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THE ANTS OF SOUTH CAROLINA

A Dissertation
Presented to
the Graduate School of
Clemson University

In Partial Fulfillment
of the Requirements for the Degree
Doctor of Philosophy
Entomology

by
Timothy S. Davis
May 2009

Accepted by:
Dr. Paul Mackey Horton, Committee Chair
Dr. Craig Allen, Co-Committee Chair
Dr. Eric Benson
Dr. Clyde Gorsuch

ABSTRACT

The ants of South Carolina were surveyed in the literature, museum, and field collections using pitfall traps. M. R. Smith was the last to survey ants in South Carolina on a statewide basis and published his list in 1934. VanPelt and Gentry conducted a survey of ants at the Savanna River Plant in the 1970's. This is the first update on the ants of South Carolina since that time.

A preliminary list of ants known to occur in South Carolina has been compiled. Ants were recently sampled on a statewide basis using pitfall traps. Two hundred and forty-three (243) transects were placed in 15 different habitat types. A total of 2673 pitfalls traps were examined, 41,414 individual ants were identified. Additionally this list is supplemented with confirmed literature identifications, museum specimens, and various hand and litter sifting collections. Hand collections and Winkler sifted litter samples near Clemson, SC yielded an additional 768 specimens. A total of 121 species from 38 genera are listed. County of record and habitats are given where known.

The data from these collections along with SC GAP Analysis data were used to map the distribution of the ants across landscape type and physiographic region. Distributions for a total of 65 species were modeled. A predicted species richness map was generated by adding the distribution maps using GIS software. Species richness ranged from zero to 41 species. Species lists by habitat affinities. These distribution models may be prove useful in predicting ant assemblages in defined landscapes which can be used in land management decisions.

DEDICATION

The Teacher sought to find delightful words,
and to write accurately truthful sayings.

The words of the sages are like prods,
and the collected sayings are like firmly fixed nails;
they are given by one shepherd.

Be warned, my son, of anything in addition to them.
There is no end to the making of many books,
and much study is exhausting to the body.

Having heard everything, I have reached this conclusion:
Fear God and keep his commandments,
because this is the whole duty of man.

For God will evaluate every deed,
including every secret thing, whether good or evil.

Ecclesiates 12: 10 -14

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Dr. Craig Allen – for the original idea to do a GAP Analysis layer for ants and for statistical, GIS, conceptual assistance along the way.

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Eric Paysen – for adding his collections to my list as well as scouring the museum for new records

Nichole Bennett, David Wagner, Will Medlin – working as an interns on the laboratory experiment for the bluebird baffle, and collection maintenance

Lex Glover – providing field data on predation of bluebirds in the Sandhill bluebird nestbox program

Student workers – who took on the ugliest job . . . separating the ants in from the pitfall traps

Dr. Henson – I didn't want to take entomology because I didn't want to have Dr. Henson. By the end of the course I had grown to love both entomology and Dr. Henson

Mr Plumb – the first teacher that didn't just let me just sit and daydream and saw how much I enjoyed science

Grampa, Mom and Dad

I must especially give my thanks and appreciation to those that have sacrificed the most . . . my family . . . Kim, William, and Zachary.

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CHAPTER ONE

INTRODUCTION

Rationale

This story begins some time ago. As a Clemson Extension Agent in Richland County the most frequent question that I received in the office was about how to control the Red Imported Fire Ant (RIFA). As a trained entomologist the public expected me to know everything about every insect. As it happened I knew very little about fire ants or the most appropriate controls for fire ants. In an effort to remedy the situation I began to work with an Extension Specialist from the Clemson University Department of Entomology – Dr. Mac Horton.

I had received a small grant to do a fire ant management demonstration. The concept was to lay out several similar in size to a typical subdivision lot at Clemson's Sandhill Research and Education Center and demonstrate several of the common management strategies available to home owners. I would document the RIFA population before and after the treatments. This was not meant to be research, but rather demonstrating for the public methods that had already been researched. This is the mission of the Extension system, to bring research based knowledge to the constituents of the system. One of the primary methods of this technology transfer system is to use demonstrations to physically show people how these methods work.

While setting up this demonstration I found several things that surprised me. First, while documenting the number of mounds for each plot I found several plots with nearly 300 mounds per acre. While I had read that this was common in places like Florida and Texas where polygyne colonies were prevalent, it was not something expected here in South Carolina. Did we have polygyne colonies in South Carolina? It turns out that we did and do have polygyne colonies in South Carolina. Polygynous colonies have been documented throughout the state (Kintz-Early et al. 2003). Prior to this time in 1996, however, they were not commonly observed or documented.

Second, I had thought I could lay the plots out in such a small area and all of the plots would have sufficient similar number of RIFA colonies for the demonstration. In reality while several of the plots had excessive amounts of RIFA as mentioned above, some of the plots had virtually no RIFA. Why was that? I noticed several possible factors. The plots with fewer RIFA were further up on a small hill. Did elevation play a role? I also noticed that the areas with few RIFA had larger numbers of native ants. Did native ants play a role?

This observation led to a whole series of questions. How might the native ant population impact the fire ant population? How do native ants interact with RIFA? What impacts do RIFA have on native ants? What impact do RIFA treatments have on native ant populations? For that matter what native ant species can be found in South Carolina?

As I contemplated these questions I noticed one species of native ant that had some ant carcasses incorporated into their mound. Were these RIFA carcasses? Who would win in that fight? I also noticed that these colonies were located fairly close to RIFA mounds. How did they survive the overwhelming numbers and aggressive nature of the RIFA? What species was this native ant that seemed able to co-exist with the RIFA so well?

A few days later Dr. Horton was at the Sandhill REC testing a then new chemistry for field efficacy on RIFA – fipronil. I was helping him assess the plots and make the applications. At lunch I began to describe the demonstration I was doing and ask the many questions that I had come across while setting the demonstration in the field.

What I discovered was that very little was known about any of the questions that had arisen. Polygyne colonies had not at the time been documented in South Carolina, but that didn't mean they weren't there; it only meant that nobody had looked for them. Three hundred mounds per acre wasn't deemed common, but we were finding this at the fipronil test site as well.

Others had observed low RIFA populations immediately adjacent to high RIFA populations. Nobody seemed to know why this might occur. What factors might make one place suitable for large numbers of colonies, but another 100 meters away might be devoid of RIFA – no answers.

Yes, we knew that some species co-existed with RIFA. Nobody could say how they were interacting. Some studies had been done to look at the impact of RIFA on native ant populations, but not the other way around (Porter and Savignano 1990, Morrison and Porter 2003). It seemed that very little had been done to see the impacts of RIFA treatments on native ants species as well.

For me the question of what species we had in South Carolina was defining. It seemed that nobody really knew that either. Ultimately this is the question that this dissertation hopes to address. What ant species are found in South Carolina and where can those species be found?

It seemed a simple question at first. Some surveys had been conducted in the state. The influential myrmecologist M. R. Smith whose name often appears in the literature even today was a student at what was then Clemson College in the late 1910's

(Smith 1916a, b, Smith and Morrison 1916, Smith 1918). He conducted a survey which was largely limited to locations around Clemson College. This list was published in 1918. This survey is believed to be the first of the ants of South Carolina.

Smith went on to publish a list of the ants of South Carolina in 1934 which was a compilation of the specimens that were sent to him for identification throughout his career (Smith 1934). The 1934 publication lists 98 species. There are two difficulties encountered with this paper First, the location of voucher specimens, if any, is not listed. Without vouchers specimens, species that have experience taxonomic splits are left in doubt as to which direction to take. This leaves less than half of the list as usable names.

The second difficulty is that the survey is not systematic – it only lists ants that were sent by a number of people for identification. Personal experience as a County Extension Agent suggests that many species would be missed. Only the species of economic importance or specimens that an especially curious person might have encountered would be included.

A second survey was conducted in the early 1970's for the Savannah River Plant (SRP) site by Van Pelt and Gentry (Van Pelt and Gentry 1985). This was a systematic survey using both hand collections and baited traps. The survey was partitioned by habitat over a total of 350 acres. The voucher specimens were deposited at the Savannah River Ecological Laboratory (SREL). The survey was published in an internal report and not in a peer reviewed journal. The greatest limitation of the report is that it is limited to the 350 acres survey limiting its use as a statewide or regional tool.

Allen et al (Allen et al. 1998c) lay out the case for the inclusion of ants in the GAP. Ants are easy to collect, relatively well known taxonomically, ecologically and taxonomically diverse, ecologically important, scale appropriate, perennial, habitat specific, and represented by diverse life histories.

The development of a GAP layer for ants would provide a method for answering my original questions, What ants do we have here in South Carolina and where are they found?

The overall goal of this dissertation is to use survey methods to determine what ants occur in South Carolina and to develop distribution models to predict where ant species may be found in South Carolina.

Objective 1: Develop a list of ant species known to occur in South Carolina.

Discussion: South Carolina has a great potential for myrmecological richness. There is a great diversity of habitats ranging from the Appalachian mountains to the coastal plains. Species that are typically more northern or boreal in distribution can be found at higher elevations in the southern Appalachians (Dennis 1938, Cole 1940, 1953, Carter 1962, Van Pelt 1963). Populations of these species located as far south as South Carolina usually exist as diminutive southern extensions of vast and continuous northern populations. There are a number of species that find their southern range in South Carolina including as *Formica argentea*, *Pachycondyla chinensis,* and *Tetramorium caespitum.* Additionally the sandhill and coastal regions of the state resemble more southern regions in both geology and species of ants. There are also a number of species which find their northern limits in South Carolina such as *Pogonomyrmex badius* and *Camponotus floridanus*. Additionally, eastern North America appears to have been an important secondary center of adaptive radiation since, with the exception of a number of neotropical and holarctic species, it has been described as a unique region of formicid endemism (Wheeler 1917, Cole 1940, Creighton 1950). Species of *Aphaenogaster*, *Formica*, *Leptothorax,* and *Myrmica* are examples that appear to have originated in the southeastern United States.

Despite the abundance and diversity of ants in this region very little myrmecological work has been done beyond applied work with the Red Imported Fire Ants *Solenopsis invicta*.

Methods: Fire ant sampling via baits and ant sampling via pitfalls was conducted by Leslie Parris throughout the state of South Carolina in 1999 and 2000 (Parris 2002). Ant sampling was stratified by physiographic region: Mountains, Piedmont, Sandhill and Coastal Plains (Figure 3.1). The sampling effort was further stratified by South Carolina Gap Analysis Program landcover types. Sixteen of the landcover types that were well represented were chosen for ant sampling (Table 1.1).

Table 1.1 South Carolina GAP Analysis Program's brief land cover descriptions for the sixteen land covers selected for statewide ant sampling in South Carolina, 1999 - 2000.

Land Cover Class	Description
Saltwater marsh	Estuaries, salt marshes, brackish marshes, tidal marshes, barrier islands
Freshwater marsh	Non-tidal streamside marshes, bogs, depression meadows, inland ponds
Bays and pocosins	Carolina bays, wetland depressions, wet evergreen
Swamps / bottomland	hardwood River flood plain hardwoods, swamps
Cleared forest	Mix of bare soil and pioneer grass species tree regeneration
Upland pine forest	Pine plantations with closed canopies, pine with oak understory
Pine woodland / longleaf pine savanna	Pine woodland, grass savanna with open canopy
Upland deciduous forest	Deciduous arboreal vegetation in dry soil
Mesic deciduous forest	Deciduous arboreal vegetation in moist soil
Upland mixed forest	Forest that are mixed with evergreen and deciduous, dry soil
Mesic mixed forest	Mixed forests of evergreen and hardwood in marginal bottomland floodplains
Grassland	Fallow fields, pastureland
Cultivated land	Agricultural land, lawns, golf courses
Maritime forest	Maritime evergreen, not bottomland floodplains
Beach Barrier islands	sand dunes, beaches
Urban development	Industrial development, residential development, city development

Approximately ten samples per landscape type per region were collected. The Mountain Region and the Piedmont Region were sampled in 1999. The Coastal Plain Region and the Sandhill Region were sampled in 2000. In all 364 locations were sampled; 11 pitfalls at each location; bringing the total number of pitfalls to approximately 4000.

The list includes species from the Clemson Arthropod Museum which contain many of the M. R. Smith identified specimens as well as more recently collected material. Also included are species from the Van Pelt and Gentry (1985) collection the Smith (1916a, 1916b, 1934), and the Smith and Morrison (1919) papers, where taxonomic changes have not obscured the original identification. Hand collected specimens from throughout the state have added many records to the list as well as a small scale survey of the Clemson University Experimental Forest (Pickens and Anderson counties) in a secondary growth pine stand. This small scale survey included both pitfall trapping and winkler litter sifting at three sites with 21 sampling stations.

The list is presented in alphabetical order rather than taxonomic classification for ease of use. Names presented generally follow those in "A New General Catalogue of the Ants of the World"(Bolton 1995), unless noted otherwise. Ants not collected in the 1999-2000 pitfall collection are noted in the list as well as the origin of the information. This collection will be deposited in the Clemson Arthropod Museum as voucher specimens.

Objective 2: Use GAP methods to develop distributions for ants collected in South Carolina

Discussion: In 1998, Allen et al. proposed two methods for spatial mapping of ant diversity. The first method used in Florida was literature based. Geographic distributions were determined at the county level using primarily published sources augmented by unpublished data and the experience of selected experts. Distributions in counties with limited information were interpolated from neighboring counties. The literature based information was used to produce an "ant by county" matrix and an "ant by habitat" matrix. The two matrices were used to produce habitat specific models of the ant distributions.

In South Carolina, however, there was very little literature based information that could be used to determine geographic distributions. Thus the collection information from this study was used to develop an "ant by county matrix" an "ant by habitat" matrix. The collection was further stratified by the physographic regions found in South Carolina. These three filters were used to develop distribution models for the ants collected in pitfalls throughout South Carolina.

Objective 3: Species Richness

Discussion: A species richness model was created using the pitfall collection data. The actual species richness that was observed can be tabulated by simply counting the number of species found in each habitat type. The species richness can also be mapped by using Geographic Information System (GIS) tools to add the distribution models together. The resulting map would show not only the species richness, but tie that information to a location. Such information can be used by future studies to target species rich locations for further study. Knowing the composition of the richness is also valuable information and has been used in other locations in conservation and restoration projects.

Objective 4: Species Abundance

Discussion: The species abundance in this study refers the total number of a given species collected in a given habitat. As such the abundance of a species is related to the probability that a given ant will be collected in a given habitat i.e. the more common an ant is the more likely it is to be collected. Such information can be important as future studies look at ant ecology. As discussed this study was initiated because I was asking questions about how RIFA interact with native species. Perhaps the most likely candidates to have significant impact would be the most abundant native species that co-occurs with RIFA. Abundance information can also be helpful when searching for a given species. What is the best place to look? It is of further value because as landscapes and ecologies change abundance may be a worthy indicator or measure of the change.

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CHAPTER TWO

LITERATURE REVIEW

With devastating losses to biodiversity occurring on the planet (Wilson 1993) the need to precisely map and document biodiversity hot spots, identify unique or at risk systems, and to monitor and preserve these locations has continued to increase (Agosti 2000a). The cost in money, time, and expertise to conduct such studies is generally prohibitively high. As such, much discussion has taken place on how to conduct such studies in a timely and efficient manner (Oliver and Beattie Andrew 1993, 1996, Pik Anthony et al. 1999).

On the first page of *The Ants* Hölldobler and Wilson state, “To a degree seldom grasped even by entomologists, the modern insect fauna has become predominately social” (Hölldobler and Wilson 1990). Some estimate that the biomass of ants, and/or social insects, may range as high as 20 – 30% of the total animal biomass, which argues for the inclusion of such an important group (Beck 1971, Fittkau and Klinge 1973).

With all of the above needs some in the scientific community as a whole today still question taxonomic or biodiversity surveys as largely qualitative rather than quantitative and lacking in intellectual merit or scientific rigor (Futuyma 1998). Unfortunately, much natural history work is perceived to be based upon inference and reasoned speculation (Allen 1979).

I believe that one of the basic human responsibilities is to be a good steward of this planet. It is not possible to be a good steward without knowing of what we are stewards. The understanding of resource management hinges upon our knowing what is being managed.

One of the challenges with biodiversity studies is the sheer magnitude of the task. I was recently reading one of my old text books and found a notation where the professor suggested that worldwide there may be as many as 1,000,000 species of plants and animals (Hickman et al. 1979). While still hotly debated other more recent estimates put the number much higher(Fittkau and Klinge 1973, Erwin 1982, 1988, Wilson 1988 , Gaston 1991a).

Other difficulties arise with finding people with expertise in some of the lesser known groups. Once outside of the popular and easily visible vertebrate species even groups that are relatively well known have a surprising lack of trained experts that can handle the taxonomic work required. There is a broad group of experts that are capable of identifying known species or species groups, but the number of people interested in and capable of going beyond basic identification and are capable of recognizing and describing specimens that are new to science is even smaller.

Given the complexity of ecological systems, the taxa represented within systems, and the large gaps in scientific knowledge of such systems it should come as no surprise that a single solution to the problems of biodiversity and the conservation of biodiversity has been elusive.

One of the many proposed solutions to the problems encountered with biodiversity studies is the GAP Analysis. Of all the approaches to these difficulties Pendergast et al. suggest that Gap Analysis Program (GAP) may currently offer the most practical solution (Prendergast et al. 1999). Gap analysis uses a Geographical Information Systems (GIS) approach to analyze the degree to which native animal species and natural communities are represented in our present-day mix of conservation lands (Scott et al. 1987, Scott et al. 1993, Jennings 1995, Scott and Jennings 1998).

The GAP Analysis program uses five objectives to accomplish its mission of providing conservation assessments. First, map landcover as closely as possible. In South Carolina this was done using remote sensing satellite imagery which was then "ground truthed" that is check for accuracy by visual ground inspections (Schmidt et al. 2001)

Second, map the predicted distribution of vertebrates and other selected taxa. Much of the data for this objective is obtained from previously published literature and the advice of recognized experts.

Third, document the representation of natural vegetation communities and animal species in areas that are being managed for the long-term maintenance of biodiversity.

Fourth, make all of the GAP data available to the public.

Fifth, build institutional cooperation in the application of this information.

As a biodiversity conservation tool GAP is not designed for the conservation of habitats for endangered species. It is not intended to replace programs such as the endangered species list. Rather, it is a tool to identify diversity hotspots and to encourage the conservation of those hotspots – thus preserving habitats that are home to a larger number of species.

The GAP has several distinct advantages. It has been widely used and tested in the United States. It has a large base of data available including natural vegetation maps to the level of dominant and co-dominant plant species, predicted distribution of native vertebrate species, comparisons between different layers within these data. It contains information on current conserved areas as well as current landownership. Lastly, this information is readily accessible at both state and national levels.

GAP does suffer from what is often colloquially referred to as a “vertebrate bias”. Without a doubt the number of vertebrate species is far exceeded by the number of invertebrate species (Gaston 1991b). The case, for the inclusion of invertebrates, particularly arthopods, in biodiversity studies, has been laid out by several authors (Landres et al. 1988, Kremen et al. 1993b, Wilson 1993). The vast number of invertebrate species brings us back to the difficulties of overwhelming the limited resources. As such the invertebrate groups chosen for inclusion in studies need to be carefully chosen to provide the most information for the least cost.

Ants have several characteristics that separate them from the invertebrate noise and bring them to notice as biological diversity indicators. First, while diverse they are not overwhelmingly so. In the United States Florida lists 290 species (Deyrup 2003c). In South Carolina thus far about 110 species have been collected. Even with additional information from museum specimens and additional studies the number in South Carolina is unlikely to exceed that of Florida. Thus, a dedicated student can learn to identify ants in a relatively short period of time. It has also been proposed that even inexperienced students can quickly learn to effectively separate and identify ants using morphospecies identifications (Oliver and Beattie 1993)

Second, ants are easily sampled using a variety of methods including baits, pitfalls, and leaf litter (Agosti 2000b). As a group the ants are nearly ubiquitous and highly abundant.

Third, ants act as keystone species within a system. Ants serve roles in seed dispersal (Majer 1978, Majer et al. 1979, Andersen 1980, Majer 1980, Handel et al. 1981, Andersen 1982, Zettler et al. 2001) , soil and nutrient movement (Lyford 1963, Beattie and Culver 1977), energy flow, pollinators, predators, herbivores, and granivores.

Fourth, ants are sensitive to environmental and ecological changes. Their mobility and shorter lifecycles allow the community to reshuffle when changes do take place (Allen et al. 1998b).

With all of these advantages there, of course, are some disadvantages. While there are often dichotomous keys available, they are scattered throughout the literature and are often regional in scale. Many of the ants in a key may not be found in the region of interest and some other members may be missing from a given key.

It is actually difficult to collect a square meter sample that does not contain several species of ants. The sheer number of specimens in a single pitfall or leaf litter collection can be daunting. Recent measurements suggest that about one-third of the entire animal biomass of the Amazonian *terra firme* rain forest is composed of ants and termites with each hectare of soil containing in excess of 8 million ants and 1 million termites. These two kinds of insects, along with the bees and wasps, make up somewhat more than 75% of the total insect biomass"(Hölldobler and Wilson 1990)

Lastly, there are gaps in the understanding of the structure of ant communities. Little is known about how these communities may react to disturbance, or how well they reflect invertebrate biodiversity as a whole. Though there is evidence that disturbance does play a large role in both species richness and abundance of ants (Graham et al. 2004).

Allen et al. (Allen et al. 1998c) laid out the case for the inclusion of ants in the GAP. Ants are easy to collect, relatively well known taxonomically, ecologically and taxonomically diverse, ecologically important, scale appropriate, perennial, habitat specific, and represented by diverse life histories.

Methods such as GAP have laid a foundation and framework for such studies. Ants meet many of the criteria proposed for indicator taxa, and are underrepresented in programs such as GAP. As such they are desirable and defensible for inclusion in such studies.

The development of a GAP layer for ants would start the process of answering some of my original questions that had been brought up during that initial fire ant management demonstration. What ants do we have here in South Carolina and where are they found?

There were of course several hurdles. Most of the GAP data relied upon literature sources or the advice of experts within the field. While Florida was able to complete an ant layer using these methods (Pearlstine et al. 2002), we did not have either of these for South Carolina. Without a doubt some collections contained specimens from South Carolina, and some were even mentioned within the literature. Detailed habitat information was very much lacking.

South Carolina has a great potential for myrmecological richness. There is a great diversity of habitats ranging from the Appalachian mountains to the coastal plains. Species that are typically more northern or boreal in distribution can be found at higher elevations in the southern Appalachians (Dennis 1938, Cole 1940, 1953, Carter 1962, Van Pelt 1963). Populations of these species located as far south as South Carolina usually exist as diminutive southern extensions of vast and continuous northern populations. There are a number of species that find their southern range in South Carolina including as *Formica argentea*, *Pachycondyla chinensis,* and *Tetramorium caespitum.* Additionally the sandhill and coastal regions of the state resemble more southern regions in both geology and species of ants. There are also a number of species which find their northern limits in South Carolina such as *Pogonomyrmex badius* and *Camponotus floridanus*. Additionally, eastern North America appears to have been an important secondary center of adaptive radiation since, with the exception of a number of neotropical and holarctic species, it has been described as a unique region of formicid endemism (Wheeler 1917, Cole 1940, Creighton 1950). Species of *Aphaenogaster*, *Formica*, *Leptothorax,* and *Myrmica* are examples that appear to have originated in the southeastern United States.

Despite abundance and diversity of ants in this region very little myrmecological work has been done beyond applied work with the Red Imported Fire Ants *Solenopsis invicta*. In 1916 M. R. Smith published a list of ants largely collected around the then Clemson College (Smith 1916a, b, Smith and Morrison 1916). This list included forty-four species. In 1934 an updated list was published which consisted of the previous list plus specimens sent to Smith over the years for identification (Smith 1934). That list included 96 species. There is no mention of voucher specimens or location where specimens may have been reposited. Due to numerous taxonomic changes, and the unfortunate inability to examine these specimens much of this work is rendered unusable.

In 1976 and 1977 Van Pelt and Gentry (Van Pelt and Gentry) conducted an intensive survey of the Savannah River Plant (SRP, South of Aiken, South Carolina) using baited traps and hand collections. Their survey found a total of 60 species on eight sites totaling approximately 350 acres. Our study represents the first statewide, collection based, information on the ant fauna of South Carolina since M. R. Smith's publication in 1934.

A brief description of the study area

Located along the eastern coast of the United States, South Carolina has a very diverse geography and associated habitats. It stretches from the Blue Ridge Mountains of the Appalachian chain to the Atlantic Ocean. It can be broken down in to three or four physiographic provinces to include the mountains, the piedmont, the sandhills, and the coastal plains.

The mountains experience the greatest amount of rainfall along the east coast. Visually, geologically and biologically the valleys and coves of this area are stunning. The flora is very diverse and rich. It includes many unique plants and animals found no place else in the world. When the Europeans arrived these forests were dominated by the oak-chestnut complex. The Chestnut blight of the early 1900's left the forest as mixed mysophytic forests consisting mainly of oak types.

The piedmont extends from the Brevard fault to the fall line. The Piedmont has been highly altered by agricultural practices over the past 300 years. This resulted in erosion and depletion of the formerly rich soils. Forests are often oak-hickory complexes in rolling hills and steep river valleys.

The Sandhills are often included as part of the coastal plains, but are generally drier and more hilly than the traditional plains. It is believed to have been the ancient beach. Much of the animal and plant life found here is also unique. It is also the northern limit of southern species such as the Florida Harvester Ant *Pogonomyrmex badius*, and the southern limit of northern species such as *Formica argentea.* While generally considered a xeric landscape the sandhill can contain a surprisingly wide variety of habitats. The land was once dominated by Longleaf pine and turkey oak, as such fire was an important part of the ecosystem.

The Costal Plains extend from the fall line to the coast. They are believed to have been formed by sediments laid down by the sea as the coast line shifted with the rising and falling of sea levels. The coastal plains are very flat with meandering rivers and streams. The dominant tree species are coniferous with hardwoods dominating in the maritime forests along the coast and hardwood bottomlands.

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CHAPTER THREE

A PRELIMINARY LIST OF SOUTH CAROLINA ANTS (HYMENTOPTERA: FORMICIDAE)

INTRODUCTION

South Carolina has a great potential for myrmecological richness. There is a great diversity of habitats ranging from the Appalachian Mountains to the Coastal Plains. Species that are typically more northern or boreal in distribution can be found at higher elevations in the southern Appalachians (Dennis 1938, Cole 1940, 1953, Carter 1962, Van Pelt 1963). Populations of these species located as far south as South Carolina usually exist as diminutive southern extensions of vast and continuous northern populations. There are a number of species that find their southern range in South Carolina including as *Formica argentea* Wheeler, 1912, *Pachycondyla chinensis* (Emery, 1895), and *Tetramorium caespitum* (L. 1758). Additionally the sandhill and coastal regions of the state resemble more southern regions in both geology and species of ants. There are also a number of species which find their northern limits in South Carolina such as *Pogonomyrmex badius* (Latreille, 1802) and *Camponotus floridanus* (Buckley, 1866). Additionally, eastern North America appears to have been an important secondary center of adaptive radiation since, with the exception of a number of neotropical and holarctic species, it has been described as a unique region of formicid endemism (Wheeler 1917, Cole 1940, Creighton 1950). Species of *Aphaenogaster*, *Formica*, *Leptothorax,* and *Myrmica* are examples that appear to have originated in the southeastern United States.

Despite abundance and diversity of ants in this region very little myrmecological work has been done beyond applied work with the Red Imported Fire Ants, *Solenopsis* *invicta*. In 1916 M. R. Smith published a list of ants largely collected around the then Clemson College (Smith 1916a, b, Smith and Morrison 1916). This list included forty-four species. In 1934 an updated list was published which consisted of the previous list plus specimens sent to Smith over the years for identification (Smith 1934). That list included 96 species. There is no mention of voucher specimens or location where specimens may have been reposited. Due to numerous taxonomic changes, and the unfortunate inability to examine these specimens many of the species mentioned are untraceable taxonomically. In the course of this study museum specimens from the Clemson Arthropod Museum were examined. Numerous specimens that were collected and identified by M.R. Smith were found. None of the M.R. Smith records were labeled as voucher specimens, but we were able to add specimens to the list by including his records.

In 1976 and 1977 Van Pelt and Gentry (1985) conducted an intensive survey of the Savannah River Plant (SRP, South of Aiken, South Carolina) using baited traps and hand collections. Their survey found a total of 60 species on eight sites totaling approximately 350 acres. My study represents the first statewide, collection based, information on the ant fauna of South Carolina since M. R. Smith's publication in 1934.

MATERIALS AND METHODS

Pitfall sampling was conducted at 243 sites throughout South Carolina in 1999 and 2000. Sampling was stratified by physiographic region: Mountain, Piedmont, Sandhills and Coastal Plains (Barry 1944) see figure 2.1.

Figure 3.1 Physiographic regions of South Carolina and collection sites for 1999 – 2000 pitfall collections.

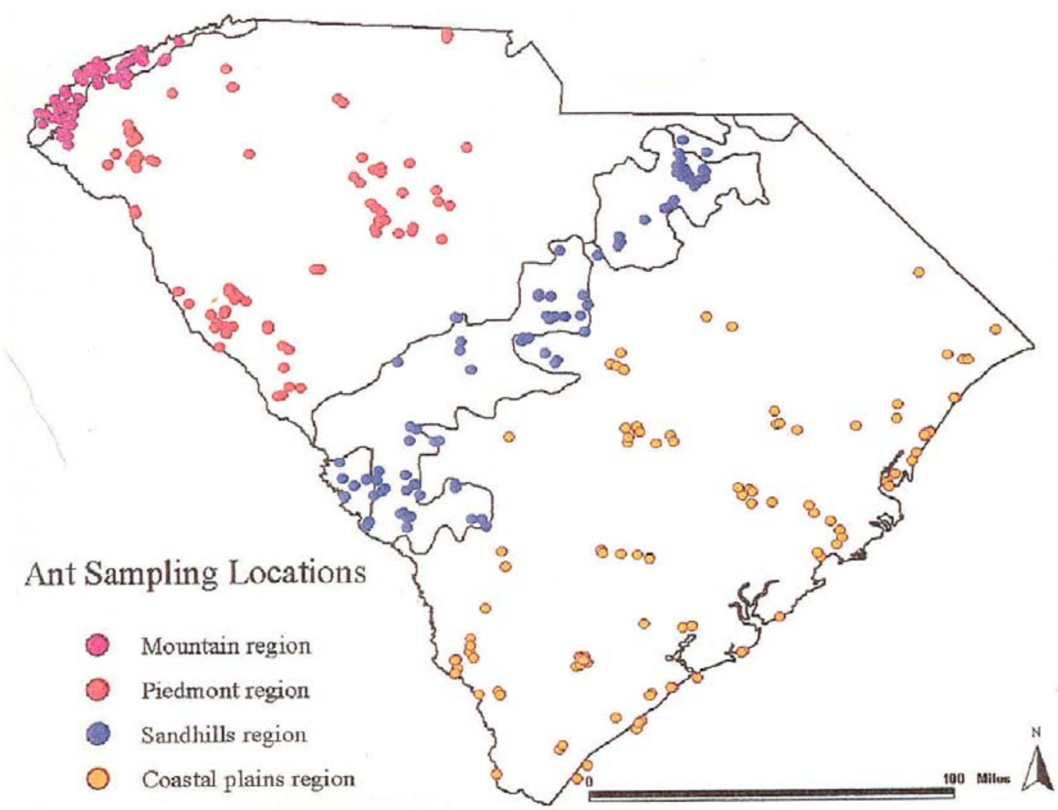


Table 3.1 Land cover descriptions for the sixteen land cover classes selected from the SC GAP analysis for statewide ant sampling in South Carolina 1999 and 2000.

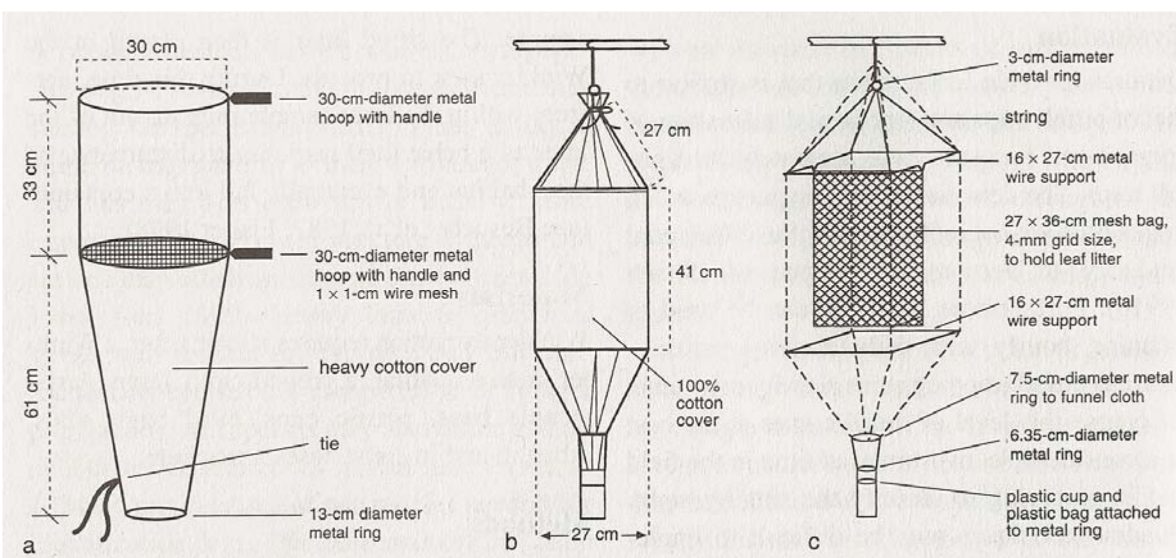
Code	Land Cover Class	Description
3	Saltwater marsh/Freshwater marsh	Estuaries, salt marshes, brackish marshes, tidal marshes, barrier islands,/Non-tidal streamside marshes, bogs, depression meadows, inland ponds
4	Bays and pocosins	Carolina bays, wetland depressions, wet evergreen
6/7	Swamps/bottomland hardwood	River flood plain hardwoods, swamps
12	Cleared forest	Mix of bare soil and pioneer grass species, tree regeneration
16	Upland pine forest	Pine plantations with closed canopies, pine with oak understory
17	Pine woodland/longleaf pine savanna	Pine woodland, grass savanna with open canopy
18	Upland deciduous forest	Deciduous arboreal vegetation in dry soil
19	Mesic deciduous forest	Deciduous arboreal vegetation in moist soil
20	Upland mixed forest	Forest that are mixed with evergreen and deciduous, dry soil
21	Mesic mixed forest	Mixed forests of evergreen and hardwood in marginal bottomland floodplains
22	Grassland	Fallow fields, pastureland
23	Cultivated land	Agricultural land, lawns, golf courses
24	Urban development	Industrial development, residential development, city development
28	Maritime forest	Maritime evergreen, not bottomland floodplains
29	Beach	Barrier islands, sand dunes, beaches

The list includes species from the Clemson Arthropod Museum which contain many of the M. R. Smith identified specimens as well as more recently collected material. Also included were species from the Van Pelt and Gentry (1985) collection, the Smith collection, (1916a, 1916b, 1934), and the Smith and Morrison (1916) papers, where taxonomic changes have not obscured the original identification.

Hand collected specimens throughout the state have added many records to the list as well as a small scale survey of the Clemson University Experimental Forest

(Pickens and Anderson counties) in a secondary growth pine stand. This small scale survey included both pitfall trapping and Winkler litter sifting at three sites with 21 one meter by one meter quadrat sampling stations See figure 2.2 for an illustration of the Winkler apparatus. Winker litter sifting is a method where litter samples are sifted to remove larger debris then placed in a "Winkler sack" for 24 to 48 hours. The Winkler sack itself is a mesh bag or box with 4mm grid size.. The litter is placed in this section of the bag. The whole apparatus is then suspended inside of a cotton cover bag with a collection cup attached to the bottom of the cotton bag. This entire apparatus is suspended for 24 to 48 hours. As the litter is disturbed during the sifting process and the litter begins to dry the ants migrate out of the litter and fall into the collection cup at the bottom. For complete description and illustrations of this method see Bestelmeyer et al. (2000)

Figure 3.2: (a) Construction of the litter sifter. (b) External dimensions of the "mini-Winkler" sack. (c) Construction of the "mini-Winkler" Sack (Fisher 1998). Illustration copied from Bestlemeyer et al. (2000)



The list is presented in alphabetical order rather than taxonomic classification for ease of use. Names presented generally follow those in “A New General Catalogue of the Ants of the World”(Bolton 1995), unless noted otherwise. Ants not collected in the 1999-2000 pitfall collection are noted in the list as well as the origin of the information. This collection will be deposited in the Clemson Arthropod Museum as voucher specimens.

RESULTS AND DISCUSSION

The following list (Table 1) represents 121 species in 38 Genera of Formicidae that were collected within the state of South Carolina. The 1999-2000 pitfall traps yielded 41,414 individual ants and the small-scale, experimental forest survey added 768 individuals. The majority of the records presented here were collected through pitfall trapping and thus comprise mostly epigeic ants. Notably missing from this list are many Dacitine ants found largely in subterranean habitats, and species that are primarily or completely arboreal. The limited (n=21) litter sifting that was conducted in Pickens and Anderson counties yielded three new records of the *Pyramica* and *Strumigenys* genera and indicates that this collection technique will probably produce many new records as it is applied in other locations within the state. Additionally some habitats, such as residential and cultivated land were not extensively sampled and some ants closely associated with these habitats are also likely under-represented. Museum records have buffered collection deficiencies to some extent and; this list will undoubtedly grow as more intensive sampling of the ant fauna is conducted by future researchers.

