To the Graduate Council:

I am submitting herewith a thesis written by John M. LaForest entitiled "Insects Associated with Yellow-Poplar, *Liriodendron tulipifera* L., in a Mixed Hardwood Forest and a Plantation in Eastern Tennessee." 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.

Dr. Paris Lambdin, Major Professor

We have read this thesis
And recommend its acceptance:

Accepted for the Council:

Interim Vice Provost and
Dean of the Graduate School

INSECTS ASSOCIATED WITH YELLOW-POPLAR, *LIRIODENDRON TULIPIFERA* L., IN A MIXED HARDWOOD FOREST AND A PLANTATION IN EASTERN TENNESSEE

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ABSTRACT

A total of 7,229 specimens representing 13 orders, 146 families, and some 727 species were collected from May 1999 to June 2000 from yellow-poplar trees located in an Arboretum (mixed hardwood forest) and a Plantation using four sampling methods (canopy fogging, direct sampling, Malaise and pan flight intercept trapping). Currently, 373 of the approximate 727 types are identified to species and an additional 122 are identified to genus. Species and family richness and specimen abundance was greater at the Arboretum than at the Plantation and greater in the lower canopy than in the higher canopy at both sites. Species and family diversity calculated using the Shannon-Wiener Diversity Index was higher at the Arboretum than at the Plantation. Species evenness and diversity was not significantly different ($p \leq 0.05$) between canopy layers. The Coleoptera contained the most species (n=301) at both sites, and the most specimens (n=1,330) at the Plantation. However, the Hymenoptera was the most abundant group collected at the Arboretum. Nearly 60% of the families were shared by the sites. Several uncommon to rare families and species were collected. Each site contained a distinct assemblage of insect species with only 16% species overlap.

The numbers of species and specimens collected by the different sampling methods used differed between the sites. Malaise and pan flight intercept trapping was more productive at the Arboretum than at the Plantation, while direct sampling and canopy fogging was more productive at the Plantation than at the Arboretum. The direct sampling method measured greatest in species diversity (H'= 4.12 (Arboretum) and 3.79

(Plantation)) and evenness (H'/Hmax = 0.88 (Arboretum) and 0.79 (Plantation)) and the lower pan traps measured the lowest at both sites.

Thirteen species were identified as exotic, 10 of which are considered to be pest species and three that are considered to be beneficial biological control agents. The exotic pest species were most abundant at the Arboretum, while the beneficial exotic species were more abundant at the Plantation. Also, 28 species representing three orders and 10 families were directly collected on yellow-poplar flowers. Species of Halictidae, Andrenidae, and Cantharidae were the most abundant. In addition, 19 beetle species collected may represent new state records for Tennessee with four representing new southern range limits in the United States. Finally, pest and beneficial species occurrence, abundance, and their potential effects on yellow-poplar are discussed.

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CHAPTER I

INTRODUCTION

Yellow-poplar, *Liriodendron tulipifera* L., is an ancient tree dating back to the Cretaceous Period some 70 million years ago when 16 species were believed to comprise the genus *Liriodendron* in North America (Southern Hardwood Producers, Inc. 1941). Fossilized material of the yellow-poplar leaf shape has been traced to the Cretaceous Period (Beck and Della-Bianca 1981). The ability of *L. tulipifera* to inhabit the southern most regions of North America is thought to have allowed this species to survive the environmental changes brought about by the ice age, while the other 15 species became extinction (Southern Hardwood Producers, Inc. 1941). The only other *Liriodendron* species in the world *(L. chinensis* Sarg.) exists in central China, and resembles the North American yellow-poplar (Sargent 1933).

Yellow-poplar, the tallest hardwood tree in the United States (Gibson 1913), is an abundant tree species within Tennessee forests constituting about 3.4% of the trees on Tennessee timberland (Vissage and Duncan 1989). Under prime conditions, some specimens may reach 61 meters in height and 2.4-3.7 meters in diameter (Beck and Della-Bianca 1981). However, a mature tree is typically 24.4-36.6 meters tall with a strikingly straight trunk 0.6-1.5 meters in diameter and a canopy that begins at 18.3-30.5 meters (Little et. al. 1962).

Yellow-poplar typically matures between 15-20 years (Little et. al. 1962). Flowering occurs from April to June depending on location and weather (USDA Forest

Service 1965). Each flower lasts only a week or two (Vick 1973) and has only a 12-24 daylight hour receptive period for pollination (Boyce and Kaeiser 1961). Seeds mature from August to October (USDA Forest Service 1974) in the form of a cone-like cluster of about 80 carpels (Carvell and Korstian 1955). Its botanical range covers practically all of the eastern United States. However, the species range is not equally distributed. The Mountain province contains 44% of the total yellow-poplar growing stock and the Piedmont province contains 29% of the total. The remaining 27% of the growing stock is spread over the Coastal Plain, Interior province, and the residual botanical range (Beck and Della-Bianca 1981).

The relatively large numbers of yellow-poplar in the eastern United States makes this species an important hardwood in forest ecology providing food and shelter for a myriad of organisms. It is a major component in four forest cover types: yellow-poplar, yellow-poplar-hemlock, yellow-poplar-white oak-northern red oak, and sweet gum-yellow-poplar, and is a minor component in an additional 12 forest cover types (USDA Forest Service 1965). Quail, purple finch, cardinal, cottontail rabbit, red squirrel, gray squirrel, white-footed mice and other forest inhabitants eat the seeds of adult trees. The twigs and foliage of young saplings provide a food source for deer, while the bark and buds of young trees are eaten by rabbits and other rodents (Beck and Della-Bianca 1981). In addition, it is known as a valuable honey tree (McCarthy 1933).

The richly diverse forests of Tennessee are of great economic importance to the region. Millions of tourists visit Tennessee's aesthetically beautiful, forested landscape each year. In addition, Tennessee is one of the nation's leading hardwood lumber-producing states making the hardwood industry important to the state's economy and

people (Hopper 1993). More than 377 million dollars of income was earned from the sale of timber in 1997 (Tennessee Department of Agriculture 1997). Tennessee's 5.5 million hectares of forest land supports a 5 billion, 60,000-job forest products industry (Tennessee Department of Forestry 1997).

Because of its beauty and importance to the state's economy, yellow-poplar was designated the state tree in 1947 (Cochran 1947). The yellow-poplar is central to Tennessee's most commercially valuable timber harvests. In 1963, yellow-poplar was second in total hardwood lumber production, third in hardwood veneer-log, and comprised 9% of the volume of all hardwoods (Vick 1973). In 1989, yellow-poplar ranked third in volume for grade three and grade two trees (13.96% and 17.05%, respectively), and second in volume for grade one trees (23.92%) among Tennessee hardwood species. In the same year, yellow-poplar constituted more than 15% of the statewide timber harvest volume for hardwood saw logs (Vissage and Duncan 1989). (The 1989 statistics relating to yellow-poplar timber represent the latest information available.)

The versatility of yellow-poplar wood contributes to its innumerable uses (Beck and Della-Bianca 1981). Throughout the yellow-poplar growing region, early pioneers preferred yellow-poplar for the construction of canoes, pirogues, keelboats, barges, and other craft for inland navigation, which were so important to commerce in the days where roads were few (Gibson 1913). Early uses for the tree also include: car building, carriage bodies, shingles, clap boards, and saddle frames. The most important and recent uses of yellow-poplar include: core stock, veneer for furniture, plywood for backs and interior parts of furniture, and pulpwood (Beck and Della-Bianca 1981). As soft woods become

scarcer, the abundant, and quick growing yellow-poplar wood, which has comparable physical qualities of softwoods, is being considered as a possible future substitute in structural framing material and for veneers in structural plywood (Beck and Della-Bianca 1981).

Because yellow-poplar has been an important resource for many years, a large amount of research has been devoted to this tree species. More than 100 insect species are known from previous studies to feed on the leaves, stems, flowers, bark or wood of this tree (Johnson and Lyon 1991, Andow 1982, Beck and Della-Bianca 1981, Futuyma and Gould 1979, Peigler 1976, Baker 1972, Burns 1970, Burns and Gibson 1968, Fattig 1947, Fattig 1944, Doane et al. 1936, Herrick 1935, Felt and Rankin 1932). However, only *Toumeyella liriodendri* (Gmelin), tuliptree scale, *Odontopus calceatus* (Say), yellow-poplar weevil, *Euzophera ostricolorella* Hulst, root-collar borer, and *Corthylus columbianus* Hopkins, Colombian timber beetle, are considered serious economic pests of this tree (Beck and Della-Bianca 1981).

The tuliptree scale damages host trees by feeding on sap and excreting honeydew, which provides a substrate for the development of sooty mold that turns foliage and bark black. Large populations on a single tree may cause loss of tree fitness, limb dieback, reduced aesthetic beauty, and possible death of the host (Simpson and Lambdin 1983). The scale is particularly destructive to young trees, where populations as low as 38 individuals per tree have been observed to kill 2-year-old saplings (Burns 1964). Predators and parasitoids have been used to control this serious pest (Beck and Della-Bianca 1981). Simpson and Lambdin (1983) listed six predators (*Laetilia coccidivora* (Comstock); four lady beetle species (*Adalia bipunctata* (L.), *Chilocorus stigma* (Say),

Cyoneda sp., and *Hyperaspis signata* Olivier, one mite (*Tyrophagus sp.*) and several parasitoids (*Aphidius sp.*, *Metaphycus flavus* (Howard), *Coccophagus sp.*, *Syntomosphyrum sp.* and *Baccha costata* (Say)) that attacked the tuliptree scale on tuliptrees in eastern Tennessee. Also, the life history of the tuliptree scale on yellow-poplar in eastern Tennessee was investigated by Simpson and Lambdin (1983).

The yellow-poplar weevil feeds on the buds and leaves of yellow-poplar causing chlorotic spots that give a burned appearance to the foliage (Beck and Della-Bianca 1981). The leaf destruction can cause serious aesthetic degradation, affect survival, and alter the growth and form of yellow-poplar (Burns 1971). Historically, infestations have been localized and the insect has not been considered a major threat to yellow-poplar timber; however, outbreaks have occurred in the Ohio River Valley (Burns and Gibson 1968). Hyche (1994) provided information on the habits and recognition of the yellow-poplar weevil in Alabama.

The root collar borer moth larva bores into phloem tissue of its host in a zone 2 feet (0.6 meters) above the soil to 2 inches (5 cm) below the soil line (Hay 1958). It tends to target trees that are at least pole size. The boring alone is usually not severely damaging to the host. However, the holes provide an entry point for disease and carpenter ants, which have been shown to cause considerable dieback and mortality (Hay 1958, Schuder and Giese 1962). Hope and Pless (1979) described the biology of the root collar borer on yellow-poplar in Tennessee.

The Columbian timber beetle is an important exotic pest to the lumber industry. All hardwoods in the eastern United States are vulnerable to Columbian timber beetle attack, but yellow-poplar, oaks, maples, birch, basswood, and elm are preferred hosts in

the South (Southeastern Area Forest Pest Management Group 1972). The pest does not kill the tree; however, the boring activity causes serious degrading of the wood through both physical wood damage and staining (Burns 1970). Even though large diameter trees are preferred, trees only 3 cm in diameter may be attacked (Southeastern Area Forest Pest Management Group 1972). Information on the life history, seasonal occurrence, and adult behavior was provided by Nord (1972).

The literature reports several beetle species that attack yellow-poplar. Franklin and Lund (1956) report four buprestid species (*Agrilus acutipennis* Mannerheim, *Buprestis rufipes* (Olivier), *Texania campestris* (Say), and *Chrysobothris femorata* (Olivier)) and one *Brachys sp.* that attack yellow-poplar bark, heartwood, and sapwood in Georgia. In Fattig's (1947) study of the Cerambycidae of Georgia, he reported that *Oncideres cingulata* (Say) girdles live branches, *Prionus laticollis* (Drury) feeds on the roots of live trees, and nine additional cerambycids develop within the wood of yellow-poplar. Knull (1946) found 11 species of Cerambycidae developing in the wood of yellow-poplar in Ohio. Of these, *Encyclops coerulea* (Say) and *Tylonotus bimaculatus* (Haldeman) are reported to attack living tissue. Three weevil species, *Cyrtepistomis castaneus* (Roelofs), *Himatium conicum* LeConte, and *Odontopus calceatus* (Say), have been reported to attack yellow-poplar. *H. conicum* attacks the bark (Baker 1972), while *C. castaneus* and *O. calceatus* feed on the leaves (Johnson and Lyon 1991, Herrick 1935). *Amphicrossus ciliatus* (Nitidulidae) has been found on yellow-poplar sap flows in Delaware (Connell 1956). Three scolytid species (*Ambrosiodmas tachygraphus* Zimmermann, *Corythylus columbianus* Hopkins, and *Xyleborus saxesensi* (Ratzeburg)) are reported to attack yellow-poplar (Baker 1972).

Thirteen lepidoptera species (*Zeuzera pyrina* L., (Cossidae), *Epimecis virginaria* Cramer (Geometridae), *Phyllocnistis liriodendronella* Clem. (Gracillariidae), *Papilio glaucus* L. (Papillionidae), *Papilio troilus* L. (Papilionidae), *Thyridopteryx ephemeraeformis* Haworth. (Psychidae), *E. ostricolorella* (Pyralidae), *Antheraea polyphemus* Cramer (Saturniidae), *Automeris io* Fab. (Saturniidae), *Callosamia angulifera* Wlk. (Saturniidae), *C. promethia* Drury (Saturniidae), *Hemileuca nevadensi* Stretch, (Saturniidae), and *Samia cynthia* Drury, (Saturniidae) have been reported to attack yellow-poplar (Baker 1972, Harris 1972, Davis1964, Craighead 1950, Brimley 1938, Howard and Chittenden 1916). All feed on the leaves with the exception of the root collar borer moth (*E. ostricolorella*).

One species of Diptera and Orthoptera are reported to attack yellow-poplar. The tulip gall-fly, *Ressiliella liriodendria* (Osten Sacken) (Diptera: Cecidomyiidae), makes an eyespot (4-7 mm in diameter) on the leaves resembling that of a fungus fruiting body. Little is known about their biology and life history (Johnson and Lyon 1991). *Oecanthus nigricornis* Walker (Gryllidae), commonly called the black-horned tree cricket, is nocturnal and feeds on a variety of plant and animal materials. Tree crickets can be pests in nurseries due to injury incurred through oviposition and subsequent disease (Johnson and Lyon 1991).

The specific natural pollinators of yellow-poplar are unknown (Andow 1982). However, they may be similar to those on *Magnolia acuminata* L. (Thien 1974, Thien et al. 1975). Wright (1953) reports flies, beetles, honeybees, and bumblebees in decreasing order of abundance on the opened flowers of tuliptrees. Andow (1982) lists seven mirids (*Lygocoris belfragii* (Reuter), *L. coryae* (Knight), *L. hirticulus* (Van Duzee), *L.*

omnivagus (Knight), *L. tiliae* (Knight), *Monosyna bohemanimma* (Fallen), and *Taedia sp.*), four cantharids (*Cantharis rectus* Melsheimer, *C. scitulus* Say, *Podabrus brunnicollis* Fabricius, and *P. rugulosus* LeConte), one cephaloid (*Cephaloon lepturides* Newman), one cerambycid (*Grammoptera haemetite* (Newman)), and one chrysomelid (*Orsodacne atra* (Ahrens)) associated with tuliptree flowers in New York.

Insect associations have been found between honeydew-producing insects and certain Hymenoptera. The wasps feeding on tuliptree scale honeydew were examined on approximately one dozen scale-infested yellow-poplar trees, varying in height from 3-9 meters in Dunn Loring, Virginia (Krombein 1951). Ninety-three species representing five families of wasps were collected from and beneath these trees. Burns (1964) lists 10 species of ants tending the tuliptree scale. Simpson and Lambdin (1983) list four ant species, a picture-winged fly (*Delphinia picta* Fab.) and one wasp (*Polistes sp.*) collecting honeydew from scales.

Even though studies have been done on various guilds of insects associated with yellow-poplar, no comprehensive study has been done on the entire insect fauna associated with this tree. Few comprehensive studies (Stanton 1994, Metcalf and Metcalf 1993) have been attempted on the other tree species native to the eastern United States as well. Stanton (1994) collected more that 541 arthropod species from a northern red oak, *Quercus rubra* L., seed orchard in Tennessee, and Metcalf and Metcalf (1993) reported more than 1,000 insect species associated with oak species. Hargrove (1986) gave an annotated species list of 75 insect herbivore species associated with black locust, *Robinia pseudoacaia,* in the southern Appalachians (North Carolina). Hughes (1993) collected 45 arthropod families representing 15 orders from Fraser fir leaf litter in the Great Smoky

Mountain National Park. Katovich and Ostry (1998) collected 87 insect species representing 37 families and seven orders associated with canker infected butternut trees.

Biodiversity is reported to be rapidly decreasing in richness throughout the world (Wilson 1997). Over exploitation of natural resources, introduction of exotic species, environmental pollution, and over development, have caused the loss of entire floral and faunal communities, both known and unknown to science (Barry 1999). Perhaps the most immediate threat to biodiversity is over development. In Tennessee, the development of privately owned land more than doubled between 1992 and 1997 (Frankenberg 2000). Between 1992 and 1997, more than 49,500 hectares of private land was developed in Tennessee compared to only 17,860 hectares between the years of 1982 and 1992 (Frankenberg 2000). Tennessee is developing its private land at a rate that is currently seventh in the United States (Frankenberg 2000). Future conservation of our remaining resources relies heavily upon obtaining knowledge concerning the make-up of the ecosystems. Scientists will then be able to use scientific data to urge policy makers to construct strategies to preserve ecosystems.

The developing concern for our dwindling natural resources has sparked a number of biodiversity studies. Because of the massive efforts involved in completing a complete census of diversity for even relatively simple systems, most researchers have chosen to use indicator groups for biodiversity studies. For example, Hammond and Miller (1998) used macrolepidopteran diversity to compare three forested ecosystems (conifers, hardwood trees and shrubs, herbs and grasses) in three areas (western Oregon, eastern Oregon and West Virginia). Holloway et. al. (1992) used moths, dung beetles, and carrion beetles to examine the effects of logging and other human disturbance on insect

diversity in Malaysia. Greenberg and Thomas (1995) studied the effects of forest management practices in Florida using beetles. Humphrey et. al. (1999) used syrphid and carabid communities as a model to evaluate the relationships between insect diversity and habitat characteristics in managed and unmanaged forest stands. Wang et. al. (2000) used ants to examine possible side effects of using microbial pesticides in an oak-dominated mixed Appalachian forest.

The content of many ecosystems almost certainly contains unknown and untapped resources for pharmaceutical, agricultural and other industries (Lovejoy 1997). However, it is nearly impossible to predict which species will prove to be important to humans beyond its natural ecological service. For example, the venom of a South American pit viper led to the discovery of the antiotensin system that regulates blood pressure in humans. As a result of this discovery, a drug was developed that is worth 1.3 billion dollars annually and benefits millions of people (Lovejoy 1997). Insect and disease resistant qualities of wild plant species have been used to upgrade domesticated agricultural species resistance (Lovejoy 1997). Penicillium mold changed the world when it sparked the advent of antibiotics (Lovejoy 1997). These are a few of the many examples where seemingly nondescript species, at least initially from the human perspective, have substantially contributed to the human quality of life.

Insects are important for numerous reasons. For example, they place pressure on plants to produce assorted and sometimes pharmaceutically valuable and agriculturally useful compounds, they pollinate many plants and trees, some species have been useful in biological control of important pest species, and their enormous numbers make them an integral component in ecosystem health. Because human existence relies heavily upon

biological ecosystems, and by learning more about these systems we can help ourselves live sustainably (Lovejoy 1997). It is important that information be obtained on the communal structure of various communities including the insect species that dominate the animal populations in ecosystems.

It is equally important that this information be accessable through a network of databases and publications. With the increase of global trade, the prevention of exotic organism introductions to new environments outside of their natural context has become a greater challenge. To illustrate this point, more than 2,000 exotic arthropod species have entered the United States (U.S. Congress Office of Technology Assessment 1993). Researchers estimate that harmful exotic arthropods will continue to immigrate to the U.S. at a rate of about 12 species per year, based upon the trends of the last three decades (Lambdin 1995).

When introduced into a new environment, and thus not exposed to their natural guild of competitors and enemies, the exotics can quickly explode in numbers severely and negatively influencing the local flora and fauna. The causitive organism of chestnut blight, *Cryphonectria parasitica* (Murrill), is a dramatic example of an exotic organism influencing the flora and fauna of the eastern United States. The introduction took place in the 1880s on imported Japanese chestnut trees and quickly infected the nonresistant American chestnut (*Castanea dentata* Marsh.) and native Chinquapins (*Castanea spp.*) (Anagnostakis 1996). The American chestnut was once a dominant species in the eastern United States, providing large sweet nuts for humans and wildlife and a high quality, versatile, rot resistant wood for building material (Anagnostakis 1996). Today, few American chestnut trees survive to maturity (Anagnostakis 1996).

Currently, the forests of the eastern United States are being attacked or threatened by several exotic insect species, i.e. the Asiatic oak weevil, Columbian timber beetle, Hemlock wooly adelgid (*Adelges tsuga* Annada), Asian long-horn beetle (*Anoplophora glabripennis* (Motschulsky)), gypsy moth (*Lymantria dispar* L.), etc. The gypsy moth has caused economic and physical damage for more than a century. Over 16 million hectares were completely defoliated from 1983-1994 (Ghent 1994). The gypsy moth has a wide host range, feeding on the foliage of more than 300 species of trees and shrubs (Mosher 1915, Montgomery 1990, Twery 1990). This exotic pest may pose a major threat to Tennessee forests as it encroaches southward despite intensive efforts to stop its progression. The gypsy moth infestation is expected to cause enormous disruption within the forest ecosystem and urban environments, especially to those communities of organisms that share host trees or shrubs with the gypsy moth.

