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# Seasonal emergence and larval habitat characteristics of ceratopogonidae in Tennessee

Daniel S. Root

To the Graduate Council:

I am submitting herewith a thesis written by Daniel S. Root entitled "Seasonal emergence and larval habitat characteristics of ceratopogonidae in Tennessee." I have examined the final electronic copy of this thesis for form and content and recommend that it be accepted in partial fulfillment of the requirements for the degree of Master of Science, with a major in Entomology and Plant Pathology.

Reid R. Gerhardt, Major Professor

We have read this thesis and recommend its acceptance:

J. F. Grant, E. C. Bernard

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Carolyn R. Hodges

Vice Provost and Dean of the Graduate School

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We have read this thesis and recommend its acceptance:

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# SEASONAL EMERGENCE AND LARVAL HABITAT CHARACTERISTICS OF CERATOPOGONIDAE IN TENNESSEE

A Thesis

Presented For The

Master Of Science

Degree

The University Of Tennessee

Daniel S. Root

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## ABSTRACT

The seasonal emergence activity of adult Ceratopogonidae and characteristics of their associated larval habitats were determined using emergence traps placed in muddy habitats in eastern Tennessee during 1985 and 1986. Species of Culicoides were identified to species, all other ceratopogonids were identified only to genus. Larval habitats were classified according to the duration of time each site was inundated with water during the study. The Culicoides spp. collected in order of abundance were C. spinosus Root and Hoffman, C. stellifer (Coquillett), C. baueri Hoffman, C. biguttatus Coquillett, C. venustus Hoffman, C. haematopotus Malloch and C. bickleyi Wirth and Hubert. Small numbers of C. obsoletus (Meigen), C. crepuscularis Malloch and C. variipennis (Coquillett) were also collected. Culicoides baueri, C. bickleyi and C. venustus were collected from sites that contained surface water throughout the study. Culicoides spinosus and C. stellifer were collected from sites of intermediate wetness, while C. haematopotus and C. biguttatus were collected from sites that were wet for less than 3 months each year. Culicoides haematopotus, C. biguttatus and C. bickleyi were present only in the spring while the rest emerged throughout the spring and summer. The effect of variation in site wetness, indicated by the presence of surface water, upon the

seasonal emergence activity of the adult Ceratopogonidae was noted for each species and genus. Culicoides haematopotus, C. spinosus and C. stellifer had extended emergence periods in sites that were wet longer than in sites that dried quickly. Other Culicoides species either occurred only in a particular habitat type or were apparently unaffected by moisture variations.

Seven genera of Ceratopogonidae other than Culicoides were collected between April and October 1986. In descending order of abundance these were Stilobezzia Kieffer, Dasyhelea Kieffer, Palpomyia Meigen, Atrichopogon Kieffer and Bezzia Kieffer. The genera Alluaudomyia Kieffer and Clinohelea Kieffer were collected infrequently. All genera except Atrichopogon and Dasyhelea emerged mostly in the spring. Atrichopogon was common throughout the spring and summer and Dasyhelea occurred mostly in late summer. These Ceratopogonidae were generally not affected by variations in wetness. Stilobezzia, however, had a second emergence peak in sites that remained wet for the majority of the season.

## TABLE OF CONTENTS

## LIST OF TABLES

LIST OF FIGURES

## CHAPTER I

## INTRODUCTION

### i - *Culicoides* Biting Midges

*Culicoides* biting midges, also known as punkies, no-see-ums or sand flies, are blood-sucking nematocerous Diptera of the family Ceratopogonidae. The adults are small but robust flies ranging from 0.9-2.0 mm in length and are light tan or gray to dark brown or black in color. Wings of this genus are characterized by various patterns of light patches on a dark background. The legless larva is narrow and elongate with a heavily sclerotized head capsule.

The taxonomy of adult *Culicoides* has been well studied. Wirth (1965) listed 97 species of *Culicoides* for America north of Mexico. Keys to the adults of 36 of the common *Culicoides* of Virginia have been published (Battle and Turner 1971). The *Culicoides* fauna of the Tennessee river basin have been well studied by Snow and co-workers (Pickard & Snow 1952, Snow et al. 1955). Only a single generic key to the larvae has been published (Glukhova 1979). No other published taxonomic keys are available, although specific descriptions are available (Kettle 1977, Linley 1970, Kettle and Elson 1975, Kettle and Elson 1976, Kettle and Elson 1978). The lack of an effective taxonomy for larvae has impaired research efforts directed at the larval stage (Kettle 1977).

The female Culicoides biting midge is the blood-feeding stage. In general, host seeking and feeding occurs in the evening hours or just before dawn although some species are day-feeding (Gerhardt 1986, Hayes et al. 1984, Humphreys and Turner 1973, Schmidtmann et al. 1980, Zimmerman and Turner 1983b). Blood sources can be mammals or birds (Kettle 1977, Humphreys and Turner 1973, Zimmerman and Turner 1983b). Most species, however, have some degree of host specificity (Bennett 1960, Schmidtmann et al. 1980, Tanner and Turner 1974, Hair and Turner 1968).

Culicoides are known vectors of several disease organisms (Foil et al. 1984, Pinheiro et al. 1982, Kettle 1977, Kramer et al. 1985a, Mullen et al. 1985a, Mullen et al. 1985b, Walker 1977). In North America, Culicoides spp. are confirmed vectors of blue-tongue virus (BTV) and epizootic hemorrhagic disease (EHD) of domestic and wild ruminants (Jones et al. 1977, Jones et al. 1983, Mullen et al. 1985a). Bluetongue virus is responsible for losses in cattle production and EHD can cause severe die-off in white-tailed deer populations (Fox and Pelton 1973, Jones et al. 1981). Two species, C. variipennis (Coquillett) and C. insignis Lutz, are believed to be the primary vectors of BTV and EHD in the United States, although C. insignis has not been confirmed by experiment as a vector (Kramer et al. 1985a, Kramer et al. 1985b, Mullens and Schmidtmann 1982).

Other species have been found to be capable of harboring the virus but their ability to transmit these pathogens is unknown (Jones et al. 1983, Mullen et al. 1985b).

In addition to their ability to transmit disease organisms, *Culicoides* females can cause great suffering to humans utilizing recreational facilities, sometimes actually forcing people to abandon these areas (Kettle 1977). Their effect on tourism has been documented (Linley and Davies 1971, Wood and Kline 1984). In one survey from the coastal areas of North Carolina, *Culicoides* biting midges were considered a more important pest of humans than were the Tabanidae or Culicidae (Gerhardt et al. 1973).

Information on the biology of the species in this genus generally has come from light or animal-baited trapping for the purposes of determining faunal lists, seasonal occurrences, or host preferences (Bennett 1960, Gerhardt 1986, Kline and Roberts 1982, Kline 1986, Messersmith 1966, Pickard and Snow 1952, Snow et al. 1955, Tanner and Turner 1975, Williams 1955, Wirth and Bottimer 1956, Zimmerman and Turner 1983a,b). Although these trapping methods are sound and provide useful data, the collections can be seriously affected by variations in meteorological conditions or moon phases (Kline and Axtell 1976). These methods may also bias the collections in favor of the more active females, especially in host-baited traps (Kline and Axtell 1976, Tanner and Turner 1975).

Several salt marsh Culicoides species such as C. furens (Poey), C. bermudensis Williams and C. hollensis (Melanderand Brues) have been studied intensively with emergence traps (Kline and Axtell 1976, Kline and Roberts 1982, Linley et al. 1970). These emergence traps provide more detailed information concerning the seasonal abundance, voltinism, and spatial distributions of these species (Kline and Axtell 1976, Kline and Axtell 1977, Kline and Roberts 1982, Kline 1986, Linley et al. 1970). Similar studies have been conducted in the inland habitats where C. variipennis occurs (Barnard 1980, Mullens and Rutz 1984). Emergence trapping has not been applied to the inland species except as aids in faunal collections or in basic larval habitat surveys (Murray 1957, Williams 1955).

Larval Culicoides spp. occur in semi-aquatic or aquatic habitats such as ponds, creeks, and spring margins, wet meadows or poorly drained depressions (Kettle 1977). Most species are believed to be predaceous although a few are detritivores (Kettle 1977). Larvae have been reared to adults using the nematode Panagrellus as a food source (Davis et al. 1983, Kettle et al. 1975, Mullens and Schmidtmann 1981).

Research concerning the larvae of Culicoides has been primarily concerned with descriptions of larval habitats. General descriptions based upon visual observations were initially the only means of classification (Battle and

Turner 1969, Battle and Turner 1970, Jones 1961, Kline and Greiner 1985, O'rourke et al. 1983, Rowley 1967, Williams 1964, Wood and Kline 1984). Investigators have examined chemical characteristics such as organic matter, pH, and salinity (Battle and Turner 1972, Kardatzke and Rowley 1971, Rowley 1967). An intensive use of soil analyses to determine key chemical factors in larval habitats was made in Virginia (Battle and Turner 1972). In all of these instances, however, the lack of uniformity and consistency in classifications has prevented comparisons between separate research efforts and geographical regions (Kettle 1977).

### ii - Other Ceratopogonids

Ceratopogonids other than the blood-feeding genera *Culicoides*, *Leptoconops* and *Forcipomyia* have received very little research attention. Most ceratopogonids are not of known economic importance, although some species are important in the pollination of rubber plants and cocoa in the tropics (Bystrak and Wirth 1978). Taxonomically, only the adults of the major genera have had modern specific revisions (Downes and Wirth 1981, Wilkening et al. 1985, Wirth 1952, Wirth 1962, Wirth 1983). Inclusive keys to the specific fauna are still lacking (Kettle 1978). Larval identification to genus is possible only for the Russian fauna (Glukhova 1979).

Ceratopogonid adults are considered to be primarily insectivorous, but one genus Dasyhelea is exclusively nectar-feeding (Downes and Wirth 1981). The larvae of Alluaudomyia, Bezzia, Palpomyia and Stilobezzia have been reared in the laboratory to adults using nematodes as food and are thought to be predaceous (Kettle 1977). The food sources of the other genera are unknown. Larval habitats of the ceratopogonids, other than the blood-feeding genera, are known mostly from specimens reared in the laboratory from field collected material. Many of these records are from single collections and thus their representative status is in question.

Seasonal occurrence of these insects is known superficially from notes in taxonomic treatments. One light trap study, conducted over a 2 year period in Connecticut, collected 16 genera and 82 species of Ceratopogonidae but only 8 species from 3 genera occurred in sufficient numbers to allow conclusions to be made concerning seasonal abundance (Lewis 1959).

# CHAPTER II

## SEASONAL EMERGENCE AND LARVAL HABITAT CHARACTERISTICS OF CULICOIDES (DIPTERA: CERATOPOGONIDAE) SPECIES IN TENNESSEE


### i - Abstract

Ten species of *Culicoides* Latreille were collected by emergence traps placed in wet soil habitats in eastern Tennessee in 1985 and 1986. The species, in descending order of abundance, were *C. spinosus*, *C. stellifer*, *C. baueri*, *C. biguttatus*, *C. venustus*, *C. haematopotus* and *C. bickleyi*. *Culicoides obsoletus*, *C. crepuscularis* and *C. variipennis* were collected infrequently. Seasonal adult emergence activity and larval habitat characteristics were determined for each species. Larval habitats were categorized according to the duration of time each site was inundated with water from April to October of both years of the study. The effect of variations in the duration of surface water on adult emergence and species abundance is documented.


### ii - Introduction

Seasonal abundance and larval habitats of many inland *Culicoides* species are known from light trap and laboratory emergence studies (Battle and Turner 1969, Battle and Turner

1972, Lewis 1959, Messersmith 1965, Murray 1957, Pickard and Snow 1959, Tanner and Turner 1975, Williams 1955, Zimmerman and Turner 1983a). Some of the limitations of these methods have been discussed (Kline and Axtell 1976). Field emergence data are considered to be a more accurate method of monitoring seasonal abundance and voltinism and directly associates specific larval habitats (with the Culicoides spp. present) (Kline & Axtell 1976, Linley et al. 1970).

Snow and co-workers have studied the adult host-seeking activity and specific fauna of many of the Culicoides species of the Tennessee river basin (Pickard and Snow 1952, Snow et al. 1955). However, no attention has been directed to describing the larval habitats of Culicoides in Tennessee.

The objectives of the present study were to monitor the seasonal emergence of Culicoides in eastern Tennessee and to characterize their larval habitats.

## iii - Materials and Methods

Culicoides adult emergence was monitored at 15 separate sites in 1985 and 24 in 1986. The collection sites were located in 4 areas of eastern Tennessee: 1) Grasslands Farm (GF), Plateau Experiment Station, 7 sites, Crossville, Cumberland Co., 2) The University of Tennessee Cherokee Woodlot (CW), 4 sites, Knoxville, Knox Co., 3) W. W. Stanley Farm (SF), Rafter, 4 sites, Monroe Co., and 4)

Cades Cove (CC), Great Smoky Mountains National Park, 10 sites, Blount Co. These four areas represent three physiographic provinces of Tennessee; 1) Cumberland Plateau (GF), 2) Ridge and Valley Province (CW), and 3) Unica Mountain province (SF and CC). At all sites, the ground water level was above or within 2-3 cm of the surface of the habitat for 3 to 9 months during the trapping season. Habitats included pond margins, spring and creek margins, and marsh-like depressions in pastures and woodland.[1]

Emergence traps used in this study were constructed from #10 food cans, 15 cm diameter x 17.5 cm in height (3 liter volume) opened at one end. A 3.75 cm diameter hole was drilled in the side of the can ca. 2 cm below the closed top. A 5 x 6 cm cellulose acetate strip covered with a thin layer of Stickem® adhesive (Seabright Enterprises, Emeryville, CA) on one side was then placed over the opening, the sticky side facing into the traps and held in position by duct tape. Each trap sampled a 200 $cm^2$ area of substrate.

Traps were placed in the ground with the open end thrust 4 to 6 cm into the mud. Each site consisted of a zone of habitat that had homogeneous moisture conditions as near as could be determined by visual inspection. Sites varied in areas from 1 $m^2$ to 1.5 hectares and the distance between traps ranged from 0.25 m to 20 m. Where space

[1]General descriptions of all sites are in Appendix B.

allowed (any site area greater than ca. 20 $m^2$), ten traps were operated. Smaller sites were trapped with fewer cans. The numbers of traps used in this study were 185 and 189 for the 1985 and 1986 trapping seasons, respectively.

Sites were visited weekly, the strips changed, and taken into the laboratory, and the traps replaced into the mud within ca. two trap diameters (45 cm) of the previous position. Emergence was monitored from mid-May to early November 1985 and from mid-March to late October in 1986.

Culicoides larval habitats were categorized according to the length of time these were wet between March and October of each year (Table 1).[2] Type 1 habitats were completely inundated with water constantly during the study period. Many of these sites were the margins of permanent springs, creeks, and ponds. Type 2 habitats were similar to Type 1 but also included temporary pools and overflow areas near streams. These sites were wet for 6 to 7 months. Type 3 habitats were typically wet meadow sites that were inundated for 4 to 5 months during the 8 months of trapping. Type 4 habitats contained water for only 2 to 3 months. These latter sites were very dry by the onset of summer and did not refill until late in the fall.

Adult Culicoides were removed from the sticky strips in the laboratory with a drop of Histoclear® solvent (National Diagnostics, Somerville, NJ) on each adult stuck

[2]All Tables and Figures can be found in Appendix A.

to the strip, rinsed for 2 minutes in 95% alcohol, then slide-mounted or stored in 70% alcohol until identified. All species were identified using the keys listed in Battle and Turner (1971). Emergence data were adjusted to the number of adults collected per trap (200 $cm^2$) for each week of the study.

## iv - Results and Discussion

A total of 2474 adults in ten species of Culicoides was collected during this study. The species in descending order of abundance were C. spinosus Root and Hoffman (32%), C. stellifer (Coquillett) (21%), C. biguttatus (Coquillett) (13%), C. baueri Hoffman (12%), C. venustus Hoffman (9%), C. haematopotus Malloch (8%) and C. bickleyi Wirth and Hubert (4%). A small number (less than 2%) of C. obsoletus (Meigen), C. crepuscularis Malloch and C. variipennis (Coquillett) were also collected.