I would estimate that this list could easily exceed 200 species of ants. When examining the literature there are numerous ants whose range includes South Carolina because of records both North and South of South Carolina, but many of these ants have not been collected in South Carolina. Visiting museums with more extensive ant collections than our own Arthropod museum will yield records that are not listed. More intensive sampling of specific habitats will also reveal new records. In fact during the course of writing our findings the list kept growing faster that we could complete the manuscript.

Some groups have received recent revisions such as *Pheidole* (Wilson 2003), Such revisions have added to our knowledge of the fauna as well as provided updated dichotomous keys which were not available beforehand.

The availability of new tools for identifying ants will also help grow the list. Electronic keys are becoming more available and are easier for new students of myrmecology to collect and find and use. It is hoped that his study will stimulate further studies of the ant fauna of South Carolina and serve as a resource for new students of the ants of South Carolina.

Collection and Identification Notes

The genus *Dorymyrmex* has been revised a couple of times in the past decade. The species *Dorymyrmex medeis* Trager was describe in 1988. Later Johnson (Johnson 1989) revised the genus and lumped this species with several species. Our field observations of this species corroborate with Deryup (Deyrup 2003b) on this genus and his assessment of Trager (Trager 1988) that this genus is more diverse and complex than presented by Johnson. Thus, we have continued to use Trager's description and taxonomy rather than Johnson's revision.

Solenopsis geminate (Fabricus) – Smith (Smith 1916a, b, Smith and Morrison 1916, Smith 1918, 1934) lists widespread records of this species. More current observations of *S. geminata* find it only in some limited locations such as Peach Tree Rock Heritage preserve (coordinates 38.022131, -81.356506) and McEntire Air National Guard Base (coordinates 34.024636, -80.926752) in mesic forests. It is hypothesized that the invasive species, *S. invicta,* has displaced much of the original distribution of *S. geminata* in the Southeastern United States.

Solenopsis xyloni (McCook) has also likely been displaced by invasive species such as *Solenopsis invicta* as it has not been collected in any of our surveys. A quick review of the CUAC specimens found none of the labeled *S. xyloni* to be correctly identified. Most were identified by students and were actually *S. invicta* Buren.

It should be noted that specific identification of individual ant specimens in the Genus *Solenopsis* is notoriously difficult and unreliable. The character most frequently listed for *S. xyloni* also is often present in *S. invicta*, but is smaller on *S. invicta*. The most reliable method for distinguishing these species is through chemical and molecular tests which was not performed on the specimens.

Another complicating factor is that some of the specimens labeled as *S. xyloni* predated our knowledge of the presence of *S. invicta* thus they were probably presumed to be *S. xyloni*. A future study could look closely at these specimens and perhaps using molecular techniques to determine their identity more conclusively. Perhaps the accepted dates for the invasion of *S. invicta* would be revised. This also could alter theories regarding the *S. invicta* invasion with regard to the timing and point of incursion/s.

Despite of the lack of sample evidence we included *S. xyloni* in the list as in Smith (1934) as it has not undergone taxonomic revision and we assume that Smith's original identifications were correct until such time as there is sufficient evidence to demonstrate otherwise.

The specific name *S. invicta* was conserved and *S. wagneri* has been suppressed (Anon. 2001). This represents a departure from Bolton (1995).

The *Technomyrmex albipes* (F. Smith) an invasive species was discovered at Riverbanks Zoo and Garden in Columbia, South Carolina in 2003. This represents the first published report of this ant species in South Carolina. Records indicate plants used in a display were shipped from nurseries in infested Florida counties. This ant is not currently under quarantine, but it would be prudent for vendors and consumers to inspect plant material shipped from these regions. This infestation is currently limited to a single building on the site. Riverbanks Zoo and Garden worked with Clemson University to establish a management plan to prevent the *T. albipes* from spreading to nearby facilities.

The status of "pest" is rather subjective since individuals react differently to ant infestations. The classification of a species as pest in this list is limited to those listed in other literature as pests.(Wojcik 1992, Klotz et al. 1995, Mallis 1997, Hedges 1999, Hansen and Klotz 2005) The inclusion of a species in this list as a pest does not necessarily imply that management is necessary.

Table 3.2. Ants collected and identified in the state of South Carolina

Table 3.2: Ants known to inhabit the state of South Carolina		
Species	**County (city)**	**Habitat/Notes**
Acanthomyops claviger (Roger)	Oconee (Walhalla), Greenwood, Pickens (Central, Clemson, Easley)	Smith 1934
Acanthomyops interjectus (Mayr)	Pickens (Clemson), Spartanburg, Newberry (Ware Shoals, Prosperity), Anderson (Pendleton), Pickens (Easley), Edgefield, Saluda, Spartanburg (Landrum), Oconee (Walhalla)	Smith 1934
Acanthomyops latipes (Walsh)	Florence (Scranton)	CUAC
Ambylopone pallipes (Haldeman)	Abbeville, Anderson, Edgefield, Oconee, Pickens, York	Swamps/Bottomland Hardwood, Pine Woodland/Longleaf Pine Savanna, Upland Deciduous Forest, Mesic Deciduous Forest, Upland Mixed Forest
Aphaenogaster flemingi M.R. Smith	Aiken, Barnwell, Horry, Richland	Upland Pine Forest, Pine Woodland/Longleaf Pine Savanna, Mesic Mixed Forest, Closed Canopy Evergreen Forest/Woodland
Aphaenogaster fulva Roger	Barnwell, Berkley, Edgefield, McCormick, Oconee, Pickens, Richland	Pocosin, Swamps/Bottomland Hardwood, Pine Woodland/Longleaf Pine Savanna, Upland Deciduous Forest, Mesic Deciduous Forest, Upland Mixed Forest

Table 3.2: Ants known to inhabit the state of South Carolina		
Species	**County (city)**	**Habitat/Notes**
Aphaenogaster lamellidens Mayr	Georgetown, Pickens (Clemson) Oconee (Walhalla, Long Creek, Seneca)	Maritime Forest
Aphaenogaster mariae Forel, 1886	Anderson, Richland	Swamps/Bottomland Hardwood, Upland Deciduous Forest
Aphaenogaster picea (Wheeler)	Abbeville, Beaufort, Berkley, Colleton, Oconee, Pickens, Union	Swamps/Bottomland Hardwood, Recently Cleared Land, Upland Pine, Pine Woodland/Longleaf Pine Savanna, Upland Deciduous Forest, Upland Deciduous Forest, Mesic Deciduous Forest, Upland Mixed Forest
Aphaenogaster tennesseensis (Mayr)	Berkley, Clarendon, Richland	Marsh/Emergent Wetland, Swamps/Bottomland Hardwood
Aphaenogaster texana (Emery)	Charleston (Adams Run)	CUAC
Aphaenogaster treatae Forel	Aiken, Barnwell, Chesterfield, Richland	Pocosin, Closed Canopy Evergreen Forest/Woodland, Pine Woodland/Longleaf Pine Savanna, Mesic Mixed Forest

Table 3.2: Ants known to inhabit the state of South Carolina		
Species	**County (city)**	**Habitat/Notes**
Apheanogaster ashmaedi (Emery)	Abbeville, Anderson, Barnwell, Charleston, Chesterfield, Edgefield, Georgetown, Greenville, Greenwood, Horry, Kershaw, Laurens, Oconee, Pickens, Richland, Spartanburg, Union	Pocosin, Recently Cleared Land, Upland Pine, Closed Canopy Evergreen Forest/Woodland, Upland Pine Forest, Pine Woodland/Longleaf Pine Savanna, Upland Deciduous Forest, Mesic Deciduous Forest, Upland Mixed Forest, Mesic Mixed Forest, Maritime Forest
Apheanogaster fulva rudis Enzmann	Statewide	Pocosin, Recently Cleared Land, Upland Pine, Closed Canopy Evergreen Forest/Woodland, Upland Pine Forest, Pine Woodland/Longleaf Pine Savanna, Upland Deciduous Forest, Mesic Deciduous Forest, Upland Mixed Forest, Maritime Forest
Brachymrymex patagonicus Mayr	Introduced pest	(MacGown et al. 2007)
Brachymyrmex depilis Emery	Richland (Columbia), Pickens (Clemson)	Hand Collection CUAC
Brachymyrmex musculus Forel	Savannah River Site	Hand Collection
Camonotus casteneus (Latreille)	Aiken, Bamberg, Barnwell, Berkeley, Charleston, Chesterfield, Clarendon, Georgetown, Horry, Kershaw, Richland, Sumter, Williamsburg Orangeburg, Pinewood, Pickens (Clemson) Pest	Marsh/Emergent Wetland, Pocosin, Swamps/Bottomland Hardwood, Recently Cleared Land, Closed Canopy Evergreen Forest/Woodland, Upland Pine Forest, Pine Woodland/Longleaf Pine Savanna, Upland Deciduous Forest, Maritime Forest

Table 3.2: Ants known to inhabit the state of South Carolina		
Species	**County (city)**	**Habitat/Notes**
Camponotus americanus (Mayr)	Abbeville, Aiken, Bamberg, Beaufort, Berkeley, Charleston Greenville, Laurens, Newberry, Oconee, Orangeburg, Pickens, Sumter, York, Pest	Swamps/Bottomland Hardwood, Recently Cleared Land, Upland Pine, Pine Woodland/Longleaf Pine Savanna, Upland Deciduous Forest, Mesic Deciduous Forest, Upland Mixed Forest, Grassland, Maritime Forest
Camponotus caryae (Fitch)	Pickens Pest	Mesic Forest Hand Collection
Camponotus chromaiodes Bolton	Aiken, Bamberg, Barnwell, Berkeley, Hampton, Kershaw, Richland, Oconee Pest	Pocosin, Swamps/Bottomland Hardwood, Closed Canopy Evergreen Forest/Woodland, Upland Pine Forest, Pine Woodland/Longleaf Pine Savanna, Upland Deciduous Forest, Mesic Deciduous Forest, Upland Mixed Forest
Camponotus decipiens Emery	Charleston (James Island), Richland (Columbia), Pickens (Clemson), Greenville, Oconee (Six Mile, Norway, Walhalla, Seneca), Edgefield, Berkley (Cross) Pest	Hand Collection CUAC
Camponotus floridanus (Buckley)	Barnwell, Jasper, Colleton, Charleston, Beaufort Pest	Closed Canopy Evergreen Forest/Woodland, Upland Pine Forest

Table 3.2: Ants known to inhabit the state of South Carolina		
Species	**County (city)**	**Habitat/Notes**
Camponotus impressus (Roger)	Beaufort (Hilton Head)	Hand Collection
Camponotus nearcticus Emery	Clemson, Greenville, Union, Chesterfield (McBee) Pest	Hand Collection CUAC
Camponotus pennsylvanicus (DeGeer)	Abbeville, Bamberg, Barnwell, Beaufort, Berkeley, Charleston, Clarendon, Georgetown, Kershaw, Laurens, McCormick, Oconee, Pickens, Richland, Sumter, York Pest	Marsh/Emergent Wetland, Pocosin, Swamps/Bottomland Hardwood, Recently Cleared Land, Upland Pine, Pine Woodland/Longleaf Pine Savanna, Maritime Forest, Upland Mixed Forest, Grassland
Camponotus snellingi Bolton	Horry, Charleston Pest	Hand Collection
Camponotus subbarbatus Emery	Oconee	Hand Collection
Cardiocondyla nuda (Mayr)	Pickens (Clemson)	Hand Collection
Crematogaster ashmeadi Mayr	Pickens, Clemson, Anderson, Edgefield, Union, Orangeburg, Horry (Myrtle Beach) Pest	Pine Woodland/Longleaf Pine Savanna

Table 3.2: Ants known to inhabit the state of South Carolina		
Species	**County (city)**	**Habitat/Notes**
Crematogaster atkinsoni (Wheeler)	Abbeville, Aiken, Anderson, Bamberg, Berkeley, Fairfield, Laurens, Oconee, Pickens	Pocosin, Swamps/Bottomland Hardwood, Upland Pine, Closed Canopy Evergreen Forest/Woodland, Pine Woodland/Longleaf Pine Savanna, Upland Deciduous Forest, Mesic Deciduous Forest, Maritime Forest
Crematogaster cerasi (Fitch)	Aiken, Bamberg, Barnwell, Beaufort, Berkeley, Georgetown, Hampton, Kershaw, McCormick, Orangeburg, Newberry, Pickens, Sumter	Swamps/Bottomland Hardwood, Recently Cleared Land, Upland Pine, Pine Woodland/Longleaf Pine Savanna, Upland Deciduous Forest, Mesic Deciduous Forest, Upland Mixed Forest, Mesic Mixed Forest, Grassland
Crematogaster lineolata (Say)	Abbeville, Aiken, Anderson, Bamberg, Barnwell, Beaufort, Berkeley, Charleston, Chesterfield, Clarendon, Edgefield, Fairfield, Georgetown, Greenville, Greenwood, Horry, Kershaw, Laurens, Lee, McCormick, Newberry, Oconee, Orangeburg, Pickens, Richland, Spartanburg, Union, Williamsburg, York Pest	Marsh/Emergent Wetland, Pocosin, Swamps/Bottomland Hardwood, Recently Cleared Land, Upland Pine, Closed Canopy Evergreen Forest/Woodland, Upland Pine Forest, Pine Woodland/Longleaf Pine Savanna, Upland Deciduous Forest, Mesic Deciduous Forest, Upland Mixed Forest, Mesic Mixed Forest
Crematogaster minutissima Mayr	Savannah River Plant	Van Pelt and Gentry (1985)

Table 3.2: Ants known to inhabit the state of South Carolina		
Species	**County (city)**	**Habitat/Notes**
Crematogaster missouriensis Emery	Pickens (Clemson)	Hand Collection
Crematogaster pilosa Emery	Abbeville, Chesterfield, Greenville, Newberry, Oconee, Pickens Pest	Pocosin, Recently Cleared Land, Pine Woodland/Longleaf Pine Savanna, Upland Deciduous Forest, Mesic Deciduous Forest, Mesic Mixed Forest, Grassland
Crematogaster punctulata Emery	Pickens	CUAC
Cyphomyrmex rimosus (Spinola)	Beaufort, Georgetown, Jasper, Williamsburg, Charleston	Recently Cleared Land, Upland Pine, Upland Pine Forest, Mesic Mixed Forest, Maritime Forest
Dolichoderous pustulatus Mayr	Aiken, Clarendon, Horry, Oconee	Marsh/Emergent Wetland, Upland Pine, Closed Canopy Evergreen Forest/Woodland Upland Pine Forest
Dolichoderus mariae Forel	Aiken, Chesterfield, Richland, Pickens (Clemson), Oconee	Closed Canopy Evergreen Forest/Woodland, Mesic Mixed Forest
Dolichoderus tashenbergi (Mayr)	Spartanburg, Clemson	CUAC
Dorymyrmex bureni Trager	Aiken, Barnwell, Beaufort, Charleston, Chesterfield, Colleton, Hampton, Horry, Kershaw, Oconee, Orangeburg, Pickens, Richland, Sumter Occasional pest	Swamps/Bottomland Hardwood, Recently Cleared Land, Upland Pine, Closed Canopy Evergreen Forest/Woodland, Upland Pine Forest, Pine Woodland/Longleaf Pine Savanna, Upland Deciduous Forest, Mesic Mixed Forest, Grassland

Table 3.2: Ants known to inhabit the state of South Carolina		
Species	**County (city)**	**Habitat/Notes**
Dorymyrmex medeis Trager	Aiken, Barnwell, Chesterfield, Kershaw, Sumter Occasional pest	Recently Cleared Land, Closed Canopy Evergreen Forest/Woodland, Mesic Mixed Forest
Forelius pruinosus (Roger)	Aiken, Barnwell, Chesterfield, Pickens	Closed Canopy Evergreen, Recently Cleared Land, Upland Pine, Upland Pine Forest Forest/Woodland, Upland Deciduous Forest, Mesic Mixed Forest, Grassland
Formica argentea Wheeler	Aiken, Richland, Oconee	Pine Woodland/Longleaf Pine Savanna, Mesic Deciduous Forest
Formica integra Nylander	Oconee, Lexington	Pine Woodland/Longleaf Pine Savanna, Upland Deciduous Forest, Mesic Deciduous Forest, Mesic Mixed Forest, Grassland
Formica pallidefulva dolosa Buren	Aiken, Barnwell, Berkeley, Chesterfield, Georgetown, Horry, Kershaw, Sumter	Pocosin, Recently Cleared Land, Upland Pine, Closed Canopy Evergreen Forest/Woodland Upland Pine Forest, Pine Woodland/Longleaf Pine Savanna
Formica pallidefulva pallidefulva Latreille	Oconee	Hand collection
Formica querquetulana Kennedy and Dennis	Pickens	Urban habitat Hand collection
Formica schaufussi Mayr	Abbeville, Bamberg, Beaufort, Berkeley, Charleston, Colleton, Edgefield, Jasper, Laurens, Newberry, Oconee, Pickens, Spartanburg, Union, York	Mesic Mixed Forest, Grassland

Table 3.2: Ants known to inhabit the state of South Carolina		
Species	**County (city)**	**Habitat/Notes**
Formica subaenescens	York	CUAC
Formica subsericea Say	Beaufort, Oconee, Pickens, Union	Upland Pine, Pine Woodland/Longleaf Pine Savanna, Upland Deciduous Forest, Mesic Deciduous Forest, Upland Mixed Forest, Grassland
Hypoponera opaciceps (Mayr)	Bamberg, Berkeley, Charleston, Chesterfield, Clarendon, Georgetown, Kershaw, Williamsburg	Marsh/Emergent Wetland, Pocosin, Recently Cleared Land, Closed Canopy Evergreen Forest/Woodland, Upland Pine Forest, Upland Deciduous Forest, Mesic Mixed Forest, Maritime Forest
Hypoponera opacior (Forel)	Barnwell, Clarendon, Georgetown, Horry, Kershaw, Richland, Sumter	Marsh/Emergent Wetland, Pocosin, Closed Canopy Evergreen Forest/Woodland, Upland Pine, Upland Pine Forest, Pine Woodland/Longleaf Pine Savanna, Mesic Mixed Forest, Maritime Forest
Hypoponera punctatissima (Roger)	Pickens (Clemson)	Urban Habitat Hand collection
Lasius alienus (Förster)	Aiken, Barnwell, Charleston, Colleton, Dorchester, Oconee, Pickens, Sumter	Pocosin, Swamps/Bottomland Hardwood, Upland Deciduous Forest, Upland Mixed Forest, Mesic Mixed Forest
Lasius flavus (Fabricius)	Pickens (Clemson) Invasive (Deyrup et al. 2000)	Hand Collection
Lasius neoniger Emery	Aiken, Chesterfield, Oconee, Pickens (Clemson)	Recently Cleared Land, Mesic Deciduous Forest, Mesic Mixed Forest

Table 3.2: Ants known to inhabit the state of South Carolina		
Species	**County (city)**	**Habitat/Notes**
Lasius umbratus (Nylander)	Aiken, Barnwell, Chesterfield	
Leptothorax curvispinosus Mayr	Savannah River Plant, Pickens (Clemson)	Van Pelt and Gentry (1985)
Leptothorax pergandei Emery	Spartanburg (Landrum) Pickens (Clemson)	Hand Collection CUAC
Leptothorax schaumii Roger	Savannah River Plant	Van Pelt and Gentry (1985)
Linepithema humile (Mayr)	Aiken, Clarendon, Pickens (Clemson), Greenville, Anderson Invasive (Deyrup et al. 2000) Pest species	Marsh/Emergent Wetland, Swamps/Bottomland Hardwood
Monomorium minimum (Buckley)	Abbeville, Anderson, Charleston, Oconee, Richland, Union, Orangeburg, Pickens Pest	Recently Cleared Land, Mesic Deciduous Forest, Mesic Mixed Forest, Grassland
Monomorium pharaonis (L.)	Widespread Invasive (Deyrup et al. 2000) Pest	Smith (1934)
Myrmecina americana Emery	Barnwell, Charleston, Fairfield, Jasper, McCormick, Oconee, Union, York, Pickens (Clemson)	Pocosin, Swamps/Bottomland Hardwood, Recently Cleared Land, Upland Pine, Closed Canopy Evergreen Forest/Woodland, Upland Pine Forest, Pine Woodland/Longleaf Pine Savanna, Upland Deciduous Forest, Mesic Deciduous Forest, Upland Mixed Forest, Maritime Forest
Myrmica americana Weber	Oconee (Walhalla)	Hand Collection
Myrmica punctiventris Roger	Pickens (Clemson)	Hand Collection

Table 3.2: Ants known to inhabit the state of South Carolina		
Species	**County (city)**	**Habitat/Notes**
Neivamyrmex carolinensis (Emery)	Spartanburg, Savannah River Plant	Smith (1934), Van Pelt and Gentry (1985)
Neivamyrmex opacithorax (Emery)	Aiken, Anderson, Barnwell, Charleston, Chesterfield, Georgetown, Greenwood, Kershaw, McCormick, Newberry, Oconee, Pickens, Richland, Sumter, Union, Williamsburg	Swamps/Bottomland Hardwood, Recently Cleared Land, Upland Pine, Closed Canopy Evergreen Forest/Woodland, Upland Pine Forest, Pine Woodland/Longleaf Pine Savanna, Upland Deciduous Forest, Mesic Deciduous Forest, Upland Mixed Forest, Grassland, Mesic Mixed Forest, Maritime Forest
Neivamyrmex texanus (Watkins)	Edgefield, Georgetown, Greenville, Horry, Pickens	Upland Pine Forest, Upland Deciduous Forest, Mesic Deciduous Forest, Upland Mixed Forest, Mesic Mixed Forest, Maritime Forest
Pachycondyla chinensis (Emery)	Oconee, Pickens, Abbeville Invasive Pest	Mesic Deciduous Forest, Mesic Mixed Forest
Paratrechina bourbonica (Forel)	Invasive (Deyrup et al. 2000) Pest	
Paratrechina concinna Trager	Aiken, Barnwell, Charleston, Georgetown, Horry, Jasper, Kershaw, Richland, Sumter, Williamsburg, Oconee	Pocosin, Recently Cleared Land, Upland Pine, Closed Canopy Evergreen Forest/Woodland, Upland Pine Forest, Pine Woodland/Longleaf Pine Savanna, Mesic Deciduous Forest, Mesic Mixed Forest

Table 3.2: Ants known to inhabit the state of South Carolina		
Species	**County (city)**	**Habitat/Notes**
Paratrechina faisonensis (Forel)	Abbeville, Aiken, Anderson, Bamberg, Barnwell, Beaufort, Berkeley, Charleston, Clarendon, Edgefield, Fairfield, Georgetown, Greenville, Greenwood, Hampton, Horry, Jasper, Kershaw, Laurens, Lee, McCormick, Newberry, Oconee, Pickens, Spartanburg, Union, York	Marsh/Emergent Wetland, Pocosin, Swamps/Bottomland Hardwood, Recently Cleared Land, Upland Pine, Closed Canopy Evergreen Forest/Woodland, Upland Pine Forest, Pine Woodland/Longleaf Pine Savanna, Upland Deciduous Forest, Mesic Deciduous Forest, Upland Mixed Forest, Mesic Mixed Forest, Grassland, Maritime Forest
Paratrechina flavipes (F. Smith)	Jasper	Upland Pine Forest
Paratrechina parvula (Mayr)	Barnwell, Beaufort, Chesterfield, Jasper, Oconee, Pickens	Swamps/Bottomland Hardwood, Closed Canopy Evergreen Forest/Woodland, Upland Pine Forest, Mesic Mixed Forest, Grassland
Paratrechina terricola (Buckley)	Williamsburg, Oconee	Upland Pine Forest, Mesic Deciduous Forest
Paratrechina vividula (Nylander)	Beaufort, Berkeley, Orangeburg	Upland Pine, Mesic Mixed Forest
Paratrechina wojciki Trager	Aiken, Georgetown, Richland	Closed Canopy Evergreen Forest/Woodland, Upland Pine Forest
Pheidole bicarinata Mayr	Pickens	Hand collection
Pheidole bicarinata vinelandica Forel	Barnwell, Charleston, Greenville, Horry, Oconee, Orangeburg, Pickens, Union	Pocosin, Recently Cleared Land, Upland Pine, Upland Pine Forest, Mesic Deciduous Forest, Mesic Mixed Forest, Grassland, Maritime Forest

Table 3.2: Ants known to inhabit the state of South Carolina		
Species	**County (city)**	**Habitat/Notes**
Pheidole crassicornis Emery	Aiken, Anderson, Bamberg, Barnwell, Beaufort, Berkeley, Charleston, Chesterfield, Georgetown, Greenville, Hampton, Kershaw, Newberry, Oconee, Orangeburg, Pickens, Richland, Sumter	Pocosin, Swamps/Bottomland Hardwood, Recently Cleared Land, Upland Pine, Closed Canopy Evergreen Forest/Woodland, Pine Woodland/Longleaf Pine Savanna, Upland Deciduous Forest, Mesic Deciduous Forest, Mesic Mixed Forest, Grassland, Maritime Forest
Pheidole davisi Wheeler	Savannah River Plant	Van Pelt and Gentry (1985)
Pheidole denata Mayr	Abbeville, Aiken, Anderson, Bamberg, Barnwell, Beaufort, Charleston, Chesterfield, Colleton, Dorchester, Edgefield, Georgetown, Greenville, Hampton, Horry, Laurens, McCormick, Oconee, Orangeburg, Pickens, Sumter, Union	Pocosin, Swamps/Bottomland Hardwood, Recently Cleared Land, Upland Pine, Closed Canopy Evergreen Forest/Woodland, Upland Pine Forest, Pine Woodland/Longleaf Pine Savanna, Upland Deciduous Forest, Mesic Deciduous Forest, Upland Mixed Forest, Mesic Mixed Forest, Grassland, Maritime Forest
Pheidole dentigula M.R. Smith	Aiken, Bamberg, Barnwell, Horry, Oconee	Pocosin, Swamps/Bottomland Hardwood, Upland Pine Forest, Upland Deciduous Forest, Grassland
Pheidole metallescens Emery	Richland (Columbia)	CUAC

Table 3.2: Ants known to inhabit the state of South Carolina		
Species	**County (city)**	**Habitat/Notes**
Pheidole morrisii Forel	Aiken, Chesterfield, Edgefield, Greenville, Richland, Oconee, Pickens, Conway, Newberry, Walhalla	Swamps/Bottomland Hardwood, Recently Cleared Land, Closed Canopy Evergreen Forest/Woodland, Pine Woodland/Longleaf Pine Savanna, Mesic Mixed Forest, Grassland
Pheidole tysoni Forel	Oconee	Mesic Mixed Forest
Pogonomyrmex badius (Latreille)	Aiken, Allendale, Barnwell, Chesterfield, Sumter	Recently Cleared Land, Closed Canopy Evergreen Forest/Woodland, Mesic Mixed Forest
Polyergus lucidus Mayr	Pickens (Clemson)	Hand collection
Ponera pennsylvanica Buckley	Pickens	Mesic Deciduous Forest
Prenolepis imparis (Say)	Abbeville, Anderson, Beaufort, Edgefield, Greenwood, Kershaw, McCormick, Oconee, Pickens	Swamps/Bottomland Hardwood, Recently Cleared Land, Upland Pine, Pine Woodland/Longleaf Pine Savanna, Upland Deciduous Forest, Mesic Deciduous Forest, Upland Mixed Forest, Mesic Mixed Forest, Grassland
Proceratium croceum (Roger)	Savannah River Plant	Van Pelt and Gentry (1985)
Proceratium pergandei (Emery)	Savannah River Plant	Van Pelt and Gentry (1985)
Proceratium silaceum Roger	Savannah River Plant	Van Pelt and Gentry (1985)
Pseudomyrmex brunneus F. Smith	Dorchester (Summerville), Sumter (Pinewood)	Smith (1934)
Pseudomyrmex ejectus Smith, F.	Sumter (Pinewood)	CUAC

Table 3.2: Ants known to inhabit the state of South Carolina		
Species	**County (city)**	**Habitat/Notes**
Pseudomyrmex flavidulus F. Smith	Williamsburg (Greeleyville), Horry, Sumter (Summerville), Dorchester, Dillon	Smith (1934)
Pseudomyrmex pallidus (Smith)	Richland (Columbia), Dorchester (Summerville)	CUAC
Pyramica clypeata Roger	Pickens (Clemson)	Hand collection Pine forest litter
Pyramica ornate Mayr	Pickens (Clemson)	Hand collection Pine forest litter
Pyramica rostrata Emery	Pickens (Clemson)	Hand collection Pine forest litter
Smithistruma louisianae Roger	Charleston, Pickens (Clemson)	Hand collection Pine forest litter CUAC
Solenopsis carolinensis (Forel)	Abbeville, Aiken, Barnwell, Beaufort, Charleston, Fairfield, Georgetown, Greenville, McCormick, Newberry, Oconee, Pickens, Spartanburg, Union Pest	Pocosin, Swamps/Bottomland Hardwood, Recently Cleared Land, Upland Pine, Closed Canopy Evergreen Forest/Woodland, Upland Pine Forest, Pine Woodland/Longleaf Pine Savanna, Upland Deciduous Forest, Mesic Deciduous Forest, Upland Mixed Forest, Mesic Mixed Forest, Grassland, Maritime Forest
Solenopsis geminata (Fabricius)	Widespread Pest	Smith (1934)
Solenopsis globularia littoralis Creighton	Savannah River Plant	Van Pelt and Gentry (1985)

Table 3.2: Ants known to inhabit the state of South Carolina		
Species	**County (city)**	**Habitat/Notes**
Solenopsis invicta Buren	All counties Invasive species(Deyrup et al. 2000) Pest	Marsh/Emergent Wetland, Pocosin, Swamps/Bottomland Hardwood, Recently Cleared Land, Upland Pine, Closed Canopy Evergreen Forest/Woodland, Upland Pine Forest, Pine Woodland/Longleaf Pine Savanna, Upland Deciduous Forest, Mesic Deciduous Forest, Upland Mixed Forest, Mesic Mixed Forest, Grassland, Maritime Forest
Solenopsis molesta Say	Pickens (Clemson) Pest	Hand Collection
Solenopsis pergandei Forel	Oconee, Beaufort	Recently Cleared Land
Solenopsis picta Emery	Savannah River Plant	Van Pelt and Gentry (1985)
Solenopsis xyloni McCook	Abbeville, Sumter (Pinewood), Edgefield	Smith (1934)
Stenamma brevicorne (Mayr)	Spartanburg	Hand Collection
Stenamma schmittii Wheeler	Oconee, Pickens	Pine Woodland/Longleaf Pine Savanna, Upland Deciduous Forest, Mesic Deciduous Forest, Upland Mixed Forest
Tapinoma melaonocephalum Fabricius	Pest species[6]	

Table 3.2: Ants known to inhabit the state of South Carolina		
Species	**County (city)**	**Habitat/Notes**
Tapinoma sessile (Say)	Abbeville, Aiken, Bamberg, Barnwell, Beaufort, Berkeley, Chesterfield, Colleton, Edgefield, Fairfield, Greenwood, Hampton, Jasper, Newberry, Oconee, Orangeburg, Pickens, Richland, Sumter, Union, Greenville Anderson Pest species	Pocosin, Swamps/Bottomland Hardwood, Recently Cleared Land, Upland Pine, Closed Canopy Evergreen Forest/Woodland, Upland Pine Forest, Pine Woodland/Longleaf Pine Savanna, Upland Deciduous Forest, Mesic Deciduous Forest, Upland Mixed Forest, Mesic Mixed Forest, Grassland
Technomyrmex albipes (F. Smith)	Richland Pest species	New record
Tetramorium caespitum (L.)	Beaufort(Deyrup et al. 2000) Pest species[6]	CUAC
Tetramorium languinosa (Mayr)	Beaufort(Deyrup et al. 2000) Pest species	CUAC
Tetramorium obesum Andre		
Tracymyrmex septentrionalis (McCook)	Aiken, Barnwell, Charleston, Chesterfield, Edgefield, Georgetown, Pickens	Swamps/Bottomland Hardwood, Recently Cleared Land, Pine Woodland/Longleaf Pine Savanna, Mesic Deciduous Forest, Mesic Mixed Forest, Maritime Forest

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CHAPTER FOUR

DISTRIBUTION AND SPECIES RICHNESS OF ANTS IN SOUTH CAROLINA

INTRODUCTION

The case for using invertebrates as indicators of biodiversity and the difficulties of relying solely upon vertebrate indicator species has been well made over the last decade(Majer 1982, 1983, Kremen et al. 1993a, Oliver and Beattie 1996b, a, Andersen 1997a, b, c, d, Vanderwoude et al. 1997). In spite of the arguments, invertebrates are only rarely used in diversity studies. The reasons are varied, but mostly come back to the overwhelming diversity of invertebrate species and the relative lack of knowledge about their taxonomy and biology.

Ants have several characteristics that separate them from the invertebrate noise and bring them to notice as biological diversity indicators. First, while diverse they are not overwhelmingly so. In the United States Florida lists 290 species (Deyrup 2003a). In South Carolina thus far 121 species have been collected and identified in the course of this study. Even with additional information from museum specimens and additional studies the number in South Carolina is unlikely to exceed that of Florida. Thus, a student can learn to identify ants in relatively short period of time. It has also been proposed that even inexperienced students can quickly learn to effectively separate and identify ants using morphospecies identifications (Oliver and Beattie 1993)

Second, ants are easily sampled using a variety of methods including baits, pitfalls, and leaf litter (Agosti et al. 2000). As a group the ants are nearly ubiquitous and highly abundant.

Third, ants act as keystone species within a system. Ants serve roles in seed dispersal (Majer 1978, Majer et al. 1979, Andersen 1980, Majer 1980, Handel et al. 1981, Andersen 1982, Zettler et al. 2001) , soil and nutrient movement (Lyford 1963, Beattie and Culver 1977), energy flow, pollinators, predators, herbivores, and granivores.

Fourth, ants are sensitive to environmental and ecological changes. Their mobility and shorter lifecycles allow the community to reshuffle when changes do take place (Allen et al. 1998b).

With all of these advantages there are some disadvantages. While there are often dichotomous keys available, they are scattered throughout the literature and are often regional in scale. Many of the ants in a key may not be found in the region of interest and some other members may be missing from a given key.

It is actually difficult to collect a square meter sample that does not contain several species of ants. The sheer number of specimens in a single pitfall or leaf litter collection can be daunting. Hölldobler and Wilson state in page one of *the Ants* "To a degree seldom grasped even by entomologist, the modern insect fauna has become predominately social. Recent measurements suggest that about one-third of the entire animal biomass of the Amazonian *terra firme* rain forest is composed of ants and termites with each hectare of soil containing in excess of 8 million ants and 1 million termites. These two kinds of insects, along with the bees and wasps, make up somewhat more than 75% of the total insect biomass"(Hölldobler and Wilson 1990)

Lastly, there are gaps in the understanding of the structure of ant communities. Little is known about how these communities may react to disturbance, or how well they reflect invertebrate biodiversity as a whole.

In 1998, Allen et al. proposed two methods for spatial mapping of ant diversity. The first method used in Florida was literature based. Geographic distributions were determined at the county level using primarily published sources augmented by unpublished data and the experience of selected experts. Distributions in counties with limited information were interpolated from neighboring counties. The literature based information was used to produce an "ant by county" matrix and an "ant by habitat" matrix. The two matrices were used to produce habitat specific models of the ant distributions.

South Carolina has a great potential for myrmecological richness. There are a great diversity of habitats ranging from the mountains to the coastal plains. There are a number of species which find their northern limits in South Carolina such as *Pogonomyrmex badius*, the Florida Harvester Ant, and *Camponotus floridanus*, the Florida Carpenter Ant. There are also a number of species that find their southern range in South Carolina such as *Formica argentea*, and *Pachycondyla chinensis.* In spite of this potential very little mymecological research has been done beyond applied work with the Red Imported Fire Ants *Solenopsis invicta*.

The last statewide work was published by M. R. Smith in 1934. This work consisted of lists of species from 1916 publications as well as material sent to him for identification throughout his career at Clemson College. None of these works mention a location for vouchered specimens. Numerous taxonomic changes have taken place since these publications and fewer than half of the 96 species listed can be reliably identified by the names.

Van Pelt and Gentry (1985) conducted a survey of ant species on 326 acres of the Savannah River Plant. This survey found 63 species to occur within this surveyed habitats. The weakness of this study is the limited scale in which it was conducted. It is difficult to extrapolate their findings to a statewide level without some supporting evidence for doing so.

With this lack of published research based information on the ant fauna of South Carolina, a similar study to that conducted in Florida was not a viable option. For this reason a sample based approach was proposed. It was proposed that sampling could be stratified by the physiographic regions and generalized by the South Carolina GAP Analysis land cover types in each region (Allen et al. 1998a). This work represents the first sample based study of the spatial distributions of ants in South Carolina.

The objective of this study was to: Use GAP methods to develop distributions, species richness and species abundance models for ants collected in South Carolina,

MATERIALS AND METHODS

Pitfall Samples

Pitfall sampling was conducted at 243 sites throughout South Carolina in 1999 and 2000 (Figure 3.1). Sampling was stratified by physiographic region: mountain, piedmont, sandhill and coastal plains (Barry 1944). Sampling was further stratified by landcover type (Table 1) as classified by the SC Gap Analysis Program (Vernon et al. 2001). Approximately ten replicates of each land cover were sampled in each region. Variation in the actual number of replicates of each habitat type was subject the availability of the particular land cover type within the physiographic region. The mountains and piedmont were sampled from May to August of 1999. The sandhills and coastal plains were sampled from May to August of 2000.