Threats to forest habitats around the world from development and exotic invasions have stimulated an urgency to measure biodiversity. This urgency has been especially true for poorly known forest canopy arthropod communities, which are a diverse and important part of the forest ecosystem (Wincester 1997; Stork et al. 1997). Efforts are underway to better understand the factors that govern arthropod distribution within forest canopies to increase sampling efficiency in biodiversity studies, which can be extremely time consuming, labor intensive, and costly.

The effects of diel patterns of canopy arthropods on three hardwood species (*Cornus florida* L., Dogwood, *Acer rubrum* L., Red Maple and *L. tulipifera*) were studied in North Carolina (Costa and Crossley 1991). They found that an average of 19.5% of observed families were found only during the day and an average of 36.3% were found

only at night. In comparing the faunas of the tree species, they reported that yellow-poplar measured the lowest in both the Shannon-Weiner diversity index (H') and evenness index (J'), but measured the highest in faunal uniqueness. Also, yellow-poplar showed the highest similarity in day and night time fauna with 80.66% similarity.

The vertical and seasonal variation in canopy arthropod communities were examined on four tree species (*Pseudotsuga menziesii* (Mirb.) Douglas fir, *Tsuga heterophylla* Sarg., western hemlock , *Abies grandis* Lindl., white fir, and *Thuja plicata* D., Don red cedar) in an old-growth conifer forest in southwestern Washington (Schowalter and Ganio 1998). They found that arthropod samples taken directly from three different canopy levels and two sampling dates (June and August) did not show distinct arthropod assemblages. However, these factors significantly influenced the abundance of 63% of the arthropod taxa. Also, all four tree species had distinguishable species composition and community structure.

The response of arthropod guild composition to season (spring versus autumn) and age (<50 years versus >80 years) was investigated in a pure stand of *Pinus sylvestris* L. Scots pine using insecticide fogging (Simandl 1993). It was reported that age had more influence than season on all guilds. Only the defoliators, predators and parasitoids responded significantly to season, while all guilds responded significantly to stand age. All guilds were found in less abundance on stands >80 years of age than on stands <50 years of age.

Because of the considerable importance of the forest as a resource, the current threats to the forest and the fact that no comprehensive database currently exists on the yellow-poplar insect fauna, this research effort was initiated. The goal of this project was

to identify those insect species associated with yellow-poplar and create a database that will help in the development of conservation strategies and management decisions to preserve selected habitats, development of biodiversity initiatives, environmental impact studies, and pest management strategies.

The objectives of this study are to:

1. develop a species list of insects associated with yellow-poplar in eastern Tennessee,
2. compare the insect fauna obtained in relationship to their location on the tree (upper and lower canopy), and
3. examine the yellow-poplar insect communities in a plantation and a Southern Appalachian mixed hardwood forest.

CHAPTER II

MATERIALS AND METHODS

Insect specimens were collected from May 1999 through June 2000 from mature yellow-poplar trees using Malaise and pan traps, netting and handpicking, and canopy fogging. Six trees were selected in each of a mixed hardwood forest, located at the University of Tennessee Forestry Experiment Station and Arboretum (Anderson County, TN) and a yellow- poplar plantation, located at the University of Tennessee Plant Science Experiment Station (Knox County, TN) for a total of 12 trees. Three of the trees at each site were used to suspend Malaise/pan traps and to take direct samples. The remaining three trees at each site were fogged exclusively.

Site Descriptions

The Plantation consists of a pure stand of 100 mature yellow-poplar bordered by the Tennessee River, a mature 200 tree pine plantation, and an adjacent grassy meadow. In addition, farm land is directly across the river and a major highway passes only a few hundred yards away. In contrast, the mixed hardwood forest site is located on approximately 915 hectares of managed forest land. About 50% of this land has always had forest cover. Approximately, 80% of the forest is greater than 5 years old, 15% is less than 5 years old, and 5% is experimental tree plots and power line right-of-ways.

Collection of Insects

Malaise/pan Trap - Two Malaise/pan traps (60 cm^3) constructed of PVC (polyvinyl chloride) pipe (2 cm ID) with No-see-um netting (73 meshes/6.45 cm^2) were suspended by 1/4" "twisted yellow poly rope" at a height representative of the upper third and lower third of the canopy on each of the six trees. The netting intercepted flying insects, which were then directed toward a collecting unit (plastic cup, 60 mm x 65 mm; 120 ml vol) at the top of the trap or directed to the pan attachment (10 cm x 10 cm x 75 cm) at the bottom of the trap. The plastic cup and the pan attachment were filled to approximately 2.5 cm with a 50% propylene glycol and water mixture. Ropes were placed into position using a lead line method, where a hand held sling shot and a 3/4" steel nut are used to shoot fishing line (30 lbs test) into the canopy. After the lead line was in position, the permanent line was tied to the lead line and pulled into the canopy and over the desired limb. Twice each month the traps were lowered out of the canopy and samples were collected. The plastic cups were removed, sealed with a lid, labeled (date, tree #, upper/lower canopy, and trap) and replaced. The pan contents were poured through a fine sieve (No-see-um netting (73 meshes/6.45 cm^2)) and into a two litter plastic bucket. The specimens were then taken from the sieve and placed in a plastic cup (60 mm x 65 mm; 120 ml vol). A water/antifreeze mixture (50:50) was poured into the plastic cup with the specimens to keep them moist. The remaining sieved mixture in the plastic bucket was then poured back into the pan trap.

Direct sampling methods - This sampling method was conducted once every two weeks for 3-4 hours per site during the late morning and afternoon using an aspirator, hand net, beat sheet, tweezers, and ethyl acetate charged killing jars. Specimens were

taken directly from the tree foliage, branches, flowers, and trunks reachable from the ground with sweeps of the hand net and hand picking. Specimens from yellow-poplar saplings were collected with a sweep net throughout the arboretum. Specimens were collected with a sweep net from the yellow-poplar flowers at the Plantation in April 2000 and were held in separate one dram plastic containers.

Fogging - One mature yellow-poplar at each site was fogged monthly beginning in June 1999 using a standard broad spectrum, synthetic, pyrethroid insecticide (Asana Xl, emulsifiable concentrate) and a modified Dyna-Fog Golden Eagle™ (model 2610) fogger. Fog samples were taken between 9:00 am and 10:00 am (EST) at the Plantation and between 1:00 pm and 2:00 pm (EST) at the Arboretum. Procedures for this collection technique have been modified from those used by Gagne (1979) and Erwin (1983). Tarpaulins (9 X 12 meters) were placed on the ground around the tree base representative of the canopy outline to collect fallen insect specimens. The fogger was only used when temperature and wind standards were satisfactory. Formulation for the insecticide was calibrated to generate a fog for 6-10 minutes at the rate of 10 ml insecticide/liter of water. Insects were collected from the tarpaulins after 4-6 hours using a hand-held, modified Dust-Buster™ vacuum and placed into plastic bags.

Preserving and Processing Specimens

Collected specimens were labeled with the date, site, tree number, sampling method and canopy layer, when applicable, taken to the laboratory and stored in a freezer or 70% alcohol until they could be mounted, pinned, or spread on a pinning board as needed to see various morphological features (Borrer et. al. 1992). Insects in the

antifreeze/water mixture were separated from the mixture as soon as possible in the lab using a sieve (73 mesh/6.45 cm^2), and then stored in a one dram glass vial with 70% alcohol. Insects collected by fogging and direct sampling were placed in Petri dishes and stored in a freezer.

Specimen Identification

Specimens were identified using standard keys and voucher specimens located in The University of Tennessee Insect Museum. Unidentified specimens were sent to specialists for identification. All identified species were systematically arranged into Cornell drawers for incorporation into The University of Tennessee Insect Museum.

Data Analysis

A species list was developed from all specimens obtained. Data consisting of: specimen code, species code, order, family, genus, species name, site, number of individuals, collection date, tree number, and sampling method were entered into Biota^R (Colwell 1996). Once entered, data were analyzed using Statistical Analysis Software (SAS Institute 1997). Insect diversity for each site, canopy layer, and collection method was determined using the Shannon-Weiner index (Smith 1980). This diversity index is based on probability and considers the number of species as well as their relative abundance (Smith 1980). Evenness was also calculated for each site and canopy layer. Evenness measures range from 0-1 (one representing the most even community possible). A paired T-test was used to determine if significant ($p=0.05$) differences of diversity and evenness values occurred between canopy layers.

Shannon-Weiner formula: $H' = \sum_{i=1}^{s} (pi)(log\ pi)$

Where H'= diversity index

S= species number

pi= proportion of the i^{th} species in the total sample.

Species evenness formula: H'/Hmax; therefore, maximum=1

CHAPTER III

RESULTS AND DISCUSSION

A total of 7,229 specimens representing 13 orders, 146 families, and some 727 morpho-types (Currently, 373 of the 727 types are identified to species and an additional 122 are identified to genus.) were collected from yellow-poplar. Of these, 4,261 specimens representing 12 orders, 123 families, and 283 species were collected and identified from the Arboretum. The Coleoptera, Hymenoptera, and Diptera were dominant at the Arboretum in terms of the number of species and specimens (Figure 1,2) comprising 81.6% of the specimens and 80.8% of the species collected at this site. The prevalence of these three groups may be a result of their considerable mobile abilities and/or tendencies combined with the sampling methodology (i.e. flight interception traps) which may favor these highly mobile orders. The relatively large number of Hymenoptera specimens collected was partially a result of social behaviors such as swarming (i.e. *Vespula maculifrons* (Buysson) (Vespidae) and *Augochlora pura* (Say) (Halictidae).

It is interesting that the number of neuropteran species and specimens collected exceeded that of the Lepidoptera and Orthoptera. The relatively high numbers of Neuroptera collected may be explained by the large aphid populations typically associated with yellow-poplar. The small number of species and specimens of Lepidoptera and Orthoptera collected at both sites suggests that the collection methods

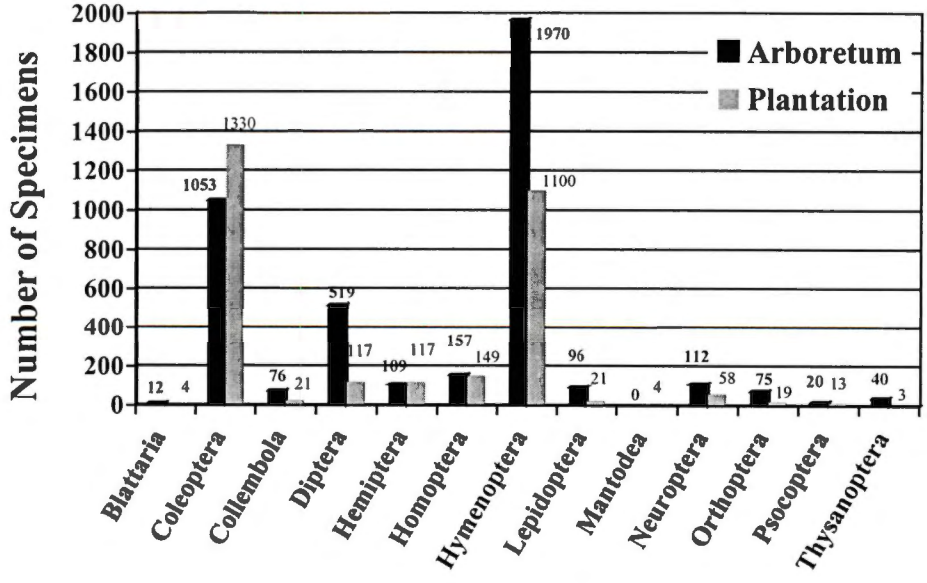


Figure 1. Number of specimens (n=7,229) within respective orders collected at the Arboretum and Plantation from May 1999 to June 2000.

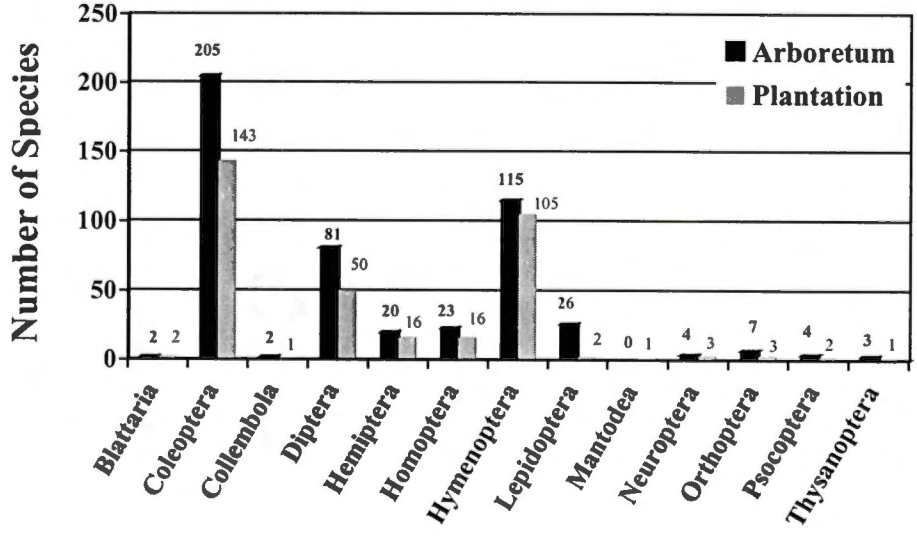


Figure 2. Number of species (n=727) within respective orders collected at the Arboretum and Plantation from May 1999 to June 2000.

used were not conducive to collecting these orders. Night fogging may have collected more orthopteran species associated with yellow-poplar and light trapping may have collected more lepidopteran species. However, using light traps would make it problematic to assert those collected specimens as associated with yellow-poplar.

A total of 2,968 specimens representing 13 orders, 108 families, and 206 species were collected and identified from the Plantation. Similarly to the Arboretum, the Hymenoptera, Coleoptera, and Diptera were dominate in numbers of species and specimens collected with all other orders being comparatively minor in representation. The Coleoptera were the most abundant and species rich group collected at the Plantation. Three species (*Notoxus murinipennis* LeConte, *Harmonia axyridis* (Pallas) and Lathridiidae sp.) combined accounted for nearly 60% of the Coleoptera specimens.

Nearly 60% of the families collected were represented at both sites. However, each site exhibited a degree of distinctiveness at the family level. Of those families that were exclusively collected at one site, almost 80% were represented by only one species. Several of the species within the families exclusively collected at the Arboretum were forest specialists, while those species within the families exclusively collected at the Plantation may have been associated with the vegetation surrounding the trees, the honeydew secreted by various homopterans infesting the trees, or the large amount of nectar and pollen produced by the flowers.

The braconids, ichneumonids, and tachinids as well as the curculionids and chrysomelids were the most species rich families (Table 1). The number of species within these 5 families contained 22% of the total number of species collected. The Braconidae, Chrysomelidae, and Formicidae were consistently among the most species rich families

Table 1. Number of insect species within the families identified from the Arboretum, Anderson Co., TN, and the Plantation, Knox Co., TN, collected from May 1999 to June 2000.

Order	Family	ARB[a]	PSF[b]	TOTAL[c]
Collembola	Entomobryidae	1	1	1
	Sminthuridae	1	0	1
Orthoptera	Gryllacrididae	1	1	1
	Gryllidae	2	1	2
	Tettigoniidae	4	1	4
Mantodea	Mantidae	0	1	1
Blatteria	Blattellidae	2	2	2
Hemiptera	Anthocoridae	4	1	4
	Berytidae	1	0	1
	Coreidae	2	2	2
	Cydnidae	0	1	1
	Isomatopidae	0	1	1
	Lygaeidae	1	2	3
	Miridae	5	4	8
	Nabidae	1	0	1
	Pentatomidae	2	1	3
	Piesmatidae	0	1	1
	Reduviidae	1	1	1
	Rhopalidae	1	0	1
	Thyreocoridae	0	1	1
	Tingidae	3	1	3
Homoptera	Acanaloniidae	2	1	2
	Aphidae	1	1	1
	Cercopidae	3	1	3
	Cicadellidae	7	6	11
	Cicadidae	0	1	1
	Cixiidae	0	1	1
	Coccidae	1	1	1
	Derbidae	2	0	2
	Flatidae	3	2	3
	Issidae	0	1	1
	Membracidae	3	2	4
Neuroptera	Chrysopidae	1	1	1
	Coniopterigidae	1	0	1
	Hemerobiidae	1	1	1
	Mantispidae	1	1	1
Coleoptera	Aderidae	3	1	3
	Alleculidae	1	3	4

Table 1 (cont.). Number of insect species within the families identified from the Arboretum, Anderson Co., TN and the Plantation, Knox Co., TN, collected from May 1999 to June 2000.

Order	Family	ARB[a]	PSF[b]	TOTAL[c]
Coleoptera	Anobiidae	5	5	8
	Anthicidae	0	1	1
	Anthribidae	2	1	2
	Bostrichidae	1	0	1
	Buprestidae	4	1	5
	Cantharidae	5	8	11
	Carabidae	1	1	2
	Cerambycidae	15	8	22
	Cerylonidae	1	0	1
	Chrysomelidae	18	14	30
	Cleridae	7	3	8
	Coccinellidae	11	18	19
	Colydiidae	0	1	1
	Corylophidae	1	1	1
	Cucujidae	2	2	4
	Cupedidae	1	0	1
	Curculionidae	30	12	36
	Dascillidae	1	0	1
	Dermestidae	2	2	2
	Elateridae	16	9	21
	Eucnemidae	8	1	9
	Helodidae	1	1	2
	Histeridae	1	2	3
	Lagriidae	1	1	2
	Lampyridae	3	3	5
	Languridae	1	0	1
	Lathridiidae	1	1	1
	Leiodidae	1	0	1
	Leptoderidae	1	0	1
	Lucanidae	1	0	1
	Lycidae	3	0	3
	Melandryidae	3	6	7
	Meloidae	0	1	1
	Melyridae	1	1	2
	Mordellidae	11	11	18
	Mycetophagidae	2	1	2
	Nitidulidae	9	6	11
	Nosodendridae	0	1	1
	Pedilidae	0	1	1

Table 1 (cont.). Number of insect species within the families identified from the Arboretum, Anderson Co., TN and the Plantation, Knox Co., TN, collected from May 1999 to June 2000.

Order	Family	ARB[a]	PSF[b]	TOTAL[c]
Coleoptera	Perothopidae	1	0	1
	Ptilodactylidae	0	1	1
	Pyrochroidae	1	0	1
	Rhizophagidae	1	1	1
	Scarabaeidae	9	2	10
	Scolytidae	3	2	4
	Silphidae	1	0	1
	Staphylinidae	9	2	10
	Tenebrionidae	5	5	10
	Throscidae	1	0	1
	Trogossitidae	2	2	3
Diptera	Anthomyidae	3	0	3
	Asilidae	5	3	6
	Aulacigastridae	1	0	1
	Calliphoridae	1	2	3
	Chloropidae	3	3	5
	Conopidae	2	0	2
	Dolichopodidae	2	3	4
	Drosophilidae	9	3	11
	Empididae	2	0	2
	Ephidridae	0	1	1
	Lauxanidae	6	1	6
	Lonchaeidae	3	2	5
	Muscidae	3	0	3
	Mycetophilidae	8	0	8
	Odiniidae	1	0	1
	Otitidae	4	4	8
	Phoridae	2	2	3
	Pipinculidae	1	0	1
	Platystomatidae	1	1	1
	Richardiidae	0	1	1
	Sarcophagidae	4	3	7
	Sciaridae	1	0	1
	Stratiomyidae	1	4	5
	Syrphidae	7	5	11
	Tachinidae	12	11	23
Lepidoptera	Vespidae	4	2	4
	Gracillariidae	0	1	1
	Noctuidae	3	1	3

Table 1 (cont.). Number of insect species within the families identified from the Arboretum, Anderson Co., TN and the Plantation, Knox Co., TN, collected from May 1999 to June 2000.

Order	Family	ARB[a]	PSF[b]	TOTAL[c]
Lepidoptera	Papillionidae	1	0	1
Hymenoptera	Andrenidae	0	10	10
	Anthophoridae	1	1	1
	Aphelinidae	0	1	1
	Apidae	2	1	2
	Bethylidae	1	1	2
	Braconidae	27	15	40
	Ceraphronidae	1	0	1
	Chrysididae	0	1	1
	Colletidae	1	0	1
	Diapriidae	5	0	5
	Eucoilidae	1	2	3
	Eupelmidae	7	2	8
	Figitidae	1	3	3
	Formicidae	16	14	18
	Halictidae	12	8	16
	Ichneumonidae	11	18	29
	Megachilidae	1	0	1
	Megaspilidae	0	3	3
	Pergidae	1	0	1
	Platygastridae	1	0	1
	Pompilidae	11	3	12
	Pteromalidae	0	1	1
	Rhopalosomatidae	1	0	1
	Scelionidae	4	8	9
	Sphecidae	2	9	11
	Tenthredinidae	0	1	1
	Tiphiidae	0	1	1
	Torymidae	3	0	3
	Vespidae	4	2	4

[a]ARB=Arboretum
[b]PSF=Plantation
[c]Total=Total number of species collected within each family

collected at both sites. The mordellids and elaterids also were common and relatively species rich at both sites (Table 1). Little information is available on the diversity and faunal composition of the mordellids in various habitats within the United States. Jackman and Nelson (1995) collected 35 species and 754 specimens from a malaise trap in Austin, Texas. In another study, 13 species and 157 specimens were collected using flight interception traps in southern Quebec (Levesque and Levesque 1995). The elaterids were among the most commonly collected groups at both sites, but particularly abundant at the Arboretum. *Melanotus similis* (Kirby) and *Ampedus melantoides* were the most commonly collected species of elaterid comprising nearly 80% (n=293) of all the elaterid specimens. The majority of specimens were collected from Malaise and pan traps.

