrose solution from cotton pads, but would not feed on a human arm during 15-minute exposures. In one group of approximately 100 flies, only 11 survived after 24 hours, and these were dead 24 hours later. Tests with other groups were less successful. Oviposition was not observed.

During warm weather species of *Tabanus* lived on an average from 2 to 3 days after capture. Less than 5 percent of the *Chrysops* lived longer than 1 day. During October when the temperature began to drop and the flies were less active, longevity in captivity increased. Ten females and two males of *Tabanus atratus* were netted around cattle pens and held in half-pint jars. The two males lived 15 and 18 days, respectively. The average life span of the 10 females after capture was 12 days and varied from 3 to 17 days. Two specimens laid egg masses on the third and fourth day, respectively, and lived 16 days each.

LARVAL STUDIES

Collecting Methods

A major problem in these studies was the difficulty of obtaining adequate numbers of the representative larval species from various areas throughout Florida. Effective surveys and collecting methods were necessary for the location of larvae and possible prediction of subsequent tabanid outbreaks, as well as for biological, ecological, and taxonomic studies.

Several methods have been advocated for the recovery of tabanid larvae from their natural habitats. Hine (1903) first used an ordinary sieve to collect larvae of *Tabanus fairchildi* in rapidly flowing water. Patton and Cragg (1913) suggested placing the material to be sampled in a pail of water and stirring it until the larvae floated to the surface. The larvae were then recovered by pouring the water through a sieve. This method proved to be most useful for examining the roots and surrounding soil of aquatic and semiaquatic plants. However, since larvae of some species, particularly those of *Chrysops*, do not float in water,

this technique is limited in use. Tashiro and Schwardt (1949) used a modified Berlese apparatus with good success in recovering larvae from soil samples.

The method most frequently employed by the authors was to scratch, dig, and screen the soil where tabanids were known or suspected to be breeding. A small percentage of the larvae in any habitat not covered with water can be located by stirring the top 2 or 3 inches of soil with any small tool such as a spatula. This method is time consuming and inefficient, because small larvae are very difficult to see in the presence of mud. A sieve was used regularly in the field, where sufficient water was available to wash out the sand and mud. A high percentage of the small larvae were washed through a 16-mesh sieve. Smaller mesh could not be used successfully, because the undecayed organic matter could not be washed through it.

A second method supplemented the first and entailed taking soil samples from the field to the laboratory. The larvae were recovered from drying racks (fig. 5). The samples were spread on a screen of ¼-inch hardware cloth placed over a tin funnel, which directed the larvae into a pan of water as they crawled out of the drying material.

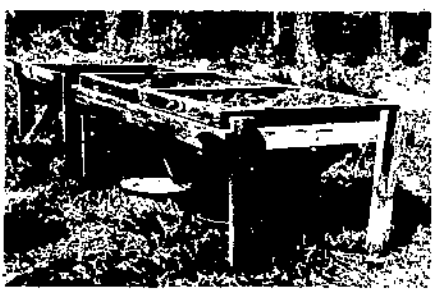


FIGURE 5.—Drying racks used in separating larvae from soil.

Accurate population indices of various habitats were obtained from measured samples dried on these screens. Almost 100 percent of all larvae were obtained from samples when allowed to dry thoroughly. The primary disadvantage of this method is the time required for the material to dry. Under ideal weather conditions from 24 to 48 hours was sufficient, but rain and high humidity greatly extended the drying time, even though the racks were covered during such periods. In spite of the time required and the fact that mud or other material from infested areas must often be transported long distances to the laboratory, this was consistently the most reliable method for obtaining healthy uninjured larvae for further biological studies. Similarly the drying screens provided the only reliable method of surveying various areas for population and species-distribution studies.

Bailey (1948) described a method for collecting large numbers of tabanid larvae by applying pyrethrum washes to the larval habitats. The pyrethrins apparently irritate the larvae and cause them to migrate to the surface, where they can be readily collected. Additional studies by Anthony (1957) included the use of different pyrethrum formulations, which were applied both on and below the soil surface. The larvae of 11 species were collected by this method. The efficacy of the method depended to a great extent on the texture and moisture content of the habitat. Good surfacing percentages were obtained where the soil was coarse

and moist. Results were poor where the soil was tight textured and very wet. Under these conditions better results were obtained when the chemicals were injected into the soil. The *Tabanus* larvae that were at least half grown when collected usually survived and many were reared to adults. Full-grown *Chrysops* larvae generally survived, whereas smaller ones frequently died.

Rearing Techniques

When this study was begun, larvae of less than 5 percent of the species in Florida could be identified. Rearing collected larvae to adults for determination was desirable in order to establish breeding areas and larval densities and to obtain information on life histories. This phase of the study has yielded both sexes of a new species and heretofore unknown males of other species.

Collected larvae, as well as those that hatched from eggs in the laboratory, were reared in half-pint mason jars and half-pint shallow jelly dishes. Both containers were satisfactory, but the latter was more convenient. To insure proper ventilation, the metal tops of the mason jars were replaced with screen wire and the lids of the jelly dishes were perforated. Clean sand was first used as a rearing medium but was later replaced with soil from the natural habitats. An inch or two of the soil was put in the bottom, banked to one side, and kept wet so the larvae could seek their own moisture level.

Attempts were made to rear the larvae of several species in small shell vials and in serological test tubes. These containers were lined with paper toweling and moistened daily. The larvae did not feed well, appeared restless, and finally died. This method was abandoned, because all rearing attempts were unsuccessful.

Most of the larvae in the laboratory appeared to thrive when given a steady diet of one or more of the following foods: Earthworms, muscoid larvae, snails, beef muscle, and beef liver. They would feed on other foods, such as boiled egg yolk, crayfish, minnows, tadpoles, and larvae of their own kind. Beef liver was used regularly because it was readily available. Approximately 1 gm. of beef liver was placed in each jar on top of the soil once or twice each week. The uneaten portion was removed the following day. Larvae of most species fed at least once each week. However, those of a few species were very reluctant or did not feed during several months in the laboratory.

The larvae were allowed to pupate in the rearing dishes. Specimens taken out of the mud immediately before they pupated usually had difficulty in working out of the larval skin. The pupae were transferred to petri dishes containing a layer of clean moist sand, where they were kept until the adults emerged.

Larvae reared from eggs varied greatly in rate of growth. *Tabanus endymion* larvae from the same egg mass varied in length from 3 mm. for those kept in dishes in the laboratory to 14 mm. for those reared under simulated natural conditions outside. These measurements were made when the larvae were 142 days old. Since those reared outside had aquatic insect larvae available for food, the difference in size was

attributed to the difficulty of getting those reared in the laboratory to feed. Even larvae kept in the laboratory varied in rate of growth. *Tabanus fumipennis* larvae from the same egg mass varied from 16 to 26 mm. at 7 months of age, although all larvae received similar food and attention. However, the largest individuals fed more readily when they were very small.

Ecology

Most of the tabanid larvae in both numbers and species are found in the top 2 or 3 inches of soil in swamps and around lakes, ponds, and streams that are permanent. Some of the typical breeding sites are shown in figures 6–8. A few larvae of

FIGURE 6.—Larvae of *Tabanus atratus*, *lineola*, and *nigripes* are frequently found along the margins of drainage ditches.

species known to prefer soil adjacent to water have been collected in dry places. However, these areas without a doubt were inundated or very near water during periods of oviposition.

Larvae of *Leucotabanus* were collected from cavities in living oak trees and decaying logs in wooded areas where standing water would never be found except perhaps in the cavity itself. Larvae of *Chlorotabanus* seem to

FIGURE 7.—A typical breeding site of *Tabanus atratus*. Larvae inhabit the soil along the margin of the water.

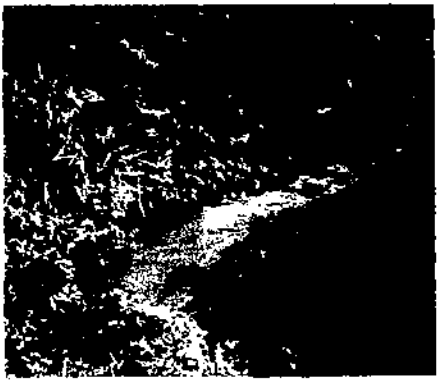


FIGURE 8.—An excellent breeding site for *Tabanus fumipennis* and *imitans excessus*. Heavy rains frequently flood the entire area.

prefer a more nearly aquatic habitat than do most other larvae. They are commonly found in floating material at the edge of stagnant water, and once they were found in large numbers—20 per square yard—in floating

hyacinths several yards from shore. They are not aggressive or cannibalistic when confined in the laboratory. Larvae of one species of the rare genus *Merycomyia* were taken exclusively from the roots of aquatic plants in ponds. A few larvae of some species of *Tabanus* and *Chrysops*, which commonly inhabit shorelines, are sometimes found among the roots of aquatic vegetation.

Information about the larval habitats of 47 tabanid species that occur in Florida is summarized in table 2.

Although *Tabanus gracilis* is included in the table, its larvae have never been identified. The absence of the larvae in collections from the typical habitats that are moist to saturated suggests that this species breeds in dry upland soil.

BIOLOGIES OF THE SPECIES

A list of the Tabanidae in Florida was published by Johnson (1913). Fairchild (1937) brought up to date the information on this group. He recorded 66 species and subspecies divided among 7 genera and subgenera as follows: *Chrysops* 22, *Diachlorus* 1, *Dicladocera* 1 (predisposed by *Agkistrocerus*), *Haematopota* 1 (predisposed by *Chrysozona*), *Microtabanus* 1, *Tabanus* 39, *Whitneyomyia* 1.

Rather intensive collecting during this study and the multitude of occasional collections by various persons have increased the list to include 118 species and subspecies divided among 14 genera as follows: *Agkistrocerus* 2, *Anacimas* 2, *Chlorotabanus* 1, *Chrysops* 40, *Chrysozona* 1, *Diachlorus* 1, *Hamatabanus* 3, *Hybomitra* 3, *Leucotabanus* 1, *Merycomyia* 2, *Microtabanus* 1, *Stenotabanus* 3, *Tabanus* 56, *Whitneyomyia* 2.

All the species known to occur in Florida are arranged alphabetically in this section under the proper subfamily and by genus. The type locality is given only if the type specimen was collected in Florida. Distribution records in the State are given by counties. The seasonal occurrence refers to Florida only, and the dates indicate when the adults were known to occur. Each date is followed by the name of the county in which the record was made.

The literature on tabanids includes numerous synonyms. They are omitted from this publication because they are readily available in the literature (Philip 1947, 1950).

It has been the endeavor to include all the information available concerning the biology of each species. Here also will be found the descriptions, heretofore unpublished, of the males of *Chrysops divisus*, *C. rittatus floridanus*, *Chrysozona punctulata*, and *Merycomyia brunnea*.

Subfamily PANGONIINAE

Chrysops abatus Philip

Type locality: Jacksonville, Duval County.

Distribution: Mississippi, South Carolina.

The type female, described by Philip (1941), was dated June 21. No additional information on its distribution is known. The male is unknown.

TABLE 2.—*Location and moisture content of tabanid larval habitats*

Species	Fresh-water habitat				Brackish-water habitat	Moisture in soil habitat				Moisture in log habitat	
	Stream	Lake	Swamp, bog, and marsh	Drainage ditch		Saturated	Wet	Moist	Dry	Wet	Damp
Pangoniinae:											
Chrysops—											
atlanticus		X								X	
cursim		X					X				
dimmocki	X	X					X				
divisus		X					X				
flavidus	X	X	X	X	X		X				
fuliginosus											
hinei				X			X				
obsoletus	X	X			?		X				
pudicus				X			X				
univittatus	X		X				X				
villatus			X				X				
villatus floridanus			X	X			X				
Merycomyia—											
brunnea		X				X	X				
whitneyi		X								X	
Tabaninae:											
Agkistrocerus megerlei		X					X				
Chlorotabanus crepuscularis		X		X		X	X				
Chrysozona punctulata		X					X				
Diachlorus ferrugatus	X	X	X		X	X	X				
Leucotabanus annulatus					X			X			X
Stenotabanus psammophilus											
Tabanus—											
atratus	X	X	X	X		X	X	X			
atratus fulvopilosus					X						
birdici		X		X			X				
endymion		X					X				
equalis									X		
fairchildi	X					X					
fumipennis		X	X			X	X	X			
gladiator	X						X				
gracilis									?		
imitans excessus		X	X			X	X				
johnsoni		X				X	X				
lineola	X	X	X	X			X	X		X	
melanocerus	X	X	X	X			X				
melanocerus lacustris		X					X				
nigripes		X	X	X			X	X			
nigrovittatus			?	?	X						
petiolatus	X	X				X	X				
pumilus	X						X				
quinquevittatus								X			
sparus milleri		X								X	
stygius		X	X	X		X	X				
sulcifrons									X		
trijunctus			X				X				
trimaculatus		X		X			X			X	
vittiger schwardti	X	X	X	X			X				
wiedemanni		X					X				
Whitneyomyia beatifica atricorpus		X					X				

***Chrysops amazon hubbelli* Philip**

Type locality: Liberty County.

Distribution: Florida only.

This melanistic form, described by Philip (1955), is known from only one female collected on April 25, 1924, at Camp Torreya, Liberty County.

***Chrysops atlanticus* Pechuman**

Distribution: From Massachusetts to Florida.

Florida counties: Alachua, Citrus, Dixie, Lafayette, Lake, Putnam.

Seasonal occurrence: April 21 to August 18 (Dixie County).

Very few specimens have been recognized by the authors. Many individuals may have been confused with *C. flavidus* during the early part of this study.

Life-history studies: Five adults were reared, four of which were males. One of the specimens emerged from a collected pupa; the others were reared from larvae. The life cycle, based on the seasonal occurrence of adults, is approximately 1 year.

Larval ecology: The immature stages were collected at lake margins beneath the bark of decaying logs and stumps, which were approximately at the water's surface.

***Chrysops beameri* Brennan**

Distribution: Eastern United States from Massachusetts to Florida and west to Kansas.

Florida county: Alachua.

Seasonal occurrence: October 5 (Alachua County).

A single collection of this species was made during this study.

***Chrysops bistellatus* Daecke**

Distribution: Atlantic and Gulf Coast States from New Jersey to Louisiana.

Florida county: Jefferson.

Seasonal occurrence: April 18 to May 21 (Jefferson County).

These data reported by Fairchild (1937) are the only known records of this species in Florida. The male is undescribed. However, a single male was collected in Mississippi during 1953. The specimen was lost before a description of it could be made. It was very similar to the female except for the usual sexual characters and was readily identified by the wing picture.

***Chrysops brimleyi* Hine**

Distribution: Atlantic and Gulf Coast States from New York to Mississippi.

Florida county: Jefferson.

Seasonal occurrence: March 21 to May 12 (Jefferson County).

These Florida records made by Fairchild (1937) are the only ones known.

***Chrysops brunneus* Hine**

Distribution: Eastern United States from New York to Florida and west to Kansas and Arizona; Ontario.

Florida counties: Alachua, Citrus, Dixie, Lafayette, Lake.

Seasonal occurrence: May 1 to August 10 (Alachua County).

Although adults were collected each year during the study, heavy populations were not noted. This species is close taxonomically to *C. atlanticus* and *flavidus*, and, although typical specimens of each species separate rather easily, the many atypical specimens have been most difficult to assign. Owing to some confusion regarding these species during the early part of this study, it is possible that *brunneus* is more abundant than the records indicate.

***Chrysops callidus* Osten Sacken**

Distribution: Collected in 34 States from Maine to Washington

in the North and Florida to Arizona in the South; occurs throughout southern Canada.

Florida counties: St. Johns, Volusia. (Fairchild lists a collection from "McIntyre, Fla." This location cannot be found on a present-day map. However, the name of the town may have been confused with McIntosh, Marion County.)

Seasonal occurrence: April 28 (McIntyre (?)) to June 11 (Volusia County).

These Florida records were reported by Fairchild (1937). The authors did not collect this species in this State.

Chrysops carbonarius Walker

Distribution: Most northern States from Alaska and California to Maine and south to North Carolina and Florida; Canadian Provinces from British Columbia to Newfoundland.

Florida county: Liberty.

Seasonal occurrence: April 12 (Liberty County).

A single female collected in the Torreya State Park, Liberty County, by H. V. Weems, Jr., is the only known State record. The determination was made by C. B. Philip. (*In* U.S. Agricultural Research Service 1961.)

Chrysops cincticornis nigropterus Fairchild

Type locality: Lloyd, Jefferson County.

Distribution: Florida only.

Seasonal occurrence: April 30 (Jefferson County).

This subspecies apparently has not been collected since it was described by Fairchild (1937). All specimens were taken at Lloyd. The male is unknown.

Chrysops cursim Whitney

Distribution: Atlantic and Gulf Coast States from New Hampshire to Mississippi.

Florida counties: Dixie, Lake, Putnam.

Seasonal occurrence: April 12 (location unknown) to September 14 (Dixie County).

Adult activity: Serious infestations were observed in Lake County in 1953, 1954, and 1955. Less significant populations were noted in Dixie and Putnam Counties during these years. August and the early part of September appear to be the period of greatest activity.

Life-history studies: Three adult females were reared from larvae collected in the field. The larvae were nearly full grown when collected and pupated in the laboratory 56, 67, and 67 days later, respectively. Their pupal period averaged 8 days. The life cycle, based on the seasonal occurrence of adults, appears to be about 1 year.

Larval ecology: The larvae were recognized in one collection only. They were taken from the wet grassy margin of a pond located in a low pineland pasture.

Chrysops dacne Philip

Distribution: Atlantic and Gulf Coast States from Connecticut to Louisiana, also Arkansas and Illinois.

Florida counties: Calhoun, Escambia, Gulf, Nassau, Santa Rosa, Walton.

Seasonal occurrence: July 1 (Escambia County) to September 13 (Gulf County).

Adult activity: This species is apparently rare in Florida. It was taken only in Gulf County during these investigations. It was recorded from the other counties by Philip (1955). Since the collections were confined to northwestern Florida, except the Nassau

County collection, this area probably represents the extreme southern distribution of *dacne*.

Chrysops dimmocki Hine

Distribution: Atlantic and Gulf Coast States from Massachusetts to Louisiana, also Michigan.

Florida counties: Alachua, Lafayette, Lake, Putnam, Volusia.

Seasonal occurrence: March 17 to May 4 (Lake County).

Adult activity: The adults were rarely observed in sufficient numbers to be considered serious pests of man or livestock. However, *dimmocki* with other early species often contributes to annoying tabanid populations.

Life-history studies: Five adults were reared from field-collected larvae. The pupal period of four specimens averaged 9 days. The life cycle, based on the seasonal occurrence of adults, appears to be almost exactly 1 year with no overlapping of generations.

Larval ecology: All the larvae were collected along the grassy margins of lakes and streams.

Chrysops divisus Walker

Distribution: Georgia, Mississippi, New Jersey.

Florida counties: Alachua, Collier, Duval, Hendry, Highlands, Hillsborough, Jefferson, Monroe, Okeechobee, Orange, Osceola, Polk, Putnam, St. Johns, Seminole.

Seasonal occurrence: February 25 (Putnam County) to July 26 (Hillsborough County).

Adult activity: This species is usually the first one observed in northern and central Florida each year. The adults are rarely numerous enough to be considered serious pests of livestock; however, they are often troublesome around inland recreation areas. Although records are available for only 15 of Florida's 67 counties, the distribution is probably statewide.

The feeding habits are similar to those of other species of *Chrysops*. Diurnal in activity, it is often a serious pest of man. It attacks the head, face, and other exposed areas. The favorite feeding locations on livestock are the head, neck, and forelegs.

Life-history studies: Seven adults were reared from field-collected larvae. Five of these were males. The pupal period averaged 9 and 10 days for females and males, respectively. The seasonal occurrence of adults indicates a single generation each year.

Larval ecology: The larvae were found in mud along the grassy margins of lakes.

Male description:

Except for usual sexual differences, male closely resembles female. Length 7.5–8.5 mm. Face has yellow pollinose stripe below antennae extending about one-third length of frontoclypeus. Similar midfacial stripe on lower one-third or one-fourth of frontoclypeus. Remainder of head same as in female except for usual sexual characters.

Thorax, abdomen, and wing same as in female.

Chrysops dorsovittatus Hine

Distribution: Maryland, North Carolina.

Florida counties: Duval, Jefferson.

Seasonal occurrence: April 15 to May 12 (Jefferson County).

These collection data reported by Fairchild (1937) are the only known record of this species in Florida.

Chrysops flavidus Wiedemann

Distribution: Eastern and Central United States from New York, Michigan, and Kansas to Gulf of Mexico and Texas.

Florida: Statewide.

Seasonal occurrence: February

25 (Monroe County) to November 28 (Alachua County).

Adult activity: This is probably the most abundant deer fly in the State. The adult females are primarily diurnal feeders, but a few specimens were taken from livestock at dusk. This species is frequently pestiferous to man. It usually attacks the head and neck, but it will readily bite any exposed area of skin. The bite is rather painful; the reaction is more severe in some individuals than others. The face, neck, legs, and underline appear to be the favorite feeding locations on horses and cattle. Observations on more than 50 engorging specimens showed an average feeding time of 2 minutes and 20 seconds.

Life-history studies: Hundreds of larvae were collected during these investigations, but rearings were unsuccessful whenever the larvae were less than half grown. A total of 38 specimens—18 males and 20 females—were reared to adults. The pupal period ranged from 5 to 13 days with an average of 8 days. Half- to full-grown larvae collected during the winter almost invariably emerged in March, April, May, or June, whereas those collected during the spring usually emerged in July, August, or September. Field observations showed that in some areas two peak populations are evident each year, one early in April and May and the other in late August and September. However, the rearing studies indicated two broods each year rather than two generations. In many localities the early and late peak populations are not recognized; instead, subcritical infestations prevail from May through September.

Two females reared from collected larvae oviposited 2 days after emerging. Oviposition took place in the rearing dishes. No food was provided. Neither of the egg masses hatched. One of the egg masses obtained is shown in figure 9.

FIGURE 9.—Egg mass of *Chrysops flavidus.*

Larval ecology: The larvae were collected from wet soil along the margins of lakes, streams, and swamps, from the margins of brackish water, and from highly alkaline soil.

***Chrysops flavidus reicherti* Fairchild**

Type locality: Monticello, Jefferson County.

Distribution: Delaware, Georgia, Louisiana, Tennessee.

Florida counties: Alachua, Dixie, Jefferson, Manatee.

Seasonal occurrence: March 25 (Manatee County) to August 23 (Alachua County).

The Jefferson County records were reported by Fairchild (1937). The authors collected very few specimens that could be positively determined as *reicherti.* However, there were many *flavidus* specimens that varied sufficiently, so that some students of the Tabanidae might assign them to the subspecies.

***Chrysops fuliginosus* Wiedemann**

Distribution: Atlantic and Gulf Coast States from Maine to Mississippi; Nova Scotia.

Florida counties: Bay, Citrus, Duval, Franklin, Lee, Levy, Nassau, St. Johns, Volusia.

Seasonal occurrence: March 4 to July 5 (Nassau County).

Adult activity: Although this species is known to be in only nine counties, it appears likely that it is present in all the coastal areas. All collections were made in or near salt marshes and mangrove swamps. Fairchild (1937) remarked that *fuliginosus* is a "salt-marsh species." The adults are most numerous during April.

Chrysops fulvistigma Hine

Distribution: Atlantic and Gulf Coast States from New Jersey to Louisiana.

The only information on this species known to the authors is a State record listed by Philip (1950). No collections were made during these investigations.

Chrysops fulvistigma dorsopunctus Fairchild

Type locality: Lloyd, Jefferson County.

Distribution: Georgia, Louisiana.

Seasonal occurrence: May 21 to June 23 (Jefferson County).

These records are by Fairchild (1937). The male is unknown. The authors have no additional information regarding this species.

Chrysops geminatus Wiedemann

Distribution: Eastern and Southern United States to Wisconsin and Oklahoma; Ontario, Quebec.

Florida county: Jefferson.

Seasonal occurrence: April 30 to May 21 (Jefferson County).

The State record is by Fairchild (1937). The authors did not collect this species.

Chrysops hinei Daecke

Distribution: Atlantic and Gulf Coast States from Massachusetts to Mississippi.

Florida counties: Alachua, Lafayette, Lake, Liberty, Marion.

Seasonal occurrence: February 18 (Sand Point, county unknown) to November 18 (Alachua County).

Adult activity: The February 18 record for this species reported by Johnson (1913) is much earlier than any of the records obtained during this study. Annoying populations were observed in Lake and Lafayette Counties during the summer and fall. The heaviest infestations were found in Lafayette County during October of 1953, and the adults were also abundant during September and October of 1954 and 1955. In other areas most of the collections were made after July 1 and before November 1 of each year.

Without exception adult activity was confined to low swampy areas. In the Steinhatchee Game Reserve, Lafayette County, the adults were found associated with titi (*Cyrilla* sp.). However, in Lake and Marion Counties the infestations were heaviest in small pine thickets adjacent to shallow ponds or swamps. Strangely, collection attempts were not successful in the wooded areas bordering streams or rivers.

Life-history studies: Two adults were reared from collected larvae. Pupation occurred in the laboratory 9 and 21 days after collection, and the adults, both females, emerged 13 and 10 days later during the usual period of adult activity.

