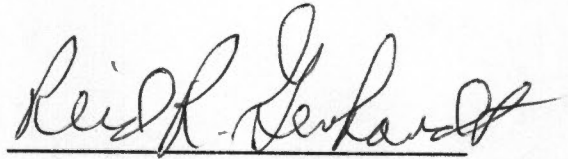


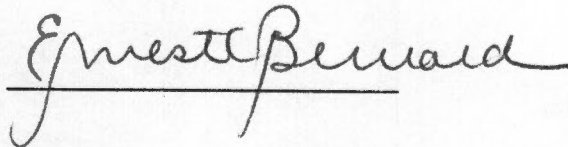
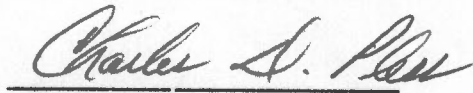
To the Graduate Council:

I am submitting herewith a thesis written by Sitan Traoré entitled "The Black Flies (Simuliidae:Diptera) of the Great Smoky Mountain National Park and Vicinity." I have examined the final 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:



Accepted for the Council:



Associate Vice Chancellor
and Dean of the Graduate School

STATEMENT OF PERMISSION TO USE

In presenting this thesis in partial fulfillment of the requirements for a master's degree at The University of Tennessee, Knoxville, I agree that the library shall make it available to borrowers under rules of the Library. Brief quotations from this thesis are allowable without special permission, provided that accurate acknowledgement of the source is made.

Permission for extensive quotation from or reproduction of this thesis may be granted by my major professor, or in his absence, by the Head of the Interlibrary Services when, in the opinion of either, the proposed use of the material is for scholarly purposes. Any copying or use of the material in this thesis for financial gain shall not be allowed without written permission.

Signature Sitan Traore'

Date 12 - 4 - 1992

**The Black Flies (Simuliidae:Diptera)
of the Great Smoky Mountain National Park
and Vicinity**

**A Thesis
Presented for the
Master of Science Degree
The University of Tennessee, Knoxville**

**Sitan Traoré
December 1992**

DEDICATION

This thesis is dedicated to my late grand-mother Mrs. Salimata Kane. And to my parents Mr. Lamine Benke Traore and Mrs. Traore Kadiatou Toure, to all my brothers and sisters, to my special friend Bekaye Haidara for the invaluable educational opportunities and constant support and encouragement.

ACKNOWLEDGEMENTS

I would like to express my sincere appreciation to the African American Institute, and my Government for the financial support throughout my study. Special thanks go to Mrs. Elizabeth Ward for her tireless enthusiasm as training advisor.

I would like to thank my major professor Dr. Reid Gerhardt for his guidance and patience during collection expedition in cold days.

I would like to extend my thanks to the other committee members, Dr. Charles Pless for being available all the time with the moral support and technical advises and Dr. Bernard for his comments and his assistance during the research work.

I also would like to express my deepest gratitude to Dr. P.H. Adler at Clemson University for serving me with his expertise for the identification of the specimens and all the assistance for this study. Special appreciation to Marriane, Charles, Kelvin and other people for their hospitality.

I would like to thank all the people, professors, friends and classmates of the Department of Entomology and Plant Pathology and Dr. L. M. Pan of the Department of Zoology, for their kind assistance. Special thanks is offered to Dave Paulsen for his kind assistance during collection and preparation of the thesis. I am grateful to Steve Huff for accompanying on collection expedition with joy. I also

would like to thank Doris Caldwell and Liz Vail for all their help in preparing my thesis.

I would like to extend my appreciation to my friend Deborah Landau for being always for all the moral support encouragement and preparation for my thesis.

I would like to express my gratitude to the Fray's family, and the Al Almi Salma family for their encouragement and support.

I would like to extend my deepest gratitude to all my friends from Zaire, Ivory Cost, Mali, Burkina Fasso, Haiti, France, Mauritius, Nigeria, Ghana, Lesotho and Sao-Tome for being there for me when I needed them most. I also thank Karen Rikett for her kindness and concern during these two years.

ABSTRACT

Larval black flies were collected monthly from four selected streams in the Great Smoky Mountains National Park between June 1991 and July 1992. One large size (13 m wide Little River), one small (1m wide Tipton Place) and two medium sized streams, one in the sun (6.45 m wide Mill Creek site #1) and one in the shade (6m wide Mill creek site #2) streams and additional creeks in Knox, Monroe, Morgan, Blount counties in eastern Tennessee and Haywood County in western North Carolina will be discussed.

Larvae of *Simulium tuberosum* (Lundstrom) complex, *S. venustum/verecundum* Say, *S. quebecense* Twinn, *S. parnassum* Malloch, *S. impar* Davies, Peterson, & Wood, *Prosimulium mixtum* Syme & Davies, and *Stegopterna mutata* Malloch were collected from leaves, sticks and rocks submerged in water from different collection sites. *S. tuberosum* larvae or pupae were present almost year around, while *S. venustum/verecundum* were present only in October, November, March, April and May in the four streams and rivers. *P. mixtum* larvae were collected when the water temperature was lowest in December, January, February, March and a few in April. *S. quebecense* larvae were rare and collected only in March, April, and May. *S. parnassum* and *S. impar* were collected from medium size and small size creeks. *Stegopterna mutata* was found only from Tipton Place and from an unnamed creek in Morgan County. *P. magnum* was collected mainly in Knox County. Some rare species such as *P. arvum*, *P. rhyzophorum* were

collected in Knox County and *S. loerchae* in Sevier County from an unnamed small creek near Pigeon River.

Chromosome identification was used to separate sibling species of black flies. Our study of chromosome identification indicated that *S. tuberosum* species complex consisted of FG/CDE, FG, CKL and A, the *S. venustum* cytospecies was CC, and *S. verecundum* cytospecies was AA, *Stegopterna mutata* was found to be diploid cytospecies. Future research will further address species differentiation with chromosome identification.

TABLE OF CONTENTS

CHAPTER	PAGE
I. INTRODUCTION	1
II. LITERATURE REVIEW	3
III. MATERIALS AND METHODS	12
IV. RESULTS AND DISCUSSION	18
V. CONCLUSIONS	39
REFERENCES CITED	41
APPENDIX	46
1. Seasonal Occurrence of <i>Simulium tuberosum</i>	47
2. Seasonal Occurrence of <i>Simulium venustum/verecundum</i>	48
3. Seasonal Occurrence of <i>Simulium quebecense</i>	49
4. Seasonal Occurrence of <i>Prosimulium mixtum</i>	50
VITA	51

LIST OF TABLES

TABLE	PAGE
1. Species of Black flies (Simuliidae) collected in eastern Tennessee and western North Carolina	19
2. Cytospecies of <i>Simulium tuberosum</i> complex	20
3. Cytospecies of <i>Prosimulium</i> , <i>Stegopterna</i> and <i>Simulium</i> complex	21
4. <i>Prosimulium</i> and <i>Simulium</i> collected in Knox Co., TN 1991-1992	27
5. Collection of <i>Prosimulium</i> , <i>Stegopterna</i> and <i>Simulium</i> found in Morgan Co., Tennessee 1991-1992	28
6. Specimens from irregular collections in Blount Co., TN. 1991-1992	30
7. Black fly collected from Monroe Co., TN. 1991	31
8. Sibling species of <i>Simulium venustum/verecudum</i> complex	34
9. <i>S. tuberosum</i> and <i>S. loerchae</i> collected in Sevier Co., TN August 1991	35
10. Collections of <i>Simulium</i> from Haywood Co., North Carolina May 1992 (Palmer's and Catalooche Creeks)	38

LIST OF FIGURES

FIGURE	PAGE
1. Seasonal Distribution of Prosimulium and Simulium collected from Little River	22
2. Seasonal Distribution of Prosimulium and Simulium collected from Mill Creek #1	23
3. Seasonal Distribution of Prosimulium and Simulium collected from Mill Creek #2	25
4. Seasonal Distribution of Prosimulium, Stegopterna and Simulium collected from Tipton Place	26

Chapter 1

INTRODUCTION

Black flies (Simuliidae: Diptera) are well known biting pests of humans and their livestock. The immature stages occur in moving water and are always associated with creeks, streams and rivers. The adults are generally strong flyers, and long-distance movement away from breeding sites have been reported for many species (Hocking 1953, Fallis 1964, Johnson 1969). Sometimes movements can involve huge numbers of flies. Baranoff (1936) reported that swarms of the Golubatz fly, *Simulium colombaschense* (Fabricus), were carried downwind from their breeding sites in Danube and invaded large areas of Yugoslavia. In Canada *S. arcticum* has been reported biting, and even killing, cattle at distances of more than 200 km from its breeding places (Fredeen 1969). *S. damnosum* s.l., in particular, is a known vector of Onchocerciasis, or "river blindness," and for many years has been considered to travel long distances (Le Berre, 1966). Accurate knowledge of their behavior is important for the planning and execution of black fly management programs.

In the southern United States the primary concern about black flies is their persistent attack of livestock, turkeys, and man (Stone and Snoddy 1969). Decreases in milk production and many deaths of cattle pastured in areas near breeding sites have been caused by fly attacks (Davies et al. 1962). Populations of cattle and horses of Edgfield County and Piedmont areas in South Carolina have suffered from

outbreaks of *S. tuberosum* (Ludstrom) and *S. vittatum* Zett (Snoddy and 1976).

At present there is a considerable body of data available on black fly larval ecology and disease organism transmission. Relatively little is known about adult feeding ecology for many species. Data on relative abundance, species succession, and landing sites (known as adult feeding ecology) are valuable in determining economic impact and disease organism transmission.

Many species of black flies can be distinguished from each other only by examining the chromosomes of the larvae (known as cytotaxonomy). Other approaches are morphotaxonomy and chemotaxonomy. Morphotaxonomy was used for generations in the taxonomy of Simuliidae. Since then, taxonomists have found other techniques, because there is considerable doubt in the reliability of morphological characters to identify Simuliidae. Currently, the status of many morphology based species are in doubt.

OBJECTIVES

The objectives of this study were to 1) Determine the seasonal succession of black fly selected communities in eastern Tennessee and 2) Determine species of larval black fly in the streams and rivers of eastern Tennessee.

Chapter 2

LITERATURE REVIEW

Black flies (Diptera:Simuliidae), also known as "Buffalo gnats" are important pests of humans, livestock and turkeys in the southeastern portion of the United States. Outbreaks of these insects in the Mississippi Valley, as well as in many other areas of the southern United States, make black flies important pests wherever they occur (Pomeroy 1916). Very little was known about these insects when Pomeroy (1916) studied them at Spartanburg, South Carolina. Snow et al. (1958) provided much additional information on the seasonal distribution and economic importance of black flies in the southern United States. *Simulium jenningsi* Malloch, *S.slossonae* (Dyar and Shannon) and *S.congreenarum* (Dyar and Shannon) have been studied primarily in their capacity as major vectors of *Leucocytozoon smithi* in South Carolina (Noblet et al. 1976) and Virginia (Underhill 1939, Voshell, 1991). Numerous other species are present in the southern United States but little is known about their economic or medical importance.

Prosimulium magnum (Dyar and Shannon)

Larvae, pupae and adult of this species were collected from the southeastern United States from January through April (Snoddy and Noblet 1976). In Tennessee it was found in Surgoinsville in spring 1954, and in Sugar Tree in March, 1955 (Snow et al. 1958). A putative *P.magnum* larva was collected but its identity was not confirmed (Snow et al. 1958). *P.magnum* was also collected at Murphy and

Hayesville, North Carolina, from ears of horses and mules (Snow et al. 1958).