Culicoides spinosus was collected in 5 of the 15 sites in 1985 and 23 of the 24 sites in 1986. In both years it was the most numerous and widely collected species. Large numbers were collected from all larval habitat types. However, the majority of adults emerged from Type 3 sites (Tables 2 and 3). The seasonal variations in surface water content of the breeding habitats had an effect upon this species' adult emergence activity (Fig. 1).[3] In the

[3] Supplemental emergence data for all sites are included in Appendix C.

permanent Type 1 habitats emergence was in several peaks from April through July. Emergence from the Type 3-4 sites occurred in a large peak beginning in April and continuing to the first week of June. Parity data for this species are not available, but from the duration of adult emergence data C. spinosus may be monovoltine.

In Virginia C. spinosus was reared in the laboratory from a wide range of habitats but in low numbers (Battle and Turner 1972). Culicoides spinosus adult females have been collected by light traps from April to August in Virginia, with peak activity in June (Messersmith 1966).

Culicoides stellifer was trapped from 2 of the 15 sites in 1985 and from 22 of the 24 sites in 1986. The majority of adults emerged from the Type 1 sites in 1985 and the Type 3 in 1986 (Tables 2 and 3). Variations in adult emergence activity were noted between Type 1-2 and Type 4 habitats. The duration of emergence, however, was limited in the Type 4 sites (Fig. 2). Adults were collected from June through August in Type 1 and 2 sites and from May to June in the Type 4 sites. Typically, peak emergence occurred during June or early July. From these data, C. stellifer may be monovoltine in Tennessee.

Previous light trap studies of adult activity collected this species from April or May to September in Virginia and Tennessee (Pickard and Snow 1952, Messersmith 1966, Zimmerman and Turner 1983a, and Tanner and Turner 1973).

Emergence data from this study do not agree with the determination of multivoltinism in C. stellifer made from collections in Virginia (Zimmerman and Turner 1983a). However, collections in Connecticut were similar to the observations of this study (Lewis 1959).

Culicoides baueri was collected from 2 of 15 sites in 1985 and 3 of the 24 sites trapped in 1986. Most adults were collected in Type 1 sites in both years of the study (Tables 2 and 3). No adults were collected from Type 4 sites in 1986. The three sites where this species was abundant were well-shaded, spring-fed habitats at the margins of clean, slightly flowing springs. One of these sites was located in the Cades Cove area, the other 2 in the Cherokee woodlot. At the Cades Cove site, this species was found with small numbers of C. venustus (22%) and C. stellifer (18%). At the Woodlot sites, C. spinosus (14%), C. haematopotus (12%) and C. stellifer (11%) were also present. Adult emergence of C. baueri occurred in seven peaks, from May through September (Fig. 3). This discrete emergence at the consistent intervals (4 to 5 weeks) approximate known larval delopment times for other species and implies that C. baueri is multivoltine.

Similar seasonal abundance results were found in previous light trap collections (Pickard and Snow 1952, Messersmith 1966), and similar larval habitat observations were noted by Jones (1961).

*Culicoides biguttatus* was collected from 5 or the 15 sites in 1985 and 21 of 24 sites in 1986. In 1985, most adults were collected from Type 4 sites while in 1986, the majority was collected from Type 3 sites (Tables 2 and 3). In this study, large numbers of *C. biguttatus* were trapped along with numerous *C. stellifer* and *C. spinosus*, usually in sunlit areas. This species was most abundant in seasonal wet meadows in the cattle pastures of the Grasslands Farm areas. Adults emerged from all sites from April to June with the largest peak in May (Fig. 4). From the limited adult emergence period during this study monovoltinism in *C. biguttatus* in Tennessee is strongly indicated.

Previous light trap studies in Virginia and Tennessee, provided similar abundance results (Pickard and Snow 1952, Messersmith 1966, Zimmerman and Turner 1983). This species is considered to be monovoltine in Virginia (Zimmerman and Turner 1983a). Battle and Turner (1972) and Hair et al. (1966) reared *C. biguttatus* from a wide variety of habitats, all shaded areas, and either alone or with low numbers of *C. stellifer*, *C. spinosus* and *C. haemotopotus*.

*Culicoides venustus* was collected from 7 of 15 and 11 of 24 sites in 1985 and 1986, respectively. The greatest numbers were trapped from Type 1 sites in both years (Tables 2 and 3). *C. venustus* was not collected from the Grasslands Farm area.

Adults emerged from May to October in 1986 with the majority trapped in May and June (Fig. 5). Light trap collections from Tennessee and Virginia had similar results (Pickard and Snow 1952, Zimmerman and Turner 1983a). This emergence activity may be an indication that *C. venustus* is multivoltine or occurs in overlapping generations in Tennessee. Zimmerman and Turner (1983a) suggested that this species was multivoltine in Virginia.

*Culicoides haematopotus* was trapped from 4 of 15 sites in 1985 and 22 of the 24 sites in 1986. The late start in the 1985 trapping season probably accounts for the small collections from that year. Most *C. haemotopotus* adults were collected from Type 1 and Type 4 sites in 1985 and 1986, respectively (Tables 2 and 3). No adults were collected from Type 2 and 3 sites in 1985. Of the two sites where this species was most abundant in 1986, one was a small oxbow pond at the Cades Cove area, Type 1, and the other was a seasonally wet meadow, Type 4, at the Grassland Farm area. In both of these sites *C. haematopotus* was the only *Culicoides* collected except for an emergence of *C. biguttatus* in the Grassland Farm area in 1985. In other sites, *C. haematopotus* existed with abundant populations of *C. spinosus*, *C. stellifer* and *C. biguttatus*. The emergence activity from these areas was distinctly different (Fig. 6). In the Type 1 site, adults emerged from May through October with a peak emergence in July and minor peaks occurring in May and October. Emergence from the wet meadow was limited to April through July with a large peak occurring in late April.

Seasonal activity of C. haemotopotus from the Type 4 site was very similar to previous seasonal abundance studies (Pickard and Snow 1952, Messersmith 1966, Tanner and Turner 1973). Tanner and Turner (1973) considered this species to be monovoltine in Virginia, however, from the emergence data in this study this species may be multivoltine when conditions are favorable.

Culicoides bickleyi was collected from 11 of the 24 sites in 1986. No adults were trapped in 1985. Approximately 80% were collected from only two sites. One of the two was the margin of a pond at the Grassland Farm area that did not have contact with cattle. The other was a spring-fed creek bed 0.2-0.5 meters wide at the W. W. Stanley Farm. Both of these sites were Type 1 habitats. The remainder of the adults were found in the Type 1 sites but a few were caught from Type 2 sites (Tables 2 and 3). Similar numbers of both C. spinosus and C. stellifer were present at these sites.

Adults were collected from April to September with two major peaks occurring in May and late July (Fig. 7). Jamnback (1965) considered C. bickleyi to be an early spring species and Tanner and Turner 1973 collected adults by light-traps and D-vac from May through July. No parity data exist at present, but from these data it is possible that two generations of this species occur in Tennessee. Due to low numbers collected during 1986 a definite conclusion is not possible.

The species C. haematopotus, C. biguttatus and C. spinosus are capable of utilizing the very temporary Type 4 habitats. These species must be able to avoid or resist the drying conditions by a resistant larva or egg. In the tropics, another ceratopogonid of the genus Dasyhelea inhabits temporary pools of rainwater and has a larva that can endure the dry conditions until the pools refill (Cantrell and McLachlan 1982). It is possible that a similar phenomenon is occurring with these inland species.

Culicoides baueri, C. bickleyi and C. venustus are most abundant in sites that are essentially permanent and very wet and tend to have more than one generation in a year. These species do, however, occur in some of the very temporary sites.

Preferences for zones of habitat of variable moisture characteristics are documented for some of the salt-marsh Culicoides species. Culicoides bermudensis, C. furens and C. hollensis are correlated with marsh land that is inundated by tides for 6% to 12%, 13% and 19% to 36% of each year, respectively (Kline and Axtell 1977). It is possible that the inland Culicoides species respond to surface water variations in a similar manner.

# CHAPTER III

# SEASONAL EMERGENCE AND LARVAL HABITATS OF NON-BLOODSUCKING CERATOPOGONIDAE (DIPTERA) IN TENNESSEE

## i - Abstract

Seasonal emergence and larval habitats for seven genera of Ceratopogonidae were determined with emergence traps placed in marshy and swampy habitats in eastern Tennessee. The genera collected were, in descending order of abundance, *Stilobezzia*, *Dasyhelea*, *Palpomyia*, *Atrichopogon* and *Bezzia*. *Alluaudomyia* and *Clinohelea* were collected infrequently. Larval habitats were classified into four types according to the duration of time these sites contained surface water from April to October of 1985 and 1986. The effect of seasonal water variations on the emergence activity and relative abundance of the genera was documented.

## ii - Introduction

The majority of literature concerning the dipteran family Ceratopogonidae, except for the bloodsucking genera, is basically taxonomic in nature. The biological information that exists for the fauna of the Nearctic Region is a result of collectors' field notes or basic summaries in taxonomic studies (Downes & Wirth 1983). In a two year light trap study in Connecticut, a total of 16 genera and 82 species was collected. Only eight species from three genera, however, were collected in sufficient numbers to determine seasonal abundance (Lewis 1959).

The purpose of the present study was to monitor the seasonal emergence of non-bloodsucking ceratopogonids in eastern Tennessee and to characterize their larval habitats.

## iii - Materials and Methods

Ceratopogonid adult emergence was monitored at 15 separate sites in 1985 and 24 in 1986. The collection sites were located in 4 areas of eastern Tennessee: 1) Grasslands Farm (GF), Plateau Experiment Station, 7 sites, Crossville, Cumberland Co., 2) The University of Tennessee Cherokee Woodlot (CW), 4 sites, Knoxville, Knox Co., 3) The W. W. Stanley Farm (SF), Rafter, 4 sites, Monroe Co., and 4) Cades Cove (CC), Great Smoky Mountains National Park, 10 sites, Blount Co. The four areas represent three physiographic provinces of Tennessee; 1) Cumberland Plateau (GF), 2) Ridge and Valley Province (CW), and 3) Unica Mountain Province (SF and CC). At all sites the ground water level was above or even with the surface of the habitat for 3 to 9 months during the trapping season. Habitats included pond margins, spring and creek margins, and marsh-like depressions in pastures and woodland.

Emergence traps were constructed from #10 food cans (height 17.5 cm, diameter 15 cm, 3 liter volume) opened at one end. A 3.7 cm diameter hole was drilled in the side of the can ca. 2 cm below the closed top. A 5.0 cm x 6.2 cm cellulose acetate strip covered with a thin layer of Stickem® adhesive (Seabright Enterprises, Emeryville, CA) on one side was then placed over the opening, the coated side facing into the trap, and held in position by duct tape. Each trap sampled from a 200 $cm^2$ area of substrate.

Traps were placed in the sites with the open end thrust 4 to 6 cm into the mud. Each site consisted of a zone of habitat that had homogenous moisture conditions as near as could be determined by visual inspection. Sites varied in size from 1 $m^2$ to 1.5 hectares. Where space allowed (area greater than 20 $m^2$), ten traps were operated. Smaller sites were trapped with fewer cans. The numbers of traps used in this study were 150 and 212 for the 1985 and 1986 trapping seasons, respectively. Sites were visited weekly, the strips changed and taken into the laboratory, and the traps replaced into the mud within ca. 2 trap diameters (45 cm) of the previous position. Emergence was monitored from mid-May to early November 1985 and from mid-March to late October in 1986. Monitoring of surface water variations began in April of both years.

Ceratopogonid larval habitats were classified according to the duration of time these were wet from March to October of 1985 and 1986 (Table 1). Type 1 habitats were inundated with water during the entire 8 month period. Many of these sites were the margins of permanent springs, creeks, or ponds. Type 2 habitats were wet for 6 to 7 months and included habitats similar to Type 1 and temporary pools and the overflow areas near streams. Type 3 habitats were inundated for 4 to 5 months and were typically wet meadow sites in pastures. Type 4 habitats contained water for only 2 to 3 months. These sites were very dry by June and did not refill with water until November or December.

Adult Ceratopogonidae were removed from the sticky strips in the laboratory with Histoclear® solvent (National Diagnostics, Somerville, NJ) rinsed in 95% alcohol for 2 minutes, then slide-mounted or stored in 70% alcohol until identified. All genera were identified using the keys by Downes and Wirth (1981). Emergence data were adjusted to the number of Ceratopogonids collected per trap (200 cm) for each week of the study.

## iv - Results and Discussion

A total of 1796 adult midges from seven genera of the family Ceratopogonidae was collected in emergence traps in 1986. In descending order of abundance these were: *Stilobezzia* Kieffer (28%), *Dasyhelea* Kieffer (25%), *Palpomyia* Meigen (17%), *Atrichopogon* Kieffer (15%) and *Bezzia* Kieffer (13%). Two genera *Clinohelea* Kieffer (10%)

and Alluaudomyia Kieffer (0.5%) were trapped infrequently. Due to taxonomic confusion specific determinations were not made at this time. No collections of these genera were made in 1985.

Stilobezzia was collected from all 24 sites trapped in 1986. The majority of the adults of this genus emerged from Type 3 sites (Table 4). Traps at the W. W. Stanley Farm area collected the largest numbers of this genus. Adults emerged in 6 peaks, from May to September in the Type 1 sites (Fig. 4). In the Type 4 sites there was a shorter duration of emergence from May to July with major peaks in May and June (Fig. 8). In Connecticut, S. lutea Malloch was found to occur from May to July (Lewis 1959). It is likely that more than one species or generation is present in the collections taken during this study.

Dasyhelea was collected from 20 of the 24 sites in 1986. Most adults were trapped from sites fitting the Type 2 classification (Table 4). Adults of this genus were most abundant in sites characterized by open mud with a thin layer of algal growth on its surface. In this study, Dasyhelea adults emerged mainly in May, July and August with small numbers present from May through September when all sites were considered (Fig. 9, See Appendix C for other emergence data). Similar seasonal abundance results were obtained for two species, D. ancora Coquillett and D. grisea Coquillett, in Connecticut (Lewis 1959). This genus is known to inhabit algal mats in a variety of aquatic habitats (Waugh and Wirth 1976).

The genus Palpomyia was trapped from 23 of the 24 sites in 1986. The majority of adults (75%) was collected from Type 1 sites (Table 4). The genus was most abundant in the Cherokee Woodlot area: a swampy creek flowage in which bald cypress trees were planted in the early 1960's. Adults typically emerged from May through September with two major peaks in May and August (Fig. 10).

Atrichopogon was also collected from 23 of the 24 sites in 1986. The majority of adult midges (55%) was found in Type 1 sites (Table 4). This genus was abundant at the W. W. Stanley Farm area and from two sites in the Cades Cove area. All were spring-fed sites with muddy sediments as the substrate. Vegetation was not present where adults were collected. Adults emerged from May to October with two major peaks in June and July (Fig. 11). The major emergence of Atrichopogon in Connecticut occurred during July and August (Lewis 1959).

Bezzia was collected from 23 of the 24 sites in this study during 1986. Most adults were trapped from Type 2 habitats (Table 4). This genus was widespread at the sites trapped. Adults typically emerged from May to August, when all sites were considered (See Appendix C). The major emergence occurred in May although in five sites in the SF and CC area, a smaller peak followed in July (Fig. 12).

Both Alluaudomyia and Clinohelea were collected from 11 of the 24 sites in 1986. The total numbers of these two genera collected were insufficient to make seasonal abundance conclusions; however, adults were only trapped from sites in the Type 1 and Type 2 classifications (Table 4). Clinohelea was trapped equally from both Type 1 and Type 2 sites, while Alluaudomyia was mostly collected from Type 1 sites (Table 4). Species of these genera apparently cannot utilize the more temporary sites.