Larval ecology: Extensive examinations of the margins of lakes, swamps, and roadside ditches adjacent to adult habitats resulted in only a single collection of larvae. These were found at the grassy margin of a roadside

ditch in the Steinhatchee Game Reserve. Other tabanid species in this habitat included *C. pudicus, vittatus floridanus*, and *Tabanus nigripes*.

***Chrysops hyalinus* Shannon**

Distribution: Maryland, North Carolina.

Florida county: Baker.

Seasonal occurrence: April 13 (Baker County).

Six females collected at Glen St. Mary in 1960 by E. W. Holder, Florida State Plant Board, are the only known State records. The determinations were made by C. B. Philip.

This very rare species is the only known *Chrysops* in the Nearctic region with entirely hyaline wings and bare face and cheeks. Philip (1955) considered these differences of more than specific significance and proposed the new subgenus *Liochrysops* for it. He noted that the specimens from Maryland and North Carolina were collected in bogs. The male is unknown.

***Chrysops macquarti* Philip**

Distribution: Maine to Florida and west to Minnesota and Oklahoma; Quebec.

Florida counties: Jefferson, Walton.

Seasonal occurrence: April 10 (Jefferson County) to November 28 (Walton County).

This well-known species was previously misidentified as *C. univittatus* Macquart (Philip 1961).

Adult activity: The only record made during this study was based on a late-season collection in Walton County. Collections in Georgia and South Carolina indicated that April through June was the principal period of adult activity in these States.

Life-history studies: The immature stages were never taken in Florida; however, adults were reared from larvae collected in other States. Larvae taken in Jasper County, S.C., and Okeefenokee Swamp Park, Ware County, Ga., produced four and three adults, respectively. The pupal period of two specimens was 8 and 11 days, respectively.

Larval ecology: The principal larval habitat appears to be the permanently wet margins of sluggish lowland streams and swamps. The soil without exception was of high organic content and slightly acid in reaction. On two occasions *macquarti* larvae were found with the immature stages of the yellow fly *Diachlorus ferrugatus*. However, they were always much nearer the surface than the yellow fly larvae.

***Chrysops moechus* Osten Sacken**

Distribution: Eastern United States to Minnesota, Kansas, and Louisiana; Quebec.

Florida county: Liberty.

Philip[4] identified a specimen for F. S. Blanton, University of Florida.

***Chrysops montanus* Osten Sacken**

Distribution: Eastern United States to Minnesota and Texas; Ontario, Quebec.

Florida county: Jefferson.

Seasonal occurrence: May 13 (Jefferson County).

The single collection listed by Fairchild (1937) is the only known State record.

***Chrysops montanus perplexus* Philip**

Distribution: North Carolina.

Florida counties: Alachua, Orange, Putnam.

[4] Personal communication from C. B. Philip to F. S. Blanton, dated Jan. 17, 1961.

Seasonal occurrence: May 1 (Putnam County) to July 7 (Orange County).

The Florida records consist of a paratype male (Philip 1955), the type specimen from which the female was described (Pechuman 1957), and two males captured at Gainesville in an ultraviolet light trap (Anthony 1960).

***Chrysops niger* Macquart**

Distribution: Eastern United States to Minnesota, Oklahoma, and Montana; Canada: New Brunswick, Newfoundland, Nova Scotia, Ontario, Quebec.

Florida counties: Unknown.

Seasonal occurrence: Unknown.

This species is listed on the authority of Philip (1950). No date or location was given.

***Chrysops niger taylori* Philip**

Type locality: Quincy, Gadsden County.

Distribution: Arkansas, North Carolina.

Seasonal occurrence: April 28 (Gadsden County).

This information was reported by Philip (1955) for the holotype female. The specimen was "caught in car." The male is unknown.

***Chrysops nigribimbo* Whitney**

Distribution: New England and Atlantic Coast States from Vermont to Florida.

Florida county: Alachua.

Seasonal occurrence: May 25 (Alachua County).

Philip (1947) included Florida in the distribution of this species. The junior author identified one specimen that was collected from a dog. The collector described it as a very weak, feeble flyer.

***Chrysops obsoletus* Wiedemann**

Distribution: Coastal part of Eastern United States from Massachusetts to Florida.

Florida counties: Alachua, Brevard, Citrus, Dixie, Duval, Lafayette, Liberty.

Seasonal occurrence: February 22 (Brevard County) to August 5 (Alachua County).

Adult activity: Serious infestations were not observed. However, owing to the long period of adult activity *obsoletus* often contributes to troublesome tabanid populations. Although principally diurnal in activity, occasional specimens were collected from livestock at dusk.

Life-history studies: Many larvae believed to be *obsoletus* were collected, but only five adult females were reared. The pupal period averaged approximately 10 days.

Larval ecology: The immature stages were found along the margins of fresh-water lakes and streams in mud of high organic content. Adult collections near salt marshes in coastal areas indicate that the larvae may be tolerant to brackish locations. However, the larvae were never found in these locations.

***Chrysops obsoletus lugens* Wiedemann**

Distribution: Coastal part of Eastern United States from Connecticut to Florida.

Florida counties: Alachua, Citrus, Dade, Dixie, Lafayette, Madison, Monroe, Palm Beach, St. Johns, Volusia.

Seasonal occurrence: February 25 (Monroe County) to September 1 (Alachua County).

Adult activity: As with true *obsoletus* the subspecies was never found in large numbers. Both occur simultaneously in many areas. All observations indicated that *obsoletus* was the dominant form.

***Chrysops parvulus* Daecke**

Distribution: Atlantic Coast

States from New York to Florida, also Arkansas.

Florida counties: Alachua, Gulf, Liberty, St. Johns.

Seasonal occurrence: March 15 (St. Johns County) to July 31 (Alachua County).

These State records were reported by Fairchild (1937). This species was not collected during these studies.

Chrysops pikei Whitney

Distribution: New York to Florida and west to Nebraska and Texas.

Florida counties: Alachua, Jefferson, Manatee.

Seasonal occurrence: April 16 to September 18 (Jefferson County).

Only a single specimen was collected during these investigations. Other State records were reported by Fairchild (1937).

Chrysops pudicus Osten Sacken

Distribution: New York to Florida and west to Oklahoma.

Florida counties: Alachua, Dixie, Lafayette, Lake, Volusia.

Seasonal occurrence: April 8 (locality unknown) to September 25 (Lafayette County).

Adult activity: Severe infestations were frequently encountered in wooded areas during April and May. In conjunction with *C. hinei*, this species contributes to serious late-season populations in certain areas. Strictly diurnal in activity, the preferred feeding locations of *pudicus* are the face and neck of horses and cattle.

Life-history studies: Three adult females were reared from collected larvae. The pupal period of one specimen was 8 days.

Larval ecology: The habitat of the larvae collected was the wet soil at the grassy margin of a roadside ditch in Lafayette County. Other tabanids in this same collection were *C. hinei, vittatus floridanus,* and *Tabanus nigripes.*

Chrysops sackeni Hine

Distribution: Eastern and Southern United States to Minnesota and Oklahoma; Ontario, Quebec.

Florida counties: Unknown.

Seasonal occurrence: April 16 "Florida."

The only known State record was reported by Brennan (1935).

Chrysops tidwelli Philip & Jones

Type locality: Escambia County.

Distribution: Florida only.

Seasonal occurrence: August 7–9 (Escambia County).

Philip and Jones (1962) described the species and gave the following information: The type and paratype specimens were collected by M. Tidwell 7 miles southwest of Cantonment, Escambia County. The collector described the terrain as gently rolling. Vegetation consisted of various pines and wiregrass on the elevated locations, whereas the lower habitats consisted predominantly of bay trees and other lowland vegetation. A small stream drained the area and was approximately 100 yards from where the specimens were taken. The collections were made from a horse between 3 and 6 p.m. on clear, sunny days.

The male is unknown.

Chrysops univittatus Macquart

Distribution: Eastern United States to Minnesota, Kansas, and Louisiana; Ontario, Quebec.

Philip (1961) indicated that this species is synonymous with *C. wiedemanni* Krober, not *C. univittatus* of authors. Philip (1950) included Florida in the State distributional records. No other information is available.

***Chrysops vittatus* Wiedemann**

Distribution: Minnesota to Texas and east to the Atlantic Coast; Nova Scotia, Ontario, Quebec.

Florida counties: Alachua, Jefferson, Liberty, Walton.

Seasonal occurrence: April 4 to September 18 (Jefferson County).

Adult activity: Fairchild (1937) noted an abrupt line of demarcation between the distribution of *vittatus* and that of the subspecies *floridanus* in Jefferson County. The former occurred north of the 50-foot contour line, whereas south of it *floridanus* was more abundant. Occasional specimens were collected in northwestern Florida. Large populations were never observed.

Life-history studies: A single specimen was reared from a larva collected in Alachua County. Other specimens were reared from larvae collected in northern Alabama. The pupal period was not determined.

Larval ecology: A high concentration of larvae, 12 to 15 per square foot, was found on Lookout Mountain, De Kalb County, Ala. The larvae were near the soil's surface in a wooded, permanently wet area.

***Chrysops vittatus floridanus* Johnson**

Distribution: Atlantic Coast States from Virginia to Florida.

Florida counties: Alachua, Bay, Jefferson, Lafayette, Levy, Madison, Orange, Putnam, Volusia, Wakulla.

Seasonal occurrence: April 5 to September 27 (Alachua County).

Adult activity: Heavy populations were noted in May and again in September of 1951 through 1953. In 1954 and 1955 the flies were present from April through September, but distinct peak populations were not evident. Usually the infestations consisted of a mixed population of *vittatus floridanus* and *C. flavidus*. The preferred feeding locations are the face, neck, and lower legs of horses and cattle. This subspecies is strictly diurnal in activity.

Life-history studies: A total of 21 adults were reared from collected larvae during these studies —13 females and 8 males. The pupal period averaged 10 days for both males and females. On the basis of the rearing studies, the late populations that occurred in 1951 through 1953 are unexplained. Full-grown larvae were collected during the early months each year of this study. However, all the reared adults except four emerged in April, May, or June. The latest date for laboratory emergence was July 30.

Larval ecology: Intensive larval surveys in areas where adults were numerous did not reveal the abundance of larvae that was expected. However, larvae were found in soil of high organic content at the edge of water in swamps and among roots of plants growing in shallow water.

Male description:

Length 8.5 mm. Readily associated with female. Other than sex characters it differs in having wings more extensively infuscated and abdominal stripes more obscure.

Hyaline triangle of wing faintly tinted and confined to apical two-thirds and one-third of first and second median cells, respectively. Crossband continuous with infuscation of first and second basal cells and posterior third of anal cell, infuscation less dense surrounding crossvein between apex of second basal cell and base of cubical cell. Basal two-thirds of anal cell faintly tinted with brown.

Median abdominal stripes very faint, evident only on posterior edge of second through fourth segment. Fifth segment brown and sixth nearly black. Venter yellow.

The specimen keys to *vittatus* in Philip's key to males (1955),

except that the apex of the hyaline triangle does not reach the fork as stated in the second part of couplet 81. It is easily separated from the male of *vittatus* by the obscure abdominal pattern and the more extensively infuscated wings.

***Merycomyia brunnea* Stone**

Type locality: New Smyrna Beach, Volusia County.

Distribution: Florida only.

Florida counties: Alachua, Lafayette, Lake, Volusia.

Seasonal occurrence: April 11 (Alachua County, reared specimen) to August 18 (Lafayette County).

Adult activity: The feeding habits of both sexes are unknown. The weakly developed mouth parts of the females suggest that they are not blood feeders. No adults were observed on livestock.

Two adult females, one of which was the type specimen, were collected. Three or four other adults were observed but evaded capture.

Oviposition was observed on June 18, 1956, in the Steinhatchee Game Reserve, Lafayette County (fig. 10). Weather conditions were favorable for tabanid activity on that date, and several species were flying. The sun was shining brightly, the temperature was between 90° and 95° F., and there was practically no wind. A female *brunnea* was located on *Peltandra* sp., which was growing in shallow water about a foot from the edge of a roadside ditch. It deposited eggs for 30 minutes. When the mass appeared to be fully formed and eggs were being deposited very slowly, the egg laying was interrupted. This mass of eggs yielded 284 larvae 12 days later. Two egg masses collected in 1955, presumably of this species,

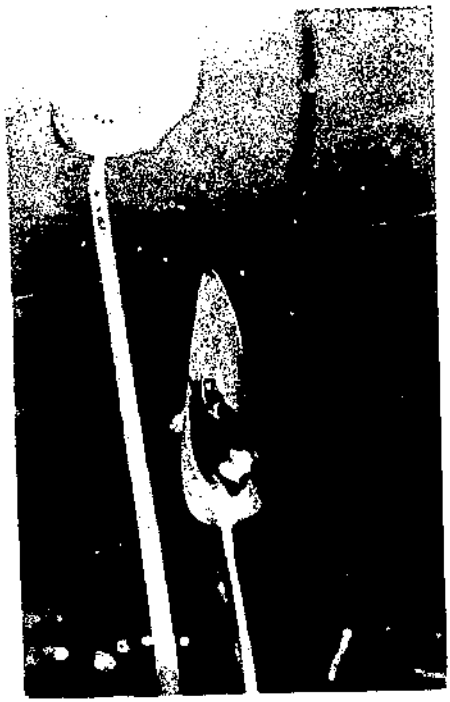


FIGURE 10.—*Merycomyia brunnea* ovipositing on *Peltandra* sp.

were parasitized by *Telenomus* sp., and only a few of the eggs hatched.

Life-history studies: A total of 10 adults—4 males and 6 females—were reared from collected larvae. Their pupal period averaged 11 days. Only full-grown larvae were successfully reared in the laboratory. One larva pupated and emerged shortly after it was collected. Other specimens were maintained in the laboratory for 8 or 9 months before they pupated. Three larvae, all apparently full grown when collected on August 17, 1953, lived in the laboratory for $2\frac{1}{2}$ to $2\frac{2}{3}$ years and then died before pupating. Attempts to rear the larvae from eggs failed completely; none lived longer than 5 months although they were separated and cared for in the usual manner. Attempts

to rear half-grown and smaller larvae were also unsuccessful, although some of them were maintained in the laboratory for periods exceeding 2 years without apparent increase in size. The length of the life cycle of *brunnea* cannot be stated, but the rearing studies indicate that 2 years and possibly longer may be required for some specimens.

Larval ecology: The larvae were collected from five localities in Florida and were considered to be relatively abundant when compared with the scarcity of the adults. The larvae were found below the surface of the water, often at depths of 2 feet or more, among the soil and roots of plants. The plants in the habitat were usually *Sagittaria* sp., *Typha* sp., and *Peltandra* sp.

Male description:

Except for usual sexual differences, male closely resembles female. Length 11.5 mm. Head as viewed from front is circular in shape. Line of demarcation between large and small facets of eyes distinct. Small facets are below antennae and extend upward along outer margins midway to ocelli. Ocellar tubercle black; ocelli yellow. Upper point of frontal triangle dark brown to black. Sunken frontoclypeus accentuated by swollen cheeks. Hairs on face slightly longer than in female and concolorous with body. Palpus short, length of second segment about 1½ times its width. Antennae same as in female.

Infuscation of wing more dilute in anal area, otherwise same as in female. Abdomen slightly paler than in female.

***Merycomyia whitneyi* (Johnson)**

Distribution: Connecticut, Indiana, Massachusetts, New Jersey, Rhode Island, Virginia.

Florida counties: Alachua, Putnam.

Seasonal occurrence: May 15 (Putnam County) to August 11 (Alachua County).

Adult activity: This species is apparently very rare in Florida. Only a few specimens have been recorded from the State.

Life-history studies: A single male specimen was reared from a larva collected in Putnam County on April 3, 1952, and the adult emerged on May 15, 1952.

Larval ecology: Only one larva was collected. It was found in a decaying pine log partially submerged in a permanent lake.

Subfamily TABANINAE

***Agkistrocerus finitimus* (Stone)**

Type locality: Jacksonville, Duval County.

Distribution: Georgia, Mississippi, Texas.

Florida counties: Bay, Duval, Lake, Orange, Polk.

Seasonal occurrence: April 14 (Duval County) to April 18 (Bay County).

The single male specimen was collected during this study. It was netted from grass in a wet meadow near Dinsmore, Duval County. The Bay County record was reported by Philip (1952).

***Agkistrocerus megerlei* (Wiedemann)**

Distribution: Alabama, Georgia, Louisiana, North Carolina.

Florida counties: Highlands, Lake, Pinellas, Polk, Putnam.

Seasonal occurrence: March 21 (Polk County) to June 4 (Putnam County).

Adults were collected infrequently. A single specimen was reared from a larva collected in Putnam County in 1951. The larva was found in soil near the edge of a lake. The area was devoid of trees and shrubs.

***Anacimas geropogon* Philip**

Distribution: North Carolina.

Florida county: Franklin.

Seasonal occurrence: October 17 (Franklin County).

Philip (1952) established the presence of this species in Florida from a male labeled "Fla., April," and a female captured on Dog Island, Franklin County.

***Anacimas limbellatus* Enderlein**

Type locality: Probably St. Johns Bluff, St. Johns River.

Distribution: South Carolina.

Florida counties: Bay, Duval, Volusia.

Seasonal occurrence: April 19 (Bay County) to August 4 (Volusia County).

These State records were reported by Stone (1938) and Philip (1952). The latter collected the allotype males from the carnivorous plant *Sarracenia flava.*

***Chlorotabanus crepuscularis* (Bequaert)**

Distribution: Atlantic and Gulf Coast States from New Jersey to Texas, west to Arizona, also Missouri and Arkansas.

Florida: Statewide.

Seasonal occurrence: March 12 (Dade County) to September 10 (Jefferson County).

Adult activity: Localized and sporadic outbreaks occur each year and are particularly serious around dairies. The females are crepuscular feeders, attacking man and livestock primarily at dawn and dusk. The severe annoyance to cattle and workers at milking time frequently forces dairymen to adjust their milking hours to avoid these pests. The populations are heaviest in May, June, and July.

Life-history studies: Twelve specimens were reared from collected larvae; nine were males. The larvae were successfully maintained for approximately 1 month in a small laboratory aquarium. Mosquito larvae were excellent food. Although the aquarium-reared larvae appeared healthy and full grown, pupation did not occur until they were removed from the water and placed in wet soil. The larvae did not molt while in the aquarium. The pupal period for the reared specimens averaged 10 days.

Larval ecology: Breeding is confined to margins of permanent ponds and lakes. The larvae are usually found at the water's surface intermingled with floating debris, algae, and water hyacinths. They have also been found in the wet soil at the water margins.

***Chrysozona punctulata* (Macquart)**

Distribution: "Carolina," Georgia, New Jersey, Pennsylvania, Rhode Island.

Florida counties: Duval, Putnam.

The adults were not collected during this study. However, a single adult male was reared from a larva collected in Putnam County on March 24, 1952. It was found near the surface in moist grass-covered sandy soil at the margin of a permanent lake. Pupation occurred in the laboratory on June 11 and the imago emerged 12 days later.

Chrysops and *Tabanus* larvae were taken on the same day from adjacent areas around the lake.

Male description:

Length 7 mm. Eye with sparse short pile, small facets distinctly smaller and sharply differentiated from large facets; former occupy part of eye below top margin of antenna and almost reach vertex along outer margin; in life small facets greenish blue with three zigzag pale-green bands on their long axis, inner band interrupted by area of large facets, which are mottled, light and dark brown. First antennal

segment 1½ times as long as greatest width and slightly shorter than third segment, subapical, dorsal, and ventral notches present, long hairs on dorsal and ventral sides, shiny dark brown except for gray pollinose area on inside of swollen area; second antennal segment small, dark brown with long hairs; basal part of third antennal segment narrow at base and enlarges to pear shape, basal half dark brown, apical half lighter, few long hairs on dorsal side, annulate part slightly shorter and darker than adjacent part of third segment, few scattered hairs on dorsal and ventral sides and apex, three indistinct annuli. Frontal triangle raised, gray with black protuberance that extends between antennae and eyes, shiny on upper margin. Cheeks gray pollinose, mottled with black patches, hairs mostly white but few black ones interspersed. First palpal segment short and rounded, second segment cylindrical, tapers gradually to blunt apex, hairs white.

Thorax, wings, and legs as in female. Abdomen colored as in female, except only faint suggestions of pale apical margins and no sublateral pale spots on tergites.

The male specimen has been deposited in the U.S. National Museum, Washington, D.C.

Diachlorus ferrugatus (Fabricius)

Distribution: Atlantic and Gulf Coast States from New Jersey to Texas; West Indies and Mexico to Honduras.

Florida: Statewide.

Seasonal occurrence: March 29 (Dade County) to November 23 (Pinellas County).

Adult activity: *Diachlorus ferrugatus* is the most aggressive tabanid pest of man in Florida, and it often severely attacks livestock pastured adjacent to infested wooded areas. The bite is painful to humans and often produces a severe reaction in some individuals. Pestiferous populations have been reported from many recreational areas throughout the State. Swimming, boating, and fishing are often curtailed during April, May, and June, when this fly is most abundant.

The wooded areas adjacent to fresh-water lakes and streams appear to be the principal adult habitats. Rarely have the adults been taken from livestock in open pastures. The face, neck, belly, and lower legs of livestock seem to be the preferred feeding locations. The engorgement time of more than 50 specimens averaged 1 minute and 47 seconds. In heavily infested areas the flies were found resting on the trunks of trees as high as 10 to 12 feet above the ground. Abundant Spanish-moss (*Tillandsia usneoides*) in the trees undoubtedly protects these flies. Large numbers were collected by disturbing the moss and then sweeping vigorously with a net.

Life-history studies: Although many larvae were collected, only 13 were successfully reared to adults. Four of these were males. The pupal period ranged from 6 to 14 days with an average of about 11 days. The life cycle, based on the seasonal occurrence of adults, is approximately 1 year. Laboratory emergence closely coincided with field emergence.

Larval ecology: The larvae are located in swamps, bogs, and around the heavily wooded margins of fresh-water lakes and streams. Without exception the larvae were found associated with roots of shingle oak *(Quercus imbricaria)*, common baldcypress *(Taxodium distichum)*, and within the root mats of other woody plants. The habitats are usually deeply shaded and rarely in open sunlit areas. The larvae are found slightly deeper and farther from the water's edge than those of other species breeding in the same general area. Most are 6 to 12 inches from the water margin

and 3 to 6 inches deep. Owing to the porosity of the soil and abundance of roots, the moisture gradient in these habitats closely approximates that at the water margin. Moisture determinations from seven habitats were made. The saturation varied from 66 to 94 percent.

***Hamatabanus annularis* (Hine)**

Distribution: Mississippi.

Florida county: Bay.

Seasonal occurrence: April 19–21 (Bay County).

The collection of four females and six males from the carnivorous plant *Sarracenia flava* by Philip (1952) near Panama City, Fla., provided a new State record for this species.

***Hamatabanus carolinensis* (Macquart)**

Distribution: Wisconsin and Michigan to and throughout the Southeastern States.

Philip (1947) included Florida in the list of States where the species occurs. The seasonal occurrence and distribution within this State are unknown to the authors.

***Hamatabanus sexfasciatus* (Stone)**

Type locality: Largo Key, Pinellas County. This locality is listed by Stone (1938). Key Largo (not Largo Key) is in Monroe County and the town of Largo is in Pinellas County. Some question arises as to the exact locality of the type.

Distribution: Georgia.

Florida counties: Duval, Monroe or Pinellas (?).

Seasonal occurrence: March 4 ("Largo Key") to April 20 (Duval County).

One specimen from the radiator of a car in Duval County was collected by the authors. The information given by Stone (1938) comprises the other known record for the State.

***Hybomitra cincta* (Fabricius)**

Distribution: Eastern United States to the Mississippi River; Manitoba, Ontario; Mexico.

Philip[5] recently identified a male of this species collected in Liberty County, Fla.

***Hybomitra difficilis* Wiedemann**

Distribution: Oklahoma to Massachusetts and south to Florida.

The collection of two females at the Torreya State Park, Liberty County, on April 12, 1960, by H. V. Weems, Jr., provides a new State record. It represents a southern extension of a species that generally occurs in hilly to mountainous regions. The determinations were made by C. B. Philip. (*In* U.S. Agricultural Research Service 1961.)

***Hybomitra hinei wrighti* (Whitney)**

Type locality: West Palm Beach, Palm Beach County.

Distribution: Georgia, Mississippi, North Carolina.

Florida counties: Bay, Highlands, Lafayette, Lake, Osceola, Palm Beach, Taylor.

Seasonal occurrence: April 19–21 (Bay County) to May 25 (Lafayette County).

A few females were collected from cattle, horses, and moving vehicles. It is doubtful if this subspecies is of any economic importance in Florida.

***Leucotabanus annulatus* (Say)**

Distribution: Kansas and Texas east to New York and Florida.

Florida counties: Alachua, Dixie, Jefferson, Lake, Orange, Putnam, Taylor.

[5] Personal communication dated Feb. 8, 1960.

Seasonal occurrence: May 25 to August 18 (Alachua County).

Adult activity: This species was never observed in large numbers; usually only single specimens were seen. There is a definite tendency toward crepuscular activity, as most of the adults were taken at dusk from livestock. The preferred feeding locations are the lower legs and belly of livestock.