Prosimulium mixtum (Syme Davies)

This species has been reported from Alabama and was considered an uncommon winter species (Snoddy and Noblet 1976). *P. mixtum* larvae occur on trailing plant material in medium size streams (Adler and Kim 1986, Snoddy and Noblet 1976, Snoddy and Snow 1969,)

Prosimulium rhyzophorum Stone and Jamback

This species was collected from Alabama. It seems to be a rare winter species, and occurs in small temporary streams from January through April (Adler and Kim 1986, Snoddy and Noblet 1976, Stone and Snoddy 1969).

Prosimulium hirtipes Fries

Whittaker (1952) found this species in the Great Smoky Mountains at an elevation of 3,100-5,600 ft., and it was the principal simuliid occurring in the subalpine forest in the summer. This species was found near Andrew in North Carolina, and was associated with *S. vittatum*, and *S. tuberosum* in February and also with elmids, *Stenelmis crenata* (Say) (Snow et al. 1958).

Stegopterna mutata Malloch

This species was collected from Alabama and the Appalachian Mountains (Stone and Snoddy 1969). *Stegopterna mutata* is a winter species collected occasionally from trailing plants in a medium sized streams with sandy bottoms (Noblet et al. 1976). The diploid has been collected from West Virginia south to Beckley (Raleigh County) (Adler and Kim 1986).

Cnephia ornithophilia David Peterson Wood

This species appears to be univoltine. Adult females were collected in Louisiana and Mississippi from February 6 to May 1. In South Carolina, adults were collected from January 11 to March 18, and in southern Virginia larvae and pupae were collected (Stone and Snoddy 1969, Noblet et al. 1976). It is found in medium size streams (Noblet et al. 1976).

Cnephia pecuarum (Riley)

Larvae pupae and adult of this species were collected in Alabama, Arkansas, Florida, Georgia, Louisiana and Mississippi. *C. pecuarum* is common in winter, and has been collected from trailing plants in medium and larger size streams. (Noblet et al 1976, Stone and Snoddy 1969)

Simulium clarkei (Stone)

Larvae and pupae of *S. clarkei* were collected in Hamblen County, Tennessee, in April (Snow et al. 1958), and in southern Virginia (Stone and Snoddy 1969). There is not much information on this species.

Simulium congreenarum (Dyar and Shannon)

The larvae were common in some streams in the Coastal Plain of South Carolina. It is common in late February, March, and April but decreases in late April and early May. Adults of *S. congreenarum* were observed feeding on turkeys from March until May at Plowden Farm in South Carolina (Noblet et al. 1972). It was collected primarily from turkeys, and cattle in Jasper County, South Carolina (Jones and Richey 1956). This species was also collected in Lee County, Alabama,

Florida, and Louisiana (Stone and Snoddy 1969). *S.congreenarum* is a winter species and occurs on plants in small coastal and inland streams (Snoddy and Noblet 1976). This species is probably univoltine.

Simulium slossonae (Dyar and Shannon)

This species occurs in South Carolina, and was reported as a vector of *Leucocytozoon smithi* Laver and Lucet. *S. slossonae* larvae, pupae, and adults were found in only two of seven streams in Jasper County South Carolina, in the first week in February. One month later when the same streams were sampled larvae were found in seven locations, and by the end of March larvae were at all locations sampled (Jones and Richey 1956). This species was collected from the Coastal Plain and Sandhill region of South Carolina (Arnold 1974). *S. slossonae* was collected in Alabama from Escambia and Washington County (Stone and Snoddy 1969). Females of this species were collected in Virginia in New Kent County (Underhill 1939, 1944). Larvae were collected during all seasons on trailing plant material in large swamp streams of the southern United States (Snoddy and Noblet 1976).

Simulium jenningsi group Malloch

This species was collected at Spartanburg, South Carolina, on November 2, 1916 (Pomeroy 1916). It was collected in Jasper County during a biological study of black flies and their relationships to *Leucocytozoon* disease transmission (Jones and Richey 1956). *S. jenningsi* was collected in the Coastal Plain and Sandhills of South Carolina from May 14 1973, to May 5, 1974 (Arnold 1974). This species was reported as abundant in the southern United States (Adler and Kim 1986). The

specimens of the *S. jenningsi* group have been collected from South Carolina, North Carolina, Virginia (misidentified as *S. nigrovum*) and Tennessee (Underhill 1939, Snow et al. 1958). Recently Moulton and Adler (1992) contended that there were fifteen species in this widely distributed species complex and the larvae are found in medium and large inland streams (Snoddy and Noblet 1976).

Simulium decorum Walker

This species is widespread in southern states, having been reported in Jasper County, South Carolina during a study of the black flies (Jones and Richey 1956), from the Tennessee River Valley during a study of black flies in 1953-1956 (Snow et al. 1958), from Alabama in a study to develop a carbon dioxide trap for Simuliidae (Snoddy et al. 1966), from Florida and in the southeastern states to the Appalachian Range (Stone and Snoddy 1969). It occurs on masonry and trailing objects below impoundments and streams of small and medium size. It is common during all seasons (Snoddy and Noblet 1976).

Simulium parnassum Malloch

This species is known from the Appalachian Mountains, Alabama, Georgia, North Carolina, Tennessee, and Virginia. Adults were collected from June 4 to August 17, and immature stages were collected in permanent cool streams (Stone and Snoddy 1969, Adler and Kim 1986).

Simulium vittatum Zetterstedt complex

This species occurs in the mountainous areas of the tributary watersheds in the Tennessee River basin (Snow et al. 1958). It was regularly found with *S. tuberosum*

and *S. venustum* (Snow et al. 1958). *S. vittatum* was found in Louisiana, Georgia, and in Alabama. It was collected in Fort Payne, Parkerson' Mill, and Creek western of Auburn (Stone and Snoddy 1969). This species is multivoltine, with at least seven generations per year in Alabama (Stone and Snoddy 1969). *Bacillus thuringiensis* var. *israelensis* de Barjac was used in early May 1981 to reduce *S. vittatum* in Kingsport Tennessee (Frommer et al. 1981). *S. vittatum* complex has two cytospecies but only one of the cytospecies IS-7, was found in Virginia and West Virginia (Adler and Kim 1986). *S. vittatum* is widespread in the southeastern United States and is often collected below domestic sewage disposal areas (Snoddy and Noblet 1976).

Simulium tuberosum Lundstrom

This species was collected in Jasper County, South Carolina (Jones and Richey 1956). In a 1973 survey in South Carolina, *S. tuberosum* was collected more often than any other species (Arnold 1974). At lower elevations *S. tuberosum* was frequently collected in mountain streams and was especially abundant at an old mill site on the Oconaluftee River near Cherokee, North Carolina (Snow et al. 1958). In the Tennessee River *S. tuberosum* was found on trailing vines and leaves during March and early April, associated with *Stegopterna mutata* and *S. vittatum* (Snow et al. 1958). In Alabama larvae and pupae of this species were present throughout the winter with an occasional emergence of adults during warmer winter periods (Snow et al. 1958). Stone and Snoddy (1969) considered *S. tuberosum* to be one of the most widespread species in Alabama, and the most persistent pest of man and livestock in

the area. This species was found feeding in ears of livestock unless crowded out by the larger species, *S. pictipes* and *S. vittatum*. *S. tuberosum* has more than five generations in Alabama (Stone and Snoddy 1969). Landau (1962) did the first work of this species, which was recognized as a sibling species. This work was greatly expanded by Manson (1982,1984). Some of the *S. tuberosum* sibling species found in the southeastern United States are listed in the "Black Flies of Pennsylvania" (Adler and Kim 1986). The *S. tuberosum* species complex is widespread, occurring in Georgia, Florida and many other locations. It is common on aquatic plants in small and medium inland and coastal streams. *S. tuberosum* is common throughout the year (Snoddy and Noblet 1976).

Simulium venustum Say complex

This species is known from South Carolina, Tennessee and Alabama (Pomeroy 1916, Jones and Richey 1956, Arnold 1974, Snow et al. 1958). *S. venustum* has at least four generations per year in the Sandhills and Coastal Plains of South Carolina (Arnold 1974). *S. venustum* was observed to be infrequent compared to *S. tuberosum* and was also less abundant than *S. parnassum* based on sweeping collections in the Great Smoky Mountains during June and July (Snow et al. 1958), and generally seems to be a less frequently collected species than other members of the group (*S. tuberosum*) (Stone and Snoddy 1969). This species was collected from Cypress Creek, Florence and other places in Alabama (Stone and Snoddy 1969). *S. venustum* is a widespread species found in medium and large sized streams (Snoddy and Noblet 1976). It has been reported that sibling species CC was found in the south through

Kentucky, Tennessee, Arkansas, and Louisiana (Rothfels et al. 1978; Rothfels 1981).

Simulium verecundum Stone and Jamnback

A single male of this species was reared from a pupa collected near Luka, Mississippi, on June 30, 1954 (Snow et al. 1958). *S. verecundum* was found in South Carolina, and it was reported to be uncommon in Alabama. It is a member of the *S. venustum* complex and is very difficult to distinguish from *S. venustum* and *S. tuberosum* in the pupa, and adult except by the shape of the ventral plate of male terminalia (Snow et al. 1958, Stone and Snoddy 1969). This species was described as being distinguishable from *S. venustum* by Stone and Jamnback (1955), based on their differences in color. The freshly preserved *S. verecundum* larvae are white; however, *S. venustum* is reddish. Rothfels et al. (1978) did not find a color relationship, but found that the best method to separate the *S. venustum* complex from *S. verecundum* is done by chromosome identification. In the southeastern United States this species occurs in medium-size streams on plant material (Snoddy and Noblet 1976). It is associated with *S. vittatum*, and *S. decorum* (Stone and Snoddy 1969).

Simulium pictipes Hagen complex

This species was found in winter in the cold mountain streams at lower elevations in Chatuge Dam which is associated with the Hiwassee River near Hayesville, North Carolina, in the fall of 1954. *S. pictipes* was overwintering as mature larvae with occasional pupae between late November and late February in Alabama, (Snow et al. 1958). It is primarily found in Elgin, Florence, in Arkansas,

Georgia, South Carolina, Virginia and West Virginia (Stone and Snoddy 1969). This species was known as species complex Stone (1964). Bedo (1975) described the chromosome of the three species. The sibling species *S. pictipes* B was found in South Carolina (Adler and Kim 1986).

Simulium meridionale Riley

A single adult of this species common in the Lower Mississippi Valley was collected at Sugar Tree in Tennessee (Snow et al. 1958). *S. meridionale* was found in Alabama in Frisco City, Monroeville (Stone and Snoddy 1969). This species is a potentially serious pest of turkeys, chickens, and pheasants (Stone and Snoddy 1969).

Simulium impar Davies, Peterson, and Wood

This species was collected in northern west Virginia (Adler and Kim 1986).

Simulium luggeri Nicholson and Mickel

This species occurs in Alabama and Virginia (Adler and Kim 1986).

Simulium emarginatum Davies, Peterson, and Wood

This species was collected from West Virginia (Golini and Rothfels 1984).

Simulium quebecence Twinn.