The SC GAP land cover map was used to identify potential sites. Potential sites were visually ground truthed for suitability. Sites were deemed suitable if the habitat patch was of a single contiguous land cover type of ≥ 60m x 80m.

Each sample represents a fifty meter transect with pitfalls placed every 5 meters. Pitfalls consisted of a PVC sleeve that was drilled into the ground a Pyrex test tube was inserted into the sleeve. The tube was level with the ground surface and remained in place for approximately one week.

Data collected at each sampling site also included: observed habitat type, date, temperature, estimated maximum vegetation height, aspect and degree of slope of the terrain, percent canopy cover, and percent of understory cover.

The predicted distribution models used collection data to predict habitat affinities and land cover data from the GAP Analysis program to highlight areas matching these affinities. The distribution was further stratified by physiographic region. County lines were used as a fine filter within physiographic regions. Ants were not modeled in a habitat if less than 5% of the species collected was represented in the habitat per physiographic region. A species was modeled however if more than 100 ants were counted even if it represented less than 5% of the total population collected in the physiographic region.

A species richness model was created by layering each of the predicted distribution maps for individual species then adding the respective layers using GIS Software. The probability of encountering a particular ant species was calculated using landscape type and physiographic region as filters. The probability was calculated as the number of ants of a given species in X landscape type and X physiographic region divided by the total number of ants collected in X landscape type and X physiographic region.

Figure 4.1 Steps used to model distribution of ant species.

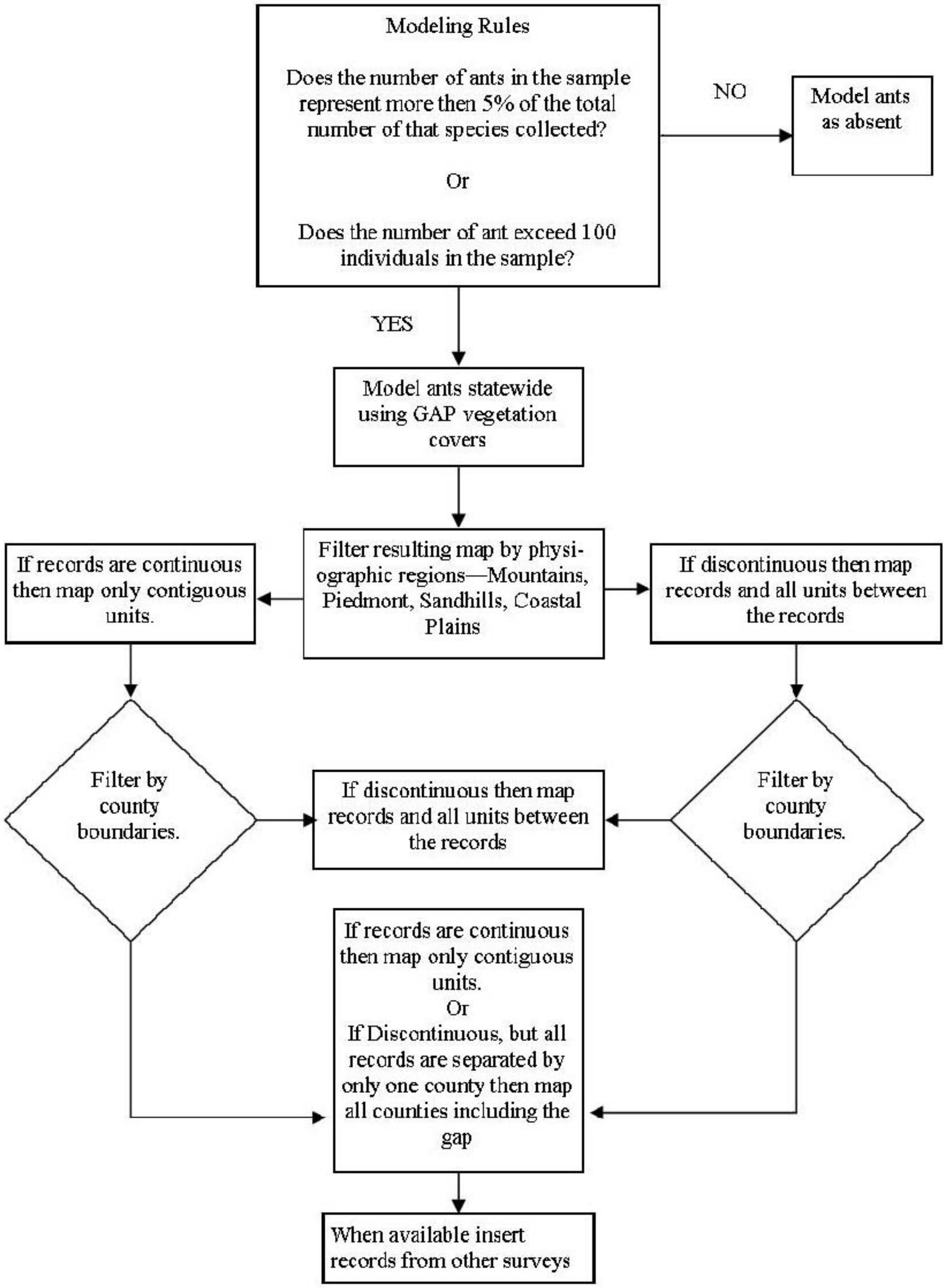
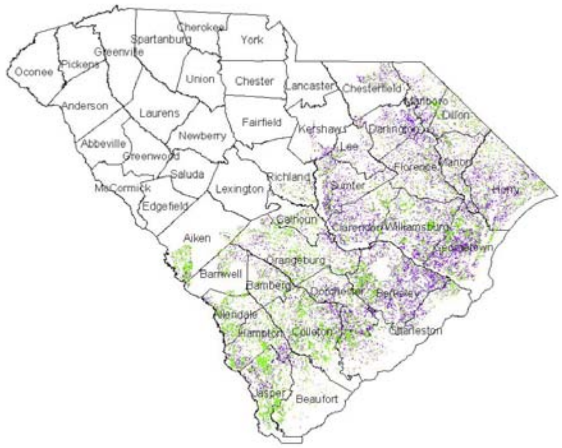
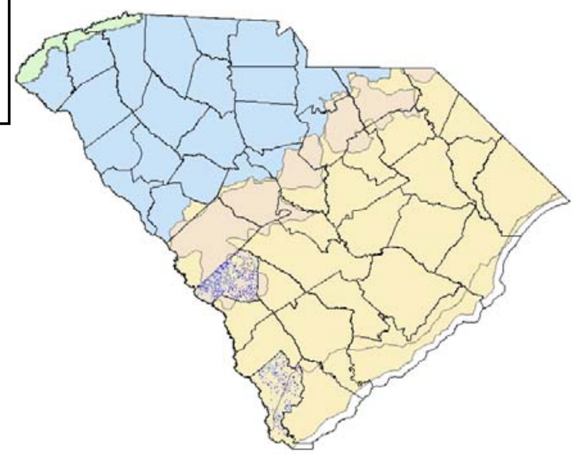


Figure 4.2: Example of decision model using *Camponotus floridanus*



Samples from collection found *C. floridanus* to occur only in the coastal plains and in vegetation type 15 and 16.



When filtered for county records found it to occur in only two counties as seen to the right.

Using the model rules the map to the left indicates the predicted distribution of the species.

However in this case there is additional information that can be added from a previous study that showed *C. floridanus* records in additional counties resulting in the final model presented on the right.

RESULTS

The collection consisted of 243 transects consisting of 2673 individual pitfall traps. A total of 41,414 individual ants were captured, counted, and identified. The distribution of 65 species were modeled.

The first modeling rule "Does the number of ants in the sample represent more than 5% of the total number of that species collected, or does the number of ants exceed 100 individuals in the sample?" did not come into play since each sample that contained a species had more than 5% of the total number of that species collected.

For results of the distribution models see Figure 3.4 – Figure 3.67. For results of the species richness model see Figure 3.68. The majority of the models were relatively straight forward with statewide distributions based upon the specimens collected.

In some cases the predicted model varied greatly from known collected samples. Distributions are provided for both the predicted or possible distribution and mapped according to known distributions. For example, *Pachycondylya chinensis* currently has only been collected in mountain and piedmont region of Oconee and Pickens Counties. The rules of the model would suggest that the possible distribution of *P. chinensis* could potential also cover all the counties of the piedmont. A distribution map for both distributions is provided. This specific situation is used as an example earlier in this chapter. The potential uses of these differing models is also discussed in the conclusion section of this chapter.

Another difficult model is *Camponotus floridanus* in the southern coastal plains. This ant was given as an example in figure 4.2. The actual distribution based upon collections is limited to the southern most counties, but the potential exists for it to be found throughout the coastal plains. This is the northern most record of the species perhaps, in this case, we are on the northern most extent of the range. Another possibility is the species has the potential to spread further and has not yet done so, or has not yet been collected in past surveys for the species. While both potential distributions are presented in the example the more restrictive model is consistent with past surveys for *C. floridanus* (Sargent 2002).

The *Apaenogaster fulva* Roger distribution map (Figure 4.5) appears at first glance to have been modeled for the mountains, sandhills, and coastal plains and not for the the piedmont regions of the state. First, the density of the darkened pixels does not represent the relative abundance of the ant. It actually represents how close the predicted habitats are to each other. Secondly, this map likely under represents the distribution of *A. fulva*. *A. fulva* is part of a species group often refered to as the "*rudis*" group. This group of ants is very similar morphologically and contains several species that are indistinguishable with morphological characters. Some species such as *A. fulva* can sometimes be distinguished with characters that are often highly variable. Usually a series of individuals from the same colony are needed to confidently identify these species. In our case the use of pitfalls excludes the use of a colony series. Thus many individuals which may have indeed been *A. fulva* could have been lumped into the rudis group in the absence of solid characters. The species was identified when the characters were strong enough to confidently do so.

The distribution of the Red Imported Fire Ant, *Solenopsis invicta* Buren, was expanded based upon this study. Parris (Parris 2002) used sugar baits concurrent with the pitfall collections. The baits did not yield any *S. invicta* hits in the mountain region. The pitfalls, however, did have one hit that met the criteria for modeling the mountain region. Further visits to the region were conducted and casual survey confirms that the ants are consistently present though they are in relatively lower numbers than are observed in the Piedmont to Coastal Plains of South Carolina. These observations along with the collection data were used to confirm that *S. invicta* should be modeled in the region.

Species Richness

The statewide richness model is presented in Figure 4.68 as well as Tables 4.2 – 4.15. The tables present a list of ants that were collected in each physiographic region and landscape type. The tables also provide an expected value for these ant species by physiographic region and landscape type.

These values show that the greater the sampling intensity the greater the observed richness. It was not practical due to the scale of this study to sample more intensively, but they also suggest that future studies are needed give the species richness picture a more robust resolution.

DISCUSSION AND CONCLUSIONS

This work represents the first systematic collection of ants in South Carolina since Van Pelt and Gentry in the mid 1970's and the first statewide survey since M. R. Smith in 1916. Of these studies this collection is the largest. The view of this study is more telescopic rather than microscopic. This collection should not, however, be the final comment on ants in South Carolina. More intensive studies of specific landscape types will undoubtedly reveal more species richness than was revealed in this collection.

It is important to realize this collection is a puzzle with several important pieces missing. Some of the habitats found in South Carolina were not surveyed such as golf courses, campgrounds, urban and residential areas. Many of the tramp ant species closely associated with human activity and disturbance are poorly represented in the collection such as *Monomorium minimum, Monomorium pharanosis, Linepithema humile*. The importance of these habitats is not to be overlooked, but because of logistical limitations a decision was made to focus on the habitats most important to natural resource managers since GAP was designed as a natural resources management tool.

The use of pitfalls means that this collection represents largely epigeic ants. Species that are primarily subterranean such as the Dacetine ants are underrepresented. The only arboreal species represented are those that spend some portion of time on the surface such as *Crematogaster*, *Leptothrorax,* or *Lasius*. Other species that have been hand collected such as the *Pseudomyrmecinae* an arboreal genus are completely missing from the collection.

Another missing puzzle piece is the temporal equation. This survey was conducted one time at each location. Variations due to the season, temperature, rainfall, or photoperiod are not well represented in this collection. For example, *Prenolepis imparis* which are active only in the fall and winter months are not represented in the portion of the collection obtained during the warmest part of the summer months, but appear in the portions collected in the fall season.

In spite of the missing puzzle pieces it is still the best picture we have of the ants of South Carolina, their associated habitats, distributions, relative abundance, and community relationships. These data provide some expected values for future studies of the ant fauna in South Carolina. Future studies can compare detailed collections of landscape types and test them for differences. These future data can be added to this information to refine and fine tune these models. It is hoped that this study can and will be used in the future to specifically fill in the gaps in South Carolina's myrmecological fauna.

Many of these landscape types and physiography are also present in our neighboring states. An examination of the literature suggests that we also share many of the same ants species (Carter 1962, Isper et al. 2004). These data could easily be expanded to make predictive models of ant populations in neighboring states. Future studies could be conducted to test the veracity of such models over a larger scale.

There are several ways this information can be useful. For example the Red Imported Fire Ant *S. invicta* is under a federal quarantine enforced by the USDA-APHIS. These data were used to predict the range of RIFA in South Carolina. Ground truthing of these predictions was conducted to substantiate the model. The resulting information was then used to support the modification of the quarantine zone. In this case, the model provided information that allowed ground observations to be targeted to the most likely locations for RIFA. The model also established a scientific basis for making the decision and removed the potential for political bias to enter the decision.

The range of RIFA is still expanding in North Carolina. This model if expanded to include North Carolina could be used in combination with other models (Thompson et al. 1998, Morrison et al. 2004), and could provide an accurate picture of the potential future RIFA range. Regulators could use such predictions in surveys for RIFA and maximize the efficiency of such surveys.

Another interesting distribution is that of an invasive species such as *P. chinensis*. *Pachycondyla chinensis* has a painful sting and the potential as species of medical and veterinary significance. Several cases of allergic reactions to the stings have been reported (Bae et al. 1999, Kim et al. 2001). Is this an invasive whose territory is expanding? *Pachycondyla chinensis* was found only in the mountains and piedmont regions of Oconee and Pickens Counties, however, it has been reported as an emerging problem (Nelder et al. 2006). Using the rules of the model the distribution of the ant would be only in those two counties. If, however, the range of this invasive ant is expanding the model could be used to predict the possibility that it could cover the entire mountain and piedmont region. This study now provides some base line data for future studies. Surveys could use them model to target surveys to the areas most likely to host this invasive ant reducing the size and scope of potential survey methods.

One of the increasing problems in South Carolina is urban sprawl. The Strom Thurmond Institute at Clemson University (STI) and the South Carolina Department of Natural Resources (SCDNR) have been involved in projects to detect change and project future growth changes in the state. SCGAP proposes that their data can be used to monitor urban sprawl and the accompanying changes in habitat (p. 95 SCGAP final report).

Ants have been used in Australia as indicators to track the progress of mine restoration projects (Majer 1982, 1983). The species profile of a restoration project is compared with the species profile of the target landscape type.

The search for the perfect indicator species does not end with the ants, however ants do provide a number of advantages as tools for indicating environmental or ecological change.

- They are present in most habitats and are found in large numbers.

- They are active in a relatively small scale and don't roam outside of the study area.
- While ant taxonomy is somewhat difficult it is relatively easy for field technicians to learn to identify a suite of ants to a morphospecies level.
- The presence of several ant species is sharply defined by the habitat types in which they are found.
- Ants are easy to collect using a number of collection methods such as pitfalls or litter samples.
- Ant species are often partitioned throughout the landscape. Some ants are found primarily or exclusively in subterranean environment, other are epigeic, still others are arboreal. Changes in any of these environments can impact the presence or absence of given ant species.

The inclusion of ants as one of an ensemble of indicator species can help with several questions facing the landscape ecologist in South Carolina. Similar to Australia ants could be a valuable contribution is answering questions surround the success of restoration projects. The addition of ants as indicators may also be able to provide ecological tools for measuring the impact of land management decisions.

These data are certainly not inclusive of all the possible ants that can be found in a given landscape type. The fact that areas that were more intensively sampled yielded a greater species richness suggests that more sampling in the future would yield a more robust view of the population. Thus these data are not a perfect tool as indicators of ecological change. These data do, however, provide a baseline and expected values for similar uses in South Carolina that can be used in future studies. They are also the *only* available view of the ant populations in South Carolina.

Figure 4.3: *Aphaenogaster flemingi* M.R. Smith, 1928

Counties: Aiken, Barnwell, Horry

Habitat: Upland Pine Forest, Pine Woodland/Longleaf Pine Savanna, Mesic Mixed Forest

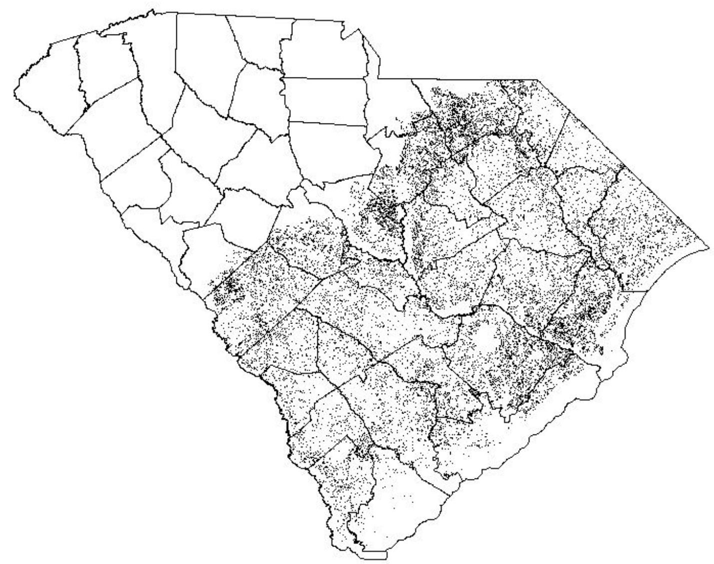


Figure 4.4 *Aphaenogaster fulva* Roger, 1863

Counties: Barnwell, Berkley, Edgefield, McCormick, Oconee, Pickens, Richland Pocosin,

Habitat: Swamps/Bottomland Hardwood, Pine Woodland/Longleaf Pine Savanna, Upland Deciduous Forest, Mesic Deciduous Forest, Upland Mixed Forest

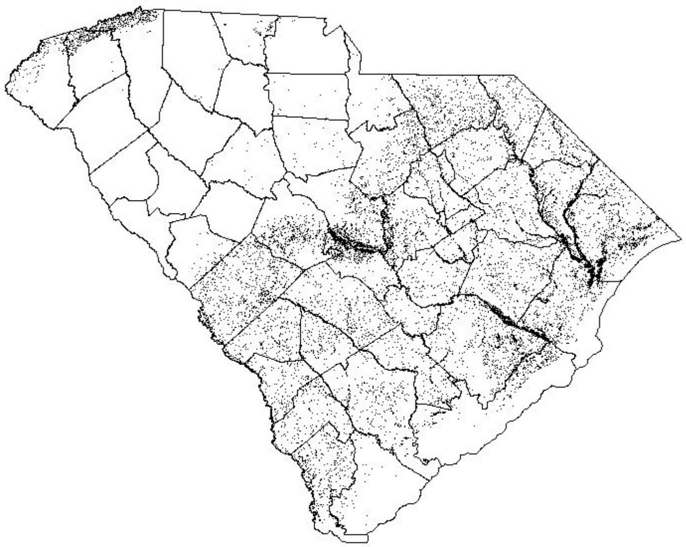


Figure 4.5 *Aphaenogaster lamellidens* Mayr, 1886

Counties: Georgetown

Habitat: Maritime Forest

Figure 4.6 *Aphaenogaster mariae* Forel, 1886

Counties: Anderson, Richland

Habitat: Swamps/Bottomland Hardwood, Upland Deciduous Forest

Figure 4.7: *Aphaenogaster picea* (Wheeler, 1908)

Counties: Abbeville, Beaufort, Berkley, Colleton, Oconee, Pickens, Union

Habitat: Swamps/Bottomland Hardwood, Recently Cleared Land, Aquatic Vegetation, Pine Woodland/Longleaf Pine Savanna, Upland Deciduous Forest, Upland Deciduous Forest, Mesic Deciduous Forest, Upland Mixed Forest

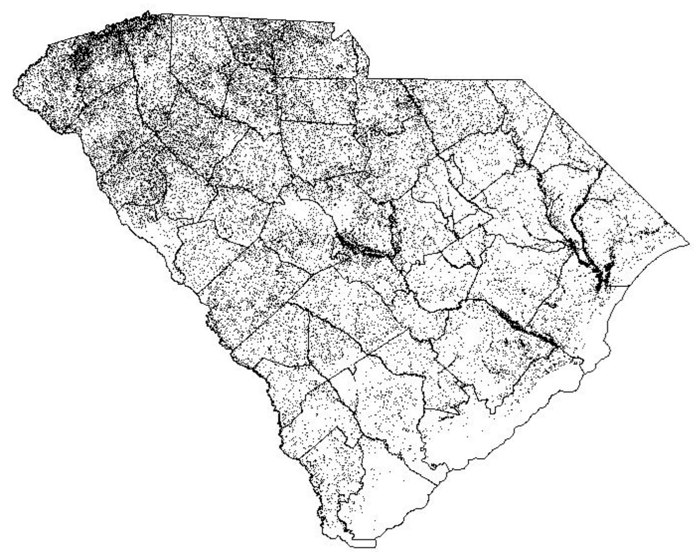


Figure 4.8 *Aphaenogaster tennesseensis* (Mayr, 1862)

Counties: Berkley, Clarendon, Richland

Habitat: Marsh/Emergent Wetland, Swamps/Bottomland Hardwood

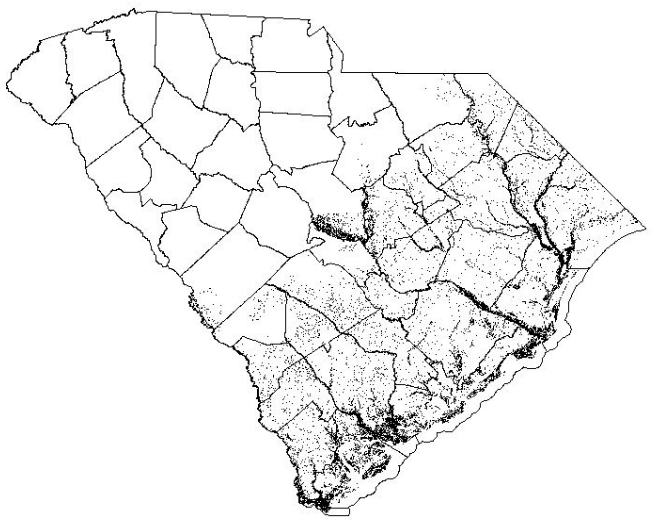


Figure 4.9 *Aphaenogaster treatae* Forel, 1886

Counties: Aiken, Barnwell, Chesterfield, Richland

Habitat: Pocosin, Closed Canopy Evergreen Forest/Woodland, Pine Woodland/Longleaf Pine Savanna, Mesic Mixed Forest

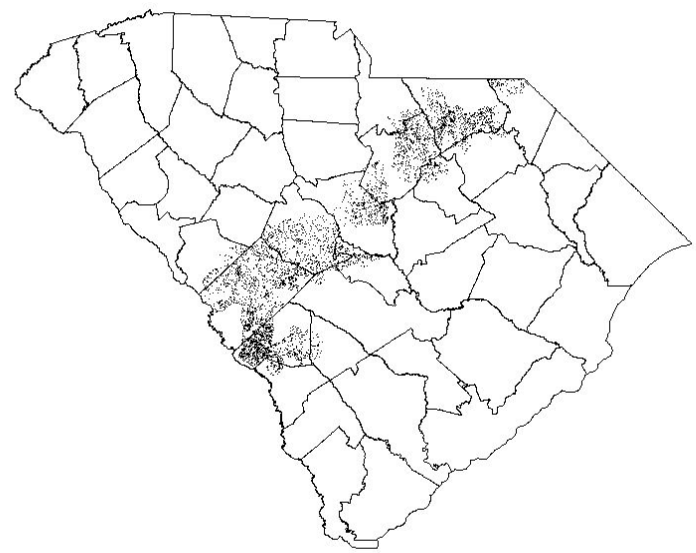


Figure 4.10 *Apheanogaster ashmaedi* (Emery, 1895)

Counties: Abbeville, Anderson, Barnwell, Charleston, Chesterfield, Edgefield, Georgetown, Greenville, Greenwood, Horry, Kershaw, Laurens, Oconee, Pickens, Richland, Spartanburg, Union

Habitat: Pocosin, Recently Cleared Land, Aquatic Vegetation, Closed Canopy Evergreen Forest/Woodland, Upland Pine Forest, Pine Woodland/Longleaf Pine Savanna, Upland Deciduous Forest, Mesic Deciduous Forest, Upland Mixed Forest, Mesic Mixed Forest, Maritime Forest

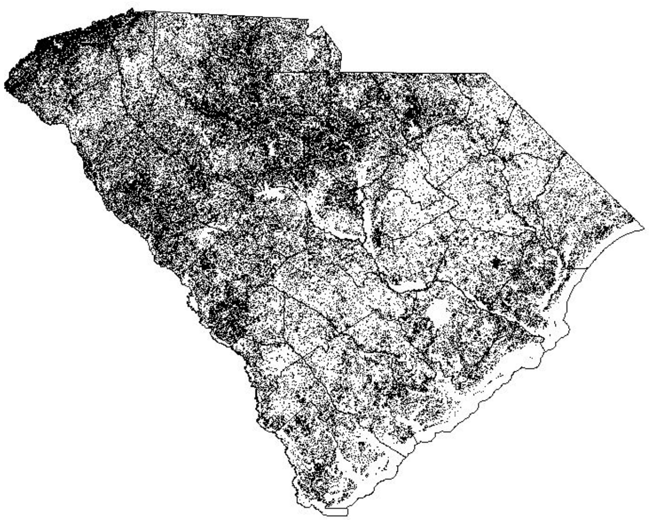


Figure 4.11 *Apheanogaster fulva rudis* Enzmann, 1947

Counties: Statewide

Habitat: Pocosin, Recently Cleared Land, Aquatic Vegetation, Closed Canopy Evergreen Forest/Woodland, Upland Pine Forest, Pine Woodland/Longleaf Pine Savanna, Upland Deciduous Forest, Mesic Deciduous Forest, Upland Mixed Forest, Maritime Forest

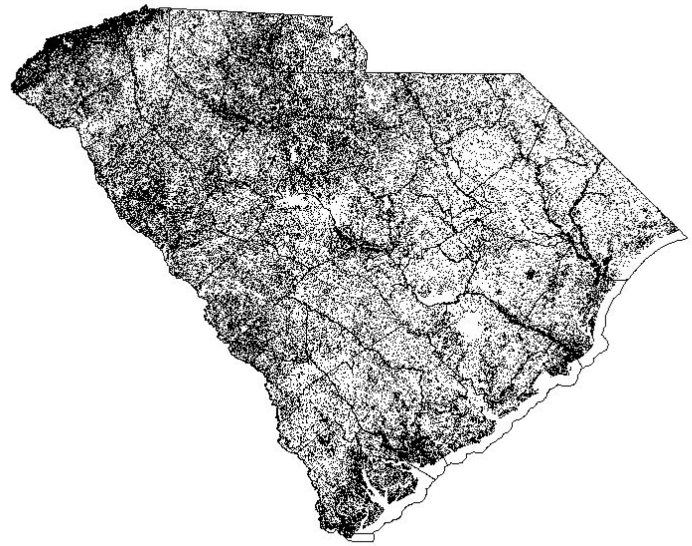


Figure 4.12 *Camonotus casteneus* (Latreille)

Counties: Aiken, Bamberg, Barnwell, Berkeley, Charleston, Cheserfield, Clarendon, Georgetown, Horry, Kershaw, Richland, Sumter, Williamsburg

Habitat: Marsh/Emergent Wetland, Pocosin, Swamps/Bottomland Hardwood, Recently Cleared Land, Closed Canopy Evergreen Forest/Woodland, Upland Pine Forest, Pine Woodland/Longleaf Pine Savanna, Upland Deciduous Forest, Maritime Forest

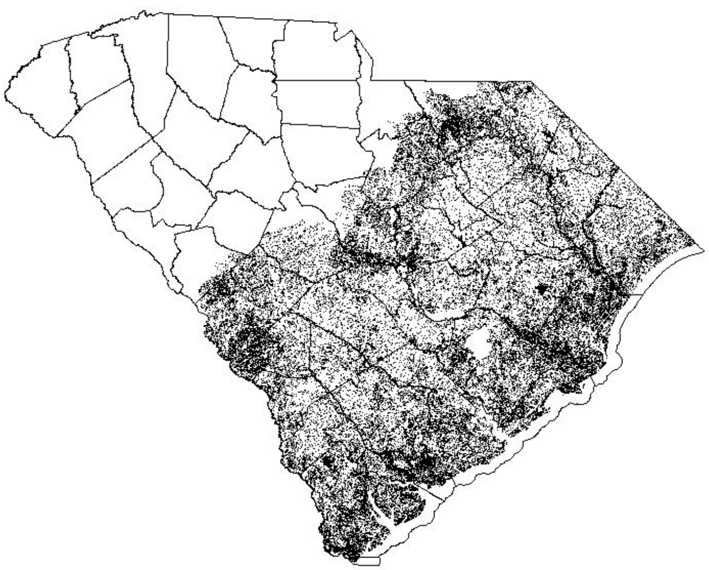


Figure 4.13 *Camponotus americanus* (Mayr, 1862)

Counties: Abbeville, Aiken, Bamberg, Beaufort, Berkeley, Charleston Greenville, Laurens,Newberry, Oconee, Orangeburg, Pickens, Sumter, York

Habitat: Swamps/Bottomland Hardwood, Recently Cleared Land, Aquatic Vegetation, Pine Woodland/Longleaf Pine Savanna, Upland Deciduous Forest, Mesic Deciduous Forest, Upland Mixed Forest, Grassland, Maritime Forest

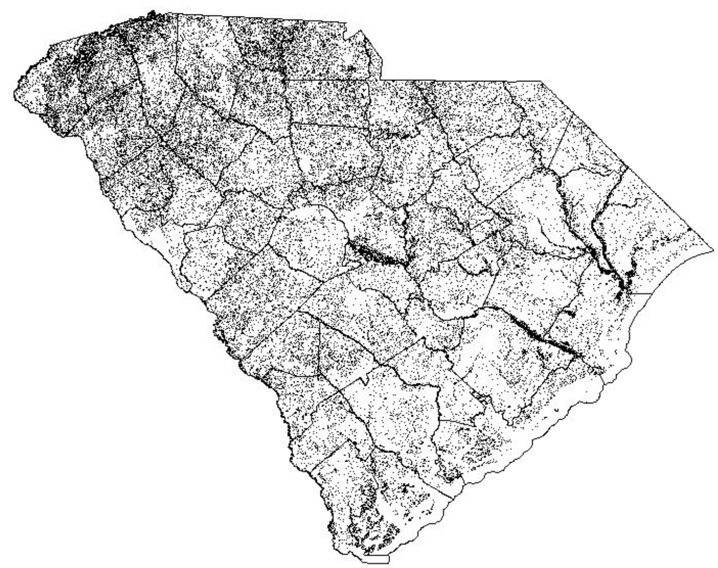


Figure 4.14 *Camponotus chromaiodes* Bolton, 1995

Counties: Aiken, Bamberg, Barnwell, Berkeley, Hampton, Kershaw, Richland, Oconee

Habitat: Pocosin, Swamps/Bottomland Hardwood, Closed Canopy Evergreen Forest/Woodland, Upland Pine Forest, Pine Woodland/Longleaf Pine Savanna, Upland Deciduous Forest, Mesic Deciduous Forest, Upland Mixed Forest

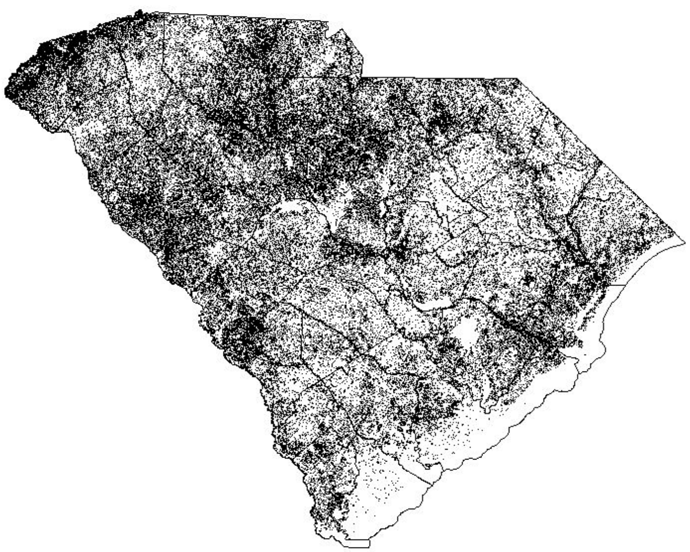


Figure 4.15 *Camponotus floridanus* (Buckley, 1866)

Counties: Barnwell, Jasper

Habitat: Closed Canopy Evergreen Forest/Woodland, Upland Pine Forest

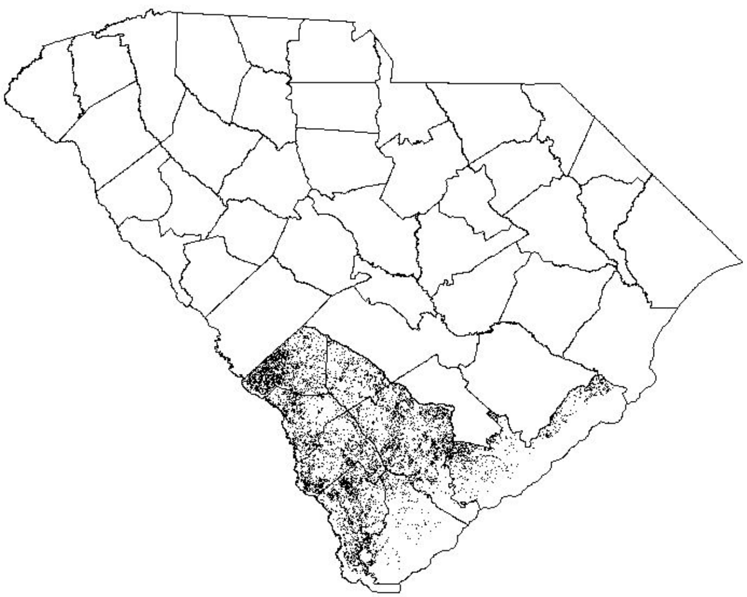


Figure 4.16 *Camponotus pennsylvanicus* (DeGeer, 1773)

Counties: Abbeville, Bamberg, Barnwell, Beaufort, Berkeley, Charleston, Clarendon, Georgetown, Kershaw, Laurens, McCormick, Oconee, Pickens, Richland, Sumter, York

Habitat: Marsh/Emergent Wetland, Pocosin, Swamps/Bottomland Hardwood, Recently Cleared Land, Aquatic Vegetation, Pine Woodland/Longleaf Pine Savanna, Maritime Forest, Upland Mixed Forest, Grassland

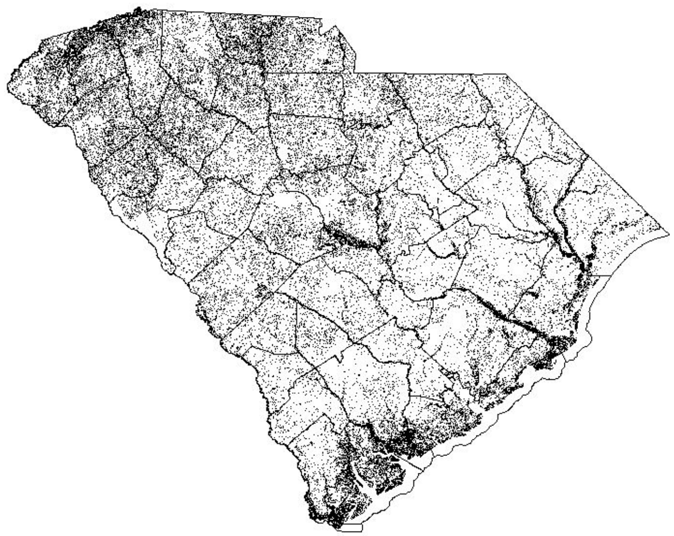


Figure 4.17 *Crematogaster ashmeadi* Mayr, 1886

Counties: Pickens

Habitat: Pine Woodland/Longleaf Pine Savanna

Figure 4.18 *Crematogaster atkinsoni* (Wheeler), 1919

Counties: Abbeville, Aiken, Anderson, Bamberg, Berkeley, Fairfield, Laurens, Oconee, Pickens

Habitat: Pocosin, Swamps/Bottomland Hardwood, Aquatic Vegetation, Closed Canopy Evergreen Forest/Woodland, Pine Woodland/Longleaf Pine Savanna, Upland Deciduous Forest, Mesic Deciduous Forest, Maritime Forest