Oviposition was observed by L. F. Lewis (1955) in Mississippi. Three eggs were deposited on a decaying stump. They were "pearly white" when laid but darkened to almost black the first day. The incubation period was 11 days.

Life-history studies: Records on 28 reared specimens revealed pupal periods of 8 to 14 days with an average of 12 days. The life cycles of collected larvae and the annual appearance of adults indicate a single generation each year with some overlapping. However, Lewis and Jones (1955) in reporting two distinct sizes of larvae at many collection sites suggest a 2-year life cycle.

Larval ecology: The larval habitats observed in Florida were very similar to those described by Lewis and Jones (1955). Larvae were found in relatively large numbers in cavities of trees, in decaying trunks of fallen trees, and in the soil beneath forest litter. These habitats were of low moisture content and not necessarily associated with swamps or bodies of water. With one exception, larvae of other tabanid species were not found in these habitats in Florida. A few *Tabanus lineola* larvae sometimes occur in cavities of trees. The larvae of *annulatus* were never found in the typical wet locations characteristic of most tabanid species.

Microtabanus pygmaeus (Williston)

Type locality: Florida.

Distribution: Alabama, Delaware, Georgia, New York, North Carolina.

Florida counties: Jefferson, Lee, Osceola.

Seasonal occurrence: July 13 (Osceola County) to August 22 (Jefferson County).

These records were reported by Philip (1936) and Fairchild (1937). The authors of this bulletin did not collect this species.

Stenotabanus daedalus Stone

Type locality: Gainesville, Alachua County.

Distribution: Georgia.

Florida counties: Alachua, Lake, Volusia.

Seasonal occurrence: August 17 (Lake County) to October 2 (Alachua County).

Only two specimens were collected during this study. They were taken from a horse in Lake County.

Stenotabanus floridensis (Hine)

Type locality: Fort Meade, Polk County.

Distribution: Georgia.

Florida counties: Alachua, Baker, Highlands, Polk, Putnam.

Seasonal occurrence: April 1 (Alachua County) to May 8 (Putnam County).

Only five adults were collected during these investigations.

Stenotabanus psammophilus (Osten Sacken)

Type locality: Fort Capron.

Distribution: Georgia.

Florida counties: Brevard, Dade, Indian River, Monroe, Palm Beach, St. Lucie.

Seasonal occurrence: February to June 18 (Dade County).

Fairchild (1937) indicated that this species had also been collected at Biscayne Key, Fla. The authors tried several times to collect this species along the Atlantic coast of Florida without success. Blickle (1958) collected the adults on white sand beaches from Sebastian Inlet to Long Key, Fla., during April and May. He stated that the species probably occurs on all the beaches on the east coast of Florida. In his publication he has described the adult habits, larval and pupal habitats, and the larva and pupa he collected.

Tabanus aar Philip

Distribution: Georgia, Louisiana, Mississippi.

Florida counties: Alachua, Baker, Brevard, Franklin, Gulf, Hillsborough, Jefferson, Lake, Lee, Marion, Nassau, Polk, Union, Wakulla, Walton.

Seasonal occurrence: July 14 (Alachua County) to September 11 (Marion County).

This species appears to be of little economic importance in Florida, as the adults were never observed in large numbers. Most collections consisted of a single specimen. The adult females apparently prefer reduced light for feeding. All collections were made either during very cloudy afternoons or at dusk. One specimen was taken at 8:30 p.m. from a horse at Gainesville, Fla.

The male is unknown.

Tabanus abdominalis Fabricius

Distribution: Nebraska to Oklahoma and east to Massachusetts and Florida.

Florida counties: Alachua, Flagler, Osceola.

Seasonal occurrence: April 28 (Osceola County) to July 28 (Flagler County).

This well-known northern and midwestern species was collected only occasionally in Florida. Serious infestations were never observed.

Tabanus acutus (Bigot)

Distribution: Georgia, Louisiana, Mississippi.

Florida counties: Franklin, Levy, Taylor.

Seasonal occurrence: July 4 (Taylor County) to July 21 (Franklin County).

These data were reported by Fairchild (1937) and Stone (1938).

Tabanus americanus Forster

Distribution: Massachusetts to Florida and west to Nebraska and Texas; Bahamas.

Florida: Statewide.

Seasonal occurrence: February 28 (Monroe County) to August 5 (Jefferson County).

Adult activity: Although this species is present throughout Florida, it is more abundant in the central and southern parts. Peak populations occur primarily in May and June. Mosier and Snyder (1919) reported seeing adults in the lower Everglades area as early as February 28, with peak flights during the last part of March.

The feeding habits of the adult females make them particularly pestiferous to livestock. The flies readily land on a host and begin to feed but leave at the slightest twitch of the animal's skin, only to immediately return and renew their attack. The junior author observed a single specimen of *americanus* interrupt the grazing of two cows for 30 minutes until the blood meal was finally obtained from one of the animals. This feeding habit causes extreme

annoyance to the host and increases the possibility of disease transmission. Figure 11 shows

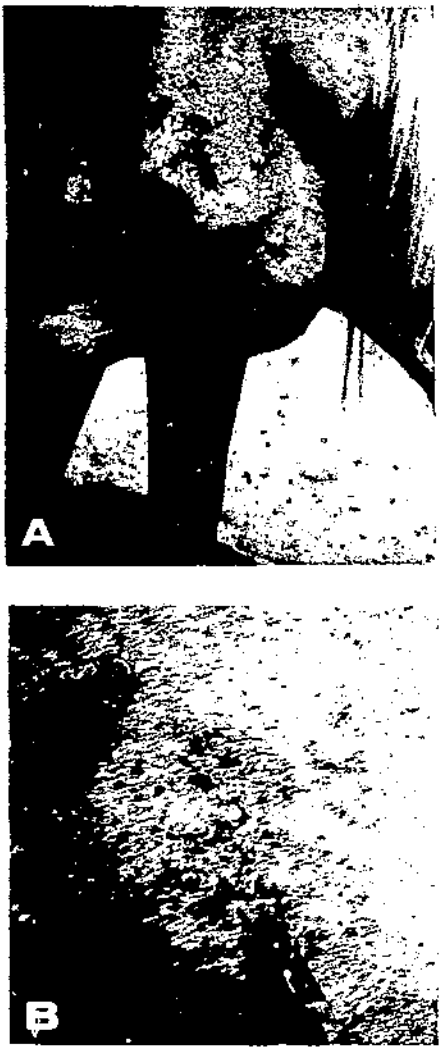


FIGURE 11.—*A*, *Tabanus americanus* feeding on a horse; *B*, encrusted blood from feeding punctures made by this species.

where these flies usually feed and the results of a severe attack.

Snyder (1917) wrote an interesting account of the abundance and daily flight habits of this species and described a part of the Everglades in Dade County where this species was studied. He described flights of countless thousands of *americanus* during the last week in March. Activity began about 4:45 a.m. with a buzzing sound, which increased to a dull roar at the peak of activity. The flights lasted 15 to 20 minutes.

Larval ecology: Although larvae of this species have never been identified, the authors believe that the larval habitat is in areas of abundant vegetation and water. In Florida the adults become most numerous in areas common to *T. trijunctus*.

Tabanus atratus Fabricius

Distribution: Entire Eastern United States to Washington, Idaho, Utah, and New Mexico.

Florida: Statewide.

Seasonal occurrence: From Gainesville, Fla., southward the adults have been observed throughout the year.

Adult activity: Although adults have been observed scattered over most of peninsular Florida even during the winter, *atratus* alone is rarely a serious pest of livestock at any one time. Normal populations are usually reached in April and maintained until mid-October, when a definite decline is noted.

The females are avid bloodsuckers and the presence of two or three flies per animal is usually sufficient to cause severe annoyance that results in interrupted grazing. The favorite feeding locations are the back and sides of horses and cattle; however, the flies readily feed on the lower legs and neck.

Males have been observed feeding on the flowers of several species of plants, and both sexes readily accept honey or sugar

solutions from saturated cotton in the laboratory.

Life-history studies: Hart (1895) observed the incubation period of *atratus* to be 7 days in the laboratory. Stone (1930) reared one male from egg to adult in 326 days. The larva emerged 5 days after the egg mass was collected and the pupal stage lasted 12 days. Schwardt (1936) reared 24 specimens from egg to adult and reported the preoviposition period of one female. He found that the incubation period was about 5 days, the larval period from 49 to 110 days, the pupal period from 6 days in midsummer to 10 days in early spring with an average of 13.3 days, and the preoviposition period 8 days. He stated that the average total developmental period was 307.1 days, based on averages for the duration of the egg, larval, pupal, and preoviposition periods. If the minimum time is taken for each stage, total development can be accomplished in 68 days.

Although hundreds of field-collected larvae were brought into the laboratory, only a small percentage were successfully reared to adults. The length of time required to develop in the laboratory prior to pupation was totally dependent on the size of the collected larva. One specimen measuring 9 mm. in length when collected pupated after 219 days. The female imago emerged 9 days later. Other specimens, obviously full grown when collected, pupated 3 days after being taken into the laboratory. The records on 15 males and 12 females indicate an average pupal period of 10.3 days, or 10.8 and 9.7 days, respectively. The immature stages of the life cycle are shown in figure 12.

Many attempts were made to complete the life cycles in the laboratory, but only two specimens were successfully reared from egg to adult. Both of these were from the same egg mass. Another specimen from an earlier egg mass attained the prepupal period but succumbed prior to pupation. The length of the life-cycle stages for these specimens is given in table 3.

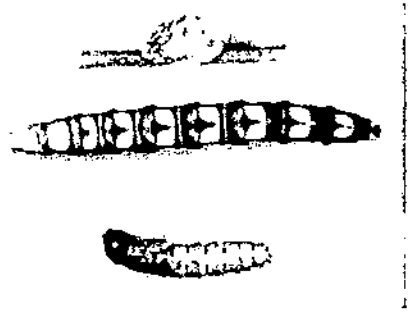


FIGURE 12. Egg mass, full-grown larva, and pupa of *Tabanus atratus*.

TABLE 3.—*Length of life-cycle stages for three specimens of* Tabanus atratus *reared in the laboratory*

Specimen No.	Incubation period	Larval period	Pupal period	Total
	Days	*Days*	*Days*	*Days*
1	5	219	Died	.....
2	1	319	9	322
3	1	331	7	345

The eggs of *atratus* are usually placed in masses of various sizes on the leaves and stems of grasses and sedges growing in marshy or wet ground but not necessarily in water. Egg masses have been collected as early as June and as late as October, but August and September appear to be the principal oviposition periods in north-central Florida. These months represent the characteristic rainy season, when the females have been noted ovipositing promiscuously on the eaves of buildings, feed shelters, culverts, and once on a windowpane. The larvae from egg masses deposited in these locations seldom survive and such placement of eggs is undoubtedly atypical. In natural habitats, as around the edges of lakes and streams, egg masses are found primarily on vertical or nearly vertical surfaces; however, horizontal surfaces are sometimes utilized.

Egg masses collected in nature usually contain from 500 to more than 800 eggs. Two masses from caged females have been smaller; one produced 371 larvae and the other 454 larvae. The eggs are white when laid and then darken, becoming nearly black as incubation progresses. The egg mass (fig. 13) is subconical, convex, oval at the base, and composed of four or five tiers. Hart (1895) has described the egg mass.

FIGURE 13.—Egg mass of *Tabanus atratus*.

Laboratory studies and field observations indicate that *atratus* has a life cycle of 1 year with overlapping generations. Eggs laid early in the season may develop into adults by late fall. Many egg masses collected in nature and obtained from caged adults show that the incubation period varies from 3.5 to 12 days, with an average of about 5 days.

Larval ecology: The abundance of larvae in comparison to relatively small adult populations each ensuing year has been noticeable throughout this study. Extreme cannibalistic tendencies of the larvae may account for this difference. Mortality of full-grown or nearly full-grown larvae in the laboratory is high. However, there are no observations to indicate that this occurs in natural habitats.

The larvae are usually numerous and are easily found along the margins of almost any permanent body of water. The usual habitat is within the top 2 inches of soil. Specimens have been found in locations with from less than 50-percent moisture content to those with completely saturated root mats. The pH of the habitats ranges from 4.7 in cypress bogs to more than 8.0 in the marl soils of the Everglades. Trails made by larvae migrating or searching for food just beneath the surface of the soil at the edge of water are seldom observed (fig. 14).

Parasitism of eggs: The egg parasite *Telenomus tabanivorus* (Ashmead) (Hymenoptera, Scelionidae) appears to be particularly devastating to *atratus* eggs. During August and September of

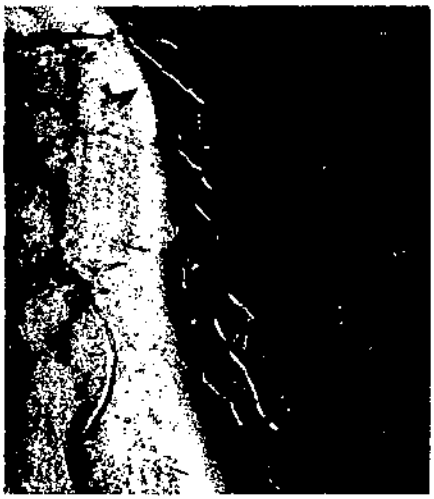


FIGURE 14.—Trail left by a larva of *Tabanus atratus* crawling beneath the surface of sand at the margin of a lake.

1951 through 1955, practically 100 percent of the egg masses deposited near Gainesville, Fla., were parasitized by this species. It was estimated that one-half to two-thirds of the *atratus* eggs laid during this period were destroyed by this small wasp.

Tabanus atratus fulvopilosus Johnson

Type locality: Orlando, Orange County.

Distribution: Atlantic Coast States from Massachusetts to Florida.

Florida counties: Brevard, Indian River, Orange, Seminole, Volusia.

Seasonal occurrence: April 28 to August 20 (Brevard County).

The largest populations were noted on Merritt Island, Brevard County. This island is separated from the mainland by the Indian River. This species probably breeds in brackish water, since there are no fresh-water streams or lakes on the island. The adults feed primarily on the backs of animals, with not more than three or four per animal.

James S. Hager, entomologist, Florida State Board of Health, informed the authors that he has observed large numbers of larvae very similar to *atratus* floating in the water after the salt marshes had been flooded. These observations made near Cocoa, Fla., and on Merritt Island probably pertained to the larvae of this subspecies.

The male is unknown.

Tabanus atratus nantuckensis Hine

Distribution: Massachusetts, New Hampshire, New York, North Carolina.

Florida counties: Hendry, Lee, Monroe.

Seasonal occurrence: April 7 (Monroe County) to June 28 (Hendry County).

These Florida data were recorded by Fairchild (1937).

Tabanus birdiei Whitney

Type locality: West Palm Beach, Palm Beach County.

Distribution: Florida only.

Florida counties: Alachua, Dade, Franklin, Lafayette, Lake, Palm Beach, Pinellas.

Seasonal occurrence: March 27 (Palm Beach County) to May 7 (Alachua County).

One female was collected from a horse during this study. Two males were reared from larvae collected on the Steinhatchee Game Reserve, Lafayette County. One specimen was taken from white sand at the margin of a shallow lake and the other specimen was found at the wet margin of a roadside ditch. The former, collected on June 25, 1954, was first observed in the pupal stage on May 12, 1955, and emerged 4 days later. During almost 11 months in the laboratory the lar-

va's increase in length from 23 to 27 mm. would indicate that the life cycle may be as much as 2 years. The other specimen was collected on March 5, 1955, pupated on April 1, and emerged 16 days later. It measured 26 mm. when it was collected.

Male description: The male of *birdiei* was reported by Pechuman (1949). A more detailed description follows.

Length 14 mm. Eye bare, purple, with single green band. Large and small facets sharply differentiated, small facets occupying lower third of eye and extending around outer margin to vertex. Vertical tubercle depressed, gray pollinose with white hairs. Antennae reddish, distal two-thirds of third segment darkened. First two segments with heavy black hair, third segment with prominent dorsal angle but only slightly excised above, basal and annulate parts of third segment equal in length. Second palpal segment dull reddish brown with mixed black and white hairs. Front and genae gray pollinose, latter with white hair.

Mesonotum reddish brown with gray lines in usual pattern and mixture of white, yellow, and black hair, last more abundant on presutal lobe. Pleura reddish with heavy vestiture of white hair, sternum gray with white hair. Coxae gray with tufts of whitish and silvery hair. Legs dark brown with mixed black and white hair. Hind tibial fringe distinct, basal half silvery, apical half black. Wing hyaline with dark spots at all crossveins and fork. Venation normal.

Abdomen above reddish brown in ground color. Tergites with broad whitish posterior margins that expand into distinct gray triangles medially and less distinct ones subiaterally. Second and third sternites very light pollinose with white hair, remaining sternites reddish brown with gray pollen and white hair on apical margins.

***Tabanus bishoppi* Stone**

Type locality: Silver Springs, Marion County.

Distribution: Florida only.

Florida counties: Charlotte, Columbia, Franklin, Indian River, Jefferson, Lake, Marion, Pinellas, St. Johns, St. Lucie.

Seasonal occurrence: March 3 (Pinellas County) to May 22 (Columbia County).

Fairchild (1937) gave localities in eight widely separated counties where *bishoppi* had been collected. A single specimen was taken in Lake County in 1949. Blickle (1959) studied hovering and mating activities of this species near Sebastian, Indian River County.

***Tabanus calens* Linnaeus**

Distribution: Kansas and Texas east to New York and Florida.

Stone (1938) reported that Florida was within the distributional range of *calens*. However, the species was not collected during this study.

Tashiro and Schwardt (1953) reared 17 specimens to adults from eggs deposited by a caged female. They referred to it as *T. gigauteus* DeGeer. They reported that the egg mass was bright orange yellow. The larval period of the reared adults varied from 22 to 24 months. Sixteen larvae that were preserved when 2 years old might have emerged as adults during the third year had the rearing been completed. The pupal period varied from 16 to 24 days.

***Tabanus cayensis* Fairchild**

Type locality: Stock Island, Monroe County.

Distribution: Florida only.

Florida counties: Collier, Monroe.

Seasonal occurrence: July 1 (Monroe County) to July 26 (Collier County).

Specimens collected on July 26, 1956, in Collier County constitute the only record known to the authors since the collections by Fairchild (1935). The male is unknown.

***Tabanus cheliopterus* Rondani**

Distribution: Southeastern United States.

Florida counties: Alachua, Bay, Brevard, Clay, Collier, Hendry, Indian River, Jefferson, Lake, Lee, Marion, Martin, Palm Beach.

Seasonal occurrence: May 6 (Hendry County) to August 19 (Alachua County).

Although this species is widespread in Florida, it alone is not troublesome. It does contribute to severe tabanid infestations, as several other species are invariably present during midsummer when it is active.

The preferred feeding locations on a host seem to be the legs and belly.

Tabanus cheliopterus fronto Osten Sacken

Distribution: Southeastern United States.

Florida counties: Alachua, Bay, Jefferson, Madison, Orange.

Seasonal occurrence: May 19 to September 27 (Alachua County).

The variety *fronto* is more troublesome in Florida than the typical species. The females are more active during late afternoon and early evening. The largest population observed was at Gainesville, Fla., during the week of July 12, 1954. From 20 to 30 flies per animal were seen feeding on two animals between 6:15 and 7:45 p.m. It was completely dark between 8:00 and 8:15, when feeding activity decreased sharply. A few specimens were collected as late as 8:45 p.m. Fewer flies were seen in June and July of 1953 and 1955.

The flies usually feed on the legs and belly of livestock. When the population is large, they also feed on the sides of the body and the neck.

Tabanus coarctatus Stone

Type locality: Immokalee, Collier County.

Distribution: Georgia.

Florida counties: Alachua, Collier, Gulf, Jefferson, Lake, Volusia, Wakulla.

Seasonal occurrence: April 28 (Jefferson and Wakulla Counties) to October 16 (Volusia County).

Although this species was collected occasionally during this study, it never became numerous enough to be considered a serious pest of livestock. The male is unknown.

Tabanus endymion Osten Sacken

Distribution: Georgia, Louisiana, North Carolina.

Florida counties: Alachua, Brevard, Dade, Flagler, Franklin, Hendry, Jefferson, Lafayette, Lake, Martin, Osceola, Palm Beach, Volusia.

Seasonal occurrence: April 29 (Brevard County) to October 16 (Volusia County).

Adult activity: Light to moderate populations were observed in various localities throughout Florida during the summer. Surveys showed that the infestations were usually confined to relatively small areas.

The preferred feeding locations on horses are the underside of the abdomen and the inner surfaces of the hindlegs. However, this species also feeds on the face, neck, and legs of horses and cattle. Man is readily attacked in the absence of livestock.

Life-history studies: Only a few adults were successfully reared from field-collected larvae. Three of the larvae were kept in the laboratory 136, 184, and 188 days, respectively, before they pupated. The pupal period averaged 9 days.

An egg mass obtained from a caged female appeared typical for the genus. The tiered mass was

white when deposited and gradually became dark brown by the time the larvae emerged.

Seven specimens were reared to adults from an egg mass obtained in the laboratory. The adults were collected on October 6, 1950. The eggs were deposited on October 13 and hatched 5 days later. The length of the life-cycle stages for these specimens is given in table 4.

TABLE 4.—*Length of life-cycle stages for seven specimens of* Tabanus endymion *reared in the laboratory*

Sex	Larval period	Pupal period	Total time from oviposition to adult
	Days	*Days*	*Days*
Male		[1]	258
Female		[1]	258
Do		[1]	259
Male	272	9	286
Do	274	9	288
Female	315	7	327
Do	317	8	330

[1] Date of pupation not observed.

The life cycle of *endymion* in the laboratory is closely correlated with that observed in the field. The time between peak emergences in the field where the laboratory-reared specimens originated was approximately 9½ months, which is close to the average time of 286.5 days from egg to adult for those reared in the laboratory.

Larval ecology: All the field-collected larvae were recovered from mud samples taken along the grassy margins of shallow lakes.

Tabanus equalis Hine

Distribution: North Central and Southern States from Kansas and Indiana to Texas and Florida.

Florida: Philip (1947) included Florida in the distribution records for this species. No locality was given.

Seasonal occurrence: Unknown.

This economically important midwestern species is apparently rare in Florida. No collections were made during this study. Schomberg and Howell (1955) collected 38 larvae in seven localities in Oklahoma. The soil where they were found was sparsely covered with low grass and shaded by elm trees (*Ulmus americana*). They concluded that this species breeds in areas where standing water would never be found.

Tabanus fairchildi Stone

Distribution: Eastern and Southern States from New York to Oklahoma and Florida.

Florida county: Jefferson.

Seasonal occurrence: May 12–28 (Jefferson County).

Stone (1938) pointed out that various authors (Hine 1903, 1906; Schwardt 1931a, 1936; and Fairchild 1937) misdetermined this species as *T. vivax* Osten Sacken. This species is apparently rare in Florida as no recent records are known.

Hine (1906) and Schwardt (1936) reported that the adult

of this species lays its eggs on rocks or other objects protruding above the surface of rapidly flowing water. The young larvae drop into the water upon hatching and apparently spend their entire life under stones or other objects in the streambed. Because of its breeding habits, it has been called the "river horse fly."

***Tabanus fulvulus* Wiedemann**

Distribution: Pennsylvania to Florida and west to Oklahoma.

Florida counties: Jefferson, Lee, Madison, Wakulla.

Seasonal occurrence: April 14 (Lee County) to May 12 (Madison County).

This species is apparently confined to northwestern Florida, as it has not been taken in the peninsular area. Serious populations were never observed.

***Tabanus fulvulus pallidescens* Philip**

Distribution: Maryland to Oklahoma and southward throughout the Southeastern States.

Florida counties: Bay, Franklin, Gulf, Jefferson, Walton.

Seasonal occurrence: May 1 (Jefferson County) to September 15 (Franklin County).

Adult activity: Similar to typical *fulvulus*, this form appears to be confined to northwestern Florida and has not been collected in the peninsular area.

One light infestation averaging one or two flies per animal in a herd of about 30 feeder cattle was observed during a steady rain.

The lower legs and underside of the belly were the favorite feeding locations. Occasional specimens were noted feeding on the neck and face.

***Tabanus fumipennis* Wiedemann**

Distribution: Georgia, South Carolina.

Florida: Throughout the State east and south of Taylor and Madison Counties. The distribution undoubtedly includes western Florida; however, no records are available from this area.

Seasonal occurrence: April 19 (Hendry County) to November 8 (Alachua County).

Adult activity: This large brown fly is one of the most common tabanids in the peninsular area of Florida. Population peaks are usually attained in June and persist through July and August. A gradual decline is evident during late September and October. Similar to *T. atratus*, most infestations of *fumipennis* are subcritical. However, several populations were observed where counts averaged 10 to 15 flies per animal in small herds of cattle.

In striking contrast to other large flies, such as *T. americanus* and *atratus*, the approach of this species is relatively silent. Feeding studies indicate that there is less annoyance accompanying the attack of *fumipennis* than of other large species. The females fly directly to the host, land on the side, back, or lower neck, and begin to feed immediately. Penetration of the skin for feeding is invariably evidenced by rather violent attempts of the host to dislodge the fly. However, such attempts often fail, as *fumipennis* apparently feeds in locations that neither the head nor tail of the animal can reach. Observations on more than 50 engorging specimens indicate an average feeding time of 2 minutes and 31 seconds. Little is known of the feeding habits of the males; however, specimens were seen visiting the blossoms of *Crotalaria intermedia* near breeding sites.