This species was collected in West Virginia, Virginia in Giles County, and from Crib Mountain Road in the Great Smoky Mountains National Park in Tennessee in April 1982 (Adler and Kim 1986).

Chapter 3

MATERIALS AND METHODS

Black fly larvae were collected from January 1991 to July 1992. Four different stream sites differing in width and shading were sampled regularly each month from June 1991 to July 1992. Additional collections were made from other locations irregularly. Water temperature was measured. The four streams sampled monthly were located in Blount County while the streams sampled irregularly were in Knox County, Monroe County, Morgan County, Sevier County, in Tennessee, and Haywood County in North Carolina.

Ecology of the regular collection sites

The four regularly sampled streams and rivers located in Great Smoky Mountains National Park were different in size and ecology. Stream were sampled each month From June 1991 to July 1992.

1. Mill Creek site #1.

This portion of the stream is shaded by rhododendron (*Rhododendron* sp.) and eastern hemlock (*Tsuga canadensis*). Mill Creek is a medium width creek 6.45 m wide and 12.5 cm deep at the collection site. It is located at parking lot for Abram's Falls on Cades Cove Loop Road. The bottom was rocky and the mean water temperature was between 4.1°C-15.1°C December to July.

2. Mill Creek site # 2.

This portion of the stream is in an open field surrounded by grass. It is located 0.3km southeast of Cades Cove Loop Road on Forge Creek Road. The bottom was muddy with a few rocks. It had fast moving water and the mean temperature was between 5.8°C-17.25°C in December to July. This medium width creek was 6m wide and 20cm deep at the collection site.

3. Tipton Place

This is a small width stream 1m wide and 5cm deep, partially shaded 0.9Km from the southern intersection of Hyatt Lane and Cades Cove Loop Road. At the collection site it had slow-moving water with a muddy bottom and small rocks. It was surrounded by alders (*Alnus* sp.) rhododendron, and hemlock. Mean water temperature was between 6.3°C-15.42C° in December to July.

4. Little River

This was a large width stream 13m wide and over 1m deep at the collection site. It was located 1 km east of the intersection of State Road 73 and Cove Road. It had very fast-moving water, large rocks in the bottom, and was surrounded with mixed vegetation. Mean water temperature was 6.4°C-17.38°C December to July.

Ecology of irregular collection sites

Tatar Branch is a small, exposed branch of Abrams Creek, that crosses the Cades Cove Loop Road 0.3 km after the Rich Mountain Road intersection.

Wild Cat Branch is a medium width, shaded branch of Mill Creek.

A collection was made at a site 300 meters upstream from the spot where it crosses Forge Creek Road; 0.75 km from the junction of Forge Creek Road and the Cades Cove Loop Road.

Forge Creek is large width , shaded creek which was sampled 1 km past the Henry Whitehead Cabin on Forge Creek Road.

Rowans Creek is a medium width partially shaded creek, which crosses the Cades Cove Loop Road 1.1 km east southern intersection of Sparks Lane.

Victoria Branch is a very small, shaded branch of Mill Creek site #1 which follows Rabbit Creek Road. It was sampled 0.1 km from Mill Creek.

Middle Prong Little River is a large, partially shaded stream which joins the Little River 0.75 km from the intersections of State Route 73 and Cove Road. It was sampled near the intersection of Cove Road and Middle Prong Road.

Knox County

Site #1 the Idumea Road collection site was in Brice Branch located 200 m west of Rutledge Pike (US 11 W) on Idumea Road in northeastern Knox County 4.16km south of Grainger County. This creek was small in width with a sandy bottom. Water temperature was 8 to 20 °C.

Site #2 was an unnamed branch of Molly Creek at junction of Hogskin and Fulton Road, in the vicinity of House Mountain State Natural Area 3.2km southwest of Idumea Road. This small width creek had a sandy bottom with small rocks. Water temperature was 9.4-21 °C

Site #3 was Flat Creek on Idumea Road 1.92km north of the junction of

Hogskin Road and continued into the intersection of Idumea Road and Washington Pike. This creek had a sandy bottom and water temperature was 11 °C in April and 21.1 °C in June.

Site #4, Little Flat Creek, was 0.64km northwest of Washington Pike on Little Flat Creek Lane. This medium width creek is surrounded with vegetation. Little Flat Creek had a muddy bottom and the water temperature was 10-21.7 °C.

Blount County, Great Smoky National Park

Site #1, Whistling Branch was at Cades Cove Loop Road, located 1.2km east of the junction of Forge Creek Road and Caves Cove Loop Road. The portion sampled was in sun surrounded with grass and few plants and the bottom was muddy. Water temperature was 6.5-20 °C.

Site #2, Arbutus Branch was approximately at 0.8km northeast of the parking lot of Abram's Falls Hiking Trail. This small width creek had rocky bottom and surrounded with rhododendron. Mean of water temperature was 4.6 -16 °C.

Sevier County

Middle Prong Little Pigeon River is located near the Greenbryer Camp Ground. This large width stream had very fast moving water. Little Pigeon River had a rocky bottom.

In the vicinity of Middle Prong Little Pigeon River an unnamed small width partially shaded creek with a sandy bottom was sampled.

Monroe County

Ball Play Creek was located 200m from the end of Nickels Branch Road,

2.08km north of the Rafter community.

Nickels Creek was located 0.8km north of Rafter community on Nickels Creek Road.

Morgan County

Site #1 Flat Fork Creek was in the Frozen Head State Park, located on Loop Trail hiking trail 300m from the parking lot. This medium width stream had a rocky bottom.

Site #2, was an unnamed creek located up South Mac hiking path in Frozen Head State Park. This small width creek had a rocky bottom.

Site #3, Lone Mountain was located at the Nature Trail at Lone Mountain State Forest Head Quarters. This medium width creek had a sandy bottom.

Specimen collection and identification

Larvae were removed with fine forceps from leaves, rocks, and sticks in the streams. They were then placed on paper towels to remove excess water and placed into the Carnoy's fixative which is one part glacial acetic acid with three part 95% ethanol (Adler and Kim 1986). A maximum of 20-30 larvae were placed into each vial. The fluid was changed three times before storing the specimens in the refrigerator for later morphological and chromosomal identification.

The specimens were tentatively identified morphologically with the aid of a dissecting microscope in the laboratory. They were then refrigerated. They were taken to Clemson University, Department of Entomology, where chromosome identifications and confirmation were done by Dr. Peter H. Adler. Specimens were

grouped into species complexes and chromosomally identified in order to separate sibling species. One or 2 vials were selected from each of 28 sites based on color and headspot pattern of the larvae. From those vials of specimens 48 vials of larvae were selected and identified chromosomally. These individuals were separated into two species complexes. One was the *Simulium tuberosum* complex the other was *Simulium venustum/ verecundum*. Less common species were also identified morphologically and chromosomally. *Prosimulium magnum*, *P. mixtum* and *P. arvum* were identified chromosomally and morphologically. *P. rhyzophorum* was identified morphologically. *Stegopeterna mutata* was identified chromosomally and morphologically. *S. impar*, *S. quebecense* *S. loerchae* and *S. parnassum* were identified morphologically.

From each vial 1-10 larvae were stained by the following method (Rothfels and Dunbar 1953): " The venter of the larval abdomen was opened, and larvae are placed sequentially into distilled water (20 minutes); preheated (30 minutes) in 1N HCL maintained at 62-65 °C (10 minutes); Fleugen stain (60 minutes); sulfur water (200 ml distilled water, 10 ml 1N HCL, 1g potassium metabisulfite; 9-12 min); and two changes cold tap water (two minutes each) until examination, at which time the salivary glands are removed and placed to a slide. A cover slip was added and thumb pressure was applied to make the squash." A Nikon interference-contrast microscope was used to study chromosomes.

Chapter 4

RESULTS AND DISCUSSION

Seventeen species of black fly larvae were collected in 28 sites in Blount, Knox, Monroe, Morgan and Sevier counties in eastern Tennessee and Haywood County North Carolina (Table 1). The numbers of each species found in each area are presented in Table 1 for morphologically identified species and Tables 2 and 3 (sibling species). Species collected in four regularly sampled sites were.

Little River

Larvae or pupae of *S. tuberosum* were collected year around from this site except when water temperature was cold (January and February). *P. mixtum* was collected from only December to April. *S. venustum/verecundum* was collected in March, April and May. Ten larvae of *S. quebecense* also were collected in this river (Fig.1)

Mill Creek #1

Larvae or pupae of *S. tuberosum* were collected year around, but very few was found when water temperature was cold. *P. mixtum* was collected from December to April; it was associated with *S. tuberosum*. *S. venustum/verecundum* and *P. magnum*. *S. parnassum*, *S. impar*, and *S. quebecense* also were present (Fig.2).

Table 1. Species of Black flies (Simuliidae) collected in eastern Tennessee and eastern North Carolina.

	Blount	Knox	Monroe	Morgan	Sevier	Haywood
<i>Prosimulium magnum</i>	44	279	0	23	0	0
<i>Prosimulium mixtum</i>	1069	156	5	21	0	0
<i>Prosimulium arvum</i>	0	12	0	0	0	0
<i>Prosimulium rhyzophorum</i>	0	1	0	0	0	0
<i>Simulium tuberosum</i>	3463	257	226	48	89	82
<i>Simulium venustum/verecundum</i>	592	358	2	0	0	156
<i>Simulium parnassum</i>	38	0	2	0	0	15
<i>Simulium impar</i>	6	0	0	1	0	0
<i>Simulium aureum</i>	0	1	0	0	0	0
<i>Simulium vitatum</i>	0	6	0	0	0	0
<i>Simulium loerche</i>	0	0	0	0	1	0
<i>Simulium quebecense</i>	10	0	0	0	0	3
<i>Stegopterna mutata</i>	3	0	0	4	0	0

Table 2. Cytospecies of the *Simulium tuberosum* complex.

Date	Location	Number/Cytospecies				
		FG	CDE	CKL	FG/CDE	A
05 Apr 1991	Rafter	10	-	-	-	-
15 Apr 1991	Wild Cat	10	-	-	-	-
15 Apr 1991	Arbutus	-	10	-	-	-
14 May 1991	Lone Mountain	-	-	10	-	-
14 Jun 1991	Cooper Br.	-	10	-	-	-
26 Jun 1991	Nickels Br.	-	-	-	-	-
26 Kim 1001	Ball Play	-	-	-	-	-
03 Jul 1991	Gray Back	10	-	-	-	-
10 Jul 1991	Middle Prong	-	20	-	-	-
17 Jul 1991	Conner Creek	-	10	-	-	-
17 Jul 1991	Butter Mill	-	-	-	-	10
01 Aug 1991	Little Pigeon River	10	-	-	-	-
08 Aug 1991	After Tipton	10	-	-	-	-
25 Sep 1991	Mill Creek #2	-	10	-	-	-
25 Oct 1991	Mill Creek #1	-	10	-	-	-
02 Nov 1991	Rafter	-	-	-	-	10
20 Nov 1991	Mill Creek #2	-	10	-	-	-
29 Jan 1992	Little Flat Creek	-	-	10	-	-
06 Mar 1992	Brice Branch	-	-	7	-	-
18 Mar 1992	Mill Creek #1	10	-	-	-	-
18 Mar 1992	Mill Creek #2	10	-	-	-	-
18 Mar 1992	Little River	-	-	-	10	-
08 Apr 1992	Site #1 on Molly Creek	-	-	5	-	-
15 Apr 1992	Arbutus	20	-	-	-	-
15 Apr 1992	Tipton Place	12	-	-	-	-
20 May 1992	Palmer Creek	15	-	-	-	-
20 May 1992	Catalooche	10	-	-	-	-
17 Jun 1992	Flat Creek	-	-	13	-	3-

Table 3. Cytospecies of *Prosimulium*, *Stegopterna*, and *Simulium* complex.