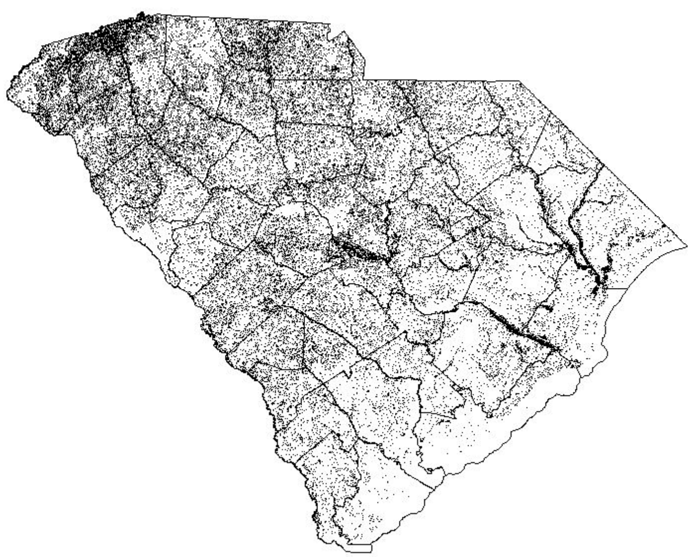


Figure 4.19 *Crematogaster cerasi* (Fitch, 1855)

Counties: Aiken, Bamberg, Barnwell, Beaufort, Berkeley, Georgetown, Hampton, Kershaw, McCormick, Orangeburg, Newberry, Pickens, Sumter

Habitat: Swamps/Bottomland Hardwood, Recently Cleared Land, Aquatic Vegetation, Pine Woodland/Longleaf Pine Savanna, Upland Deciduous Forest, Mesic Deciduous Forest, Upland Mixed Forest, Mesic Mixed Forest, Grassland

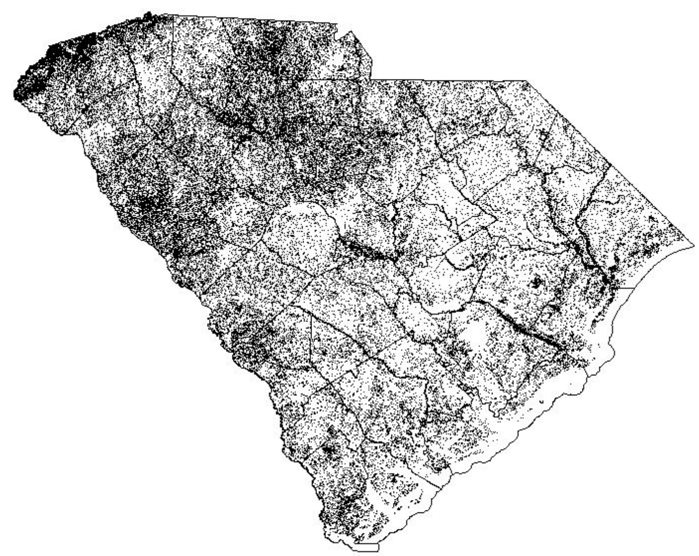


Figure 4.20 *Crematogaster lineolata* (Say. 1836)

Counties: Abbeville, Aiken, Anderson, Bamberg, Barnwell, Beaufort, Berkeley, Charleston, Chesterfield, Clarendon,Edgefield, Fairfield, Georgetown, Greenville, Greenwood, Horry, Kershaw, Laurens, Lee, McCormick, Newberry, Oconee, Orangeburg, Pickens, Richland, Spartanburg, Union, Williamsburg, York

Habitat: Marsh/Emergent Wetland, Pocosin, Swamps/Bottomland Hardwood, Recently Cleared Land, Aquatic Vegetation, Closed Canopy Evergreen Forest/Woodland, Upland Pine Forest, Pine Woodland/Longleaf Pine Savanna, Upland Deciduous Forest, Mesic Deciduous Forest, Upland Mixed Forest, Mesic Mixed Forest

Figure 4.21 *Crematogaster pilosa* Emery, 1895

Counties: Abbeville, Chesterfield, Greenville, Newberry, Oconee, Pickens

Habitat: Pocosin, Recently Cleared Land, Pine Woodland/Longleaf Pine Savanna, Upland Deciduous Forest, Mesic Deciduous Forest, Mesic Mixed Forest, Grassland

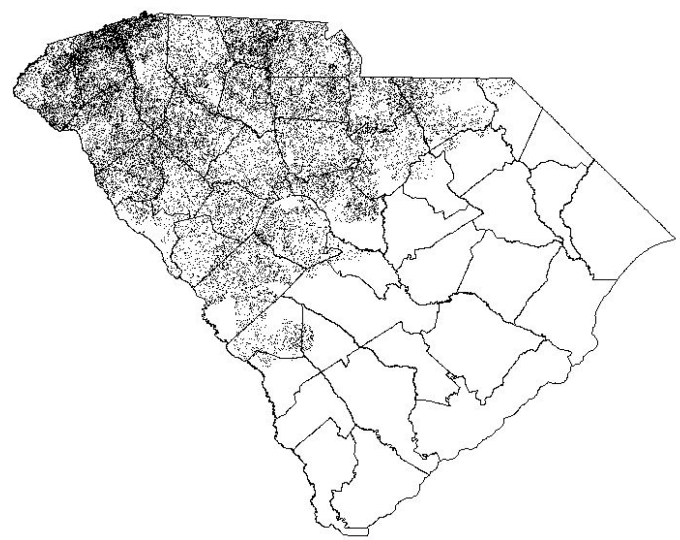


Figure 4.22 *Cyphomyrmex rimosus* (Spinola, 1853)

Counties: Beaufort, Georgetown, Jasper, Williamsburg

Habitat: Recently Cleared Land, Aquatic Vegetation, Upland Pine Forest, Mesic Mixed Forest, Maritime Forest

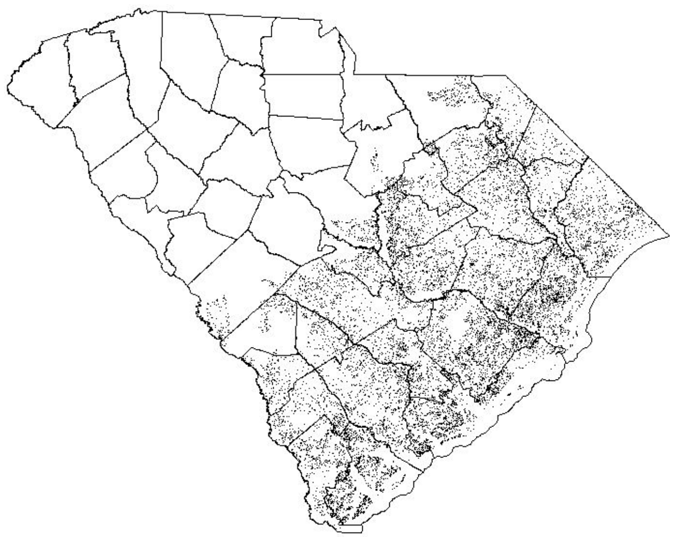


Figure 4.23 *Dolichoderous pustulatus* Mayr, 1886

Counties: Aiken, Clarendon, Horry, Oconee

Habitat: Marsh/Emergent Wetland, Aquatic Vegetation, Closed Canopy Evergreen Forest/Woodland Upland Pine Forest

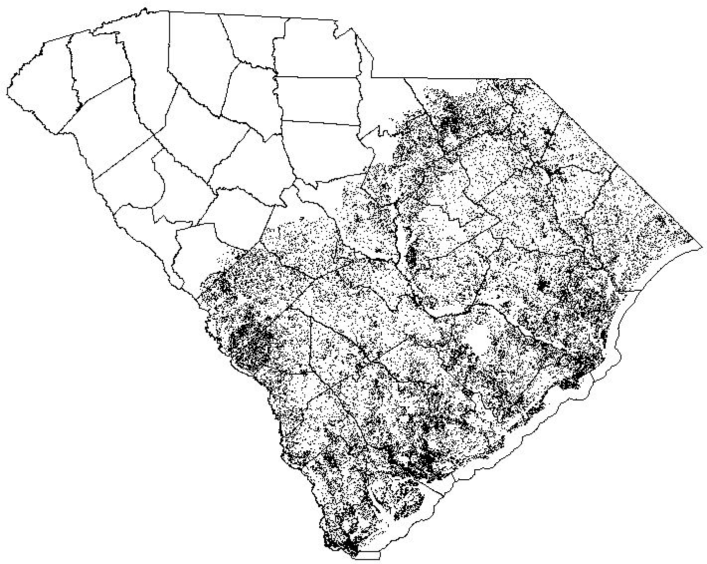


Figure 4.24 *Dolichoderus mariae* Forel, 1885

Counties: Aiken, Chesterfield, Richland

Habitat: Closed Canopy Evergreen Forest/Woodland, Mesic Mixed Forest

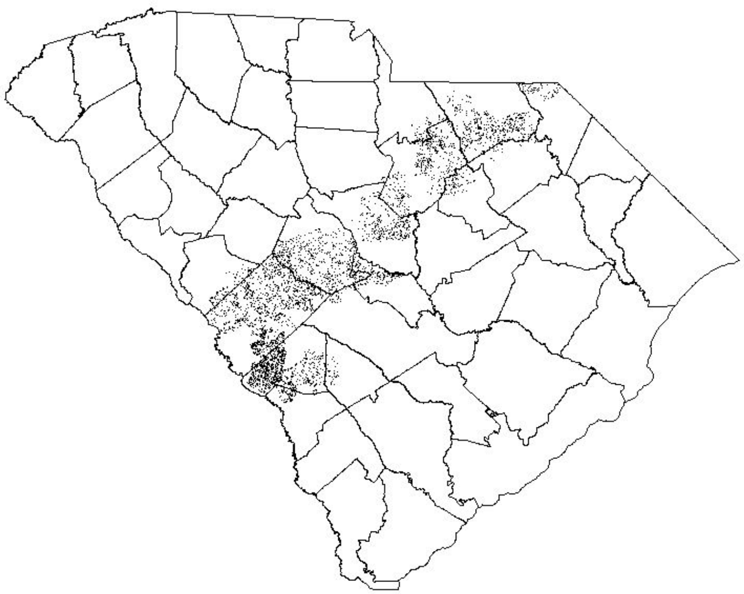


Figure 4.25 *Dorymyrmex bureni* Trager, 19881

Counties: Aiken, Barnwell, Beaufort, Charleston, Chesterfield, Colleton, Hampton, Horry, Kershaw, Oconee, Orangeburg, Pickens, Richland, Sumter

Habitat: Swamps/Bottomland Hardwood, Recently Cleared Land, Aquatic Vegetation, Closed Canopy Evergreen Forest/Woodland, Upland Pine Forest, Pine Woodland/Longleaf Pine Savanna, Upland Deciduous Forest, Mesic Mixed Forest, Grassland

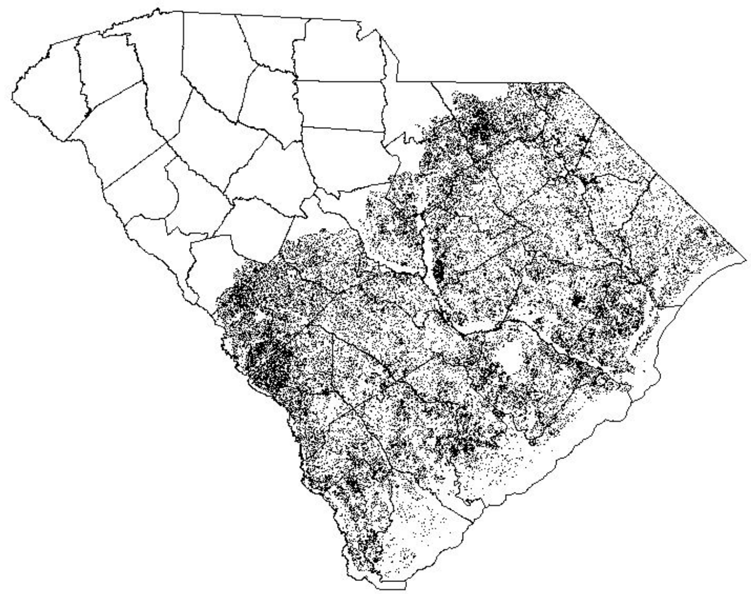


Figure 4.26 *Dorymyrmex medeis* Trager, 1981

Counties: Aiken, Barnwell, Chesterfield, Kershaw, Sumter

Habitat: Recently Cleared Land, Closed Canopy Evergreen Forest/Woodland, Mesic Mixed Forest

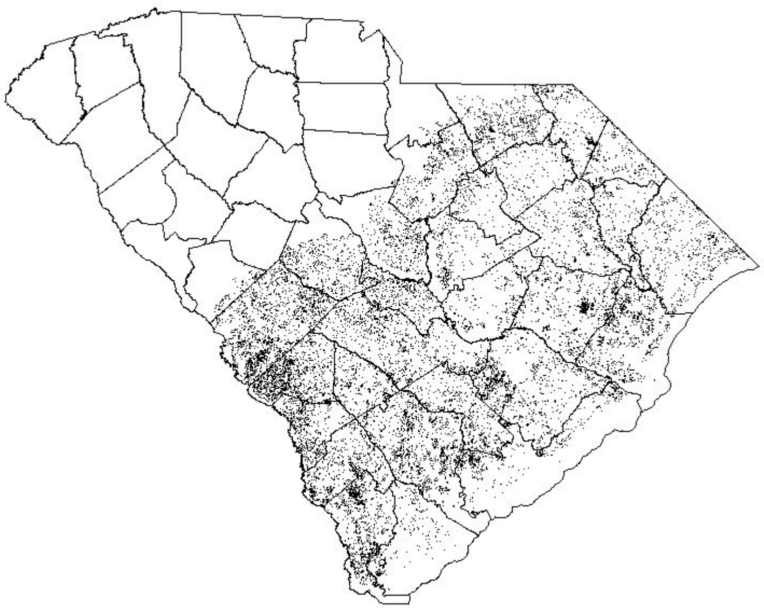


Figure 4.27 *Forelius mccooki* (McCook, 1879)

Counties: Horry, Oconee, Sumter, Union

Habitat: Recently Cleared Land, Aquatic Vegetation, Upland Pine Forest, Mesic Mixed Forest, Grassland

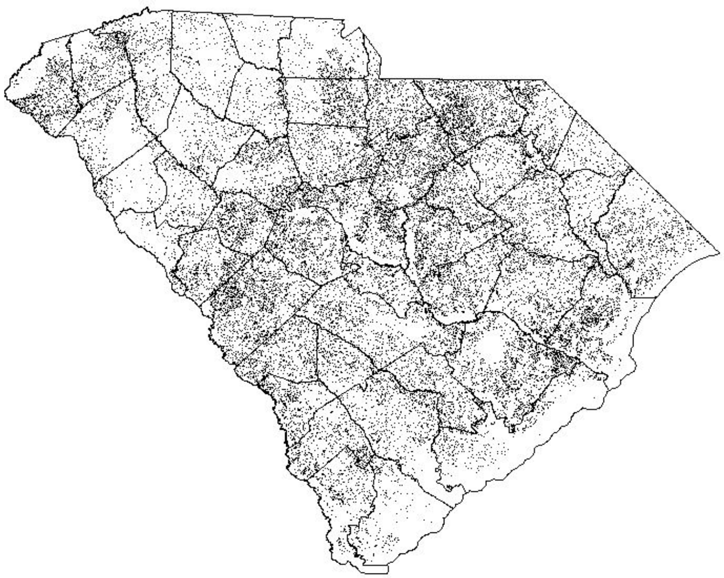


Figure 4.28 *Forelius pruinosus* (Roger, 1863)

Counties: Aiken, Barnwell, Chesterfield, Pickens

Habitat: Closed Canopy Evergreen Forest/Woodland, Upland Deciduous Forest, Mesic Mixed Forest

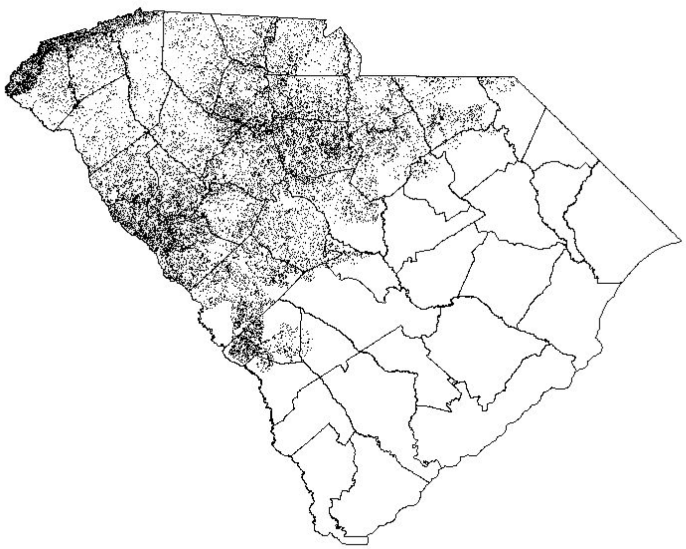


Figure 4.29 *Formica argentea* Wheeler, 1912

Counties: Aiken, Richland, Oconee

Habitat: Pine Woodland/Longleaf Pine Savanna, Mesic Deciduoous Forest

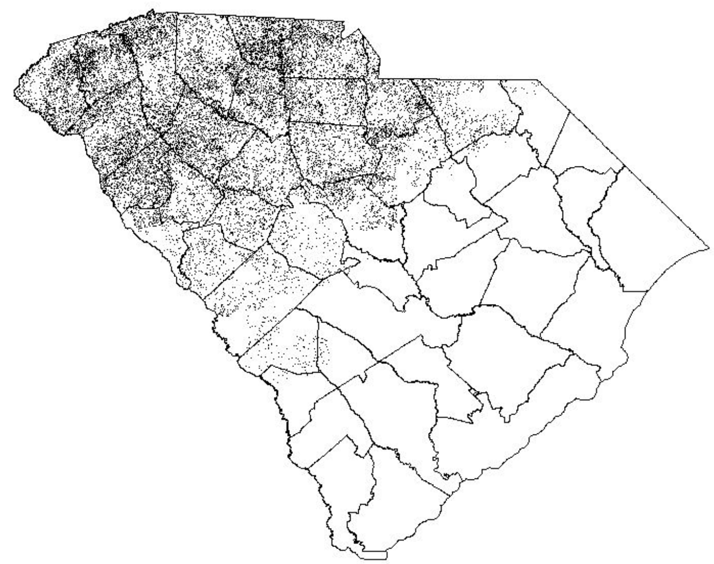


Figure 4.30 *Formica integra* Nylander, 1856

Counties: Oconee, Lexington

Habitat: Pine Woodland/Longleaf Pine Savanna, Upland Deciduous Forest, Mesic Deciduous Forest, Mesic Mixed Forest, Grassland

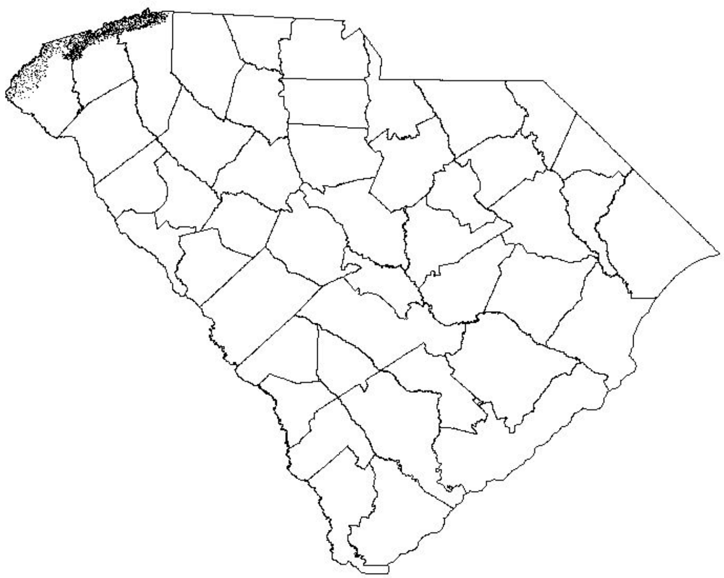


Figure 4.31 *Formica pallidefulva dolosa* Buren, 1944

Counties: Aiken, Barnwell, Berkeley, Chesterfield, Georgetown, Horry, Kershaw, Sumter

Habitat: Pocosin, Recently Cleared Land, Aquatic Vegetation, Closed Canopy Evergreen Forest/Woodland Upland Pine Forest, Pine Woodland/Longleaf Pine Savanna

Figure 4.32 *Formica schaufussi* Mayr, 1886

Counties: Abbeville, Bamberg, Beaufort, Berkeley, Charleston, Colleton, Edgefield, Jasper, Laurens, Newberry, Oconee, Pickens, Spartanburg, Union, York

Habitat: Mesic Mixed Forest, Grassland

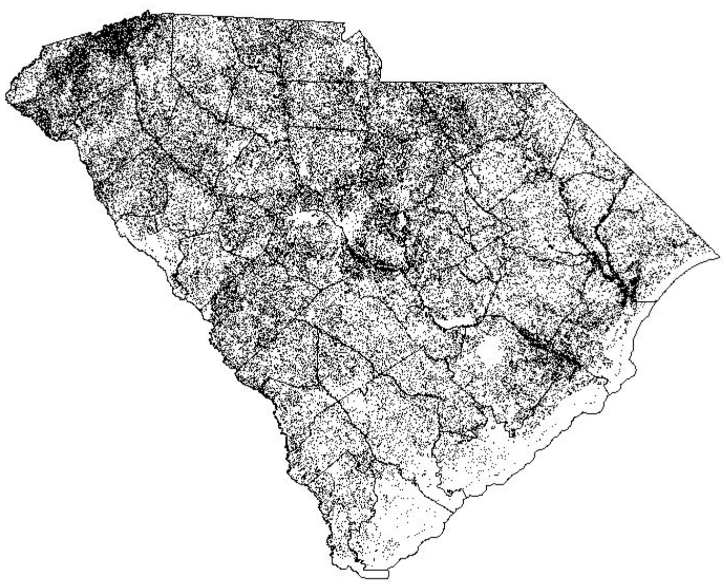


Figure 4.33 *Formica subsericea* Say, 1836

Counties: Beaufort, Oconee, Pickens, Union

Habitat: Aquatic Vegetation, Pine Woodland/Longleaf Pine Savanna, Upland Deciduous Forest, Mesic Deciduous Forest, Upland Mixed Forest, Grassland

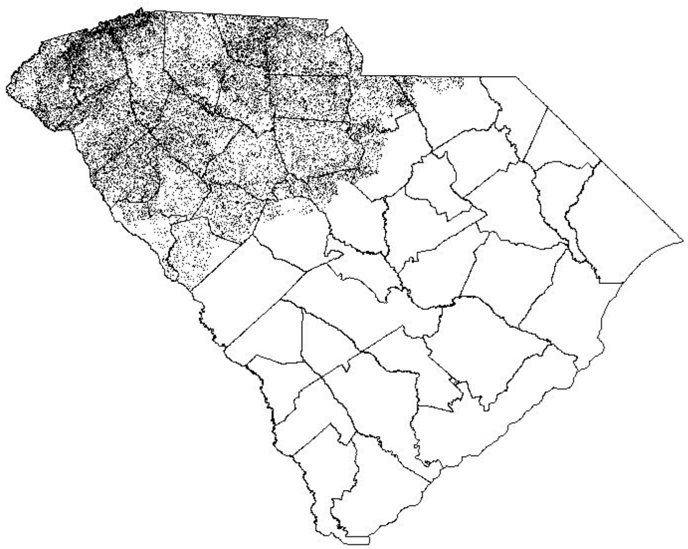


Figure 4.34 *Hypoponera opaciceps* (Mayr, 1887)

Counties: Bamberg, Berkeley, Charleston, Chesterfield, Clarendon, Georgetown, Kershaw, Williamsburg

Habitat: Marsh/Emergent Wetland, Pocosin, Recently Cleared Land, Closed Canopy Evergreen Forest/Woodland, Upland Pine Forest, Upland Deciduous Forest, Mesic Mixed Forest, Maritime Forest

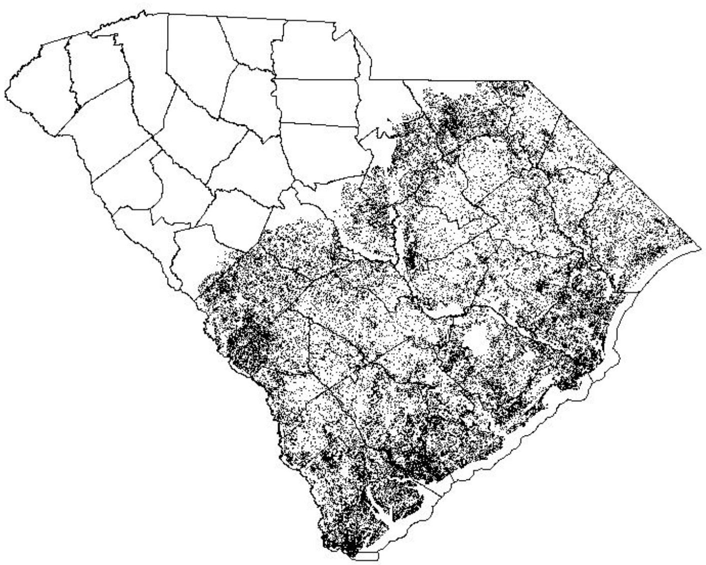


Figure 4.35 *Hypoponera opacior* (Forel, 1893)

Counties: Barnwell, Clarendon, Georgetown, Horry, Kershaw, Richland, Sumter

Habitat: Marsh/Emergent Wetland, Pocosin, Closed Canopy Evergreen Forest/Woodland, Aquatic Vegetation, Upland Pine Forest, Pine Woodland/Longleaf Pine Savanna, Mesic Mixed Forest, Maritime Forest

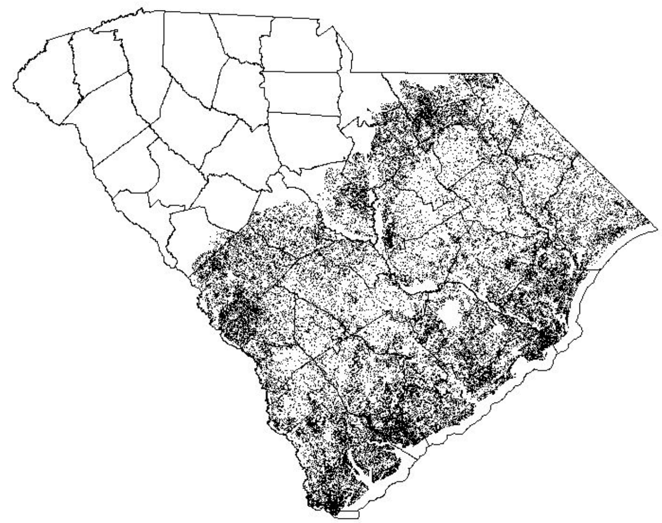


Figure 4.36 *Lasius alienus* (Förster, 1850)

Counties: Aiken, Barnwell, Charleston, Colleton, Dorchester, Oconee, Pickens, Sumter

Habitat: Pocosin, Swamps/Bottomland Hardwood, Upland Deciduous Forest, Upland Mixed Forest, Mesic Mixed Forest

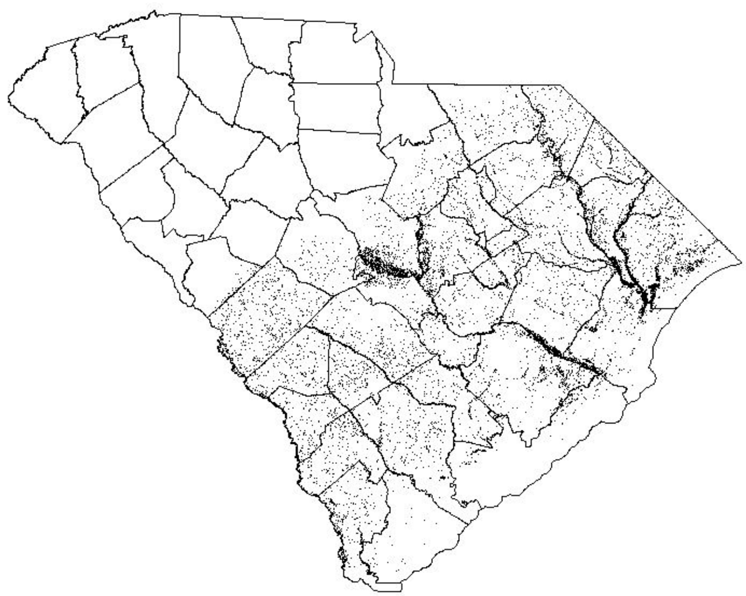


Figure 4.37 *Lasius neoniger* Emery, 1893

Counties: Aiken, Chesterfield, Oconee

Habitat: Recently Cleared Land,Mesic Deciduous Forest, Mesic Mixed Forest

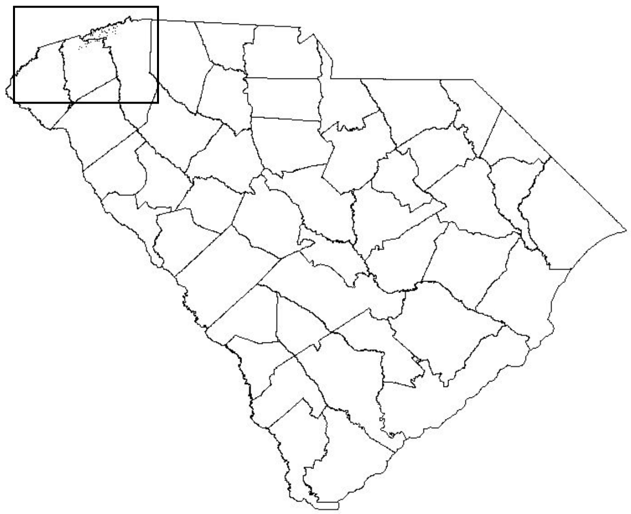


Figure 4.38 *Lasius umbratus* (Nylander, 1846)

Counties: Aiken, Barnwell, Chesterfield

Habitat:

Figure 4.39 *Monomorium minimum* (Buckley, 1867)

Counties: Abbeville, Anderson, Charleston, Oconee, Richland, Union

Habitat: Recently Cleared Land, Mesic Deciduous Forest, Mesic Mixed Forest, Grassland

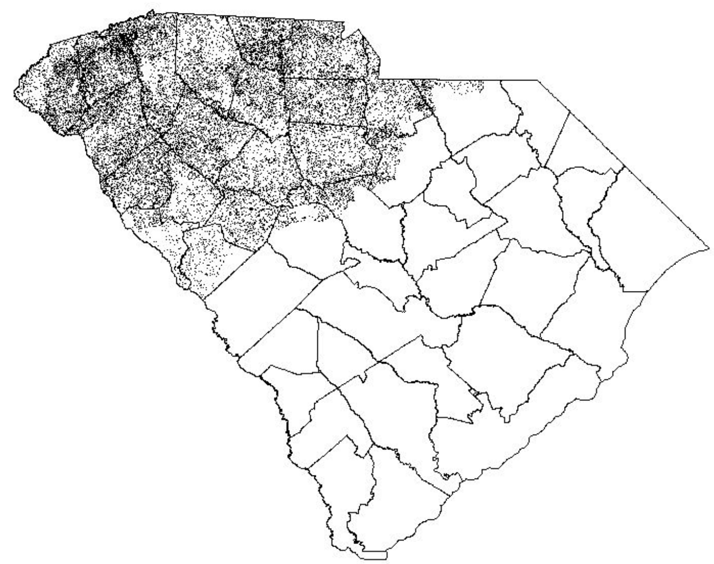


Figure 4.40 *Myrmecina americana* Emery, 1895

Counties: Barnwell, Charleston, Fairfield, Jasper, Mccormick, Oconee, Union, York

Habitat: Pocosin, Swamps/Bottomland Hardwood, Recently Cleared Land, Aquatic Vegetation, Closed Canopy Evergreen Forest/Woodland, Upland Pine Forest, Pine Woodland/Longleaf Pine Savanna, Upland Deciduous Forest, Mesic Deciduous Forest, Upland Mixed Forest, Maritime Forest

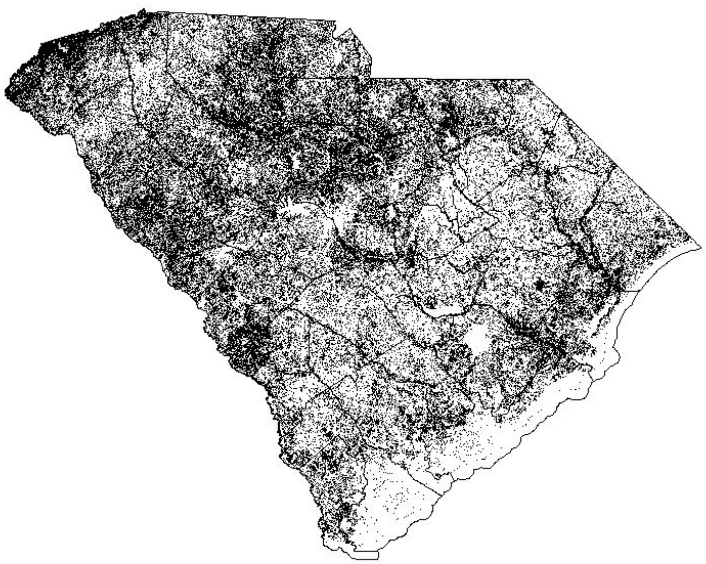


Figure 4.41 *Neivamyrmex opacithorax* (Emery, 1894)

Counties: Aiken, Anderson, Barnwell, Charleston, Chesterfield, Georgetown, Greenwood, Kershaw, McCormick, Newberrry, Oconee, Pickens, Richland, Sumter, Union, Williamsburg

Habitat: Swamps/Bottomland Hardwood, Recently Cleared Land, Aquatic Vegetation, Closed Canopy Evergreen Forest/Woodland, Upland Pine Forest, Pine Woodland/Longleaf Pine Savanna, Upland Deciduous Forest, Mesic Deciduous Forest, Upland Mixed Forest, Grassland, Mesic Mixed Forest, Maritime Forest

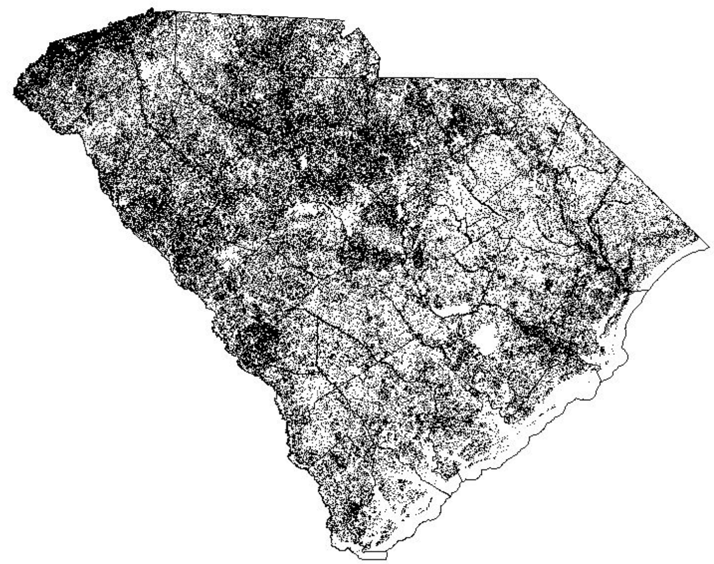


Figure 4.42 *Neivamyrmex texanus* (Watkins, 1972)

Counties: Edgefield, Georgetown, Greenville, Horry, Pickens

Habitat: Upland Pine Forest, Upland Deciduous Forest, Mesic Deciduous Forest, Upland Mixed Forest, Mesic Mixed Forest, Maritime Forest

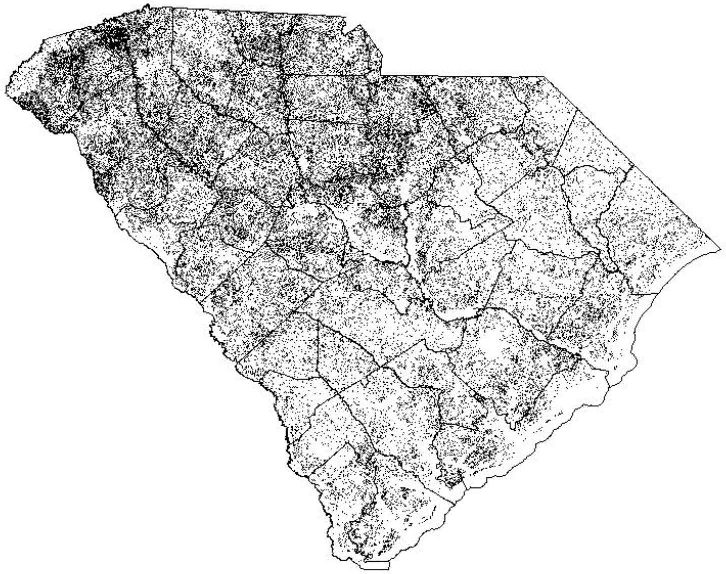


Figure 4.43 *Pachycondyla chinensis* (Emery, 1895)

Counties: Oconee, Pickens

Habitat: Mesic Deciduous Forest, Mesic Mixed Forest

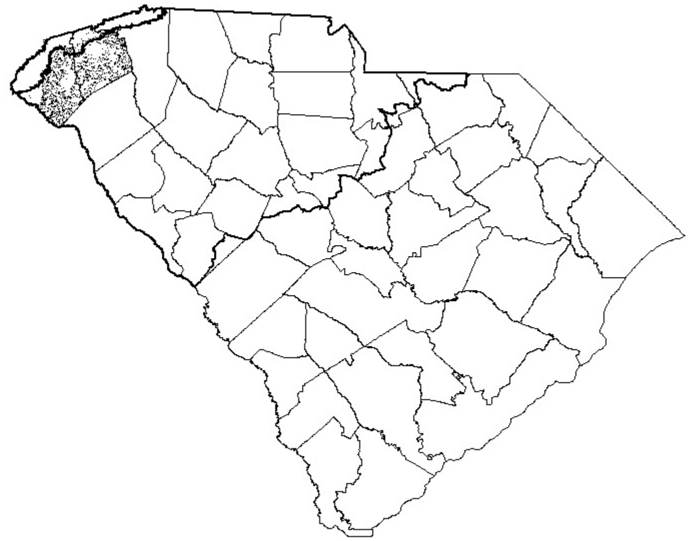


Figure 4.44 *Pachycondyla chinensis* (Emery, 1895)