Both males and females readily accept honey or sucrose solutions when caged in the laboratory. In

1950, 1951, and 1954, males were seen resting on many types of vegetation close to a breeding area near Gainesville, Fla. Females were also noted resting on buildings, fenceposts, trunks of trees, and vegetation adjacent to pastures containing livestock.

Oviposition was observed on several occasions. Vertical surfaces seem to be preferred in natural habitats, although horizontal surfaces are utilized. The females take a characteristic head-down stance and the egg mass is formed by a probing motion of the abdomen as the eggs are laid. The egg mass is subconical in shape, measuring from 10 to 14 mm. in length, 8 to 12 mm. in width, and 5 to 7 mm. in height. The completed mass usually contains four or five tiers of eggs, one obliquely above the other, and is gummed together firmly. The eggs are 2.3 to 2.5 mm. in length, approximately 0.5 mm. in diameter, cylindrical, tapering at both ends, and usually rather crescent shaped. When first laid they are pearly white; they darken to a creamy white upon maturation. Five egg masses collected from natural habitats were allowed to hatch in the laboratory, and 868 larvae, on an average, emerged from them.

Life-history studies: Thirty-eight specimens were reared from field-collected larvae; only 10 were females. This male to female ratio of approximately 3:1 seems slightly divergent from that of the natural populations, with the exception of 1950, when large numbers of males were observed late in the period of adult activity. In general, females were found to be far more abundant than males in the natural habitats. Field-collected larvae remained in the laboratory for varying lengths of time before pupating. One specimen that appeared to be full grown when collected lived 584 days. It died before pupating. Another specimen pupated and emerged after 421 days in the laboratory. The emergence of most of the reared specimens coincided with the emergence in the field.

Although many attempts were made, only three specimens were reared to adults from eggs. The incubation period of several egg masses was 5 days. The three completed life histories required 311, 329, and 334 days, respectively, from egg to adult. A fourth specimen that died before pupating lived 330 days. These life-history studies and the seasonal occurrence in nature indicate a 1-year life cycle with some overlapping of the generations.

Larval ecology: With the exception of *T. atratus, fumipennis* larvae are probably most numerous and most easily found. The larvae are abundant along the grassy margins of lakes and marshes and among the roots of plants growing in shallow water. They were found only in wet locations and usually in the top 2 inches of soil. They are often found in the crown of plants and infrequently from 6 to 10 inches below the water's surface in the roots and surrounding soil. Full-grown larvae tend to stay close to the soil surface, and pupae are almost always found in drier locations, usually with the anterior end exposed.

***Tabanus fusconervosus* Macquart**

Distribution: Massachusetts to Florida.

Stone (1938) and Philip (1947) included Florida in the distributional range of this species. The authors of this bulletin did not collect this species in Florida.

***Tabanus gladiator* Stone**

Distribution: Georgia, North Carolina, South Carolina, Texas, Virginia.

Florida counties: Alachua, Bay, Franklin, Gulf, Jefferson, Martin, Wakulla.

Seasonal occurrence: June 18 (Martin County) to October 6 (Alachua County).

Adult activity: Surveys have shown that this species is far more abundant in the northwestern counties than in the peninsular area of Florida. The heaviest infestations were observed during August and September in Bay, Franklin, and Gulf Counties. These populations of *gladiator* alone were not of outbreak proportions; they rarely averaged more than one or two flies per animal in most herds. However, the presence of this species in conjunction with other smaller species was responsible for serious tabanid problems throughout much of western Florida.

The sides, back, and lower neck of cattle are the preferred feeding locations. The adult females fly about the animal causing considerable annoyance before attempting to feed. The actual feeding is equally annoying to the host. The slightest movement of the animal will dislodge the flies, which immediately return and renew the attack.

Life-history studies: Very few larvae of this species were collected. Two specimens were reared to adults from collected larvae. Both larvae were taken from Alice Lake, Gainesville, Fla., in March 1954. One specimen pupated on August 18 and the female imago emerged 8 days later. The second specimen passed the following winter in the larval stage, although it appeared to be full grown before the end of the summer. Pupation took place on April 10, 1955, and the male imago emerged on April 16. The collection from which these two specimens were obtained contained nine other larvae, all presumably of this species. Six died after becoming full grown and three died in the pupal stage.

Larval ecology: The larvae were taken from mud among or near the roots of sedge (*Carex* sp.) growing at the edge of a permanent stream. The habitat was moist but not saturated.

***Tabanus gracilis* Wiedemann**

Distribution: Atlantic Coast States from New Jersey to Florida and west to Arkansas and Mississippi.

Florida: Statewide.

Seasonal occurrence: June 15 (Dade County) to October 21 (Alachua County).

Adult activity: Adults are numerous from June through August. They are encountered in wooded areas commonly known in Florida as "sand hills." The characteristic vegetation includes pine, oak, and palmetto. Adults are not abundant in open areas.

Adult females are fierce biters. Man and most kinds of livestock are attacked. The favorite feeding locations are the belly and the upper inside part of the hindlegs of horses and cattle. A few specimens were observed feeding between the forelegs.

Larval ecology: The larvae of *gracilis* are not known. The data from larval surveys throughout the State indicate that this species breeds in much drier locations than the typical Florida tabanid habitat. The adults are numerous in upland locations away from bodies of water, and their absence from the collected and reared material was conspicuous. The areas

near outbreaks were searched for larvae without success.

Tabanus imitans Walker

Distribution: Southeastern United States west to Texas.

Florida counties: Highlands, Jefferson, Lake, Taylor.

Seasonal occurrence: April 1 (Highlands County) to April 11 (Lake County).

The authors have no information on the distribution of *imitans* in Florida. Since the new subspecies *T. imitans pechumani* was established (Philip 1960), a reexamination of museum specimens will be necessary to establish distribution from past collections.

Tabanus imitans excessus Stone

Type locality: Enterprise, Volusia County.

Distribution: Florida, Georgia.

Florida counties: Alachua, Brevard, Duval, Lake, Orange, Putnam, Seminole, Volusia.

Seasonal occurrence: April 3 to May 23 (Alachua County).

Adult activity: This subspecies was collected more frequently in central Florida than true *imitans* or *T. imitans pechumani.* Heavy populations were not observed, and it was difficult to determine when peak populations occurred.

The flies prefer to feed on the back, sides, and lower neck of horses and cattle.

Life-history studies: Twenty-four collected larvae were reared to the adult stage in the laboratory. Fourteen of these were females. The pupal period ranged from 9 to 17 days with an average of 12 days.

Emergence in the laboratory occurred at the same time that adults were emerging in the field. The life cycle, based on the seasonal occurrence of the adults, is almost exactly 1 year with little or no overlapping of generations.

Larval ecology: The larvae of *excessus* were found in large numbers in or surrounding the root mats of aquatic and semiaquatic plants. Most of them were in the top 2 or 3 inches of root mat and soil or, if in the crown of plants, nearer the surface. However, it is not uncommon to find the larvae 8 to 12 inches below the surface in a nearly fluid medium. The largest concentrations were in areas where standing water was present at least part of each year. They were associated with the following plants that customarily grow in or at the edge of water: Sedge (*Carex* sp.), mockbishopweed (*Ptilimnium capillaceum*), maidencane (*Panicum hemitomon*), and cattail (*Typha latifolia*). It is of interest to the biologist that the abundance of *excessus* larvae seems to be out of proportion to the number of adults observed.

Tabanus imitans pechumani Philip

Distribution: Georgia.

Florida counties: Alachua, Brevard, Dade, Highlands, Hillsborough, Indian River, Levy, Marion, Pinellas, St. Johns, Seminole, Taylor.

Seasonal occurrence: March 26 (Marion County) to May 10 (Alachua County).

Occasional specimens were collected during April and May each year during this study. The preferred feeding locations are the back, sides, and neck of horses and cattle. The larvae, if collected, were not recognized.

Tabanus johnsoni Hine

Type locality: St. Augustine, St. Johns County.

Distribution: Florida only.

Florida counties: Alachua, Collier, Dade, Lake, Madison, Martin, St. Johns.

Seasonal occurrence: April 25 (Madison County) to October 21 (Alachua County).

Adult activity: Heavy populations were noted in Alachua County during August of 1952 and 1954 and light populations during 1951, 1953, and 1955. The peak emergence occurred in August of each year.

The females fed primarily after sundown and an hour or two after dark. The neck and abdomen were the preferred feeding locations on horses and cattle. As many as 17 flies per animal were observed on horses and cattle at dusk on August 17, 1954. A short time later that evening approximately 200 engorged females were discovered resting on the rafters and ceiling of animal shelters. Males were not observed.

Life-history studies: Three adult specimens were reared from collected larvae. These studies indicate a 2-year life cycle, and the heavy population of adults in nature during 1952 and 1954 further emphasizes this probability.

One larva that measured 11 mm. when collected on November 7, 1952, attained a length of 26 mm. before pupating on July 11, 1953. The male imago emerged 9 days later. Two other larvae measured 24 mm. when collected on February 25, 1953. They measured 30 and 32 mm. when full grown. One pupated on May 6, 1954, and emerged 14 days later. The other larva pupated on June 3, 1954, and emerged 7 days later. Both were females.

Larval ecology: The larvae were recovered from mud samples taken from the grassy margins of lakes in Alachua County. Their habitat was nearly or completely saturated. Other tabanid species taken from these samples included *T. fumipennis* and *lineola*.

Tabanus lineola Fabricius

Distribution: Eastern United States to Louisiana and Kansas; Ontario, Quebec.

Florida: Statewide.

Seasonal occurrence: Throughout the year in southern Florida.

Adult activity: Although *lineola* does not become abundant, it is one of the most troublesome species in Florida owing to its continual presence from early spring until late fall. The heaviest populations were noted from May through August.

The females are avid bloodsuckers, usually attacking most kinds of livestock on the lower legs, belly, face, and neck. In the absence of livestock, man is frequently attacked. The feeding habits of males in nature are unknown. However, caged specimens readily accept honey or sucrose solutions from saturated cotton, as do females.

One female was observed ovipositing above a flooded rice field. She was resting head down about a foot above the water on a rice plant (fig. 15).

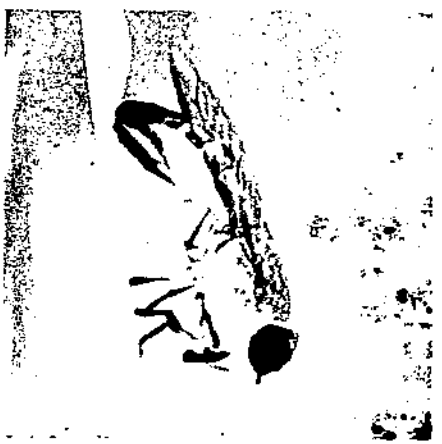


FIGURE 15.—*Tabanus lineola* ovipositing.

Life-history studies: Records on 41 adult specimens reared from collected larvae indicate the possibility of more than a single generation a year. It is quite probable that eggs deposited early in the year develop to adults by late fall. Three specimens reared from small larvae collected in November 1954 emerged in April 1955, after 124, 142, and 144 days, respectively, in the laboratory. These larvae were approximately 9 mm. long when collected, and it is assumed that they were about one-third grown. Among the reared specimens the ratio of males to females was 1.7:1. The pupal period ranged from 4 to 12 days with an average of 8 days.

Schwardt (1931) reported on the life history of *lineola*, but Philip (1942) determined that the species involved was principally *T. vittiger schwardti* Philip.

Larval ecology: The larvae of *lineola* can apparently tolerate a wide range of habitats. They were abundant at the edge of lakes, streams, and irrigation or roadside ditches. Others were found in floating logs with varying degrees of decay and in tree holes with larvae of *Leucotabanus annulatus*. A few specimens were collected as far as 30 feet from the water in sod where standing water would rarely or never be present.

Tabanus longiusculus Hine

Distribution: Georgia, North Carolina.

Florida counties: Alachua, Jefferson, Leon.

Seasonal occurrence: May 17 to June 30 (Jefferson County).

Only three specimens, all females, were collected during the study—two in 1953 and one in 1954.

Tabanus melanocerus Wiedemann

Distribution: Atlantic and Gulf Coast States from Connecticut to Louisiana and Arkansas.

Florida counties: Alachua, Bay, Dade, Dixie, Jackson, Jefferson, Lafayette, Lake, Marion, Orange, Osceola, Putnam, St. Johns, Taylor, Volusia, Walton.

Seasonal occurrence: May 25 (Jefferson County) to August 15 (Alachua County).

Adult activity: June is, without exception, the principal period of adult activity. Alone, *melanocerus* rarely occurs in sufficient numbers to be considered a serious pest of livestock. However, this species often contributes substantially to serious tabanid outbreaks. The females prefer to feed on the legs, underside of the belly, lower neck, and face of livestock. Although primarily a diurnal species, the adults were taken at dusk and after dark.

Life-history studies: The information obtained from rearing collected larvae and from observations on the seasonal occurrence of adults in the field indicates a life cycle of 1 year with little or no overlapping of generations. Laboratory emergence coincided closely with emergence in the field. Two collected larvae remained 197 and 209 days, respectively, in the laboratory before the adults emerged. Two others lived 371 and 417 days, respectively, but died before pupating. Seven specimens had an average pupal period of 10 days with a range of 5 to 13 days.

Larval ecology: The larvae were never found in abundance. They were located in the mud at the edge of small sluggish streams and roadside and irrigation ditches and in marshy areas of lake margins. Various aquatic and

semiaquatic grasses may grow in the habitat. The larvae are almost always found in conjunction with *T. petiolatus* and *nigripes*, which seem to be closely related morphologically and biologically.

***Tabanus melanocerus lacustris* Stone**

Type locality: Lakeland, Polk County.

Distribution: Georgia.

Florida counties: Alachua, Bay, Dixie, Franklin, Highlands, Lafayette, Osceola, Putnam, Taylor.

Seasonal occurrence: May 25 (Taylor County) to July 28 (Franklin County).

Adult activity: The heaviest populations were observed in June. This form is usually present in populations of typical *melanocerus*. The latter was more numerous in all populations observed except two, where both forms were present in about equal numbers.

The feeding habits of *lacustris* closely parallel those of *melanocerus;* the legs, belly, and lower neck of livestock are the preferred feeding locations. Although specimens have been collected late in the afternoon, none were taken after sundown.

Life-history studies: A single specimen was reared to the adult stage. The larva was collected on January 28, 1953, in Putnam County. The pupa was discovered in the rearing dish on May 8, and the adult emerged 8 days later. The life cycle is similar to that of typical *melanocerus* and appears to be about 1 year with no overlapping of generations. The larva very closely resembled that of *T. petiolatus* and *melanocerus*.

Larval ecology: The single specimen collected was found in the grassy margin of a shallow lake. The mud sample also contained larvae of *T. melanocerus, nigripes*, and *lineola*.

***Tabanus molestus* Say**

Distribution: New Jersey to Florida and west to Iowa, Kansas, and Louisiana.

Florida counties: Alachua, Flagler, Jefferson, Lake, Madison, Marion, Orange, Osceola.

Seasonal occurrence: April 24 (Jefferson County) to August 4 (Alachua County).

Serious infestations never became evident during these studies. The greatest numbers of adults were seen during the last half of May and during June each year.

The females feed on the legs, belly, lower neck, and occasionally on the head and face of livestock. Although *molestus* is not truly crepuscular in habit, the greatest feeding activity was observed from late afternoon until dark. Some feeding activity was noted throughout the day.

***Tabanus molestus mixis* Philip**

Distribution: Southeastern United States.

Florida counties: Lafayette, Liberty.

Seasonal occurrence: May 25 (Lafayette County) to June 2 (Liberty County).

This dark form of *molestus* is apparently restricted in Florida to the northern and western parts. Very few specimens were seen.

***Tabanus mularis* Stone**

Distribution: Maryland to Florida and west to Kansas and Texas.

Florida counties: Alachua, Franklin, Gulf, Hillsborough, Jefferson, Liberty, Nassau, Osceola, Wakulla, Walton.

Seasonal occurrence: April 29 (Osceola County) to September 23 (Hillsborough County).

Occasional specimens were collected in central Florida. However, the records of Fairchild (1937) and collections made by the authors in 1955 indicate that the species is more abundant in northern and western Florida.

The females prefer to feed on the legs, belly, and face of livestock.

Tabanus nigrescens Palisot de Beauvois

Distribution: Massachusetts to Florida and west to Michigan and Arkansas.

Florida: Philip (1947) included Florida in the distribution records for this species.

The authors do not have information about the seasonal occurrence or locality records.

Tabanus nigrescens atripennis Stone

Distribution: Southeastern United States from Maryland to Florida and west to Texas and Oklahoma.

Florida county: Jefferson.

Seasonal occurrence: June 3 (Monticello, Jefferson County) (Fairchild 1937).

Additional Florida records for this species were not found.

Tabanus nigripes Wiedemann

Distribution: Eastern United States from Massachusetts to Florida and west to Michigan and Louisiana.

Florida: Statewide.

Seasonal occurrence: March 24 (Alachua County) to September 21 (Jefferson County).

Adult activity: Adults are most abundant throughout May, June, and July. Most infestations are not serious; however, the presence of *nigripes* throughout the season contributes to many serious tabanid problems. The favorite feeding locations are the lower legs and face of domestic animals. In recreational areas adjacent to lakes where livestock is not present this species is often reported as a serious pest of man.

Life-history studies: Twenty-seven adults were reared from collected larvae. Thirteen of these were males and 14 were females. The pupal period ranged from 6 to 15 days with an average of 11 days. All the reared specimens were from larvae that were half grown or larger when collected. Several attempts to rear small larvae failed. The life cycle of *nigripes* seems to be approximately 1 year with considerable overlapping of generations.

Larval ecology: The larvae inhabit wet areas containing grass or decaying organic matter along the margins of lakes, swamps, and roadside ditches. Many larvae were also found above the water's surface in clumps of grass growing in shallow water.

Tabanus nigrovittatus Macquart

Distribution: Eastern and Southern States from Massachusetts to Florida and west to Texas; Nova Scotia.

Florida: Coastal areas throughout the State.

Seasonal occurrence: March 10 (Monroe County) to July 14 (Taylor County).

The complexity of the *nigrovittatus* group was not recognized while the study was being made. Some specimens were misdetermined as *T. fuscicostatus* Hine, which apparently does not occur in Florida.

The specimens presently available for study can be placed in three groups. They are easily separated by characters given in the key. One group seems to be typical *nigrovittatus*. Another group is very near "typical" *nigrovittatus*, except for the straw-colored basal callus, pre-

dominantly yellowish legs, and the annuli of third antennal segments, which are longer than the plates. The third group is considered in this bulletin to be *nigrovittatus* subspecies *fulvilineis* (Philip 1957), although the flies are larger (12 to 14 mm. long) and the basal callus has rounded corners above rather than being tridentate.

Adult activity: Large populations of *nigrovittatus* were not observed. Their activity coincides with that of several other species and contributes to serious tabanid infestations.

Tashiro and Schwardt (1949) reported that when flies were numerous in New York it was not uncommon for 90 individuals to engorge on a single animal per hour for 8 or 9 hours per day. By weighing unfed and engorged flies they determined that an average blood meal for this species was 0.074 cc.

Larval ecology: This species is generally believed to breed in salt marshes. Gerry (1949) referred to it as a salt-marsh greenhead and stated that larvae tend to concentrate in that section of the marsh reached only by a high tide.

Tabanus nigrovittatus fulvilineis Philip

Distribution: Louisiana, Mississippi; Bahamas, British West Indies.

Florida counties: Brevard, Dade, Hernando, Hillsborough, Levy, Manatee, Monroe, Wakulla.

Seasonal occurrence: April 10 (Monroe County) to August 20 (Hernando County).

Large numbers of adults were observed during March and April in the Everglades National Park and on the islands along the highway from the Florida mainland to Key West. The only places the flies were collected during this study were from buildings and vegetation. No domesticated animals were nearby. One might conclude from the collection data that this species inhabits coastal areas.

Tabanus petiolatus Hine

Distribution: Delaware to Florida and west to Texas.

Florida counties: Alachua, Dixie, Jefferson, Lafayette, Levy, Madison, Putnam.

Seasonal occurrence: April 22 (Alachua County) to August 1 (Jefferson County).

Adult activity: June and July are the principal periods of adult activity. Adults inhabit wooded areas surrounding lakes, rivers, or swamps. They are rarely observed in open pastures. Like many other species, *petiolatus* was never observed in sufficient numbers to be considered a serious pest of livestock, but its presence with other tabanids often contributed substantially to serious infestations.

Strictly diurnal in feeding activity, females prefer to feed on the legs, neck, and head of horses and cattle.

Life-history studies: Twenty-one adults were reared from collected larvae. Only three of these were males. One larval specimen 6 mm. in length collected on July 9, 1952, pupated on May 15, 1953, and emerged on May 22, 1953, after 319 days in the laboratory. Although this was the smallest larval specimen to complete development, the other rearings indicate a similar larval period. The pupal periods ranged from 7 to 15 days with an average of 11 days. The rearing data and observations on seasonal occurrence of adults indicate that the life cycle requires 1 year and that there is no overlapping of generations.

Larval ecology: Larvae were found associated with those of *T. nigripes, melanocerus, fumipennis,* and occasionally *atratus* in the wet margins of freshwater lakes and streams. The larvae are usually found within the top 2 inches of soil, but may be located deeper among the roots of semiaquatic plants.

Tabanus proximus Walker

Distribution: Virginia to Florida and west to Illinois and Texas.

Florida: Stone (1938) included Florida in the distribution records of this species; no locality was given. The authors have no records of this species from this State.

Tabanus pumilus Macquart

Distribution: Maine to Florida and west to Illinois and Texas.

Florida counties: Alachua, Baker, Dixie, Lafayette, Lake, Marion, Putnam.

Seasonal occurrence: March 25 (Alachua County) to May 6 (Putnam County).

Adult activity: Adults are abundant during April in wooded areas adjacent to lakes, streams, or swamps. Only occasional specimens were collected in open pastures.

Females usually attack animals around the head and neck, and in the absence of livestock man is readily bitten.

Life-history studies: Three adults—two females and one male—were reared from collected larvae. The average pupal period was 9 days. The life cycle, based on the annual appearance of adults, appears to be almost exactly 1 year.

Larval ecology: Only one collection of larvae was made. They were found in an accumulation of dead leaves and silt at the edge of a small heavily shaded stream near Gainesville, Fla.

Tabanus quinquevittatus Wiedemann

Distribution: Eastern United States to South Dakota and Texas; Nova Scotia, Ontario, Quebec.

Florida counties: Alachua, Brevard, Broward, Hendry, Lee, Sarasota, Taylor, Volusia.

Seasonal occurrence: April 20 (Volusia County) to August 11 (Alachua County).

This species probably occurs throughout Florida. It is morphologically very close to forms of the *T. nigrovittatus* complex. It is now realized after examining pinned specimens that some were misdetermined as *T. nigrovittatus* and that the latter occur in coastal areas.

Adult activity: Severe outbreaks were confined, almost without exception, to low meadows. Animals in adjacent high-ground pastures were not severely attacked. Observations at night in a wet pasture in Alachua County revealed large numbers of both males and females resting on weeds and grass. The ratio of males to females was about 2:1. It appears to be a well-defined habit of the females to rest on vegetation awaiting a host to come by.

Life-history studies: Logathetis and Schwardt (1948) concluded that this species, referred to as *vicarius,* could grow to maturity in pastures and meadows and that in New York these places are its normal breeding grounds. Night sweepings in meadows during the season of adult activity yielded 5 to 15 adults for each 100 strokes of the net. They reported that of 115 flies reared from eggs to adults in the laboratory, only 10 emerged within approximately 1

year after hatching; the remainder required 2 years to complete the cycle.

***Tabanus quirinus* Philip**

Type locality: Port St. Joe.
Distribution: Florida only.
Florida county: Gulf.
Seasonal occurrence: April 7 (Gulf County).

The authors have no information on *quirinus* except that given for the holotype male by Philip (1950). He wrote, "A letter from the collector states the fly was taken on the outskirts of town near the municipal auditorium in a scrub pine area in which cattle graze." Only the male of this species is known.

***Tabanus rufofrater* Walker**

Distribution: Georgia, Mississippi, North Carolina.

Florida counties: Brevard, Columbia, Flagler, Highlands, Jefferson, Lee, Madison, Palm Beach, Pinellas, Seminole, Volusia.

Seasonal occurrence: March 16 (Palm Beach County) to June 3 (Jefferson County).

Adult activity: The authors have not seen serious infestations of this species, although the adults become abundant in certain areas. Peak populations occur during the last half of April and in May. Light infestations were noted in Flagler and Volusia Counties during the week of May 7, 1956. Counts averaging one to two flies per animal in small herds of cattle were recorded.

The adult females prefer to feed on the legs, belly, and neck of horses and cattle.

Life-history studies: Engorged females were collected in Volusia County from a horse on April 24, 1950, and were kept in a cage in the laboratory. One egg mass was obtained on April 30 and 5 days later 283 larvae emerged. All but six died within 2 months, and only two of these survived the following winter. One specimen pupated when it was 381 days old, but died 10 days later before emerging. The other specimen remained 679 days in the larval stage, pupated, then died the following day.

***Tabanus sparus* Whitney**

Distribution: New Hampshire to Florida and west to Michigan and Mississippi.