A few uncommonly collected and poorly known families were collected. Five specimens of *Odontomera* sp. (Diptera: Richardiidae) were collected from the Plantation. Little is known about this rarely encountered family for which only 10 species are known to occur in North America (Borror et al. 1992). Fifteen specimens of the "relatively rare" (Borror et al. 1992) and predaceous *Corticoris pulchellus* (Hemiptera: Isomatopidae), or jumping tree bug, were collected from a fog sample taken at the Plantation. This family is a small one with only five species known in the eastern United States (Blatchley 1926). Two specimens of the "rare" (Borror et al. 1992) species *Rhopalosoma nearticum* Brues (Hymenoptera: Rhopalosomatidae) were collected at the Arboretum. The family consists of only three species in the eastern United States. The larvae develop in crickets (Borror et al. 1992).

White (1983) lists 114 beetle families and rates them in terms of abundance from common to rare. Four beetle families (Cupedidae, Dascillidae, Leptoderidae, and Perothopidae), all exclusively collected at the Arboretum, were classified as uncommon to rare. The cupedids are a small family consisting of four species, and are believed to be the most primitive of all living beetles (White 1983). Adults are usually found under bark (Borror et al. 1992). The dascillids, also known as soft-bodied plant beetles, are associated with vegetation near water and consist of 25 known species in North America (Borror et al. 1992). The leptoderids, commonly called the small carrion beetles, are a medium sized group consisting of 81 species, and are scavengers of carrion, dung, fungi, and humus in a variety of habitats, such as the forest floor, underneath bark, caves, and animal nests (White 1983). Perothopids, also are known as the beech-tree beetles, closely resemble click beetles (Downie and Arnett 1996). Only three species of this family occur in the United States (Downie and Arnett 1996). The larvae are unknown (Borror et al. 1992).

A distinct assemblage of insect species was collected from each site. Only 115 of 727 or 16% of the species were collected at both sites. Of those 115 species (Table 2), representing 11 orders and 63 families, most (70%) were Coleoptera (51 species) or Hymenoptera (28 species). Species of Formicidae (11) and Coccinellidae (9) were the dominant taxa. The collection of a relatively large number of species and specimens within these predaceous families suggests that there may be abundant food sources available for these species associated with yellow-poplar. The honeydew secreted by *Toumeyella liriodendri* (Gmelin), tulip tree scale, and *Illinoia liriodenri* (Monell), tulip tree aphid, is a documented source of food for many formicids, while most coccinellids

Table 2. Insect species occurring at both the Arboretum, Anderson Co., TN and the Plantation, Knox Co., TN, from May 1999 to June 2000.

Order	Family	Genus	Species	# Individuals
Collembola	Entomobryidae	Unknown	species	97
Orthoptera	Gryllacrididae	*Camptonotus*	*carolinesis*	55
	Gryllidae	*Orocharis*	*saltator*	24
	Tettigoniidae	*Scudderia*	species	3
Blatteria	Blattellidae	*Parcoblatta*	species 1	10
	Blattellidae	*Parcoblatta*	species 2	5
Psocoptera	Unknown	Unknown	species 1	9
Hemiptera	Anthocoridae	*Orius*	*insidiosus*	4
	Coreidae	*Acanthocephala*	*confraterna*	5
	Coreidae	*Leptoglossus*	*oppositus*	24
	Miridae	*Hyaliodes*	*vitripennis*	22
	Reduviidae	*Epicoris*	*tuberculatus*	3
	Tingidae	*Melanorhopala*	*infuscata*	68
Homoptera	Acanaloniidae	*Acanalonia*	species	14
	Aphidae	*Illinoia*	*liriodendri*	134
	Cercopidae	Unknown	species 5	14
	Cicadellidae	*Agallia*	*constricta*	3
	Cicadellidae	*Jassus*	*olitorius*	44
	Coccidae	*Toumellya*	*liriodendri*	20
	Flatidae	Unknown	species 1	22
	Flatidae	Unknown	species 2	11
	Membracidae	*Stictocephala*	species	2
Thysanoptera	Unknown	Unknown	species 1	41
Neuroptera	Chrysopidae	*Chrysoperla*	species	131
	Hemerobiidae	*Hemerobius*	*stigma*	34
	Mantispidae	*Mantispa*	species	3
Coleoptera	Aderidae	*Zonantes*	*fasciatus*	7
	Anobiidae	*Oligomerus*	*alterans*	6
	Anobiidae	*Trichodesma*	*gibbosa*	2
	Anthribidae	*Ormiscus*	*saltator*	3
	Cantharidae	*Cantharis*	*bilineatus*	24
	Cantharidae	*Chauliognathus*	*marginatus*	26
	Cerambycidae	*Stranglia*	*luteicornis*	13
	Chrysomelidae	*Tymnes*	metasternalis	74
	Chrysomelidae	*Demotina*	modestus	6
	Cleridae	*Placopterus*	thoracicus	4
	Cleridae	*Cymatodera*	undulata	38
	Coccinellidae	*Harmonia*	axyridis	259

Table 2 (cont.). Insect species occurring at both the Arboretum, Anderson Co., TN and the Plantation, Knox Co., TN, from May 1999 to June 2000.

Order	Family	Genus	Species	# Individuals
Coleoptera	Coccinellidae	*Zilus*	*horni*	27
	Coccinellidae	*Scymnus*	*loewii*	2
	Coccinellidae	*Mulsantina*	*picta*	2
	Coccinellidae	*Didion*	*punctatum*	2
	Coccinellidae	*Scymnus*	*securus*	2
	Coccinellidae	*Coccinella*	*septempunctata*	16
	Coccinellidae	*Hyperaspis*	*signata*	9
	Coccinellidae	*Chilocorus*	*stigma*	29
	Coccinellidae	*Psyllobora*	*vigintimaculata*	26
	Corylophidae	*Corylophodes*	*marginicollis*	6
	Curculionidae	*Conotrachelus*	*anaglypticus*	2
	Curculionidae	*Odontopus*	*calceatus*	8
	Curculionidae	*Cyrtepistomis*	*castaneus*	24
	Curculionidae	*Himatium*	*errans*	33
	Curculionidae	*Naupactus*	*leucoloma*	10
	Curculionidae	*Lechriops*	*oculata*	10
	Dermestidae	*Cryptorhopalum*	*haemorrhoidale*	23
	Dermestidae	*Cryptorhopalum*	*triste*	22
	Elateridae	*Limonius*	*auripilis*	10
	Elateridae	*Melanotus*	*communis*	6
	Elateridae	*Ampedus*	*melantoides*	70
	Elateridae	*Melanotus*	*morosus*	6
	Lampyridae	*Pyractomena*	*borealis*	19
	Lathridiidae	Unknown	species	519
	Melandryidae	*Canifa*	*pallipes*	5
	Melandryidae	*Microtonus*	*sericans*	2
	Mordellidae	*Mordellistena*	*ambusta*	3
	Mordellidae	*Mordellistena*	*masoni*	5
	Mordellidae	*Mordellistena*	*ornata*	4
	Mordellidae	*Mordellistena*	*trifasiata*	23
	Mycetophagidae	*Litargus*	*tetraspilotus*	22
	Nitidulidae	*Amphicrossus*	*ciliatus*	1
	Nitidulidae	*Cryptarcha*	*concinna*	15
	Nitidulidae	*Glischrochilus*	*obtusus*	2
	Nitidulidae	*Colopterus*	*truncatas*	8
	Rhizophagidae	*Europs*	*pallipennis*	41
	Scarabaeidae	*Papillia*	*japonica*	5
	Scolytidae	*Xylosandrus*	*crassiusculus*	2

Table 2 (cont.). Insect species occurring at both the Arboretum, Anderson Co., TN and the Plantation, Knox Co., TN, from May 1999 to June 2000.

Order	Family	Genus	Species	# Individuals
Coleoptera	Staphylinidae	Unknown	species 2	5
	Trogossitidae	*Thymalus*	*marginicollis*	2
Diptera	Asilidae	*Efferia*	species 1	2
	Asilidae	*Efferia*	species 2	6
	Chloropidae	*Chlorops*	species 1	6
	Dolichopodidae	*Condylostylus*	species 2	13
	Drosophilidae	*Drosophila*	species 1	14
	Lauxanidae	*Minetta*	species	91
	Phoridae	*Dohriniphora*	species 1	20
	Platystomatidae	*Rivellia*	species	2
	Syrphidae	*Toxomeris*	*geminatus*	6
Hymenoptera	Anthophoridae	*Xylocopa*	*virginica*	3
	Apidae	*Bombus*	*impatiens*	14
	Braconidae	Unknown	species 11	2
Hymenoptera	Braconidae	Unknown	species 24	3
	Eupelmidae	Unknown	species 2	4
	Figitidae	Unknown	species 2	2
	Formicidae	*Camponotus*	*americanus*	217
	Formicidae	*Crematogaster*	*ashmeadi*	95
	Formicidae	*Formica*	*fusca*	93
	Formicidae	*Prenolepsis*	*imparis*	11
	Formicidae	*Monomorium*	*minimum*	92
	Formicidae	*Formica*	*pallidefulva*	63
	Formicidae	*Camponotus*	*pennsylvanicus*	137
	Formicidae	*Crematogaster*	*pilosa*	9
	Formicidae	*Leptothorax*	*schaumi*	102
	Formicidae	*Tapinoma*	*sessile*	196
	Formicidae	*Camponotus*	species	178
	Halictidae	*Dialictus*	*admirandus*	8
	Halictidae	*Dialictus*	*bruneri*	8
	Halictidae	*Augochlora*	*pura*	703
	Halictidae	*Halictus*	*rubicundus*	3
	Pompilidae	Unknown	species 12	3
	Pompilidae	Unknown	species 2	6
	Scelionidae	Unknown	species 1	164
	Scelionidae	Unknown	species 2	82
	Scelionidae	Unknown	species 9	2
	Vespidae	*Vespa*	*cabro*	3
	Vespidae	*Polistes*	species	2

also were associated with these homopterans, but in a predator/prey role. Those insect species that were collected at both sites are probably habitat generalists and/or are associated with or have a preference for yellow-poplar.

A listing of the most abundant species collected, those with at least 15 or more total specimens, is given in Table 3. While these 56 species represented less than 8% of the total number of species collected, they accounted for 76% of the total number of specimens collected. The Hymenoptera represented over one-half of the specimens from this list with the formicids being the dominant hymenopteran family containing 10 species and 1,383 specimens. The Coleoptera contained the most species (25) and accounted for more than 31% of the number of specimens. Approximately 51% of the Coleoptera specimens belonged to the lathridiid, coccinellid, or elaterid families. The tulip tree aphid was the most abundant Homoptera collected, while the aphid predators *Chrysoperla* sp., (Chysopidae) and *Camptonotus carolinesis* Gerstaecker (Gryllacrididae), the leaf-rolling cricket, were the most abundant species within their respective order. The Diptera contained the third most species (5) and specimens (319). A picture-wing fly, *Pseudotephritis* sp., was the most abundant Diptera collected. The tingid, *Melanorhopala infuscata* Parshley, which is reported to feed on yellow-poplar (Henry and Wheeler 1986), was the most abundant Hemiptera collected. Many of these species appear to prefer one site or another with 20 of the 56 species collected exclusively at one site or the other.

Comparison of the Sampling Methodology

Sampling methodology was not equally effective at both sites (Figures 3 and 4). The direct sampling method showed the least difference (5%) in the number of species

Table 3. Species most commonly* collected from the Arboretum, Anderson Co., TN, and the Plantation, Knoxville, TN, from May 1999 to June 2000.

Order	Family	Genus	Species	ARB[a]	PSF[b]	Total[c]
Orthoptera	Gryllacrididae	*Camptonotus*	*carolinesis*	45	10	55
	Gryllidae	*Orocharis*	*saltator*	16	8	24
Hemiptera	Anthocoridae	*Asthenidea*	*temnostethoides*	37	0	37
	Coreidae	*Leptoglossus*	*oppositus*	7	17	24
	Tingidae	*Melanorhopala*	*infuscata*	5	63	68
Homoptera	Aphidae	*Illinoia*	*liriodendri*	35	99	134
	Cicadellidae	*Jassus*	*olitorius*	42	2	44
	Flatidae	Unknown	species 1	32	10	42
Neuroptera	Chrysopidae	*Chrysoperla*	species	91	41	132
	Hemerobiidae	*Hemerobius*	*stigma*	19	15	34
Coleoptera	Anobiidae	*Ptalium*	*brevisetum*	0	25	25
	Anthicidae	*Notoxus*	*murinipennis*	0	174	174
	Cantharidae	*Cantharis*	*bilineatus*	4	20	24
	Cantharidae	*Cantharis*	*marginata*	17	0	17
	Cantharidae	*Chauliognathus*	*marginatus*	14	12	26
	Chrysomelidae	*Tymnes*	*metasternalis*	40	34	74
	Cleridae	*Cymatodera*	*Undulata*	36	2	38
	Coccinellidae	*Chilocorus*	*stigma*	5	24	29
	Coccinellidae	*Coccinella*	*septempunctata*	7	9	16
	Coccinellidae	*Harmonia*	*axyridis*	42	217	259
	Coccinellidae	*Psyllobora*	*vigintimaculata*	21	5	26
	Coccinellidae	*Stethorus*	*punctum*	0	24	24
	Coccinellidae	*Zilus*	*horni*	1	26	27
	Curculionidae	*Cyrtepistomis*	*castaneus*	19	5	24
	Curculionidae	*Himatium*	*errans*	23	10	33
	Dermestidae	*Cryptorhopalum*	*triste*	15	7	22
	Dermestidae	*Cryptorhopalum*	*haemorrhoidale*	15	8	23
	Elateridae	*Ampedus*	*Melantoides*	69	1	70
	Elateridae	*Melanotus*	*americanus*	15	0	15
	Elateridae	*Melanotus*	*similis*	164	0	164
	Lampyridae	*Pyractomena*	*borealis*	11	8	19
	Lathridiidae	Unknown	species	115	404	519

Table 3 (cont.). Species most commonly* collected from the Arboretum, Anderson Co., TN, and the Plantation, Knoxville, TN, from May 1999 to June 2000.

Order	Family	Genus	Species	ARB[a]	PSF[b]	Total[c]
Coleoptera	Mycetophagidae	*Litargus*	*nebulosus*	14	9	23
	Nitidulidae	*Cryptarcha*	*Concinna*	8	7	15
	Rhizophagidae	*Europs*	*pallipennis*	21	20	41
Diptera	Empididae	*Oedalea*	species	31	0	31
	Lauxanidae	*Minetta*	species	91	3	94
	Otitidae	*Pseudotephritis*	species 1	119	0	119
	Phoridae	*Dohriniphora*	species 1	19	1	20
	Phoridae	*Dohriniphora*	species 2	55	0	55
Hymenoptera	Apidae	*Bombus*	*impatiens*	10	5	15
	Formicidae	*Camponotus*	*americanus*	165	52	217
	Formicidae	*Camponotus*	*pennsylvanicus*	122	15	137
	Formicidae	*Camponotus*	species	51	126	177
	Formicidae	*Crematogaster*	*ashmeadi*	57	38	95
	Formicidae	*Formica*	*fusca*	84	9	93
	Formicidae	*Formica*	*pallidefulva*	6	57	63
	Formicidae	*Lasius*	*niger*	0	211	211
	Formicidae	*Leptothorax*	*schaumi*	30	72	102
	Formicidae	*Monomorium*	*minimum*	4	88	92
	Formicidae	*Tapinoma*	*sessile*	2	194	196
	Halictidae	*Augochlora*	*pura*	701	2	703
	Halictidae	*Dialictus*	*laevissimus*	28	0	28
	Scelionidae	Unknown	species 1	83	83	166
	Scelionidae	Unknown	species 2	78	4	82
	Vespidae	*Vespula*	*maculifrons*	480	0	480

*15 or more specimens

[a] ARB=Arboretum

[b] PSF=Plantation

[c] Total= number of specimens of each species

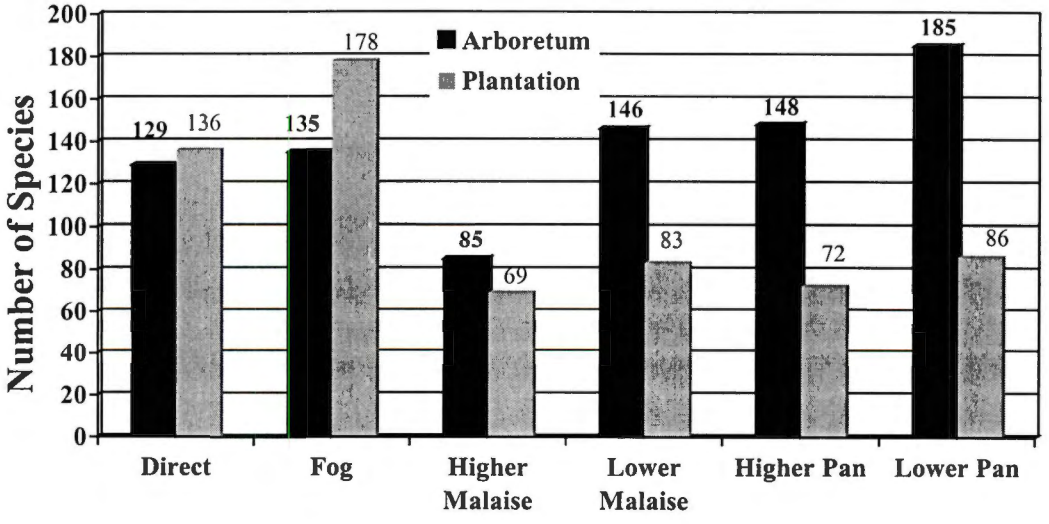


Figure 3. Number of species collected by sampling method at the Arboretum, Anderson Co., TN, and the Plantation, Knox Co., TN, from May 1999 to June 2000.

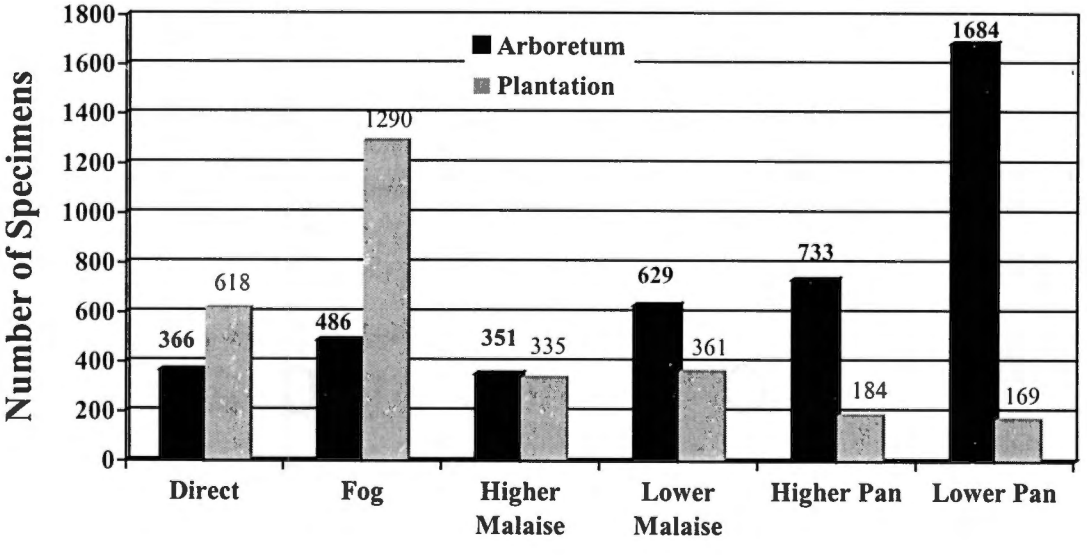


Figure 4. Number of specimens collected by sampling method at the Arboretum, Anderson Co., TN, and the Plantation, Knox Co., TN, from May 1999 to June 2000.

collected from each site, while the lower pan method showed the greatest difference (54%). The lower canopy traps yielded 25% more species than the higher canopy traps. This higher yield may be a result of closer proximity of the lower canopy traps to the understory traffic of flying adult insects. The pan traps collected 22% more species than the Malaise traps and were more productive in terms of species collected than the Malaise traps regardless of the site location. Curiously, the lower pan traps collected the most specimens at the Arboretum, but the fewest at the Plantation. Fog sampling collected the most species at the Plantation and, along with direct sampling, was the only method to collect more specimens at the Plantation than at the Arboretum. The larger number of species collected by direct sampling and fogging at the Plantation may be due to the large canopy size and/or the large amount of pollen and nectar available from the Plantation trees, which flowered in large numbers. The Malaise/pan collection methods, which are alike in that they collect specimens that are flying through the canopy and they are passive methods, collected 45% more species at the Arboretum than at the Plantation. However, the direct and fogging collection methods, which are alike in that they collect specimens that are physically on the tree at the time of collection and they are aggressive methods, collected 16% more species at the Plantation than at the Arboretum.