In general, species of these seven ceratopogonid genera prefer the more permanent Type 1 and 2 sites. Members of the genus Bezzia, however, were the most abundant in the Type 4 sites and Stilobezzia spp. were collected in large numbers from Type 3 sites. Members of these two genera must be capable of resisting the dry conditions during a few months of each year. A Dasyhelea sp. which inhabits temporary rain pools in the tropics has been documented as having a resistant larva that can survive in the dry soil between wet periods. (Cantrell and McLachlan 1982). Species of Stilobezzia and Bezzia may also have an equivalent ability.

# REFERENCES CITED

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Barnard, D. R. 1980. Assessment of diel emergence in Culicoides variipennis. Ann. Entomol. Soc. Am. 73:367-368.

Battle, F. V. and E. C. Turner, Jr. 1971. The Insects of Virginia, No. 3. A systematic review of the genus Culicoides (Diptera: Ceratopogonidae) of Virginia, with a geographic catalog of the species occurring in the eastern United States north of Florida. Va. Polytech. Inst. and State Univ. Res. Div. Bull. 44, 129 pp.

Battle, F. V. and E. C. Turner, Jr. 1969. New records of Virginia Culicoides (Diptera: Ceratopogonidae). Va. J. Sci. 20:44-46.

Battle, F. V. and E. C. Turner, Jr. 1970. Culicoides (Diptera: Ceretopogonidae) reared from breeding site collections in North Carolina with a summary of the species occurring in that state. Mosq. News 30:425-427.

Battle, F. V. and E. C. Turner, Jr. 1972. Some nutritional and chemical properties of the larval habitats of certain species of Culicoides (Diptera: Ceratopogonidae). J. Med. Entomol. 9:32-35.

Bennett, G. F. 1960. On some ornithophilic blood-sucking Diptera in Algonquin Park, Ontario, Canada. Can. J. Zool. 38:377-389.

Boreham, M. M. 1981. A new method for sampling mangrove mud for Culicoides larva and pupae, with notes on factors affecting its use. Mosq. News 41:1-6.

Bystrak, P. G. and W. W. Wirth. 1978. The North American species of Forcipomyia, subgenus Euprojoannisia (Diptera: Ceratopogonidae) Tech. Bull. U. S. Dept. Agric. 1591:1-58.

Cantrell, M. A. and A. J. McLachlan. 1982. Habitat duration and Dipteran larvae in tropical rain pools. Oikos 38:343-348.

Davis, E. L., D. L. Kline, J. F. Reinert, R. H. Roberts and J. F. Butler. 1983. Development of immature Culicoides mississippiensis (Diptera: Ceratopogonidae) in the laboratory. Ann. Entomol. Soc. Am. 76:918-924.

Downes, J. A. and W. W. Wirth. 1981. Chapter 28. Ceratopogonidae. Pp. 393-421. In McAlpine, J. Fetal., eds., Manual of Nearctic Diptera. Vol. 1, Agric. Canada Monogr. 27. Ottawa. 674 pp.

Foil, L., D. Stage and T. R. Klei. 1984. Assessment of wild-caught Culicoides (Ceratopogonidae) species as natural vectors of Onchocerca cervicalis in Louisianna. Mosq. News 44:204-206.

Fox, J. R. and M. R. Pelton. 1973. Observations on a white-tailed deer die-off in The Great Smoky Mountains National Park. Proc. 27th. Ann. Conf. S. E. Game and Fish Comm. 1973. pp. 297-301.

Gerhardt, R. R. 1986. Culicoides spp. attracted to ruminants in The Great Smoky Mountains National Park, Tennessee. J. Agric. Entomol. 3:192-197.

Gerhardt, R. R., J. C. Dukes, J. F. Falter and R. C. Axtell. 1973. Public opinion on insect pest management in coastal North Carolina. N. C. Agric. Ext. Serv. Misc. Publ. No. 97, 81 pp.

Glukhova, V. M. 1979. Larval midges of the subfamilies Palpomyiinae and Ceratopogoninae of the fauna of the U. S. S. R. Nauka Publishers, Leningrad. 230 pp.

Hair, J. A. and E. C. Turner, Jr. 1968. Preliminary host preference studies on Virginia Culicoides (Diptera: Ceratopogonidae). Mosq. News 28:103-107.

Hayes, M. E., G. R. Mullen and K. E. Nusbaum. 1984. Comparison of Culicoides spp. (Diptera: Ceratopogonidae) attracted to cattle in an open pasture and bordering woodland. Mosq. New 44:368-370.

Humphreys, J. G. and E. C. Turner, Jr. 1973. Blood-feeding activity of female Culicoides (Diptera: Ceratopogonidae). J. Med. Entomol. 10:79-83.

Jamnback, H. 1965. The Culicoides of New York State (Diptera: Ceratopogonidae). N. Y. State Mus. Sci. Bull. 399. 154 pp.

Jones, R. H. 1961. Observations on the larval habitats of some North American species of Culicoides (Diptera: Ceratopogonidae). Ann. Entomol. Soc. Am. 54:702-710.

Jones, R. H., A. J. Luedke, T. E. Walton and H. E. Metcalf. 1981. Bluetongue in The United States, an entomological perspective toward control. World Anim. Rev. 38:2-8.

Jones, R. H., R. D. Roughton, N. M. Foster and B. M. Banda. 1977. Culicoides, The vector of epizootic hemorrhagic disease in white-tailed deer in Kentucky in 1971. J. Wildl. Dis. 13:2-8.

Jones, R. H., E. T. Schmidtmann and N. M. Foster. 1983. Vector-competence studies for bluetongue and epizootic hemorrhagic disease viruses with Culicoides venustus (Ceratopogonidae). Mosq. News 43:184-186.

Kardatzke, J. T. and W. A. Rowley. 1971. Comparison of Culicoides larval habitats and populations in Central Iowa. Ann. Entomol. Soc. Am. 64:215-218.

Kettle, D. S. 1977. Biology and bionomics of bloodsucking ceratopogonids. Ann. Rev. Entomol. 22:33-51.

Kettle, D. S. and M. M. Elson. 1976. The immature stages of some Australian Culicoides Latreille (Diptera: Ceratopogonidae). J. Aust. Entomol. Soc. 15:303-332.

Kettle, D. S. and M. M. Elson. 1975. The immature stages of Culicoides belkini Wirth and Arnaud (Diptera: Ceratopogonidae), with notes on pupal terminology. J. Med. Entomol. 12:256-258.

Kettle, D. S. and M. M. Elson. 1978. The immature stages of more Australian Culicoides Latreille (Diptera: Ceratopogonidae). J. Aust. Entomol. Soc. 17:171-187.

Kettle, D. S., C. H. Wild and M. M. Elson. 1975. A new technique for rearing individual Culicoides larvae (Diptera: Ceratopogonidae). J. Med. Entomol. 12:263-264.

Kline, D. L. and R. C. Axtell. 1976. Salt marsh Culicoides (Diptera: Ceratopogonidea): Species, seasonal abundance, and comparisons of trapping methods. Mosq. News 36:1-10.

Kline, D. L. and R. C. Axtell. 1977. Distribution of Culicoides hollensis, C. furens, and C. bermudensis in relation to plant cover in a North Carolina salt marsh (Diptera: Ceratopogonidae). J. Med. Entomol. 13:545-552.

Kline, D. L. and E. C. Greiner. 1985. Observations on larval habitats of suspected Culicoides vectors of bluetongue virus in Florida, from Bluetongue and Related

Orbiviruses. Alan R. Liss, Inc. pp. 221-227.

Kline, D. L. and R. H. Roberts. 1982. Daily and seasonal abundance of Culicoides spp. biting midges (Diptera: Ceratopogonidae) in selected mangrove areas in Lee County, Florida. Florida Entomol. 65:126-135.

Kline, D. L. 1986. Seasonal abundance of adult Culicoides spp. (Diptera: Ceratopogonidae) in a salt marsh in Florida, USA. J. Med. Entomol. 23:16-22.

Kramer, W. L., E. C. Greiner and E. P. J. Gibbs. 1985a. Seasonal variations in population size, fecundity, and parity rates of Culicoides insignis (Diptera: Ceratopogonidae) in Florida, USA. J. Med. Entomol. 22:163-169.

Kramer, W. L., E. C. Greiner and E. P. J. Gibbs. 1985b. A survey of Culicodes midges (Diptera: Ceratopogonidae) associated with cattle operations in Florida, USA. J. Med. Entomol. 22:153-162.

Lewis, F. B. 1959. Abundance and seasonal distribution of the common species of Ceratopogonidae (Diptera) occurring in the state of Connecticut. Can. Entomol. 91:15-28.

Linley, J. R. 1970. The immature stages of Culicoides arboricola Root and Hoffman (Diptera: Ceratopogonidae). J. Med. Entomol. 6:717-721.

Linley, J. R. and J. B. Davies. 1971. Sandflies and tourism in Florida and the Bahamas and Caribbean area. J. Econ. Entomol. 64:264-278.

Linley, J. R., F. D. S. Evans and H. T. Evans. 1970. Seasonal emergence of Culicoides furens (Diptera: Ceratopogonidae) at Vero Beach, Florida. Ann Entomol. Soc. Am. 63:1332-1339.

Messersmith, D. H. 1966. Report of a collection of Culicoides (Diptera: Ceratopogonidae) from Western Virginia. Va. J. Sci. 17:83-104.

Mullen, G. R., M. E. Hayes and K. E. Nusbaum. 1985a. Potential vectors of bluetongue and epizootic hemorrhagic disease viruses of cattle and white-tailed deer in Alabama. From: Bluetongue and Related Orbiviruses, Alan R. Liss, Inc. pp. 201-206.

Mullen, G. R., R. H. Jones, Y. Braverman and K. E. Nusbaum.

1985b. Laboratory infections of Culicoides debilipalpis and C. stellifer (Diptera: Ceratopogonidae) with bluetongue virus. From: Bluetongue and Related Orbiviruses, pp. 239-243. Alan R. Liss, Inc.

Murray, W. S. 1957. Investigations on the bionomics of Culicoides obsoletus (Meigen) and other biting midges at Mount Solon, Virginia. Mosq. News 17:77-82.

Mullens, B.A. and D. A. Rutz. 1983. Voltinism and seasonal abundance of Culicoides variipennis (Diptera: Ceratopogonidae) in central New York State. Ann. Entomol. Soc. Am. 76:913-917.

Mullens, B. A. and E. T. Schmidtmann. 1981. Colonization of Culicoides wisconsinensis Jones (Diptera: Ceratopogonidae). Mosq. News 41:564-566.

Mullens, B. A. and E. T. Schmidtman. 1982. The gonotrophic cycle of Culicoides variipennis (Diptera: Ceratopogonidae) and its implications in age-grading field populations in New York State, USA. J. Med. Entomol. 19:340-349.

O'rourke, M. J., E. C. Loomis and D. W. Smith. 1983. Observations on some Culicoides variipennis (Diptera: Ceratopogonidae) larval habitats in areas of bluetongue virus outbreaks in California. Mosq. News 43:147-152.

Pickard, E. and W. E. Snow. 1952. Light trap collections of punkies (Family Heleidae, Genus Culicoides) McMinn County, Tennessee, April-September. J. Tennessee Acad. Sci. 38:15-18.

Pinheiro, F. P., A. P. A. Trarassos Da Rosa, M. L. C. Gomes, J. W. Leduc and A. L. Hoch. 1982. Transmission of oropouche virus from man to hamster by the midge Culicoides paraensis. Science 215:1251-1252.

Rowley, W. A. 1967. Observations on larval habitats and The winter bionomics of some common species of Culicoides (Diptera: Ceratopogonidae) in the Central Columbia Basin. Mosq. News 27:495-505.

Schmidtmann, E. T., J. F. Abend and M. E. Valla. 1980. Nocturnal blood-feeding from pastured calves by the ceratopogonidae midge, Culicoides venustus, in New York State. Mosq. News 40:571-577.

Snow, W. E. et al. 1955. Feeding activities of some blood-sucking Diptera with reference to vertical distribution in bottomland forest. Ann. Entomol. Soc. Am. 48:512-521.

Tanner, G. D. and E. C. Turner, Jr. 1974. Vertical activities and host preferences of several Culicoides species in a southwestern Virginia Forest. Mosq. News 34:66-70.

Tanner, G. D. and E. C. Turner, Jr. 1975. Seasonal abundance of Culicoides spp. as determined by three trapping methods. J. Med. Entomol. 12:87-91.

Walker, A. R. 1977. Adult lifespan and reproductive status of Culicoides species (Diptera: Ceratopogonidae) in Kenya, with references to virus transmission. Bull. Entomol. Res. 67:205-215.

Waugh, W. T. and W. W. Wirth. 1976. A revision of the genus Dasyhelea Kieffer of the Eastern United States North of Florida (Diptera: Ceratopogonidae). Ann. Entomol. Soc. Am. 69:219-247.

Wilkening, A. J., D. L. Kline and W. W. Wirth. 1985. An annotated checklist of the Ceratopogonidae (Diptera) of Florida with a new synonymy. Florida Entomol. 68:511-537.

Williams, R. W. 1955. Studies on the Culicoides of Baker County, Georgia (Diptera: Ceratopogonidae). I. Preliminary Survey and Observations. Ann. Entomol. Soc. Am. 48:30-34.

Williams, R. W. 1964. Observations on habitats of Culicoides larvae in Trinidad, W. I. (Diptera: Ceratopogonidae). Ann. Entomol. Soc. Am. 57:462-466.

Wirth, W. W. 1952. The genus Alluaudomyia Kieffer in North American (Diptera: Heleidae). Ann. Entomol. Soc. Am. 45:423-434.

Wirth, W. W. 1962. A reclassification of the Palpomyia-Bezzia-Macropeza groups, and a revision of the North American Sphaeromiini (Diptera: Ceratopogonidae). Ann. Entomol. Soc. Am. 55:272-287.

Wirth, W. W. 1965. Family Ceratopogonidae. In Stone et al., A catalog of the Diptera of America north of Mexico. U. S. D. A., U. S. Gov. Print. Office, Washington. pp. 121-142.

Wirth, W. W. 1983. The North American predaceous midges of the Bezzia bicolor group (Diptera: Ceratopogonidae). Florida Entomol. 66:292-310.

Wirth, W. W. and L. J. Bottimer. 1956. A population study of the Culicoides midges of the Edwards Plateau Region of Texas. Mosq. News 16:256-266.

Wood, J. R. and D. L. Kline. 1984. A survey of Ceratopogonidae biting midge problems associated with Posada Del Sol Resort, Guanaja, Honduras. J. Florida Anti-Mosq. Assoc. 55:22-27.

Zimmerman, R. H. and E. C. Turner, Jr. 1983a. Seasonal abundance and parity of common Culicoides collected in blacklight traps in Virginia pastures. Mosq. News 43:63-69.

Zimmerman, R. H. and E. C. Turner, Jr. 1983b. Host feeding patterns of Culicoides (Diptera: Ceratopogonidae) collected from livestock in Virginia, USA. J. Med. Entomol. 20:514-519.

## APPENDICES

APPENDIX A

Table 1. Summary of Habitat Classification System

| Habitat Type | Time Wet (Months)[a] | Number of Sites 1985 | 1986 | Summary Description |
|---|---|---|---|---|
| 1 | 8 | 6 | 7 | Open mud with no vegetation Permanently wet, pond, creek, spring margins. |
| 2 | 6-7 | 3 | 6 | Open mud and occasional vegetation. pond,creek spring margins plus stream bed overflows, temporary pools. |
| 3 | 4-5 | 2 | 4 | Open mud with abundant rushes and sedges. Seasonally wet meadow. |
| 4 | 2-3 | 3 | 7 | Some open mud, pasture grasses. Wet for only a short time. |

[a]- Survey beginning 1 April 1985 and 1986.