Florida counties: Lee (Pine Island), Monroe.

Seasonal occurrence: May 9 (Monroe County) to September 8 (Lee County).

True *sparus* as identified by the unbanded eye in life has not been taken by the authors. The collection data were reported by Stone (1938).

***Tabanus sparus milleri* Whitney**

Type locality: Cotype, St. Augustine.

Distribution: New York to Florida and west to Kansas and Oklahoma.

Florida counties: Alachua, Bay, Citrus, Dade, Dixie, Gulf, Jefferson, Lafayette, Lake, Lee, Pinellas, Putnam, St. Johns.

Seasonal occurrence: March 18 (Citrus County) to June 5 (Jefferson County).

Adult activity: Infestations in open pastures were usually light. However, the flies were often troublesome to man and livestock in wooded areas adjacent to lakes, streams, or swamps. The adults were most numerous during April and the first half of May.

Life-history studies: A single larval specimen was taken from a decaying log floating in Lake Alice, Gainesville, Fla., on January 5, 1952. This larva pupated on April 24 and emerged 15 days later.

***Tabanus stygius* Say**

Distribution: Eastern United States to Minnesota, Nebraska, and Texas; Ontario.

Florida counties: Alachua, Brevard, Jefferson, Lake, Osceola.

Seasonal occurrence: May 27 (Jefferson County) to July 7 (Brevard County).

Adult activity: No population peaks were evident as only occasional specimens were seen or collected.

Life-history studies: Only a single male specimen was reared from many collected larvae. Large larvae taken during the winter often lived through the following summer and winter and died either prior to or shortly after entering the pupal stage. The single specimen that emerged was collected from the submerged root mat of an aquatic plant on February 27, 1953. Pupation occurred on April 13 and the male imago emerged 17 days later.

Hine (1906) stated that *stygius* oviposits principally on the leaves of *Sagittaria* standing in shallow water, habitually placing the eggs just above the point where the petiole meets the expanded part of the leaf. He was not successful in his attempts to rear adults from eggs that hatched during July in the laboratory. The largest larvae attained a length of 10 mm., but died the following spring. He was able to rear collected larvae to the adult stage. He concluded that under natural conditions the larvae probably hibernate for two winters.

Studies by Schwardt (1936) in Arkansas confirm the oviposition habits and life history as reported by Hine. Eggs were collected from arrowhead and cattail growing in water. He stated that in size and general shape the egg mass resembles that of *T. atratus*, but it is dark reddish brown. The larval period, according to Schwardt, may be completed in approximately 1 or 2 years. From one series of larvae of known age, three adults emerged in 320 days on an average and 15 emerged after approximately 720 days.

Larval ecology: Very few larvae were collected. The preferred larval habitat appears to be beneath the water's surface among the roots of various aquatic plants. Most of the larvae were among the roots of *Peltandra* and *Sagittaria* growing in shallow water at the edge of a lake, stream, or marsh.

***Tabanus sulcifrons* Macquart**

Distribution: Eastern United States to Nebraska and Texas.

Florida counties: Alachua, Brevard, Putnam.

Seasonal occurrence: July 26 (Brevard County) to October 30 (Putnam County).

Adult activity: This economically important midwestern species appears to be rare in Florida. Very few adults were seen or collected.

Life-history studies: Schwardt (1936) in Arkansas successfully reared seven specimens from egg to adult. He reported the following data: Number of eggs per mass 419 to 587, duration of incubation period 9 to 11 days, larval period 308 to 363 days, pupal period 13 to 18 days. From data on a few collected larvae Schwardt concluded that the species does not require much moisture in the larval stage and might even be intolerant of excessive moisture. MacCreary (1940) collected five larvae in Delaware from soil where standing water would never be present.

Schomberg (1952) concluded after collecting 255 *sulcifrons* larvae in 37 locations in Oklahoma

that the typical larval habitat is well-drained gullies. All locations except three were shaded by American elm. His observations suggest that *sulcifrons* may have either a 1- or 2-year life cycle.

***Tabanus trijunctus* Walker**

Type locality: Florida.

Distribution: Alabama, Georgia, Mississippi; Bahama Islands.

Florida counties: Alachua, Brevard, Broward, Collier, Hendry, Monroe, Osceola, St. Johns, Volusia.

Seasonal occurrence: March 25 to June 4 (Monroe County).

Adult activity: This species was observed by the authors to be the most abundant and troublesome tabanid in Florida. It reached its peak abundance in the Big Cypress Swamp and Everglades area south of Lake Okeechobee. Very few specimens were seen in northern and central Florida. Heavy populations appeared late in April, persisted for 4 to 6 weeks, and disappeared by mid-June.

During the last week in May 1951, a typical annual population was observed at the Big Cypress Seminole Indian Reservation, Hendry County. As many as 100 flies at a given time were feeding on a single horse. Flies were attacking, engorging, then leaving so rapidly that accurate counts were virtually impossible. Cattle would bunch together and mill around during the day in an attempt to find some relief from the flies, and a group of 15 horses remained in a darkened barn most of the day. Stockmen in the area stated that this species drives the cattle from the swampy rangeland and actually facilitates the roundup of cattle, which would otherwise be very difficult.

The favorite feeding locations are the abdomen, legs, and neck of livestock; however, during peak abundance these flies literally cover the animals.

Life-history studies: Eight females and four males were reared from collected larvae. Their emergence coincided with emergence in the field. Based on the seasonal occurrence of the adults in southern Florida, the life cycle is almost exactly 1 year with no overlapping of generations. The reared specimens had an average pupal period of 14 days.

Larval ecology: All the larvae were found in partially inundated marshes of sawgrass (*Cladium jamaicensis*). The larvae were usually within 2 or 3 feet of the water's edge in the top 2 inches of soil. They were not necessarily associated with the roots of the sawgrass. In spite of the heavy populations of adults that develop each year, the larvae were never found in large numbers. However, when one views the extensive natural habitats of this species in southern Florida, it is realized that only a few larvae per acre could easily give rise to a devastating population of adults.

***Tabanus trimaculatus* Palisot de Beauvois**

Distribution: Eastern United States to Minnesota, Nebraska, and Texas; Quebec.

Florida counties: Jefferson, Madison.

Seasonal occurrence: May 12 (Jefferson County) to May 18 (Madison County).

These Florida records were reported by Fairchild (1937). The authors do not have any additional information on *trimaculatus* in Florida.

Life-history studies: Schwardt (1936) reported the following developmental data on 10 specimens: Incubation period 6 days; larval period 307 to 365 days,

average 351.4; pupal period 8 to 16 days, average 11 days. Hine (1906) reported that egg masses of *trimaculatus* commonly contained 500 eggs. Schwardt (1936) noted that egg masses are usually deposited on low-growing vegetation at the water's edge. He counted the larvae from three masses and found 350, 350, and 413, respectively.

Larval ecology: Larvae of *trimaculatus* were not collected in Florida but were taken in Mississippi and Oklahoma. They were found in permanently wet places, such as borders of ponds, lakes, and drainage areas. This habitat agrees with that reported by Jones and Bradley (1923) and Schwardt (1936). Brimley (1911) reared an adult from one of two larvae taken under the bark of a soggy log near water.

***Tabanus turbidus* Wiedemann**

Distribution: Southeastern United States.

Florida counties: Alachua, Jefferson, Orange, and Osceola.

Seasonal occurrence: April 30 (Osceola County) to August 27 (Jefferson County).

Although *turbidus* has been taken from time to time by several workers in Florida, this species appears to be comparatively rare. The authors made no collections in the State.

***Tabanus vittiger guatemalanus* Hine**

Distribution: Florida; British Honduras; Cayman Islands; Saint Thomas, Jamaica; Campeche, Mexico; Tortuguero, Puerto Rico; South Bimini Island.

Florida counties: Dade, Monroe, Pinellas.

Seasonal occurrence: March 20 to July 25 (Monroe County).

Occasional specimens were collected in southern Florida. Philip (1957) pointed out that one might suspect from the various collection localities that this subspecies is a coastal inhabitant.

***Tabanus vittiger schwardti* Philip**

Distribution: Southern United States to Massachusetts, Ohio, Kansas, and Arizona.

Florida counties: Bay, Dade, Escambia.

Seasonal occurrence: April 19–21 (Bay County) to August 15 (Escambia County).

The specimens Schwardt (1931) reared and identified as *T. lineola* were later reported by Philip (1942) to be *vittiger schwardti*. After studying female specimens from Oklahoma and Mississippi, the authors of this bulletin are aware that this species may have been overlooked in the Florida study.

Life-history studies: Schwardt (1931) reported the following average duration of the developmental stages: Incubation 4 days, larval period 48.8 days, pupal period 8.1 days, and preoviposition 9 days.

Larval ecology: The work by Schwardt and the authors' collections in Oklahoma and Mississippi show that *schwardti* and *T. lineola* have similar larval habitats. The two specimens recorded from Florida (Philip 1942, 1952) were collected at almost extreme ends of the State.

***Tabanus wiedemanni* Osten Sacken**

Type locality: Enterprise, Volusia County.

Distribution: Georgia, Kentucky, North Carolina.

Florida counties: Alachua, Brevard, Clay, Dixie, Orange, Osceola, Volusia.

Seasonal occurrence: April 19 to July 20 (Alachua County).

Adult activity: The adults were

not observed in sufficient numbers to be considered serious pests of livestock. Only occasional specimens were collected during this study.

Life-history studies: Three larvae were collected and reared to adults—two males and one female. All of them were apparently full grown when collected. The average pupal period was 9 days. The adults emerged in May and June.

Larval ecology: The larvae were found primarily in and among the roots of *Peltandra, Carex, Sagittaria,* and *Panicum* growing at the edge of shallow water. Most of the specimens were near the surface of the root mat in the vicinity of the crown of the plant. One larva was found by breaking the stems of *Peltandra* near the crown. It was in the folds of the stem. This species has twice been found associated with the larvae of *Merycomyia brunnea.*

Tabanus zythicolor Philip

Distribution: Southeastern United States west to Oklahoma.

Florida counties: Alachua, Bay, Dixie, Franklin, Gulf, Lafayette, Lake, Leon, Levy, Liberty, Marion, Putnam, Taylor, Wakulla, Walton, Washington.

Seasonal occurrence: April 5 to September 27 (Alachua County).

Adult activity: The adult habitats and feeding tendencies closely parallel those of *T. gracilis.* Serious infestations occur in July and August in the wooded sand-hill sections of Florida.

The preferred feeding locations on horses and cattle are the inner surfaces of the hindlegs, underside of the abdomen, and occasionally between the front legs. Man is readily attacked in the absence of livestock.

Whitneyomyia beatifica (Whitney)

Distribution: Georgia, Louisiana, North Carolina, South Carolina, Texas. This distribution includes the melanistic form *W. b. atricorpus.*

Florida county: Franklin.

Seasonal occurrence: April 29 (Franklin County).

Stone (1938) stated that the typical *beatifica* with white hairs laterally on the abdomen is less common than the form with an entirely black abdomen, and that it may become necessary to consider the latter as a distinct form. This was done by Philip (1950a). This so-called typical form is apparently very rare in Florida. Philip (op. cit.) reported the distributional data for the State.

Whitneyomyia beatifica atricorpus Philip

Type locality: Alachua County.

Distribution: Texas.

Florida counties: Alachua, Duval, Lake, Osceola, Sarasota, Volusia.

Seasonal occurrence: March 9 (Lake County) to July 17 (Alachua County).

Adult activity: This melanistic form of *beatifica* was collected each year during this study. However, it was never noted as a serious pest of livestock.

Life-history studies: Six adult females were reared from field-collected larvae. The pupal period required 10 days on an average. All the adults were reared from larvae that were full grown or nearly so when they were collected. Owing to the limited rearing data and paucity of adults each year, no statement can be made regarding the length of the life cycle.

No suitable characters have

been found on either the larvae or pupae for accurate differentiation of this species from the species of *Tabanus*.

Larval ecology: All the larvae were taken from the wet, grassy margins of permanent freshwater lakes.

CONTROL

Natural Enemies

Only a detailed survey reveals the effect that parasites and predators may exert on the enormous populations of tabanids. Although these natural enemies are seldom observed, they continually keep the potential population at a lower level. A review of the literature shows that there are no less than six species of hymenopterous parasites of eggs, three species of dipterous parasites of larvae, and two species of hymenopterous parasites of pupae. In addition, there are many predators, including several species of insects (at least four orders), spiders, lizards, birds, and fish. Although all the recognized parasites of tabanids are not known to be present in Florida, their economic importance warrants a complete review of the literature on them.

EGG PARASITES

Phanurus emersoni Girault, family Scelionidae, is probably the most widespread and beneficial of the egg parasites. Parman (1928) reported that during early September 1914 a survey of egg masses of *Tabanus dorsifer* Walker near Uvalde, Tex., showed that 97 percent were parasitized and that from 6 to 83 *P. emersoni* adults emerged from each mass. From his studies on the collection and dissemination of infested egg masses, he estimated that the parasite destroyed 50 percent or more of the tabanid eggs during the most favorable seasons and 10 percent or less in the most unfavorable seasons. He concluded that the parasite is most effective during seasons with a great deal of sunshine.

Practically every egg mass of *Tabanus punctifer* Osten Sacken collected by Webb and Wells (1924) in the Antelope Valley of California and Nevada was infested with *Phanurus emersoni*. Cameron (1926) found this parasite to be common in *Chrysops aestuans* Wulp and *mitis* Osten Sacken eggs in Saskatchewan, and he frequently found it in the same egg masses with *Trichogramma evanescens* (=*minutum* Riley), family Chalcididae. The parasitization of individual egg masses varied from 3 to 30 percent. In Minnesota Philip (1931) found three *Chrysops* egg masses containing 221, 241, and 296 eggs that produced 5, 29, and 33 *P. emersoni* adults, respectively. He also reared this parasite from *Hybomitra lasiophthalmus* Macquart. MacCreary (1940) found this parasite in tabanid eggs in Delaware. The senior author of this bulletin reared it from *Tabanus* sp. eggs collected from stones projecting above the water in a mountain stream in northeastern Alabama. It was not found in Florida.

Cameron (1926) was the first to report the parasitization of tabanid eggs by *Trichogramma evanescens*. The parasitization of *Chrysops* eggs varied from 4 to 36 percent in Saskatchewan. In Minnesota Philip (1931) observed

that from 4 to 24 percent of the individual eggs were infested in 11 masses taken to the laboratory for study.

Schwardt (1936) observed that *Telenomus goniops* Crawford, family Scelionidae, completely destroyed many egg masses of *Goniops chrysocoma* (Osten Sacken) in northwestern Arkansas. This parasite has not been reported otherwise.

A single reference was found on the parasitization of tabanid eggs by *Anaphoidea* sp., family Chalcididae. This unnamed species was reared by Philip (1931) from two egg masses of *Chrysops aestuans* collected in Minnesota. He reported that it was not so common in that area as *Trichogramma evanescens* and *Phanurus emersoni*.

Tabanus sp. egg masses collected in 1954 from grass growing in a small stream in Jasper County, S. C., were heavily parasitized. Specimens emerging in the laboratory were determined by C. F. W. Muesebeck of the U.S. National Museum as "*Telenomus* sp., probably new." This or another unknown species of *Telenomus* was reared from tabanid eggs collected at Gainesville, Fla., in 1950.

Hart (1895) first reported *Telenomus tabanivorus* (Ashmead) as a parasite of tabanid eggs. He found it in *Tabanus atratus* eggs in Illinois. Hine (1907) reared this parasite from egg masses collected in Ohio and Louisiana. This species was observed to be the most important natural enemy of tabanid eggs in Florida.

During August, September, and October of each year from 1950 through 1955, *Telenomus tabanivorus* was very active around the corrals at the laboratory on the University of Florida campus. Alice Lake and other favorable breeding sites for tabanids were within several hundred yards. Tabanids were constantly being attracted to experimental cattle corralled throughout the fly season. During this period each year rains were usually frequent and heavy, and the lots remained wet and muddy most of the time.

In barns, feed sheds, and fences at this location the authors saw and collected more egg masses than at any other place in the State. Practically all of them were deposited by *Tabanus atratus*. These oviposition sites were considered atypical, because it was thought that the soil remained too dry over extended periods for the newly hatched larvae to survive. This high concentration of egg masses was favorable for a buildup in parasite population. Almost 100 percent of the egg masses were infested to some degree, especially during the last half of August and early September. *Telenomus tabanivorus* adults were observed laying their eggs within a few minutes after the tabanids finished ovipositing.

Laboratory studies showed that the attractiveness of egg masses to this parasite decreased considerably after 3 or 4 hours and completely diminished in 24 hours. The life cycle of the parasite was from 8 to 12 days.

The following figures show the extent to which several egg masses were parasitized:

Number of tabanid eggs hatched per mass	Number of parasites emerged per mass
139	187
176	218
193	336
963	13

	212	231
	576	177
	15	317
	301	298
	440	64
Average..	335	204.5

Tabanus atratus lays on an average 750 eggs per mass. It is evident from these figures that the parasites could destroy 55 percent of the tabanid eggs laid under the conditions described. Figure

FIGURE 16. *Tabanus atratus* egg mass parasitized by *Telenomus tabanivorus:* Left, dorsal view; note adult parasite. Right, ventral view of same egg mass; the dark eggs are parasitized.

16 shows an egg mass after most of the parasites have emerged.

LARVAL PARASITES

The first record of an insect parasitizing tabanid larvae was reported by Jones and Bradley (1923). They obtained one specimen of *Phasiops flava* Coquillett, family Larvaevoridae, from a larva collected in Louisiana. The host was believed to have been *Tabanus trimaculatus.*

The other known records of *Phasiops flava* parasitizing tabanid larvae were obtained during this study. On January 8, 1952, a nearly full-grown larva of *Tabanus* sp., probably *petiolatus,* was collected from the mud at the edge of a lake near Gainesville, Fla. It was not suspected of being parasitized. This larva was cared for in the laboratory in the same way as others that were reared to adults for identification. On March 31 it was slightly discolored, especially at both ends. It was placed on moist paper in a petri dish. The following day the *Phasiops* pupa was found separated from the eviscerated

larva, and 21 days later the adult emerged.

A single larva of *Tabanus* sp. collected during November 1955 in Putnam County, Fla., was later found to be parasitized. An adult parasite of *Ormia punctata* Rogineau-Desvoidy, family Larvaevoridae, emerged on July 27, 1956, 9 days after pupating. The determination was made by H. V. Weems, Jr., entomologist, Florida State Plant Board.

Myocera tabanivora Hall, family Larvaevoridae, a rare dipterous parasite of tabanid larvae, was reared from *Tabanus trimaculatus* collected in Minnesota by Philip (1931).

Jones and Bradley (1923) reared *Anthrax lateralis* Say, family Bombyliidae, from tabanid larvae. The two specimens, they stated, came indirectly from the larvae, although the bombyliids freed themselves from the tabanid pupae.

PUPAL PARASITES

Cameron (1926) first reported hymenopterous parasites of tabanid pupae. He reared *Diglochis occidentalis* Ashmead, family Chalcididae, from three species of *Chrysops* collected in Saskatchewan. The numbers emerging from a single pupa varied from 15 to 31. Four out of eleven pupae of *Chrysops mitis* collected by Philip (1931) in Minnesota were found to be parasitized by this chalcid. Seven to twelve adults emerged from each of these pupae.

Cameron (1926) also reared *Trichopria tabanivora* Fouts, family Diapriidae, from the pupae of *Chrysops mitis* and *Tabanus reinwardtii* Wiedemann in Saskatchewan. Two pupae produced 98 and 112 specimens, respectively. Bailey (1947) reported what he believed to be the first record of this parasite in tabanids since Cameron's original observation. A score of adults emerged from a pupa of *Tabanus nigrovittatus* found in a pile of drift near a marsh in Massachusetts.

This species is the only pupal parasite noted in Florida. On September 21, 1950, eight *Tabanus lineola* pupae were collected from decaying tree trunks partially submerged or floating in a lake at Gainesville, Fla. Adults failed to emerge from four of these because of *Trichopria tabanivora*. Eighteen days after the pupae were collected, approximately 100 parasites emerged from each of two pupae.

CANNIBALISM AMONG LARVAE

Practically all students of Tabanidae have expressed beliefs that cannibalistic tendencies, particularly in the genus *Tabanus*, greatly reduce larval populations. Although cannibalism has been noted in several species, medium- to large-size larvae of *Tabanus atratus* are extremely aggressive. When two or more are placed in the same container, only a short time usually elapses before all are dead except one. The survivor will feed on the victim if hungry, but generally it appears that a larva kills to avoid being killed. In this study only one larva survived to maturity in rearing tanks with approximately 5 square feet of surface area. However, in natural habitats populations of *T. atratus* larvae sometimes averaged one per square foot of surface area.

PREDATORS OF ADULTS

Hine (1906, 1907), Webb and Wells (1924), Philip (1931), MacCreary (1940), Fattig (1946), and others observed many natural

enemies of adult horse flies and deer flies. Those most frequently mentioned are several species of asilids, wasps, spiders, and birds.

Hine (1906, 1907) reported that although the robber fly (*Erax aestuans* Linnaeus) destroys tabanids, it is not so important economically as the horse guard (*Sticta carolina* Fabricius), because the robber fly captures insects for its own food and does not attend its larvae during growth. Hine gave an extensive account of the habits of all stages of this common southern horse guard. A burrow he examined contained one pupa, and with it he found 122 wings of horse flies. This wasp is fairly abundant in localized areas throughout Florida.

In these studies horse guards were observed flying around a horse during July 1952. In 15 minutes they captured one *Tabanus americanus*, two *nigripes*, and three *lineola* adults. *T. nigripes* and *lineola*, which were fully engorged, were captured immediately on leaving the host. The large *T. americanus* was attacked as soon as it lit on the host. Complete paralysis of the fly was apparently accomplished immediately, since there was no struggle as the predator flew away with its prey.

Odonata species breed in large numbers throughout Florida in close proximity to tabanid infestations. Many of the larger species are often seen darting after and capturing tabanids that are pestering livestock pastured or corralled near bodies of water. These predators probably account for the scarcity of such species as *Mesocomyia brunnea* and *Chrysozona punctulata*, which apparently never leave the breeding areas in search of blood meals.

Another interesting predator, although perhaps relatively unimportant economically, is the lizard *Anolis carolinensis* Voight, commonly called the chameleon. It is abundant around barns, corrals, and fences in some areas. Even the largest of the tabanids resting after a blood meal are an easy prey for this reptile.

The examination of the stomach and crop contents of a few insectivorous and marsh-inhabiting birds for tabanid larvae and adults has been negative. According to Beal and McAtee (1927), 49 species of southeastern birds prey on tabanids. The stomach of one killdeer contained 40 horse fly larvae.

No scientific data have been collected on the extent to which fish prey on horse fly larvae, but it is believed that when the larvae of such important species as *Tabanus atratus* and *lineola* are flushed from their habitats by rising water, they are quickly seized by minnows and fish near the surface.

During the *Tabanus trijunctus* outbreak in the Big Cypress Swamp, Fla., in May 1952, a pile of "sawdust" was noted at the base of a dead cypress tree. Examination of several burrows in the tree trunk from 1 to 3 feet above the ground indicated that the inhabitants fed almost exclusively on adult horse flies. The single pupa taken from one of the burrows yielded an adult of *Ectemnius 10-maculatus tequesta* Pate, a wasp of the family Sphecidae.

Although Philip (1931) noted mites on several species of both *Chrysops* and *Tabanus*, he stated that they cause no apparent inconvenience to the host. Adult flies have been captured near Gainesville, Fla., with as many as

six mites attached to the legs and abdomen of each. The following mites were identified: *Typhlodromus* sp., family Laelaptidae; *Tydeus* sp., family Tydeidae; and *Erythreus* sp., family Erythraeidae.

A single adult of *Tabanus fumipennis* captured at Alice Lake, Gainesville, was the host of two observed stylopids. The cephalic ends of two females were protruding from between its abdominal segments. The specimens were dissected out, but unfortunately they were lost before their identity was determined.

Chemical Control

Research efforts directed toward the control of tabanids have not been very rewarding. Control of the flies is difficult, because the larval habitats are extensive and the adult females spend short periods of time on a host. The wide dispersal of the females when not feeding and of the males makes the treatment of large areas impractical except by aircraft. Aerial applications of insecticides must be confined to areas not used for forage or livestock grazing. Furthermore, concentrations of insecticides necessary for the control of both larvae and adults may be detrimental to wildlife.

Livestock sprays have not been very successful. The chlorinated hydrocarbon insecticides applied to animals kill a high percentage of tabanids for the first 2 or 3 days, but the animals do not get relief from attacks. The only satisfactory protectant spray consists of pyrethrum formulations. Its short duration of effectiveness and high cost limit its use to dairy cattle and valuable or sick animals that can conveniently be treated individually and at frequent intervals.

That larvae are susceptible to chlorinated hydrocarbon insecticides was demonstrated by Hansens (1956) and Jamnback and Wall (1957). These workers found that aerial applications of dieldrin at 0.09 to 0.2 pound per acre eliminated larvae from salt-marsh areas for approximately 1 year. Hansens reported that DDT, BHC, and aldrin gave good initial kill but were ineffective as residual treatments. In tests by Jamnback and Wall, heptachlor, chlordane, aldrin, and DDT, in the order named, were less effective than dieldrin.