Diversity and evenness was the highest for direct sampling, based on the Shannon-Wiener diversity index, and the lowest for the lower pan trap (Table 4). This suggests that the stationary insect community is more diverse and even than the actively flying insect community. All the methods and the overall indices measured a greater diversity at the Arboretum than at the Plantation. This consistency suggests that the insect community structure at the Arboretum is more diverse and even than at the

Table 4. Species diversity indices and species evenness by sampling method and site.

Sampling Method	Shannon-Wiener Diversity Index		Species Evenness	
	Arboretum	Plantation	Arboretum	Plantation
Direct	4.12	3.79	0.88	0.79
Fog	3.62	3.62	0.76	0.70
Higher Malaise	3.43	2.70	0.80	0.68
Higher Pan	3.80	2.64	0.77	0.71
Lower Malaise	4.06	2.58	0.82	0.64
Lower Pan	3.12	2.41	0.60	0.64
Overall	3.69	2.96	0.77	0.69

Plantation. The greatest contrast in sampling method diversity and evenness occurring between the sites involved the lower Malaise trap. This may be due to the swarming behavior of *V. maculifrons* and *A. pura*, which were collected at the Arboretum and not at the Plantation.

Comparison of the Canopy Levels

In a comparison of the number of species and specimens represented within the orders at the Arboretum collected from the lower and higher canopy levels, the Coleoptera contained the most species (Figure 5) in both canopy layers, while the Hymenoptera were the most abundant (Figure 6) in both canopy layers. With about 63% more species collected in the lower canopy than in the higher canopy, the Diptera showed the most variation in the number of species distributed among the canopy layers at the Arboretum. The number of species in the remaining orders was relatively similar.

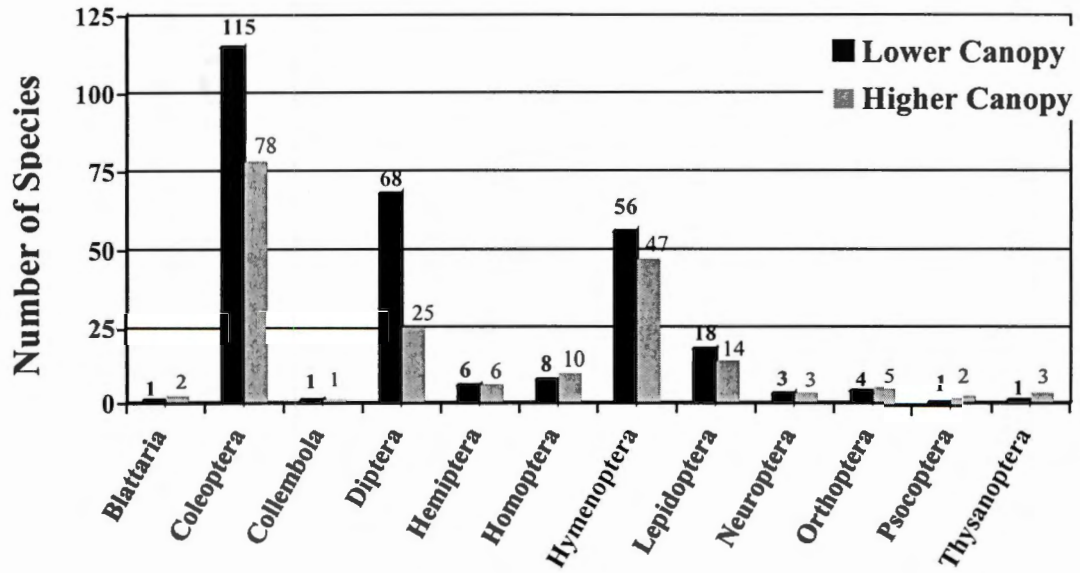


Figure 5. Number of species (n=478) within respective orders collected from the lower and higher canopy at the Arboretum, Anderson Co., TN, from May 1999 to June 2000.

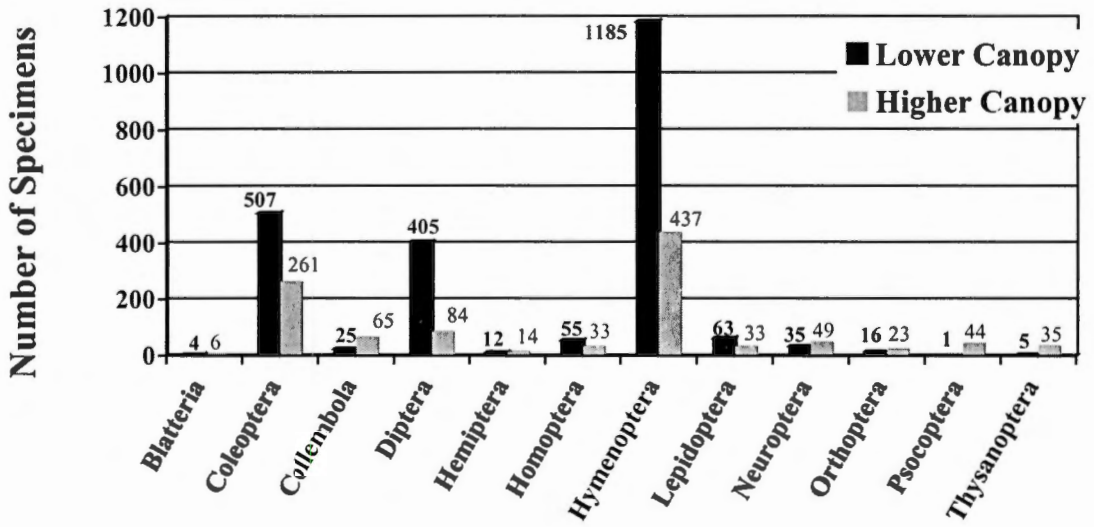


Figure 6. Number of specimens (N=3,397) within respective orders collected from the lower and higher canopy at the Arboretum, Anderson Co., TN, from May 1999 to June 2000.

Specimen numbers were higher (more than 55%) in the lower canopy than in the higher canopy at the Arboretum. All of the major orders collected were more abundant in the lower canopy than in the higher canopy.

A comparison of the number of species and specimens represented in each order within the lower and higher canopies at the Plantation is presented in Figures 7 and 8, respectively. The highest number of species represented were from taxa similar to that of the Arboretum (i.e. Coleoptera, Hymenoptera, and Diptera comprised the dominant orders collected in both canopy layers). The number of dipteran species collected in the higher canopy at the Plantation slightly exceeded the number collected in the lower canopy.

The number of specimens and species collected from the lower canopy and higher canopy with the Malaise and pan traps is summarized in Table 5. While the lower canopy yielded more specimens and species than the higher canopy at both sites, the difference was considerably more distinct at the Arboretum. The comparitively large difference in the number of specimens and species collected from the lower canopy versus the higher canopy at the Arboretum suggests that insects may have a prefered flying hieght relative to the ground surface that is closer to the lower canopy than the higher canopy.

No significant ($p \leq 0.05$) differences were found in the Shannon-Wiener Diversity Index or species evenness between the lower and higher canopy layers at either site (Table 6). The insignificant differences in the species diversity indices and species evenness value suggests that Malaise and pan trap placement with respect to vertical

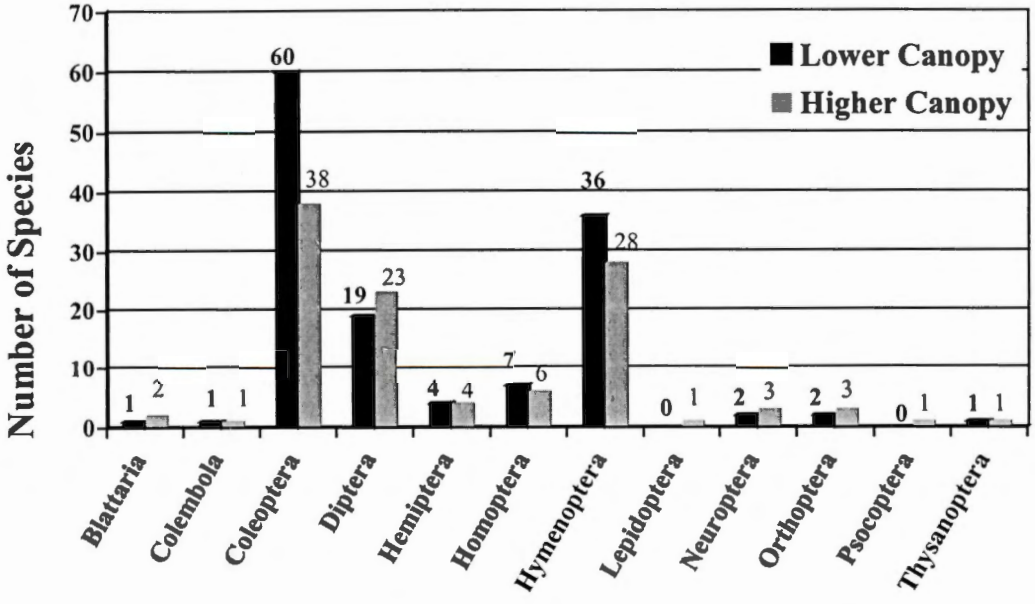


Figure 7. Number of species (N=244) within respective orders collected from the lower and higher canopy at the Plantation, Knox Co., TN, from May 1999 to June 2000.

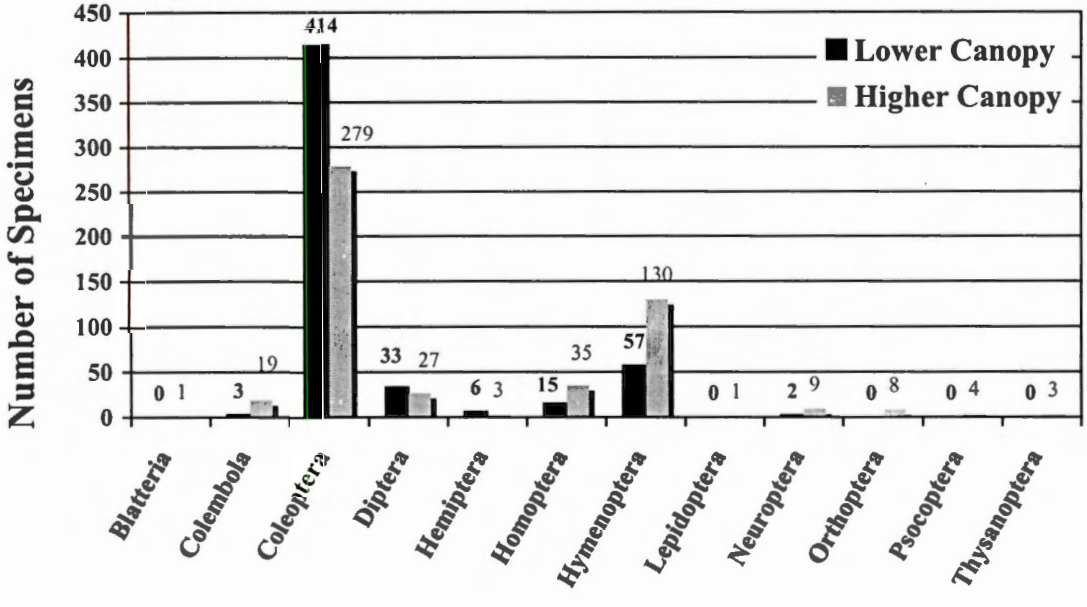


Figure 8. Number of specimens (n=1,049) within respective orders collected from the lower and higher canopy at the Plantation, Knox Co., TN, from May 1999 to June 2000.

Table 5. Number of insect specimens and species collected within the lower and higher canopy at the Arboretum, Anderson Co., TN, and the Plantation, Knox Co., TN, from May, 1999 to June, 2000.

Canopy Level	**Arboretum**		**Plantation**	
	Specimens	Species	Specimens	Species
Lower Canopy	2,313	283	530	135
Higher Canopy	1,084	195	519	113

Table 6. Diversity indices and species evenness for insects collected in the higher and lower canopies at each site.

	Shannon-Wiener Diversity Index (mean ± SE)		**Species Evenness** (mean ± SE)	
Site	Higher Canopy	Lower Canopy	Higher Canopy	Lower Canopy
Arboretum	3.61 ± 0.25 a*	3.59 ± 0.66 a	0.78 ± 0.02 a	0.71 ± 0.16 a
Plantation	2.67 ± 0.04 a	2.49 ± 0.12 a	0.70 ± 0.02 a	0.64 ± 0.01 a

*Numbers within a row followed by different letters are significantly different ($p \leq 0.05$). Analysis of Variance was conducted using a paired T-test.

position within a canopy will have little effect upon the diversity of insects that will be collected.

A greater number of species were collected exclusively in the lower canopy Malaise/pan traps than were collected exclusively in the higher canopy Malaise/pan traps at both sites (Table 7). More than 30% of all the species collected at the Arboretum and 10% of the species collected at the Plantation were collected exclusively in the lower

Table 7. Number of species collected exclusively in the lower canopy traps and higher canopy traps at the Arboretum, Anderson Co., TN, and Plantation, Knox Co., TN, from May 1999 to June 2000.

Trap	Arboretum	Plantation	Total
Lower Canopy Malaise/pan	152	35	187
Higher Canopy Malaise/pan	70	23	93

canopy flight interception traps. Only 14% (Arboretum) and 7% (Plantation) were collected exclusively in higher canopy traps. Overall, the lower canopy traps collected almost twice as many exclusive species as the higher canopy traps.

Exotic Species Associated with Yellow-Poplar

A total of 13 exotic species representing two orders and eight families were identified in this study (Table 8). Ten of these were unintentionally introduced and are potentially destructive pests, while the remaining three species have been introduced by entomologists as biological control agents.

The Asiatic oak weevil, *C. castaneus*, was the most common pest species collected and, was collected almost four times as often at the Arboretum than at the Plantation. This species, native to northeastern Asia and first reported in New Jersey in 1933, is known to feed on at least 36 woody plants including yellow-poplar (Johnson and Lyon 1991).

The Japanese beetle, *Popilia japonica* Newman, was introduced in 1916 from Japan in flowering cherry tree roots and may be generally the most destructive of the

Table 8. Exotic insect species introduced into the U. S. and numbers collected at the Arboretum, Anderson Co., TN, and at the Plantation, Knox Co., TN, in 1999 and 2000.

Order	Family	Genus	Species	Site		
				ARB[a]	PSF[b]	Total
Coleoptera	Chrysomelidae	*Demotina*	*modesta*	3	3	6
	Coccinellidae	*Coccinella*	*septempunctata*	7	9	16
	Coccinellidae	*Harmonia*	*axyridis*	42	217	259
	Curculionidae	*Cyrtepistomis*	*castaneus*	19	5	24
	Curculionidae	*Naupactus*	*leucoloma*	1	9	10
	Curculionidae	*Pantomorus*	*cervinus*	0	1	1
	Eucnemidae	*Dirrhagofarsus*	*lewisi*	1	0	1
	Scarabaeidae	*Popillia*	*japonica*	2	3	5
	Scolytidae	*Xyleborinus*	*saxeseni*	16	4	20
	Scolytidae	*Xylosandrus*	*crassiusculus*	1	1	2
	Scolytidae	*Xylosandrus*	*germanus*	2	0	2
Hymenoptera	Tiphiidae	*Tiphia*	*vernalis*	0	6	6
	Vespidae	*Vespa*	*cabro*	2	1	3

[a]ARB=Arboretum
[b]PSF=Plantation

introduced pests collected. The few specimens obtained in this study were collected from the leaves on lower branches. Evidence of their feeding on the foliage was minimal.

The coccinellids *H. axyridis*, introduced in the late 1970's and early 1980's from East Asia, and *Coccinella septempuncta* L., introduced in 1956-1971 in the eastern U.S. from Europe, were imported to help control orchard and field crop pests (Gordon 1985). Both species were more common at the Plantation where tulip tree aphids were plentiful.

The parasitic wasp, *Tiphia vernalis* Rohwer, was first imported in 1925 from Korea and Northern China to help control the Japanese beetle. It was observed on yellow-poplar in late April feeding on nectar and aphid honeydew.Three exotic scolytid species were collected. *Xlosandrus germanus* (Blandford), a native of Asia, was reported in Connecticut and New Jersey, west to Illinois and Kentucky in 1932 (Mattson et al. 1994). It is reported to be increasing in economic importance and has damaged a yellow-poplar Plantation in Ohio (Weber and Mcpherson 1983). *Xylosandrus crassiusculus* (Motschulscky) was first recorded in Charleston, South Carolina in 1975. It is polyphagous, attacking the seedlings and new-cut logs of hardwoods (Mattson et al. 1994). *Xyleborinus saxeseni* (Ratzeburg), a native of Europe, is a serious pest of hardwoods and is found throughout eastern North America (Mattson et al. 1994). It was among the most common exotic species collected and was found at both sites.

Dirrhagofarsus lewisi Fleutiaux (Eucnemidae) was first detected in the U.S. in 1976 at Leakin Park, Baltimore, Maryland, where specimens were taken from a fallen beech tree (*Fagus grandifloia* Ehr.) (Hoebeke and Wheeler 1983). Japan is probably the country of origin for this species, where little or nothing is known about it (Hoebeke and Wheeler 1983).

The European hornet, *Vespa cabro* L., introduced into New York between 1840 and 1860 (Shaw and Weidhaas 1956), typically build nests in hollow trees in forested habitat (Akre et al. 1981). Workers are predaceous, harvesting an assortment of large prey species (Akre et al. 1981). They have also been reported to girdle stems of several trees and shrubs, where they imbibe sap and sometimes collect fibers (Akre and et al. 1981).

A single specimen of the Fuller rose beetle, *Pantomorus cervinus* (Boheman), was collected from the Plantation. This exotic species was first recorded in the U.S. in 1879 and today is a pest of outdoor ornamentals, fruit trees, and vegetable crops throughout the southeastern U.S. (Johnson and Lyon 1991).

The chrysomelid, *Demotina modesta* Baly, was collected at both sites. It is native to Japan, where it feeds mainly on oak in deciduous forests (Isono 1988). No published records were found on this species in the United States.

The white-fringed weevil, *Naupactus leucoloma* (Boheman), a native of South America, was first recorded in the United States in 1936 from a peanut field in Florida (Zehnder 1997). Today, it is established throughout the southeastern U.S. (Warner 1975), where it is known to feed on some 385 species of plants (Young et al. 1950). The weevil was collected at both sites, using canopy fogging. Their presence in fog samples is somewhat interesting considering the white-fringed weevil is incapable of flight and is often found feeding on plants near the soil surface (Young et al. 1950). The evident willingness of this weevil species to expend the energy to climb into the canopy of yellow-poplar suggests some degree of preference for yellow-poplar leaves.

Tennessee Records

Large scale insect sampling and cataloging for many groups has not been as extensive in Tennessee as it has in other eastern states, i.e. New York, Indiana, North Carolina, Florida, Virginia, and others. As a result, Tennessee is often missing from insect checklists. Only new Tennessee occurrence records for the beetles were attempted since relatively recent publications with distribution records and checklists for this order are reasonably complete and easy to find. Nineteen beetle species collected in this study may represent new state records for Tennessee (Table 9).

The weevil, *Himatium errans* LeConte, was surprisingly the most abundant weevil collected, even though it tends to be rare in collections (O'Brien, personal communication). It has been found living inquilinously in the galleries of bark beetles (O'Brien and Wibmer 1982).

Another rarely collected insect was *Inopeplus immunda* Reitter (Cucujidae). Revisions have resulted in the transfer of this species to several families over the years. Some authorities place this genus with the Salpingidae, while others consider it with the Staphylinidae. Little information was found on this uncommon beetle, which is reported to be attracted to lights (Downie and Arnett 1996).

New southern range limits have been established for four species: *Dromaeolus pusillus* Horn (Eucnemidae), *Tomoxia serval* Say (Mordellidae), *Eurypogon niger* (Melsheimer) (Dascillidae) and *Nosodendron unicolor* Say (Nosodendridae). The literature offers little information for the other species considered new state records.

Table 9. Species of Coleoptera not previously recorded in Tennessee collected in 1999 and 2000.

Family	Genus	Species	Geographical Distribution*
Aderidae	*Emelinus*	*melsheimeri*	MA, PA, NJ, MD, DC, OH, IN, IL, WV, FL
Curculionidae	*Himatium*	*errans*	DC, IN, MA, MD, NJ, NS, NY, OH, PA, FL, GA, MS, NC, SC
Curculionidae	*Myrmex*	*myrmex*	CT, DC, IN, MD, NJ, NY, ON, WI, AL, AR, FL, GA, MS, NC, SC, VA, IA
Curculionidae	*Pentarthrinus*	*parvicollis*	MD, NJ, NY, PA, FL, GA, SC, VA
Curculionidae	*Piazorhinus*	*pictus*	DC, IL, IN, NJ, NY, OH, PA, WI, FL, GA, SC, MO, Can.
Curculionidae	*Piazorhinus*	*scutellaris*	CT, DC, IL, IN, ME, MI, NJ, NY, OH, ON, PA, PQ, UT, GA, MS, NC, SC, VA, AZ, IA, NE, Guat., Hond., Mex., Nic., Pan.
Curculionidae	*Pseudopentarthrum*	*simplex*	IN, MS, NC, SC, NE
Curculionidae	*Rhynchaenus*	*pallicornis*	CT, DC, IL, IN, MA, MD, MI, NE, NJ, MY, OH, ON, PA, GA, KY, NC, VA, CA, TX, BC, ID, OR, WA, AB, CO, IA, MO, MT
Curculionidae	*Sitona*	*lepidus*	CT, DC, IN, MI, NF, NJ, NS, NY, OH, PA, WI, FL, CA, TX, BC, ID, OR, WA, AB, CO, IA, MN, MT, SC, Mex.
Curculionidae	*Stenoscelis*	*brevis*	CT, DC, IN, MA, MD, MI, NH, NY, OH, NJ, ON, PA, PQ, VT, WI, AL, FL, GA, LA, MS, NC, SC, VA, WV, IA, KS, MN
Cucujidae	*Inopeplus*	*immunda*	MD, VA

Table 9 (cont.). Species of Coleoptera not previously recorded in Tennessee collected in 1999 and 2000.