Counties: Oconee, Pickens

Habitat: Mesic Deciduous Forest, Mesic Mixed Forest

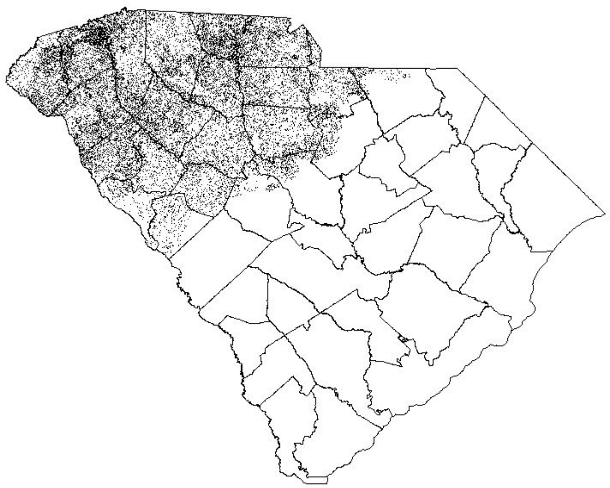


Figure 4.45 *Paratrechina concinna* Trager, 1984

Counties: Aiken, Barnwell, Charleston, Georgetown, Horry, Jasper, Kershaw, Richland, Sumter, WilliamsburgOconee

Habitat: Pocosin, Recently Cleared Land, Aquatic Vegetation, Closed Canopy Evergreen Forest/Woodland, Upland Pine Forest, Pine Woodland/Longleaf Pine Savanna, Mesic Deciduous Forest, Mesic Mixed Forest

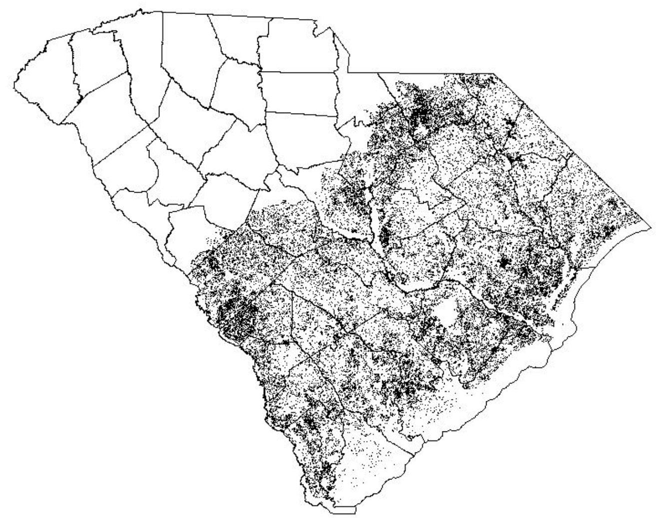


Figure 4.46 *Paratrechina faisonensis* (Forel, 1922)

Counties: Abbeville, Aiken, Anderson, Bamberg, Barnwell, Beaufort, Berkeley, Charleston, Clarendon, Edgefield, Fairfield, Georgetown, Greenville, Greenwood, Hampton, Horry, Jasper, Kershaw, Laurens, Lee, McCormick, Newberry, Oconee, Pickens, Spartanburg, Union, York

Habitat: Marsh/Emergent Wetland, Pocosin, Swamps/Bottomland Hardwood, Recently Cleared Land, Aquatic Vegetation, Closed Canopy Evergreen Forest/Woodland, Upland Pine Forest, Pine Woodland/Longleaf Pine Savanna, Upland Deciduous Forest, Mesic Deciduous Forest, Upland Mixed Forest, Mesic Mixed Forest, Grassland, Maritime Forest

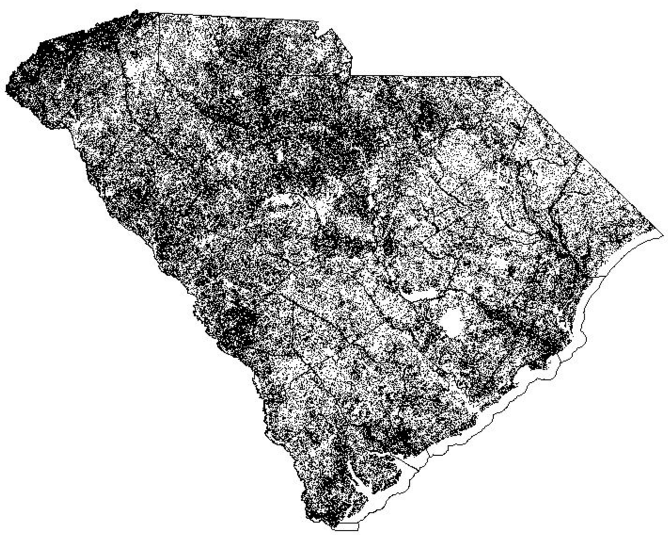


Figure 4.47 *Paratrechina flavipes* (F. Smith, 1874)

Counties: Jasper

Habitat: Upland Pine Forest

Figure 4.48 *Paratrechina parvula* (Mayr, 1870)

Counties: Barnwell, Beaufort, Chesterfield, Jasper, Oconee, Pickens

Habitat: Swamps/Bottomland Hardwood, Closed Canopy Evergreen Forest/Woodland, Upland Pine Forest, Mesic Mixed Forest, Grassland

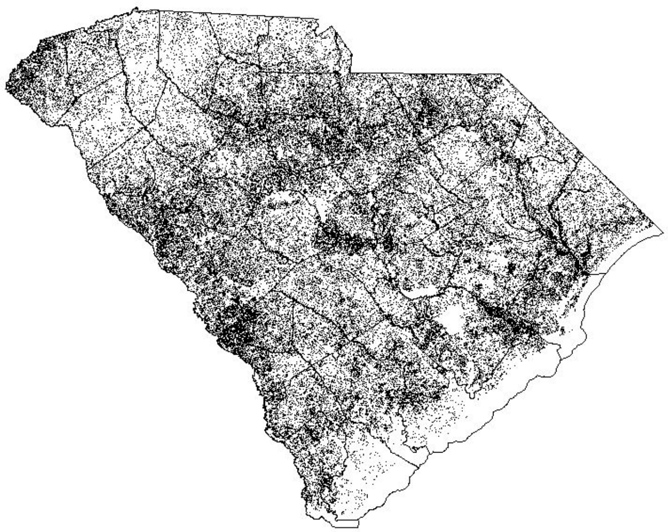


Figure 4.49 *Paratrechina terricola* (Buckley, 1866)

Counties: Williamsburg, Oconee

Habitat: Upland Pine Forest, Mesic Deciduous Forest

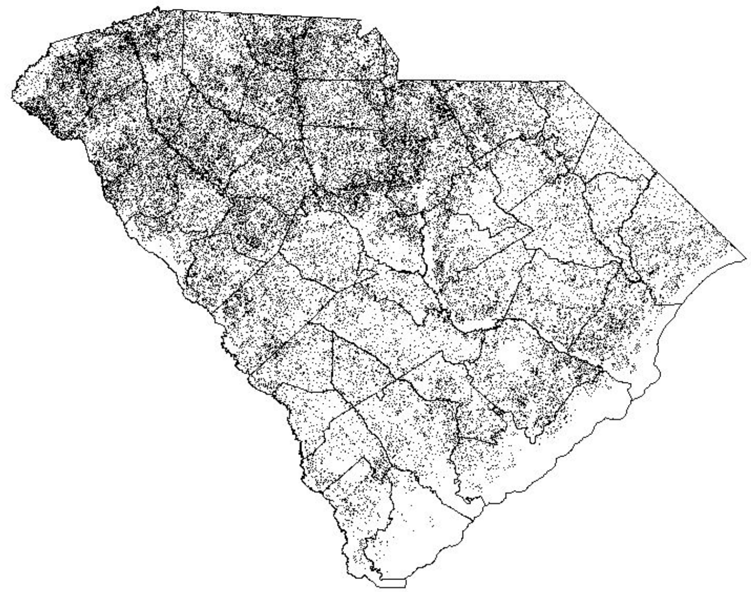


Figure 4.50 *Paratrechina vividula* (Nylander, 1846)

Counties: Beaufort, Berkeley, Orangeburg

Habitat: Aquatic Vegetation, Mesic Mixed Forest

Figure 4.51 *Paratrechina wojciki* Trager, 1984

Counties: Aiken, Georgetown, Richland

Habitat: Closed Canopy Evergreen Forest/Woodland, Upland Pine Forest

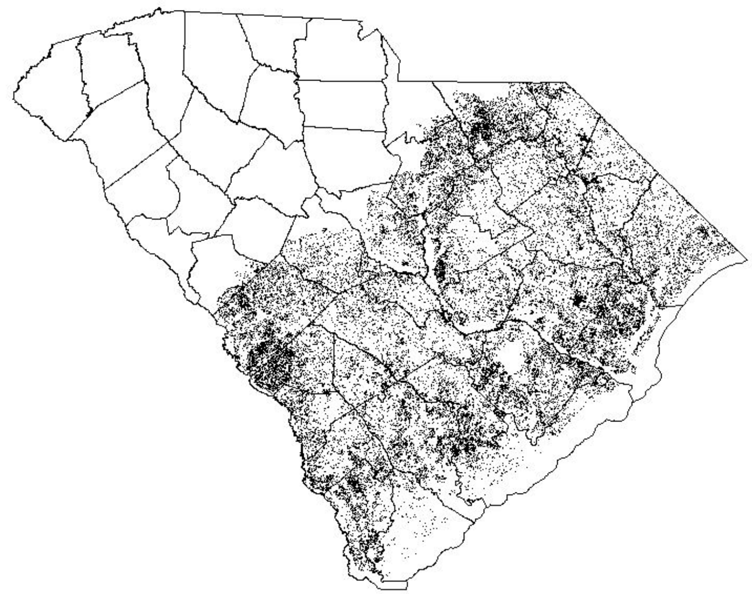


Figure 4.52 *Pheidole bicarinata vinelandica* Forel, 1886

Counties: Barnwell, Charleston, Greenville, Horry, Oconee, Orangeburg, Pickens, Union

Habitat: Pocosin, Recently Cleared Land, Aquatic Vegetation, Upland Pine Forest, Mesic Deciduous Forest, Mesic Mixed Forest, Grassland, Maritime Forest

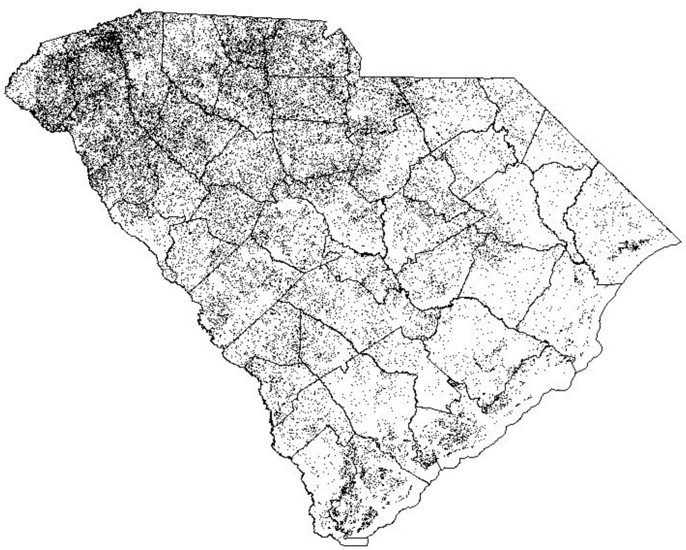


Figure 4.53 *Pheidole crassicornis* Emery, 1895

Counties: Aiken, Anderson, Bamberg, Barnewell, Beaufort, Berkeley, Charleston, Chesterfield, Georgetown, Greenville, Hampton, Kershaw, Newberry, Oconee, Orangeburg, Pickens, Richland, Sumter

Habitat: Pocosin, Swamps/Bottomland Hardwood, Recently Cleared Land, Aquatic Vegetation, Closed Canopy Evergreen Forest/Woodland, Pine Woodland/Longleaf Pine Savanna, Upland Deciduous Forest, Mesic Deciduous Forest, Mesic Mixed Forest, Grassland, Maritime Forest

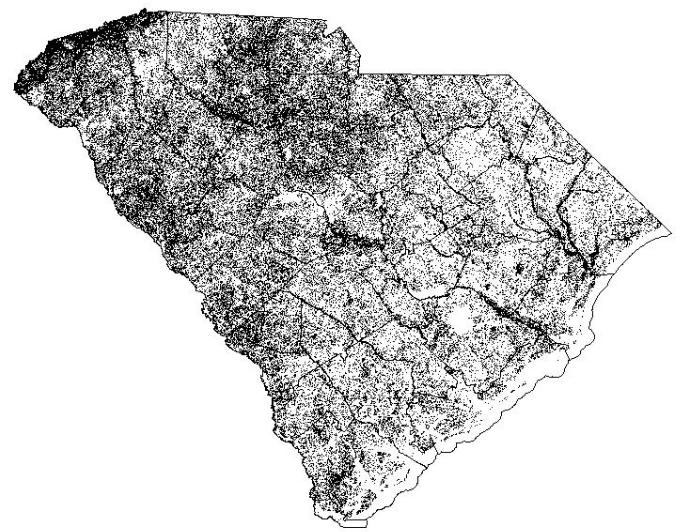


Figure 4.54 *Pheidole denata* Mayr, 1886

Counties: Abbeville, Aiken, Anderson, Bamberg, Barnwell, Beaufort, Charleston, Chesterfield, Colleton, Dorchester, Edgefield, Georgetown, Greenville, Hampton, Horry, Laurens, McCormick, Oconee, Orangeburg, Pickens, Sumter, Union

Habitat: Pocosin, Swamps/Bottomland Hardwood, Recently Cleared Land, Aquatic Vegetation, Closed Canopy Evergreen Forest/Woodland, Upland Pine Forest, Pine Woodland/Longleaf Pine Savanna, Upland Deciduous Forest, Mesic Deciduous Forest, Upland Mixed Forest, Mesic Mixed Forest, Grassland, Maritime Forest

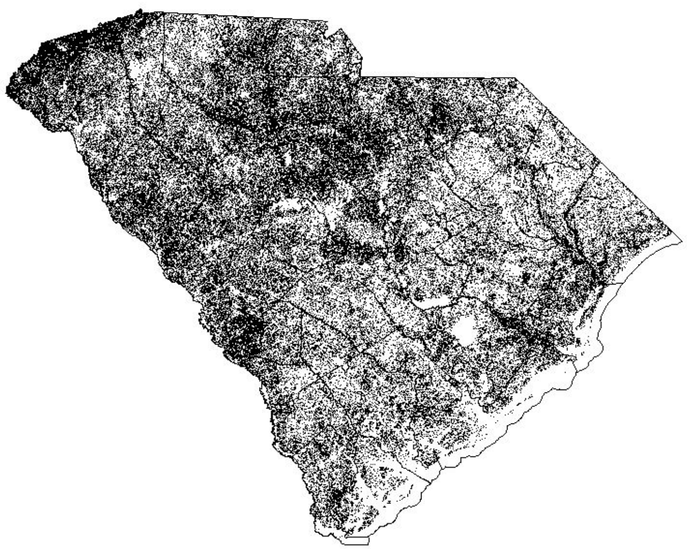


Figure 4.55 *Pheidole dentigula* M.R. Smith, 1927

Counties: Aiken, Bamberg, Barnwell, Horry, Oconee

Habitat: Pocosin, Swamps/Bottomland Hardwood, Upland Pine Forest, Upland Deciduous Forest, Grassland

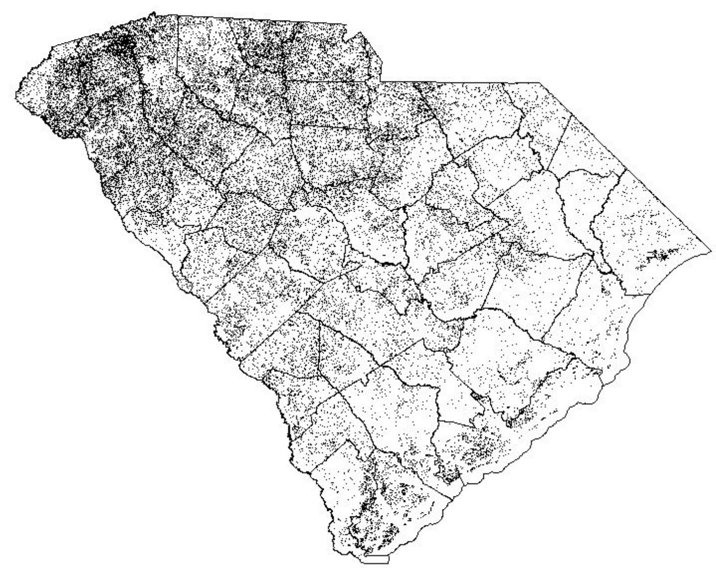


Figure 4.56 *Pheidole morrisii* Forel, 1886

Counties: Aiken, Chesterfield, Edgefield, Greenville, Richland, Oconee, Pickens

Habitat: Swamps/Bottomland Hardwood, Recently Cleared Land, Closed Canopy Evergreen Forest/Woodland, Pine Woodland/Longleaf Pine Savanna, Mesic Mixed Forest, Grassland

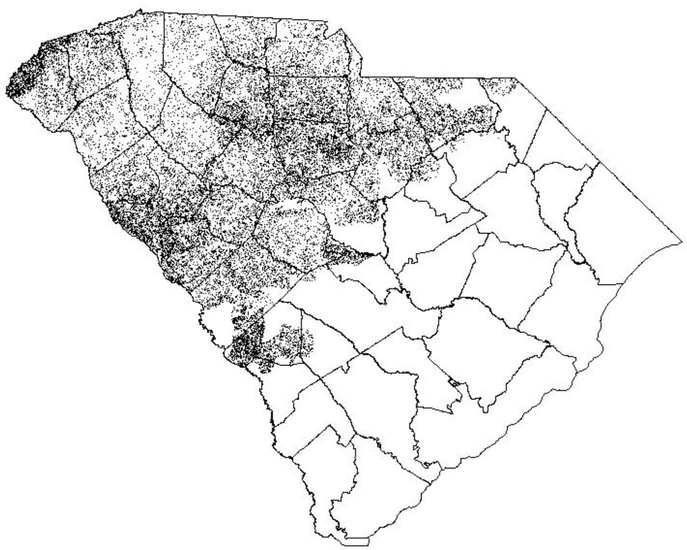


Figure 4.57 *Pheidole tysoni* Forel, 1901

Counties: Oconee

Habitat: Mesic Mixed Forest

Figure 4.58 *Pogonomyrmex badius* (Latreille, 1802)

Counties: Aiken, Allendale, Barnwell, Chesterfield, Sumter

Habitat: Recently Cleared Land, Closed Canopy Evergreen Forest/Woodland, Mesic Mixed Forest

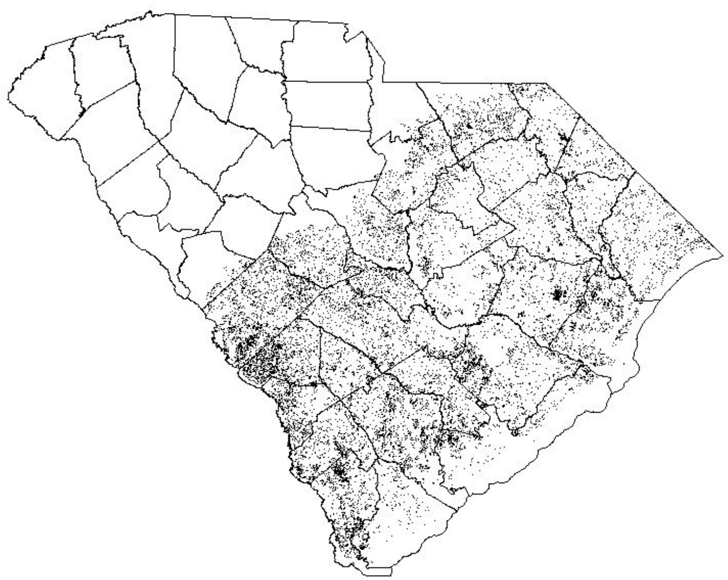


Figure 4.59 *Ponera pennsylvanica* Buckley, 1866

Counties: Pickens

Habitat: Mesic Deciduous Forest

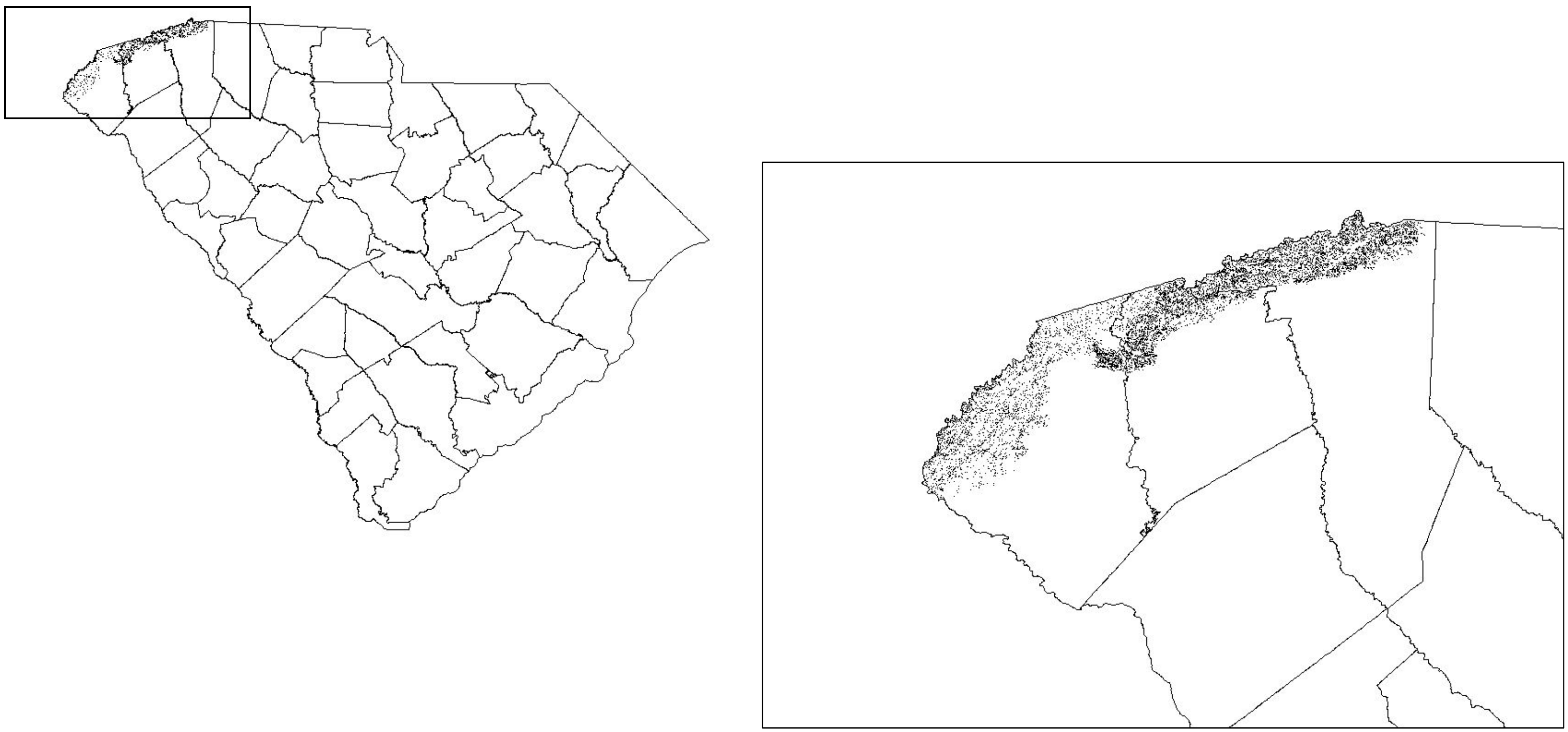


Figure 4.60 *Prenolepis imparis* (Say, 1836)

Counties: Abbeville, Anderson, Beaufort, Edgefield, Greenwood, Kershaw, McCormick, Oconee, Pickens

Habitat: Swamps/Bottomland Hardwood, Recently Cleared Land, Aquatic Vegetation, Pine Woodland/Longleaf Pine Savanna, Upland Deciduous Forest, Mesic Deciduous Forest, Upland Mixed Forest, Mesic Mixed Forest, Grassland

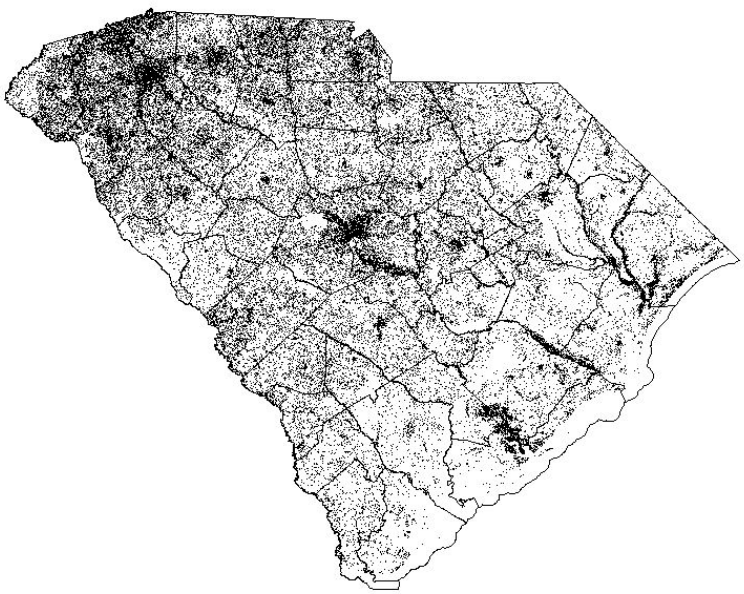


Figure 4.61 *Solenopsis carolinensis* (Forel, 1901)

Counties: Abbeville, Aiken, Barnwell, Beaufort, Charleston, Fairfield, Georgetown, Greenville, McCormick, Newberry, Oconee, Pickens, Spartanburg Union

Habitat: Pocosin, Swamps/Bottomland Hardwood, Recently Cleared Land, Aquatic Vegetation, Closed Canopy Evergreen Forest/Woodland, Upland Pine Forest, Pine Woodland/Longleaf Pine Savanna, Upland Deciduous Forest, Mesic Deciduous Forest, Upland Mixed Forest, Mesic Mixed Forest, Grassland, Maritime Forest

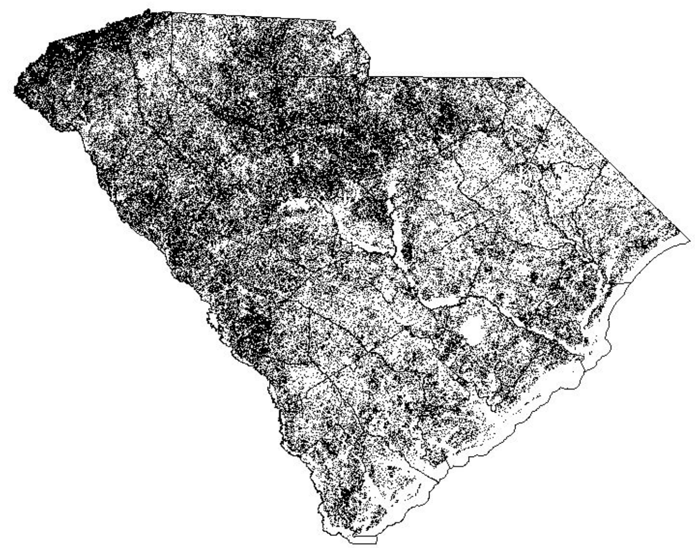


Figure 4.62 *Solenopsis invicta* Buren, 19724

Counties: All counties

Habitat: Marsh/Emergent Wetland, Pocosin, Swamps/Bottomland Hardwood, Recently Cleared Land, Aquatic Vegetation, Closed Canopy Evergreen Forest/Woodland, Upland Pine Forest, Pine Woodland/Longleaf Pine Savanna, Upland Deciduous Forest, Mesic Deciduous Forest, Upland Mixed Forest, Mesic Mixed Forest, Grassland, Maritime Forest

Figure 4.63 *Solenopsis pergandei* Forel, 1901

Counties: Oconee

Habitat: Recently Cleared Land

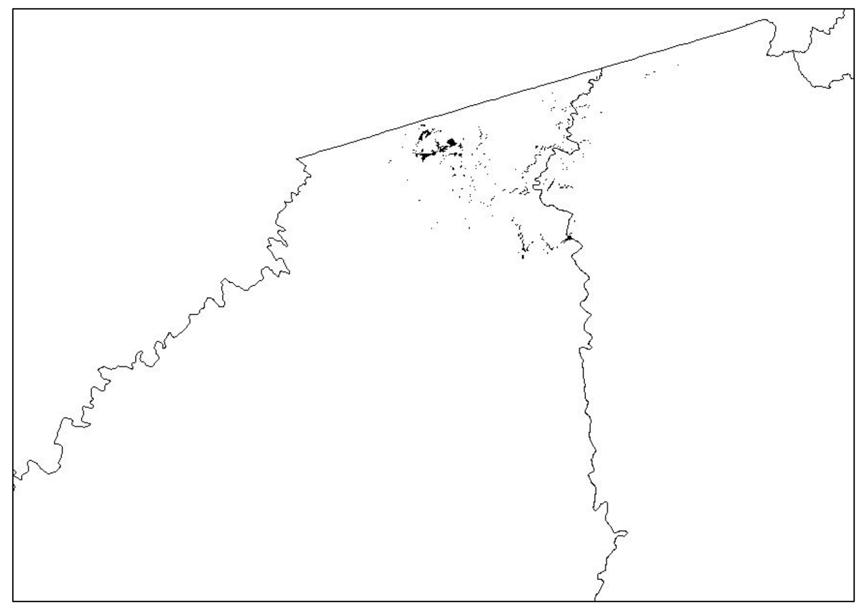
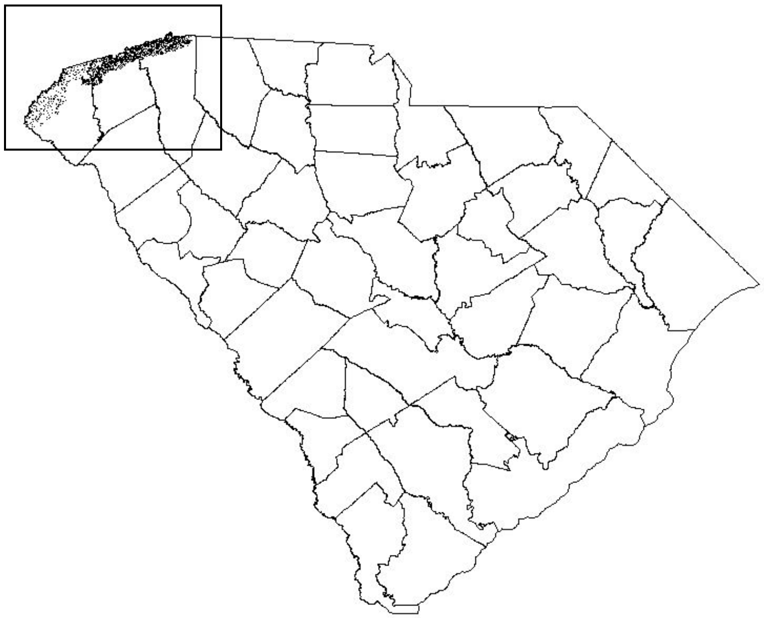


Figure 4.64 *Stenamma schmittii* Wheeler, 1903

Counties: Oconee, Pickens

Habitat: Pine Woodland/Longleaf Pine Savanna, Upland Deciduous Forest, Mesic Deciduous Forest, Upland Mixed Forest



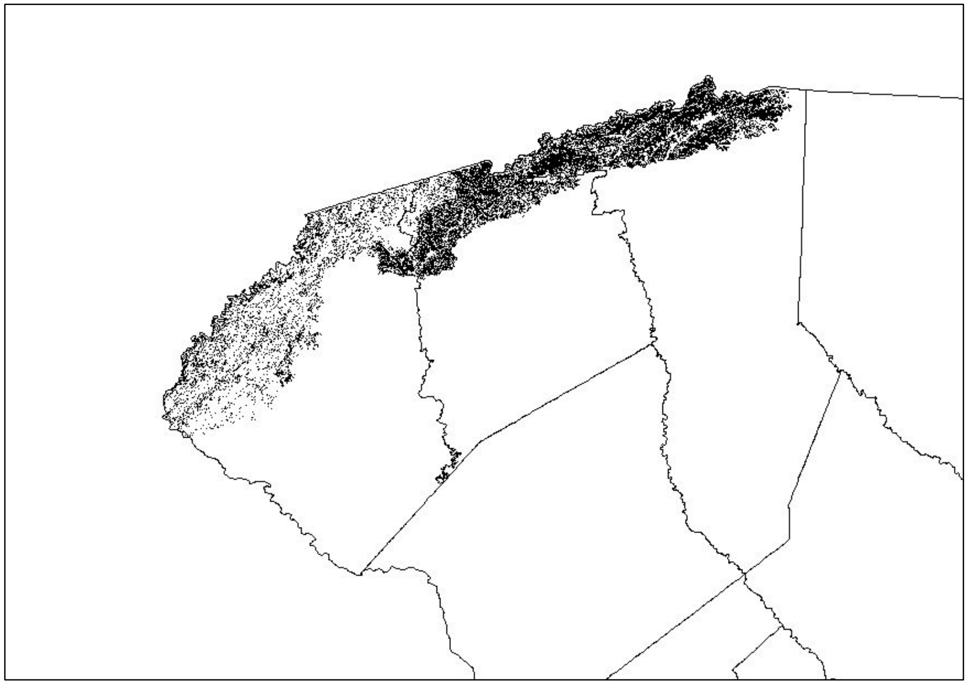


Figure 4.65 *Tapinoma sessile* (Say, 1836)

Counties: Abbeville, Aiken, Bamberg, Barnwell, Beaufort, Berkeley, Chesterfield, Colleton, Edgefield, Fairfield, Greenwood, Hampton, Jasper, Newberry, Oconee, Orangeburg, Pickens, Richland, Sumter, Union

Habitat: Pocosin, Swamps/Bottomland Hardwood, Recently Cleared Land, Aquatic Vegetation, Closed Canopy Evergreen Forest/Woodland, Upland Pine Forest, Pine Woodland/Longleaf Pine Savanna, Upland Deciduous Forest, Mesic Deciduous Forest, Upland Mixed Forest, Mesic Mixed Forest, Grassland

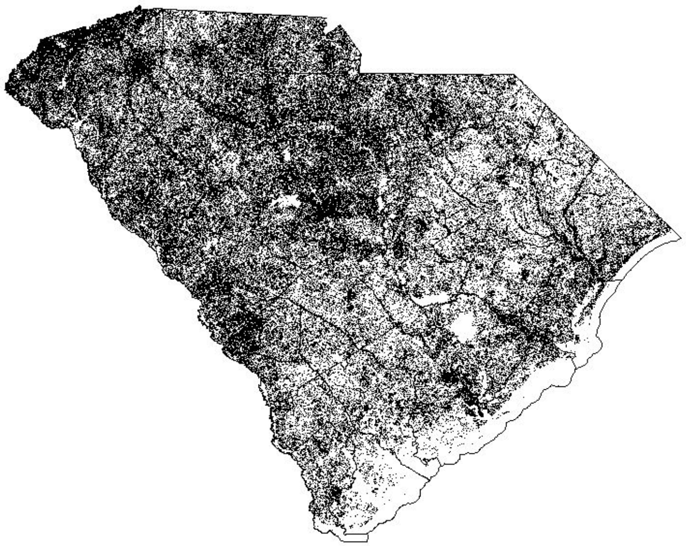


Figure 4.66 *Tracymyrmex septentrionalis* (McCook, 1881)

Counties: Aiken, Barnwell, Charleston, Chesterfield, Edgefield, Georgetown, Pickens,

Habitat: Swamps/Bottomland Hardwood, Recently Cleared Land, Pine Woodland/Longleaf Pine Savanna, Mesic Deciduous Forest, Mesic Mixed Forest, Maritime Forest

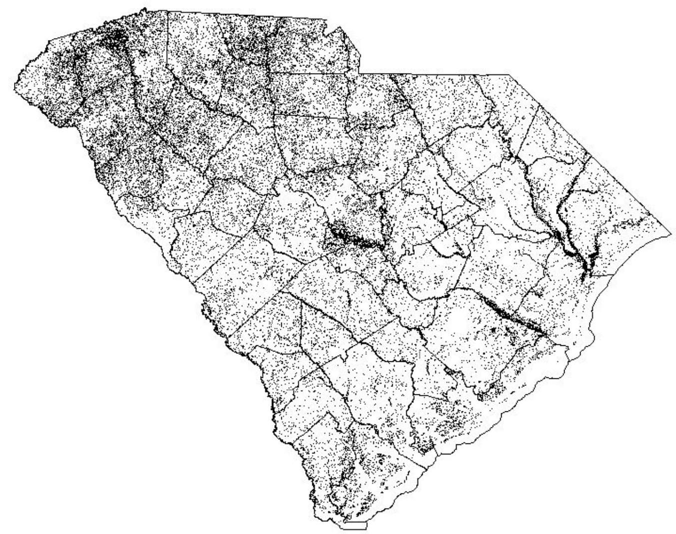
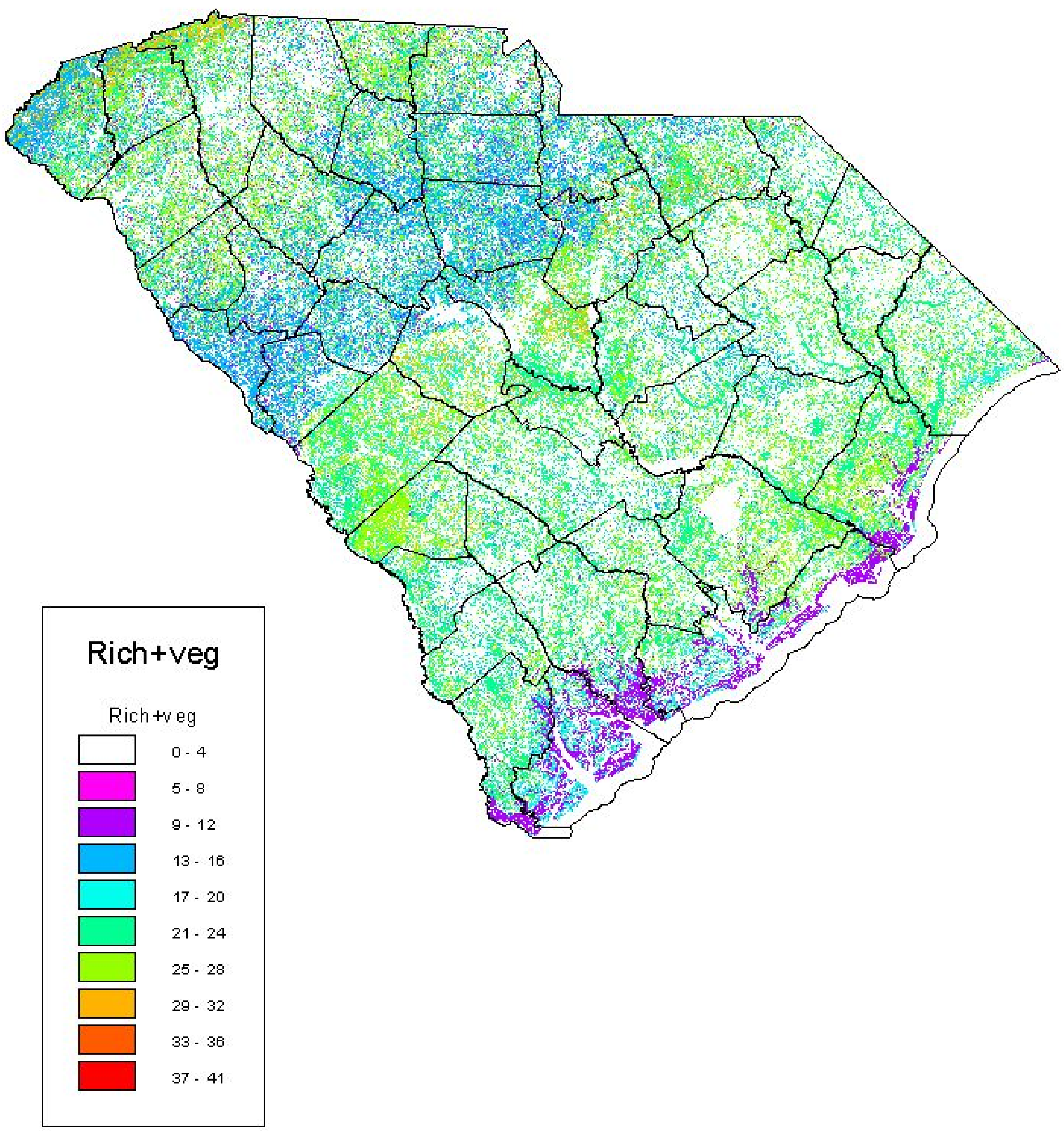


Figure 4.67 Overall Species Richness for the Ants of South Carolina



TABLES

Table 4.1: Number of ant sampling replicates in the mountain, piedmont, coastal plain, and Sandhill regions of South Carolina partitioned by land cover class 1999 – 2000.