Table 2. Average Collection per Trap of Culicoides Adults From Each Habitat Category in 1985.

| species | Habitat Type 1[a] | 2 | 3 | 4 |
|---|---|---|---|---|
| spinosus | 0.13 | 0.02 | 0.19 | 0.08 |
| stellifer | 0.29 | 0.10 | 0.17 | 0.05 |
| baueri | 0.66 | 0.48 | 0.31 | 0.18 |
| biguttatus | 0.08 | 0.04 | 0.32 | 1.36 |
| venustus | 0.61 | 0.08 | 0.17 | 0.05 |
| haematopotus | 0.18 | 0.00 | 0.00 | 0.03 |
| bickleyi | 0.00 | 0.00 | 0.00 | 0.00 |

[a]- The numbers of traps in each habitat category were 38, 48, 59 and 39 for Types 1, 2, 3 and 4, respectively.

Table 3. Average Collection per Trap of *Culicoides* Adults in Each Habitat Category During 1986.

| species | Habitat Type 1[a] | 2 | 3 | 4 |
|---|---|---|---|---|
| *spinosus* | 2.48 | 1.73 | 5.73 | 4.04 |
| *stellifer* | 1.92 | 1.63 | 3.68 | 1.16 |
| *baueri* | 3.46 | 2.78 | 0.10 | 0.00 |
| *biguttatus* | 0.63 | 0.36 | 5.60 | 0.60 |
| *venustus* | 1.98 | 1.63 | 0.63 | 0.16 |
| *haematopotus* | 0.86 | 1.69 | 0.24 | 4.38 |
| *bickleyi* | 0.52 | 0.04 | 0.18 | 0.00 |

[a]- The numbers of traps in each category were 61, 48, 30 and 50 for Types 1, 2, 3 and 4, respectively.

Table 4. Average Collection per Trap of Ceratopogonid Genera Other Than <u>Culicoides</u> From Each Habitat Category.

| species | Habitat Type 1[a] | 2 | 3 | 4 |
|---|---|---|---|---|
| Stilobezzia | 3.54 | 1.98 | 4.90 | 1.08 |
| Dasyhelea | 1.34 | 5.54 | 2.07 | 1.16 |
| Palpomyia | 1.97 | 2.52 | 1.07 | 0.38 |
| Atrichopogon | 3.13 | 0.96 | 1.00 | 0.32 |
| Bezzia | 0.87 | 2.40 | 1.00 | 1.30 |
| Clinohelea | 0.16 | 0.17 | 0.00 | 0.00 |
| Alluaudomyia | 0.13 | 0.04 | 0.00 | 0.00 |

[a]- The numbers of traps in each habitat category were 61, 48, 30 and 50 for Types 1, 2, 3 and 4, respectively.

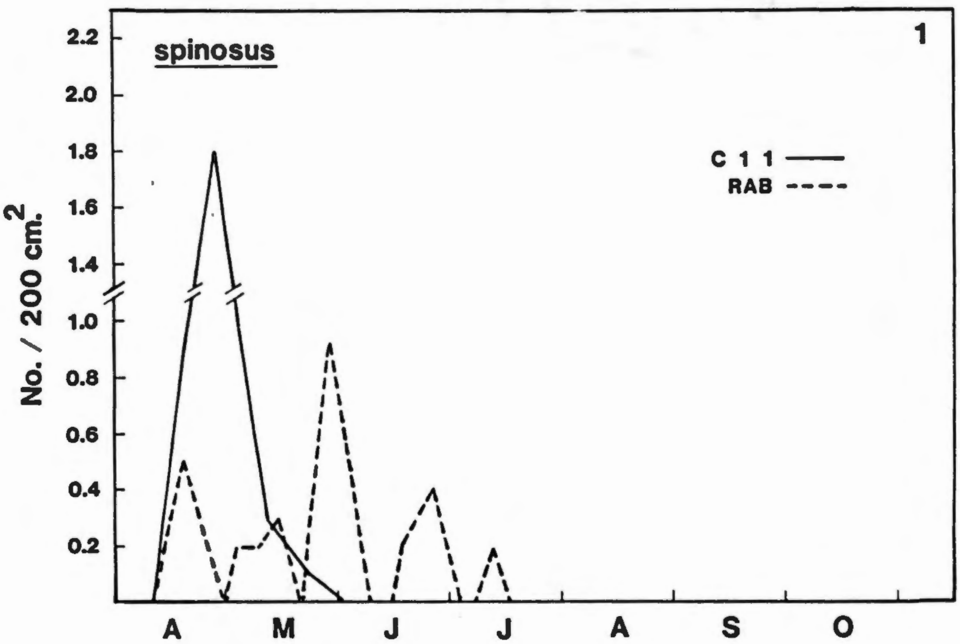


Figure 1. Seasonal Emergence of _C_. _spinosus_ during 1986.

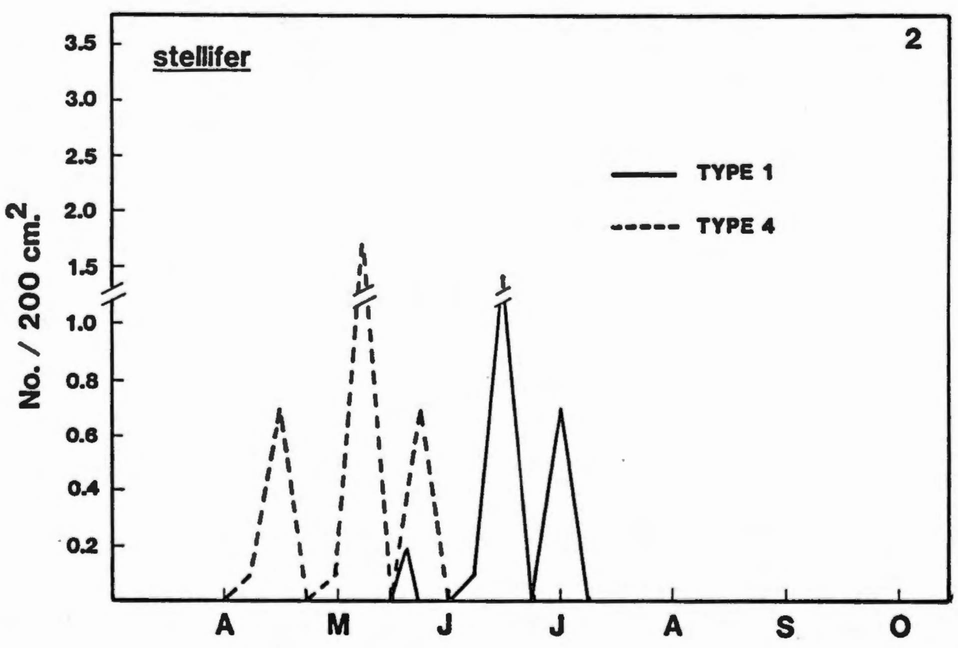


Figure 2. Seasonal Emergence of _C_. _stellifer_ during 1986.

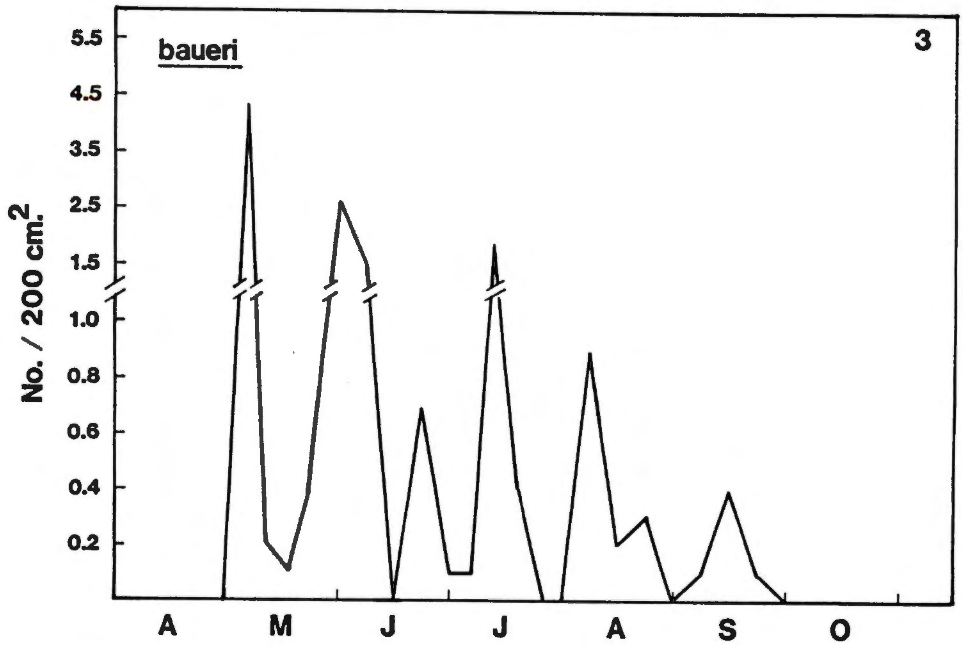


Figure 3. Seasonal Emergence of C. baueri during 1986.

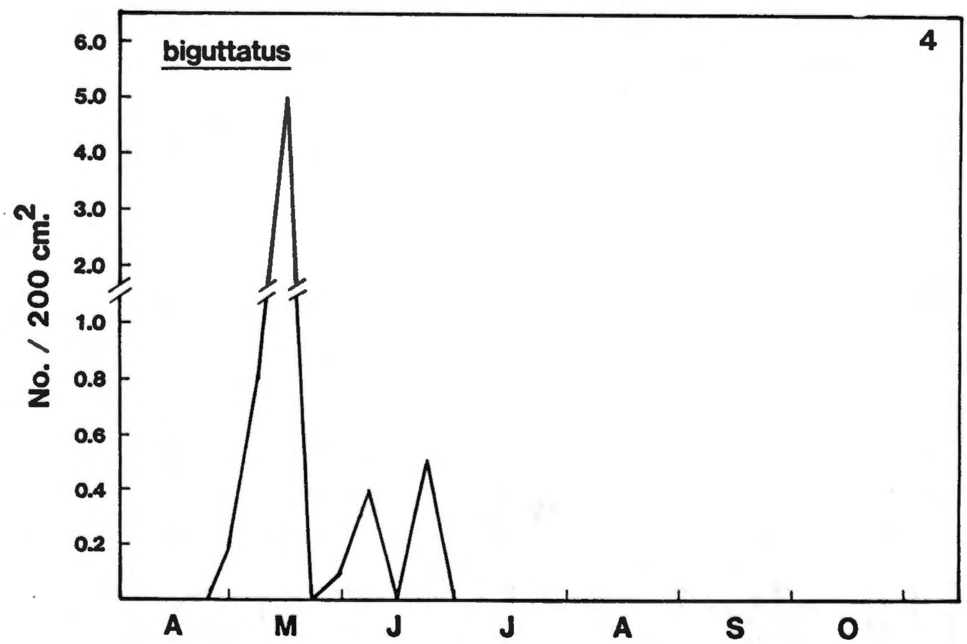


Figure 4. Seasonal Emergence of C. biguttatus during 1986.

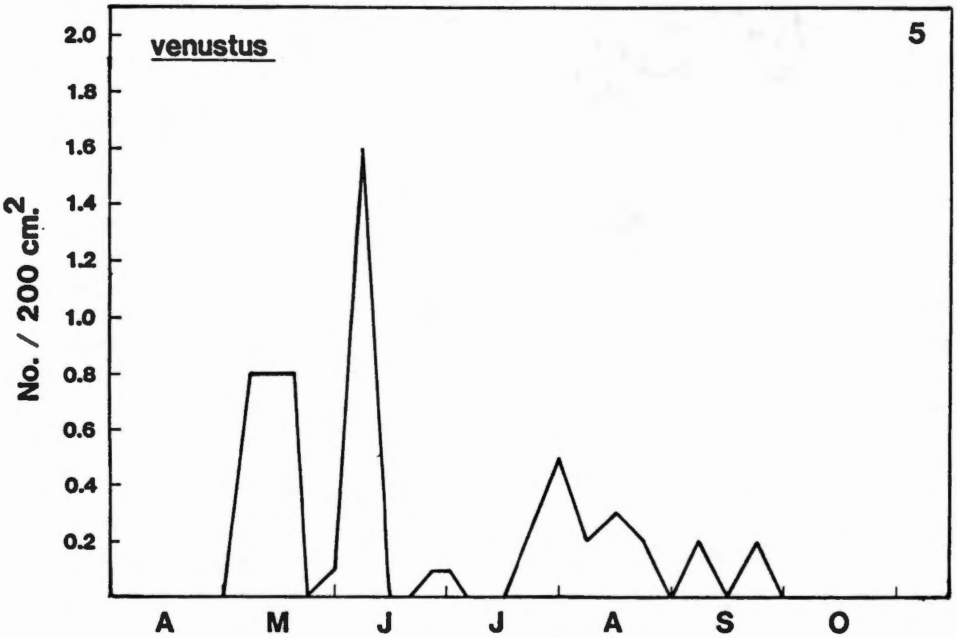


Figure 5. Seasonal Emergence of C. venustus during 1986.

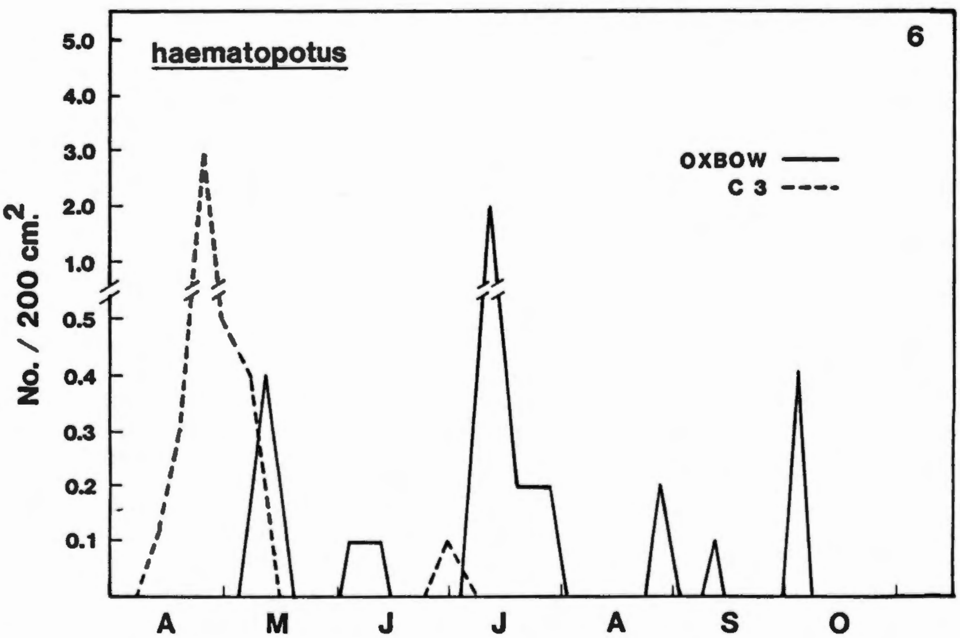


Figure 6. Seasonal Emergence of C. haematopotus during 1986.

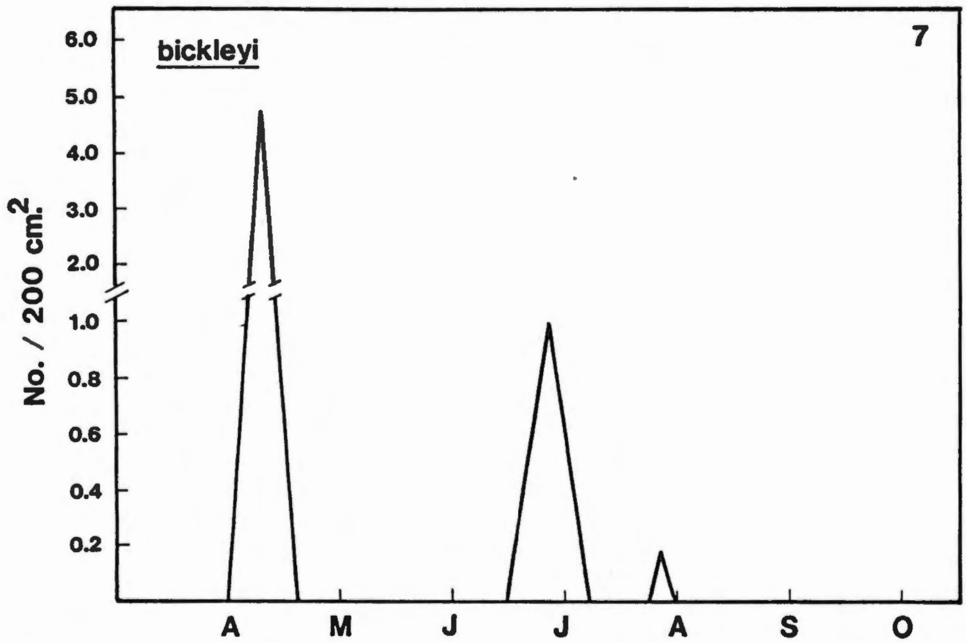


Figure 7. Seasonal Emergence of C. bickleyi during 1986.