Date	Location	Number/Cytospecies				
		St. mutata diploid	S. vittatum III-L-1	S. aureum	P. arvum	P. magnum B.
20 Mar 1991	Frozen Head (South Mac)	1	-	-	-	-
21 Jun 1991	Little Flat Cr.	-	2	-	-	-
21 Jun 1991	Little Flat Cr.	-	-	3	-	-
29 Jan 1992	Little Flat Cr.	-	-	-	4	-
29 Jan 1992	Little Flat Cr.	-	2	-	-	-
12 Feb 1992	Whistling Br.	3	-	-	-	-
12 Feb 1992	Tipton Place	1	-	-	-	-
28 Feb 1992	Frozen Head (South Mac)	2	-	-	-	-
06 Mar 1992	Molly Cr.	-	-	-	-	5

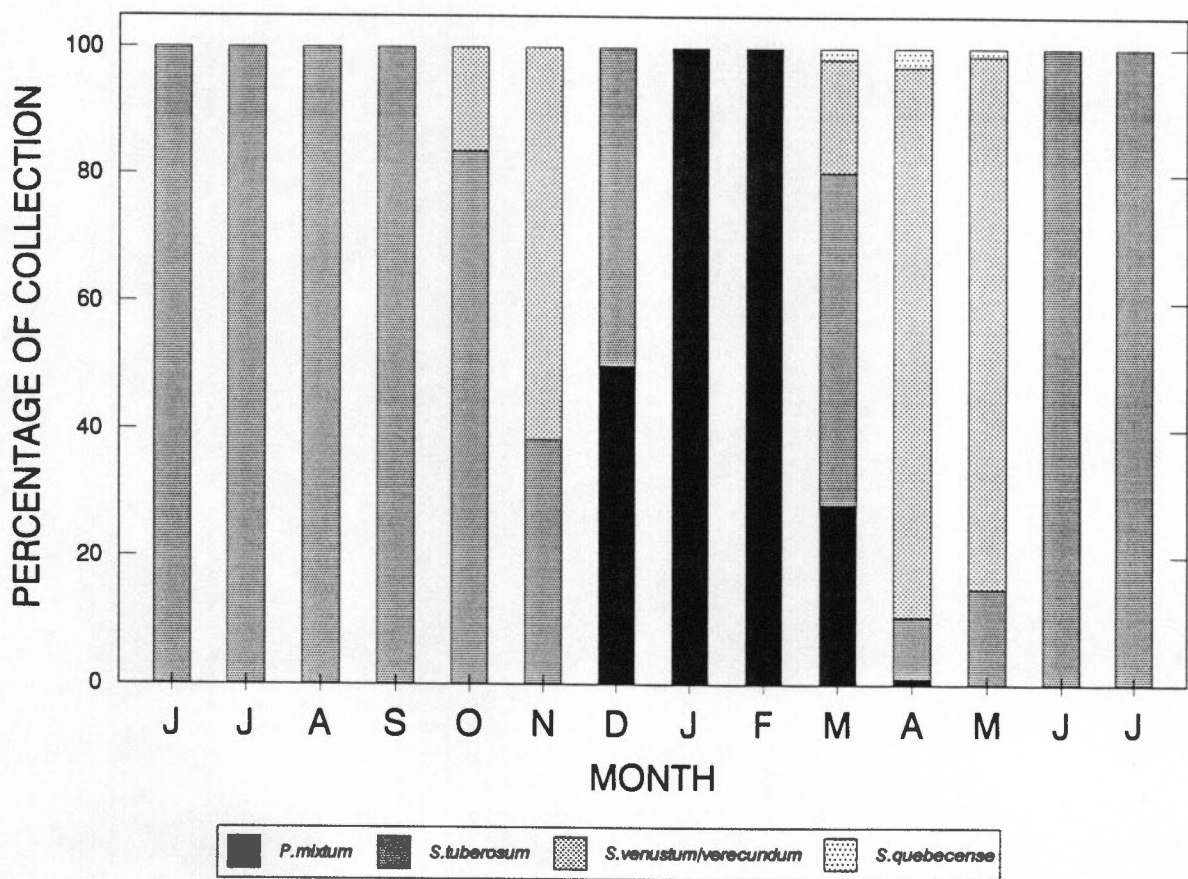


Figure 1. Seasonal distribution of Prosimulium and Simulium collected from Little River.

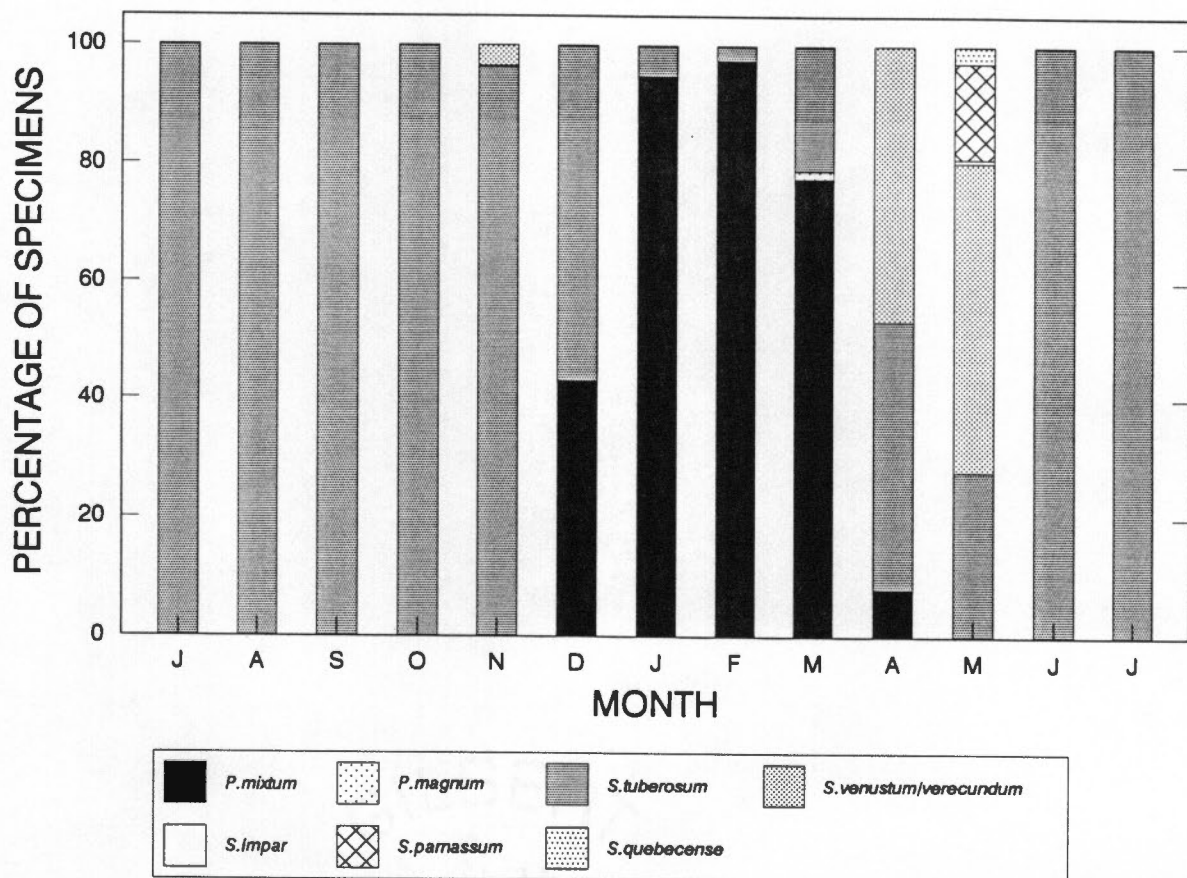


Figure 2. Seasonal distribution of Prosimulium and Simulium collected from Mill Creek #1.

Mill Creek #2

Larvae or pupae of *S.tuberosum* were collected a throughout the year. *P.mixtum* was collected in December through April, it was associated with *S.venustum/ verecundum* and *S.tuberosum*. *S.impar* and *S. parnassum* also were collected (Fig.3).

Tipton Place

Larvae or pupae of *S.tuberosum* were collected year around. *P. mixtum* was collected in January through March and it was associated with *Stegopterna mutata*. *S.venustum/verecundum* was collected from March to May; it was associated with *S.tuberosum*, *S. impar* and *S. parnassum* (Fig.4).
Species colleted in additional creeks and rivers.

In March and April 1992, 38 larvae and 6 pupae of *P. magnum* were collected in Blount County, Tennessee, from Abram's Creek,. The larvae and pupae were collected from leaves in the stream whose mean water temperature was 12 °C. In Knox County, 279 and larvae pupae were collected, which was more than from any other county (Table 1). Eighty-three percent of the *P.magnum* specimens were found on rocks covered with moss and on leaves in Brice Branch. Mean water temperature at the time of collection was 9-10 °C. Specimens were collected Knox County in February 1991, and January, March and April 1992. The *P. magnum* were associated with *P. mixtum*, *P. arvum* (Table 4), and a few *S. tuberosum*. In one collection in Morgan County, 23 larvae were found which associated with *Segopterna mutata*, *P. mixtum* and *S.tuberosum* (Table 5).