Aerial applications of insecticides for the control of adults have been made by several workers. Gerry (1949) obtained control of *Tabanus nigrovittatus* in resort areas in Massachusetts by the proper timing and dosage of DDT to marsh areas adjacent to the resorts. By treating all salt marshes within half a mile of individual recreational areas with about 1.7 pounds of DDT in oil per acre, the numbers of the flies were reduced by 90 percent. However, Howell et al. (1949) failed to obtain appreciable decreases in adult populations of *Tabanus abactor* Philip and *sulcifrons* in Oklahoma by aerial applications of DDT, methoxychlor, toxaphene, or chlordane.

Brown and Morrison (1955) eliminated tabanids for 2 days from an open spruce forest at Goose Bay, Labrador, with 0.5 pound per acre of gamma BHC. The same treatment gave only 82-percent reduction in a dense spruce forest with alder under-

brush. A dosage of 0.25 pound per acre was insufficient for decisive results even in open forests. DDT at 0.25 to 2 pounds per acre gave temporary reductions of 50 to 100 percent. Dieldrin gave negligible reductions at 0.5 pound per acre and only a temporary reduction at 1 pound per acre.

In Russia, Skuf'in (1949) reported that pools of water frequented by tabanids were oiled during periods of hot, dry weather. He stated that the numbers of flies killed in 24 hours ranged up to 500 per square meter of oiled surface.

Howell (1949), Bruce and Decker (1951), Goodwin et al. (1952, 1954), and others reported good protection of cattle from horse flies with pyrethrum formulations containing piperonyl butoxide. Concentrations of 0.1 percent of pyrethrins and 1 percent of piperonyl butoxide applied in an emulsion or suspension at the rate of 2 quarts per animal or an oil solution containing 1 percent of pyrethrins and 10 percent of piperonyl butoxide applied as a mist at the rate of 1 to 2 ounces per animal gave excellent protection for 2 to 5 days. The duration of effectiveness varies with weather conditions and the feeding habits of the flies involved.

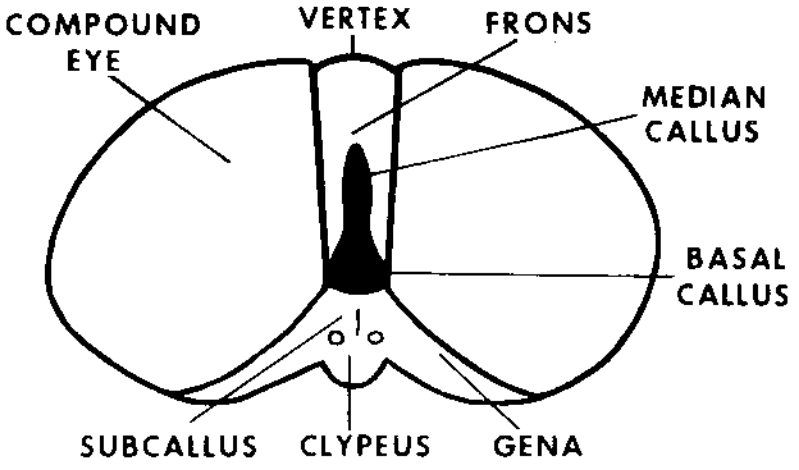
In Florida, dairy cattle sprayed with 1 to 2 quarts of an emulsion or suspension containing 0.1 percent of pyrethrins and 1 percent of piperonyl butoxide were protected from attacks for 2 days where *Tabanus nigrovittatus, lineola,* and *Chlorotabanus crepuscularis* were predominant. These flies feed primarily on the lower parts of the legs. The duration of effectiveness in these tests was no doubt reduced because of the removal of the insecticide as the cattle walked through shallow water and wet grass. A single application on horses that were used to tend cattle remained effective for only 2 to 3 hours, especially when the animals were perspiring.

The control of tabanids on cattle in Florida with pyrethrum formulations applied by treadle-type, walk-through devices was unsatisfactory. No appreciable reductions of biting flies were noted. These devices apparently did not thoroughly treat the legs and lower part of the bodies of the animals–the places where *Tabanus lineola, nigrovittatus, petiolatus, melanocerus,* and *quinquevittatus* feed. In localities where the principal species of flies feed on the back and sides of the animals, livestock can be protected with sprays applied by treadle-type, walk-through devices (Bruce and Decker 1951).

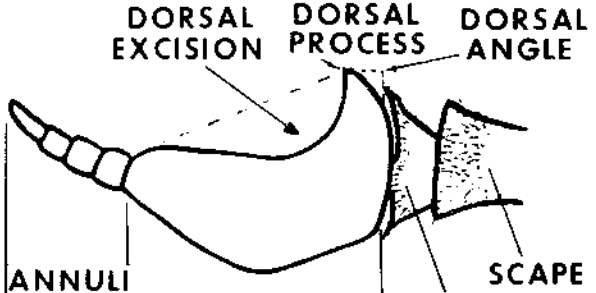
Hoffman et al. (1961) showed that daily treatments with synergized pyrethrins applied with a photoactuated self-spraying device would reduce tabanid infestations and also the transmission of bovine anaplasmosis.

Cultural Control

The reduction of tabanids by eliminating breeding sites is, in general, not practical. Vast reclamation of low, swampy land for farming or improved pastures no doubt affects the numbers and species of flies in a given area. However, it is doubtful that satisfactory control would ever be achieved. Complete elimination of breeding sites would be impossible; furthermore, the adults are strong fliers.



A



B

FIGURE 17.– *A*, Head, frontal view, and *B*, antenna, lateral view, of *Tabanus*.

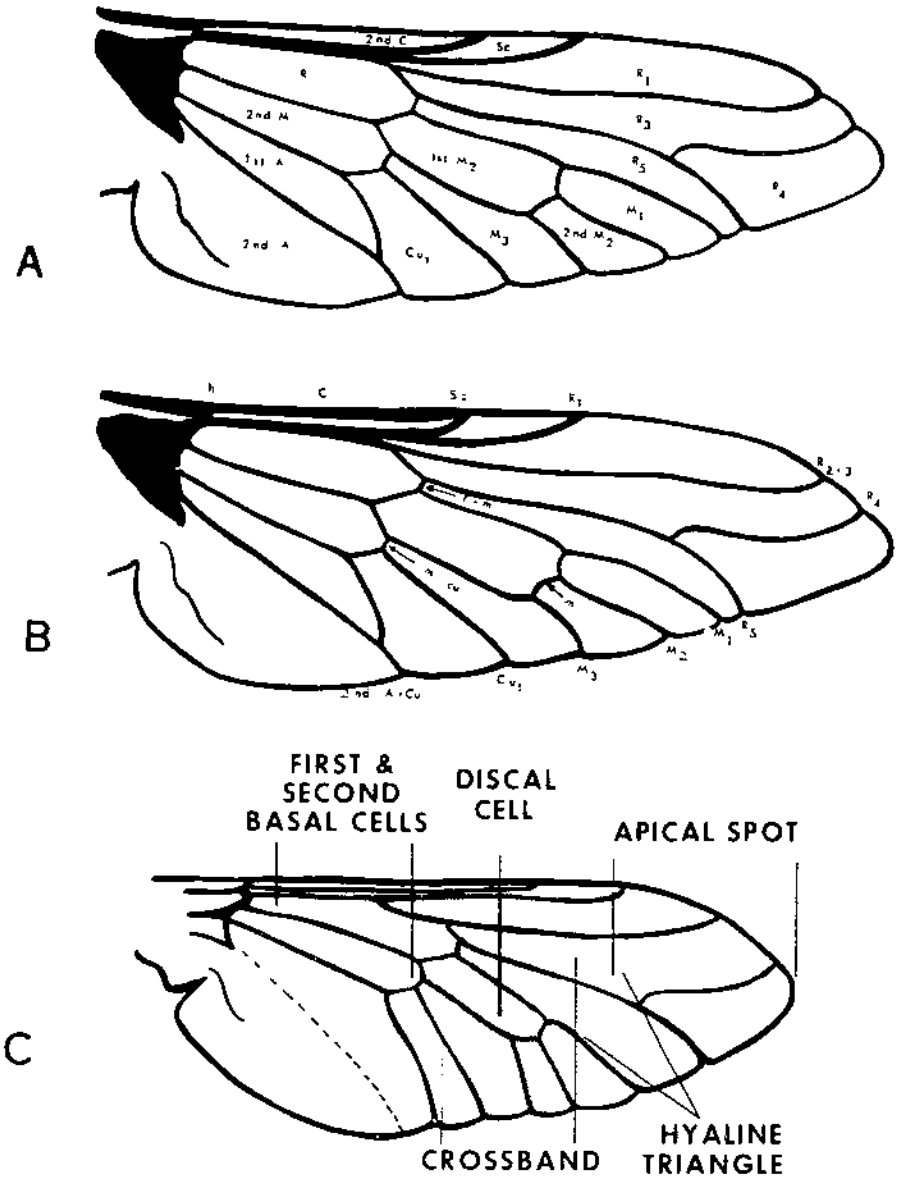


FIGURE 18.—Diagrams of *Tabanus* wings showing cells (*A*) and veins (*B*); C, diagram of *Chrysops* wing.

TAXONOMY

The dichotomic groupings in the following keys are presented to enable students of Tabanidae to identify quickly the genus and species to which specimens collected in Florida belong. Although the keys include only those species in this State, they will be

helpful to those studying the fauna in Alabama and Georgia.

The keys to genera and both sexes of *Chrysops* were taken from Philip (1941, 1955). The genera and species not occurring in Florida were deleted, and a few changes in phraseology were made in an attempt to simplify the keying of certain specimens. Stone's keys (1938) were used as a basis for both sexes of *Tabanus*. Several new species and previously unknown males have been described since his work was published. After these were added and the species foreign to the State were omitted, an extensive reorganization of the groupings was necessary. The frequent loss of pollen or hairs or both, the greasing, and the variability in the distinctness of abdominal patterns in certain specimens made duplication necessary in the keys.

The terminology for the wing veins and cells is that used by Stone (1938), Philip (1955), and others. To facilitate the use of the keys, diagrammatic sketches of some of the principal structures are given in figures 17 and 18.

No attempt was made to differentiate between the intraspecific ranks of subspecies and the variety, because it seemed best to await more complete data on geographical distribution and biology.

Males of the following species are unknown: *Chrysops abatus, amazon hubbelli, bistellatus, cincticornis nigropterus, fulvistigma dorsopunctus, hyalinus, niger taylori,* and *tidwelli;* and *Tabanus aar, atratus fulvopilosus, cayensis,* and *coarctatus.* The female of *Tabanus quirinus* is also unknown.

Key to Genera of Tabanidae

ADULTS

1. Hindtibiae with two apical spurs matching those of midtibiae (small in *Merycomyia*) subfamily Pangoniinae 2
   Hindtibiae without spurs, subfamily Tabaninae 3
2. Third antennal segment with five divisions (four annuli) .. *Chrysops* Meigen
   Third antennal segment with three divisions (two annuli) *Merycomyia* Hine
3. Frons of female without callosity; body compact, uniformly greenish yellow ..... *Chlorotabanus* Lutz
   Frons of female with callosity; color of body not as above 4
4. Third antennal segment with forward-projecting hooklike process above; eye pilose 5
   If third antennal segment has forward-projecting process, eye is bare; if eye is hairy, there is no forward-projecting process on third antennal segment 6
5. Subcallus with erect black hairs laterally ..... *Agkistrocerus* Philip
   Subcallus without such hairs ..... *Hamatabanus* Philip
6. First antennal segment considerably longer than thick; eye in life and wing with irregular bands and spots ..... *Chrysozona* Meigen
   First antennal segment scarcely longer than thick; eye in life banded or unicolorous 7
7. Vertex with distinct ocelligerous tubercle 8
   Vertex without such tubercle; if vertex is raised in male, it is pollinose .. 9
8. Eye ostensibly bare; frons narrow, callosity long and narrow; scutellum pallid ..... *Leucotabanus* Lutz
   Eye usually distinctly pilose; frons variable in width, basal callus correspondingly broad; scutellum dark ..... *Hybomitra* Enderlein
9. Subcallus very swollen and shiny; genae denuded and shiny; black species *Whitneyomyia* Bequaert
   If subcallus is slightly swollen, genae are pollinose 10

10. Third antennal segment with no dorsal angle; frons of female very narrow, height seven times width at base, median callus a very slender line; wing with at least a subapical brown spot ..... *Diachlorus* Osten Sacken
Without this combination of characters 11
11. Antenna and palpus with erect hair, palpus blunt and stout; proboscis relatively small ..... *Anacimas* Enderlein
Without this combination of characters 12
12. Small fly, 7–9 mm.; annulate part of third antennal segment with three divisions ..... *Microtabanus* Fairchild
Annulate part of third antennal segment usually with four divisions, if less than four, flies are 10 mm. or more in length 13
13. Third antennal segment with plate usually rounded above, if there is suggestion of dorsal angle or excision, frons is widened below; small species, 10–14 mm. long ..... *Stenotabanus* Lutz
Third antennal segment with distinct dorsal angle and usually excised; frons never widened below; small (9–11 mm.) to large (25–30 mm.) flies ..... *Tabanus* Linnaeus

FULL-GROWN LARVAE

1. Distal antennal segment longer than preceding segment; full-grown larvae 15 mm. or less in length 2
Distal antennal segment shorter than preceding segment; full-grown larvae 10 mm. or more in length 3
2. Tracheal trunks (seen in living larvae) unswollen and sinuous; body almost entirely striated; usually protrusible stigmatal spine ..... *Chrysops*
Tracheal trunks swollen (not visible unless pubescence is rubbed off); no body striations; no stigmatal spine; body brownish yellow ..... *Diachlorus*
3. Tracheal trunks not swollen; full-grown larvae approximately 10–15 mm. in length 4
Tracheal trunks swollen (trachea not seen in *Chlorotabanus* except in rubbed specimens); full-grown larvae range from small to large 5
4. Body white with very faint markings confined largely to thoracic and anal segments; body entirely striated; anal segment blunt with very short siphon; approximately 15 mm. in length ..... *Leucotabanus*
Body creamy white with no distinct markings; no body striations; approximately 10–12 mm. in length ..... *Chrysozona*
5. Entire body fuscous to fuscopiceous, finely mottled, and densely pubescent—sometimes with deep metallic hues of green or blue green; about 20 mm. in length when full grown ..... *Chlorotabanus*
Full-grown larvae variable; white to brownish with faint to dark ornamentation; small (10–12 mm. in length) to large (sometimes over 50 mm.); with or without stigmatal spine ..... *Tabanus*

Key to Species of *Chrysops*

FEMALES

1. Wings entirely hyaline. Small blackish species with bare black face and genae ..... *hyalinus* Shannon
Wings infuscated (occasionally faint) to varying extent 2
2. Apex of wing beyond crossband hyaline, at most occasional, indefinite trace of infuscation along costa 3
Apex of wing beyond crossband infuscated; i.e., apical spot present 10
3. Midfacial pollinose stripe beneath antennae one-half to three-fourths distance to oral margin 4
No midfacial pollinose stripe 5
4. Cell Cu with basal hyaline lunule, anal area of wing clear ..... *carbonarius* Walker
Cell Cu entirely infuscated basally, anal area of wing smoky ..... *cincticornis nigropterus* Fairchild
5. Entire wing in basal two-thirds infuscated ..... *divisus* Walker
Wing with definite hyaline areas in basal and anal cells 6
6. Wing picture dilute, crossband fading well before hindmargin 7
Wing picture with crossband saturate and complete to hindmargin 9

7. Both basal cells entirely hyaline, abdomen with yellow pattern basally .. 8
First basal cell dilutely infuscated, abdomen entirely dark
nigribimbo Whitney

8. Median dark figure on tergite 2 paired and not reaching anterior margin
fulvistigma Hine
Median figure a solid triangle crossing tergite anteriorly
fulvistigma dorsopunctus Fairchild

9. Crossband usually brown, terminating abruptly in cell M_3; face broadly yellow to oral margin between sutures ..... *niger* Macquart
Crossband blackish, invading cell Cu_1; midfacial yellow reduced and not reaching oral margin ..... *niger taylori* Philip

10. Face with distinct median pollinose stripe 11
Face bare in middle of at least lower two-thirds (sometimes short transverse pollinose spur below each antenna and exceptionally attenuated, adventitious median one) 13

11. Midfacial pollinosity complete to oral margin ..... *abatus* Philip
Midfacial pollinose spur incomplete but extending downward at least to middle of face 12

12. First basal cell completely infuscated, second entirely hyaline; abdomen yellow with uniform, longitudinal, blackish middorsal band
dorsovittatus Hine
Both basal cells partially infuscated; abdomen black .. *amazon hubbelli* Philip

13. Base of vein R_1 (fork) with prominent, isolated cloud or this may be extension from crossband (occasionally faint in dusky *brimleyi*) 14
Fork with no prominent cloud though area may be included in apical tinting of wings 15

14. Apical spot narrow, just reaching into outer corner of cell R_1; outer margin of crossband nearly straight or gently bowed ..... *brimleyi* Hine
Apical spot broad and drop shaped; outer margin of crossband strongly bowed ..... *fuliginosus* Wiedemann

15. First basal cell completely infuscated, if there is hyaline spot in apex, it does not plainly cross cell; crossband always reaching hindmargin 16
First basal cell with at least subapical hyaline spot crossing cell, sometimes almost entirely hyaline (in *montanus* spur occasionally reaches apex); crossband not always reaching hindmargin 30

16. Wing pattern dilute luteofuscous and with usual hyaline areas luteous or tinted ..... (some *brunneus* Hine, see couplet 38)
Wing pattern in sharper contrast with definite hyaline areas 17

17. Apex of hyaline triangle nearly reaching or crossing vein R_{2+3} and often crescentic above (its projection above fork in R_3 in occasional *parvulus* and *ducue* is only vaguely indicated by a reduced subhyaline crescentic margin along crossband) 23
Apex of hyaline triangle seldom reaching point just enveloping fork and never crescentic above (entire apex of wing in *bistellatus* infuscated except for isolated fenestrate spot in cell R_3 above fork) 18

18. Entire apex of wing infuscated except for isolated fenestrate spot in cell R_3 above fork ..... *bistellatus* Daecke
Apical wing pattern otherwise 19

19. Crossband continuing across at least base of cell Cu_1 21
Crossband terminating abruptly in cell M_3 though vein behind cell Cu_1 may be faintly infuscated 20

20. Hyaline triangle sharply limited to apices of cells M_1 and M_2, cell R_5 usually completely infuscated ..... *moechus* Osten Sacken
Hyaline triangle invading cell R_5; abdomen with two submedian dark lines expanded caudally (rarely obsolescent), sides yellow at least anteriorly
macquarti Philip

21. Frontal callosity and scutellum entirely yellow 22
Frontal callosity and scutellum predominantly dark
(occasional *montanus* Osten Sacken and *montanus perplexus* Philip, see couplet 32)

22. Abdominal stripes conspicuous, black; apical spot with at most a spur in cell R_5 ..... *vittatus* Wiedemann
Abdominal and thoracic pattern indistinct; brownish apical spot continuous into cell R_5 ..... *vittatus floridanus* Johnson

23. Frontal callosity yellow, often with brown upper margin 24
Frontal callosity black or occasionally with brown shades 26
24. Abdomen bicolored; two basal tergites yellow, remainder black; hindfemora entirely yellow ..... *tidwelli* Philip & Jones
Abdomen striate; hindfemora predominantly brown 25
25. Hyaline triangle with wide base on hindmargin behind cell R_1; crossband never invading cell Cu_1; abdomen usually quadristriate
beameri Brennan
Hyaline triangle very narrow, more crescentic, apical spot usually invading cell M_3, crossband often crossing cell Cu_1 as a lighter shadow; abdomen usually with two accentuated submedian stripes ..... *hinei* Daecke
26. Abdomen yellow with two submedian black stripes; apex of hyaline triangle a blunt spot above fork ..... *pikei* Whitney
Abdomen dusky, sometimes with one or three abbreviated rather obscure reddish lines 27
27. Thorax with conspicuous yellow stripe on each side above wing base 28
Thoracic bands confined to pleura 29
28. Abdominal pattern usually consisting of three dirty, yellowish stripes, sometimes obsolescent laterally ..... *obsoletus* Wiedemann
Abdomen dark, without pattern or only trace of median yellow stripe
obsoletus lugens Wiedemann
29. Hindlegs predominantly yellowish to brown; abdomen usually with at least suggestions of one or three gray or yellowish stripes; apical spot crossing into cell R_5 at least as a shadow ..... *dacne* Philip
Hindlegs predominantly fuscous; abdomen dark, seldom with obscure pattern on tergite 2; apical spot usually fading in cell R_1 ..... *parvulus* Daecke
30. Apical spot just wider than cell R_1 at its origin and only exceptionally expanded distally; about half and fourth of respective two basal cells infuscated; frontal callosity customarily yellow with brown upper margin rounded and almost as tall as broad; tergite 1 and 2 yellow with connected, sharp black hourglass-shaped spot, not widest below, enclosed yellow triangle on 2 usually equilateral; sternites 2 and 3 with sublateral spots
sackeni Hine
Without this combination of characters 31
31. Abdomen quadristriate or quadrivittate, usually with median inverted "V" on tergite 2; apical spot drop shaped, usually filling half of cell R_4, apex of hyaline triangle often reaching or even slightly crossing vein R_{2+3}; frontal callosity and scutellum typically black but former occasionally yellowish 32
Without this combination of characters 33
32. Apical spot not extending beyond cell R_1, sometimes not beyond apex
montanus Osten Sacken
Apical spot much more extensive; hyaline triangle reduced to circular spot in cell R_5 and narrow stripe in first and second posterior cells and cell Cu_1, it reaches wing margin in latter as subhyaline area
montanus perplexus Philip
33. Apex of hyaline triangle clearly reaching or crossing vein R_{2+3}, first basal cell infuscated to about half or less than half its length 34
Apex of hyaline triangle not reaching vein R_{2+3}, first basal cell with infuscation usually reaching to or beyond basal two-thirds 38
34. Apical spot narrow, seldom widened apically ..... *callidus* Osten Sacken
Apical spot widened beyond its origin, more or less drop shaped and usually extending into more than just apex of cell R_1 35
35. Abdomen predominantly blackish with long, middorsal yellow stripe attenuated caudally, and sometimes with abbreviated ones on either side
univittatus Macquart
Abdomen predominantly yellow and otherwise patterned 36
36. Apical spot practically or quite separated from crossband by apex of hyaline triangle and occupying nearly whole of cell R_1; crossband filling cell M_3 to margin; second tergite with pair of submedian dashes
geminatus Wiedemann
Apical spot joined to crossband by about width of cell R_1 37
37. Crossband rather dilute and bowed mesally; hindfemora and frontal callosity yellow; median spots on tergites 1 and 2 very reduced .. *cursim* Whitney
Crossband more saturate and usually with straighter outer margin; hind-

femora and callosity usually fuscous; if latter is yellow, upper margin is brown; conspicuous spot beneath scutellum on tergite 1; inverted "V" on tergite 2 darker and often produced laterally ..... *pudicus* Osten Sacken

38. Apical spot extended dilutely along whole hindmargin of wing enclosing subhyaline streak (sickle) along outer border of crossband; scapes enlarged; callus yellow; body rich brownish red with indefinite abdominal pattern ..... *brunneus* Hine

Without this combination of characters 39

39. Inverted "V" on tergite 2 tall, crossing tergite and enclosing equilateral triangle; hindfemora and tibia usually predominantly black; frontal callus only occasionally yellow ..... *dimmocki* Hine

Inverted "V" usually flattened, when occasionally attaining anterior margin, enclosed triangle is broader than tall, frontal callus is yellow, and hindfemora and tibia predominantly so 40

40. Wing pattern distinctly outlined; basal segments of antennae but little swollen 41

Wing pattern not sharply outlined, usual hyaline areas tinted; antennae moderately swollen but not to extent in *brunneus;* mesonotum typically grayish green with blackish stripes ..... *atlanticus* Pechuman

41. Thorax typically yellowish with brown stripes; outer margins of crossband usually rather straight; inverted brown "V" on tergite 2 not especially flattened and sides of this tergite brownish yellow .... *flavidus* Wiedemann

Outer margin of crossband usually sinuous; tergite 2 with median "V" flattened to about one-half length of tergite leaving anterior "collar" of pale greenish yellow; thorax with yellow and brown stripes

flavidus reicherti Fairchild

MALES

1. Apex of wing beyond crossband hyaline, at most occasional indefinite trace of infuscation along costa 2

"Apical spot" present and distinct 6

2. Entire wing in basal two-thirds infuscated ..... *divisus* Walker

Wing with definite hyaline areas in basal and anal cells 3

3. Wing picture saturate, infuscated and hyaline areas contrasting sharply . 4

Wing picture dilute, almost obsolete 5

4. Cell Cu, with basal hyaline lunule ..... *carbonarius* Walker

Cell Cu, infuscated basally ..... *niger* Macquart

5. Abdomen and first basal cell entirely blackish ..... *nigribimbo* Whitney

Abdomen with basal yellow pattern; first basal cell not infuscated

fulvistigma Hine

6. Midfacial pollinose stripe complete or nearly so and/or lateral facial tubercles often protuberant and scapes incrassate 7

Midface bare, or abbreviated spur on usually much less than upper half of face; facial tubercles only exceptionally protuberant 8