Family	Genus	Species	Geographical Distribution*
Dascillidae	*Eurypogon*	*Niger*	PQ, NY, PA
Euecnemidae	*Dromaeolus*	*pusillus*	NY, IL, IN, OH, VA, TX, KS
Perothopidae	*Perothops*	*mucida*	NY, PA, IN, VA, GA, FL
Tenebrionidae	*Strongylium*	*terminatum*	MI, NY, PA, MD, VA, GA, FL, LA, OD, IA, SD, NE, KS
Mordellidae	*Tomoxia*	*lineella*	NB, ME, NY, MD, PA, MD, OH, IN, IL, MI, GA, IA
Mordellidae	*Tomoxia*	*fascifera*	DC, NC, FL, TX
Mordellidae	*Tomoxia*	*serval*	PQ, ON, NY, ME, PA, MD, OH, IN, IL, MI, OK, IA, MO, MB
Nosodendridae	*Nosodendron*	*unicolor*	NY, IL, IN, TX, KS

* As provided by Downie and Arnett (1996), Liljeblad (1945), O'Brien and Wibmer (1982).

Insects Associated with Various Structures of Yellow-Poplar

The greatest portion of insect orders, families, and species identified were foliage feeders (Table 10). Of these insects associated with foliage, the coleopteran (i.e. chrysomelids, elaterids, curculionids) and homopteran (i.e. aphids, cicadellids, flatids) groups dominated. A relatively large number of species collected were associated with wood and/or bark; however, these were all members of Coleoptera, with most species belonging to the cerambycids or anobiids. Only two species, both in the family Coreidae, were associated with seeds.

A relatively large number of species collected potentially visit yellow-poplar flowers. Yellow-poplar attracts a unique insect fauna compared to other important

Table 10. Number of insect orders, families, and species potentially feeding on various structures of yellow-poplar.

Structure	Orders	Families	Species
Foliage	5	36	165
Flowers	4	15	68
Wood/bark	1	16	76
Seeds	1	1	2
Stems	1	2	2

hardwood species because of its large flowers. Some 41 Hymenoptera, 15 Coleoptera, and 4 Diptera, representing 28 species and 10 families, were directly collected from yellow-poplar flowers at the Plantation in spring 2000 (Table 11). Most of the Hymenoptera (81%) were species of Halictidae or Andrenidae, while most of the Coleoptera (60%) were species of Cantharidae. Four syrphid specimens were collected representing two species. The syrphids were observed on the leaves and petals feeding on the nectar only. All of the halictids and andrenids collected had yellow-poplar pollen grains attached to their bodies. None of the 15 species listed by (Andow 1982) were collected, which suggest that a wide range of insects visit yellow-poplar flowers and that geographical area and the surrounding habitat may have a big impact on the specific visitors. Also, yellow-poplar flowers in the southern states will typically develop sooner that those in the northern states introducing a timing factor that could influence the insect visitors in a geographic region.

Table 11. Native insect species collected on yellow-poplar flowers at the Plantation, Knox County, TN in 2000.

Order	Family	Genus	Species	# Individuals[a]
Coleoptera	Cantharidae	*Cantharis*	*bilineatus*	4
	Cantharidae	*Cantharis*	*carolinus*	1
	Cantharidae	*Cantharis*	*dentiger*	1
	Cantharidae	*Cantharis*	species	2
	Cantharidae	*Chauliognathus*	*marginatus*	1
	Cerambycidae	*Brachyleptura*	*circumdata*	1
	Cerambycidae	*Callimoxys*	*sanguinicollis*	1
	Cleridae	*Placoopterus*	*thoracicus*	1
	Dermestidae	*Cryptorhopalum*	*triste*	2
	Pedilidae	*Pedilus*	*terminalis*	1
Diptera	Syrphidae	*Allograpta*	*obliqua*	1
	Syrphidae	*Epistrophe*	*emarginata*	3
Hymenoptera	Andrenidae	*Andrena*	*imitatrix*	6
	Andrenidae	*Andrena*	*morrisonella*	2
	Andrenidae	*Andrena*	*nasonii*	1
	Andrenidae	*Andrena*	*personata*	2
	Andrenidae	*Andrena*	*pruni*	2
	Andrenidae	*Andrena*	*spiraeana*	1
	Andrenidae	*Andrena*	*vicina*	1
	Anthoporidae	*Xylocopia*	*virginica*	1
	Halictidae	*Augochlorella*	*striata*	2
	Halictidae	*Dialictus*	*admirandus*	7
	Halictidae	*Dialictus*	*bruneri*	6
	Halictidae	*Dialictus*	*illinoensis*	2
	Halictidae	*Dialictus*	*zephyrus*	5
	Halictidae	*Sphecodes*	*aroniae*	1
	Vespidae	*Polistes*	species	1
	Vespidae	*Vespa*	*cabro*	1

[a] # Individuals=Number of individuals of each species collected.

Potential Pests

Some 167 insect species representing 22 families were identified as potential pests of yellow-poplar (Table 12). Species causing obvious visual damage to the trees at the sites included: *O. calceatus, P. liriodendri, I. liriodendri, T. liriodendri*, *E. ostricolorella*, and *L. oppositus*. *T. metasternalis* was the most commonly collected chrysomelid, and adults were observed feeding and ovipositing on yellow-poplar leaves in the laboratory.

Table 12. Number of potentially harmful species within families collected from yellow-poplar at the Arboretum, Anderson Co., TN, and the Plantation, Knox Co., TN, from May, 1999 to June, 2000.

Order	Family	Number of Species
Orthoptera	Tettigoniidae	4
Hemiptera	Coreidae	2
	Tingidae	3
	Acanaloniidae	2
	Aphidae	1
	Cicadellidae	11
	Coccidae	1
	Flatidae	4
	Membracidae	4
	Pentatomidae	2
Coleoptera	Buprestidae	6
	Cerambycidae	22
	Chrysomelidae	31
	Curculionidae	12
	Elateridae	21
	Eucnemidae	9
	Lagriidae	2
	Mordellidae	18
	Scarabaeidae	6
	Scolytidae	4
Lepidoptera	Gracillariidae	1
	Papillionidae	1

Potential Beneficials

Some 274 species representing 54 families and 7 orders collected were identified as potentially beneficial to yellow-poplar as predators or parasitoids of pest species (Table 13). Orthoptera are rarely considered to be a beneficial group in any agricultural system. However, *C. carolinensis*, which was collected more than all other orthopterans combined, is known to be a nocturnal predator of aphids. The arboreal, predaceous cricket *Oecanthus augustipennis* Fitch, (Gryllidae) was commonly collected at the Arboretum. However, females can seriously damage host plants with their ovipositing behavior, which may outweigh any benefit from their feeding habits.

Mantodea are considered to be ineffective biological control agents because of their cannibalistic tendencies and general appetites. However, they are included here because they contribute to the guild of zoophagous insect species feeding on insects associated with yellow-poplar. Only two adult *Stagmomantis carolina*, Carolina mantid, specimens were collected along with several egg cases. The adults and egg cases were directly collected in late summer. Adults were located at the ends of low hanging branches and the egg cases within the bark crevices on the trunks.

The predaceous Hemiptera were represented by eight families and 13 species. *Jaylsus spinosus* (Say) (Berytidae), *Podisus maculiventris* Say (Pentatomidae), and *Nabis annulatus* Reuter (Nabidae) were collected only at the Arboretum, while *Myodocha serripes* Olivier (Lygaeidae), *Geocoris uliginosus* (Say) (Lygaeidae), and *Corticoris pulchellus* Neidemann (Isomatopidae) were only collected at the Plantation. Fifteen specimens of the uncommon group Isomatopidae (jumping tree bugs) were collected from a fog sample at the Plantation, but none was collected at the Arboretum.

Table 13. Number of potentially beneficial species within families collected from yellow-poplar at the Arboretum, Anderson Co., TN, and the Plantation, Knox Co., TN, from May, 1999 to June, 2000.

Order	Family	Number of species
Orthoptera	Gryllacrididae	1
	Gryllidae	1
Mantodea	Mantidae	1
Hemiptera	Anthocoridae	4
	Berytidae	1
	Isomatopidae	1
	Lygaeidae	2
	Miridae	2
	Nabidae	1
	Pentatomidae	1
	Reduviidae	1
Neuroptera	Chrysopidae	1
	Coniopterigidae	1
	Hemerobiidae	1
	Mantispidae	1
Coleoptera	Cantharidae	11
	Carabidae	2
	Cerylonidae	1
	Cleridae	8
	Coccinellidae	18
	Histeridae	3
	Lampyridae	5
	Lycidae	3
	Melyridae	2
	Pyrochroidae	1
	Staphylinidae	10
	Throscidae	1
	Trogossitidae	3
Diptera	Asilidae	6
	Conopidae	2
	Dolichopodidae	4
	Pipinculidae	1
	Syrphidae	10
Diptera	Tachinidae	23
Hymenoptera	Aphelinidae	1
	Bethylidae	2
	Braconidae	40
	Ceraphronidae	1

Table 13 (cont.). Number of potentially beneficial species within families collected from yellow-poplar at the Arboretum, Anderson Co., TN, and the Plantation, Knox Co., TN, from May, 1999 to June, 2000.

Order	Family	Number of species
Hymenoptera	Chrysididae	1
	Diapriidae	5
	Eucoilidae	3
	Eupelmidae	8
	Figitidae	3
	Ichneumonidae	30
	Megaspilidae	3
	Platygastridae	1
	Pompilidae	12
	Pteromalidae	1
	Rhopalosomatidae	1
	Scelionidae	9
	Sphecidae	12
	Tiphiidae	1
	Torymidae	3
	Vespidae	3

Anthocoridae were represented at the Arboretum by four species with *Asthenidea temnostethoides* Reuter being the most common anthocorid at this site. *Orius insidiosus* Say was the only anthocorid collected at the Plantation.

Four species of Neuroptera representing four families were collected. The lacewings were represented by *Hemerobidus stigma* Stephens (Hemerobiidae) and *Chrysoperla* sp. (Chrysopidae). The hemerobiids were uncommon in the collections relative to the number of chrysopids. The other two species of Neuroptera, *Mantispa* sp. (Mantispidae) and an unknown species of Coniopterigidae, were rare in collections.

Sixty-eight species and 13 families of potentially beneficial beetles were collected. The coccinellids probably represent the most beneficial group associated with yellow-poplar because of their ability to control potentially lethal aphid and scale

populations. Over 400 predaceous coccinellids were collected representing 11 genera and 18 species. Three coccinellids (*H. axyridis, C. munda* (Say), and *C. septempunctata*) and one cantharid (*Podabrus rugosulus* LeConte) were observed feeding on tulip tree aphids during this study. The Cantharidae were represented by 11 species. Of these, only two species *Cantharis bilineatus* Say and *Chauliognathus marginatus* (Fab.) were collected from both sites. The anthicid, *N. murinipennis*, was one of the most common insects collected at the Plantation. The beetle was observed in the field on yellow-poplar leaves and on the small branches. Because some species within the genus are recognized as beneficial predators in field crops, this species may be feeding on tulip tree pests. However, no predatory behavior was noted from limited field observations of this species. In addition, tulip tree aphids were offered to beetle specimens under laboratory conditions for three consecutive days resulting in no predatory behavior. Therefore, it is likely that they are not predators or that they are preying upon a different organism(s). Nevertheless, they appear to be strongly attracted to the yellow-poplar trees at the Plantation. The clerids were a commonly collected group, particularly at the Arboretum. They were represented by eight species with *Cymatodera undulata* clearly being the dominant clerid species.

The potentially beneficial Diptera were represented by six families and 46 species. None of the Diptera species collected was particularly abundant at either site. However, the tachinids and syrphids were represented by a relatively large number of species.

The Hymenoptera were represented by the most potentially beneficial families and species. The majority of the families and species collected were parasitoids or

parasites. A scelionid was observed ovipositing in the eggs of the yellow-poplar pest *L. oppositus*, and adults were subsequently reared out of these eggs in the laboratory. The predator and sometimes agricultural pest *V. maculifrons* was among the most abundant insects collected at the Arboretum, but not collected from the Plantation.

CHAPTER IV

CONCLUSIONS

A total of 13 orders, 146 families, and some 727 species of insects were collected from yellow-poplar trees at two sites in 1999 and 2000. The insect fauna at the Arboretum was more abundant (number of specimens collected), diverse (H'), even (H'/Hmax), and rich (number of species collected) than the insect fauna at the Plantation.

The Coleoptera, Hymenoptera, and Diptera were dominate at both sites in terms of specimens and species collected. The prevalence of the members within these three groups may be a result of their mobile abilities and/or tendencies combined with the sampling methodology (i.e. flight interception traps) which may have favored these highly mobile orders. Also, the availability of prey and honeydew associated with yellow-poplar (i.e. tulip tree aphids and tulip tree scale) appeared to attract several species to yellow-poplar.

The fauna collected at each site was distinct. This distinctiveness is probably closely linked to the physical characteristics of the trees, the flora surrounding the sites, and the physical characteristics (i.e. amount of shade versus sunlight, windbreak, and floor cover) of the surrounding environment. Several specific faunal differences are contributed to the physical characteristics of the trees at each site. For example, the greater flower abundance and density characteristic of the plantation trees attracted more pollinators. Also, the larger canopies of the plantation trees supported a dense population of tulip tree aphids, which probably resulted in the collection of a comparatively large

and diverse guild of coccinellids. In addition, the copious amounts of honeydew and overflowing nectar in the early spring provided a substrate for the growth of sooty mold on the leaves at the plantation site. The mold may have attracted a guild of insects unique to the plantation site.

The various sampling methodologies were not equally effective at both sites. This variation illustrates the importance of considering site characteristics when choosing sampling methodology for biodiversity studies or species inventory projects.

A large portion of the species collected at each site was collected exclusively from the lower or higher canopy. However, these species were relatively rare in the collections and a pattern of preference could not be discerned. Therefore, it seems advisable for future studies with the intention of collecting as many species and specimens as possible in the shortest amount of time to place flight interception traps in the lower canopy rather than the higher canopy of trees in forest and plantation environments. On the other hand, if the intention of the study is to collect all species within a given forest or plantation environment it is advisable to place flight interception traps in both the lower and higher canopy.

A total of 13 exotic species representing two orders and eight families was collected from this study. Ten of these were unintentionally introduced and are potentially destructive pests, while the remaining three species have been introduced by entomologists as biological control agents. The most influential exotic species collected was the beneficial predator *H. axyridis*. None of the exotic pest species collected are considered major pests of yellow-poplar trees.

Nineteen beetle species collected in this study may represent new state records for Tennessee. The uncommonly collected weevil, *H. errans*, was surprisingly the most abundant weevil collected in the entire study. Also, new southern range limits have been established for four beetle species: *D. pusillus*, *T. serval*, *E. niger* and *N. unicolor*.

The majority of the insects associated with yellow-poplar are associated with the foliage of yellow-poplar. However, a large number of insect species were found in association with the flowers of yellow-poplar, many for the first time. The large flowers of yellow-poplar attract numerous insect species that may not be associated with other economically and ecologically important hardwoods.

A total of 22 families containing 167 species were identified as potential pests of yellow-poplar. However, only a few species themselves were observed causing obvious damage to the trees. In addition, several potentially beneficial insects were collected. Among these, the predaceous coccinellids were especially abundant and well represented, along with the parasitoids in the braconid, inchneumonid, and tachinid families.

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APPENDIX

Appendix. Insect species collected (n=727) from May 1999 to June 2000 at Knox Co., TN, and Anderson Co, TN.

Order	Family	Genus	Species	Sites[a]	Sample Method[b]	Y.P. association[c]	No. Specimens
Collembola	Entomobryidae	Unknown	species	A,P	HM,HP,LM	Unknown	97
	Sminthuridae	Unknown	species	A	LP	Unknown	3
Orthoptera	Gryllacrididae	*Camptonotus*	*carolinesis*	A,P	D,F,HM,HP,LM,LP	Predator	55
	Gryllidae	*Oecanthus*	*angustipennis*	A	F,HP	Predator	5
	Gryllidae	*Orocharis*	*saltator*	A,P	D,F,HM,HP,LM,LP	Unknown	24
	Tettigoniidae	*Atlanticus*	species	A	LM	Foliage	2
	Tettigoniidae	*Orchelium*	*vulgare*	A	HM	Foliage	1
	Tettigoniidae	*Pterophylla*	*camellifolia*	A	F,LP	Foliage	4
	Tettigoniidae	*Scudderia*	species	A,P	D,HM	Foliage	3
Mantodea	Mantidae	*Stagmomantis*	*carolina*	P	D,F	Predator	4
Blatteria	Blattellidae	*Parcoblatta*	species 1	A,P	F,HM,HP,LP	Scavenger	10
	Blattellidae	*Parcoblatta*	species 2	A,P	F,HP	Scavenger	5
Psocoptera	Unknown	Unknown	species 1	A	HM	Algae/Lichen/Debris	25
	Unknown	Unknown	species 2	A,P	HM,HP	Algae/Lichen/Debris	9
	Unknown	Unknown	species 3	A	HM	Algae/Lichen/Debris	14
	Unknown	Unknown	species 4	P	F	Algae/Lichen/Debris	9
	Unknown	Unknown	species 5	A	LM	Algae/Lichen/Debris	1
Hemiptera	Anthocoridae	*Asthenidea*	*temnostethoides*	A	F	Predator	37
	Anthocoridae	*Cardiastethus*	species	A	LP	Predator	1
	Anthocoridae	*Lasiochilus*	*pallidulus*	A	F,HP	Predator	3
	Anthocoridae	*Orius*	*insidiosus*	A,P	F,LM,LP	Predator	4

Appendix. (cont.). Insect species collected (n=727) from May 1999 to June 2000 at Knox Co., TN, and Anderson Co, TN.

Order	Family	Genus	Species	Site[a]	Sample Method[b]	Y.P. association[c]	No. Specimens
Hemiptera	Berytidae	*Jalysus*	*spinosus*	A	D	Predator	6
	Coreidae	*Acanthocephala*	*confraterna*	A,P	D,LM,LP	Seed	5
	Coreidae	*Leptoglossus*	*oppositus*	A,P	D,F,HM,HP,LM	Seed	24
	Cydnidae	*Sehirus*	*cinctus*	P	F	Foliage	2
	Isomatopidae	*Corticoris*	*pulchellus*	P	F	Predator	15
	Lygaeidae	*Geocoris*	*uliginosus*	P	F	Predator	1
	Lygaeidae	*Myodocha*	*serripes*	P	F	Predator	1
	Lygaeidae	*Orthaea*	*longulus*	A	HM	Foliage	3
	Miridae	*Alepidia*	*gracilis*	A	F	Foliage	3
	Miridae	*Coquillettia*	*mimetica*	A	F	Foliage	3
	Miridae	*Eurychilopterella*	*luridula*	P	HP	Predator	1
	Miridae	*Hyaliodes*	*vitripennis*	A,P	D,F	Predator	22
	Miridae	*Lopidea*	*davisi*	P	D	Foliage	1
	Miridae	*Phytocoris*	*quercicola*	A	F	Foliage	2
	Miridae	*Spanagonicus*	*albofasciatus*	P	F	Foliage	1
	Nabidae	*Nabis*	*annulatus*	A	D	Predator	1
	Pentatomidae	*Acrosternum*	*hilare*	A	LM	Foliage	2
	Pentatomidae	*Euschistus*	*tristigmus*	P	D	Foliage	7
	Pentatomidae	*Podisus*	*maculiventris*	A	D	Predator	1
	Piesmatidae	*Piesma*	species	P	F	Foliage	1
	Reduviidae	*Epicoris*	*tuberculatus*	A,P	F,HP	Predator	3

Appendix. (cont.). Insect species collected (n=727) from May 1999 to June 2000 at Knox Co., TN, andAnderson Co, TN.