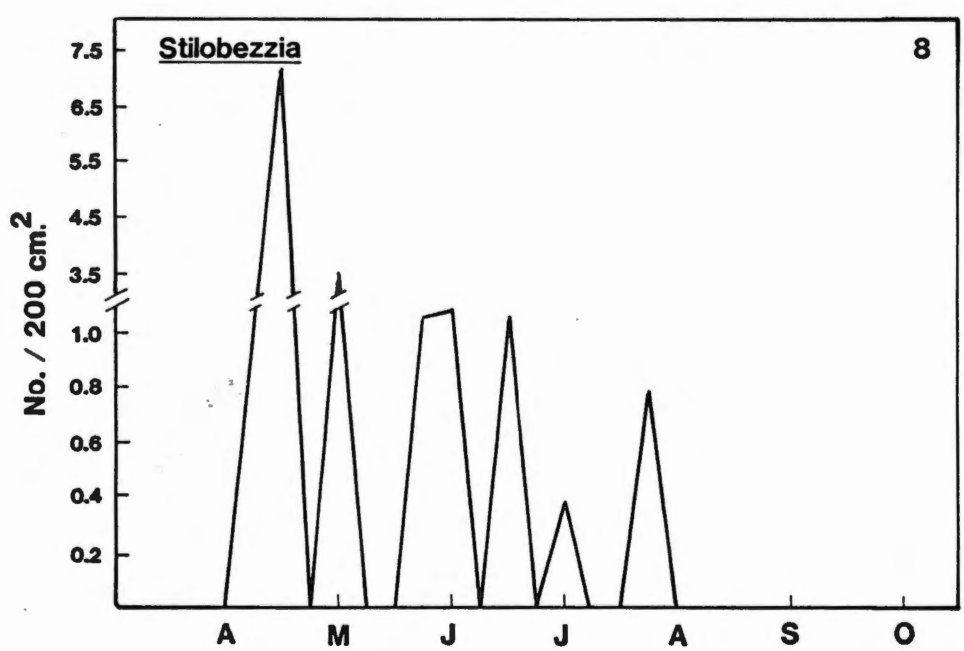


Figure 8. Seasonal Emergence of Stilobezzia during 1986.

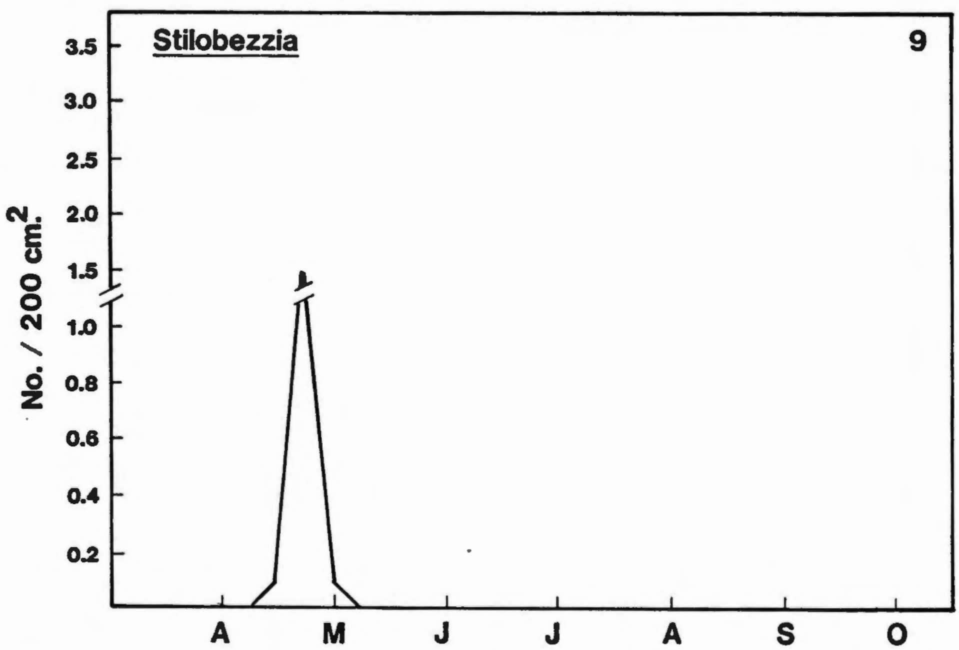


Figure 9. Seasonal Emergence of Stilobezzia during 1986.

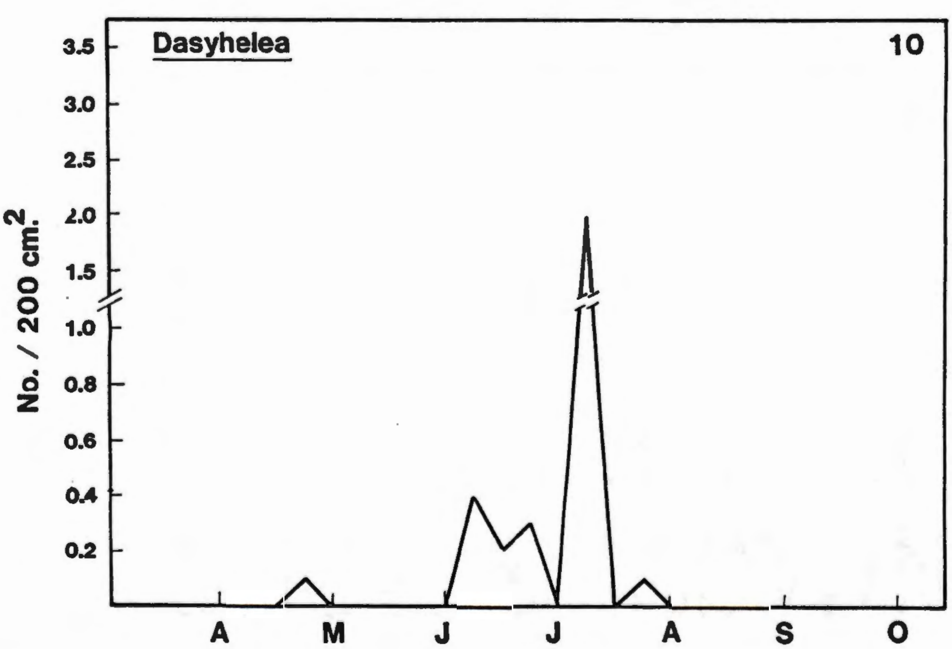


Figure 10. Seasonal Emergence of Dasyhelea during 1986.

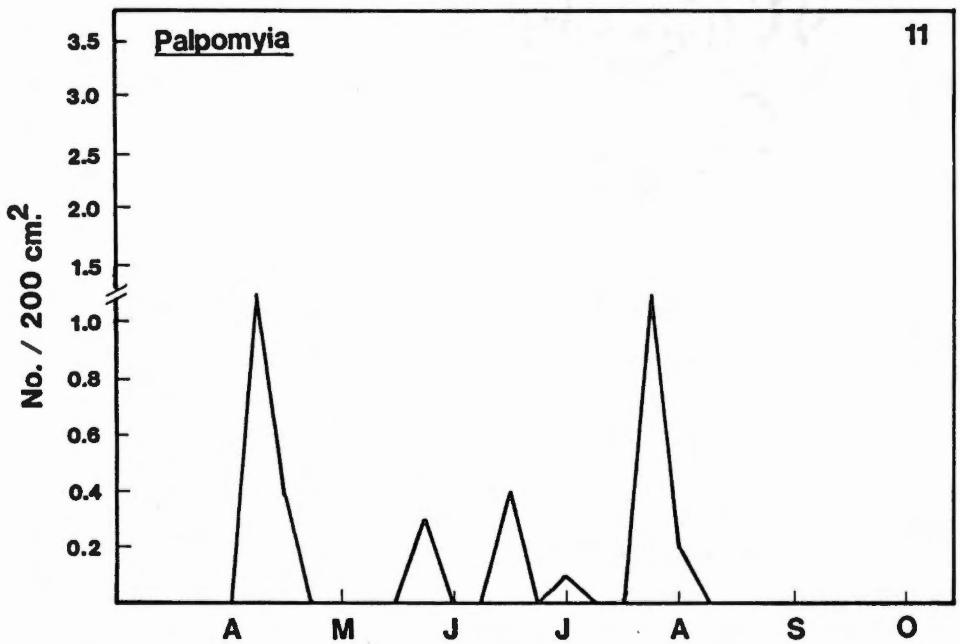


Figure 11. Seasonal Emergence of Palpomyia during 1986

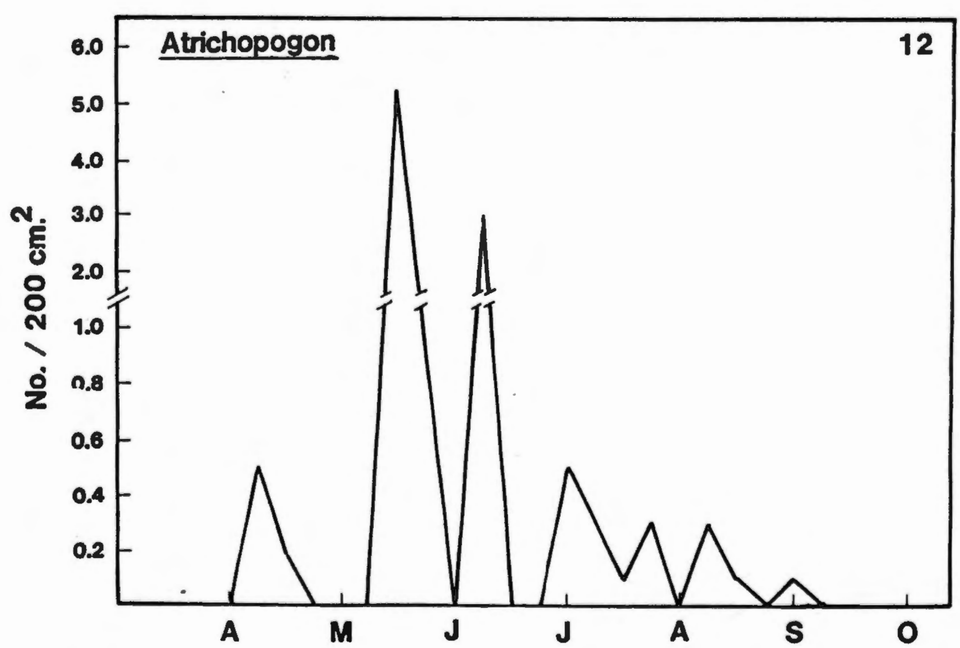


Figure 12. Seasonal Emergence of Atrichopogon during 1986.

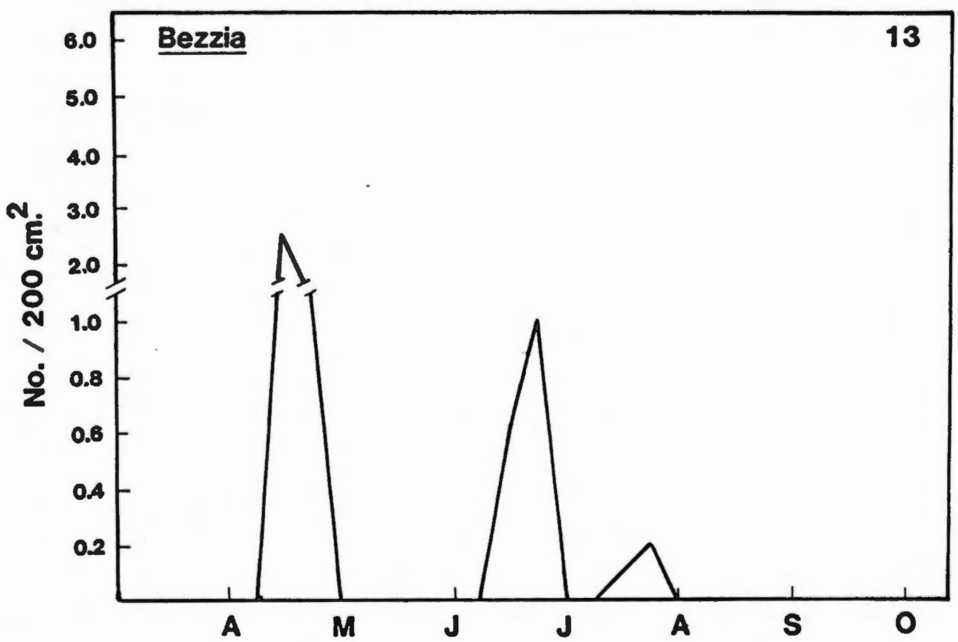


Figure 13. Seasonal Emergence of Bezzia during 1986.

APPENDIX B

# Appendix B

## General Site Descriptions

I. Grassland Farm Area

Site: C5

Area: ca. 20 $m^2$

Description: Margin of a pond without contact from cattle. Open mud or mud covered wth decaying vegetation. Several small willow trees in site. Type 1.

Trap placement: Four traps placed along edge of water and the other six placed along wettest zone of the site.

Trap spacing: 0.5 to 2.0 meters.

Site: C11

Area: ca. 40 $m^2$

Description: main channel of a seasonally wet meadow. sedges, rush, and open mud. Type 3.

Trap placement: Ten traps placed along edge of channel.

Trap spacing: 4 to 10 meters.

Site: C12

Area: ca. 80 $m^2$

Description: Slightly drier zone of C11. Type 3.

Trap placement: Ten traps placed in a line parallel to C11 traps.

Trap spacing: same as C11

Site: C21

Area: ca. 100 $m^2$

Description: Channel of seasonally wet meadow similar to C11 and C12. Type 4.

Trap placement: Ten traps placed along edge of channel.

Trap spacing: 8 to 10 meters.

Site: C22

Area: ca. 150 $m^2$

Description: Same area as C21, a less muddy zone. Type 4.

Trap placement: Ten traps in a line parallel to the C21 trap line.

Trap spacing: 10-12 meters.

Site: C31

Area: ca. 40 $m^2$

Description: main channel of wet meadow area cattle disturbed, Type 4, mostly pasture grasses and open mud.

Trap placement: Ten traps in the main channel.

Trap spacing: 0.5 to 2 meters.

Site: C32

Area: ca. 80 $m^2$

Description: Less muddy zone of same wet meadow as C31. Type 4.

Trap placement: Ten traps parallel to C31 trap line

Trap spacing: 0.5 to 2 meters

II. Cherokee Woodlot Area

Site: CWA

Area: ca. 20 $m^2$

Description: A marshy creek flow draining a grove of bald cypress. Open mud with some grasses. Type 1.

Trap placement: Ten traps placed in two trap lines, five in main channel ; five parellel in less muddy zone.

Trap spacing: 2 meters.

Site: CWB

Area: ca. 30 $m^2$

Descriptions: swampy, creek flow in grove of bald-cypress. Open mud, shaded. Type 2.

Trap placement: Ten traps in sinuous trap line across creek channel and into open mud.

Trap spacing: 1.5 meters

Site: CWC

Area: ca. 40 $m^2$

Descriptions: Same creek flow as CWA and CWB but open to sunlight. Reeds and grasses present. Usually 4-6 cm of water over substrate. Type 1.