7. Abdomen reddish yellow with contrasting middorsal black stripe

dorsavittatus Hine

Abdomen blackish brown, slightly paler laterally on first two segments

ducne Philip

8. Wing pattern dilute and indefinite, whole apical area of wing smoky enclosing hyaline triangle, and second basal cell extensively hyaline; scapes robust to noticeably swollen 9

Wing pattern normally saturate, sharp and contrasting with definite apical spot; scapes occasionally robust but not swollen 10

9. Yellowish-brown species with moderately robust scapes, a median series of indefinite geminate spots on abdomen, and very indefinite pattern outwardly on wing ..... *atlanticus* Pechuman

Reddish-brown species with swollen scapes, very indefinite abdominal pattern, and enclosed hyaline sickle beyond crossband ..... *brunneus* Hine

10. Apical spot including practically all of cell R_5, often invading cell R_3 21

Apical spot narrower, seldom reaching beyond half of R_5 11

11. Apical spot relatively slender and reaching narrowly into apex of cell R_5, hardly widened beyond its juncture with crossband 12

Apical spot noticeably widened beyond origin; sometimes separated from crossband, or broadly joined, and usually invading about half of cell R_5 13

12. Apical spot little wider than cell R_1 ..... *sackeni* Hine
Apical spot at its origin not wider than cell R_1 ..... *callidus* Osten Sacken
13. Body without yellow markings; usually definite cloud on base of vein R_4 at fork 14
Body with various yellow patterns; no cloud on fork 15
14. Outer margin of crossband noticeably bowed (some *fuliginosus* Wiedemann, see couplet 22)
Outer margin of crossband nearly straight ..... *brimleyi* Hine
15. Sides of face and cheeks with large black spots or latter entirely black; abdomen fuscous with conspicuous middorsal yellow stripe attentuated caudad ..... *univittatus* Macquart
Face and cheeks entirely yellow 16
16. Second basal cell predominantly hyaline; (base of cell R_2 often with subhyaline spot); abdomen pale yellow, often with indefinite light-brown or fuscous markings, that on tergite 2 and inverted "V" usually not reaching anterior margin 17
Both basal cells predominantly infuscated; base of cell R_2 not usually paler than rest of crossband; abdominal pattern otherwise 20
17. Ground color of thoracic dorsum and scutellum typically yellow 18
Ground color of thoracic dorsum and scutellum typically green gray 19
18. Tergite 2 with broad greenish-yellow basal band, and flat, broad, brown inverted "V"; outer margin of crossband strongly sinuous *flavidus reicherti* Fairchild
Base of tergite 2 about same color as others, and median figure usually taller; outer margin of crossband nearly straight or gently sinuous *flavidus* Wiedemann
19. Inner margin of crossband practically filling discal and R_2 cells to their bases ..... *pudicus* Osten Sacken
Inner margin of crossband dilute, bases of discal and R_2 cells extensively subhyaline ..... *cursim* Whitney
20. Tergite 2 with sublateral black spots ..... *montanus* Osten Sacken
Tergite 2 yellow on either side of median figure ..... *dimmocki* Hine
21. Body predominantly blackish, abdomen sometimes with one or three obscure reddish stripes 22
At least abdomen with extensive yellow and dark pattern 27
22. Femora and forecoxae black, no suggestions of abdominal stripes and no yellow thoracic stripes though pleura may have plumbeous markings .. 23
Femora and forecoxae extensively yellow; sides of thorax and often abdomen with yellow stripes 25
23. Hyaline triangle sharply limited to apices of cells M_1 and M_2 (cell R_2 entirely infuscated) ..... *moechus* Osten Sacken
Hyaline triangle at least invading cell R_2 24
24. Outer border of crossband relatively straight, apex of hyaline triangle crossing vein R_{2+3}; small isolated spot at base of vein R_1 and definite hyaline spots in apices of basal cells ..... (some *brimleyi* Hine, see couplet 13)
Outer border of crossband sinuous, sometimes connecting along vein R_{4+5} with spot at fork, thus isolating diagonal dash in cell R_3, which represents apex of hyaline triangle; whole apex of wing and apices of basal cells may otherwise be tinted ..... *fuliginosus* Wiedemann
25. Yellow stripe on each side of thorax above wing base 26
No pale stripe on thorax above wing base, gray stripes confined to pleura *parvulus* Daecke
26. Abdomen with one or three definite reddish-yellow lines *obsoletus* Wiedemann
Abdomen dark, at most trace of median line on tergite 2 *obsoletus lugens* Wiedemann
27. Wing entirely dark except for narrow subhyaline streaks diagonally in parts of apices of both basal cells and along outer margin of crossband enclosed by fumose apex; tergites 1–4 with median row of geminate spots and narrower sublateral lines that also may be geminate with median ones *montanus perplexus* Philip
Wing with hyaline areas more extensive, hyaline triangle usually open to hindmargin; abdomen otherwise usually striate 28

28. Apex of hyaline triangle nearly or quite reaching vein R_{2+3}; sometimes crossing it 29
Apex of hyaline triangle just enveloping fork 32
29. Apex of hyaline triangle terminating in cell R_5; abdomen with two to four black lines 30
Apical spot quite or almost separated from crossband by extension of hyaline triangle into cell R_1; tergite 2 with two joined or divided diagonal black dashes ..... *geminatus* Wiedemann
30. Facial tubercles and cheeks predominantly dark brownish to black, leaving narrow midstripe of yellow ..... *pikei* Whitney
Facial tubercles and cheeks predominantly yellow, lateral sutures narrowly darkened 31
31. Hyaline triangle with blunt apex in cell R_5; cell Cu_1 predominantly hyaline *beameri* Brennan
Hyaline triangle acuminate and crescentic; cell Cu_1 predominantly fumose with restricted hyaline spot basally ..... *hinei* Daecke
32. Abdominal pattern transverse; first basal cell hyaline in apex (occasional dark *flavidus*)
Abdominal pattern linear; first basal cell infuscated to apex 33
33. Ground color of thorax and scutellum plumbeous ..... *macquarti* Philip
Ground color of thorax and scutellum yellow 34
34. Abdominal stripes conspicuous, black ..... *vittatus* Wiedemann
Abdominal and thoracic pattern indistinct ..... *vittatus floridanus* Johnson

Key to Species of *Tabanus*

FEMALES

1. Eye pilose; (length 11–13 mm.; yellowish brown with median stripe and subquadrate, sublateral spots on abdomen; palpus very slender) *bishoppi* Stone
Eye bare 2
2. Abdomen dorsally with both median and sublateral pale spots or triangles (sublateral spots very faint on *acutus*) 3
Abdomen dorsally unicolorous (except dark markings on *fumipennis* and some *abdominalis*) or with single median row of pale spots or triangles, which sometimes arise from pale apical bands, these bands may widen laterally but do not form distinct sublateral spots or triangles (sublateral pale spots sometimes present on tergite 2 only) . 22
3. Abdomen dorsally with median, parallel-sided pale stripe 14
Abdomen dorsally with median row of pale spots or triangles, which may be contiguous but do not form parallel-sided stripe 4
4. Fork (furcation of veins R_4 and R_5) with distinct dark spot 5
Fork without distinct dark spot 6
5. Frons 2½ times as high as wide, sides parallel; wing hyaline; tergites pale reddish brown with broad, whitish posterior margins, which expand into gray median triangles that do not reach anterior margins *birdiei* Whitney
Frons little over four times as high as width at base, slightly widened above; wing suffused with brown; abdomen above brown or orange brown with median row of faint sublateral spots ....*johnsoni* Hine
6. Mesonotum covered with yellow hair, without longitudinal stripes; conspicuous middorsal stripe formed by triangles that widen posteriorly on each tergite; frons narrow, widened above 7
Without this combination of characters 8
7. Third antennal segment with annulate part black; femora largely grayish ..... *fulvulus* Wiedemann
Third antennal segment entirely orange; femora entirely yellowish *fulvulus pallidescens* Philip
8. Length 12 mm. or more; frons parallel sided or only slightly widened above 9
Length less than 12 mm.; frons distinctly widened above 12
9. Third antennal segment with plate black ..... *fairchildi* Stone
Third antennal segment with plate mostly orange 10

10. All wing veins margined with brown; basal and median calli broadly joined ..... *gracilis* Wiedemann
Longitudinal veins not margined with brown; basal and median calli separated or only narrowly joined 11
11. Third antennal segment uniformly brown ..... *zythicolor* Philip
Third antennal segment with annulate part black .. *longiusculus* Hine
12. Eye in life or relaxed specimens with two purple bands; median callus subquadrate; palpus not strongly swollen basally and not sharply pointed ..... *pumilus* Macquart
Eye unicolorous or with one purple band; median callus slender; palpus strongly swollen basally with apex acute 13
13. Eye unicolorous ..... *sparus* Whitney
Eye with single purple band ..... *sparus milleri* Whitney
14 (3). Length 16–19 mm.; fork with small dark spot ..... *acutus* (Bigot)
Length 9–15 mm.; fork without dark spot 15
15. Eye in fresh or relaxed specimens with single purple band; frons nearly parallel sided; costal cell colored, sometimes faintly 16
Eye in fresh or relaxed specimens with two purple bands; frons widened above; costal cell as hyaline as rest of wing 20
16. Frons about 2½ to 3 times as high as wide; wing subhyaline, veins faintly margined with brown; small slender species *cayensis* Fairchild
Height of frons at least three times width at base; wing clear except yellowish costal cell; slightly larger species and not so slender ... 17
17. Palpus, pleura, costal cell distinctly yellow; thorax and yellowish stripe of abdomen golden pollinose ..... *quinquevittatus* Wiedemann
Palpus white or creamy white; pleura grayish, dorsum grayish to cinereous; costal cell variable 18
18. Abdomen predominantly black laterally, sublateral pale spots faint; costal cell deeply yellow ..... *mularis* Stone
Abdomen predominantly yellowish laterally; costal cell yellowish (*nigrovittatus* complex*) 19
19. Femora gray to black, apical part of tibia and tarsi black or dark brown; basal callus dark brown to black .... *nigrovittatus* Macquart
Legs predominantly yellow to reddish yellow with pale hairs except for dark-brown to black hairs on tarsi and apex of tibiae; basal callus yellow to dark brown ..... *nigrovittatus fulvilineis* Philip
20 (15). Scutellum and thorax concolorous, dark ..... *lineola* Fabricius
Scutellum reddish at posterior margin 21
21. Legs predominantly pale or reddish ..... *vittiger guatemalanus* Hine
Femora of at least fore and hind pair infuscated or cinereous *vittiger schwardti* Philip
22 (2). Abdomen unicolorous, except dark abdominal markings on *fumipennis* and some *abdominalis* 23
Abdomen bicolorous; faint to distinct pale median triangles or spots with or without apical bands, or bands only 34
23. Fork without distinct dark spot, although whole wing may be infuscated 24
Fork with distinct dark spot 28
24. Thorax and abdomen reddish brown; wing hyaline except strongly infuscated costal cell ..... *americanus* Forster
Thorax and abdomen black; wing infuscated 25
25. Basal callus wider than high 26
Basal callus as high as wide ..... *wiedemanni* Osten Sacken
26. Mesonotum with bright-yellow or orange hair laterally *atratus fulvopilosus* Johnson
Mesonotum with entirely dark hair 27
27. Wing uniformly dark brown to black ..... *atratus* Fabricius
Wing brown with distinct yellow tinge along hindmargin *atratus nantuckensis* Hine
28 (23). Mesonotum brown to black 29
Mesonotum covered with white hair and pollen ..... *stygius* Say
29. Frons narrow at base, widened above 30
Frons moderate in width, sides almost parallel 32

* For comments on this complex, see page 46.

39. Cell R_5 narrowed or closed apically 31
Cell R_5 not narrowed apically ..... *aar* Philip
31. Genae with orange-brown to black hair ..... *proximus* Walker
Genae with light-gray to pale-yellow hair (see couplet 60)
gladiator Stone, *abdominalis* Fabricius
32. Antennae dark; thorax and abdomen nearly black 33
Antennae uniformly orange; abdomen orange with poorly defined median black spot, narrow on tergite 1 and 2, widening posteriorly
fumipennis Wiedemann
33. Wing nearly hyaline distad of basal crossvein
nigrescens Palisot de Beauvois
Wing nearly uniformly dark ..... *nigrescens atripennis* Stone
34 (22). Fork without infuscation or if fork faintly infuscated, legs predominantly black 35
Fork with infuscation (faint in *equalis*, *turbidus*, and *coarctatus*) and legs reddish to orange brown 41
35. Median abdominal spots, if present, faint or not contrasting sharply with remainder of tergites; abdomen reddish brown to almost black 36
Prominent median abdominal triangles present dorsally, abdomen dark brown to almost black 38
36. Medium-sized fly; costal cell hyaline ..... *rufofrater* Walker
Large fly; costal cell yellow or brown 37
37. Wing hyaline, costal cell dark brown; abdomen usually with apical bands ..... *americanus* Forster
Wing uniformly dilute brown, costal cell yellow ..... *calens* Linnaeus
38. Small compact fly not over 15 mm. long, brownish black and single median row of triangles on abdomen arising from pale posterior bands; subcallus denuded or very thin pollinose; foretibia not distinctly bicolored, although there may be pale hair basally
nigripes Wiedemann
Without this combination of characters 39
39. Vein R_4 with stump; fork faintly margined with brown; hindtibia with apical half black ..... some *melanocerus lacustris* Stone
Without this combination of characters 40
40. Median triangle on tergite 2 slightly expanded anteriorly and meeting pale triangle on tergite 1; cell R_5 closed and petiolate; hindtibia uniformly yellowish with black hair ..... *petiolatus* Hine
Median triangle on tergite 2 not expanded anteriorly and often not reaching anterior margin; cell R_5 usually narrowed or just closed; hindtibia with extreme apex usually blackened
melanocerus Wiedemann
41 (34). Abdomen with distinct, contrasting, pale median spots or triangles 42
Abdomen with faint or indistinct median spots or triangles 57
42. No median spot on tergite 2; foretibia distinctly bicolored; venter of aodomen with distinct median brown stripe; furcation and crossveins faintly margined with brown; sublateral pale spots sometimes present on tergite 2 ..... *trimaculatus* Palisot de Beauvois
Median pale spot on tergite 2 and differing in at least one other character 43
43. Median spot on tergite 2 distinctly smaller than those on tergites 3 and 4; scutellum with distinct pale pile; foretibia nearly uniform in color 44
Without this combination of characters 45
44. Genae, pleura, and venter pale pilose and pollinose ..... *molestus* Say
Genae and pleura brownish pilose and pollinose, sternites dark with contrasting pale posterior margins ..... *molestus mixis* Philip
45. Vein R_4 with stump ..... *melanocerus lacustris* Stone
Vein R_4 without stump 46
46. Foretibia unicolorous or rarely base brownish, with orange hair, apex darker 47
Foretibia bicolored, basal part yellowish brown with pale hair, apical part dark brown with black hair ..... *sulcifrons* Macquart
47. Venter of abdomen black with strongly contrasting, rather broad white bands ..... *trijunctus* Walker

Venter of abdomen brownish, pale bands, if present, not strongly contrasting 48

48. Plate of third antennal segment with slight or no dorsal excision *endymion* Osten Sacken

Plate of third antennal segment distinctly excised above 49

49. Abdomen dorsally orange brown or grayish brown with rather large median triangles 50

Abdomen dark reddish to nearly black with small median white spots that may be longer than broad 54

50. Frons about four or more times as high as width at base, widened above; cell R_5 not narrowed apically 51

Frons 2½ to 3½ times as high as wide with parallel sides; cell R_5 narrowed apically 53

51. Third antennal segment with annulate part distinctly shorter than plate ..... *coarctatus* Stone

Third antennal segment with annulate part as long or longer than plate 52

52. Frons 4½ to 5 times as high as width at base, slightly widened above; wing hyaline, crossveins and fork distinctly margined with brown *equalis* Hine

Frons six to seven times as high as width at base, distinctly widened above; wing faintly tinged with brown, crossveins, fork, and sometimes all veins margined with brown ..... *turbidus* Wiedemann

53. Plate of third antennal segment only slightly longer than broad; frons 2½ to 3 times as high as wide; grayish species, 14–17 mm. long *birdiei* Whitney

Plate of third antennal segment 1½ to 2 times as long as broad; frons 3 to 3½ times as high as width at base; brownish species, 19–20 mm. long ..... *cheliopterus fronto* Osten Sacken

54. Abdominal spots very small, as broad as long 55

Abdominal spots at least on tergites 3, 4, and 5 considerably longer than broad ..... *fusconervosus* Macquart

55. Plate of third antennal segment with prominent, forward-projecting dorsal process 56

Dorsal angle of plate not projecting forward ... *imitans excessus* Stone

56. Hind tibial fringe variable in color; yellow or black, if black, few yellow hairs may be present; basal callus oval above; basicosta with black hairs ..... *imitans* Walker

Hind tibial fringe orange brown; basal callus taller and drop shaped above; basicosta with orange hairs ..... *imitans pechumani* Philip

57 (41). Cell R_5 narrowed or closed apically 58

Cell R_5 not narrowed apically 61

58. Legs predominantly orange brown 59

Legs, at least femora, predominantly black 60

59. Frons little over four times as high as width at base, slightly widened above; wing suffused with brown ..... *johnsoni* Hine

Frons 3 to 3½ times as high as wide, sides parallel; wing hyaline with brown veins, costal cell, margins of crossveins, fork, and sometimes longitudinal veins strongly tinged with brown .. *cheliopterus* Rondani

60. Abdomen reddish brown; mesonotum reddish brown, fine grayish pollen giving lavender tone, with narrow gray lines; hindtibia nearly or quite black; palpus slender, straplike, with apex truncate *gladiator* Stone

Abdomen orange; mesonotum yellowish with dark lines; hindtibia orange except apical one-fourth, which is dark brown to black; palpus swollen basally, tapering to narrow apex ..... *abdominalis* Fabricius

61 (57). Clypeus, genae, and pleura brown with concolorous hair; abdomen with only faint suggestions of middorsal triangles; length 20–25 mm. *aar* Philip

Clypeus, genae, and pleura gray to grayish brown with pale hair; abdomen with middorsal triangles faint but discernible 62

62. Legs dark brown to black, hairs on forefemora black, tibial fringes mostly black, hairs on rest of legs white or mixed black and white *rufofrater* Walker

Legs uniformly reddish to reddish brown with white or concolorous hair 63

63. Third antennal segment with annulate part distinctly shorter than plate ..... *coarctatus* Stone

Third antennal segment with annulate part as long or longer than plate 64

64. Frons 4½ to 5 times as high as width at base, slightly widened above; costal cell nearly hyaline, crossveins and fork tinged with brown *equalis* Hine

Frons six to seven times as high as width at base, distinctly widened above; costal cell infuscated, crossveins, fork, and sometimes all longitudinal veins margined with brown ..... *turbidus* Wiedemann

MALES

1. Eye pilose 2
Eye bare 4

2. Abdomen above with row of median triangles and sublateral pale spots ..... *fairchildi* Stone

Abdomen above with pale median stripe extending from base to apex, with or without sublateral pale spots 3

3. Eye facets nearly uniform in size; frontal triangle gray, distinctly swollen ..... *bishoppi* Stone

Eye with upper facets distinctly enlarged; frontal triangle yellowish brown and not swollen ..... *vittiger schwardti* Philip

4 (1). Abdomen unicolorous or tergites with narrow, indistinct, apical pollinose bands; dorsal median triangles, when present, small or vague 5

Abdomen bicolorous, light or dark markings broad and distinct 19

5. Palpus orange brown to white 6
Palpus dark brown to black 12

6. Fork with at least faint brown spot 7
Fork clear 11

7. Fork and crossveins with large, distinct, brown maculations 8

Fork and veins slightly tinged with brown, entire wing sometimes tinted with brown 10

8. Basal part of third antennal segment with prominent forward-projecting dorsal process 9

Dorsal process of third antennal segment not projecting forward *imitans excessus* Stone

9. Hind tibial fringe variable in color; yellow or black, if black, few yellow hairs may be present; narrow band of small facets extending along outer margin of eye to vertex narrow ..... *imitans* Walker

Hind tibial fringe orange brown; band of small facets extending along outer margin of eye to vertex wide ..... *imitans pechumani* Philip

10. Eye facets of uniform size ..... *quirinus* Philip

Eye with enlarged facets occupying about upper two-thirds of eye *aar* Philip

11 (6). Hind tibial fringe brown; wing mostly hyaline .... *americanus* Forster

Hind tibial fringe black; wing dilute, brownish ..... *calens* Linnaeus

12 (5). Fork without dark spot although entire wing may be dark 13
Fork with distinct brown spot 15

13. Third antennal segment with basal part deeply excised above, dorsal angle with forward-projecting process; eye with broad band of small facets around upper margin, contrasting sharply with large facets below; length 20–28 mm 14

Third antennal segment with basal part moderately excised above, dorsal angle not projecting forward; small facets around upper margin of eye not sharply differentiated; length 12–20 mm. *wiedemanni* Osten Sacken

14. Wing entirely black ..... *atratus* Fabricius

Wing yellowish along posterior margin .... *atratus nantuckensis* Hine

15. Genae light (yellowish white to gray) 16
Genae dark (brown to barely black) 17

16. Eye with areas of large and small facets distinctly differentiated; genae gray with orange-brown to black hair ..... *proximus* Walker

Eye facets uniformly small; genae yellowish white with concolorous hair ..... *gladiator* Stone

17. Antenna orange ..... *stygius* Say
Antenna black 18

18. Wing subhyaline, yellowish, apical and marginal half nearly clear *nigrescens* Palisot de Beauvois
Wing deeply smoky, only slightly paler posteriorly if at all *nigrescens atripennis* Stone

19 (4). Abdomen above orange brown with median dark spots or stripes ... 20
Abdomen above with median pale spots, triangles, or a stripe 21

20. Abdomen above with median dark stripe; wing almost uniformly yellow brown ..... *fumipennis* Wiedemann
Abdomen above with median dark spots not forming continuous stripe; wing dilute brown, crossveins and fork more distinctly infuscated *abdominalis* Fabricius

21. Abdomen above with median row of pale spots not forming a parallel-sided stripe, no distinct sublateral pale spots although broad apical bands may be present that tend to obliterate median triangles 22
Abdomen otherwise 43

22. Eye with upper facets distinctly larger than those below, small facets extending in band around outer margin to vertex, line of demarcation between large and small facets distinct 23
Eye facets uniformly small or at most only slightly enlarged above, line of demarcation if present indistinct 40

23. Fork with more or less distinct brown spot (may be faint in *trimaculatus*, *molestus*, and some *cheliopterus*) 24
Fork not margined with brown 37

24. Abdomen above with pale median triangles, most evident on tergites 2 through 5 25
Abdomen without pale median triangle on tergite 2 or 5 36

25. Dorsal abdominal triangles small, rarely extending more than one-third length of tergites 26
Dorsal abdominal triangles large and broad, usually extending at least half length of tergites 28

26. Basal part of third antennal segment with prominent forward-projecting dorsal process 27
Basal part of third antennal segment without prominent forward-projecting dorsal process ..... *imitans excessus* Stone

27. Hind tibial fringe variable in color; yellow or black, if black few yellow hairs may be present; wide band of small facets extending along outer margin of eye to vertex narrow ..... *imitans* Walker
Hind tibial fringe orange brown; band of small facets extending along outer margin of eye to vertex wide ..... *imitans pechumani* Philip

28. Third antennal segment uniformly orange brown 29
Third antennal segment at least annulate part darkened 32

29. Abdomen attenuated apically 31
Abdomen not attenuated, rounded apically 30

30. Palpi, legs, and venter of abdomen light reddish; median abdominal triangles and posterior bands not prominent; length 13–16 mm. *cheliopterus* Rondani
Palpi, legs, and venter of abdomen dark brown, forefemora almost black; abdomen with prominent posterior white bands on sternites and tergites, prominent median triangle on tergites, usually median anterior black spot on tergite 2; length 17–20 mm. *cheliopterus fronto* Osten Sacken

31. Thorax and abdomen dorsally reddish mahogany brown, former with pale longitudinal lines that may or may not be prominent; abdomen above with prominent middorsal pale triangles, those on tergites 3 and 4 extending to preceding tergite, no sublateral spots evident; basal part of third antennal segment distinctly longer than annuli; fore tarsal claws subequal ..... *turbidus* Wiedemann
Thorax and abdomen yellowish brown, former with only faint suggestions of longitudinal lines dorsally; abdomen with yellowish middorsal triangles and faint sublateral pale spots; third antennal

segment with basal and annulate parts about equal; fore tarsal claws equal ..... *johnsoni* Hine

32. Vein R_4 with stump ..... *melanocerus lacustris* Stone
Vein R_4 without stump 33

33. Palpi yellow to grayish orange with mixed black and white hair; basal part of third antennal segment dark brown to black 34
Palpi dark brown to black with black hair; basal part of third antennal segment mostly orange brown ..... *sulcifrons* Macquart

34. Scutellum completely covered with white pile and pollen; median abdominal triangles distinct, no evidence of sublateral pale spots; basal part of third antennal segment distinctly excised above 35
Scutellum with white pile only around margin; median abdominal triangles sometimes nearly obliterated by wide apical bands that may widen laterally into more or less distinct sublateral spots; basal part of third antennal segment very slightly excised above *birdiei* Whitney