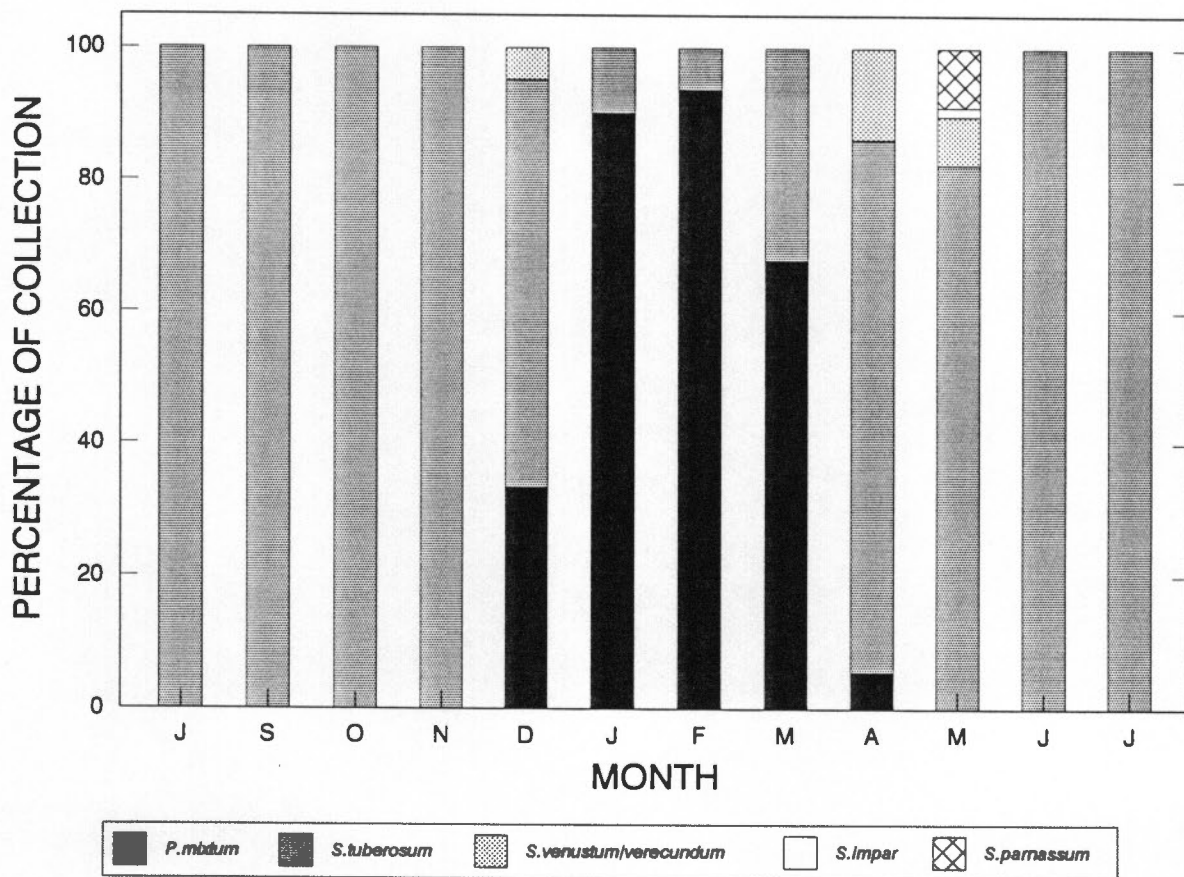


Figure 3. Seasonal distribution of Prosimulium and Simulium collected from Mill Creek #2.

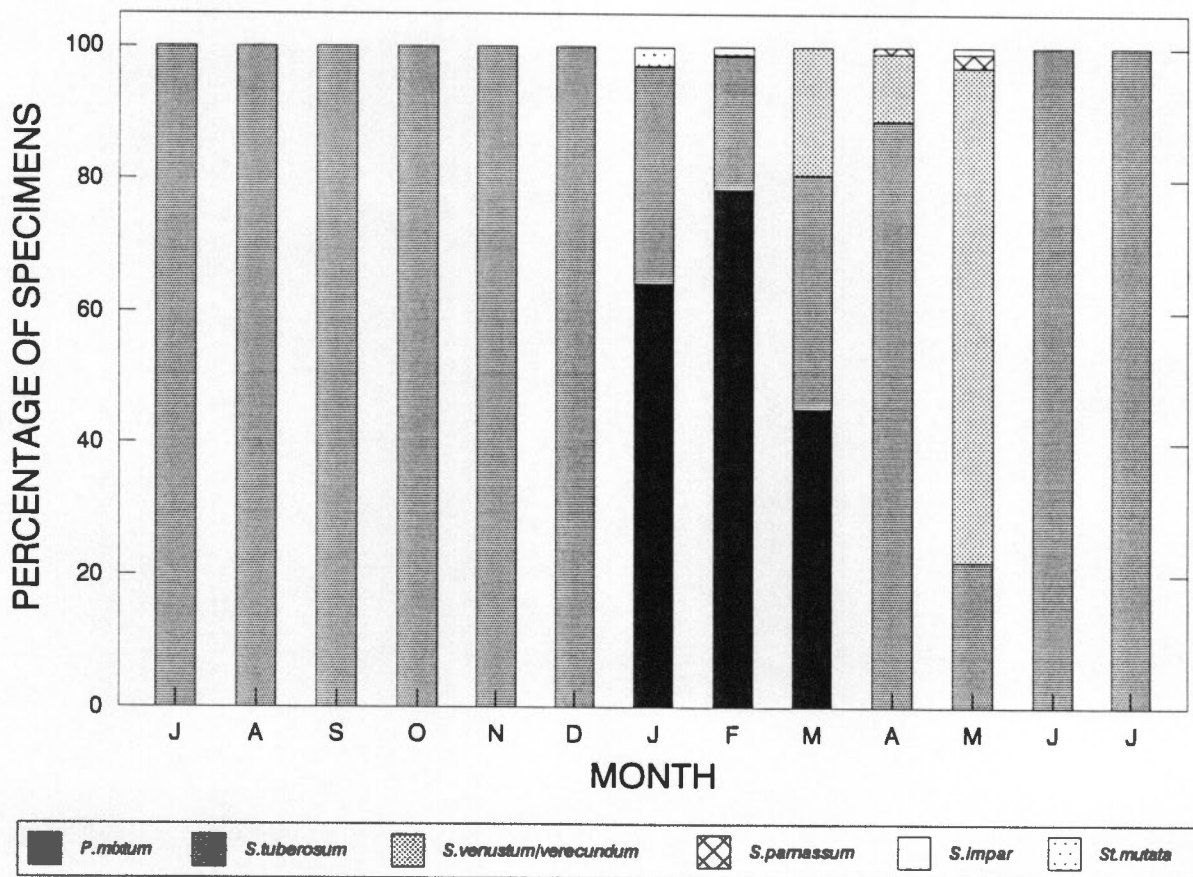


Figure 4. Seasonal distribution of Prosimulium, Stegopterna, and Simulium collected from Tipton PLace.

Table 4. *Prosimulum* and *Simulium* collected in Knox Co., TN 1991-1992

Date	Species Name	Location and Number/Species			
		Molly Cr.	Brice Br.	Little Flat Cr.	Flat Cr.
08 Feb 1991	<i>P. magnum</i>	70	0	0	2
08 Feb 1991	<i>P. mixtum</i>	4	18	0	0
08 Feb 1991	<i>P. arvum</i>	3	1	0	0
08 Feb 1991	<i>S. tuberosum</i>	0	7	29	10
21 Jun 1992	<i>S. aureum</i>	0	0	1	0
21 Jun 1992	<i>S. tuberosum</i>	17	57	29	10
21 Jun 1992	<i>S. vittatum</i>	0	0	6	0
21 Jun 1992	<i>S. ven./ver.</i>	34	0	33	0
29 Jan 1992	<i>P. magnum</i>	49	0	0	0
29 Jan 1992	<i>P. mixtum</i>	18	97	0	0
29 Jan 1992	<i>P. arvum</i>	0	0	7	0
29 Jan 1992	<i>S. vittatum</i>	0	0	2	0
29 Jan 1992	<i>S. tuberosum</i>	2	0	23	0
29 Jan 1992	<i>S. ven./ver.</i>	34	0	25	0
06 Mar 1992	<i>P. magnum</i>	84	0	0	0
06 Mar 1992	<i>P. mixtum</i>	0	17	0	0
06 Mar 1992	<i>P. rhizophorum</i>	0	1	0	0
06 Mar 1992	<i>S. impar</i>	0	2	0	0
06 Mar 1992	<i>S. tuberosum</i>	1	13	11	0
06 Mar 1992	<i>S. ven./ver.</i>	0	0	66	0
08 Apr 1992	<i>P. magnum</i>	44	27	0	3
08 Apr 1992	<i>P. mixtum</i>	1	0	0	1
08 Apr 1992	<i>S. tuberosum</i>	5	0	5	8
08 Apr 1992	<i>S. ven./ver.</i>	3	0	74	123
17 Jun 1992	<i>S. Tuberosum</i>	0	4	20	45
17 Jun 1992	<i>S. ven./ver.</i>	0	0	0	0

Table 5. Collections of *Prosimulium*, *Stegopterna*, and *Simulium* found in Morgan County Tennessee 1991-1992.

Dates	Species names	Location	Number
20-March-1991	<i>P.magnum</i>	Frozen Head St.	0
	<i>P.mixtum</i>	Park (South Mac	1
	<i>S.tuberosum</i>	trail)	0
	<i>S.impar</i>		0
	<i>St.mutata</i>		3
14-May-1991	<i>P.magnum</i>	Lone Mountain	0
	<i>P.mixtum</i>		0
	<i>S.tuberosum</i>		43
	<i>S.impar</i>		1
	<i>St.mutata</i>		0
28-February-1992	<i>P.magnum</i>	Frozen Head St.	19
	<i>P.mixtum</i>	Park (South mac	5
	<i>S.tuberosum</i>	trail)	5
	<i>S.impar</i>		0
	<i>St.mutata</i>		0
	<i>P.magnum</i>	Frozen Haed St.	4
	<i>P.mixtum</i>	Park (Loop trail)	15
	<i>S.tuberosum</i>		0
	<i>S.impar</i>		0
	<i>St.mutata</i>		1

Prosimulium mixtum Syme & Davies

Larvae of *P. mixtum* were found in all four counties sampled eastern Tennessee. In Blount county, 1069 larvae of *P. mixtum* were collected (Tables 1 and 6). They were collected from both large and small streams as well as from sunny and shady locations. Collections were made from December 1991 to April 1992. The seasonal abundance of *P. mixtum* and its association with other simuliids are presented in (Fig.1,2,3,4). From Knox County, it was found in three different places in February 1991, and January to April 1992 (Table 4). In Monroe County, few collections were made; although, five larvae were collected in April 1991 (Table 7). Morgan County was sampled three times, yielding 21 larvae of *P. mixtum* which were found in March 1991 and February 1992 (Table 5).

Prosimulium arvum Adler & Kim

This species was not found in any of the selected streams in Blount County; however, 12 larvae were collected from Knox County. In Brice Branch 1 larva of *P. arvum* was found in February 1991, seven larvae of this species were collected in Little Flat Creek in January 1992. Other collections included 3 larvae at site #2 on Molly Creek in February, 1991 and 1 in April 1992. This species was associated with *P. mixtum*, *S. tuberosum*, *S. venustum/verecundum* and *S. vittatum* (Table 4). Water temperature was between 9 and 10°C.

Stegopterna mutata Malloch

This species was collected in Blount County from a small creek (Tipton Place and Whistling Branch). A single larva was collected from Whistling Branch (Table 6)

Table 6. Specimens from irregular collections in Blount Co., TN. 1991-1992

Date	Location	Number/species						
		<i>Siegopterna mutata</i>	<i>S. parnassium</i>	<i>S. impar</i>	<i>S. ven. /ver.</i>	<i>S. suberosum</i>	<i>P. mixtum</i>	<i>P. magnum</i>
19 Mar 1991	Whistling Br.	0	0	0	15	83	28	0
15 Apr 1991	Arbutus Br.	0	0	1	14	106	3	0
15 Apr 1991	Wild Cat Br.	0	0	1	114	78	0	0
15 May 1991	Whistling Br.(sun)	0	2	0	7	0	0	0
15 May 1991	Whistling Br.(shade)	0	2	0	0	8	0	0
15 May 1991	Arbutus Br.	0	0	0	0	46	0	0
15 May 1991	Forge Cr.	0	0	0	0	0	4	0
15 May 1991	Rowans Cr.	0	1	0	0	3	0	0
05 Jun 1991	Victoria Br.	0	0	2	0	0	0	0
14 Jun 1991	Abrams Cr.	0	0	0	0	96	0	0
14 Jun 1991	Victoria Br.	0	0	0	0	72	0	0
14 Jun 1991	Cooper	0	0	0	0	7	0	0
03 Jul 1991	Gray Ball Cr.	0	0	0	0	85	0	0
10 Jul 1991	Middle Prong	0	0	0	0	179	0	0
17 Jul 1991	Cornner Cr.	0	0	0	0	59	0	0
08 Aug 1991	Arbutus Br.	0	0	0	0	80	0	0
25 Oct 1991	Arbutus Br.	0	0	0	0	101	0	0
20 Nov 1991	Whistling Br.	0	0	0	0	7	0	0
14 Jan 1992	Whistling Br.	0	0	0	0	28	32	0
12 Feb 1992	Whistling Br.	1	0	0	0	50	46	0
12 Feb 1992	Arbutus Br.	0	0	0	0	33	128	0
15 Apr 1992	Whistling Br.	0	0	0	2	21	0	0
15 Apr 1992	Arbutus Br.	0	0	1	19	19	3	44
14 May 1992	Whistling Br.	0	0	0	0	166	0	0
16 Jun 1992	Arbutus Br.	0	0	0	0	166	0	0
14 Jul 1992	Whistling Br.	0	0	0	17	8	0	0

Table 7. Black Fly collected from Monroe Co.TN, 1991.