		Region			
GAP classification code	Land Cover Class	Mountain	Piedmont	Coastal Plain	Sandhill
0	Recreation Area	0	1	0	0
3	Fresh and Saltwater Marsh	0	0	1	0
4	Bay/Pocosin	0	0	0	7
6	Swamp and Bottomland Hardwood	0	10	7	6
11	Cleared Land	5	7	9	3
14/15	Upland Pine Forest	7	10	5	10
16	Longleaf Pine Forest	0	0	10	0
17	Upland Deciduous Forest	10	10	0	10
18	Mesic Deciduous Forest	9	10	10	0
19	Upland Mixed Forest	27	10	0	0
20	Mesic Mixed Forest	10	10	0	0
21	Grassland	3	10	10	11
22	Cultivated	2	1	1	0
28	Maritime Forest	0	0	6	0

Table 4.2 Fresh and Saltwater Marsh: A total of 167 ants were identified over 1 transect in one separate physiographic region.	
Region	C
Landscape type	3 Fresh and Saltwater Marsh
N	1
Total	167
Apheanogaster rudis	0.0539±0.2258
Aphaenogaster tenn	0.006±0.0772
Camonotus casteneas	0.012±0.1089
Camponotus pennslyvanicus	0.0599±0.2373
Crematogaster lineolata	0.1198±0.3247
Dolichoderous pustulatus	0.006±0.0772
Hypoponera opaciceps	0.024±0.153
Hypoponera opacior	0.006±0.0772
Lineopithema humile	0.006±0.0772
Paratrechina faisonensis	0.018±0.133
Solenopsis invicta	0.6886±0.4631

Table 4.3: Bay/Pocosin: A total of 840 ants were identified over 7 transects in one separate physiographic region.	
Region	S
Landscape type	4 Bay/Pocosin
N	7
Total	840
Apheanogaster ashmaedi	0.0071±0.0317
Apheanogaster fulva	0.0131±0.043
Apheanogaster ashmeadi	0.006±0.0292
Apheanogaster rudis	0.2452±0.1626
Aphaenogaster treatae	0.0012±0.0131
Camonotus casteneas	0.0048±0.0261
Camponotus chromoides	0.0369±0.0713
Camponotus pennslyvanicus	0.0024±0.0185
Crematogaster cerasi	0.0048±0.0261
Crematogaster lineolata	0.0952±0.1109
Crematogaster pilosa	0.0012±0.0131
Formica dolosa	0.0024±0.0185
Hypoponera opaciceps	0.0024±0.0185
Hypoponera opacior	0.006±0.0292
Lasius alenius	0.2381±0.161
Lasius umbratus	0.0107±0.0389
Myrmecina americana	0.0024±0.0185
Paratrechina concinna	0.006±0.0292
Paratrechina faisonensis	0.0036±0.0226
Phidole crassicornis	0.0131±0.043
Phidole denata	0.1179±0.1219
Phidole dentigula	0.0012±0.0131
Phidole vinlandica	0.0048±0.0261
Solenopsis carolinensis	0.0012±0.0131
Solenopsis invicta	0.1381±0.1304
Tapinoma sessile	0.0071±0.0317
Tracymyrmex spetentrionalis	0.0274±0.0617

Table 4.4 Swamp and Bottomland Hardwood: A total of 1523 ants were identified over 23 transects in three separate physiographic regions.			
region	C	P	S
Landscape type	6 Swamp and Bottomland Hardwood		
N	7	10	6
total	614	577	332
Ambylopone	--	0.0052±0.0227	--
Apheanogaster fulva	0.0065±0.0304	0.0035±0.0187	0.003±0.0223
Apheanogaster mariae	--	0.0017±0.013	--
Apheanogaster picea	0.0651±0.0932	0.0052±0.0227	--
Apheanogaster rudis	0.1156±0.1209	0.1629±0.1168	0.0873±0.1152
Aphaenogaster tenn	0.0244±0.0583	--	--
Camponotus americanus	0.0163±0.0479	--	--
Camonotus casteneas	--	--	0.006±0.0315
Camponotus chromoides	--	--	0.003±0.0223
Camponotus pennslyvanicus	0.1433±0.1324	0.0069±0.0262	0.0753±0.1077
Crematogaster Cerasi	0.0244±0.0583	--	0.003±0.0223
Crematogaster atkinsoni	--	0.0035±0.0187	--
Crematogaster lineolata	--	0.0052±0.0227	0.006±0.0315
Dorymyrmex bureni	--	--	0.012±0.0445
Formica schaufussi	0.0081±0.0339	--	--
Hypoponera	0.0879±0.107	0.0104±0.0321	--
Lasius alenius	0.0798±0.0702	0.0468±0.0668	0.0151±0.0498
Leptothorax	--	0.0104±0.0321	--
Lineopithema humile	--	--	0.003±0.0223
Myrmecina americana	0.0033±0.0217	0.0087±0.0294	0.003±0.0223
Myrmica	--	0.0191±0.0433	--
Neivamyrmex opacithorax	--	0.0156±0.0392	--
Paratrechina faisonensis	0.0016±0.0151	0.0364±0.0592	0.012±0.0445
Paratrechina parvula	0.0033±0.0217	--	--
Phidole crassicornis	0.0033±0.0217	--	--
Phidole denata	0.0684±0.0671	0.0346±0.0412	0.0542±0.0924
Phidole dentigula	--	--	0.012±0.0445
Phidole morrisi	--	--	0.0271±0.0663
Prenolepis imparis	--	0.4021±0.1551	--
Solenopsis carolinensis	--	0.0017±0.013	--
Solenopsis invicta	0.3013±0.1734	0.2132±0.1295	0.6145±0.1987
Strumygenys spp.	--	0.0035±0.0187	--
Tapinoma sessile	0.0472±0.0802	0.0035±0.0187	0.0422±0.0821

Table 4.4 Swamp and Bottomland Hardwood: A total of 1523 ants were identified over 23 transects in three separate physiographic regions.			
Tracymyrmex spetentrionalis	--	--	0.0211±0.0587

Table 4.5: Cleared Land: A total of 5535 ants were identified over 24 transects in four separate physiographic regions.				
Region	C	M	P	S
Landscape type	11 Cleared Land			
N	9	5	7	3
Total	1929	1107	3285	2243
Apheanogaster ashmeadi	--	--	0.0024±0.0185	0.0004±0.0115
Apheanogaster picea	0.0021±0.0153	0.0027±0.0232	--	0.0027±0.03
Apheanogaster rudis	0.0031±0.0185	0.0361±0.0834	0.0046±0.0256	0.0004±0.0115
Camponotus americanus	--	--	0.0006±0.0093	0.0009±0.0173
Camonotus casteneas	0.001±0.0105	--	--	--
Camponotus pennslyvanicus	--	0.0009±0.0134	--	--
Crematogaster atkinsoni	--	0.0054±0.0328	--	0.0004±0.0115
Crematogaster lineolata	0.0005±0.0075	0.0533±0.1005	0.003±0.0207	--
Crematogaster pilosa	--	0.0108±0.0462	0.0003±0.0065	--
Cyphomyrmex rimosus	0.0098±0.0328	--	--	--
Dorymyrmex bureni	0.1125±0.1053	--	--	0.0058±0.0438
Dorymyrmex medeis	0.0021±0.0153	--	--	0.786±0.2368
Forelius mccooki	0.0062±0.0262	--	--	--
Formica dolosa	0.001±0.0105	--	--	--
Formica schaufussi	0.0041±0.0213	0.0009±0.0134	0.0027±0.0196	--
Hypoponera opaciceps	0.0005±0.0075	--	--	0.0004±0.0115
Hypoponera opacior	0.0047±0.0228	0.0081±0.0401	--	--
Lasius neoniger	--	--	--	0.0009±0.0173
Lasius umbratus	--	--	--	0.0031±0.0321
Leptothorax	--	0.0027±0.0232	--	--
Monomorium minimum	--	0.0009±0.0134	0.0003±0.0065	--
Monomorium trageri	--	0.0018±0.019	--	--
Myrmecina americana	0.0005±0.0075	0.0145±0.0535	0.0006±0.0093	0.0027±0.03
Myrmica americana	--	0.0009±0.0134	--	--
Neivamyrmex opacithorax	--	0.0181±0.0596	--	0.0076±0.0501
Paratrechina concinna	0.001±0.0105	--	--	--
Paratrechina faisonensis	0.0119±0.0361	0.0045±0.0299	0.0183±0.0507	0.0022±0.0271
Phidole crassicornis	0.0171±0.0432	--	0.003±0.0207	--
Phidole denata	0.0036±0.02	0.0054±0.0328	--	--
Phidole morrisi	--	--	0.0012±0.0131	--
Phidole vinlandica	--	0.0009±0.0134	--	--
Pogonomyrmex badius	0.001±0.0105	--	--	--
Prenolepis impairs	--	0.1238±0.1473	0.0009±0.0113	--

Table 4.5: Cleared Land: A total of 5535 ants were identified over 24 transects in four separate physiographic regions.				
Solenopsis carolinensis	--	0.0045±0.0299	0.0009±0.0113	0.0004±0.0115
Solenopsis invicta	0.8154±0.1293	0.6305±0.2159	0.8027±0.1504	0.1792±0.2214
Solenopsis pergandei	--	0.0641±0.1095	--	--
Tapinoma sessile	0.0016±0.0133	0.0018±0.019	0.1537±0.1363	0.0045±0.0386
Tracymyrmex spetentrionalis	--	--	--	0.0022±0.0271

Table 4.6 Upland Pine Forest A total of 3774 ants were identified over 32 transects in four separate physiographic regions.				
Region	C	M	P	S
Landscape type	14 Upland Pine Forest			
N	5	7	10	10
Total	1184	737	893	960
Apheanogaster ashmeadi	0.0008±0.0126	0.0027±0.0196	0.0269±0.0512	0.0209±0.0451
Apheanogaster floridana	--	--	--	0.0083±0.0287
Apheanogaster picea	0.011±0.0466	--	0.0045±0.0212	--
Apheanogaster rudis	0.0101±0.0447	0.2171±0.1558	0.215±0.1299	0.0615±0.076
Aphaenogaster treatae	--	--	--	0.026±0.0503
Brachymyrmex	0.0017±0.0184	--	--	--
Camponotus americanus	0.0084±0.0408	0.0068±0.0311	0.0011±0.0105	--
Camonotus casteneas	--	--	--	0.0198±0.0441
Camponotus chromoides	--	--	--	0.0021±0.0145
Camponotus floridanus	--	--	--	0.001±0.01
Camponotus pennslyvanicus	--	0.0122±0.0415	0.0011±0.0105	--
Crematogaster cerasi	--	--	0.0011±0.0105	0.001±0.01
Crematogaster atkinsoni	0.0008±0.0126	0.0163±0.0479	--	--
Crematogaster lineolata	0.0017±0.0184	0.2904±0.1716	0.0761±0.0839	0.1458±0.1116
Cyphomyrmex rimosus	0.0008±0.0126	--	--	--
Dolichoderous mariae	--	--	--	0.001±0.01
Dolichoderous pustulatus	--	0.0014±0.0141	--	0.0354±0.0584
Dorymyrmex bureni	0.0084±0.0408	--	--	0.1313±0.1068
Dorymyrmex medeis	--	--	--	0.0146±0.0379
Forelius mccooki	--	0.0014±0.0141	--	--
Forelius pruniosis	--	--	--	0.0094±0.0305
Formica dolosa	0.0051±0.0319	--	--	0.0083±0.0287
Formica schaufussi	--	0.0027±0.0196	0.0325±0.0561	--
Formica subsericea	0.0008±0.0126	0.0014±0.0141	0.0022±0.0148	--
Hypoponera	0.0118±0.0483	--	0.0067±0.0258	--
Hypoponera opaciceps	--	--	--	0.001±0.01
Hypoponera opacior	0.0008±0.0126	--	--	0.0031±0.0176
Lasius	--	--	0.0291±0.0532	--
Leptothorax	--	0.0068±0.0311	0.0022±0.0148	--
Myrmecina americana	0.0068±0.0368	0.0081±0.0339	0.0112±0.0333	0.0063±0.025
Myrmica americana	--	0.0014±0.0141	0.0034±0.0184	--
Myrmica	--	0.0393±0.0734	--	--
Neivamyrmex opacithorax	--	0.0041±0.0242	0.0336±0.057	0.024±0.0484

Table 4.6 Upland Pine Forest A total of 3774 ants were identified over 32 transects in four separate physiographic regions.				
Paratrechina concinna	0.0017±0.0184	--	--	0.001±0.01
Paratrechina faisonensis	0.0431±0.0908	0.0611±0.0905	0.0325±0.0561	0.0052±0.0227
Paratrechina parvula	--	--	--	0.001±0.01
Paratrechina Rudis	--	0.0014±0.0141	--	--
Paratrechina vividula	0.0194±0.0617	--	--	--
Paratrechina wojicki	--	--	--	0.0042±0.0205
Phidole crassicornis	0.016±0.0561	0.0109±0.0392	0.0067±0.0258	0.0729±0.0822
Phidole denata	0.0008±0.0126	0.038±0.0723	0.019±0.0432	0.0635±0.0771
Phidole morrisi	--	--	--	0.0531±0.0709
Phidole vinlandica	--	0.0014±0.0141	0.0022±0.0148	--
Pogonomyrmex badius	--	--	--	0.0031±0.0176
Prenolepis imparis	0.0017±0.0184	0.2022±0.1518	0.0011±0.0105	--
Solenopsis carolinensis	0.0017±0.0184	0.0176±0.0497	0.0067±0.0258	0.0063±0.025
Solenopsis invicta	0.8438±0.1624	--	0.4457±0.1572	0.2563±0.1381
Stenamma schmittii	--	0.0014±0.0141	--	--
Strumygenys gundlachi	0.0017±0.0184	0.0027±0.0196	0.0011±0.0105	--
Tapinoma sessile	--	0.0014±0.0141	0.0101±0.0316	0.0115±0.0337

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Table 4.7: Longleaf Pine Forest A total of 2628 ants were identified over 10 transects in one separate physiographic region	
Region	C
Landscape type	16 Longleaf Pine Forest
N	10
Total	2628
Apheanogaster ashmeadi	0.0011±0.0105
Aphanogaster flemingi	0.0004±0.0063
Apheanogaster floridana	0.003±0.0173
Apheanogaster rudis	0.0057±0.0238
Brachymyrmex	0.0004±0.0063
Camonotus casteneas	0.0049±0.0221
Camponotus chromoides	0.0004±0.0063
Camponotus floridanus	0.0065±0.0254
Crematogaster lineolata	0.0635±0.0771
Cyphomyrmex rimosus	0.003±0.0173
Dolichoderous pustulatus	0.0008±0.0089
Dorymyrmex bureni	0.0209±0.0452
Forelius mccooki	0.0126±0.0353
Formica dolosa	0.0019±0.0138
Formica schaufussi	0.0011±0.0105
Hypoponera	0.0068±0.026
Hypoponera opaciceps	0.0023±0.0151
Hypoponera opacior	0.0004±0.0063
Leptothorax	0.0004±0.0063
Myrmecina americana	0.0019±0.0138
Neivamyrmex opacithorax	0.0171±0.041
Neivamyrmex texanus	0.0004±0.0063
Paratrechina concinna	0.0323±0.0559
Paratrechina faisonensis	0.0084±0.0289
Paratrechina flavipes	0.0042±0.0205
Paratrechina parvula	0.0011±0.0105
Paratrechina terricola	0.0004±0.0063
Paratrechina wojicki	0.0011±0.0105
Phidole denata	0.0049±0.0221
Phidole dentigula	0.0004±0.0063
Phidole vinlandica	0.0008±0.0089

Table 4.7: Longleaf Pine Forest A total of 2628 ants were identified over 10 transects in one separate physiographic region	
Solenopsis carolinensis	0.0019±0.0138
Solenopsis invicta	0.7873±0.1294
Tapinoma sessile	0.0004±0.0063

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Table 4.8: Upland Deciduous Forest: A total of 2784 ants were identified over 30 transects in three separate physiographic regions			
Region	M	P	S
Landscape type	17 Upland Deciduous Forest		
N	10	10	10
Total	899	536	1349
Ambylopone	0.0011±0.0105	0.0037±0.0192	--
Apheanogaster ashmaedi	--	--	0.0193±0.0435
Apheanogaster fulva	0.0011±0.0105	--	0.003±0.0173
Apheanogaster ashmeadi	--	0.0019±0.0138	0.0015±0.0122
Aphanogaster flemingi	--	--	0.0007±0.0084
Apheanogaster picea	0.099±0.0944	--	--
Apheanogaster rudis	0.1279±0.1056	0.4235±0.1563	0.0897±0.0904
Aphaenogaster treatae	--	--	0.0007±0.0084
Camponotus americanus	0.0022±0.0148	0.0112±0.0333	0.0022±0.0148
Camonotus casteneas	--	--	0.0222±0.0466
Camponotus chromoides	0.0111±0.0331	--	0.0267±0.051
Camponotus pennslyvanicus	0.0423±0.0636	0.0205±0.0448	0.0059±0.0242
Crematogaster ahmeadi	0.0011±0.0105	--	--
Crematogaster Cerasi	±0.0148	--	--
Crematogaster atkinsoni	--	0.0037±0.0192	0.0007±0.0084
Crematogaster lineolata	0.0133±0.0362	0.2425±0.1355	0.0482±0.0677
Crematogaster pilosa	--	0.0075±0.0273	--
Dorymyrmex bureni	--	--	0.0007±0.0084
Formica argentia	--	--	0.0304±0.0543
Formica dolosa	--	--	0.0007±0.0084
Formica integra	0.0022±0.0148	--	--
Formica schaufussi	0.0011±0.0105	0.0168±0.0406	--
Formica subsericea	0.4672±0.1578	--	--
Hypoponera	0.0033±0.0181	--	--
Hypoponera opacior	--	--	0.0015±0.0122
Lasius umbratus	--	--	0.0156±0.0392
Leptothorax	0.0033±0.0181	0.0075±0.0273	0.0007±0.0084
Myrmecina americana	0.0378±0.0603	0.0299±0.0539	0.0044±0.0209
Myrmica americana	0.0011±0.0105	--	--
Myrmica	0.0222±0.0466	--	--
Neivamyrmex opacithorax	--	0.0019±0.0138	0.0467±0.0667
Paratrechina concinna	--	--	0.0037±0.0192
Paratrechina faisonensis	0.0111±0.0331	0.0317±0.0554	0.0037±0.0192

Table 4.8: Upland Deciduous Forest: A total of 2784 ants were identified over 30 transects in three separate physiographic regions			
Phidole crassicornis	--	0.0019±0.0138	0.0082±0.0285
Phidole denata	--	0.0616±0.076	0.0326±0.0562
Phidole morrisi	--	0.0019±0.0138	--
Prenolepis imparis	0.0945±0.0925	0.0616±0.076	0.0193±0.0435
Solenopsis carolinensis	0.0022±0.0148	0.0037±0.0192	0.0007±0.0084
Solenopsis invicta	0.0434±0.0644	--	0.6056±0.1545
Stenamma schmittii	0.0033±0.0181	--	--
Strumygenys gundlachi	0.0033±0.0181	--	0.0007±0.0084
Tapinoma sessile	0.0022±0.0148	0.0019±0.0138	--
Tracymyrmex spetentrionalis	--	--	0.0037±0.0192

Table 4.9: Mesic Deciduous Forest: A total of 3042 ants were identified over 27 transects in three separate physiographic regions			
Region	C	M	P
Landscape type	18 Mesic Deciduous Forest		
N	10	10	7
Total	1533	709	800
Ambylopone	--	--	0.0013
Apheanogaster fulva	--	0.0028±0.0167	--
Apheanogaster ashmeadi	--	--	0.0013±0.0136
Apheanogaster mariae	--	--	0.0025±0.0189
Apheanogaster picea	0.0528±0.0707	0.3131±0.1467	0.0013±0.0136
Apheanogaster rudis	0.1122±0.0998	0.0733±0.0824	0.1375±0.1302
Brachymyrmex	--	0.0014±0.0118	--
Camponotus americanus	0.0104±0.0321	0.0635±0.0771	0.0025±0.0189
Camonotus casteneas	0.0026±0.0161	--	--
Camponotus chromoides	0.0085±0.029	0.0014±0.0118	--
Camponotus pennslyvanicus	0.002±0.0141	0.0931±0.0919	0.0038±0.0233
Crematogaster cerasi	0.0059±0.0242	--	0.0038±0.0233
Crematogaster atkinsoni	0.0052±0.0227	--	0.0013±0.0136
Crematogaster lineolata	0.0065±0.0254	--	0.0313±0.0658
Crematogaster pilosa	--	0.0014±0.0118	--
Dorymyrmex bureni	0.0776±0.0846	--	--
Forelius pruniosis	--	0.0042±0.0205	--
Formica integra	--	0.141±0.1101	--
Formica schaufussi	0.0007±0.0084	--	--
Formica subsericea	--	0.1142±0.1006	0.0025±0.0189
Hypoponera	0.0046±0.0214	--	0.0063±0.0299
Hypoponera opaciceps	0.0013±0.0114	--	--
Lasius alenius	0.0091±0.03	--	--
Leptothorax	0.0007±0.0084	0.0014±0.0118	0.0025±0.0189
Myrmecina americana	0.0085±0.029	0.0381±0.0605	0.0025±0.0189
Myrmica	0.002±0.0141	0.0254±0.0498	0.0138±0.0441
Myrmica puntiventris	--	0.0014±0.0118	--
Neivamyrmex opacithorax	0.0026±0.0161	0.0014±0.0118	0.0413±0.0752
Neivamyrmex texanus	--	0.0014±0.0118	--
Paratrechina faisonensis	0.015±0.0384	0.0028±0.0167	0.025±0.059
Phidole crassicornis	0.0496±0.0687	--	0.0063±0.0299
Phidole denata	0.0672±0.0792	--	0.0025±0.0189

Table 4.9: Mesic Deciduous Forest: A total of 3042 ants were identified over 27 transects in three separate physiographic regions			
Phidole dentigula	0.0046±0.0214	--	--
Prenolepis imparis	--	0.1016±0.0955	0.5863±0.1861
Solenopsis carolinensis	--	--	0.0075±0.0326
Solenopsis invicta	0.4534±0.1574	--	0.1013±0.114
Solenopsis pergandei	--	--	--
Stenamma brevicore	--	0.0028±0.0167	--
Stenamma schmittii	--	0.0085±0.029	--
Strumygenys gundlachi	0.0013±0.0114	0.0028±0.0167	--
Tapinoma sessile	--	0.0028±0.0167	--

Table 4.10: Upland Mixed Forest: A total of 5459 ants were identified over 37 transects in two separate physiographic regions.		
Region	M	P
Landscape type	19 Upland Mixed Forest	
N	27	10
Total	4403	1056
Ambylopone	0.0005±0.0043	0.0009±0.0095
Apheanogaster fulva	0.0016±0.0077	--
Apheanogaster ashmeadi	--	0.0104±0.0321
Apheanogaster picea	0.0486±0.0414	--
Apheanogaster rudis	0.064±0.0471	0.1686±0.1184
Camponotus americanus	0.0064±0.0153	0.0019±0.0138
Camponotus chromoides	0.002±0.0086	--
Camponotus pennslyvanicus	0.0177±0.0254	--
Crematogaster cerasi	--	0.0057±0.0238
Crematogaster atkinsoni	0.002±0.0086	0.0038±0.0195
Crematogaster lineolata	0.0304±0.033	0.0938±0.0922
Crematogaster pilosa	0.0018±0.0082	--
Formica argentia	0.0032±0.0109	--
Formica dolosa	--	--
Formica integra	0.3443±0.0914	--
Formica schaufussi	0.0014±0.0072	--
Formica subsericea	0.0874±0.0544	--
Hypoponera	0.0032±0.0109	--
Lasius neoniger	0.0002±0.0027	--
Leptothorax	0.0018±0.0082	0.0019±0.0138
Monomorium trageri	0.0009±0.0058	--
Myrmecina americana	0.0132±0.022	0.0123±0.0349
Myrmica	0.0075±0.0166	--
Neivamyrmex opacithorax	0.0005±0.0043	--
Neivamyrmex texanus	0.0011±0.0064	0.0047±0.0216
Pacycondyla	--	0.0038±0.0195
Paratrechina concinna	0.0005±0.0043	--
Paratrechina faisonensis	0.012±0.021	0.0104±0.0321
Paratrechina terricola	0.0002±0.0027	--
Phidole crassicornis	0.0041±0.0123	0.0028±0.0167
Phidole denata	0.0797±0.0521	0.0199±0.0442
Phidole vinlandica	0.0007±0.0051	--

Table 4.10: Upland Mixed Forest: A total of 5459 ants were identified over 37 transects in two separate physiographic regions.		
Ponera	±0.0043	--
Prenolepis imparis	0.179±0.0738	0.59±0.1555
Solenopsis carolinensis	0.0055±0.0142	0.0009±0.0095
Solenopsis invicta	0.0043±0.0126	0.0445±0.0652
Stenamma schmittii	0.002±0.0086	--
Strumygenys sp	0.0005±0.0043	0.0009±0.0095
Tapinoma sessile	0.0043±0.0126	--

Table 4.11: Mesic Mixed Forest: A total of 3591 ants were identified over 17 transects in two separate physiographic regions.

region	M	P
Landscape type	20 Mesic Mixed Forest	
n	10	7
total	771	588
Ambylopone	--	0.0017±0.0156
Apheanogaster fulva	0.0298±0.0538	--
Apheanogaster ashmeadi	--	0.0034±0.022
Apheanogaster picea	0.144±0.111	--
Apheanogaster rudis	0.1543±0.1142	0.2466±0.1629
Camponotus americanus	--	0.0017±0.0156
Camponotus chromoides	0.0259±0.0502	--
Camponotus pennslyvanicus	0.0117±0.034	--
Crematogaster atkinsoni	--	0.0017±0.0156
Crematogaster lineolata	0.0065±0.0254	0.0153±0.0464
Formica schaufussi	--	0.0017±0.0156
Formica subsericea	0.1556±0.1146	--
Hypoponera	0.0013±0.0114	0.0034±0.022
Lasius alenius	0.0039±0.0161	--
Leptothorax	0.0013±0.0114	0.0034±0.022
Myrmecina americana	0.0273±0.0408	0.0221±0.0489
Neivamyrmex opacithorax	0.0065±0.0254	--
Neivamyrmex texanus	--	0.1548±0.1367
Paratrechina faisonensis	0.0169±0.0408	0.051±0.0832
Phidole denata	0.0182±0.0423	0.0051±0.0269
Prenolepis imparis	0.3528±0.1511	0.3554±0.1809
Solenopsis carolinensis	0.0039±0.0197	0.0187±0.0512
Solenopsis Invicta	--	0.0629±0.0918
Stenamma schmittii	0.0156±0.0375	--
Strumygenys spp	0.0052±0.0197	0.0136±0.0438
Tapinoma sessile	0.0013±0.0114	0.0102±0.038

Table 4.12: Grassland: A total of 8980 ants were identified over 22 transects in four separate physiographic regions.

region	C	M	P	S
Landscape type	21 Grassland			
n	7	3	7	5
total	3222	1992	1970	1796
Apheanogaster ashmeadi	--	--	0.003±0.0207	0.0006±0.011
Aphanogaster flemingi	--	--	--	0.0006±0.011
Apheanogaster rudis	0.0006±0.0093	0.006±0.0446	0.0005±0.0084	0.0006±0.011
Aphaenogaster treatae	--	--	--	0.0022±0.021
Brachymyrmex	0.0003±0.0065	--	--	--
Crematogaster atkinsoni	--	0.004±0.0364	--	--
Crematogaster lineolata	--	0.0286±0.0962	0.002±0.0169	0.0006±0.011
Crematogaster pilosa	--	0.0176±0.0759	0.0005±0.0084	0.0006±0.011
Cyphomyrmex rimosus	0.0003±0.0065	--	--	--
Dolichoderous mariae	--	--	--	0.0045±0.0299
Dorymyrmex bureni	0.0413±0.0752	--	0.0015±0.0146	0.2834±0.2015
Dorymyrmex medeis	--	--	--	0.0095±0.0434
Forelius Mccooki	--	0.0015±0.0223	--	--
Forelius Pruniosis	--	--	--	0.0011±0.0148
Formica integra	--	0.0015±0.0223	0.0015±0.0146	--
Formica pallidefulva	--	--	0.0005±0.0084	--
Formica schaufussi	--	0.0075±0.0498	0.0005±0.0084	--
Hypoponera	--	0.0015±0.0223	0.0071±0.0317	--
Hypoponera opaciceps	0.0012±0.0131	--	--	--
Hypoponera opacior	--	--	--	0.0006±0.011
Lasius alenius	--	--	±0.0084	--
Lasius neoniger	--	0.6507±0.2672	--	0.0022±0.021
Lasius umbratus	--	--	--	0.0846±0.1245
Leptothorax	0.013±0.0428	0.0211±0.083	0.0157±0.047	--
Leptothorax pergandei	--	0.0005±0.0129	--	--
Monomorium minimum	--	--	0.0005±0.0084	--
Myrmica	--	0.0146±0.0693	--	--
Neivamyrmex opacithorax	--	--	--	0.0184±0.0601
Neivamyrmex texanus	--	--	0.0025±0.0189	--
Pacycondyla chinensis	--	0.1938±0.2282	--	--
Paratrechina arenivaga	--	--	0.0005±0.0084	--
Paratrechina concinna	0.0037±0.0229	--	--	0.0028±0.0236
Paratrechina faisonensis	0.0025±0.0189	0.002±0.0258	0.0117±0.0406	0.0028±0.0236

Table 4.12: Grassland: A total of 8980 ants were identified over 22 transects in four separate physiographic regions.

Paratrechina parvula	--	--	0.002±0.0169	0.0006±0.011
Paratrechina vividula	0.0034±0.022	--	--	--
Phidole crassicornis	0.0003±0.0065	--	0.032±0.0665	0.0017±0.0184
Phidole denata	0.0016±0.0151	--	0.0213±0.0546	0.0033±0.0256
Phidole morrisi	--	0.008±0.0514	0.0299±0.0644	0.005±0.0315
Phidole tysoni	--	--	0.0254±0.0595	--
Phidole vinlandica	0.0012±0.0131	0.006±0.0446	0.0066±0.0306	0.0006±0.011
Pogonomyrmex badius	--	--	--	0.0189±0.0609
Prenolepis imparis	--	0.002±0.0258	0.0107±0.0389	--
Solenopsis carolinensis	0.0012±0.0131	0.01±0.0574	0.0005±0.0084	--
Solenopsis invicta	0.9212±0.1018	--	0.6508±0.1802	0.5546±0.2223
Tapinoma sessile	0.005±0.0267	0.007±0.0481	0.0406±0.0746	0.0006±0.011

Table 4.13: Cultivated: A total of 1315 ants were identified over 4 transects in three separate physiographic regions. Twenty-two species were identified in 12 genera.			
Region	Coastal Plains	Mountains	Peidmont
Landscape type	22 Cultivated		
N	1	2	1
Total	409	669	237
Apheanogaster rudis	--	0.0135±0.0816	0.0084±0.0913
Camponotus americanus	0.0073±0.0851	--	--
Camponotus pennslyvanicus	--	0.0015±0.0274	--
Crematogaster atkinsoni	--	0.0015±0.0274	--
Crematogaster lineolata	--	0.0942±0.2066	--
Crematogaster pilosa	--	0.0075±0.061	--
Dorymyrmex bureni	0.0196±0.1386	0.0404±0.1392	--
Forelius Mccooki	--	0.003±0.0387	--
Formica integra	--	0.0045±0.0473	--
Formica pallidefulva	--	0.009±0.0668	--
Formica schaufussi	--	0.0105±0.0721	--
Formica subsericea	--	0.009±0.0668	--
Hypoponera	0.0073±0.0851	0.0194±0.0975	0.0211±0.1437
Lasius	--	0.299±0.3237	0.0042±0.0647
Leptothorax	--	0.0075±0.061	--
Monomorium trageri	--	0.0015±0.0274	--
Myrmica	--	0.009±0.0668	--
Paratrechina faisonensis	0.0024±0.0489	--	0.0338±0.1807
Paratrechina flavipes	--	--	--
Paratrechina parvula	--	0.0015±0.0274	--
Phidole crassicornis	0.0293±0.1686	--	0.0042±0.0647
Phidole denata	--	0.012±0.077	--
Phidole dentigula	--	0.0075±0.061	--
Phidole morrisi	--	0.1525±0.2542	--
Phidole vinlandica	--	0.0389±0.1367	--
Prenolepis imparis	--	0.0299±0.1204	--
Solenopsis carolinensis	--	0.006±0.0546	--
Solenopsis invicta	0.9046±0.2938	--	0.9241±0.2648
Tapinoma sessile	--	0.0105±0.0721	--

Table 4.14: Maritime Forest: A total of 624 ants were collected over six sample transects. Twenty-four species were identified in 13 genera.	
Region	Coastal Plains
Landscape type	28 Maritime Forest
N	6
Total	624
Apheanogaster ashmeadi	0.0577±0.0753
Apheanogaster lamellidans	0.0016±0.0163
Apheanogaster rudis	0.2067±0.1653
Camponotus americanus	0.0176±0.0537
Camonotus casteneas	0.0192±0.056
Camponotus pennslyvanicus	0.0096±0.0398
Crematogaster cerasi	0.0128±0.0459
Crematogaster lineolata	0.016±0.0512
Cyphomyrmex rimosus	0.0032±0.0231
Formica schaufussi	0.0048±0.0282
Hypoponera opaciceps	0.0016±0.0163
Hypoponera opacior	0.0016±0.0163
Myrmecina americana	0.008±0.0364
Neivamyrmex opacithorax	0.0321±0.072
Neivamyrmex texanus	0.0048±0.0282
Paratrechina faisonensis	0.0032±0.0231
Phidole crassicornis	0.0769±0.1088
Phidole denata	0.1058±0.1256
Phidole vinlandica	0.008±0.0364
Solenopsis carolinensis	0.0016±0.0163
Solenopsis invicta	0.024±0.0625

Table 4.15: Species Richness Summary: The total number of species found in each landscape type by physiographic region as well as the average number of species per sample ± standard error is represented in this table.