35. Face and pleurae gray pollinose; some sternites with wide white bands *molestus* Say
Entire body dark brown to blackish including venter, which has very narrow yellowish incisures ..... *molestus mixis* Philip

36 (24). Abdomen with distinct median triangles on tergites 3, 4, and 5, rarely faint triangle on tergite 2; foretibia bicolored; venter of abdomen with more or less distinct median brown stripe *trimaculatus* Palisot de Beauvois
Abdomen with distinct median triangles on tergites 2, 3, and 4; foretibia unicolorous; venter of abdomen black with strongly contrasting white bands on apices of sternites ..... *trijunctus* Walker

37 (23). Foretibia distinctly bicolored 38
Foretibia unicolorous 39

38. Median triangle on tergite 2 expanded anteriorly and usually widening at anterior margin to form "hour-glass" pattern .... *petiolatus* Hine
Median triangle on tergite 2 not expanded anteriorly and not touching anterior margin ..... *melanocerus* Wiedemann

39. Frontal triangle shiny and somewhat protuberant; genae, pleurae, and sternum brown with concolorous hair; scutellum devoid of white pile or pollen ..... *nigripes* Wiedemann
Frontal triangle neither shiny nor protuberant; genae, pleurae, and sternum yellowish white with gray and white hair; scutellum completely covered with white pile or pollen ..... *molestus* Say

40 (22). Palpus orange brown to brown 41
Palpus yellow ..... *equalis* Hine

41. Third antennal segment with basal part deeply excised above *fusconervosus* Macquart
Third antennal segment with basal part only slightly excised above..42

42. Antennae uniformly orange brown, basal part not excised above; genae gray pollinose with white hair ..... *endymion* Osten Sacken
Antennae brown to black, basal part slightly excised above; genae grayish brown with rufous hairs ..... *rufofrater* Walker

43 (21). Abdomen dorsally with three pale spots on some tergites, spots of median row sometimes contiguous but not forming a parallel-sided stripe 44
Abdomen dorsally with well-defined parallel-sided median pale stripe 53

44. Grayish-black species, 10 mm. or less in length; costal cell hyaline; sublateral abdominal spots rounded and usually completely separated from posterior margins of tergites (*pumilus*, *sparus*, and *sparus milleri*) 45
Brownish, yellowish, or blackish species, 12 mm. or more in length, or if less, costal cell brown; sublateral abdominal spots usually reaching posterior margins on some tergites 47

45. Eye in life or relaxed specimens with two green bands; abdomen somewhat tapered apically; vein R_4 sometimes with short stump *pumilus* Macquart
Eye unbanded or with single green band; abdomen rounded apically; vein R_4 without stump 46

46. Eye unbanded ..... *sparus* Whitney
Eye in life or relaxed specimens with single green band
sparus milleri Whitney

47. Costal cell dark brown or deep yellow 48
Costal cell hyaline or tinged with yellow 50

48. Antenna entirely light orange 49
Antenna with basal part of third segment orange, annulate part black
longiusculus Hine

49. Eye with large and small facets sharply differentiated, line of demarcation pronounced ..... *johnsoni* Hine
Eye with large and small facets not sharply differentiated, line of demarcation vague or obscure ..... *zythicolor* Philip

50. Blackish species; fork and crossveins distinctly margined with brown; costal cell hyaline ..... *birdiei* Whitney
Yellowish or brownish species; fork and crossveins without brown spots although longitudinal veins may be faintly margined with brown; costal cell subhyaline or tinged with yellow 51

51. Eye with areas of large and small facets weakly differentiated
fulvulus Wiedemann
Eye with areas of large and small facets distinctly differentiated .. 52

52. Sublateral abdominal spots large, yellow, often reaching anterior margin of tergites; mesonotum with yellow hair
fulvulus pallidescens Philip
Sublateral abdominal spots small, pale brown, rarely reaching anterior margin of tergites, mesonotum with grayish-brown hair
gracilis Wiedemann

53 (43). Fork with small dark spot ..... *acutus* (Bigot)
Fork clear 54

54. Eye densely pilose, facets nearly uniformly small ..... *bishoppi* Stone
Eye bare or sparsely pilose 55

55. Annulate part of third antennal segment as long or longer than basal part; costal cell colored, sometimes faintly; prescutal lobe usually concolorous with rest of mesonotum 56
Annulate part of third antennal segment shorter than basal part; costal cell hyaline; prescutal lobe usually paler than rest of mesonotum 59

56. Palpus, pleura, and costal cell strongly yellow
quinquevittatus Wiedemann
Palpus white; pleura grayish; costal cell variable 57

57. Costal cell deep brown; small species with abdomen darker apically
mularis Stone
Costal cell rather pale yellowish; abdomen broadly yellowish brown laterally 58

58. Femora gray to black, apical part of tibia and tarsi dark brown or black ..... *nigrovittatus* Macquart
Legs predominantly yellow to reddish yellow with pale hairs except for dark-brown to black hairs on tarsi and apex of tibiae
nigrovittatus fulvilineis Philip

59. Scutellum and thorax concolorous, dark ..... *lineola* Fabricius
Scutellum reddish on posterior margin 60

60. Upper eye facets little differentiated, bare under hand lens; legs predominantly reddish ..... *vittiger guatemalanus* Hine
Upper eye facets much enlarged, at least sparsely pilose under hand lens; forelegs and hindlegs, and sometimes all legs, predominantly infuscated ..... *vittiger schwardti* Philip

Keys to Species of Minor Genera

AGKISTROCERUS

Abdomen distinctly bicolored, reddish gray with broad median black stripe above, lateral margins above and below black; veins in basal two-thirds of wing broadly margined with brown ..... *megerlei* (Wiedemann)
Abdomen uniformly dark brown to black except for pale hairs on lateral margins

of tergites and apical margins of sternites; longitudinal veins extending to base of wing not extensively margined with brown ..... *finitimus* (Stone)

ANACIMAS

Length 13 mm.; brownish with indistinct dark median stripe on abdomen; plate of third antennal segment distinctly convex below, dorsal angle near middle *limbellatus* Enderlein

Length 16 mm.; brown with dark-brown median stripe on abdomen; plate of third antennal segment more elongate, scarcely convex below, dorsal angle rounded and near basal end ..... *geropogon* Philip

HAMATABANUS

1. Abdomen with conspicuous light-gray sublateral spots *carolinensis* (Maequart)

   Abdomen without distinct sublateral spots 2

2. Antennae nearly black, dorsal process of third segment reaching almost to annuli, not curved downward at tip; dorsum of abdomen distinctly darkened medially ..... *annularis* (Hine)

   Antennae mostly orange brown, dorsal process extending slightly beyond base of annuli and distinctly curved down at tip; abdomen not noticeably darkened medially ..... *sexfasciatus* (Stone)

HYBOMITRA

1. Length 19–22 mm.; wing smoky brown, darker along vein margins *cincta* (Fabricius)

   Length 10–15 mm.; wing otherwise 2

2. Mesonotum black, shiny; wing with distinct cloud in region of stigma *hinei wrighti* (Whitney)

   Mesonotum dark brown with mixed white and yellowish-brown hair; wing hyaline ..... *difficilis* Wiedemann

MERYCOMYIA

Length 12 mm.; entire body uniformly brown ..... *brunnea* Stone

Length 19 mm.; abdomen reddish brown, tergites 4 and 5 each with two distinct white patches ..... *whitneyi* (Johnson)

STENOTABANUS

1. Frons of female 4½ to 5 times as high as width at basal callus, slightly widened above; brown species with three rows of faint brownish spots on abdomen ..... *daedalus* Stone

   Frons of female about 2½ times as high as wide at base; brownish or whitish species 2

2. Almost uniformly whitish species, abdomen not marked with dark spots; frons slightly widened above ..... *psammophilus* (Osten Sacken)

   Abdomen dark brown above, posterior margins of tergites, median triangles, and sublateral spots gray with white hairs; frons slightly narrowed above *floridensis* (Hine)

WHITNEYOMYIA

Abdomen above with lateral longitudinal bands of pale vestiture and hairs, sometimes restricted to first three or four tergites; third antennal segment with plate reddish brown ..... *beatifica* (Whitney)

Abdomen and antennae unicolorous, dark brown to black *beatifica atricorpus* Philip

LITERATURE CITED

ANTHONY, D. W.
1957. PYRETHRUM EMULSIONS FOR SURVEYS OF TABANID LARVAE. Jour. Econ. Ent. 50: 740–742.

1960. TABANIDAE ATTRACTED TO AN ULTRAVIOLET LIGHT TRAP. Fla. Ent. 43: 77–80.

1962. TABANIDAE AS DISEASE VECTORS. BIOLOGICAL TRANSMISSION OF DISEASE AGENTS. 192 pp. New York and London.

BAILEY, N. S.
1947. TRICHOPRIA TABANIVORA FOUTS IN MASSACHUSETTS (HYMENOPTERA, DIAPRIIDAE). Psyche 54: 142.

1948. A MASS COLLECTION AND POPULATION SURVEY TECHNIQUE FOR LARVAE OF TABANIDAE (DIPTERA). Brooklyn Ent. Soc. Bul. 43: 22–29.

1949. THE HOVERING AND MATING OF TABANIDAE: A REVIEW OF THE LITERATURE AND SOME ORIGINAL OBSERVATIONS. Amer. Ent. Soc. Ann. 41: 403–412.

BEAL, F. E. L., and MCATEE, W. L.
1927. COMMON BIRDS OF SOUTHEASTERN UNITED STATES IN RELATION TO AGRICULTURE. U.S. Dept. Agr. Farmers' Bul. 755, 44 pp.

BICKLE, R. L.
1958. NOTES ON AEGIALOMYIA PSAMMOPHILA (O. S.) (TABANIDAE: DIPTERA). Fla. Ent. 41: 129–131.

1959. OBSERVATIONS ON THE HOVERING AND MATING OF TABANUS BISHOPPI STONE (DIPTERA, TABANIDAE). Amer. Ent. Soc. Ann. 52: 183–190.

BRENNAN, J. M.
1935. THE PANGONIINAE OF NEARCTIC AMERICA (TABANIDAE, DIPTERA). Kans. Univ. Sci. Bul. 22: 249–401.

BRIMLEY, C. S.
1911. NOTES ON THE LIFE HISTORIES OF TABANIDAE. Ent. News 22: 133.

BROWN, A. W. A., and MORRISON, P. E.
1955. CONTROL OF ADULT TABANIDS BY AERIAL SPRAYING. Jour. Econ. Ent. 48: 125–129.

BRUCE, W. N., and DECKER, G. C.
1951. TABANID CONTROL ON DAIRY AND BEEF CATTLE WITH SYNERGIZED PYRETHRINS. Jour. Econ. Ent. 44: 154–159.

CAMERON, A. E.
1926. BIONOMICS OF THE TABANIDAE (DIPTERA) OF THE CANADIAN PRAIRIE. Bul. Ent. Res. 17: 1–42.

CHAMBERLIN, J. C., and LAWSON, F. R.
1940. A MECHANICAL TRAP FOR THE SAMPLING OF AERIAL INSECT POPULATIONS. U.S. Bur. Ent. and Plant Quar. ET–163, 6 pp.

DOVE, W. E., and PARMAN, D. C.
1935. SCREW-WORMS IN THE SOUTHEASTERN STATES. Jour. Econ. Ent. 28: 765–772.

FAIRCHILD, G. B.
1935. A NEW TABANUS (DIPTERA) FROM FLORIDA. TABANUS CAYENSIS N. SP. Fla. Ent. 18: 53–54.

1937. A PRELIMINARY LIST OF THE TABANIDAE (DIPTERA) OF FLORIDA. Fla. Ent. 19: 58–63 and 20: 10–11.

FATTIG, P. W.
1946. THE TABANIDAE OR HORSEFLIES AND DEERFLIES OF GEORGIA. Emory Univ. Mus. Bul. 4: 1–26.

FRANCIS, E., and MAYNE, B.
1921. EXPERIMENTAL TRANSMISSION OF TULAREMIA BY FLIES OF THE SPECIES CHRYSOPS DISCALIS. U.S. Pub. Health Serv. Rpts. 36: 1738–1746.

GERRY, R. J.
1949. CONTROL OF A SALT MARSH TABANID BY MEANS OF RESIDUAL DDT-OIL SPRAY. Jour. Econ. Ent. 42: 888–890.

GOODWIN, W. J., MOORE III, S., and SCHWARDT, H. H.
1954. HORSE FLY AND HORN FLY REPELLENT TESTS ON CATTLE IN NEW YORK. Jour. Econ. Ent. 46: 1088–1089.
——— SLOAN, M. J., and SCHWARDT, H. H.
1952. REPELLENCY TEST FOR HORSE FLIES AND HORN FLIES IN NEW YORK STATE. Jour. Econ. Ent. 45: 121–122.
HANSENS, E. J.
1956. GRANULATED INSECTICIDES AGAINST GREENHEAD (TABANUS) LARVAE IN THE SALT MARSH. Jour. Econ. Ent. 49: 401–403.
HART, C. A.
1895. ON THE ENTOMOLOGY OF THE ILLINOIS RIVER AND ADJACENT WATER. Ill. State Lab. Nat. Hist. Bul. 4: 220–247.
HINE, J. S.
1903. TABANIDAE OF OHIO WITH A CATALOGUE AND BIBLIOGRAPHY OF THE SPECIES FROM AMERICA NORTH OF MEXICO. Ohio Acad. Sci. Spec. Papers 5, 63 pp.
———
1906. HABITS AND LIFE HISTORIES OF SOME FLIES OF THE FAMILY TABANIDAE. U.S. Dept. Agr., Bur. Ent. Tech. Ser. 12, Pt. 2, 38 pp.
———
1907. SECOND REPORT UPON THE HORSEFLIES OF LOUISIANA. La. Agr. Expt. Sta. Bul. 93, 59 pp.
HOFFMAN, R. A., SMITH, K. O., COLLINS, J. C., and MOTT, L. O.
1961. INSECT CONTROL CAN REDUCE SPREAD OF ANAPLASMOSIS. Miss. Farm Res. 24 (4): 1.
HOWELL, D. E.
1949. PIPERONYL FORMULATIONS AS HORSE FLY REPELLENTS. Jour. Econ. Ent. 42: 401–402, 404.
——— EDDY, G. W., and CUFF, R. L.
1949. EFFECT ON HORSE FLY POPULATIONS OF AERIAL SPRAY APPLICATIONS TO WOODED AREAS. Jour. Econ. Ent. 42: 644–646.
JAMNBACK, H., and WALL, W.
1957. CONTROL OF SALT MARSH TABANUS LARVAE WITH GRANULATED INSECTICIDES. Jour. Econ. Ent. 50: 379–382.
JOHNSON, C. W.
1913. INSECTS OF FLORIDA, I. DIPTERA. Amer. Mus. Nat. Hist. Bul. 32 (Art. 3): 87–90.
JONES, T. H., and BRADLEY, W. G.
1923. OBSERVATIONS ON TABANIDAE (HORSEFLIES) IN LOUISIANA. Jour. Econ. Ent. 16: 307–312.
KNOWLTON, G. F., and ROWE, J. A.
1937. PRELIMINARY STUDIES OF INSECT TRANSMISSION OF EQUINE ENCEPHALOMYELITIS. Utah Acad. Sci., Arts and Letters Proc. 11: 267–270.
LEWIS, L. F.
1955. HORSE FLIES AND DEER FLIES. I MISSISSIPPI STUDIES. U.S. Ent. Res. Branch Monthly Newsletter 1 (July-Aug.), 26 pp. Kerrville, Tex. [Processed.]
——— and JONES, C. M.
1955. THE BIOLOGY OF TABANIDS IN THE YAZOO-MISSISSIPPI DELTA. Jour. Econ. Ent. 48: 609–610.
LOGATHETIS, C., and SCHWARDT, H. H.
1948. BIOLOGICAL STUDIES ON THE HORSE FLIES OF NEW YORK. Jour. Econ. Ent. 41: 335–336.
MACCREARY, D.
1940. REPORT ON THE TABANIDAE OF DELAWARE. Del. Agr. Expt. Sta. Bul. 226, 41 pp.
MORRIS, H.
1918. BLOOD-SUCKING INSECTS AS TRANSMITTERS OF ANTHRAX OR CHARBON. La. Agr. Expt. Sta. Bul. 163, 15 pp.
MOSIER, C. A., and SNYDER, T. E.
1919. NOTES ON THE SEASONAL ACTIVITY OF TABANIDAE IN THE LOWER EVERGLADES OF FLORIDA. Wash. Ent. Soc. Proc. 21: 186–197.
PARMAN, D. C.
1928. EXPERIMENTAL DISSEMINATION OF THE TABANID EGG PARASITE PHANURUS EMERSONI GIRAULT AND BIOLOGICAL NOTES ON THE SPECIES. U.S. Dept. Agr. Cir. 18, 7 pp.

PATTON, W. S., and CRAGG, F. W.
1913. TEXTBOOK OF MEDICAL ENTOMOLOGY. 764 pp., 89 plates. Christian Literature Society for India. London, Madras, and Calcutta.

PECHUMAN, L. L.
1949. SOME NOTES ON TABANIDAE (DIPTERA) AND THE DESCRIPTION OF TWO NEW CHRYSOPS. Canad. Ent. 81: 77–84.

———
1957. DESCRIPTIONS OF TABANIDAE PREVIOUSLY KNOWN FROM ONE SEX ONLY (DIPTERA). Brooklyn Ent. Soc. Bul. 52: 29–34.

PHILIP, C. B.
1931. THE TABANIDAE (HORSEFLIES) OF MINNESOTA WITH SPECIAL REFERENCE TO THEIR BIOLOGIES AND TAXONOMY. Minn. Agr. Expt. Sta. Tech. Bul. 80, 132 pp., illus.

———
1936. NOTES ON CERTAIN MALES OF NORTH AMERICAN HORSEFLIES (TABANIDAE). Brooklyn Ent. Soc. Bul. 31: 189–197.

———
1941. NOTES ON NEARCTIC PANGONIINAE (DIPTERA, TABANIDAE). Wash. Ent. Soc. Proc. 43: 113–130.

———
1942. NOTES ON NEARCTIC TABANINAE. PT. III. THE TABANUS LINEOLA COMPLEX. Psyche 49: 25–40.

———
1947. A CATALOG OF THE BLOOD-SUCKING FLY FAMILY TABANIDAE (HORSEFLIES AND DEERFLIES) OF THE NEARCTIC REGION NORTH OF MEXICO. Amer. Midland Nat. 37: 257–324.

———
1950. CORRECTIONS AND ADDENDA TO A CATALOG OF NEARCTIC TABANIDAE. Amer. Midland Nat. 43: 430–437.

———
1950a. NEW NORTH AMERICAN TABANIDAE (DIPTERA). Pt. II. Tabanidae. Amer. Ent. Soc. Ann. 43: 115–122.

———
1952. NOTES ON TABANID FLIES AND OTHER VICTIMS CAUGHT BY THE CARNIVOROUS PLANT, SARRACENIA FLAVA. Fla. Ent. 35: 151–155.

———
1955. NEW NORTH AMERICAN TABANIDAE. IX. NOTES ON AND KEYS TO THE GENUS CHRYSOPS MEIGEN. Rev. Brasil. Ent. 3: 47–128.

———
1957. NEW RECORDS OF TABANIDAE (DIPTERA) IN THE ANTILLES. Amer. Mus. Novitates, 1858, 16 pp.

———
1960. NEW NORTH AMERICAN TABANIDAE. XII. A NEW VARIETY OF TABANUS IMITANS WALKER. Fla. Ent. 43: 171–174.

———
1961. NEW NORTH AMERICAN TABANIDAE. XIII. CHANGE OF NAME FOR A WELL-KNOWN SPECIES OF CHRYSOPS. Ent. News 62: 160–162.

——— and JONES, C. M.
1962. NEW NORTH AMERICAN TABANIDAE. XV. ADDITIONS TO RECORDS OF CHRYSOPS IN FLORIDA. Fla. Ent. 45: 67–69.

ROTH, A. R., and LINDQUIST, A. W.
1948. ECOLOGICAL NOTES ON THE DEER FLY AT SUMMER LAKE, OREGON. Jour. Econ. Ent. 41: 473–476.

——— and LINDQUIST, A. W.
1952. INCIDENCE AND HABITS OF TABANIDAE AT SUMMER LAKE, OREGON. Jour. Econ. Ent. 45: 527–531.

SANBORN, C. E., STILES, G. W., JR., and MOE, L. H.
1932. PRELIMINARY EXPERIMENTS IN THE TRANSMISSION OF ANAPLASMOSIS BY HORSEFLIES. Okla. Agr. Expt. Sta. Bul. 204, [16 pp.].

SCHOMBERG, O.
1952. LARVAL HABITAT OF TABANUS SULCIFRONS IN OKLAHOMA. Jour. Econ. Ent. 45: 747.

——— and HOWELL, D. E.
1955. BIOLOGICAL NOTES ON TABANUS ABACTOR PHIL. AND EQUALIS HINE. Jour. Econ. Ent. 48: 618–619.

SCHWARDT, H. H.
1931. THE BIOLOGY OF TABANUS LINEOLA FABR. Amer. Ent. Soc. Ann. 24: 409–416.

———
1931a. NOTES ON THE IMMATURE STAGES OF ARKANSAS TABANIDAE. Kans. Ent. Soc. Jour. 4: 1–15.

———
1936. HORSEFLIES OF ARKANSAS. Ark. Agr. Expt. Sta. Bul. 332, 66 pp.
SCOTT, J. W.
1920. EXPERIMENTAL TRANSMISSION OF SWAMP FEVER OR INFECTIOUS ANEMIA BY MEANS OF INSECTS. Amer. Vet. Med. Assoc. Jour. 56: 448–454.
SKUF'IN, K. V.
1949. CONTRIBUTION TO THE ECOLOGY OF TABANIDS IN THE PROVINCE OF VORONEZH. Zool. Zhur. 28: 145–156. [In Russian.] (Abstract) Rev. Appl. Ent. B 41: 18.
SNYDER, T. E.
1917. A PECULIAR HABIT OF A HORSEFLY (TABANUS AMERICANUS) IN THE FLORIDA EVERGLADES. Wash. Ent. Soc. Proc. 19: 141–145.
STONE, A.
1930. THE BIONOMICS OF SOME TABANIDAE (DIPTERA). Amer. Ent. Soc. Ann. 22: 261–304.

———
1938. THE HORSEFLIES OF THE SUBFAMILY TABANINAE OF THE NEARCTIC REGION. U.S. Dept. Agr. Misc. Pub. 305, 172 pp.
TASHIRO, H., and SCHWARDT, H. H.
1949. BIOLOGY OF THE MAJOR SPECIES OF HORSE FLIES OF CENTRAL NEW YORK. Jour. Econ. Ent. 42: 269–272.
——— and SCHWARDT, H. H.
1953. NOTES ON THE BIOLOGY OF TABANUS GIGANTEUS. Jour. Econ. Ent. 46: 681–682.
THORSTEINSON, A. J.
1958. THE ORIENTATION OF HORSE FLIES AND DEER FLIES (TABANIDAE, DIPTERA): I. THE ATTRACTANCE OF HEAT TO TABANIDS. Ent. Expt. Appl. 1: 191–196. [Summary in French.] (Abstract) Rev. Appl. Ent. B 47: 183.
U.S. AGRICULTURAL RESEARCH SERVICE, PLANT PEST CONTROL DIVISION.
1961. [N.T.] Coop. Econ. Insect Rpt. 11: 41–52.
WEBB, J. L., and WELLS, R. W.
1924. HORSE-FLIES: BIOLOGIES AND RELATION TO WESTERN AGRICULTURE. U.S. Dept. Agr. Bul. 1218, 36 pp.

GLOSSARY

Annuli—subdivided part of third antennal segment beyond usually larger first subdivision. (See fig. 17, *B*.)

Apical spot—infuscated spot in apical area of wing concolorous with crossband (*Chrysops* spp.). (See fig. 18, *C*.)

Callus, basal—denuded swelling on lower part of frons, base of which is near level of lower inner angles of eyes. (See fig. 17, *A*.)

Callus, median—swelling above basal callus, usually much narrower and elongate and may or may not be joined to it. (See fig. 17, *A*.)

Dorsal angle—anterior or posterior or both angles of dorsal process on plate of third antennal segment (subfamily Tabaninae). (For posterior angle only, see fig. 17, *B*.)

Fork—furcation of veins R_4 and R_5.

Hyaline triangle—clear area of wing usually triangular in shape and bounded by crossband, apical spot, and trailing edge of wing (*Chrysops* spp.). (See fig. 18, *C*.)

Ocellar tubercle—swelling at vertex on which ocelli, when present (seldom found in subfamily Tabaninae), are situated.

Plate—basal part of third antennal segment (in subfamily Tabaninae). (See fig. 17, *B*.)

Prescutal lobe—antealar or posterolateral lobes of prescutum.

Stump vein—short vein at base of R_1.

Subcallus—area of frons between basal callus and antennae. (See fig. 17, *A*.)

Sublateral pale spots—spots or triangles on dorsal surface of abdomen lateral to median spots or triangles.

INDEX TO SPECIES

Subfamily PANGONIINAE Loew

Subfamily TABANINAE Loew

☆ U.S. GOVERNMENT PRINTING OFFICE: 1964—693-407

END