Order	Family	Genus	Species	Site[a]	Sample Method[b]	Y.P. association[*]	No. Specimens
Hemiptera	Rhopalidae	*Harmostes*	*fraterculus*	A	D	Flower	1
	Thyreocoridae	*Galgupha*	*nigra*	P	F	Foliage	1
	Tingidae	*Corythuca*	*arcuata*	A	F	Foliage	1
	Tingidae	*Corythuca*	*pallipes*	A	HM	Foliage	4
	Tingidae	*Melanorhopala*	*infuscata*	A,P	D,F,HM,LM	Foliage	68
Homoptera	Acanaloniidae	*Acanalonia*	*bivittata*	A	D	Foliage	1
	Acanaloniidae	*Acanalonia*	species	A,P	D,HM,LP	Foliage	14
	Aphidae	*Illinoia*	*liriodendri*	A,P	D,F,HM,HP,LM,LP	Foliage	134
	Cercopidae	*Aulacizes*	*irrorata*	A	D	Foliage	1
	Cercopidae	*Aphrophora*	*parallela*	A	LM	Foliage	2
	Cercopidae	Unknown	species	A,P	D,F,HM,HP,LM	Foliage	14
	Cicadellidae	*Agallia*	*constricta*	A,P	D,F	Foliage	3
	Cicadellidae	*Amplicephalus*	*estacadus*	P	F	Foliage	3
	Cicadellidae	*Aphrodes*	*albifrons*	P	F	Unknown	7
	Cicadellidae	*Clastoptera*	species	A	D,HM	Foliage	3
	Cicadellidae	*Cloanthus*	species	A	D	Foliage	1
	Cicadellidae	*Exitianus*	*obscurinervis*	P	F	Foliage	1
	Cicadellidae	*Hebecephalus*	*cruciatus*	P	F	Foliage	2
	Cicadellidae	*Jassus*	*borealis*	A	D,HM	Foliage	3
	Cicadellidae	*Jassus*	*olitorius*	A,P	D,F,HM,HP,LM,LP	Foliage	44
	Cicadellidae	*Philaenus*	*leucophthalmus*	A	D	Foliage	2

Appendix. (cont.). Insect species collected (n=727) from May 1999 to June 2000 at Knox Co., TN, andAnderson Co, TN.

Order	Family	Genus	Species	Site[a]	Sample Method[b]	Y.P. association[c]	No. Specimens
Homoptera	Cicadellidae	*Platymetopius*	*vitellinus*	A	D	Foliage	1
	Cicadidae	*Tibicen*	*pruinosa*	P	D,HP,LP	Stems/Branches	6
	Cixiidae	*Oliarus*	species	A	D,HP,LP	Foliage	6
	Coccidae	*Toumeyella*	*liriodendri*	A,P	D	Stems/Branches	20
	Derbidae	*Otiocerus*	species	A	D	Foliage	1
	Derbidae	*Syntames*	*uhleri*	A	D	Foliage	7
	Flatidae	Unknown	species 1	A,P	D	Foliage	22
	Flatidae	Unknown	species 2	A,P	D,F,HP,LM	Foliage	11
	Flatidae	Unknown	species 3	A	D,HM,HP,LM	Foliage	9
	Issidae	*Bruchomorphus*	species	P	LM	Foliage	1
	Membracidae	*Crytolobus*	species	P	D	Foliage	2
	Membracidae	*Enchenopa*	*binotata*	A	F	Foliage	2
	Membracidae	*Hiliria*	*molaris*	A	HP	Foliage	1
	Membracidae	*Stictocephala*	*species*	A,P	D	Foliage	2
Thysanoptera	Unknown	Unknown	species 1	A,P	HP,LM	Unknown	41
	Unknown	Unknown	species 2	A	HP	Unknown	1
	Unknown	Unknown	species 3	A	HP	Unknown	1
Neuroptera	Chrysopidae	*Chrysoperla*	*species*	A,P	D,F,HM,HP,LM,LP	Predator	131
	Coniopterigidae	Unknown	species	A	LP	Predator	1
	Hemerobiidae	*Hemerobius*	*stigma*	A,P	D,F,HM,HP,LP,	Predator	34
	Mantispidae	*Mantispa*	species	A,P	HM,HP	Predator	3

Appendix. (cont.). Insect species collected (n=727) from May 1999 to June 2000 at Knox Co., TN, andAnderson Co, TN.

Order	Family	Genus	Species	Site[a]	Sample Method[b]	Y.P. association[c]	No. Specimens
Coleoptera	Aderidae	*Zonantes*	*fasciatus*	A,P	F,LP	Foliage/Flowers	7
	Aderidae	*Emelinus*	*melsheimeri*	A	F	Foliage/Flowers	2
	Aderidae	*Zonantes*	*subfasciatus*	A	D	Foliage/Flowers	3
	Alleculidae	*Hymenorus*	*obscurus*	P	F	Flower	1
	Alleculidae	*Hymenorus*	species 1	P	F	Flower	4
	Alleculidae	*Hymenorus*	species 2	A	F	Flower	1
	Alleculidae	*Mycetochara*	*binotata*	P	F	Flower	1
	Anobiidae	*Caenocara*	*oculata*	P	F	Wood/bark	2
	Anobiidae	*Euvrilletta*	*peltata*	P	F	Under Bark	3
	Anobiidae	*Oligomerus*	*alterans*	A,P	D,F,HP	Wood/bark	6
	Anobiidae	*Petalium*	*bistriatus*	A	F,LP	Wood/bark	5
	Anobiidae	*Petalium*	*brevisetum*	P	F,HM,HP,LM,LP	Wood/bark	25
	Anobiidae	*Petalium*	species	A	F	Wood/bark	2
	Anobiidae	*Trichodesma*	*gibbosa*	A,P	F,LM	Wood/bark	2
	Anobiidae	*Tricorynus*	*punctatum*	A	HM	Wood/bark	1
	Anthicidae	*Notoxus*	*murinipennis*	P	D,F,HM,HP,LM,LP	Scavenger	174
	Anthribidae	*Euparius*	*marmoreus*	A	D	Foliage	1
	Anthribidae	*Ormiscus*	*saltator*	A,P	D,HP,LM	Foliage	3
	Bostrichidae	*Xylobiops*	*basilaris*	A	LP	Wood	2
	Buprestidae	*Buprestis*	*rufipes*	A	F	Wood	1
	Buprestidae	*Chrysobothris*	*femorata*	A	F	Wood	1

Appendix. (cont.). Insect species collected (n=727) from May 1999 to June 2000 at Knox Co., TN, andAnderson Co, TN.

Order	Family	Genus	Species	Site[a]	Sample Method[b]	Y.P. association[*]	No. Specimens
Coleoptera	Buprestidae	*Dicerca*	species	A	LP	Wood	1
	Buprestidae	*Haplanthaxia*	species	P	D	Wood	1
	Buprestidae	*Melanophila*	*aeneola*	A	F	Wood	1
	Cantharidae	*Cantharis*	*bilineatus*	A,P	D,HM,LM	Predator/Flower	24
	Cantharidae	*Cantharis*	*carolinus*	P	D	Predator/Flower	2
	Cantharidae	*Cantharis*	*dentiger*	P	D	Predator/Flower	2
	Cantharidae	*Cantharis*	*marginata*	A	D	Predator/Flower	17
	Cantharidae	*Cantharis*	*nigriceps*	A	D	Predator/Flower	1
	Cantharidae	*Cantharis*	*scitulus*	A	D	Predator/Flower	4
	Cantharidae	*Cantharis*	species 1	P	D,F	Predator/Flower	2
	Cantharidae	*Cantharis*	species 2	P	D	Predator/Flower	1
	Cantharidae	*Chauliognathus*	*marginatus*	A,P	D,F,HM,LM	Predator/Flower	26
	Cantharidae	*Podabrus*	*rugosulus*	P	D	Predator/Flower	9
	Cantharidae	*Silis*	*percomis*	P	D	Predator/Flower	2
	Carabidae	*Lebia*	*ornata*	P	F	Predator	1
	Carabidae	*Lebia*	species	A	F	Predator	8
	Cerambycidae	*Aegomorphus*	*modestus*	P	F	Wood	2
	Cerambycidae	*Anelaphus*	*villosus*	P	LP	Wood	1
	Cerambycidae	*Astylopsis*	*macula*	A	LM	Wood	1
	Cerambycidae	*Brachyleptura*	*circumdata*	P	D	Wood	1
	Cerambycidae	*Callimoxys*	*sanguinicollis*	P	D	Wood	1

Appendix. (cont.). Insect species collected (n=727) from May 1999 to June 2000 at Knox Co., TN, andAnderson Co, TN.

Order	Family	Genus	Species	Site[a]	Sample Method[b]	Y.P. association*	No. Specimens
Coleoptera	Cerambycidae	*Cyrtophorus*	*verrucosus*	A	LM,LP	Wood	6
	Cerambycidae	*Eburia*	*quadrigeminata*	A	HP,LP	Wood	4
	Cerambycidae	*Ecyrus*	*dasycerus*	A	LM	Wood	2
	Cerambycidae	*Eupogonius*	*tomentosus*	A	F	Wood	1
	Cerambycidae	*Heterachthes*	*pallidus*	A	LP	Wood	1
	Cerambycidae	*Hyperplatys*	*maculata*	A	F,HP	Wood	2
	Cerambycidae	*Judolia*	*cordifera*	A	HP	Wood	1
	Cerambycidae	*Leptosylus*	*asperatus*	P	F	Wood	1
	Cerambycidae	*Molorchus*	*bimaculatus*	P	D	Wood	1
	Cerambycidae	*Oncideres*	*cingulata*	A	F	Wood	1
	Cerambycidae	*Parandra*	*brunnea*	P	D	Wood	1
	Cerambycidae	*Pidonia*	*aurata*	A	LP	Wood	1
	Cerambycidae	*Stenocorus*	*cinnamopterus*	A	HM,LM	Wood	2
	Cerambycidae	*Strangalepta*	*abbreviata*	A	HP	Wood	1
	Cerambycidae	*Strangelepta*	*pubera*	A	LP	Wood	1
	Cerambycidae	*Stranglia*	*bicolor*	A	HP	Wood	1
	Cerambycidae	*Stranglia*	*luteicornis*	A,P	D,HP,LP	Wood	13
	Cerylonidae	*Cerylon*	*unicolor*	A	LP	Predator	1
	Chrysomelidae	*Altica*	species 1	A	HM,LM,LP	Foliage	3
	Chrysomelidae	*Altica*	species 2	A	F	Foliage	2
	Chrysomelidae	*Babia*	*quadriguttata*	A	D	Foliage	1

Appendix. (cont.). Insect species collected (n=727) from May 1999 to June 2000 at Knox Co., TN, andAnderson Co, TN.

Order	Family	Genus	Species	Site[a]	Sample Method[b]	Y.P. association[*]	No. Specimens
Coleoptera	Chrysomelidae	*Capraita*	*thyamoides*	P	F	Foliage	1
	Chrysomelidae	*Colaspis*	*brunnea*	P	F,HP	Foliage	3
	Chrysomelidae	*Cryptocephalus*	*guttulatus*	A	D	Foliage	1
	Chrysomelidae	*Cryptocephalus*	*mutabilis*	A	D	Foliage	2
	Chrysomelidae	*Cryptocephalus*	*tinctus*	A	F	Foliage	1
	Chrysomelidae	*Demotina*	*modestus*	A,P	D,F,HP,LM	Foliage	6
	Chrysomelidae	*Diabrotica*	*undecimpunctata*	P	F	Foliage	1
	Chrysomelidae	*Gibbobruchus*	*mimus*	P	D	Foliage/Flower	2
	Chrysomelidae	*Odontota*	*dorsalis*	P	F	Foliage	2
	Chrysomelidae	*Paria*	species 1	A	D	Foliage	1
	Chrysomelidae	*Paria*	species 2	A	HM,LM	Foliage	4
	Chrysomelidae	*Stenispa*	*metallica*	P	F	Foliage	1
	Chrysomelidae	*Systena*	*marginalis*	A	D	Foliage	1
	Chrysomelidae	*Tymnes*	*metasternalis*	A,P	D,F,HM,HP,LM,LP	Foliage	74
	Chrysomelidae	*Tymnes*	*tricolor*	P	D,F	Foliage	6
	Chrysomelidae	Unknown	species 1	A	D	Unknown	1
	Chrysomelidae	Unknown	species 2	A	D	Unknown	1
	Chrysomelidae	Unknown	species 3	A	F	Unknown	1
	Chrysomelidae	Unknown	species 4	A	LM	Unknown	1
	Chrysomelidae	Unknown	species 5	P	D	Unknown	1
	Chrysomelidae	Unknown	species 6	P	D	Unknown	1

Appendix. (cont.). Insect species collected (n=727) from May 1999 to June 2000 at Knox Co., TN, andAnderson Co, TN.

Order	Family	Genus	Species	Site[a]	Sample Method[b]	Y.P. association[c]	No. Specimens
Coleoptera	Chrysomelidae	Unknown	species 7	A	D	Unknown	2
	Chrysomelidae	Unknown	species 8	P	D	Unknown	1
	Chrysomelidae	Unknown	species 9	A	LP	Unknown	1
	Chrysomelidae	Unknown	species 10	A	D	Unknown	1
	Chrysomelidae	Unknown	species 11	P	F	Unknown	2
	Chrysomelidae	Unknown	species 12	P	F	Unknown	1
	Chrysomelidae	Unknown	species 13	A	HP	Unknown	1
	Cleridae	*Cymatodera*	*bicolor*	A	F	Predator	1
	Cleridae	*Cymatodera*	*inornata*	A	HM,HP,LM	Predator	3
	Cleridae	*Cymatodera*	*undulata*	A,P	F,HM,HP,LM,LP	Predator	38
	Cleridae	*Enoclerus*	*nigripes*	P	HP	Predator	1
	Cleridae	*Phyllobaenus*	*humeralis*	A	D,F,HM,HP	Predator	8
	Cleridae	*Phyllobaenus*	*pallipennis*	A	D,F,HM	Predator	12
	Cleridae	*Phyllobaenus*	*verticalis*	A	F	Predator	1
	Cleridae	*Placopterus*	*thoracicus*	A,P	D,HM,LM	Predator	4
	Coccinellidae	*Brachiacantha*	*felina*	P	F	Predator	2
	Coccinellidae	*Brachiacantha*	*ursina*	P	F	Predator	1
	Coccinellidae	*Cephaloscymnus*	*zimmermani*	P	F	Predator	1
	Coccinellidae	*Chilocorus*	*stigma*	A,P	D,F,HM,LM	Predator	29
	Coccinellidae	*Coccinella*	*septempunctata*	A,P	D	Predator	16
	Coccinellidae	*Cycloneda*	*munda*	A	D	Predator	3

Appendix. (cont.). Insect species collected (n=727) from May 1999 to June 2000 at Knox Co., TN, andAnderson Co, TN.

Order	Family	Genus	Species	Site[a]	Sample Method[b]	Y.P. association[c]	No. Specimens
Coleoptera	Coccinellidae	*Didion*	*punctatum*	A,P	F,HP	Predator	2
	Coccinellidae	*Diomus*	*myrmidon*	P	F,HP	Predator	3
	Coccinellidae	*Diomus*	*terminatus*	P	LM	Predator	1
	Coccinellidae	*Harmonia*	*axyridis*	A,P	D,F,HM,LM,LP	Predator	259
	Coccinellidae	*Hyperaspis*	*signata*	A,P	D,F	Predator	9
	Coccinellidae	*Mulsantina*	*picta*	A,P	HM	Predator	2
	Coccinellidae	*Psyllobora*	*vigintimaculata*	A,P	D,F,HM,HP,LM,LP	Mold	26
	Coccinellidae	*Scymnus*	*americanus*	P	F	Predator	2
	Coccinellidae	*Scymnus*	*loewii*	A,P	D,LM	Predator	2
	Coccinellidae	*Scymnus*	*securus*	A,P	F,LP	Predator	2
	Coccinellidae	*Scymnus*	species	P	F	Predator	1
	Coccinellidae	*Stethorus*	*punctum*	P	D,F,LM	Predator	24
	Coccinellidae	*Zilus*	*horni*	A,P	D,F,LM	Predator	27
	Colydiidae	*Namunaria*	*guttulata*	P	F	Bark/Fungus	1
	Corylophidae	*Corylophodes*	*marginicollis*	A,P	F,HP,LP	Mold	6
	Cucujidae	*Ahasverus*	*advena*	P	F	Grains	1
	Cucujidae	*Catogenus*	*rufus*	A	HM,HP	Parasite	2
	Cucujidae	*Inopeplus*	*immunda*	P	F	Bark	2
	Cucujidae	*Oryzaephilus*	*mercater*	A	LP	Unknown	1
	Cupedidae	*Cupes*	*concolor*	A	HP	Wood	1
	Curculionidae	*Apion*	species	A	D	Foliage	2

Appendix. (cont.). Insect species collected (n=727) from May 1999 to June 2000 at Knox Co., TN, andAnderson Co, TN.

Order	Family	Genus	Species	Site[a]	Sample Method[b]	Y.P. association[c]	No. Specimens
Coleoptera	Curculionidae	*Apteromechus*	*ferratus*	A	LP	Foliage	1
	Curculionidae	*Attelabus*	*nigripes*	A	D	Foliage	1
	Curculionidae	*Conotrachelus*	*anaglypticus*	A,P	F,LM	Bark	2
	Curculionidae	*Conotrachelus*	*posticatus*	A	F	Unknown	1
	Curculionidae	*Conotrachelus*	species	A	LM,LP	Unknown	2
	Curculionidae	*Cossonus*	*impressifrons*	A	HP	Bark	1
	Curculionidae	*Cyrtepistomis*	*castaneus*	A,P	D,F,HP,LP	Foliage	24
	Curculionidae	*Himatium*	*errans*	A,P	F,LP	Bark	33
	Curculionidae	*Lechriops*	*oculata*	A,P	D,LM,LP	Foliage	10
	Curculionidae	*Myrmex*	*myrmex*	P	F	Hardwoods	1
	Curculionidae	*Naupactus*	*leucoloma*	A,P	F	Foliage	10
	Curculionidae	*Odontopus*	*calceatus*	A,P	D,HP	Foliage	8
	Curculionidae	*Pachylobius*	*picivorus*	A	LM	Bark/roots conifers	1
	Curculionidae	*Pandeleteius*	*hilaris*	A	F	Foliage	1
	Curculionidae	*Pantomorus*	*cervinus*	P	F	Foliage	1
	Curculionidae	*Pentarthrinus*	*parvicollis*	A	F	Foliage	1
	Curculionidae	*Piazorhinus*	*pictus*	A	F	Foliage	1
	Curculionidae	*Piazorhinus*	*scutellaris*	P	D	Unknown	1
	Curculionidae	*Pselaphorhynchites*	*aeratus*	A	F	Unknown	1
	Curculionidae	*Pseudopentarthrum*	*simplex*	P	F	Foliage	11
	Curculionidae	*Rhynchaenus*	*pallicornis*	A	F	Foliage	2

Appendix. (cont.). Insect species collected (n=727) from May 1999 to June 2000 at Knox Co., TN, andAnderson Co, TN.

Order	Family	Genus	Species	Site[a]	Sample Method[b]	Y.P. association[c]	No. Specimens
Coleoptera	Curculionidae	*Sitona*	*lepidus*	P	F	Foliage	1
	Curculionidae	*Sitophilus*	*oryzae*	P	F	Unknown	1
	Curculionidae	*Stenoscelis*	*brevis*	A	LP	Wood/Bark	1
	Curculionidae	Unknown	species 1	A	HM	Unknown	1
	Curculionidae	Unknown	species 2	A	LP	Unknown	1
	Curculionidae	Unknown	species 3	A	LM	Unknown	1
	Curculionidae	Unknown	species 4	A	LM	Unknown	1
	Curculionidae	Unknown	species 5	A	LP	Unknown	1
	Curculionidae	Unknown	species 6	A	LP	Unknown	1
	Curculionidae	Unknown	species 7	A	HP	Unknown	1
	Curculionidae	Unknown	species 8	A	HP	Unknown	1
	Curculionidae	Unknown	species 9	A	HP	Unknown	1
	Curculionidae	Unknown	species 10	A	HM	Unknown	1
	Curculionidae	*Curculio*	*sulcatulus*	A	HP	Unknown	2
	Dascillidae	*Eurypogon*	*niger*	A	D	Foliage	1
	Dermestidae	*Cryptorhopalum*	*haemorrhoidale*	A,P	D,F,HP,LM,LP	Flower	23
	Dermestidae	*Cryptorhopalum*	*triste*	A,P	D,HP,LM,LP	Flower	22
	Elateridae	*Aeolus*	*mellillus*	P	F	Foliage	1
	Elateridae	*Agriotes*	*oblongicollis*	A	LP	Foliage	1
	Elateridae	*Alaus*	*occulatus*	A	HP	Foliage	1
	Elateridae	*Ampedus*	*impolitus*	A	LP	Foliage	1

Appendix. (cont.). Insect species collected (n=727) from May 1999 to June 2000 at Knox Co., TN, andAnderson Co, TN.

Order	Family	Genus	Species	Site[a]	Sample Method[b]	Y.P. association[c]	No. Specimens
Coleoptera	Elateridae	*Ampedus*	*luteolus*	P	LP	Foliage	1
	Elateridae	*Ampedus*	*melantoides*	A,P	D,F,HM,HP,LM,LP	Foliage	70
	Elateridae	*Ampedus*	*verticinus*	A	LP	Foliage	1
	Elateridae	*Conoderus*	*lividus*	P	F	Foliage	1
	Elateridae	*Ctenicera*	*insidiosa*	A	LP	Foliage	1
	Elateridae	*Limonius*	*auripilis*	A,P	D,HP,LP	Foliage	10
	Elateridae	*Limonius*	*basillaris*	A	F	Foliage	1
	Elateridae	*Limonius*	*griseus*	P	D	Foliage	2
	Elateridae	*Limonius*	*nimbatus*	A	F	Foliage	1
	Elateridae	*Limonius*	*quercinus*	A	F	Foliage	2
	Elateridae	*Melanotus*	*americanus*	A	D,F,HP,LP	Foliage	15
	Elateridae	*Melanotus*	*communis*	A,P	D,F,LP	Foliage	6
	Elateridae	*Melanotus*	*cribiventris*	A	D	Foliage	1
	Elateridae	*Melanotus*	*morosus*	A,P	D,HP,LP	Foliage	6
	Elateridae	*Melanotus*	*similis*	A	D,HP,LM,LP	Foliage	164
	Elateridae	*Melanotus*	*verberans*	P	HP	Foliage	1
	Elateridae	*Orthostethus*	*infuscatus*	A	HP,LP	Foliage	6
	Eucnemide	*Deltometopus*	*amoenicornis*	P	LP	Wood	1
	Eucnemidae	*Drhagofarsus*	*lewisi*	A	LP	Wood	1
	Eucnemidae	*Dromaeolus*	*badius*	A	F	Wood	1
	Eucnemidae	*Dromaeolus*	*pusillus*	A	LM,LP	Wood	2

Appendix. (cont.). Insect species collected (n=727) from May 1999 to June 2000 at Knox Co., TN, andAnderson Co, TN.