Dates	Species names	Location	Number
5-April-1991	<i>P.mixtum</i>	Rafter	5
	<i>S.tuberosum</i>		57
	<i>S.venustum/verecundum</i>		2
	<i>S.parnassum</i>		2
26-June-1991	<i>P.mixtum</i>	Nickel Creek	0
	<i>S.tuberosum</i>		39
	<i>S.venustum/verecundum</i>		0
	<i>S.parnassum</i>		0
	<i>P.mixtum</i>	Ball Play Creek	0
	<i>S.tuberosum</i>		4
	<i>S.venustum/verecundum</i>		0
	<i>S.parnassum</i>		0
2-November-1991	<i>P.mixtum</i>	Rafter	0
	<i>S.tuberosum</i>		39
	<i>S.venustum/verecundum</i>		0
	<i>S.parnassum</i>		0

Four larvae were collected in Morgan County; (Table 5). *Stegopterna mutata* diploid cytospecies was found in Morgan County (Table 3), and in Tipton Place.

Simulium tuberosum (Lundstrom) complex

Larvae and pupae of this species were found in all 28 collection sites.

Members of *S. tuberosum* complex were found almost year round from June 5, 1991 to July 14, 1992. Analysis of the polytene chromosome of the salivary gland was used to differentiate between sibling species. In Blount County, *S. tuberosum* cytospecies FG and CDE were the most common. *S. tuberosum* FG siblings were found in August 1991 and April 1992, but CDE were found in April, June, September, October and November 1991, and March, and April, 1992. Water temperatures ranged between 9-22 °C. In Knox County *S. tuberosum* cytospecies CKL was the most common species. It was collected in January, March, April, and June (Table 2). The water temperature ranged from 9-14 °C. *S. tuberosum* were associated with *S. venustum/verecundum*, *P. mixtum*, *P. rhizophorum* and *P. magnum*. *S. tuberosum* cytospecies A was found in both Monroe and Morgan counties, in November 1991. Water temperature was not known. One collection was made in North Carolina in Palmer's Creek, Cataloochee Cove. The *S. tuberosum* cytospecies FG was found in the different streams sampled.

Simulium venustum Say

S. venustum species was found in most counties sampled (Table).

S. venustum was found in Blount County, where 592 larvae and pupae of this species were collected. They were found in March, October and December 1991, and

in April and May, 1992. The water temperature was 5-17 °C. *S. venustum* CC sibling species was found at all the collection sites in Blount County. This species was associated with *S.tuberosum*, *S.impar*, *S.parnassum*, *P.mixtum* and *P.magnum*. *S. venustum* was collected from all selected streams in Knox County except Brice Branch. A total of 358 larvae was collected in June 1991, and March, April and June, 1992. The species associated with *S.venustum* were *S.tuberosum*, *S.vittatum*, *P.magnum*, *P.arvum*. The water temperature was between 11-22°C. *S. venustum* CC sibling species were found (Table 8). In Monroe county (Table 9) only two larvae of *S.venustum* were found and none was collected in Morgan County (Table 5). Three different sites were sampled in May 20, 1992 in North Carolina. One was Palmer's Creek and two were from Catalooche Creek (Table 10) twenty seven larvae of the 156 larvae collected, were identified chromosomally as *S. venustum* cytospecies CC.

Simulium verecundum complex Stone and Jamback

S. verecundum was collected with *S. venustum* complex. These are not distinguishable from each other, except by chromosome identification (Stone and Snoddy 1969). This complex was collected from Blount County, from irregularly sampled sites (Table 6). In Knox County it was collected from all the three streams except Brice Branch where it was totally absent. The cytological identification confirm that the cytospecies *S. verecundum* AA were found from Butter Mill in July 17, 1991 in Blount County, probably cytospecies *S. verecundum* AA from Corner Creek and from Little Flat Creek in June 21, 1991 (Table 8).

Table 8. Sibling species of the *Simulium venustum/verecundum* complex.

Date	Location	Number/Cytopspecies	
		CC	AA
05 Apr 1991	Rafter	5	-
15 Apr 1991	Wild Cat	10	-
14 May 1991	Whistling Br.	10	-
26 Jun 1991	Molly Cr.	10	-
26 Jun 1991	Little Flat Cr.	15	15
17 Jul 1991	Conner Creek	-	-
17 Jul 1991	Butter Mill	10	10
06 Mar 1992	Little Flat Creek	10	-
18 Mar 1992	Little River	10	-
08 Apr 1992	Flat Creek	10	-
08 Apr 1992	Molly Cr.	10	-
15 Apr 1992	Mill Br. #1	20	-
15 Apr 1992	Arbutus Br.	10	-
14 May 1992	Whistling Br #2	8	-
14 May 1992	Mill Br. #2	-	-
14 May 1992	Tipton Br.	7	-
20 May 1992	Catalooche	17	-
20 May 1992	Palmer Creek	10	-
14 Jul 1992	Whistling Br.	4	-

Table 9. *S. tuberosum* and *S. loerchae* were collected in Sevier Co., TN August 1991.

S = small; M = medium; B = big size stream

Date	Species name	Location	Number
1-August-1991	<i>S.tuberosum</i>	Little Pigeon River B.	87
	<i>S.tuberosum</i>	Little Pigeon River B.	30
	<i>S.tuberosum</i>	Little Pigeon River M.	9
	<i>S.tuberosum</i>	Little Pigeon River S.	50
	<i>S.loerchae</i>	Little Pigeon River S.	1

Simulium aureum complex Fries

A single larva was collected in June 21, 1991 from Little Flat Creek in Knox County. This species was associated with *S.tuberosum*, *S.venustum/verecundum* and *S.vittatum*. Chromosome identification confirmed that it is *S. aureum* cytospecies B.

Simulium vittatum complex Zetterstedt

This species was collected only in Knox County and mostly from Little Flat Creek in June 21, 1991 and January 29, 1992 (Table 4). The sibling species found was *S. vittatum* IIIIL-1.

Simulium loerchae (Adler)

A single larva was collected in August 1, 1991 From Sevier County in a small width, unnamed stream near the Pigeon River. *S.loerchae* was associated with *S.tuberosum* (Table 9).

Simulium impar Davies, Peterson, and Wood.

During the 1991-1992 survey this species was collected in Blount County from irregularly sampled sites (Table 6). *S. impar* from regularly sampled sites was found in Tipton Place in May 14, 1992, and Mill Creek site #1 in May 1992 . It was associated with *P.mixtum*, *S.venustum/verecundum*, *S.parnassum*, *S.quebecense*. *S.impar* was collected from Morgan County (Table 5) and from Knox County (Table 4).

Simulium parnassum Malloch

S. parnassum were collected in small and medium width streams in sun and shade in Blount County. This species occurred when water

temperature reached 12-15 °C in April and May 1991-1992 (fig.2, 3 and 4).

S. parnassum was collected in Haywood (Table 10) County.

Simulium quebecense Twinn.

S.quebecense was collected from Blount County from medium width shady and large width creeks (Fig. 1 and 2). This species was also collected from Haywood County North Carolina, in May 20, 1992 from a large stream in Cataloochee Cove (Table 10). *S.quebence* was absent in the areas sampled in Knox County.

Table 10. Collections from Haywood County North Carolina May 1992.
(Palmer's and Catalooche Creeks)

S = small; M = medium; B = big size streams

Date	Species names	Location	Number
20-May-1992	<i>S.tuberosum</i>	Palmer S.	31
	<i>S.venustum/verecund</i>		60
	<i>um</i>		4
	<i>S.parnassum</i>		0
	<i>S.quebecense</i>		
	<i>S.tuberosum</i>	Catalooche S.	30
	<i>S.venustum/verecund</i>		41
	<i>um</i>		1
	<i>S.parnassum</i>		0
	<i>S.quebecense</i>		
	<i>S.tuberosum</i>	Catalooche M.	16
	<i>S.venustum/verecund</i>		45
	<i>um</i>		2
	<i>S.parnassum</i>		0
	<i>S.quebecense</i>		
	<i>S.tuberosum</i>	Catalooche B.	5
	<i>S.venustum/verecund</i>		10
	<i>um</i>		8
	<i>S.parnassum</i>		3
	<i>S.quebecense</i>		

Chapter 5

CONCLUSIONS

Research was conducted in the Great Smoky Mountains National Park where four streams were regularly sampled. From all the sites *Simulium tuberosum* was abundant throughout the year except when water temperature was below 4 °C. *S. venustum/verecundum* was found at all sites but, it was less abundant than *S. tuberosum*. *Prosimulium mixtum* was collected from all the sampled streams when mean water temperature was between 4.5-6.2 °C from January to March. Numbers of this species decreased in April and were absent the rest of the year. No *P. magnum* was collected in the four regularly sampled sites except one larva from Mill Creek site #1. *P. magnum* was abundant in site #2 on Molly Creek, pupae and larvae were found in Brice Branch in Knox County. Water level decreased in both creeks in June and very few *S. tuberosum* were collected. *S. quebecense* was collected from only three sites: Little River, Mill Creek and Cataloochee Creek. *S. parnassum* and *S. impar* were collected from Mill Creek #1, Mill Creek #2 and Tipton Creek. Some rare species were collected, such as *S. loerchea*, in small creek near Little Pigeon River, and *P. rhyzophorum* in Brice Branch in Knox County. *Stegopterna mutata* was collected from Tipton Place and in Morgan County Frozen Head State Park (South Mac Trail creek).

Chromosome identification indicates that *S. tuberosum* cytospecies FG was common from all the collection sites. *S. venustum* CC was also found from all the

collection sites. *S. verecundum* cytospecies AA was found in Knox County and Butter Mill, from Blount County. *S. vittatum* IIL-1 was collected from Flat Creek. *S. aureum* B was collected from Little Flat Creek. Cytospecies *Stegopterna mutata* diploid was found in South Mac Trail. Sibling species *P. magnum* 1 was collected from site #2 of Molly Creek.

The use of chromosome identification of black flies for sibling species differentiation is essential for the proper identification of this insect. Future research in this area can help to decrease the notorious effects of Simuliidae which plagues so many people and animals today.