Trap placement: Ten traps in a line across site.

Trap spacing: 3 meters

III. Stanley Farm Area

Site: RAA

Area: ca. 20 $m^2$

Description: Spring-fed wet meadow, some grasses and a few willow trees. Type 3.

Trap placement: Ten traps in a line across an area of open mud.

Trap spacing: 1 to 5 meters.

Site: RAB

Area: ca. 40 $m^2$

Description: Wetter zone of same habitat as RAA. Type 1.

Trap placement: Ten traps parallel to the RAA trap line.

Trap spacing: Same as RAA.

Site: RB

Area: ca. 10 $m^2$

Description: Margin of small wet meadow at the edge of a small creek (width 0.5 meters). Open mud, reeds and mosses. Type 2.

Trap placement: Ten traps placed at the margins of the creek and spring.

Trap spacing: 1 to 3 meters.

Site: RS

Area: ca. 10 $m^2$

Description: Small permanent creek 0.2 to 1 meter in width. Open mud. No vegetation in creek bed. Type 1.

Trap placement: Seven traps placed in margin of creek along its length. Open mud sampled only.

Trap spacing: 1 to 15 meters.

IV. Cades Cove Area.

Site: OX

Area: ca. 100 $m^2$

Description: Oxbow pond in watershed of Abram's Creek. Open mud. Type 2.

Trap placement: Ten traps positioned at the margins of the pond.

Trap spacing: 3 to 15 meters.

Site: AG.

Area: ca. 200 $m^2$

Description: Large water-soaked depression. Alder and grasses present. Type 4.

Trap placement: Ten traps scattered in the wettest zone of the site.

Trap spacing: 5 to 10 meters.

Site: ACS.

Area: ca. 30 $m^2$

Description: Margins of two springs of a tributary of Abram's Creek. Open mud, algae and grasses. Type 1.

Trap placement: Ten traps positioned at the edges of the springs.

Trap spacing: 0.5 to 1 meter.

Site: DPA, DPB and DPC.

Area: ca. 20 $m^2$

Description: An overflow area of Wildcat Branch, a small creek tributary of Abram's Creek. These sites were located in woodlands and were well shaded. Also, wild hogs constantly disturbed the mud. DPA and DPB were Type 2 and DPC was Type 1.

Trap placement: DPA and DPB were parallel eight trap lines following the bed of the overflow depression. DPC was a much wetter zone of another overflow site within 20 meters of the DPA and DPB.

Trap spacing: 1 to 3 meters.

Site: BMF.

Area: ca. 100 $m^2$

Description: Drainage ditch of a wet meadow area. Type 4.

Trap placement: Ten traps positioned in the wettest zone of the ditch spread out along its length.

Trap spacing: 2 to 15 meters.

Site: WBA.

Area: ca. 10 $m^2$

Description: Margin of a wet meadow area bordering a small creek. Frequently disturbed by hogs. Open mud. Type 4.

Trap placement: Four traps placed in a line in the wettest spots in the site.

Trap spacing: 1 to 3 meters.

Site: WBB.

Area: ca. 10 $m^2$

Description: Same as WBA but open to sunlight. Type 4.

Trap placement: Two traps placed in the wettest zone of site.

Trap spacing: 4 meters.

Site: WBC.

Area: ca. 20 $m^2$

Description: Spring margin. Well shaded and hog disturbed, some grasses and moss present. Type 1.

Trap placement: Ten traps positioned at the margins of the spring.

Trap spacing: 1 to 2 meters.

# APPENDIX C

# SUPPLEMENTAL DATA

Cherokee Woodlot Area 1985

Weekly Adult Emergence Date (Julian days)

| Genus or species | 182 | 189 | 207 | 213 | 224 | 232 | 241 | 248 | 259 | 256 |
|---|---|---|---|---|---|---|---|---|---|---|
| *Culicoides spinosus* | | | 1 | | | 1 | | | | |
| *C. stellifer* | | | 3 | | 1 | 2 | | | | |
| *C. baueri* | | | 4 | | | | | | 5 | |
| *C. biguttatus* | | | | | | 1 | | | | |
| *C. venustus* | | | 3 | | | | | | | |
| *C. haematopotus* | | | | | | | | | 7 | |
| *C. bickleyi* | | | | | | | | | | |

Grasslands Farm 1985

Weekly Adult Emergence Date (Julian days)

| Genus or species | 147 | 154 | 157 | 164 | 169 | 176 | 183 | 204 | 211 | 218 | 225 | 232 | 239 | 246 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| *C. spinosus* | | 7 | 1 | | 1 | | 2 | | | | | | | |
| *C. stellifer* | | 10 | 4 | 4 | | | | | 3 | 1 | 12 | 4 | 2 | |
| *C. baueri* | | | | | | | | | | | | | | |
| *C. biguttatus* | | 65 | 1 | 3 | | 2 | 7 | | | | | | | |
| *C. venustus* | | | | | | | | | | | | | | |
| *C. haematopotus* | | | | | | | | 1 | | | | | | |
| *C. bickleyi* | | | | | | | | | | | | | | |

Cades Cove 1985

Weekly Adult Emergence Date (Julian days)

| Genus or species | 164 | 171 | 178 | 184 | 192 | 199 | 206 | 213 | 220 | 227 | 233 | 240 | 248 | 256 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| *C. spinosus* | | | | | | | | | | | | | | |
| *C. stellifer* | | | | 4 | | 1 | 1 | | | | | | | |
| *C. baueri* | | | | | | 2 | | | | 1 | | | | |
| *C. biguttatus* | | | | | | | | | | | | | | |
| *C. venustus* | | | | | 1 | | 1 | 1 | | | | | | |
| *C. haematopotus* | | | | | | | | | | | | | 1 | |
| *C. bickleyi* | | | | | | | | | | | | | | |

Stanley Farm 1985

Weekly Adult Emergence Date (Julian days)

| Genus or species | 149 | 156 | 163 | 170 | 177 | 186 | 193 | 198 | 205 | 219 | 226 | 233 | 240 | 247 | 254 | 261 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| *C. spinosus* | | 2 | | | 1 | | | | | | | | | | | |
| *C. stellifer* | | | | | | 1 | | 1 | 2 | | 2 | | | | 1 | |
| *C. baueri* | | | | | | | | | 1 | | | | | | | |
| *C. biguttatus* | | | | | | 1 | | | 1 | | | | | | | |
| *C. venustus* | | | | | 2 | 1 | | 1 | 2 | | 5 | | | | 5 | |
| *C. haematopotus* | | | | | | | | | | | | | | | | |
| *C. bickleyi* | | | | | | | | | | | | | | | | |

C5 1986

Weekly Adult Emergence
Date (Julian days)

| Genus or species | 98 | 105 | 115 | 119 | 126 | 133 | 140 | 147 | 154 | 161 | 168 | 175 | 182 | 189 | 196 | 203 | 210 | 217 | 224 | 231 | 238 | 252 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| C. spinosus | | | | | | | 3 | | | | | | | | | | | | | | | |
| C. stellifer | | | | | | | 1 | | | | 7 | 1 | | | | | | | | | 1 | |
| C. baueri | | | | | | | | | | | | | | | | | | | | | | |
| C. biguttatus | | | | | | | 4 | | | | 1 | | | | | | | | | | | |
| C. venustus | | | | | | | | | | | | | | | | | | | | | | |
| C. haemotopotus | | | | | | | | | | | | | 1 | | | | | | | 1 | 2 | |
| C. bickleyi | | | | | | 4 | | 1 | | | | 3 | | | | | | | 1 | 3 | | |
| Stilobezzia | | | | | | | | 1 | | | | | | | | | | | | | | |
| Dasyhelea | | | | | | | | | | | 1 | | | 3 | | | | | | 1 | 4 | 1 |
| Palpomyia | | | | | | | | | | | | | | | | 1 | | 2 | | | | |
| Atrichopogon | | | | | | | | | | | | | | | | | | 1 | | | | |
| Bezzia | | | | | | | | | | | | | | | | 1 | | 1 | | | 1 | |
| Clinohelea | | | | | | | | | | | | | | | | | | | | | | |
| Alluaudomyia | | | | | | | | | | | | | | | | | | 1 | | | | |

C11 1986

Weekly Adult Emergence
Date (Julian days)

| Genus or species | 98 | 105 | 115 | 119 | 126 | 133 | 140 | 147 | 154 | 161 | 168 | 175 | 182 | 189 | 196 | 203 | 210 | 217 | 224 | 231 | 238 | 252 | 259 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| C. spinosus | | | 9 | 40 | 19 | 4 | 1 | | | | | | | | | | | | | | | | |
| C. stellifer | | | | | | | 1 | 8 | 2 | 29 | 5 | 3 | 1 | | | | | | | | | | |
| C. baueri | | | | | | | | | | | | | | | | | | | | | | | |
| C. biguttatus | | | 1 | | 1 | | 10 | 1 | | | | 1 | | | | | | | | | | | |
| C. venustus | | | | | | | | | | | | | | | | | | | | | | | |
| C. haemotopotus | | | | 1 | | | | | | | | | 1 | | | | | | | | | | |
| C. bickleyi | | | | | | | | | | | | | | | | | | | | | | | |
| Stilobezzia | | | | | | 1 | 15 | 1 | | | | | | | | | | | | | | | |
| Dasyhelea | | | | | | | | 1 | | 1 | 1 | 1 | | | | | | 3 | | | | | |
| Palpomyia | | | | | | 1 | | | | | 1 | | | | | 1 | | | | | | | |
| Atrichopogon | | | | | | | | | | | | | | | | | | | | | | | |
| Bezzia | | | | 1 | | 3 | 1 | 1 | 1 | 1 | | | | | | | | | | | | | |
| Clinohelea | | | | | | | | | | | | | | | | | | | | | | | |
| Alluaudomyia | | | | | | | | | | | | | | | | | | | | | | | |

C12 1986

Weekly Adult Emergence
Date (Julian days)

| Genus or species | 98 | 105 | 115 | 119 | 126 | 133 | 140 | 147 | 154 | 161 | 168 | 175 | 182 | 189 | 196 | 203 | 210 | 217 | 224 | 231 | 238 | 252 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| C. spinosus | | | 8 | 19 | 32 | 54 | 4 | | | 10 | | | | | | | | | | | | |
| C. stellifer | | 1 | | | 1 | 7 | | 1 | 18 | | 7 | | | | | | | | | | | |
| C. baueri | | | | | | | | | | | | | | | | | | | | | | |
| C. biguttatus | | | | | 2 | 8 | 49 | | 1 | 4 | | 5 | | | | | | | | | | |
| C. venustus | | | | 1 | | | | | | | | | | | | 1 | | | | | | |
| C. haemotopotus | | | | | 1 | 1 | | | | | | | | | | | | | | | | |
| C. bickleyi | | | 4 | 1 | | | | | | 5 | | | | | | | | | | | | |
| Stilobezzia | | | | | | 32 | 1 | | | 4 | | 1 | | | | | | | | | | |
| Dasyhelea | | 1 | 1 | | | 3 | | | | | 1 | | | | | 1 | 3 | | | | | 1 |
| Palpomyia | | | 2 | | | 1 | | | | | | 4 | | | | | | 5 | | | | |
| Atrichopogon | | | | | | | | | | | | | | | | | | | | | | |
| Bezzia | | | | | | 1 | 6 | 1 | | 3 | | | | | | 1 | | | | | | |
| Clinohelea | | | | | | | | | | | | | | | | | | | | | | |
| Alluaudomyia | | | | | | | | | | | | | | | | | | | | | | |

C21 1986

Weekly Adult Emergence
Date (Julian days)

| Genus or species | 98 | 105 | 115 | 119 | 126 | 133 | 140 | 147 | 154 | 161 | 168 | 175 | 182 | 189 | 196 | 203 | 210 | 217 | 224 | 231 | 238 | 252 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| C. spinosus | | | 10 | 40 | 20 | 13 | | | | | | | | | | | | | | | | |
| C. stellifer | | | | | | | 1 | 2 | | 3 | | 1 | | | | | | | | | | |
| C. baueri | | | | | | | | | | | | | | | | | | | | | | |
| C. biguttatus | | | | | 2 | 3 | | | | | | | | | | | | | | | | |
| C. venustus | | | | | | | | | | | | | | | | | | | | | | |
| C. haemotopotus | | | | 2 | 1 | | | | | | | | | | | | | | | | | |
| C. bickleyi | | | | 1 | | | | | | | | | | | | | | | | | | |
| Stilobezzia | | | | | | 7 | 2 | | | | | | | | | | | | | | | 1 |
| Dasyhelea | | | | | | | | 1 | | 3 | | 1 | | | | | | | | 1 | | |
| Palpomyia | | | | | | 1 | | | | | | | | | | | 2 | | | | | |
| Atrichopogon | | | | | | | | | | | | | | | | | | 1 | | | | |
| Bezzia | | | 1 | | | | 1 | | | | | | | | | | | | | | | |
| Clinohelea | | | | | | | | | | | | | | | | | | | | | | |
| Alluaudomyia | | | | | | | | | | | | | | | | | | | | | | |

C22 1986

| Genus or species | 98 | 105 | 115 | 119 | 126 | 133 | 140 | 147 | 154 | 161 | 168 | 175 | 182 | 189 | 196 | 203 | 210 | 217 | 224 | 231 | 238 | 252 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Weekly Adult Emergence Date (Julian days) | | | | | | | | | | | | | | | | | | | | | |
| C. spinosus | | 4 | 1 | 3 | 13 | | 3 | | | | | | | | | | | | | | | |
| C. stellifer | | 1 | | | | | | | | 5 | | | | | | 1 | | | | | | |
| C. baueri | | | | | | | | | | | | | | | | | | | | | | |
| C. biguttatus | | 14 | | | | | | | | | 1 | | | | | | | | | | | |
| C. venustus | | | | | | | | | | | | | | | | | | | | | | |
| C. haemotopotus | | | | 1 | | | | | | | | | | | | | | | | | | |
| C. bickleyi | | | | | | | | | | | | | | | | | | | | | | |
| Stilobezzia | | | | | | 8 | 3 | | | | | | | | | | | | | | | |
| Dasyhelea | | | | | | 1 | 1 | | | 12 | 3 | 4 | | 3 | | | 2 | | | | | |
| Palpomyia | | | | | | 3 | | | | | | | | | | | | | | | | |
| Atrichopogon | | | | | | | | | | 1 | | | 1 | | | | | | | | | |
| Bezzia | | | | | | 7 | 1 | | | 2 | | | | | | | | | | | | |
| Clinohelea | | | | | | | | | | | | | | | | | | | | | | |
| Alluaudomyia | | | | | | | | | | | | | | | | | | | | | | |

C31 1986

| Genus or species | 98 | 105 | 115 | 119 | 126 | 133 | 140 | 147 | 154 | 161 | 168 | 175 | 182 | 189 | 196 | 203 | 210 | 217 | 224 | 231 | 238 | 252 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Weekly Adult Emergence Date (Julian days) | | | | | | | | | | | | | | | | | | | | | |
| C. spinosus | | 1 | | | | 1 | | | | | | | | | | | | | | | | |
| C. stellifer | | | | | | | | | | | | | | | | | | | | | | |
| C. baueri | | | | | | | | | | | | | | | | | | | | | | |
| C. biguttatus | | | | 5 | 2 | | | | | | | | | | | | | | | | | |
| C. venustus | | | | | | | | | | | | | | | | | | | | | | |
| C. haemotopotus | | 1 | 3 | 27 | 5 | 4 | | | | | | | | | | | | | | | | |
| C. bickleyi | | | | | | | | | | | | | | | | | | | | | | |
| Stilobezzia | | | | | | 4 | | | | 1 | | | | | | | | | 1 | | | |
| Dasyhelea | | | 1 | | | 1 | | | | | | | | | | | | | | 1 | | |
| Palpomyia | | 4 | | | | | | | | | | | | | | | | | | | | |
| Atrichopogon | | 4 | 1 | | | | | | | | | | | | | | | | | 1 | | |
| Bezzia | | 7 | 1 | | | 6 | | | | 1 | | | | | | | | | | | | |
| Clinohelea | | | | | | | | | | | | | | | | | | | | | | |
| Alluaudomyia | | | | | | | | | | | | | | | | | | | | | | |