Order	Family	Genus	Species	Site[a]	Sample Method[b]	Y.P. association[c]	No. Specimens
Coleoptera	Eucnemidae	*Entomophthalus*	*Rufiolus*	A	LP	Wood	1
	Eucnemidae	*Isorhipis*	*obliqua*	A	LP	Wood	5
	Eucnemidae	*Isorhipis*	*obliqua*	A	LP	Wood	2
	Eucnemidae	*Nematodes*	*penetrans*	A	LP	Wood	4
	Eucnemidae	*Rhagomicrus*	*bonvoulari*	A	LM,LP	Wood	2
	Helodidae	*Scirtes*	*orbiculatus*	P	D,F,LP	Unknown	5
	Helodidae	*Elodes*	*pulchella*	A	D,LM	Unknown	3
	Histeridae	*Acritus*	species	P	LM,LP	Predator	4
	Histeridae	*Marginotus*	species	A	LP	Predator	1
	Histeridae	*Platylomalus*	*aequalis*	P	D	Predator	1
	Lagriidae	*Arthromacra*	*aenea*	A	F,HM,LM	Foliage	6
	Lagriidae	*Statira*	*gagatina*	P	F	Foliage	2
	Lampyridae	*Ellychnia*	*corrusca*	A	LM	Predator	1
	Lampyridae	*Photinus*	*marginellus*	A	F,LM	Predator	3
	Lampyridae	*Photuris*	*versicolor*	P	F	Predator	3
	Lampyridae	*Pyractomena*	*borealis*	A,P	D,HM,LM	Predator	19
	Lampyridae	*Pyropyga*	species	P	D	Predator	1
	Languridae	*Acropteroxys*	*gracilis*	A	HM	Foliage	1
	Lathridiidae	Unknown	species	A,P	D,F,HM,HP,LM,LP	Unknown	519
	Leiodidae	*Agathidium*	*exiguum*	A	LP	Mold/Fungus	1
	Leptoderidae	*Colon*	species	A	LM	Scavenger	1

Appendix. (cont.). Insect species collected (n=727) from May 1999 to June 2000 at Knox Co., TN, andAnderson Co, TN.

Order	Family	Genus	Species	Site[a]	Sample Method[b]	Y.P. association[c]	No. Specimens
Coleoptera	Lucanidae	*Lucanus*	*elephus*	A	HP	Wood	1
	Lycidae	*Caenia*	*dimidiata*	A	D,LM	Predator	2
	Lycidae	*Calopteron*	*reticulatum*	A	F,LP	Predator	2
	Lycidae	*Calopteron*	*terminale*	A	D	Predator	1
	Melandryidae	*Canifa*	*pallipes*	A,P	F	Bark/Fungi	5
	Melandryidae	*Dircaea*	*liturata*	A	F	Bark/Fungi	1
	Melandryidae	*Microtonus*	*sericans*	A,P	F	Bark/Fungi	2
	Melandryidae	*Orchesia*	*castanea*	P	F	Bark Borer	1
	Melandryidae	Unknown	species 1	P	F	Bark/Fungi	1
	Melandryidae	Unknown	species 2	P	F	Bark/Fungi	2
	Melandryidae	Unknown	species 3	P	F	Bark/Fungi	1
	Meloidae	*Epicauta*	*pestifera*	P	D	Foliage	1
	Melyridae	*Attlalus*	*scincetus*	P	D	Predator	3
	Melyridae	*Melyrodes*	*cribrata*	A	D,F	Predator	2
	Mordellidae	*Mordellistena*	*ambusta*	A,P	HP,LP	Foliage	3
	Mordellidae	*Mordellistena*	*atrata*	A	HP	Foliage	2
	Mordellidae	*Mordellistena*	*hebraica*	P	D,LP	Foliage	3
	Mordellidae	*Mordellistena*	*imaptiens*	A	LM	Foliage	1
	Mordellidae	*Mordellistena*	*limbalis*	A	LP	Foliage	1
	Mordellidae	*Mordellistena*	*liturata*	A	HP,LP	Foliage	2
	Mordellidae	*Mordellistena*	*masoni*	A,P	F,LP	Foliage	5

Appendix. (cont.). Insect species collected (n=727) from May 1999 to June 2000 at Knox Co., TN, andAnderson Co, TN.

Order	Family	Genus	Species	Site[a]	Sample Method[b]	Y.P. association[c]	No. Specimens
Coleoptera	Mordellidae	*Mordellistena*	*ornata*	A,P	HP,LP	Foliage	4
	Mordellidae	*Mordellistena*	*pubescens*	P	D,LM	Foliage	3
	Mordellidae	*Mordellistena*	*syntaenia*	A	HP,LP	Foliage	9
	Mordellidae	*Mordellistena*	*trifasciatus*	P	D	Foliage	6
	Mordellidae	*Mordellistena*	*trifasiata*	A,P	D,F,LM	Foliage	23
	Mordellidae	*Tomoxia*	*fascifera*	A	HM	Foliage	1
	Mordellidae	*Tomoxia*	*lineella*	P	D	Foliage	1
	Mordellidae	*Tomoxia*	*serval*	A	HP	Foliage	1
	Mordellidae	*Tomoxia*	*trifasciatus*	P	D	Foliage	5
	Mordellidae	*Tomoxia*	*triloba*	P	D,F,LM	Foliage	10
	Mordellidae	*Tomoxia*	*undulata*	P	F	Foliage	2
	Mycetophagidae	*Litargus*	*nebulosus*	A	LP	Fungus	1
	Mycetophagidae	*Litargus*	*tetraspilotus*	A,P	D,F,HM,HP,LM,LP	Fungus	22
	Nitidulidae	*Amphicrossus*	*ciliatus*	A,P	HP,LP	Tree Sap	1
	Nitidulidae	*Carpophilus*	*sayi*	A	LP	Tree Sap	1
	Nitidulidae	*Carpophilus*	species	P	LP	Tree Sap	2
	Nitidulidae	*Colopterus*	*maculatus*	P	LP	Tree Sap	2
	Nitidulidae	*Colopterus*	*truncatas*	A,P	HP,LP	Tree Sap	8
	Nitidulidae	*Cryptarcha*	*ampla*	A	HP	Tree Sap	1
	Nitidulidae	*Cryptarcha*	*concinna*	A,P	HP,LP	Tree Sap	15
	Nitidulidae	*Cryptarcha*	*strigatula*	A	HP,LM,LP	Tree Sap	10

Appendix. (cont.). Insect species collected (n=727) from May 1999 to June 2000 at Knox Co., TN, andAnderson Co, TN.

Order	Family	Genus	Species	Site[a]	Sample Method[b]	Y.P. association[c]	No. Specimens
Coleoptera	Nitidulidae	*Glischrochilus*	*fasciatus*	A	LP	Tree Sap	1
	Nitidulidae	*Glischrochilus*	*obtusus*	A,P	LP	Tree Sap	2
	Nitidulidae	*Glischrochilus*	*sanguinolentus*	A	HP	Tree Sap	1
	Nosodendridae	*Nosodendron*	*unicolor*	P	F	Tree Sap	1
	Pedilidae	*Pedilus*	*terminalis*	P	D	Flowers/Foliage	3
	Perothopidae	*Perothops*	*mucida*	A	LP	Foliage	1
	Ptilodactylidae	*Ptilodactyla*	species	P	LP	Foliage	1
	Pyrochroidae	*Dendroides*	*canadensis*	A	HP	Predator	1
	Rhizophagidae	*Europs*	*pallipennis*	A,P	D,HM,HP,LM,LP	Bark	41
	Scarabaeidae	*Cloeotus*	*globosus*	A	F,HP	Unknown	2
	Scarabaeidae	*Euphoria*	*fulgida*	A	HP,LP	Foliage	3
	Scarabaeidae	*Euphoria*	*inda*	P	LP	Foliage	1
	Scarabaeidae	*Gnorimella*	*maculosa*	A	LP	Unknown	1
	Scarabaeidae	*Osmodera*	*eremicola*	A	LP	Wood	1
	Scarabaeidae	*Papillia*	*japonica*	A,P	LP,D	Foliage	5
	Scarabaeidae	*Pelidnota*	*punctata*	A	LP	Foliage	1
	Scarabaeidae	*Phileurus*	*castaneus*	A	HP	Wood	1
	Scarabaeidae	*Phyllophaga*	*vilifrons*	A	LP	Foliage	1
	Scarabaeidae	*Phylophaga*	species	A	LP	Foliage	1
	Scolytidae	*Chramesus*	*hicoriae*	A	HP	Wood	1
	Scolytidae	*Hypothenemus*	species	P	D	Wood	7

Appendix. (cont.). Insect species collected (n=727) from May 1999 to June 2000 at Knox Co., TN, andAnderson Co, TN.

Order	Family	Genus	Species	Site[a]	Sample Method[b]	Y.P. association[c]	No. Specimens
Coleoptera	Scolytidae	*Xyleborinus*	*Saxeseni*	A,P	HP,LP	Wood	20
	Scolytidae	*Xylosandrus*	*crassiusculus*	A,P	HP,LP	Wood	2
	Scolytidae	*Xylosandrus*	*germanus*	A	LP	Wood	2
	Silphidae	*Nicrophorus*	*pustulatus*	A	LP	Saprophage	3
	Staphylinidae	Unknown	species 1	A	F	Predator	4
	Staphylinidae	Unknown	species 2	A,P	HP,LP	Predator	5
	Staphylinidae	Unknown	species 3	P	LP	Predator	2
	Staphylinidae	Unknown	species 4	A	F	Predator	2
	Staphylinidae	Unknown	species 5	A	LP	Predator	2
	Staphylinidae	Unknown	species 6	A	LP	Predator	2
	Staphylinidae	Unknown	species 7	A	LP	Predator	1
	Staphylinidae	Unknown	species 8	A	F	Predator	1
	Staphylinidae	Unknown	species 9	A	LP	Predator	1
	Staphylinidae	Unknown	species 10	A	LP	Predator	1
	Tenebrionidae	*Alobates*	*pennsylvanica*	P	D	Predator	1
	Tenebrionidae	*Meracantha*	*contracta*	A	F	Bark	3
	Tenebrionidae	*Paratenetus*	*punctatus*	A	D,F,HM	Unknown	3
	Tenebrionidae	*Platydema*	*excavatum*	P	F	Bark	12
	Tenebrionidae	*Platydema*	*nigratum*	P	F	Bark	1
	Tenebrionidae	*Platydema*	*picilabrum*	A	F	Bark	1
	Tenebrionidae	*Strongylium*	*terminatum*	P	F	Bark	1

Appendix. (cont.). Insect species collected (n=727) from May 1999 to June 2000 at Knox Co., TN, andAnderson Co, TN.

Order	Family	Genus	Species	Site[a]	Sample Method[b]	Y.P. association[c]	No. Specimens
Coleoptera	Tenebrionidae	*Tarpela*	*Micans*	A	F,LM,LP	Bark	3
	Tenebrionidae	*Tarpela*	*undulata*	A	F	Bark	1
	Tenebrionidae	*Xylopinus*	*aenescens*	P	LP	Bark	1
	Throscidae	*Aulonothroscus*	*convergens*	A	HP,LM,LP	Predator	5
	Trogossitidae	*Tenebroides*	*bimaculatus*	A	HM	Predator	1
	Trogossitidae	*Tenebroides*	*corticalis*	P	D	Predator	1
	Trogossitidae	*Thymalus*	*marginicollis*	A,P	LP	Predator	2
Diptera	Anthomyiidae	*Anthomyia*	species	A	LP	Unknown	1
	Anthomyiidae	*Hydrophoria*	species	A	LP	Unknown	1
	Anthomyiidae	*Paraprosalpia*	species	A	LP	Unknown	1
	Asilidae	*Atomosia*	species	P	F	Predator	1
	Asilidae	*Cerotania*	*albipilosa*	A	D,F	Predator	2
	Asilidae	*Efferia*	species 1	A,P	HP,LM	Predator	2
	Asilidae	*Efferia*	species 2	A,P	F,HP,LP	Predator	6
	Asilidae	*Laphria*	species	A	D,LM	Predator	2
	Asilidae	*Neoitamus*	species	A	LM,LP	Predator	2
	Aulacigastridae	*Aulacigaster*	*leucopeza*	A	D,LP	Tree Sap	7
	Calliphoridae	*Pollenia*	*rudis*	P	HP	Flower	2
	Calliphoridae	*Phainicia*	species	A	D,LP	Flower	2
	Calliphoridae	*Pollenia*	species	P	F	Flower	1
	Chloropidae	*Rhopalopterum*	species	A	LP	Unknown	1

Appendix. (cont.). Insect species collected (n=727) from May 1999 to June 2000 at Knox Co., TN, andAnderson Co, TN.

Order	Family	Genus	Species	Site[a]	Sample Method[b]	Y.P. association[c]	No. Specimens
Diptera	Chloropidae	*Chlorops*	species 1	A,P	HM,LP	Unknown	6
	Chloropidae	*Chlorops*	species 2	A	LP	Unknown	1
	Chloropidae	*Incertella*	species	P	HM	Unknown	1
	Chloropidae	*Neoscinella*	species	P	LM	Unknown	2
	Conopidae	*Physocephala*	species	A	HM	Parasite	1
	Conopidae	*Zodion*	species	A	LM	Parasite	3
	Dolichopodidae	*Medetera*	species	A	LM	Predator	5
	Dolichopodidae	*Chrysotus*	species	P	D,F,HM,LM	Predator	10
	Dolichopodidae	*Condylostylus*	species 1	P	D,F,LM	Predator	9
	Dolichopodidae	*Condylostylus*	species 2	A,P	D,HM,LM	Predator	13
	Drosophilidae	*Amiota*	species	A	HP,LP	Unknown	3
	Drosophilidae	*Cladochaeta*	species	A	LP	Unknown	2
	Drosophilidae	*Drosophila*	*athabasca*	A	HP	Unknown	5
	Drosophilidae	*Drosophila*	*funebris*	A	LP	Unknown	1
	Drosophilidae	*Drosophila*	species 1	A,P	D,HP,LP	Unknown	14
	Drosophilidae	*Drosophila*	species 2	A	LM,LP	Unknown	5
	Drosophilidae	*Drosophila*	species 3	P	LP	Unknown	1
	Drosophilidae	*Leucophenga*	*maculata*	A	LP	Unknown	2
	Drosophilidae	*Microdrosophila*	*quadrata*	A	LM	Unknown	2
	Drosophilidae	*Scaptomyza*	species 1	A	LM	Unknown	2
	Drosophilidae	*Scaptomyza*	species 2	P	HM	Unknown	1

Appendix. (cont.). Insect species collected (n=727) from May 1999 to June 2000 at Knox Co., TN, andAnderson Co, TN.

Order	Family	Genus	Species	Site[a]	Sample Method[b]	Y.P. association[c]	No. Specimens
Diptera	Empididae	*Oedalea*	*astylata*	A	LP	Predator	5
	Empididae	*Oedalea*	species	A	HP,LP	Predator	37
	Ephydridae	*Hyadina*	species	P	F	Unknown	7
	Lauxaniidae	*Homoneura*	species	A	D,HM,HP	Unknown	5
	Lauxaniidae	*Melanomyza*	species 1	A	D,HP	Unknown	5
	Lauxaniidae	*Melanomyza*	species 2	A	LP	Unknown	5
	Lauxanidae	*Minetta*	species	A,P	D,F,HM,HP,LM,LP	Unknown	91
	Lauxaniidae	*Neogriphoneura*	*sordida*	A	HP,LP	Unknown	3
	Lauxaniidae	*Poecilominettia*	species	A	LM	Unknown	6
	Lonchaeidae	*Lonchaea*	species 1	A	LP	Unknown	4
	Lonchaeidae	*Lonchaea*	species 2	A	LP	Unknown	3
	Lonchaeidae	*Lonchaea*	species 3	P	F	Unknown	1
	Lonchaeidae	*Lonchaea*	species 4	A	LP	Unknown	1
	Lonchaeidae	*Lonchaea*	species 5	P	D	Unknown	2
	Muscidae	*Hydrotaea*	species	A	LM	Unknown	1
	Muscidae	*Phaonia*	species	A	HP,LP	Unknown	5
	Muscidae	*Thycops*	species	A	LP	Unknown	4
	Mycetophilidae	*Brevicornu*	species	A	LP	Fungus	1
	Mycetophilidae	*Mycetophila*	species 1	A	LP	Fungus	1
	Mycetophilidae	*Mycetophila*	species 2	A	LP	Fungus	1
	Mycetophilidae	*Mycetophila*	species 3	A	LP	Fungus	1

Appendix. (cont.). Insect species collected (n=727) from May 1999 to June 2000 at Knox Co., TN, andAnderson Co, TN.

Order	Family	Genus	Species	Site[a]	Sample Method[b]	Y.P. association[c]	No. Specimens
Diptera	Mycetophilidae	*Mycetophila*	species 4	A	LP	Fungus	1
	Mycetophilidae	*Syntemna*	species	A	LM	Fungus	1
	Mycetophilidae	*Trichonta*	species	A	LP	Fungus	1
	Mycetophilidae	*Zygomia*	species	A	LP	Fungus	1
	Odiniidae	*Odinia*	*picta*	A	LM	Unknown	2
	Otitidae	*Delphinia*	*picta*	P	D,F	Unknown	3
	Otitidae	*Pseudotephritis*	*approximata*	A	LP	Unknown	5
	Otitidae	*Pseudotephritis*	species 1	A	HP,LP	Unknown	117
	Otitidae	*Pseudotephritis*	species 2	A	LP	Unknown	1
	Otitidae	*Seioptera*	species	A	LP	Unknown	26
	Otitidae	*Tritoxa*	*flexa*	P	D,F	Unknown	3
	Otitidae	*Tritoxa*	species	P	D,F	Unknown	6
	Otitidae	*Zacompsia*	*fulva*	P	F	Unknown	1
	Phoridae	*Dohriniphora*	species 1	A,P	LM,LP	Unknown	20
	Phoridae	*Dohrniphora*	species 2	A	LM,LP	Unknown	55
	Phoridae	*Phora*	species	P	F	Unknown	1
	Pipinculidae	*Pipunculus*	species	A	LM	Parasite	1
	Platystomatidae	*Rivellia*	species	A,P	LM,LP	Unknown	2
	Richardiidae	*Odontomera*	species	P	D,HM	Unknown	5
	Sarcophagidae	*Boettcharia*	species 1	P	HM	Unknown	1
	Sarcophagidae	*Boettcheria*	species 2	P	HP	Unknown	1

Appendix. (cont.). Insect species collected (n=727) from May 1999 to June 2000 at Knox Co., TN, andAnderson Co, TN.

Order	Family	Genus	Species	Site[a]	Sample Method[b]	Y.P. association[c]	No. Specimens
Diptera	Sarcophagidae	*Fletcherimyia*	species	A	LP	Unknown	1
	Sarcophagidae	*Ravinia*	species	A	D,HP	Unknown	3
	Sarcophagidae	*Sarcodexia*	species 1	P	F	Unknown	1
	Sarcophagidae	*Sarcodexia*	species 2	A	LP	Unknown	1
	Sarcophagidae	*Servaisia*	species	P	F,HP	Unknown	2
	Sciaridae	*Bradysia*	species	A	F	Unknown	3
	Stratiomyidae	*Actina*	*viridis*	A	HM,LM	Unknown	2
	Stratiomyidae	*Allognosta*	species	P	HM	Unknown	1
	Stratiomyidae	*Microchrysa*	*polita*	P	LP	Unknown	1
	Stratiomyidae	*Neopachygaster*	species	P	F	Unknown	2
	Stratiomyidae	Unknown	species	P	LP	Unknown	1
	Syrphidae	*Allograpta*	*obliqua*	P	D	Flower/Predator	1
	Syrphidae	*Blera*	*umbratilis*	A	LM	Flower	1
	Syrphidae	*Epistrophe*	*emarginata*	P	D	Flower/Predator	3
	Syrphidae	*Mallota*	*posticata*	A	LP	Flower	1
	Syrphidae	*Milesia*	*virginiensis*	A	HP	Flower	1
	Syrphidae	*Pterallastes*	*thoracius*	A	LP	Flower	1
	Syrphidae	*Toxomeris*	*geminatus*	A,P	HM,HP,LM	Flower	6
	Syrphidae	*Toxomerus*	species	A	LM	Flower	1
	Syrphidae	*Tricopsomyia*	species	P	HM	Flower	1
	Syrphidae	Unknown	species 1	P	D	Flower	1

Appendix. (cont.). Insect species collected (n=727) from May 1999 to June 2000 at Knox Co., TN, andAnderson Co, TN.