REFERENCES CITED

REFERENCES

- Adler, P. H. and K.C. Kim. 1986. The black flies (Simuliidae, Diptera) of Pennsylvania: bionomics, taxonomy and distribution. Pa. State Univ. Agric. Exp. Bull. 856.
- Arnold, D. C. 1974. Black flies of the Coastal Plains and Sandhills of South Carolina. M.S. Thesis, Clemson University, Clemson S.C., pp. 84-121
- Arthur W. Jobbins-Pomeroy. 1916. Notes on Five American Buffalo Gnats of the Genus *Simulium*. Washington, D.C. United States Dept. of Agric. Bull. 329.
- Baranoff, N. 1936. *Simulium* (Danubiosimulium) *columbaczense* Shonb.en Yugoslavia. Studien an pathogenen und parasitischen Iseckten IV. Institut fur Higiene und Volkgesundheit in Zagreb. 36 pp.
- Bedo, D. G. 1975. Polytene chromosomes of three species of blackflies in *Simulium pictipes* group. Can.J. Zool. 53:1174-1164.
- Davies, D. M. B. V. Peterson, and D. M. Wood. 1962. The black flies (Diptera: Simuliidae) of Ontario. Part I. Adult identification and distribution with descriptions of six new species. Proc. Entomol. Soc. Ont. (1961) 92:69-154.
- Fallis, A. M. 1964. Feeding and related behavior of female *Simulium* (Diptera) EXP. Parasitol. 15:439-470.
- Fredeen, F. J. 1969. Outbreaks of the black fly *Simulium articum* Malloch in Alberta. Quaest. Entomol. 5: 341-372

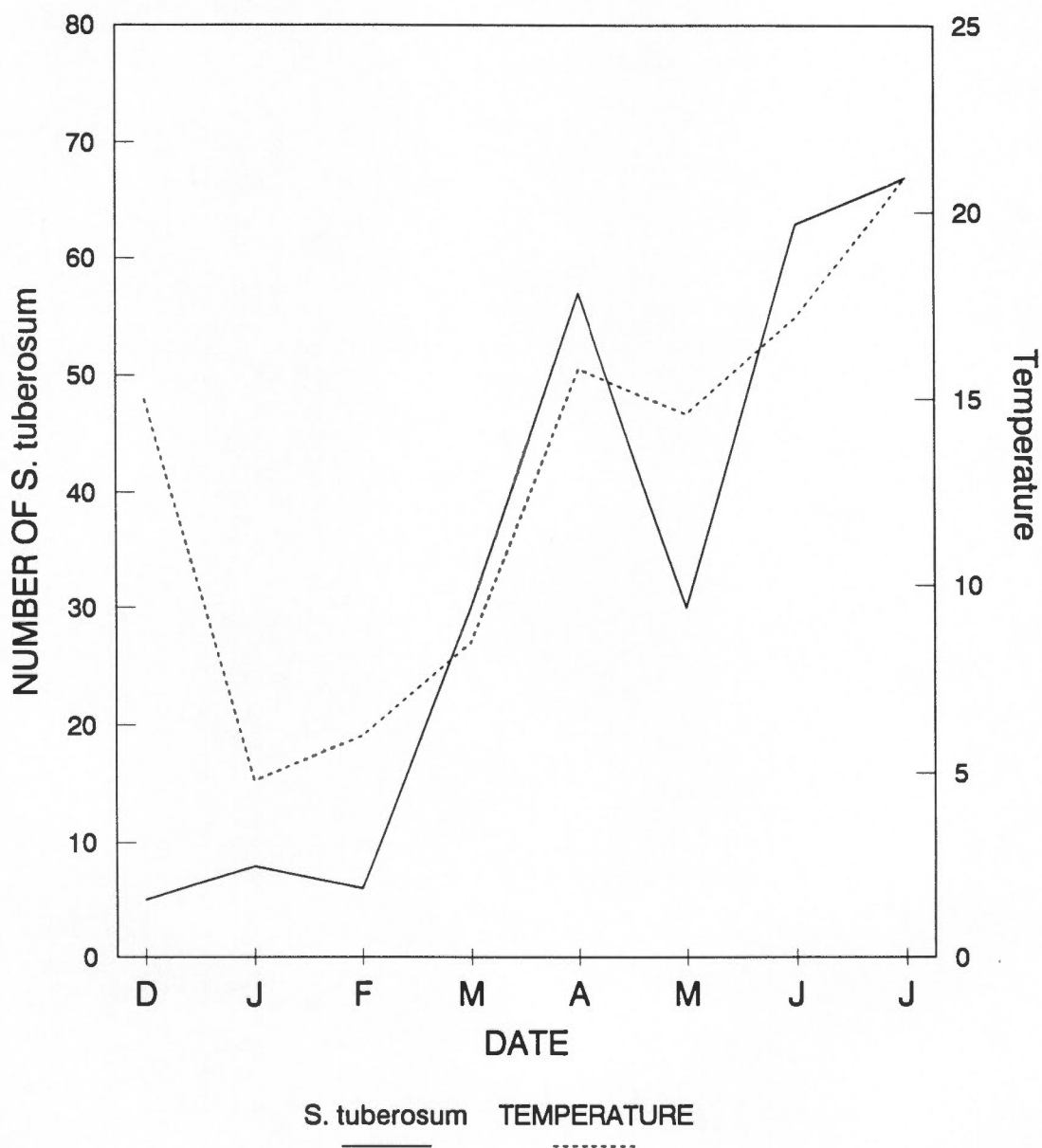
- Formmer, R. L., J.H. Nelson, M. P. Remington and P.H. Gibbs. 1981a. The influence of extensive aquatic vegetative growth on the larvicidal activity of *Bacillus thuringiensis var. israelensis* in reducing *Simulium vittatum* (Diptera:Simuliidae) larvae in their naturel habitat. Mosq. News. 41:707-712
- Golni, V. I., and K. Rothfels. 1984. The polytene chromosomes of North American black flies in the *Eusimulium canonilum* group (Diptera: Simuliidae). Can. J. Zool. 62:2097-2109.
- Hocking, B. 1953. The intrinsic range and speed of flight of insects. Tras. R. Entomol. Soc. London 104:223-345.
- Johnson, C. G. 1969. Migration and dispersal of insects by flight. Methuen, London. 763pp.
- Jones, C. M. and D.J. Richey. 1956. Biology of black flies in Jasper County, South, Carolina, and some relationships to a Leucocytozoon Disease of Turkeys. J. Econ. Entomol. 49:121-123
- Landau, R. 1962. Four forms of *Simulium tuberosum* (Lundstr.) in southern Ontario: a salivary gland chromosome study. Can.J.Zool.40:921-939.
- Le Berre, R. 1966. Contribution a L'etude biologique et ecologique de *Simulium damnos um* Theobald, 1903 (Diptera:Simuliidae) Mem. Orstom 17.204pp
- Manson, G. F. 1982. Cytological studies of sibling species of *Simulium tuberosum* (Lundstrom) Diptera:Simuliidae). Can. J. Zool.60:292-303.
- Manson, G. F. 1984. Sex chromosome polymorphism in the *Simulium tuberosum*

- (Lundstrom) (Diptera:Simuliidae). Can. Zool.62:647-658
- Moulton, J. K. and P.H. Adler. 1992. New species in the *Simulium jenningsae* group (Diptera Simuliidae) from the southeastern United States. Ann. Entomol. Soc. Am. 85:393-399
- Noblet, R. T. R. Adkins, Jr., and J. B. Kissam. 1972. *Simulium congreanarum* (Diptera:Simuliidae) a new vector of *Leucocytozoon smithi* (Sporozoa:Leucocytozoidae) in domestic turkeys. J. Med. Entomol.9:580
- Noblet, R. D. C. Arnold, and E. L. Snoddy. 1976. Distribution of *Simulium* vectors of *Leucocytozoon smithi* in South Carolina. J Econ. Entomol.69:481-483.
- Rothfels, K. H., and R. W. Dunbar. 1953. The salivary gland chromosomes of the black fly *Simulium vittatum* Zett. Can. J. Zool. 31:226-241.
- Rothfels, K. H., R. Feraday, and A. Kaneps. 1978. A cytological description of species of the *Simulium venustum* and *S.verecundum* with standard maps for the subgenus *Simulium* Davies (Diptera). Can. Zool. 56:1110-1128.ina.
- Rothfels, K. H. 1981. Cytotaxonomy: Principles and their application to some nothern species-complexs in *Simulium*. Pp. 19-29. In M. Laird (ed.). Blackflies. Academic Press, N.Y
- Snoddy, E.L. and K.L. Hays. 1966. A carbon dioxide trap for Simuliidae (Diptera). J. Econ. Entomol. 59:242-243.
- Snoddy, E. L. and Noblet R. 1976. Identification of the immature black flies (Diptera: Simulidae) of the southeastern U.S. with some aspects with the adult role in transmission of *Leucocytozoon smith* to turkeys. S.C. Agric. Exp. Sta.