C32 1986

| Genus or species | Weekly Adult Emergence Date (Julian days) | | | | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 98 | 105 | 115 | 119 | 126 | 133 | 140 | 147 | 154 | 161 | 168 | 175 | 182 | 189 | 196 | 203 | 210 | 217 | 224 | 231 | 238 | 252 | 259 |
| _C. spinosus_ | | 1 | | | 1 | | | | | | | | | | | | | | | | | |
| _C. stellifer_ | | | | | | | | | | | | | | | | | | | | | | |
| _C. baueri_ | | | | | | | | | | | | | | | | | | | | | | |
| _C. biguttatus_ | | | | | | | | | | | | | | | | | | | | | | |
| _C. venustus_ | | | | | | | | | | | | | | | | | | | | | | |
| _C. haemotopotus_ | | | | 1 | | | | | | | | | | | | | | | | | | |
| _C. bickleyi_ | | | | | | | | | | | | | | | | | | | | | | |
| _Stilobezzia_ | | | | | | | | | | | | | | | | | | | | | | |
| _Dasyhelea_ | | 2 | 1 | | | | | | 1 | 2 | | | | | | | | | | | | |
| _Palpomyia_ | | 3 | | | | | | | | | | | | | | | | | | | | |
| _Atrichopogon_ | | 1 | | | | | | | | | | | | | | | | | | | | |
| _Bezzia_ | | | | | | 6 | | | | 1 | | | | | | | | | | | | |
| _Clinohelea_ | | | | | | | | | | | | | | | | | | | | | | |
| _Alluaudomyia_ | | | | | | | | | | | | | | | | | | | | | | |

CWA 1986

| Genus or species | Weekly Adult Emergence Date (Julian days) | | | | | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 100 | 107 | 114 | 121 | 128 | 133 | 142 | 150 | 156 | 164 | 170 | 176 | 184 | 192 | 199 | 206 | 213 | 220 | 227 | 234 | 245 | 254 | 261 |
| _C. spinosus_ | | | 2 | | 10 | 1 | 4 | | | | | | | | | 2 | | | | | | | |
| _C. stellifer_ | | | | | | | | | | | | 13 | | | 1 | 1 | | | | | | | |
| _C. baueri_ | | | | 3 | | 2 | 4 | 1 | | | | 56 | | 2 | | | | | | | 3 | | |
| _C. biguttatus_ | | | | | | | 2 | | | | | 6 | | | | | | | | | | | |
| _C. venustus_ | | | | | | | 1 | 1 | | | | | | | | | | | | | | | |
| _C. haematopotus_ | | | | | | 4 | 2 | | | | | 8 | | | 1 | | | | | 1 | | | |
| _C. bickleyi_ | | | | | | | 1 | | | | | | | | | | | | | | | | |
| _Stilobezzia_ | | | | | | | 6 | | | | | 6 | | | 2 | | 6 | | | 2 | 1 | | |
| _Dasyhelea_ | | | | | | | 1 | | | | | 5 | | 5 | | | 18 | | | | 2 | | |
| _Palpomyia_ | | | | | | 12 | 4 | | | | | 3 | | | 4 | | 1 | | | 12 | 2 | | |
| _Atrichopogon_ | | | | | | | | | | | | | | | | | | | | | | | |
| _Bezzia_ | | | | | | | 8 | | | | | 1 | | | 1 | | 3 | | 1 | | | | |
| _Clinohelea_ | | | | | | | | | | | | 2 | | | | | | | | | | | |
| _Alluaudomyia_ | | | | | | | | | | | | | | | | | | | | | | | |

| CWB 1986 Genus or species | Weekly Adult Emergence Date (Julian days) | | | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 100 | 107 | 114 | 121 | 128 | 133 | 142 | 150 | 156 | 164 | 170 | 176 | 184 | 192 | 199 | 206 | 213 | 220 | 227 | 234 | 245 | 254 |
| <u>C. spinosus</u> | | | 4 | | 19 | | 3 | | | | | 1 | | | | 1 | | | | | | |
| <u>C. stellifer</u> | | | | | | | | | | | | 2 | | 1 | | | | | | | | |
| <u>C. baueri</u> | | | | | 2 | | 1 | 1 | | | | 19 | | | 1 | | | | | | | |
| <u>C. biguttatus</u> | | | | | | | 2 | 1 | | | | | | | | | | | | | | |
| <u>C. venustus</u> | | | | 1 | | | 1 | 1 | | | | 3 | | | | | | | | | | |
| <u>C. haematopotus</u> | | | | | 1 | 2 | | | | | | 12 | | 2 | 1 | 1 | | | | | | |
| <u>C. bickleyi</u> | | | | | | | | | | | | | | | | | | | | | | |
| <u>Stilobezzia</u> | | | | | | | 2 | | | | | 17 | | | 5 | 10 | | 2 | | | 3 | |
| <u>Dasyhelea</u> | | | | | | | | 1 | | | | | | 4 | 2 | 3 | | 20 | | 1 | | |
| <u>Palpomyia</u> | | | | | | 8 | 11 | 3 | | | | 1 | | | 5 | 2 | | 11 | | 8 | 1 | |
| <u>Atrichopogon</u> | | | | | | | | 1 | | | | 2 | | | | | | | | | | 1 |
| <u>Bezzia</u> | | | | | | | 25 | 15 | | | | | | | 6 | 12 | | | 1 | 2 | | |
| <u>Clinohelea</u> | | | | | | | | | | | | 1 | | | | | | | | | | |
| <u>Alluaudomyia</u> | | | | | | | | | | | | | | | | | | | | | | |

| CWC 1986 Genus or species | Weekly Adult Emergence Date (Julian days) | | | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 100 | 107 | 114 | 121 | 128 | 133 | 142 | 150 | 156 | 164 | 170 | 176 | 184 | 192 | 199 | 206 | 213 | 220 | 227 | 234 | 245 | 254 |
| <u>C. spinosus</u> | | | | | 12 | 3 | 4 | | | | | | | | | 1 | | | | | | |
| <u>C. stellifer</u> | | | | | | | | 2 | | | | | | | 3 | | | | | | | |
| <u>C. baueri</u> | | | | | | | | 2 | | | | | | | 4 | | | | | | | |
| <u>C. biguttatus</u> | | | | | | 4 | | | | | | | | | | | | | | | | |
| <u>C. venustus</u> | | | | | | | 1 | | | | | | | | | | | | | | | |
| <u>C. haematopotus</u> | | | | | | 2 | 6 | 1 | | | | 2 | | | | 2 | | | | | | |
| <u>C. bickleyi</u> | | | | | | | 1 | | | | | | | | | | | | | | | |
| <u>Stilobezzia</u> | | | | | | 1 | 9 | 4 | | | | 3 | | 3 | 13 | 5 | | 1 | | | | |
| <u>Dasyhelea</u> | | | | | | 2 | | 1 | | | | | | 1 | 2 | 2 | | | | 4 | | |
| <u>Palpomyia</u> | | | | | | 31 | 5 | 4 | | | | | | | 2 | 4 | | 4 | | 5 | 1 | |
| <u>Atrichopogon</u> | | | | | | | | | | | | 3 | | | | | | | | 3 | | |
| <u>Bezzia</u> | | | | | | | 16 | 2 | | | | | | | | | | | 1 | 1 | | |
| <u>Clinohelea</u> | | | | | | | | | | | | | | 1 | | | | | | | | |
| <u>Alluaudomyia</u> | | | | | | 1 | | | | | | | | | | | | | | | | |

RAA 1986

| Genus or species | 112 | 121 | 128 | 133 | 143 | 150 | 157 | 164 | 171 | 178 | 184 | 192 | 199 | 206 | 213 | 220 | 227 | 234 | 241 | 248 | 255 | 262 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Weekly Adult Emergence Date (Julian days) | | | | | | | | | | | | | | | | | | | | | |
| C. spinosus | 8 | 4 | 2 | 3 | | 9 | | | | | | | | | | | | | | | | |
| C. stellifer | 7 | 2 | | | | 1 | | | 7 | 2 | | 2 | | | | | | | | | 1 | |
| C. baueri | 1 | | | | | | | | 1 | 1 | | | | | | | | | | | | |
| C. biguttatus | | | | | | | | | | | | | | | | | | | | | | |
| C. venustus | 6 | 2 | 2 | 2 | | 3 | | | 6 | | | 1 | | | | | | 5 | 2 | | | 1 |
| C. haemotopotus | | | | 4 | | | | | | | | 2 | | | | | | | | | | |
| C. bickleyi | 7 | | | | | | | | | | | | | | | | | | | | | |
| Stilobezzia | | | 18 | 72 | | 35 | | | 18 | 21 | | 17 | | | | 2 | | | 7 | | | |
| Dasyhelea | | | 3 | 12 | | 8 | | | 9 | 4 | | 3 | 2 | | | 1 | | | | | | 2 |
| Palpomyia | | | 6 | 3 | | 4 | | | | | | 2 | | | | | | | 2 | | | |
| Atrichopogon | | | 15 | | | | | | 6 | | | | | | | | | | 8 | | 1 | |
| Bezzia | | | 2 | 2 | | | | | 3 | 1 | | | | | | | | | | | | |
| Clinohelea | | | | | | | | | 2 | | | | | | | | | | | | | |
| Alluadomyia | | | | | | | | | | | | | | | | | | | | | | |

RAB 1986

| Genus or species | 112 | 121 | 128 | 133 | 143 | 150 | 157 | 164 | 171 | 178 | 184 | 192 | 199 | 206 | 213 | 220 | 227 | 234 | 241 | 248 | 255 | 262 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Weekly Adult Emergence Date (Julian days) | | | | | | | | | | | | | | | | | | | | | |
| C. spinosus | 5 | 2 | 2 | 3 | | 9 | | | 2 | 4 | | 2 | | | | | | | | | | |
| C. stellifer | | 1 | | | | | | | 5 | 6 | | 9 | 1 | | | | | | | | | |
| C. baueri | | | | | | | | | 8 | 5 | | | | | | | | | | | | |
| C. biguttatus | | | | | | 1 | | | | | | | | | | | | | | | | |
| C. venustus | | 1 | | 1 | | | | | 12 | 7 | | 11 | 2 | | 14 | 2 | 6 | 1 | | | 1 | |
| C. haemotopotus | | 1 | | | | 2 | | | 2 | | | | | | 1 | | | | | | | |
| C. bickleyi | | | | | | 2 | | | | 1 | | | | | | | | | | | | |
| Stilobezzia | | | 12 | 8 | | 34 | | | 2 | 3 | | 19 | 8 | | | 6 | 7 | 6 | | | | |
| Dasyhelea | | | | | | 3 | | | 1 | | | 4 | | | | | 2 | 3 | | | | |
| Palpomyia | | | 3 | 1 | | 6 | | | 6 | 1 | | | | | | | | 2 | | | | |
| Atrichopogon | | | 5 | 2 | | | | | 47 | 9 | | 29 | | | | 5 | 3 | 1 | 3 | | 3 | 1 |
| Bezzia | | | | | | | | | | 3 | | 4 | | | | | | | | | | |
| Clinohelea | | | | | | | | | 2 | | | | | | | 1 | | | | | | |
| Alluadomyia | | | | 2 | | | | | | | | 1 | | | | | | | | | | |

| RB 1986 Genus or species | Weekly Adult Emergence Date (Julian days) | | | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 112 | 121 | 128 | 133 | 143 | 150 | 157 | 164 | 171 | 178 | 184 | 192 | 199 | 206 | 213 | 220 | 227 | 234 | 241 | 248 | 255 | 262 |
| C. spinosus | | 4 | 1 | 6 | | 12 | | | 2 | 3 | | 1 | | | | | | | | | | |
| C. stellifer | | | | | | | | | 1 | | | 2 | 6 | 7 | | | | | 2 | | | |
| C. baueri | | | | | | | | | 2 | | | | | | | | | | | | | |
| C. biguttatus | | 1 | 3 | | | | | | 1 | | | | | | | | | | | | | |
| C. venustus | | | | | | | | | | 2 | | 1 | 1 | 2 | | | | | | | | |
| C. haemotopotus | | | | | | 1 | | | 2 | 1 | | | 1 | 2 | | | | | | | | |
| C. bickleyi | | | | | | | | | | | | | | | | | | | | | | |
| Stilobezzia | | | | 7 | | 12 | | | 2 | 2 | | 1 | | | | | | | | | | |
| Dasyhelea | | | | | | | | | 2 | 1 | | 6 | 1 | 3 | | 1 | | | | | | |
| Palpomyia | | | 1 | 2 | | 5 | | | 2 | 2 | | | 1 | 3 | 4 | 2 | | | | | | |
| Atrichopogon | | | 1 | 1 | | 5 | | | 12 | 3 | | 3 | 2 | 4 | 3 | | 1 | 1 | 1 | 3 | | |
| Bezzia | | | | | | | | | 2 | 4 | | | | | | | | | | | | |
| Clinohelea | | | | | | | | | 1 | 2 | | | | | | | | | | | | |
| Alluadomyia | | | | | | | | | | | | | | | | | | | | | | |

| RS 1986 Genus or species | Weekly Adult Emergence Date (Julian days) | | | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 112 | 121 | 128 | 133 | 143 | 150 | 157 | 164 | 171 | 178 | 184 | 192 | 199 | 206 | 213 | 220 | 227 | 234 | 241 | 248 | 255 | 262 |
| C. spinosus | 2 | | 7 | | | 37 | | | 1 | 1 | | | 1 | | | | | | | | | |
| C. stellifer | | | | | | 1 | | | | | | | 4 | 2 | 1 | | | | | | | |
| C. baueri | | | | | | | | | | | | | | 1 | | | | | | | | |
| C. biguttatus | | 5 | | | | 2 | | | | | | | | | | | | | | | | |
| C. venustus | | | | | | 1 | | | | 2 | | 2 | 3 | 2 | | | | | | | 5 | |
| C. haemotopotus | | | | | | | | | | | | | | | | | | | | | | |
| C. bickleyi | | | 24 | | | | | | | | | | | 5 | | | | | 1 | | | |
| Stilobezzia | | | | | | | | | | | | 9 | | | 1 | | | | | | | |
| Dasyhelea | | | | | | | | | | | | 4 | 10 | 2 | | | | | | | | |
| Palpomyia | | | 4 | 1 | | 3 | | | 1 | 2 | | | | 7 | | | 2 | 1 | | | | |
| Atrichopogon | | | | | | | | | | 1 | | 4 | 2 | | 1 | 1 | | 1 | | 1 | 7 | |
| Bezzia | | | | | | | | | | | | | 3 | 1 | | | | | | | | |
| Clinohelea | | | | | | | | | | | | 1 | | | | | | | | | | |
| Alluadomyia | | | | 3 | | | | | | | | | | 1 | | | | | | | | |

AG 1986

| Genus or species | 121 | 129 | 136 | 142 | 149 | 156 | 163 | 170 | 178 | 184 | 191 | 198 | 205 | 212 | 220 | 226 | 233 | 241 | 247 | 254 | 261 | 268 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| *C. spinosus* | | | | | | | | | | | | | | | | | | | | | | |
| *C. stellifer* | | | | | | | 1 | | | | | | 1 | | | | | | | | | |
| *C. baueri* | | | | | | | 1 | | | | | | | | | | | | | | | |
| *C. biguttatus* | | | | | | 1 | 9 | | | | | | | | | | | | | | | |
| *C. venustus* | | | | | | | | | | | | | | | | | | | | | | |
| *C. haematopotus* | | | | | | | | | | | | | | | | | | | | | | |
| *C. bickleyi* | | 1 | | | | | | | | | | | | | | | | | | | | |
| *Stilobezzia* | | | | 1 | | | 2 | | 1 | 1 | | | | | | | | | | | | |
| *Dasyhelea* | | | | | | | | | | | | | | | | | | | | | | |
| *Palpomyia* | | | | 1 | | | | 1 | 1 | | | | | | | | | | | | | |
| *Atrichopogon* | | | | | | | | | | | | | | | | | | | | | | |
| *Bezzia* | | | | | | | 1 | | | | | | | | | | | | | | | |
| *Clinohelea* | | | | | | | | | | | | | | | | | | | | | | |
| *Alluaudomyia* | | | | | | | | | | | | | | | | | | | | | | |