	Region							
Land Cover Class	Mountain		Piedmont		Coastal Plain		Sandhill	
	Total Species	Average	Total Species	Average	Total Species	Average	Total Species	Average
Recreation Area			11[1]					
Fresh and Saltwater Marsh					11[1]			
Bay/Pocosin							27	8.6±0.5
Swamp and Bottomland Hardwood			22	7.0±1.1	19	7.7±0.7	18	5.2±1.0
Cleared Land	24	10.0±1.6	17	5.3±0.5	20	4.4±0.9	17	7.7±3.7
Upland Pine Forest	26	10.4±2.6	25	8.2±1.1	24	7.9±1.0	31	7.4±1.3
Longleaf Pine Forest					35	9.5±1.0		
Upland Deciduous Forest	25	7.3±0.9	20	6.2±0.6			29	7.6±0.3
Mesic Deciduous Forest	23	7.0±0.5	23	7.1±0.6	26	8.4±1.7		
Upland Mixed Forest	38	9.3±0.7	19	5.8±0.6				
Mesic Mixed Forest	25	6.4±0.8	21	6.6±1.2				
Grassland	21	11.3±5.0	27	8.4±1.4	16	3.9±1.0	24	8.8±2.1
Cultivated	25	20.5±4.5	7[1]		7[1]			
Maritime Forest					24	10.2±1.5		

[1] Only a single sample is represented in the collection.

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CHAPTER FIVE

SUMMARY AND DISCUSSION

One hundred and twenty-one (121) species in 38 Genera of Formicidae that were collected within the state of South Carolina during the course of this study. The 1999-2000 pitfall traps yielded 41,414 individual ants and the small-scale, experimental forest survey added 768 individuals. The majority of the records presented here were collected through pitfall trapping and thus comprise mostly epigeic ants. Notably missing from this list are many Dacitine ants found largely in subterranean habitats, and species that are primarily or completely arboreal.

The only arboreal species represented are those that spend some portion of time on the surface such as *Crematogaster*, *Leptothrorax,* or *Lasius*. Several species of *Lasius* spends most of it's lifecycle in the trees. It usually is found in the soil profile only during mating flights which occur in the early fall season, and is likely under-represented even though it has been found in the pitfall collections. It would not be surprising if this particular natural history has contributed to an underestimation of the distribution of thsese species. Other species that have been hand collected such as the *Pseudomyrmecinae* an arboreal genus are completely missing from the pitfall collection.

Another missing puzzle piece is the temporal equation. This survey was conducted one time at each location. Variations due to the season, temperature, rainfall, or photoperiod are not well represented in this collection. For example, *Prenolepis imparis* which are active only in the fall and winter months are not represented in the portion of the collection obtained during the warmest part of the summer months, but appear in the portions collected in the fall season. During times of drought I've been told, as a county agent, by the public that fire ants are no longer a problem. Having spent a great deal of time in the field doing bait studies I know that fire ants are present and active, but the mounds are not easy to find. In spite of the missing puzzle pieces it is still the best picture we have of the ants of South Carolina, their associated habitats, distributions, relative abundance, and community relationships.

The limited litter sifting that was conducted in Pickens and Anderson counties yielded three new records of the *Pyramica* and *Strumigenys* genera and indicates that this collection technique will probably produce many new records as it is applied in other locations within the state. Additionally some habitats, such as residential and cultivated land were not extensively sampled and some ants closely associated with these habitats are also likely under-represented. Museum records have buffered collection deficiencies to some extent and; this list will undoubtedly grow as more intensive sampling of the ant fauna is conducted by future researchers.

I would estimate that this list could easily exceed 200 species of ants. When examining the literature there are numerous ants whose range includes South Carolina because of records both North and South of South Carolina, but many of these ants have not been collected in South Carolina. Visiting museums with more extensive ant collections than our own Arthropod museum will yield records that are not listed. More intensive sampling of specific habitats will also reveal new records. In fact during the course of writing my findings the list kept growing faster that I could complete the manuscript.

Some groups have received recent revisions such as *Pheidole* (Wilson 2003). Such revisions have added to our knowledge of the fauna as well as provided updated dichotomous keys which were not available beforehand.

The availability of new tools for identifying ants will also help grow the list. Electronic keys are becoming more available and are easier for new students of myrmecology to collect and find and use. It is hoped that his study will stimulate further studies of the ant fauna of South Carolina and serve as a resource for new students of the ants of South Carolina.

Use GAP methods to develop distributions for ants collected in South Carolina

Many of the GAP landscape types and physiography are also present in our neighboring states. An examination of the literature suggests that we also share many of the same ants species (Carter 1962, Isper et al. 2004). These data could easily be expanded to make predictive models of ant populations in neighboring states. Future studies could be conducted to test the veracity of such models over a larger scale.

There are several ways this information can be useful. For example the Red Imported Fire Ant (RIFA) *Solenopsis invicta* is under a federal quarantine enforced by the USDA-APHIS. These data were used to predict the range of RIFA in South Carolina. Ground truthing of these predictions was conducted to substantiate the model. The resulting information was then used to support the modification of the quarantine zone. In this case, the model provided information that allowed ground observations to be targeted to the most likely locations for RIFA. The model also established a scientific basis for making the decision and removed the potential for political bias to enter the decision.

The range of RIFA is still expanding in North Carolina. This model if expanded to include North Carolina could be used in combination with other models (Thompson et al. 1998, Morrison et al. 2004), and could provide an accurate picture of the potential future RIFA range. Regulators could use such predictions in surveys for RIFA and maximize the efficiency of such surveys.

Another interesting distribution is that of an invasive species such as *P. chinensis*. *Pachycondyla chinensis* has a painful sting and the potential as species of medical and veterinary significance. Several cases of allergic reactions to the stings have been reported (Bae et al. 1999, Kim et al. 2001). Is this an invasive whose territory is expanding? *Pachycondyla chinensis* was found only in the mountains and piedmont regions of Oconee and Pickens Counties, however, it has been reported as an emerging problem (Nelder et al. 2006). Using the rules of the model the distribution of the ant would be only in those two counties. If, however, the range of this invasive ant is expanding the model could be used to predict the possibility that it could cover the entire mountain and piedmont region. This study now provides some base line data for future studies. Surveys could use them model to target surveys to the areas most likely to host this invasive ant reducing the size and scope of potential survey methods.

One of the increasing problems in South Carolina is urban sprawl. The Strom Thurmond Institute at Clemson University (STI) and the South Carolina Department of Natural Resources (SCDNR) have been involved in projects to detect change and project future growth changes in the state. SCGAP proposes that their data can be used to monitor urban sprawl and the accompanying changes in habitat (p. 95 SCGAP final report).

Ants have been used in Australia as indicators to track the progress of mine restoration projects (Majer 1982, 1983). The species profile of a restoration project is compared with the species profile of the target landscape type.

The search for the perfect indicator species does not end with the ants, however ants do provide a number of advantages as tools for indicating environmental or ecological change.

- They are present in most habitats and are found in large numbers.
- They are active in a relatively small scale and don't roam outside of the study area.
- While ant taxonomy is somewhat difficult it is relatively easy for field technicians to learn to identify a suite of ants to a morphospecies level.
- The presence of several ant species is sharply defined by the habitat types in which they are found.
- Ants are easy to collect using a number of collection methods such as pitfalls or litter samples.
- Ant species are often partitioned throughout the landscape. Some ants are found primarily or exclusively in subterranean environment, other are epigeic, still others are arboreal. Changes in any of these environments can impact the presence or absence of given ant species.

The inclusion of ants as one of an ensemble of indicator species can help with several questions facing the landscape ecologist in South Carolina. Similar to Australia ants could be a valuable contribution is answering questions surround the success of restoration projects. The addition of ants as indicators may also be able to provide ecological tools for measuring the impact of land management decisions.

These data are certainly not inclusive of all the possible ants that can be found in a given landscape type. The fact that areas that were more intensively sampled yielded a greater species richness suggests that more sampling in the future would yield a more robust view of the population. Thus these data are not a perfect tool as indicators of ecological change. These data do, however, provide a baseline and expected values for similar uses in South Carolina that can be used in future studies. They are also the *only* available view of the ant populations in South Carolina.

Species Richness and Species Abundance

Speices richness is a key concept in the GAP Analysis. The primary goal of the program is to "keep common species common". To do this habitats with high species richness is preserved. GAP, like most preservation programs has a strong vertebrate bias, but invertebrates are more abundant and play an important role in any habitat or ecosystem. These data provide some expected values for future studies of the ant fauna in South Carolina. Future studies can compare detailed collections of landscape types and test them for differences. These future data can be added to this information to refine and fine tune these models. It is hoped that this study can and will be used in the future to specifically fill in the gaps in South Carolina's myrmecological fauna.

Without a doubt this data has not been fully mined for information regarding species richness and abundance. One interesting eyeball type observation of the data suggests that when fire ants (*Solenopsis invicta*) were present they represented as much as 90+% of the ants collected. In some of the habitats that were collected across all four physiographic regions fire ants were not present in the mountain region. It might be enlightening to analyize the abundance and composition of the ant communities impacted by fire ants. There are of course some problems that might be encountered because the species composition might be inherently different across the physiographic regions without regard the presence of fire ants. Such “statistical noise” might render such analysis difficult to defend.

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APPENDICES

Appendix A

Pitfall Location Data

GPS file names were assigned to each sample location. This file helps associate the collection information in Appendix A and Appendix B. The regions represent abbreviations for the physiographic regions of South Carolina M=Mountains, P=Piedmont, S=Sandhills, and C=Coastal Plains. Pitfall date represents the date the pitfall was placed in the ground (mmddyy). Pitfall #'s represent the actual pitfall number/s from each sample and also help relate Appendix A and B. The Universal Transverse Mercator (UTM) coordinates for each location are given as UTM east and UTM north.

GPS file name	Region	Research classification	Pitfall date	Pitfall #	UTM east	UTM north
r051116a	M	Mesic Mixed Forest	051199	0-10	315257	3875373
r051118a	M	Mesic Deciduous Forest	051199	12-22a	315421	3877210
r051217a	M	Mesic Deciduous Forest	051299	22b-32	313402	3875227
r051218a	M	Mesic Mixed Forest	051299	33-43	312479	3875050
r051317a	M	Upland Mixed Forest	051399	44-54	310903	
r051319a	M	Upland Mixed Forest	051399	55-65	306971	3871940
r051716a	M	Mesic Mixed Forest	051799	88-98	305610	3857538
r051718b	M	Upland Diciduous Forest	051799	66-76	309159	3869033

GPS file name	Region	Research classification	Pitfall date	Pitfall #	UTM east	UTM north
r051720a	M	Mesic Deciduous Forest	051799	77-87	307373	3858731
r051817a	M	Mesic Mixed Forest	051899	100-110	300806	3865000
r051817b	M	Upland Mixed Forest	051899	111-121	301988	3862943
r051820a	M	Grassland	051899	122-132	306686	3861723
r052017a	M	Upland Mixed Forest	052099	133-143	304493	3853796
r052018b	M	Cultivated	052099	144-154	295620	3852342
r052118r	M	Upland Mixed Forest	052199	155-165	302483	3849424
r052120a	M	Cultivated	052199	166-176	302205	3844222
r052519a	M	Upland Mixed Forest	052599	177-187	302308	3854507
r052520a	M	Upland Mixed Forest	052599	188-198	300834	3856867
r052717a	M	Upland Pine Forest	052799	199-209	297481	2858631
r052718a	M	Mesic Mixed Forest	052799	210-220	296580	3860783
r052719a	M	Upland Diciduous Forest	052799	221-231	303455	3850638
r052813b	M	Mesic Deciduous Forest	052799	232-242	302108	3848376
r052814a	M	Cleared Land	052899	243-253	301649	3852344
r052816a	M	Upland Mixed Forest	052899	254-264	298729	3851673
r052817a	M	Upland Mixed Forest	052899	265-275	296133	3852424
r060118a	M	Mesic Deciduous Forest	060199	276-286	315286	3869650
r060119a	M	Cleared Land	060199	287-297	316050	3866807
r060214a	M	Grassland	060299	398-308	317177	3876118
r060215a	M	Upland Mixed Forest	060299	309-319	318389	3874032
r060219a	M	Mesic Mixed	060299	320-330	315190	3874858

GPS file name	Region	Research classification	Pitfall date	Pitfall #	UTM east	UTM north
		Forest				
r060316a	M	Mesic Mixed Forest	060399	331-341	314620	3871828
r060418a	M	Upland Mixed Forest	060499	342-352	307943	3859841
r060420a	M	Mesic Deciduous Forest	060499	364-374	307337	3860352
r060718a	M	Upland Diciduous Forest	060799	375-385	328866	3871364
r060719a	M	Mesic Mixed Forest	060799	286-396	327946	3871733
r060719b	M	Upland Mixed Forest	060799	397-407	328058	3872052
r060721a	M	Upland Mixed Forest	060799	408-418	327336	3872399
r060819a	M	Upland Mixed Forest	060899	419-429	326741	3872675
r060914a	M	Upland Diciduous Forest	060999	430-440	326986	3873997
r060915a	M	Cleared Land	060999	441-451	326997	3874862
r060915r	M	Upland Mixed Forest	060999	452-462	327710	3875996
r060916r	M	Upland Mixed Forest	060999	463-473	328268	3876841
r061018a	M	Mesic Deciduous Forest	061099	474-484	329395	3877513
r061114r	M	Upland Mixed Forest	062199	353-363	307515	3860868
r061716a	M	Upland Mixed Forest	061799	496-506	331477	3878544
r061821r	M	Mesic Deciduous Forest	061899	518-528	326827	3875247
r062215a	M	Mesic Mixed Forest	062299	529-539	334566	3880651
r062216a	M	Mesic Deciduous	062299	540-550	334469	3882323

GPS file name	Region	Research classification	Pitfall date	Pitfall #	UTM east	UTM north
		Forest				
r062218a	M	Upland Mixed Forest	062299	551-561	335424	3879911
r062218b	M	Upland Diciduous Forest	062299	562-572	335384	3878337
r062316a	M	Upland Mixed Forest	062399	573-583	327490	3867754
r062317a	M	Upland Diciduous Forest	062399	584-594	327584	3867184
r062318a	M	Upland Pine Forest	062399	595-605	328096	3867040
r062319a	M	Upland Mixed Forest	062399	606-616	328009	3866892
r062414a	M	Upland Diciduous Forest	061799	507-517	332407	3878829
r062414b	M	Mesic Deciduous Forest	061099	485-495	330854	3877515
r062817a	M	Upland Mixed Forest	062899	617-627	321807	3869189
r062817b	M	Upland Mixed Forest	062899	628-638	321625	3869754
r062918a	M	Upland Diciduous Forest	062999	639-649	333050	3879961
r062919r	M	Mesic Mixed Forest	062999	650-660	334024	3880069
r063017A	M	Upland Mixed Forest	063099	661-671	345066	3878218
r063018a	M	Upland Diciduous Forest	063099	672-682	344287	3877155
r063019a	M	Upland Mixed Forest	063099	683-693	345612	3878678
r063020r	M	Upland Mixed Forest	063099	694-704	345083	3877924
r070115a	M	Upland Mixed Forest	070199	705-715	325730	3874830

GPS file name	Region	Research classification	Pitfall date	Pitfall #	UTM east	UTM north
r070116a	M	Upland Diciduous Forest	070199	716-726	325721	3873455
r071414b	M	Cleared Land	071499	727-737	292241	3854141
r071416a	M	Grassland	071499	738-748	290948	3849776
r071420a	M	Cleared Land	**071499**	749-759	302629	3840363
r072016a	M	Upland Pine Forest	072099	881-891	304074	3849497
r072019a	M	Upland Pine Forest	**072099**	892-902	299553	3846132
r072613a	P	Upland Pine Forest	072699	947-957	436507	3802378
r072613b	P	Cultivated	072699	958-968	437985	3804722
r072614a	P	Mesic Mixed Forest	072699	969-979	438281	3806148
r072616a	P	Upland Diciduous Forest	072699	991-1001	441039	3805897
r072715a	M	Upland Pine Forest	072799	1002-1012	298098	3856181
r072716a	M	Upland Pine Forest	072799	1013-1023	300325	3858255
r072719b	M	Upland Pine Forest	072799	1024-1034	299637	3843925
r072913r	P	Recreation Area	072999	1035-1045	439237	3829614
r072914a	P	Upland Pine Forest	072999	1046-1056	439177	3827266
r072917a	P	Upland Pine Forest	072999	1057-1067	431154	3834098
r073015a	P	Upland Pine Forest	072399	903-913	434373	3813527
r073015b	P	Upland Mixed Forest	072399	914-924	436646	3811461
r073016a	P	Upland Mixed Forest	072399	925-935	439101	3809590
r081012b	P	Mesic Deciduous Forest	081099	1068-1078	374322	3865618
r081015a	P	Mesic Mixed Forest	081099	1090-1100	420718	3860044

GPS file name	Region	Research classification	Pitfall date	Pitfall #	UTM east	UTM north
r081016a	P	Mesic Mixed Forest	081099	1101-1111	420717	3860047
r081113a	P	Cleared Land	081199	1112-1122	427229	3825416
r081113b	P	Cleared Land	081199	1123-1133	436104	3828567
r081115r	P	Upland Diciduous Forest	081199	1134-1144	430187	3822591
r081212a	P	Upland Pine Forest	081299	1145-1155	446588	3800336
r081213a	P	Upland Pine Forest	081299	1156-1166	453171	3802937
r081215a	P	Upland Pine Forest	081299	1178-1188	465510	3797485
r081813a	P	Cleared Land	081899	1189-1199	469584	3812335
r081814a	P	Upland Diciduous Forest	081899	1200-1210	469561	3812314
r081815a	P	Mesic Mixed Forest	081899	1211-1221	464213	3814360
r081913a	P	Upland Pine Forest	081999	1222-1232	448720	3818380
r082013a	P	Upland Diciduous Forest	082099	1244-1254	451767	3831278
r082014b	P	Upland Diciduous Forest	082099	1255-1265	468843	3887844
r082017r	P	Upland Diciduous Forest	082099	1277-1287	468381	3889635
r082611a	P	Upland Diciduous Forest	082699	1288-1298	374757	3773934
r082612a	P	Upland Pine Forest	082699	1310-1320	376776	3771992
r082613a	P	Upland Pine Forest	082699	1299-1309	380106	3770292
r082713a	P	Upland Mixed	082799	1321-	330455	3845970

GPS file name	Region	Research classification	Pitfall date	Pitfall #	UTM east	UTM north
		Forest		1331		
r082714a	P	Mesic Deciduous Forest	082799	1376-1386	329946	3847327
r083012a	P	Grassland	083099	1332-1342	372534	3776245
r083014a	P	Cleared Land	083099	1354-1364	372681	3774424
r083014b	P	Cleared Land	083099	1343-1353	374807	3771054
r083015r	P	Swamp and Bottomland Hardwood	083099	1365-1375	374841	3771054
r090216r	P	Mesic Deciduous Forest	090299	1398-1408	371474	3756749
r090314b	P	Upland Diciduous Forest	090399	1409-1419	329604	3847390
r090315a	P	Mesic Deciduous Forest	090399	1420-1430	329177	3846088
r090713a	P	Swamp and Bottomland Hardwood	090799	1452-1462	369177	3846088
r090714a	P	Swamp and Bottomland Hardwood	090799	1463-1473	367138	3761090
r090913b	P	Upland Mixed Forest	090999	1474-1484	331542	3811095
r090915a	P	Upland Mixed Forest	090999	1496-1506	350882	3774511
r091014r	P	Swamp and Bottomland Hardwood	091099	1507-1517	389263	3759623
r091313a	P	Swamp and Bottomland Hardwood	091399	1518-1528	395567	3750427
r091315r	P	Upland Mixed Forest	091399	1529-1539	398329	3748900
r091316r	P	Swamp and	091399	1540-	395988	3740532

GPS file name	Region	Research classification	Pitfall date	Pitfall #	UTM east	UTM north
		Bottomland Hardwood		1550		
r091414a	P	Swamp and Bottomland Hardwood	091499	1551-1561	366584	3758609
r091714r	P	Upland Diciduous Forest	091799	1562-1572	330033	3845185
r091717a	P	Cleared Land	091799	1584-1594	329085	3849564
r092115a	P	Swamp and Bottomland Hardwood	092199	1595-1605	393407	3728120
r092116a	P	Cleared Land	092199	1606-1616	398611	3731900
r092117r	P	Mesic Mixed Forest	092199	1617-1627	403451	3731226
r092313a	P	Grassland	092399	1628-1638	371986	3873404
r092415b	P	Upland Diciduous Forest	092499	1639-1649	330532	3841840
r092416a	P	Upland Mixed Forest	092499	1650-1660	333076	3842928
r093012a	P	Grassland	093099	1683-1693	333511	3834356
r093013a	P	Upland Mixed Forest	093099	1661-1671	331088	3832811
r100215a	P	Mesic Deciduous Forest	100299	1705-1715	332423	3833060
r100216a	P	Swamp and Bottomland Hardwood	100299	1716-1726	332580	3830116
r100615a	P	Grassland	100699	1727-1737	340665	3832874
r100615b	P	Grassland	100699	1738-1748	338819	3833614
r100617a	P	Mesic Mixed Forest	100699	1749-1759	331599	3834798
r100618a	P	Mesic	100699	1760-	332471	3835848

GPS file name	Region	Research classification	Pitfall date	Pitfall #	UTM east	UTM north
		Deciduous Forest		1770		
r100717a	P	Mesic Deciduous Forest	100799	1771-1781	319932	3831591
r100718a	P	Grassland	100799	1782-1792	319735	3831495
r101118a	P	Upland Mixed Forest	101199	1793-1803	331114	3832066
r101120a	P	Grassland	101199	1804-1814	332321	3833286
r101417a	P	Upland Mixed Forest	101499	1815-1825	348334	3863063
r102217a	P	Mesic Mixed Forest	102299	1837-1847	412179	3784371
r102218r	P	Swamp and Bottomland Hardwood	102299	1848-1858	410218	3886914
t051214a	C	Mesic Deciduous Forest	051200	1859-1869	491700	3658075
t051221b	C	Mesic Deciduous Forest	051200	1881-1891	484208	3632534
t051411a	C	Cleared Land	051400	1936-1946	477162	3613477
t051411b	C	Grassland	051400	1947-1957	477297	3619383
t051721a	C	Swamp and Bottomland Hardwood	051700	2002-2012	525819	3611256
t051811a	C	Cleared Land	051800	2024-2034	524347	3606441
t051812a	C	Cleared Land	051800	2035-2045	528125	3610904
t051821a	C	Upland Pine Forest	051800	2046-2056	529143	3608383
t051822a	C	Mesic Deciduous Forest	051800	2057-2067	528557	3609178
t051923b	C	Upland Pine	051900	2079-	527423	3609913

GPS file name	Region	Research classification	Pitfall date	Pitfall #	UTM east	UTM north
		Forest		2089		
t052011a	C	Cultivated	051900	2090-2100	526406	3610109
t052022a	C	Maritime Forest	052000	2112-2122	527758	3609419
t052911b	C	Swamp and Bottomland Hardwood	052900	2167-2177	535875	3658471
t052914b	C	Mesic Deciduous Forest	052900	2200-2210	556885	3654528
t053011a	C	Cleared Land	053000	2211-2221	551662	3656369
t053122a	C	Longleaf Pine Forest	053100	2244-2254	490435	3594757
t053123a	C	Longleaf Pine Forest	053100	2255-2265	489553	3595732
t053123b	C	Longleaf Pine Forest	053100	2266-2276	490510	3593866
t060513a	C	Swamp and Bottomland Hardwood	060500	2332-2342	575440	3624620
t060514a	C	Grassland	060500	2343-2353	571331	3623656
t060516a	C	Maritime Forest	060500	2365-2375	575199	3624028
t061410a	C	Swamp and Bottomland Hardwood	061400	2387-2397	601358	3685313
t061413a	C	Upland Pine Forest	061400	2398-2408	601938	3678538
t061511a	C	Grassland	061400	2409-2419	547262	3706319
t061513a	C	Mesic Deciduous Forest	061500	2431-2441	548045	3708368
t061523a	C	Swamp and Bottomland Hardwood	061500	2442-2452	611069	3679319
t061615a	C	Longleaf Pine Forest	061600	2464-2474	582529	3762428

GPS file name	Region	Research classification	Pitfall date	Pitfall #	UTM east	UTM north
t061622b	C	Swamp and Bottomland Hardwood	061600	2475-2485	598009	3682218
t062014a	C	Grassland	062000	2541-2551	595968	3685765
t062022a	C	Cleared Land	062000	2508-2518	602323	3684137
t062113a	C	Swamp and Bottomland Hardwood	062100	2519-2529	540368	3741536
t062114a	C	Upland Pine Forest	062100	2552-2562	544853	3746231
t062122a	C	Mesic Deciduous Forest	062100	2563-2573	543068	3740487
t062123a	C	Cleared Land	062100	2574-2584	545976	3738656
t062813a	C	Fresh and Saltwater Marsh	062800	2596-2606	567847	3706797
t062912a	C	Longleaf Pine Forest	062900	2607-2617	636685	3670632
t062914a	C	Mesic Deciduous Forest	062900	2618-2628	640779	3666518
t063011b	C	Cleared Land	063000	2651-2661	627176	3677987
t063023a	C	Grassland	063000	2662-2672	639413	3660232
t070112a	C	Maritime Forest	070100	2673-2683	632055	3654641
t070122a	C	Longleaf Pine Forest	070100	2684-2694	661751	3687976
t070123a	C	Maritime Forest	070200	2695-2705	662300	3685805
t070213a	C	Upland Pine Forest	070200	2706-2716	665284	3691435
t070511a	C	Longleaf Pine Forest	070500	2728-2738	622274	3711174
t070513a	C	Mesic Deciduous	070500	2739-2749	612316	3719973

GPS file name	Region	Research classification	Pitfall date	Pitfall #	UTM east	UTM north
		Forest				
t070823a	C	Grassland	070800	2860-2870	630988	3656495
t071013a	C	Longleaf Pine Forest	071000	2871-2881	676545	3781168
t071114a	C	Mesic Deciduous Forest	071100	2882-2892	648261	3712968
t071122a	C	Longleaf Pine Forest	071100	2893-2903	695378	3742617
t072023b	C	Grassland	072000	2794-2804	614645	3714544
t072111a	C	Cleared Land	072100	2805-2815	666055	3716053
t072122a	C	Maritime Forest	072100	2838-2848	679017	3709881
t072125a	C	Maritime Forest	072100	2915-2925	678243	3708750
t072212a	C	Longleaf Pine Forest	072200	2926-2936	697557	3742277
t072213a	C	Cleared Land	072200	2937-2947	710095	3755494
t072312a	C	Mesic Deciduous Forest	072300	2959-2969	691378	3725212
t080214a	S	Swamp and Bottomland Hardwood	080200	3036-3046	449068	3692472
t080308a	S	Bay/Pocosin	080300	3047-3057	449580	3685571
t080314a	S	Bay/Pocosin	080300	3069-3079	446871	3675269
t080315a	S	Bay/Pocosin	080300	3080-3090	448060	3675642
t080318a	S	Upland Pine Forest	080300	3090-3101	452989	3688096
t080408a	S	Upland Diciduous Forest	080400	3102-3112	431899	3690549
t080409a	S	Upland Pine Forest	080400	3113-3123	436372	3690077

GPS file name	Region	Research classification	Pitfall date	Pitfall #	UTM east	UTM north
t080413a	S	Upland Pine Forest	080400	3135-3145	449270	3668928
t080414a	S	Upland Pine Forest	080400	3146-3156	451264	3673596
t080512a	S	Upland Diciduous Forest	080500	3124-3134	439940	3686305
t080514a	S	Upland Diciduous Forest	080500	3157-3167	438866	3684869
t080613a	S	Bay/Pocosin	080600	3234-3244	449717	3673543
t080614a	S	Bay/Pocosin	080600	3179-3189	432707	3671565
t080615a	S	Swamp and Bottomland Hardwood	080600	3190-3200	431951	3669827
t080923a	S	Swamp and Bottomland Hardwood	080900	3212-3222	422297	3682951
t081112a	S	Upland Pine Forest	081100	3245-3255	462090	3707298
t081113a	S	Cleared Land	081100	3256-3266	463941	3707422
t081612a	S	Bay/Pocosin	081600	3300-3310	484732	3669286
t081613a	S	Grassland	081600	3366-3376	478508	3672491
t081712a	S	Upland Diciduous Forest	081700	3377-3387	471345	3688287
t081713a	S	Grassland	081700	3388-3398	471233	3686440
t081812a	S	Swamp and Bottomland Hardwood	081800	3399-3409	451159	3714032
t081813a	S	Grassland	081800	3410-3420	450819	3707720
t082215a	S	Upland Diciduous Forest	082200	3432-3442	527079	3763090

GPS file name	Region	Research classification	Pitfall date	Pitfall #	UTM east	UTM north
t082223a	S	Upland Diciduous Forest	082200	3443-3453	513613	3761490
t082312a	S	Upland Pine Forest	082300	3454-3464	513829	3771918
t082812a	S	Upland Diciduous Forest	082800	3487-3497	530188	3767800
t082813a	S	Cleared Land	082800	3498-3508	528415	3772148
t082913a	S	Upland Pine Forest	082900	3520-3530	508452	3772509
t083013b	S	Swamp and Bottomland Hardwood	083000	3597-3607	504010	3753378
t083021a	S	Swamp and Bottomland Hardwood	083000	3608-3618	511339	3746267
t090721a	S	Upland Diciduous Forest	090700	3564-3574	520337	376205
t090722a	S	Upland Diciduous Forest	090700	3619-3629	512113	3763342
t090822a	S	Grassland	090800	3630-3640	574986	3825360
t090913a	S	Bay/Pocosin	090900	3740-3750	544162	3798199
t090914b	S	Upland Pine Forest	090900	3751-3761	544624	3795620
t090922a	S	Grassland	090900	3783-3793	570154	3829363
t091013a	S	Upland Pine Forest	091000	3794-3804	571725	3832046
t091014a	S	Upland Pine Forest	091000	3805-3815	571046	3834843
t091122a	S	Cleared Land	091100	3848-3858	567574	3812406
t091222a	S	Upland Diciduous Forest	091200	3859-3869	518066	3792050

Appendix B

Pitfall Collection Data

GPS file names were assigned to each sample location. This file helps associate the collection information in Appendix A and Appendix B. Research Classification is the classification code assigned by the GAP analysis project to each habitat type a key to the code types can be found in Table 3.1. Pitfall #'s represent the actual pitfall number/s from each sample and also help relate Appendix A and B. The regions represent abbreviations for the physiographic regions of South Carolina M=Mountains, P=Piedmont, S=Sandhills, and C=Coastal Plains. Species represents the ant species that were identified in each sample. Number is the number of individuals of a given species that were found in each sample.

File Name	Research Classification	Pitfall #s	Region	Species	number
r051116a	20	0-10	M	*Apheanogaster fulva*	13
				Apheanogaster picea	7
				Apheanogaster rudis	32
r051118a	18	12-22a	M	*Apheanogaster fulva*	13
				Apheanogaster picea	7
				Apheanogaster rudis	32
				Prenolepis imparis	32
				Stenamma schmittii	4
r051217a	18	22b-32	M	*Apheanogaster fulva*	2
				Apheanogaster picea	21
				Apheanogaster rudis	1
				Camponotus	1
				pennsylvanicus	3
				Myrmecina americana	4
				Myrmica	1
				Myrmica punctiventris	5
				Stenamma schmittii	

File Name	Research Classification	Pitfall #s	Region	Species	number
r051218a	20	331-341	M	*Apheanogaster rudis* *Camponotus* *chromaiodes* *Camponotus* *pennsylvanicus* *Formica subsericea* *Myrmecina americana* *Myrmica* *Paratrechina faisonensis*	16 2 6 69 3 1 1
r051317a	19	44-54	M	*Apheanogaster picea* *Camponotus* *pennsylvanicus* *Formica subsericea* *Lasius* *Myrmecina americana* *Prenolepis imparis*	39 2 163 7 3 29
r051319a	19	55-65	M	*Apheanogaster picea* *Apheanogaster rudis* *Lasius* *Paratrechina concinna*	1 4 113 1
r051716a	20	88-98	M	*Apheanogaster fulva* *Apheanogaster rudis* *Camponotus* *chromaiodes* *Myrmecina americana* *Prenolepis imparis* *Stenamma schmittii*	 1 11 17 1 61 3
r051718b	17	66-76	M	*Apheanogaster fulva* *Apheanogaster picea* *Apheanogaster rudis* *Camponotus* *chromaiodes* *Camponotus* *pennsylvanicus* *Formica integra* *Formica subsericea* *Myrmecina americana* *Myrmica americana* *Myrmica* *Paratrechina faisonensis* *Prenolepis imparis* *Stenamma*	 1 2 14 10 3 2 2 9 1 11 1 20 1

File Name	Research Classification	Pitfall #s	Region	Species	number
r051720a	18	77-87	M	*Apheanogaster rudis*	
				Camponotus americanus	2
				Camponotus	1
				chromaiodes	1
				Myrmecina americana	5
				Prenolepis imparis	14
				Stenamma	1
r051817a	20	100-110	M	*Apheanogaster rudis*	
				Camponotus	10
				chromaiodes	1
				Leptothorax	1
				Myrmecina americana	1
				Paratrechina faisonensis	2
				Prenolepis imparis	58
r051817b	19	111-121	M	*Apheanogaster rudis*	3
				Formica integra	990
				Formica subsericea	80
				Myrmecina americana	1
				Paratrechina faisonensis	2
				Prenolepis imparis	11
				Stenamma	4
				Stenamma schmittii	4
r051820a	21	122-132	M	*Apheanogaster rudis*	6
				Crematogaster atkinsoni	8
				Formica schaufussi	15
				Lasius	62
				Leptothorax	4
				Myrmica	5
				Paratrechina faisonensis	2
				Phidole	16
				Phidole morrisii	16
				Prenolepis imparis	4
				Solenopsis carolinensis	4
				Tapinoma sessile	14

File Name	Research Classification	Pitfall #s	Region	Species	number
r052017a	19	133-143	M	*Apheanogaster rudis*	1
				Crematogaster atkinsoni	3
				Crematogaster lineolata	35
				Crematogaster pilosa	5
				Formica subsericea	3
				Hypoponera	3
				Myrmecina americana	1
				Phidole denata	13
				Prenolepis imparis	39
r052018b	22	144-154	M	*Camponotus*	
				pennsylvanicus	1
				Crematogaster atkinsoni	1
				Crematogaster pilosa	5
				Formica integra	3
				Formica pallidefulva	4
				Formica schaufussi	3
				Hypoponera	10
				Lasius	87
				Lasius alienus	
				Lasius neoniger	
				Lasius umbratus	
				Leptothorax	3
				Phidole denata	7
				Phidole dentigula	5
				Phidole morrisii	85
				Phidole vinelandica	8
				Prenolepis imparis	18
				Solenopsis carolinensis	2
r052118r	19	155-165	M	*Apheanogaster fulva*	6
				Apheanogaster rudis	10
				Camponotus americanus	1
				Camponotus	4
				pennsylvanicus	14
				Formica argentea	525
				Formica integra	75
				Formica subsericea	4
				Leptothorax	3
				Myrmica	1
				Paratrechina faisonensis	24
				Prenolepis imparis	4
				Solenopsis carolinensis	1
				Stenamma	

File Name	Research Classification	Pitfall #s	Region	Species	number
r052120a	22	166-176	M	*Apheanogaster rudis*	9
				Crematogaster lineolata	63
				Dorymyrmex bureni	27
				Forelius mccooki	2
				Formica pallidefulva	2
				Formica schaufussi	4
				Formica subsericea	6
				Hypoponera	3
				Lasius	113
				Leptothorax	2
				Monomorium trageri	1
				Myrmica	6
				Paratrechina parvula	1
				Phidole	36
				Phidole denata	1
				Phidole morrisii	17
				Phidole vinelandica	18
				Prenolepis imparis	2
				Solenopsis carolinensis	2
				Tapinoma sessile	7
r052519a	19	177-187	M	*Apheanogaster rudis*	
				Camponotus americanus	9
				Camponotus	10
				pennsylvanicus	2
				Crematogaster lineolata	1
				Formica integra	1
				Formica subsericea	27
				Monomorium trageri	1
				Myrmecina americana	4
				Myrmica	4
				Paratrechina faisonensis	5
				Phidole	16
				Phidole denata	16
				Prenolepis imparis	71
				Solenopsis carolinensis	7
				Stenamma	1