Order	Family	Genus	Species	Site[a]	Sample Method[b]	Y.P. association[c]	No. Specimens
Diptera	Syrphidae	Unknown	species 2	A	HM	Flower	1
	Tachinidae	*Buquetia*	*obscura*	A	LM	Parasite	1
	Tachinidae	*Paradidyma*	species	P	F	Parasite	1
	Tachinidae	*Siphosturmia*	species	P	F	Parasite	1
	Tachinidae	Unknown	species 1	P	HM	Parasite	1
	Tachinidae	Unknown	species 2	P	LM	Parasite	4
	Tachinidae	Unknown	species 3	A	HP	Parasite	1
	Tachinidae	Unknown	species 4	A	LP	Parasite	1
	Tachinidae	Unknown	species 5	P	LM	Parasite	3
	Tachinidae	Unknown	species 6	P	HM	Parasite	1
	Tachinidae	Unknown	species 7	P	HM	Parasite	1
	Tachinidae	Unknown	species 8	P	HM	Parasite	1
	Tachinidae	Unknown	species 9	A	LM	Parasite	1
	Tachinidae	Unknown	species 10	A	LM	Parasite	1
	Tachinidae	Unknown	species 11	A	LM	Parasite	1
	Tachinidae	Unknown	species 12	A	LM	Parasite	1
	Tachinidae	Unknown	species 13	P	LP	Parasite	5
	Tachinidae	Unknown	species 14	A	HP	Parasite	1
	Tachinidae	Unknown	species 15	A	LM	Parasite	1
	Tachinidae	Unknown	species 16	P	HM,LM	Parasite	3
	Tachinidae	Unknown	species 17	A	LM	Parasite	1

Appendix. (cont.). Insect species collected (n=727) from May 1999 to June 2000 at Knox Co., TN, andAnderson Co, TN.

Order	Family	Genus	Species	Site[a]	Sample Method[b]	Y.P. association[c]	No. Specimens
Diptera	Tachinidae	Unknown	species 18	A	HP	Parasite	1
	Tachinidae	Unknown	species 19	A	HM	Parasite	1
	Tachinidae	Unknown	species 20	P	HM	Parasite	2
Lepidoptera	Gracillariidae	*Phyllocnistis*	*liriodendronella*	P	D	Foliage	20
	Noctuidae	*Catocala*	*ilia*	A	HP,LP	Foliage	11
	Noctuidae	*Catocala*	species 1	A	HP	Foliage	1
	Noctuidae	*Catocala*	species 2	A	LM	Foliage	1
	Papillionidae	*Pterorourus*	*glaucus*	A	HP	Foliage	1
	Unknown	Unknown	species 1	A	HP	Foliage	5
	Unknown	Unknown	species 2	A	LM	Foliage	6
	Unknown	Unknown	species 3	A	HP,LM	Foliage	10
	Unknown	Unknown	species 4	A	LM,LP	Foliage	11
	Unknown	Unknown	species 5	A	HP	Foliage	3
	Unknown	Unknown	species 6	A	HM,LM	Foliage	2
	Unknown	Unknown	species 7	A	HP	Foliage	2
	Unknown	Unknown	species 8	A	HP	Foliage	2
	Unknown	Unknown	species 9	A	LP	Foliage	4
	Unknown	Unknown	species 10	A	HM	Foliage	1
	Unknown	Unknown	species 11	P	HM	Foliage	1
	Unknown	Unknown	species 12	A	HP,LP	Foliage	5
	Unknown	Unknown	species 13	A	LM	Foliage	5

Appendix. (cont.). Insect species collected (n=727) from May 1999 to June 2000 at Knox Co., TN, andAnderson Co, TN.

Order	Family	Genus	Species	Site[a]	Sample Method[b]	Y.P. association[c]	No. Specimens
Lepidoptera	Unknown	Unknown	species 14	A	LM	Foliage	2
	Unknown	Unknown	species 15	A	HP	Foliage	4
	Unknown	Unknown	species 16	A	HM,LM	Foliage	7
	Unknown	Unknown	species 17	A	LM	Foliage	2
	Unknown	Unknown	species 18	A	LM	Foliage	1
	Unknown	Unknown	species 19	A	LM	Foliage	1
	Unknown	Unknown	species 20	A	HM,LM	Foliage	6
	Unknown	Unknown	species 21	A	LM	Foliage	1
	Unknown	Unknown	species 22	A	LP	Foliage	1
	Unknown	Unknown	species 23	A	LM	Foliage	1
Hymenoptera	Andrenidae	*Andrena*	*fragilis*	P	D	Flower	2
	Andrenidae	*Andrena*	*gardineri*	P	F	Flower	1
	Andrenidae	*Andrena*	*imitatrix*	P	D	Flower	6
	Andrenidae	*Andrena*	*morrisonella*	P	D	Flower	2
	Andrenidae	*Andrena*	*nasonii*	P	D	Flower	7
	Andrenidae	*Andrena*	*personata*	P	D	Flower	2
	Andrenidae	*Andrena*	*pruni*	P	D	Flower	2
	Andrenidae	*Andrena*	*spiraeana*	P	D	Flower	1
	Andrenidae	*Andrena*	*vicina*	P	D	Flower	1
	Andrenidae	*Hellisodes*	*rustica*	P	LP	Flower	1
	Anthophoridae	*Xylocopa*	*virginica*	A,P	D,HM,LP	Flower	3

Appendix. (cont.). Insect species collected (n=727) from May 1999 to June 2000 at Knox Co., TN, andAnderson Co, TN.

Order	Family	Genus	Species	Site[a]	Sample Method[b]	Y.P. association[c]	No. Specimens
Hymenoptera	Aphelinidae	Unknown	species	P	F	Parasite	8
	Apidae	*Bombus*	*bimaculatus*	A	LP	Flower	1
	Apidae	*Bombus*	*impatiens*	A,P	F,HP,LM,LP	Flower	14
	Bethylidae	Unknown	species 1	P	LM	Parasite	1
	Bethylidae	Unknown	species 2	A	LP	Parasite	1
	Braconidae	Unknown	species 1	P	LM	Parasite	1
	Braconidae	Unknown	species 2	A	F,LM	Parasite	2
	Braconidae	Unknown	species 3	A	F,HP	Parasite	2
	Braconidae	Unknown	species 4	A	HP	Parasite	1
	Braconidae	Unknown	species 5	P	D,F	Parasite	4
	Braconidae	Unknown	species 6	A	LM	Parasite	1
	Braconidae	Unknown	species 7	A	HP	Parasite	1
	Braconidae	Unknown	species 8	A	F	Parasite	3
	Braconidae	Unknown	species 9	A	F	Parasite	1
	Braconidae	Unknown	species 10	A	F	Parasite	2
	Braconidae	Unknown	species 11	A,P	F	Parasite	2
	Braconidae	Unknown	species 12	P	LM	Parasite	4
	Braconidae	Unknown	species 13	P	F	Parasite	1
	Braconidae	Unknown	species 14	P	F	Parasite	1
	Braconidae	Unknown	species 15	P	F	Parasite	1
	Braconidae	Unknown	species 16	A	D	Parasite	1

Appendix. (cont.). Insect species collected (n=727) from May 1999 to June 2000 at Knox Co., TN, andAnderson Co, TN.

Order	Family	Genus	Species	Site[a]	Sample Method[b]	Y.P. association[c]	No. Specimens
Hymenoptera	Braconidae	Unknown	species 17	P	F	Parasite	1
	Braconidae	Unknown	species 18	P	F	Parasite	1
	Braconidae	Unknown	species 19	A	D	Parasite	1
	Braconidae	Unknown	species 20	A	D	Parasite	1
	Braconidae	Unknown	species 21	A	D	Parasite	1
	Braconidae	Unknown	species 22	P	F	Parasite	1
	Braconidae	Unknown	species 23	P	F	Parasite	1
	Braconidae	Unknown	species 24	A,P	F	Parasite	3
	Braconidae	Unknown	species 25	A	F	Parasite	1
	Braconidae	Unknown	species 26	A	F	Parasite	1
	Braconidae	Unknown	species 27	A	F	Parasite	7
	Braconidae	Unknown	species 28	A	F	Parasite	2
	Braconidae	Unknown	species 29	A	F	Parasite	1
	Braconidae	Unknown	species 30	A	F	Parasite	1
	Braconidae	Unknown	species 31	P	F	Parasite	1
	Braconidae	Unknown	species 32	P	F	Parasite	1
	Braconidae	Unknown	species 33	A	F	Parasite	1
	Braconidae	Unknown	species 34	A	F	Parasite	1
	Braconidae	Unknown	species 35	P	F	Parasite	1
	Braconidae	Unknown	species 36	A	F	Parasite	1
	Braconidae	Unknown	species 37	A	F	Parasite	1

Appendix. (cont.). Insect species collected (n=727) from May 1999 to June 2000 at Knox Co., TN, andAnderson Co, TN.

Order	Family	Genus	Species	Site[a]	Sample Method[b]	Y.P. association[c]	No. Specimens
Hymenoptera	Braconidae	Unknown	species 38	A	D	Parasite	1
	Braconidae	Unknown	species 39	A	D	Parasite	5
	Ceraphronidae	Unknown	species	A	LM	Parasite	1
	Chrysididae	Unknown	species	P	F	Parasite	1
	Colletidae	*Hylaeus*	*modestus*	A	LP	Flower	3
	Diapriidae	Unknown	species 1	A	D	Parasite	1
	Diapriidae	Unknown	species 2	A	LM	Parasite	1
	Diapriidae	Unknown	species 3	A	LM	Parasite	1
	Diapriidae	Unknown	species 4	A	D	Parasite	1
	Diapriidae	Unknown	species 5	A	HP	Parasite	1
	Eucoilidae	Unknown	species 1	P	HP	Parasite	1
	Eucoilidae	Unknown	species 2	P	LP	Parasite	1
	Eucoilidae	Unknown	species 3	A	F	Parasite	1
	Eupelmidae	Unknown	species 1	A	LM	Parasite	3
	Eupelmidae	Unknown	species 2	A,P	F,LM	Parasite	4
	Eupelmidae	Unknown	species 3	P	F,LM	Parasite	4
	Eupelmidae	Unknown	species 4	A	HP	Parasite	1
	Eupelmidae	Unknown	species 5	A	HP	Parasite	1
	Eupelmidae	Unknown	species 6	A	HM	Parasite	1
	Eupelmidae	Unknown	species 7	A	F	Parasite	1
	Eupelmidae	Unknown	species 8	A	F	Parasite	2

Appendix. (cont.). Insect species collected (n=727) from May 1999 to June 2000 at Knox Co., TN, andAnderson Co, TN.

Order	Family	Genus	Species	Site[a]	Sample Method[b]	Y.P. association[c]	No. Specimens
Hymenoptera	Figitidae	Unknown	species 1	P	F	Parasite	1
	Figitidae	Unknown	species 2	A,P	F,HM	Parasite	2
	Figitidae	Unknown	species 3	P	F	Parasite	1
	Formicidae	*Aphaenogaster*	*mariae*	A	F	Generalist	1
	Formicidae	*Aphenogaster*	*tennesseensis*	P	D	Generalist	8
	Formicidae	*Camponotus*	*americanus*	A,P	D,F,HM,HP,LM,LP	Generalist	217
	Formicidae	*Camponotus*	*nearcticus*	P	F	Generalist	14
	Formicidae	*Camponotus*	*pennsylvanicus*	A,P	D,F,HM,HP,LM,LP	Generalist	137
	Formicidae	*Camponotus*	species	A,P	D,F,HM,HP,LM,LP	Generalist	178
	Formicidae	*Crematogaster*	*ashmeadi*	A,P	D,F,LM	Generalist	95
	Formicidae	*Crematogaster*	*lineolata*	A	D	Generalist	6
	Formicidae	*Crematogaster*	*pilosa*	A,P	D	Generalist	9
	Formicidae	*Formica*	*fusca*	A,P	D,F,HM,HP,LM,LP	Generalist	93
	Formicidae	*Formica*	*pallidefulva*	A,P	D,F	Generalist	63
	Formicidae	*Lasius*	*niger*	P	D,F,HM,HP	Generalist	211
	Formicidae	*Leptothorax*	*curvispinosus*	A	F,HP	Generalist	2
	Formicidae	*Leptothorax*	*schaumi*	A,P	D,F,HM,LM,LP	Generalist	102
	Formicidae	*Monomorium*	*minimum*	A,P	F,LM	Generalist	92
	Formicidae	*Myrmecina*	*americana*	A	D	Generalist	1
	Formicidae	*Paratrechina*	*melanderi*	A	D,LM	Generalist	5
	Formicidae	*Prenolepsis*	*imparis*	A,P	D,HM,LM,LP	Generalist	11

Appendix. (cont.). Insect species collected (n=727) from May 1999 to June 2000 at Knox Co., TN, andAnderson Co, TN.

Order	Family	Genus	Species	Site[a]	Sample Method[b]	Y.P. association[c]	No. Specimens
Hymenoptera	Formicidae	*Tapinoma*	*sessile*	A,P	F,HM,LP	Generalist	196
	Halictidae	*Augochlora*	*pura*	A,P	D,HP,LM,LP	Flower	703
	Halictidae	*Augochlorella*	*striata*	P	D	Flower	2
	Halictidae	*Dialictus*	*admirandus*	A,P	D,LP	Flower	8
	Halictidae	*Dialictus*	*bruneri*	A,P	D,HP,LP	Flower	8
	Halictidae	*Dialictus*	*coeruleus*	A	LP	Flower	5
	Halictidae	*Dialictus*	*cressoni*	A	HP	Flower	6
	Halictidae	*Dialictus*	*heterognathus*	A	LP	Flower	1
	Halictidae	*Dialictus*	*illinoensis*	P	D	Flower	2
	Halictidae	*Dialictus*	*imitatus*	A	LP	Flower	10
	Halictidae	*Dialictus*	*laevissimus*	A	HP,LP	Flower	28
	Halictidae	*Dialictus*	*zephyrus*	P	D	Flower	5
	Halictidae	*Halictus*	*rubicundus*	A,P	HP,LP	Flower	3
	Halictidae	*Lasioglossum*	*coriaceum*	A	HP,LP	Flower	5
	Halictidae	*Lasioglossum*	*forbessi*	A	LP	Flower	1
	Halictidae	*Lasioglossum*	*fuscipenne*	A	HP	Flower	8
	Halictidae	*Sphecodes*	*aroniae*	P	D	Flower	1
	Ichneumonidae	Unknown	species 1	A	HP,LP	Parasite	3
	Ichneumonidae	Unknown	species 2	A	D	Parasite	1
	Icneumonidae	Unknown	species 3	A	LP	Parasite	1
	Ichneumonidae	Unknown	species 4	P	F	Parasite	1

Appendix. (cont.). Insect species collected (n=727) from May 1999 to June 2000 at Knox Co., TN, andAnderson Co, TN.

Order	Family	Genus	Species	Site[a]	Sample Method[b]	Y.P. association[c]	No. Specimens
Hymenoptera	Ichneumonidae	Unknown	species 5	P	F	Parasite	1
	Ichneumonidae	Unknown	species 6	A	D	Parasite	1
	Ichneumonidae	Unknown	species 7	P	F	Parasite	1
	Ichneumonidae	Unknown	species 8	P	HM	Parasite	1
	Ichneumonidae	Unknown	species 9	A	LM	Parasite	1
	Ichneumonidae	Unknown	species 10	A	HP	Parasite	1
	Ichneumonidae	Unknown	Species 11	A	LM	Parasite	1
	Ichneumonidae	Unknown	species 12	P	LM	Parasite	2
	Ichneumonidae	Unknown	species 13	P	LM	Parasite	1
	Ichneumonidae	Unknown	species 14	A	LM	Parasite	1
	Ichneumonidae	Unknown	species 15	P	HM	Parasite	1
	Ichneumonidae	Unknown	species 16	P	F	Parasite	1
	Ichneumonidae	Unknown	species 17	P	F	Parasite	1
	Ichneumonidae	Unknown	species 18	P	LM	Parasite	1
	Ichneumonidae	Unknown	species 19	A	LP	Parasite	1
	Ichneumonidae	Unknown	species 20	P	D	Parasite	1
	Ichneumonidae	Unknown	species 21	P	F	Parasite	1
	Ichneumonidae	Unknown	species 22	P	F	Parasite	3
	Ichneumonidae	Unknown	species 23	A	F	Parasite	1
	Ichneumonidae	Unknown	species 24	P	HM	Parasite	1
	Ichneumonidae	Unknown	species 25	A	LM	Parasite	1

Appendix. (cont.). Insect species collected (n=727) from May 1999 to June 2000 at Knox Co., TN, andAnderson Co, TN.

Order	Family	Genus	Species	Site[a]	Sample Method[b]	Y.P. association[c]	No. Specimens
Hymenoptera	Ichneumonidae	Unknown	species 26	P	HM,LM	Parasite	4
	Ichneumonidae	Unknown	species 27	P	HM	Parasite	1
	Ichneumonidae	Unknown	species 28	P	F,HM	Parasite	17
	Ichneumonidae	Unknown	species 29	A	LM	Parasite	1
	Ichneumonidae	Unknown	species 30	P	F	Parasite	1
	Megachilidae	*Osmia*	species	A	HP	Flower	1
	Megaspilidae	Unknown	species 1	P	LP	Parasite	1
	Megaspilidae	Unknown	species 2	P	F	Parasite	1
	Megaspilidae	Unknown	species 3	P	F	Parasite	1
	Pergidae	*Acordulecera*	species	A	HM,LM	Foliage	6
	Platygastridae	Unknown	species	A	LP	Parasite	1
	Pompilidae	Unknown	species 1	A	HM	Predator	1
	Pompilidae	Unknown	species 2	A,P	HM,HP,LP	Predator	6
	Pompilidae	Unknown	species 3	A	LM	Predator	1
	Pompilidae	Unknown	species 4	A	HM	Predator	1
	Pompilidae	Unknown	species 5	A	LM	Predator	1
	Pompilidae	Unknown	species 6	A	HP	Predator	1
	Pompilidae	Unknown	species 7	A	HP	Predator	1
	Pompilidae	Unknown	species 8	A	HP	Predator	1
	Pompilidae	Unknown	species 9	A	HM	Predator	1
	Pompilidae	Unknown	species 10	P	F	Predator	1

Appendix. (cont.). Insect species collected (n=727) from May 1999 to June 2000 at Knox Co., TN, andAnderson Co, TN.

Order	Family	Genus	Species	Site[a]	Sample Method[b]	Y.P. association[c]	No. Specimens
Hymenoptera	Pompilidae	Unknown	species 11	A	HP,LM,LP	Predator	6
	Pompilidae	Unknown	species 12	A,P	D,LM,LP	Predator	3
	Pteromalidae	Unknown	species	P	F	Parasite	1
	Rhopalosomatidae	*Rhopalosoma*	*nearcticum*	A	LM	Parasite	2
	Scelionidae	Unknown	species 1	A,P	D,HM,HP,LM,LP	Parasite	164
	Scelionidae	Unknown	species 2	A,P	HM,HP,LM,LP	Parasite	82
	Scelionidae	Unknown	species 3	A	LM	Parasite	2
	Scelionidae	Unknown	species 4	P	F	Parasite	1
	Scelionidae	Unknown	species 5	P	HM	Parasite	1
	Scelionidae	Unknown	species 6	P	F	Parasite	1
	Scelionidae	Unknown	species 7	P	LM	Parasite	1
	Scelionidae	Unknown	species 8	P	LM	Parasite	1
	Scelionidae	Unknown	species 9	A,P	HP,LP	Parasite	2
	Sphecidae	Rhopalum	species	P	F	Predator	1
	Sphecidae	Unknown	species 1	P	F	Predator	1
	Sphecidae	Unknown	species 2	P	F	Predator	1
	Sphecidae	Unknown	species 3	P	F	Predator	1
	Sphecidae	Unknown	species 4	P	F	Predator	1
	Sphecidae	Unknown	species 5	P	F	Predator	1
	Sphecidae	Unknown	Species 6	P	LM	Predator	1
	Sphecidae	Unknown	species 7	P	LM	Predator	1

Appendix. (cont.). Insect species collected (n=727) from May 1999 to June 2000 at Knox Co., TN, andAnderson Co, TN.

Order	Family	Genus	Species	Site[a]	Sample Method[b]	Y.P.[c] association	No. Specimens
Hymenoptera	Sphecidae	Unknown	species 8	P	HM	Predator	1
	Sphecidae	Unknown	species 9	A	HP	Predator	1
	Sphecidae	Unknown	species 10	A	LP	Predator	1
	Sphecidae	Unknown	species 11	P	F	Predator	1
	Tenthredinidae	Unknown	species	P	D	Foliage	1
	Tiphiidae	*Tiphia*	*vernalis*	P	D	Parasite	6
	Torymidae	Unknown	species 1	A	LM	Parasite	4
	Torymidae	Unknown	species 2	A	HP	Parasite	2
	Torymidae	Unknown	species 3	A	LM	Parasite	1
	Vespidae	*Polistes*	species	A,P	D,LM	Predator	2
	Vespidae	*Vespa*	*cabro*	A,P	D,HM,HP	Predator	3
	Vespidae	*Vespula*	*maculata*	A	HP	Predator	1
	Vespidae	*Vespula*	*maculifrons*	A	D,HM,HP,LM,LP	Predator	284

[a]Site- P=Plantation and A=Arboretum
[b]Sampling Method- HM=Higher Malaise, HP=Higher Pan, LM=Lower Malaise, LP=Lower Pan, F=Fog, D=Direct
[c]Y.P. association= Yellow-Poplar

VITA

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