Weekly Adult Emergence Date (Julian days)

OX 1986

| Genus or species | 121 | 129 | 136 | 142 | 149 | 156 | 163 | 170 | 178 | 184 | 191 | 198 | 205 | 212 | 220 | 226 | 233 | 241 | 247 | 254 | 261 | 268 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| *C. spinosus* | | | | | | 1 | | | | | | | | | | | | | | | | |
| *C. stellifer* | | | | | | | | | | | | | | | | | | | | | | |
| *C. baueri* | | | | | | | | | | | | 1 | | | | | | | | | | |
| *C. biguttatus* | | | | | | | 1 | | | | | | | | | | | | | | | |
| *C. venustus* | | | | | | | | | | | | | | | | | | | | | | |
| *C. haematopotus* | | 4 | | | | 1 | 1 | | | | 20 | 2 | | 2 | 1 | | | 2 | | 1 | | |
| *C. bickleyi* | | | | 1 | | | | | | | | | | | | | | | | | | |
| *Stilobezzia* | | | | | 2 | 2 | 1 | | | | | 1 | | | | | | | | 1 | | |
| *Dasyhelea* | | 1 | | | | | | | 1 | 13 | 27 | 30 | | 24 | 25 | 30 | 4 | 5 | 4 | 11 | 12 | |
| *Palpomyia* | | 7 | | | | 1 | | 1 | | | 1 | | | | | | | | | | | |
| *Atrichopogon* | | | | | | | | | | | | | | | 2 | | | | | | | |
| *Bezzia* | | 2 | | 5 | 4 | 1 | | | | | 2 | | | | | | | | | | 5 | |
| *Clinohelea* | | | | | | | | | | | | | | | | | | | | | | |
| *Alluaudomyia* | | | | | | | | 1 | 1 | | | | | | | | | | | | | |

Weekly Adult Emergence Date (Julian days)

| ACS 1986 Genus or species | Weekly Adult Emergence Date (Julian days) | | | | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 121 | 129 | 136 | 142 | 149 | 156 | 163 | 170 | 178 | 184 | 191 | 198 | 205 | 212 | 220 | 226 | 233 | 241 | 247 | 254 | 261 | 268 | 275 |
| C. spinosus | | | | 4 | 1 | 1 | | | 1 | | 1 | | | | | | | | | | | | |
| C. stellifer | | | | | | | 12 | 2 | | 6 | | 4 | | 3 | | | | | | | | | |
| C. baueri | | 42 | 2 | 1 | 4 | 27 | 14 | 7 | 7 | 1 | 1 | 16 | 3 | | 5 | 9 | 2 | 3 | | 1 | 4 | 1 | |
| C. biguttatus | | | | | | | 1 | | | | | | | | | | | | | | | | |
| C. venustus | | 8 | 8 | | 2 | 14 | 1 | 1 | 1 | 1 | | 2 | 4 | 1 | 2 | 1 | | 2 | | 2 | | | 1 |
| C. haematopotus | | 2 | 1 | | | 1 | | | | | | 1 | | | | 1 | | | | | | | |
| C. bickleyi | | | | | | 1 | | | | | | | | | | | | | | | | | |
| Stilobezzia | | 4 | 2 | 1 | 1 | | | 1 | 1 | | 2 | 2 | 7 | 5 | 1 | 5 | | | | | | | |
| Dasyhelea | | 5 | | | | | | | | 2 | 2 | 2 | 1 | 1 | 2 | | 1 | | 1 | 2 | | | |
| Palpomyia | | | 4 | 6 | | 1 | | | | | | | 1 | 2 | 1 | | | | | | | | |
| Atrichopogon | | | | | | | 1 | 4 | 6 | 4 | 4 | 4 | 2 | 1 | 6 | | | | 1 | | 1 | | |
| Bezzia | | | 1 | | | 4 | | | | 2 | 2 | 1 | | | | | | | | | | | |
| Clinohelea | | | | | | | | | | | | | | | | | | | | | | | |
| Alluaudomyia | | | | | | | | | | 1 | | 1 | | | | | | | | | | | |

| BMF 1986 Genus or species | Weekly Adult Emergence Date (Julian days) | | | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 121 | 129 | 136 | 142 | 149 | 156 | 163 | 170 | 178 | 184 | 191 | 198 | 205 | 212 | 220 | 226 | 233 | 241 | 247 | 254 | 261 | 268 |
| C. spinosus | | | | | | | | | | | | | | | | | | | | | | |
| C. stellifer | | | | | | | | | | | | | | | | | | | | | | 1 |
| C. baueri | | | | | | | | | | | | | | | | | | | | | | |
| C. biguttatus | | 2 | 7 | | | | | | | | | | | | | | | | | | | |
| C. venustus | | | | | | | | | | | | | | | | | | | | | | |
| C. haematopotus | | 1 | | | | | | | | | | | | | | | | | | | | |
| C. bickleyi | | | | | | | | | | | | | | | | | | | | | | |
| Stilobezzia | | | | | | 2 | | | | 1 | | | | 1 | | | | | | | | |
| Dasyhelea | | | 1 | | | | | | | | | | | | | | | | | | | |
| Palpomyia | | | | | | | | | | | | | | | | | | | | | | |
| Atrichopogon | | | | | | | | | | | | | | | | | | | | | | |
| Bezzia | | | 1 | | | | | 1 | | 2 | | | 1 | | | | | | | | | |
| Clinohelea | | | | | | | | | | | | | | | | | | | | | | |
| Alluaudomyia | | | | | | | | | | | | | | | | | | | | | | |

DPA 1986

| Genus or species | 121 | 129 | 136 | 142 | 149 | 156 | 163 | 170 | 178 | 184 | 191 | 198 | 205 | 212 | 220 | 226 | 233 | 241 | 247 | 254 | 261 | 268 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Weekly Adult Emergence Date (Julian days) | | | | | | | | | | | | | | | | | | | | | |
| C. spinosus | | 2 | 3 | | | | | 1 | | | | | | | | | | | | | | |
| C. stellifer | | | | | | | 2 | 10 | 3 | | 1 | | | | | | | | | | | |
| C. baueri | | | 2 | | | | | 5 | | | | | | | | | | | | | | |
| C. biguttatus | | | 1 | | | | | | | | | | | | | | | | | | | |
| C. venustus | | | 4 | | | | | | | | | | | | | | | | | | | |
| C. haematopotus | | | | | | | | | | | | | | | 1 | | | | | | | |
| C. bickleyi | | | | | | | | | | | | | | | | | | | | | | |
| Stilobezzia | | | 1 | | | | | | | | | | | | | | | | | | | |
| Dasyhelea | | 1 | 1 | | | | | | | | | | | | | | | | | | | |
| Palpomyia | | 1 | 2 | 8 | | | | | 1 | 1 | | | | | | | | | | | | |
| Atrichopogon | | | | | | | | | | | | | | | | | | | | | | |
| Bezzia | | | | | | | | 2 | 1 | 1 | | | | | | | | | | | | |
| Clinohelea | | | | | | | | | | | | | | | | | | | | | | |
| Alluaudomyia | | | | | | | | | | | | | | | | | | | | | | |

DPB 1986

| Genus or species | 121 | 129 | 136 | 142 | 149 | 156 | 163 | 170 | 178 | 184 | 191 | 198 | 205 | 212 | 220 | 226 | 233 | 241 | 247 | 254 | 261 | 268 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Weekly Adult Emergence Date (Julian days) | | | | | | | | | | | | | | | | | | | | | |
| C. spinosus | 6 | | | | | 1 | | | 1 | | | | | | | | | | | | | |
| C. stellifer | | | | | | | | 4 | 8 | 1 | 1 | | | | | | | | | | | |
| C. baueri | | | | | | | 8 | | | | | | | | | | | | | | | |
| C. biguttatus | | | | | | | | | | | | | | | | | | | | | | |
| C. venustus | | | | | | | | | | | | | | | | | | | | | | |
| C. haematopotus | | | | | | | | | | | | | | | | | | | | | | |
| C. bickleyi | | | 1 | | | | | | | | | | | | | | | | | | | |
| Stilobezzia | | | | | | 1 | | | | | | | | | | | | | | | | |
| Dasyhelea | | | | | | | | | | | | | | | | | | | | | | |
| Palpomyia | 2 | | | | | | | | 1 | | | | | | | | | | | | | |
| Atrichopogon | | | | | | | | | | | | | | | | | | | | | | |
| Bezzia | | | 1 | | | 1 | | 3 | 2 | | | | | | | | | | | | | |
| Clinohelea | | | | | | | | | | | | | | | | | | | | | | |
| Alluaudomyia | | | | | | | | | | | | | | | | | | | | | | |

DPC 1986

| Genus or species | 121 | 129 | 136 | 142 | 149 | 156 | 163 | 170 | 178 | 184 | 191 | 198 | 205 | 212 | 220 | 226 | 233 | 241 | 247 | 254 | 261 | 268 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| *C. spinosus* | | 2 | | | | | | 2 | | | | | | | | | | | | | | |
| *C. stellifer* | | | | | | 5 | 4 | 7 | 7 | 1 | 1 | | | | | | | | | | | |
| *C. baueri* | | | | | | | | | | | | | | | | | | | | | | |
| *C. biguttatus* | | 2 | 13 | 1 | | | | | | | | | | | | | | | | | | |
| *C. venustus* | | | | | | | | | | | | | | | | | | | | | | |
| *C. haematopotus* | | | | | | | | | | | | | | | | | | | | | | |
| *C. bickleyi* | | | | | | | | | | | | | | | | | | | | | | |
| *Stilobezzia* | | 1 | 1 | | | | | 1 | | | | | | | | | | | | | | |
| *Dasyhelea* | | | | | | | | | | | | 1 | | 2 | | | | | | | | |
| *Palpomyia* | | | | | | | | | 2 | | | | | | | | | | | | | |
| *Atrichopogon* | | | | | | | | | | | | | | | | | | | | | | |
| *Bezzia* | | | | | | | 1 | | | | | | | | | | | | | | | |
| *Clinohelea* | | | | | | | | | | | | | | | | | | | | | | |
| *Alluaudomyia* | | | | | | | | | | | | | | | | | | | | | | |

Weekly Adult Emergence Date (Julian days)

WBA 1986

| Genus or species | 121 | 129 | 136 | 142 | 149 | 156 | 163 | 170 | 178 | 184 | 191 | 198 | 205 | 212 | 220 | 226 | 233 | 241 | 247 | 254 | 261 | 268 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| *C. spinosus* | | | | | | | | | | | | | | | | | | | | | | |
| *C. stellifer* | | | | | | | | | | | | | | | | | | | | | | |
| *C. baueri* | | | | | | | | | | | | | | | | | | | | | | |
| *C. biguttatus* | | | | | | | | | | | | | | | | | | | | | | |
| *C. venustus* | | | | | | | | | | | | | | | | | | | | | | |
| *C. haematopotus* | | | | | 2 | | | | | | | | | | | | | | | | | |
| *C. bickleyi* | | | | | | | | | | 1 | | | | | | | | | | | | |
| *Stilobezzia* | | | | | 2 | | | | | | | | | | | | | | | | | |
| *Dasyhelea* | | | | | | | | | | | | | | | | | | | | | | |
| *Palpomyia* | | | | | 2 | | | | | | | | | | | | | | | | | |
| *Atrichopogon* | | | | | | | | | | | | | | | | | | | | | | |
| *Bezzia* | | | | | | | | | | | | | | | | | | | | | | |
| *Clinohelea* | | | | | | | | | | | | | | | | | | | | | | |
| *Alluaudomyia* | | | | | | | | | | | | | | | | | | | | | | |

Weekly Adult Emergence Date (Julian days)

WBB 1986

Weekly Adult Emergence Date (Julian days)

| Genus or species | 121 | 129 | 136 | 142 | 149 | 156 | 163 | 170 | 178 | 184 | 191 | 198 | 205 | 212 | 220 | 226 | 233 | 241 | 247 | 254 | 261 | 268 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| C. spinosus | | | | | | 1 | | | | 2 | | | | | | | | | 1 | | | |
| C. stellifer | | | | | | | 1 | | | 3 | | | | | | | 2 | | 1 | | | |
| C. baueri | | | | | | | | | | | | | | | | | | | | | | |
| C. biguttatus | | | | | | | | | | | | | | | | | | | | | | |
| C. venustus | | | | | | | | 1 | | 1 | | | | 1 | 1 | 1 | 1 | | 2 | | | |
| C. haematopotus | | | | 5 | | | | | | | | | | | | | | | | | | |
| C. bickleyi | | | | | | | | | | | | | | | | | | | | | | |
| Stilobezzia | | 1 | | 4 | | 1 | | 2 | | | | | | | | | | | | | | |
| Dasyhelea | | | | | | | | 1 | | | | | | | | | | | | | | |
| Palpomyia | | | | | | | | | | | | | | | | | | | | | | |
| Atrichopogon | | 1 | | | | | | | | | | | | | | | 2 | | | 1 | | |
| Bezzia | | | | 2 | | 1 | 4 | | | | | | | | | | | | | | | |
| Clinohelea | | | | | | | | | | | | | | | | | | | | | | |
| Alluaudomyia | | | | | | | | | | | | | | | | | | | | | | |

WBC 1986

Weekly Adult Emergence Date (Julian days)

| Genus or species | 121 | 129 | 136 | 142 | 149 | 156 | 163 | 170 | 178 | 184 | 191 | 198 | 205 | 212 | 220 | 226 | 233 | 241 | 247 | 254 | 261 | 268 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| C. spinosus | | 3 | | | | | 3 | 1 | | | | | | | | | | | | | | |
| C. stellifer | | | | | | | | 2 | | 1 | 6 | 13 | | 7 | | | | | | | | |
| C. baueri | | | | | | | 3 | 1 | | 2 | | 2 | | | | | | | | | | |
| C. biguttatus | | | | | | | 5 | | | | | | | | | | | | | | | |
| C. venustus | | | | 1 | | | | | | | | | | 1 | | | | | | | | |
| C. haematopotus | | | | | | | | | | | | | | | | | | | | | | |
| C. bickleyi | | 2 | | | | | | | | 1 | | | | | | | | | | | | |
| Stilobezzia | | | | 1 | | 8 | 3 | | | 11 | | 1 | | 2 | | | | | | | | |
| Dasyhelea | | 1 | | | | | | 2 | | | 1 | | | 2 | | 1 | 1 | | | | | |
| Palpomyia | | 1 | | | | 3 | 1 | 1 | | 1 | | | | | | | | | | | | |
| Atrichopogon | | | | | | | 1 | 4 | | 11 | 1 | 1 | | 5 | | | | | | | | |
| Bezzia | | 2 | | | | | | | | | 1 | | | | | 1 | | | | | | |
| Clinohelea | | | | | | | | 2 | | 3 | | | | | | | | | | | | |
| Alluaudomyia | | | | | | | | | | | | | | | | | | | | | | |

# VITA

Daniel S. Root was born in Greenfield, Massachusetts on November 17 1959. He attended elementary school in that town, and graduated from Greenfield High School in June 1978. The following September he entered Greenfield Community College where he graduated with honors in June 1981. In September of that same year he began classes at the University of Massachusetts. In February 1984 he received a Bachelor of Arts Degree in Chemistry.

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The author is a member of the Tennessee Entomological Society, The Entomological Society of America and Phi Kappa Phi. Mr. Root will continue his education at North Carolina State University, Raleigh, where he will be working on his Doctoral Degree in Entomology.