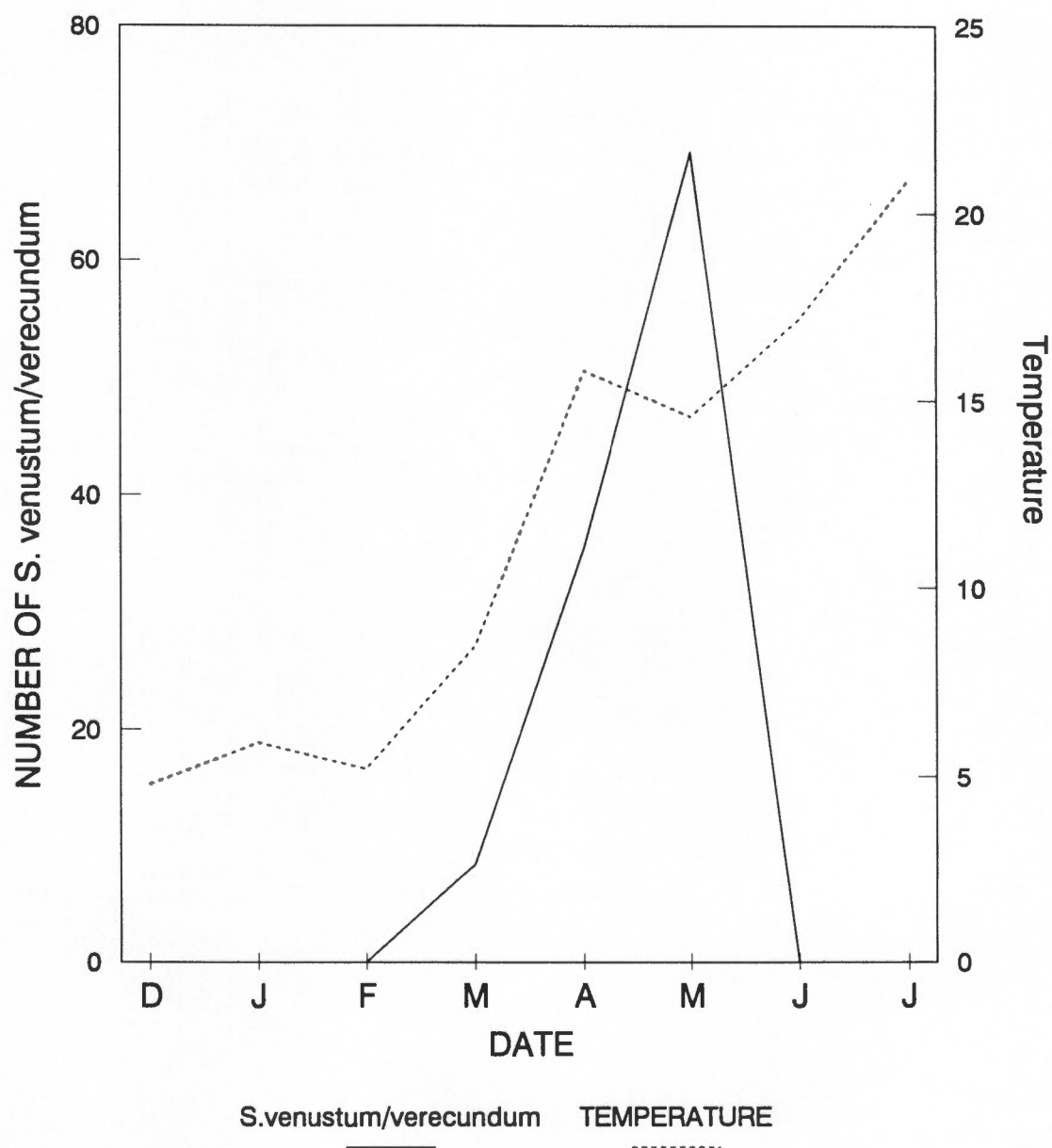
- role in transmission of *Leucocytozoon smith* to turkeys. S.C. Agric. Exp. Sta. Tech. Bull. 1057. 58 pp.
- Stone, A. and Jamnback. 1955. The blackflies of New York State (Diptera: Simuliidae). N. Y. State Mus. Bull. 349, pp. 1-144.
- Stone, A. 1964. Simuliidae and Thaumaleidae. Guide to the Insects of Connecticut, Part VI. The Diptera or True flies of Connecticut. State Geol. and Nat. Hist. Surv. Conn. Bull. 97, 126pp.
- Stone, Alan and E.L. Snoddy. 1969. The black flies of Alabama (Diptera: Simuliidae). Aub. Univ. Agric. Exp. Stat. Bull. 390: 1-93pp
- Snow, W. E., E. Pickard, and J. B. Moore. 1958. Observations on black flies (Simuliidae) in the Tennessee River Basin. J. Tenn. Acad. Sci. 33: 5-23.
- Underhill, G. W. 1939. Two Simuliid found feeding on turkeys in Virginia. Jour. Econ. Ent. 32 (6): 765-768.
- Underhill, G. W. 1944. Black flies found on turkeys in Virginia (*Simulium nigroparvum* Twin and *Simulium slossonae* (Dyar & Shannon)). Va. Agric. Exp. Sta. Tech. Bull. 94. 32 pp.
- Voshell, J. R., 1991. Life cycle of *Simulium jenningsi* (Diptera: Simuliidae) in southern West Virginia. J. Econ. Entomol. 84(4): 1220-1226.
- Whittaker, R.H., 1952. A study of summer foliage insect communities in the Great Smoky Mountains. Ecol. Monogr. 22: 1-44

APPENDIX

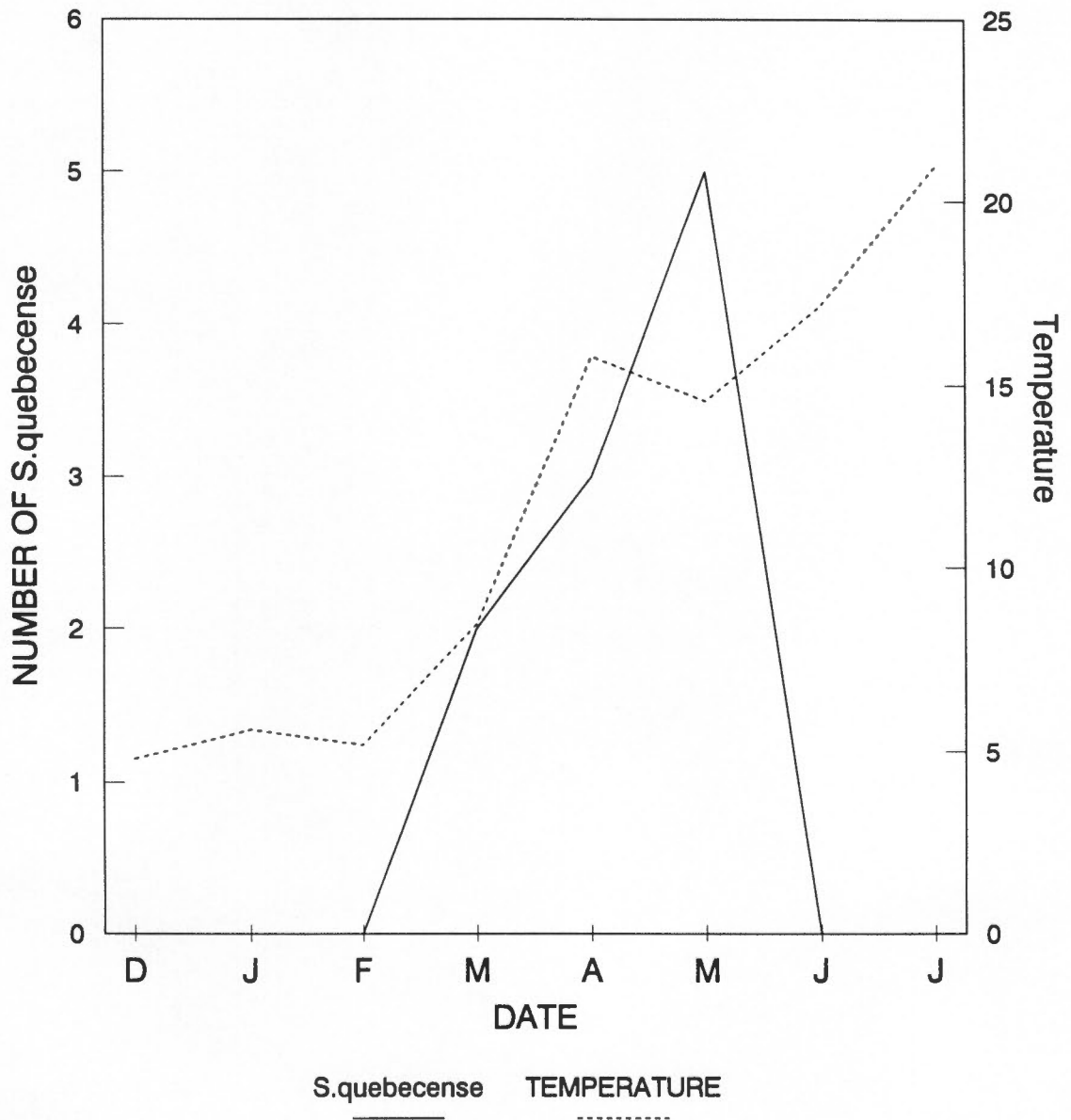
Appendix 1. Seasonal Occurrence of *Simulium tuberosum*



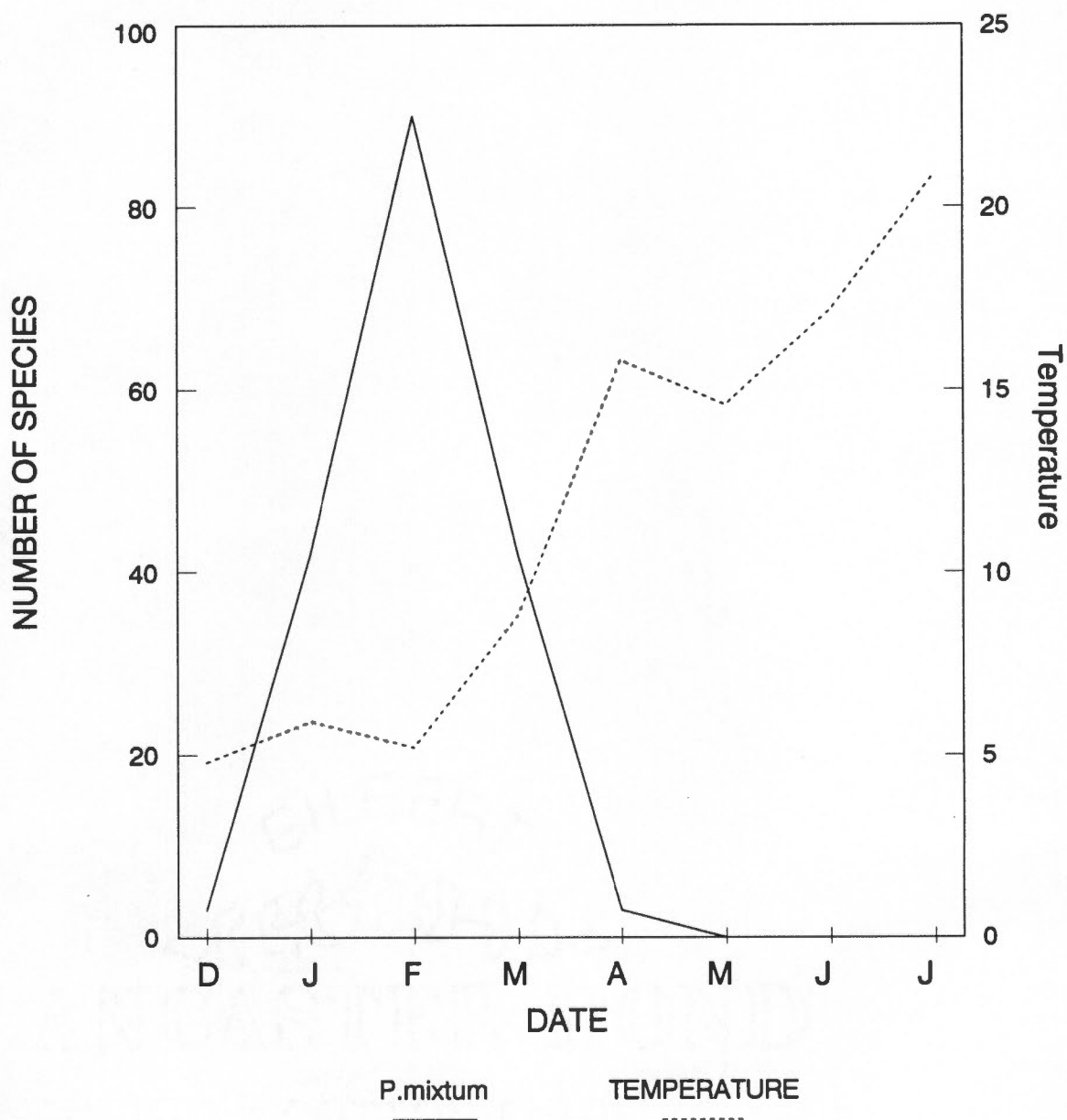
Appendix 2. Seasonal Occurrence of *Simulium venustum/verecundum*



Appendix 3. Seasonal Occurrence of *Simulium quebecense*



Appendix 4. Seasonal Occurrence of *Prosimulium mixtum*



VITA

The author graduated from Lycee Bouillagui Fadiga (High school) Bamako Mali (West Africa) in 1976. She attended the College of Juhasz Gyula Hungary from 1979-1983 and graduated with a Major in Biology and Electro-technique. She taught biology for five years in Lycee Askia Mohamed Bamako (High school).

She received a scholarship from African-American Institute and attended the University of Tennessee in August 1989 for English language and attended the Departement of Entomology and Plant Pathology in June 1990 to December 1992. She received her Master of Science Degree with major in Entomology.