File Name	Research Classification	Pitfall #s	Region	Species	number
r052520a	19	188-198	M	*Apheanogaster rudis*	
				Camponotus americanus	10
				Camponotus	2
				pennsylvanicus	3
				Crematogaster lineolata	1
				Hypoponera	1
				Myrmecina americana	2
				Paratrechina faisonensis	13
				Phidole	1
				Phidole vinelandica	1
				Prenolepis imparis	29
				Tapinoma sessile	2
r052717a	14	199-209	M	*Apheanogaster rudis*	
				Camponotus	1
				pennsylvanicus	3
				Formica schaufussi	2
				Myrmecina americana	2
				Paratrechina faisonensis	3
				Phidole denata	2
				Prenolepis imparis	132
r052718a	20	210-220	M	*Apheanogaster rudis*	
				Camponotus	26
				pennsylvanicus	2
				Formica subsericea	31
				Hypoponera	1
				Myrmecina americana	1
				Myrmica	7
				Paratrechina faisonensis	2
				Prenolepis imparis	113
				Solenopsis carolinensis	1
				Strumigenys gundlachi	1
r052719a	17	221-231	M	*Apheanogaster rudis*	
				Camponotus americanus	2
				Camponotus	1
				pennsylvanicus	3
				Crematogaster lineolata	3
				Formica subsericea	320
				Myrmecina americana	3
				Prenolepis imparis	9
				Solenopsis carolinensis	1

File Name	Research Classification	Pitfall #s	Region	Species	number
r052813b	18	232-242	M	*Apheanogaster picea*	
				Apheanogaster rudis	1
				Brachymyrmex	19
				Camponotus americanus	1
				Camponotus	41
				pennsylvanicus	8
				Formica subsericea	16
				Myrmecina americana	5
				Myrmica	7
r052814a	11	243-253	M	*Apheanogaster rudis*	6
				Camponotus	1
				Crematogaster lineolata	31
				Crematogaster pilosa	12
				Hypoponera	2
				Leptothorax	3
				Monomorium trageri	2
				Myrmecina americana	2
				Phidole denata	6
				Prenolepis imparis	5
				Solenopsis carolinensis	2
r052816a	19	254-264	M	*Ambylopone*	
				Apheanogaster rudis	1
				Camponotus	8
				pennsylvanicus	7
				Crematogaster atkinsoni	4
				Crematogaster lineolata	3
				Formica schaufussi	2
				Formica subsericea	5
				Hypoponera	1
				Leptothorax	2
				Monomorium trageri	3
				Myrmecina americana	4
				Paratrechina faisonensis	3
				Phidole denata	200
				Phidole vinelandica	2
				Prenolepis imparis	31
				Solenopsis carolinensis	2
				Tapinoma sessile	9

File Name	Research Classification	Pitfall #s	Region	Species	number
r052817a	19	265-275	M	*Apheanogaster rudis*	26
				Camponotus floridanus	13
				Crematogaster cerasi	1
				Crematogaster atkinsoni	3
				Formica schaufussi	20
				Monomorium trageri	1
				Myrmica americana	7
				Paratrechina concinna	4
				Prenolepis imparis	96
r060118a	18	276-286	M	*Apheanogaster rudis*	
				Camponotus americanus	4
				Camponotus	1
				pennsylvanicus	37
				Formica subsericea	1
				Prenolepis imparis	16
r060119a	11	287-297	M	*Apheanogaster picea*	2
				Apheanogaster rudis	15
				Crematogaster lineolata	4
				Monomorium minimum	1
				Myrmecina americana	4
				Myrmica americana	1
				Paratrechina faisonensis	1
				Prenolepis imparis	130
				Solenopsis carolinensis	1
r060214a	19	397-407	M	*Apheanogaster rudis*	
				Camponotus americanus	22
				Hypoponera	3
				Myrmecina americana	1
				Phidole denata	2
				Prenolepis imparis	106
				Solenopsis carolinensis	50
				Stenamma	1
				Tracymyrmex	1
				septentrionalis	1

File Name	Research Classification	Pitfall #s	Region	Species	number
r060215a	15	3090-3101	S	*Apheanogaster rudis*	1
				Aphaenogaster treatae	8
				Crematogaster lineolata	21
				Dorymyrmex bureni	1
				Formica dolosa	5
				Hypoponera opacior	1
				Myrmecina americana	3
				Paratrechina faisonensis	1
				Paratrechina parvula	1
				Phidole crassicornis	2
				Phidole denata	19
				Solenopsis carolinensis	1
				Solenopsis invicta	34
r060219a	6	3190-3200	S	*Apheanogaster rudis*	
				Camonotus casteneus	
				Camponotus	14
				chromaiodes	2
				Camponotus	1
				pennsylvanicus	22
				Paratrechina faisonensis	1
				Phidole denata	18
				Solenopsis invicta	29
				Tapinoma sessile	7
				Tetramorium	7
r060316a	4	3300-3310	S	*Apheanogaster rudis*	6
				Crematogaster cerasi	2
				Hypoponera opaciceps	2
				Phidole crassicornis	5
				Phidole denata	2
				Solenopsis invicta	45
				Tapinoma sessile	3
r060418a	21	3410-3420	S	*Dorymyrmex bureni*	130
				Paratrechina concinna	4
				Solenopsis invicta	420

File Name	Research Classification	Pitfall #s	Region	Species	number
r060420a	21	3630-	S	*Apheanogaster*	
		3640		*ashmaedi*	
				Apheanogaster rudis	
				Aphaenogaster treatae	1
				Crematogaster pilosa	1
				Dolichoderous mariae	4
				Dorymyrmex bureni	1
				Forelius pruinosus	8
				Lasius neoniger	19
				Lasius umbratus	1
				Neivamyrmex	1
				opacithorax	152
				Paratrechina parvula	14
				Phidole denata	1
				Solenopsis invicta	1
				Tracymyrmex	2
				septentrionalis	4
r060718a	15	3751-	S	*Apheanogaster*	
		3761		*ashmeadi*	1
				Apheanogaster rudis	6
				Crematogaster lineolata	3
				Formica dolosa	1
				Phidole crassicornis	3
r060719a	17	3859-	S	*Apheanogaster rudis*	
		3869		*Camonotus casteneus*	13
				Camponotus	3
				pennsylvanicus	1
				Crematogaster lineolata	1
				Paratrechina concinna	1
				Prenolepis imparis	26
				Solenopsis invicta	6
r060719b	20	386-	M	*Apheanogaster fulva*	
		396		*Apheanogaster rudis*	4
				Myrmecina americana	20
				Neivamyrmex	3
				opacithorax	5
				Paratrechina faisonensis	7
				Phidole	14
				Phidole denata	14
				Solenopsis carolinensis	2

File Name	Research Classification	Pitfall #s	Region	Species	number
r060721a	19	408-	M	*Apheanogaster rudis*	21
		418		*Crematogaster lineolata*	4
				Hypoponera	1
				Myrmecina americana	2
				Phidole denata	7
				Prenolepis imparis	21
r060819a	19	419-	M	*Apheanogaster picea*	2
		429		*Apheanogaster rudis*	7
				Myrmecina americana	1
				Neivamyrmex texanus	3
				Ponera	1
				Solenopsis invicta	19
r060914a	17	430-	M	*Apheanogaster picea*	2
		440		*Crematogaster cerasi*	2
				Crematogaster lineolata	2
				Formica schaufussi	1
				Hypoponera	1
				Myrmecina americana	2
				Prenolepis imparis	15
				Solenopsis invicta	39
r060915a	11	441-	M	*Apheanogaster picea*	1
		451		*Apheanogaster rudis*	12
				Crematogaster atkinsoni	6
				Crematogaster lineolata	4
				Formica schaufussi	1
				Myrmecina americana	1
				Paratrechina faisonensis	1
				Phidole vinelandica	1
				Tapinoma sessile	2
r060915r	19	452-	M	*Apheanogaster picea*	
		462		*Apheanogaster rudis*	58
				Camponotus	1
				pennsylvanicus	1
				Crematogaster lineolata	13
				Leptothorax	1
				Myrmecina americana	2
				Myrmica	1
				Paratrechina faisonensis	1
				Prenolepis imparis	1
				Stenamma	1
				Tapinoma sessile	1

File Name	Research Classification	Pitfall #s	Region	Species	number
r060916r	19	463-	M	*Apheanogaster picea*	
		473		*Apheanogaster rudis*	14
				Camponotus	3
				pennsylvanicus	3
				Formica subsericea	5
				Myrmecina americana	2
				Neivamyrmex texanus	2
				Prenolepis imparis	8
				Tapinoma sessile	2
r061018a	18	474-	M	*Apheanogaster picea*	
		484		*Camponotus*	41
				pennsylvanicus	6
				Crematogaster pilosa	1
				Formica subsericea	5
				Myrmecina americana	2
				Myrmica	1
				Prenolepis imparis	1
				Stenamma schmittii	1
				Tapinoma sessile	2
r061114r	15	3520-	S	*Dorymyrmex bureni*	43
		3530		*Hypoponera opacior*	1
				Paratrechina faisonensis	3
				Solenopsis invicta	48
r061716a	19	496-	M	*Apheanogaster picea*	
		506		*Apheanogaster rudis*	16
				Camponotus	4
				pennsylvanicus	3
				Myrmecina americana	4
				Myrmica	4
				Paratrechina faisonensis	1
				Prenolepis imparis	49
				Stenamma	1
				Tapinoma sessile	1
r061821r	18	518-	M	*Apheanogaster picea*	
		528		*Apheanogaster rudis*	104
				Camponotus americanus	1
				Formica subsericea	1
				Myrmecina americana	20
				Neivamyrmex	1
				opacithorax	1

File Name	Research Classification	Pitfall #s	Region	Species	number
r062215a	20	529-539	M	*Apheanogaster picea*	
				Camponotus	45
				pennsylvanicus	1
				Tapinoma sessile	1
r062216a	18	540-550	M	*Apheanogaster picea*	
				Camponotus	25
				pennsylvanicus	1
				Forelius pruinosus	3
				Formica subsericea	5
				Myrmecina americana	3
				Neivamyrmex texanus	1
				Prenolepis imparis	2
r062218a	19	551-561	M	*Apheanogaster picea*	29
				Formica subsericea	4
				Myrmecina americana	1
				Ponera	1
				Prenolepis imparis	2
r062218b	17	562-572	M	*Ambylopone*	
				Apheanogaster picea	1
				Camponotus	23
				pennsylvanicus	4
				Formica subsericea	81
				Prenolepis imparis	1
r062316a	19	573-583	M	*Apheanogaster picea*	
				Apheanogaster rudis	
				Camponotus	13
				pennsylvanicus	11
				Myrmecina americana	2
				Neivamyrmex	1
				opacithorax	2
				Phidole	1
				Phidole crassicornis	1
r062317a	17	584-594	M	*Apheanogaster rudis*	
				Camponotus	17
				pennsylvanicus	1
				Formica subsericea	16
				Paratrechina faisonensis	1
r062318a	14	595-605	M	*Apheanogaster rudis*	21
				Myrmecina americana	2
				Phidole denata	10
				Prenolepis imparis	6

File Name	Research Classification	Pitfall #s	Region	Species	number
r062319a	19	606-616	M		
r062414a	17	507-517	M	*Apheanogaster picea*	
				Camponotus	11
				pennsylvanicus	1
				Formica subsericea	1
				Leptothorax	1
				Myrmecina americana	4
				Myrmica	2
				Stenamma schmittii	2
r062414b	18	485-495	M	*Apheanogaster picea*	
				Camponotus	14
				pennsylvanicus	1
				Formica subsericea	17
				Myrmecina americana	2
				Myrmica	6
r62817a	19	617-627	M	*Apheanogaster rudis*	
				Camponotus americanus	13
				Camponotus	1
				pennsylvanicus	1
				Crematogaster lineolata	9
				Hypoponera	1
				Myrmecina americana	9
				Myrmica	5
				Phidole crassicornis	1
				Phidole denata	2
				Solenopsis carolinensis	1
r62817b	19	628-638	M	*Apheanogaster rudis*	25
				Camponotus americanus	3
				Crematogaster lineolata	24
				Paratrechina faisonensis	1
				Solenopsis carolinensis	1
r62918a	17	639-649	M	*Apheanogaster picea*	
				Apheanogaster rudis	28
				Camponotus	6
				pennsylvanicus	1
				Myrmecina americana	5
r062919r	20	650-660	M	*Apheanogaster picea*	30
				Lasius	1
				Myrmecina americana	1

File Name	Research Classification	Pitfall #s	Region	Species	number
r063017A	19	661-671	M	*Apheanogaster rudis*	
				Camponotus	18
				pennsylvanicus	6
				Crematogaster lineolata	1
				Hypoponera	4
				Myrmecina americana	6
				Myrmica	1
				Paratrechina faisonensis	4
				Solenopsis carolinensis	3
r063018a	17	672-682	M	*Apheanogaster picea*	
				Apheanogaster rudis	2
				Camponotus	28
				pennsylvanicus	11
				Crematogaster lineolata	6
				Hypoponera	2
				Leptothorax	2
				Myrmecina americana	3
				Myrmica	4
				Paratrechina faisonensis	5
				Solenopsis carolinensis	1
				Strumigenys gundlachi	3
r063019a	19	683-693	M	*Apheanogaster rudis*	
				Camponotus americanus	21
				Camponotus	2
				pennsylvanicus	7
				Crematogaster lineolata	11
				Myrmecina americana	4
				Myrmica	2
				Paratrechina faisonensis	1
				Phidole crassicornis	16
r063020r	19	694-704	M	*Apheanogaster mariae*	1
				Apheanogaster picea	19
				Crematogaster atkinsoni	12
				Crematogaster lineolata	1
				Hypoponera	4
				Myrmecina americana	4
				Myrmica	1
				Phidole denata	1

File Name	Research Classification	Pitfall #s	Region	Species	number
r070115a	19	705-	M	*Ambylopone*	
		715		*Apheanogaster picea*	1
				Camponotus	39
				pennsylvanicus	3
				Paratrechina faisonensis	2
r070116a	17	716-	M	*Apheanogaster picea*	
		726		*Apheanogaster rudis*	21
				Camponotus americanus	18
				Camponotus	1
				pennsylvanicus	14
				Crematogaster lineolata	1
				Myrmecina americana	1
r071414b	11	727-	M	*Camponotus*	
		737		*pennsylvanicus*	1
				Crematogaster lineolata	9
				Hypoponera	1
				Paratrechina faisonensis	1
				Solenopsis invicta	698
				Solenopsis pergandei	71
r71416a	21	738-	M	*Apheanogaster rudis*	6
		748		*Crematogaster lineolata*	57
				Crematogaster pilosa	35
				Forelius mccooki	3
				Hypoponera	3
				Lasius neoniger	619
				Leptothorax	38
				Leptothorax pergandei	1
				Myrmica	24
				Paratrechina faisonensis	2
				Phidole vinelandica	12
				Solenopsis carolinensis	16
r071420a	11	749-	M	*Apheanogaster rudis*	
		759		*Crematogaster lineolata*	7
				Hypoponera	11
				Myrmecina americana	6
				Neivamyrmex	9
				opacithorax	20
				Paratrechina faisonensis	2
				Prenolepis imparis	2
				Solenopsis carolinensis	2

File Name	Research Classification	Pitfall #s	Region	Species	number
r072016a	14	881-891	M	*Apheanogaster rudis*	3
				Camponotus	3
				pennsylvanicus	79
				Crematogaster lineolata	1
				Dolichoderous pustulatus	3
				Leptothorax	1
				Myrmecina americana	3
				Neivamyrmex	3
				opacithorax	2
r072019a	14	892-902	M	*Apheanogaster rudis*	37
				Camponotus americanus	2
				Crematogaster lineolata	34
				Myrmecina americana	1
				Paratrechina faisonensis	7
				Phidole denata	12
				Phidole vinelandica	1
				Prenolepis imparis	7
				Strumigenys	1
r72613a	14	947-957	P	*Apheanogaster rudis*	17
				Crematogaster cerasi	1
				Crematogaster lineolata	3
				Hypoponera	5
				Lasius	25
				Myrmecina americana	1
				Paratrechina faisonensis	5
				Phidole	6
				Phidole crassicornis	6
				Solenopsis carolinensis	1
				Solenopsis invicta	30
r072613b	22	958-968	P	*Apheanogaster rudis*	2
				Hypoponera	5
				Lasius	1
				Paratrechina faisonensis	8
				Phidole crassicornis	1
				Solenopsis invicta	219

File Name	Research Classification	Pitfall #s	Region	Species	number
r072614a	20	969-979	P	*Apheanogaster rudis*	46
				Camponotus americanus	1
				Crematogaster lineolata	4
				Lasius	12
				Leptothorax	2
				Myrmecina americana	2
				Myrmica	3
				Paratrechina faisonensis	7
				Solenopsis carolinensis	1
				Strumigenys	2
r072616a	17	991-1001	P	*Apheanogaster rudis*	34
				Camponotus americanus	1
				Crematogaster lineolata	59
				Crematogaster pilosa	4
				Myrmecina americana	2
				Neivamyrmex	1
				opacithorax	1
				Paratrechina faisonensis	
r072715a	14	1002-1012	M	*Ambylopone*	2
				Apheanogaster picea	19
				Apheanogaster rudis	1
				Camponotus americanus	1
				Crematogaster lineolata	28
				Formica subsericea	1
				Leptothorax	2
				Paratrechina faisonensis	16
				Paratrechina Rudis	1
				Solenopsis carolinensis	13
r072716a	14	1013-1023	M	*Apheanogaster rudis*	53
				Camponotus americanus	1
				Camponotus	2
				pennsylvanicus	29
				Myrmica	10
				Paratrechina faisonensis	

File Name	Research Classification	Pitfall #s	Region	Species	number
r072719b	14	1024-1034	M	*Apheanogaster rudis*	26
				Camponotus americanus	1
				Camponotus	1
				pennsylvanicus	11
				Crematogaster atkinsoni	73
				Crematogaster lineolata	1
				Forelius mccooki	1
				Myrmica americana	6
				Paratrechina faisonensis	10
				Phidole	8
				Phidole crassicornis	2
				Phidole denata	4
				Prenolepis imparis	1
				Stenamma	1
				Strumigenys gundlachi	1
				Tapinoma sessile	
r072913r		1035-1045	P	*Apheanogaster*	
				ashmeadi	1
				Apheanogaster rudis	4
				Forelius mccooki	23
				Formica schaufussi	1
				Hypoponera	60
				Lasius	1
				Monomorium trageri	6
				Paratrechina faisonensis	1
				Phidole vinelandica	44
				Solenopsis invicta	132
r072914a	14	1046-1056	P	*Apheanogaster*	
				ashmeadi	9
				Apheanogaster rudis	14
				Crematogaster lineolata	4
				Formica subsericea	2
				Lasius	1
				Leptothorax	1
				Myrmecina americana	3
				Myrmica americana	1
				Paratrechina faisonensis	3
				Phidole vinelandica	2
				Solenopsis carolinensis	1
				Solenopsis invicta	32

File Name	Research Classification	Pitfall #s	Region	Species	number
r072917a	14	1057-	P	*Camponotus floridanus*	
		1067		*Camponotus*	
				pennsylvanicus	4
				Crematogaster ashmeadi	18
				Crematogaster atkinsoni	25
				Crematogaster lineolata	4
				Formica schaufussi	2
				Neivamyrmex	2
				opacithorax	30
				Paratrechina faisonensis	1
				Phidole denata	7
				Solenopsis invicta	1
r073015a	14	903-	P	*Apheanogaster rudis*	40
		913		*Camponotus americanus*	1
				Crematogaster lineolata	5
				Paratrechina faisonensis	1
r073015b	19	914-	P	*Apheanogaster picea*	45
		924		*Crematogaster ashmeadi*	6
				Crematogaster atkinsoni	17
				Crematogaster lineolata	1
				Leptothorax	1
				Myrmecina americana	7
r073016a	19	925-	P	*Apheanogaster rudis*	24
		935		*Crematogaster lineolata*	7
				Myrmecina americana	1
				Paratrechina faisonensis	2
r081012b	18	1068-	P	*Apheanogaster rudis*	44
		1078		*Camponotus americanus*	1
				Crematogaster lineolata	13
				Hypoponera	1
				Lasius	6
				Leptothorax	2
				Paratrechina faisonensis	8
				Solenopsis carolinensis	4
r081015a	20	1090-	P	*Apheanogaster rudis*	22
		1100		*Crematogaster lineolata*	2
				Formica schaufussi	1
				Myrmecina americana	1
				Paratrechina faisonensis	4

File Name	Research Classification	Pitfall #s	Region	Species	number
r081016a	20	1101-	P	*Apheanogaster floridana*	2
		1111		*Crematogaster atkinsoni*	20
				Crematogaster lineolata	2
				Lasius	1
				Myrmecina americana	2
				Paratrechina faisonensis	8
				Prenolepis imparis	1
				Solenopsis carolinensis	3
r081113a	11	1112-	P	*Lasius*	1
		1122		*Paratrechina faisonensis*	9
				Solenopsis invicta	726
				Tapinoma sessile	11
r081113b	11	1123-	P	*Apheanogaster rudis*	1
		1133		*Formica schaufussi*	1
				Paratrechina faisonensis	9
				Solenopsis invicta	556
r081115r	17	1134-	P	*Apheanogaster*	1
		1144		*ashmeadi*	23
				Apheanogaster rudis	1
				Camponotus	1
				pennsylvanicus	22
				Crematogaster atkinsoni	7
				Crematogaster lineolata	27
				Formica schaufussi	
				Phidole denata	
r081212a	14	1145-	P	*Crematogaster lineolata*	4
		1155		*Formica schaufussi*	17
				Hypoponera	1
				Paratrechina faisonensis	10
				Solenopsis invicta	295
				Tapinoma sessile	3
r81213a	14	1156-	P	*Apheanogaster rudis*	30
		1166		*Crematogaster lineolata*	4
				Formica schaufussi	1
				Paratrechina faisonensis	3
				Solenopsis carolinensis	2
				Solenopsis invicta	1
				Tapinoma sessile	5

File Name	Research Classification	Pitfall #s	Region	Species	number
r081215a	14	1178-1188	P	*Apheanogaster rudis*	10
				Crematogaster lineolata	1
				Formica schaufussi	6
				Myrmecina americana	1
				Paratrechina faisonensis	2
r81813a	11	1189-1199	P	*Apheanogaster rudis*	1
				Myrmecina americana	2
				Paratrechina faisonensis	5
				Solenopsis invicta	522
r081814a	17	1200-1210	P	*Apheanogaster rudis*	15
				Crematogaster lineolata	28
				Paratrechina faisonensis	5
				Solenopsis carolinensis	2
				Tapinoma sessile	1
r081815a	20	1211-1221	P	*Apheanogaster rudis*	5
				Crematogaster atkinsoni	1
				Hypoponera	2
				Myrmecina americana	2
				Paratrechina faisonensis	10
				Solenopsis carolinensis	9
				Solenopsis invicta	37
				Strumigenys gundlachi	3
				Tapinoma sessile	6
r081913a	14	1222-1232	P	*Apheanogaster ashmeadi*	2
				Apheanogaster rudis	5
				Crematogaster lineolata	6
				Phidole denata	1
r082013a	17	1244-1254	P	*Apheanogaster rudis*	
				Camponotus americanus	29
				Camponotus	1
				pennsylvanicus	8
				Crematogaster lineolata	4
				Formica schaufussi	1
				Myrmecina americana	2
				Paratrechina faisonensis	8
r082014b	17	1255-1265	P	*Apheanogaster rudis*	14
				Camponotus americanus	3
				Paratrechina faisonensis	2

File Name	Research Classification	Pitfall #s	Region	Species	number
r082017r	17	1277-1287	P	*Ambylopone*	
				Apheanogaster rudis	1
				Camponotus	48
				pennsylvanicus	1
				Crematogaster lineolata	1
				Formica schaufussi	1
				Myrmecina americana	3
				Paratrechina faisonensis	1
r082611a	17	1288-1298	P	*Ambylopone*	
				Apheanogaster rudis	1
				Camponotus americanus	28
				Camponotus	1
				pennsylvanicus	1
				Leptothorax	2
				Myrmecina americana	1
				Prenolepis imparis	1
r082612a	14	1310-1320	P	*Apheanogaster ashmeadi*	
				Apheanogaster rudis	1
				Camponotus	19
				pennsylvanicus	1
				Crematogaster lineolata	15
				Formica schaufussi	1
				Leptothorax	1
				Phidole denata	9
				Prenolepis imparis	1
				Solenopsis carolinensis	2
				Solenopsis invicta	23
				Strumigenys gundlachi	1
r082613a	14	1299-1309	P	*Apheanogaster ashmeadi*	1
				Apheanogaster rudis	39
				Crematogaster lineolata	1
				Myrmecina americana	3
				Paratrechina faisonensis	4
				Solenopsis carolinensis	16
				Strumigenys	1

File Name	Research Classification	Pitfall #s	Region	Species	number
r082713a	19	1321-1331	P	*Apheanogaster ashmeadi*	9
				Apheanogaster rudis	14
				Crematogaster lineolata	34
				Myrmecina americana	2
				Neivamyrmex texanus	5
				Phidole	3
				Phidole crassicornis	3
				Solenopsis carolinensis	1
r082714a	18	1376-1386	P	*Apheanogaster picea*	
				Apheanogaster rudis	1
				Camponotus	3
				pennsylvanicus	3
				Crematogaster cerasi	2
				Crematogaster lineolata	2
				Hypoponera	4
				Paratrechina faisonensis	5
				Phidole denata	1
r083012a	21	1332-1342	P	*Hypoponera*	2
				Leptothorax	27
				Paratrechina arenivaga	1
				Paratrechina faisonensis	11
				Solenopsis invicta	613
				Tapinoma sessile	80
r083014a	11	1354-1364	P	*Apheanogaster ashmeadi*	7
				Crematogaster lineolata	2
				Paratrechina faisonensis	21
				Solenopsis carolinensis	3
				Solenopsis invicta	337
				Tapinoma sessile	54
r083014b	11	1343-1353	P	*Apheanogaster lamellidens*	10
				Camponotus americanus	2
				Crematogaster pilosa	1
				Formica schaufussi	7
				Monomorium minimum	1
				Paratrechina faisonensis	16
				Solenopsis invicta	477
				Tapinoma sessile	439

File Name	Research Classification	Pitfall #s	Region	Species	number
r083015r	6	1365-1375	P	*Apheanogaster picea*	3
				Apheanogaster rudis	6
				Crematogaster atkinsoni	2
				Lasius	1
				Myrmica	4
				Paratrechina faisonensis	7
				Solenopsis carolinensis	1
				Tapinoma sessile	1
r090216r	18	1398-1408	P	*Apheanogaster rudis*	20
				Crematogaster cerasi	1
				Crematogaster atkinsoni	1
				Crematogaster lineolata	4
				Paratrechina faisonensis	5
				Phidole	1
				Phidole denata	1
				Solenopsis carolinensis	2
				Solenopsis invicta	29
r090314b	17	1409-1419	P	*Apheanogaster rudis*	16
				Crematogaster atkinsoni	1
				Myrmecina americana	2
r090315a	18	1420-1430	P	*Ambylopone*	1
				Apheanogaster rudis	17
				Crematogaster lineolata	3
				Formica subsericea	2
				Myrmecina americana	2
				Paratrechina faisonensis	1
r090713a	6	1452-1462	P	*Apheanogaster rudis*	
				Crematogaster lineolata	41
				Lasius	1
				Neivamyrmex	21
				opacithorax	7
				Prenolepis imparis	34
				Solenopsis invicta	1
r090714a	6	1463-1473	P	*Apheanogaster rudis*	
				Camponotus	5
				pennsylvanicus	4
				Hypoponera	1
				Phidole	2
				Phidole denata	2
				Solenopsis invicta	63

File Name	Research Classification	Pitfall #s	Region	Species	number
r090913b	19	1474-	P	*Apheanogaster rudis*	30
		1484		*Crematogaster atkinsoni*	2
				Crematogaster lineolata	4
				Myrmecina americana	4
				Prenolepis imparis	1
				Solenopsis invicta	1
r090915a	19	1496-	P	*Apheanogaster rudis*	26
		1506		*Camponotus americanus*	2
				Crematogaster atkinsoni	2
				Crematogaster lineolata	22
				Leptothorax	1
				Myrmecina americana	1
				Prenolepis imparis	1
				Solenopsis invicta	46
r091014r	6	1507-	P	*Apheanogaster fulva*	1
		1517		*Apheanogaster rudis*	1
				Hypoponera	1
				Myrmica	1
				Paratrechina faisonensis	2
				Solenopsis invicta	2
r091313a	6	1518-	P	*Apheanogaster rudis*	7
		1528		*Hypoponera*	1
				Lasius	4
				Leptothorax	1
				Myrmica	2
				Paratrechina faisonensis	11
				Phidole denata	8
				Tapinoma sessile	1
r091315r	19	1529-	P	*Apheanogaster*	
		1539		*ashmeadi*	2
				Apheanogaster rudis	5
				Crematogaster lineolata	4
				Phidole denata	21
				Prenolepis imparis	12
				Strumigenys	1
r091316r	6	1540-	P	*Apheanogaster fulva*	
		1550		*Apheanogaster rudis*	1
				Paratrechina faisonensis	7
				Prenolepis imparis	1
				Solenopsis invicta	4
				Tracymyrmex	9
				septentrionalis	1

File Name	Research Classification	Pitfall #s	Region	Species	number
r091414a	6	1551-1561	P	*Apheanogaster rudis*	5
				Leptothorax	1
				Myrmecina americana	5
				Prenolepis imparis	7
				Solenopsis invicta	39
r091714r	17	1562-1572	P	*Aphaenogaster tennesseensis*	12
				Crematogaster lineolata	13
				Leptothorax	2
				Myrmecina americana	3
				Phidole crassicornis	1
				Phidole denata	6
				Prenolepis imparis	11
r091717a	11	1584-1594	P	*Apheanogaster ashmeadi*	1
				Apheanogaster rudis	7
				Crematogaster lineolata	8
				Phidole crassicornis	10
				Prenolepis imparis	3
r092115a	6	1595-1605	P	*Apheanogaster rudis*	12
				Hypoponera	3
				Lasius	1
				Leptothorax	4
				Solenopsis invicta	9
				Strumigenys	1
r092116a	11	1606-1616	P	*Apheanogaster rudis*	6
				Formica schaufussi	1
				Phidole morrisii	4
				Solenopsis invicta	19
				Tapinoma sessile	1
r092117r	20	1617-1627	P	*Ambylopone*	1
				Apheanogaster rudis	14
				Crematogaster lineolata	1
				Myrmecina americana	1
				Neivamyrmex texanus	91
				Paratrechina faisonensis	1
				Phidole denata	3
				Prenolepis imparis	5

File Name	Research Classification	Pitfall #s	Region	Species	number
r092313a	21	1628-1638	P	*Apheanogaster ashmeadi*	5
				Crematogaster pilosa	1
				Hypoponera	1
				Lasius	18
				Leptothorax	3
				Neivamyrmex texanus	5
				Paratrechina faisonensis	5
				Phidole	84
				Phidole crassicornis	19
				Phidole denata	2
				Phidole morrisii	59
				Phidole vinelandica	4
				Solenopsis carolinensis	1
r092415b	17	1639-1649	P	*Apheanogaster rudis*	
				Crematogaster lineolata	8
				Myrmecina americana	3
				Phidole morrisii	3
				Prenolepis imparis	1
				Tracymyrmex	21
				septentrionalis	1
r092416a	19	1650-1660	P	*Ambylopone*	1
				Apheanogaster rudis	14
				Paratrechina faisonensis	1
				Prenolepis imparis	21
r093012a	21	1683-1693	P	*Hypoponera*	3
				Paratrechina faisonensis	1
				Phidole denata	1
				Solenopsis invicta	422
r093013a	19	1661-1671	P	*Apheanogaster rudis*	7
				Crematogaster lineolata	1
				Myrmecina americana	1
				Paratrechina faisonensis	1
				Prenolepis imparis	89
r100215a	18	1705-1715	P	*Apheanogaster mariae*	2
				Apheanogaster rudis	10
				Crematogaster lineolata	3
				Myrmica	1
				Paratrechina faisonensis	1
				Prenolepis imparis	67
				Solenopsis invicta	52

File Name	Research Classification	Pitfall #s	Region	Species	number
r100216a	6	1716-	P	*Ambylopone*	3
		1726		*Apheanogaster mariae*	1
				Apheanogaster rudis	7
				Myrmica	4
				Prenolepis imparis	74
				Strumigenys	1
r100615a	21	1727-	P	*Apheanogaster*	
		1737		*ashmeadi*	1
				Leptothorax	1
				Paratrechina faisonensis	3
				Solenopsis invicta	213
r100615b	21	1738-	P	*Hypoponera*	5
		1748		*Monomorium minimum*	1
				Paratrechina faisonensis	1
				Phidole	37
				Phidole crassicornis	35
				Phidole denata	2
				Prenolepis imparis	1
				Solenopsis invicta	34
r100617a	20	1749-	P	*Apheanogaster rudis*	22
		1759		*Myrmecina americana*	2
				Prenolepis imparis	143
r100618a	18	1760-	P	*Apheanogaster*	
		1770		*ashmeadi*	
				Apheanogaster rudis	1
				Myrmica	2
				Neivamyrmex	10
				opacithorax	7
				Prenolepis imparis	187
r100717a	18	1771-	P	*Apheanogaster rudis*	14
		1781		*Camponotus americanus*	1
				Neivamyrmex	26
				opacithorax	5
				Phidole	5
				Phidole crassicornis	215
				Prenolepis imparis	

File Name	Research Classification	Pitfall #s	Region	Species	number
r100718a	21	1782-1792	P	*Apheanogaster rudis*	1
				Formica integra	3
				Formica pallidefulva	1
				Formica schaufussi	1
				Hypoponera	1
				Paratrechina faisonensis	1
				Phidole denata	14
				Phidole tysoni	50
				Phidole vinelandica	2
				Prenolepis imparis	2
r101118a	19	1793-1803	P	*Apheanogaster rudis*	8
				Crematogaster lineolata	4
				Myrmecina americana	3
				Prenolepis imparis	396
r101120a	21	1804-1814	P	*Crematogaster lineolata*	4
				Dorymyrmex bureni	3
				Hypoponera	2
				Lasius alienus	1
				Paratrechina faisonensis	1
				Paratrechina parvula	4
				Phidole crassicornis	9
				Phidole denata	23
				Phidole vinelandica	7
				Prenolepis imparis	18
r101417a	19	1815-1825	P	*Apheanogaster rudis*	5
				Crematogaster lineolata	6
				Pachycondyla	4
				Prenolepis imparis	103
r102217a	20	1837-1847	P	*Apheanogaster rudis*	16
				Prenolepis imparis	61
r102218r	6	1848-1858	P	*Aphaenogaster*	
				tennesseensis	
				Neivamyrmex	3
				opacithorax	2
				Neivamyrmex texanus	2
				Solenopsis carolinensis	113

File Name	Research Classification	Pitfall #s	Region	Species	number
t051214a	18	1859-1869	C	*Apheanogaster picea*	
				Apheanogaster rudis	
				Camponotus americanus	22
				Camonotus casteneus	2
				Camponotus	1
				chromaiodes	9
				Camponotus	2
				pennsylvanicus	8
				Crematogaster atkinsoni	6
				Crematogaster lineolata	1
				Formica schaufussi	2
				Myrmica	1
				Paratrechina faisonensis	6
				Phidole denata	7
				Phidole dentigula	27
t051221b	18	1881-1891	C	*Apheanogaster rudis*	
				Camponotus	32
				chromaiodes	4
				Crematogaster cerasi	4
				Myrmica	1
				Paratrechina faisonensis	10
				Phidole	3
				Phidole crassicornis	1
				Phidole denata	2
				Solenopsis invicta	3
				Strumigenys	1
t051411a	11	1936-1946	C	*Apheanogaster rudis*	1
				Paratrechina faisonensis	1
				Solenopsis invicta	22
t051411b	21	1947-1957	C	*Dorymyrmex bureni*	25
				Paratrechina faisonensis	7
				Solenopsis invicta	314
				Tapinoma sessile	1

File Name	Research Classification	Pitfall #s	Region	Species	number
t051721a	6	2002-2012	C	*Apheanogaster picea*	
				Apheanogaster rudis	10
				Camponotus americanus	8
				Camponotus	1
				pennsylvanicus	24
				Crematogaster cerasi	5
				Hypoponera	2
				Paratrechina parvula	2
				Phidole denata	7
				Solenopsis invicta	21
				Tapinoma sessile	5
t051811a	11	2024-2034	C	*Cyphomyrmex rimosus*	5
				Hypoponera	8
				Paratrechina faisonensis	4
				Solenopsis invicta	443
t051812a	11	2035-2045	C	*Apheanogaster picea*	4
				Cyphomyrmex rimosus	14
				Hypoponera	1
				Paratrechina faisonensis	12
				Solenopsis invicta	792
t051821a	14	2046-2056	C	*Brachymyrmex*	2
				Cyphomyrmex rimosus	1
				Hypoponera	7
				Myrmecina americana	5
				Paratrechina faisonensis	27
				Paratrechina vividula	22
				Prenolepis imparis	2
				Solenopsis invicta	531
				Strumigenys	2
t051822a	18	2057-2067	C	*Apheanogaster picea*	81
				Apheanogaster rudis	6
				Camponotus americanus	5
				Crematogaster lineolata	3
				Hypoponera	7
				Myrmecina americana	4
				Paratrechina faisonensis	6
				Phidole denata	50
				Solenopsis invicta	98

File Name	Research Classification	Pitfall #s	Region	Species	number
t051923b	14	2079-2089	C	*Apheanogaster picea*	13
				Apheanogaster rudis	4
				Camponotus americanus	8
				Formica subsericea	1
				Hypoponera	6
				Myrmecina americana	3
				Paratrechina faisonensis	21
				Phidole	1
				Phidole denata	1
				Solenopsis carolinensis	2
				Solenopsis invicta	237
t052011a	22	2090-2100	C	*Camponotus americanus*	3
				Dorymyrmex bureni	8
				Hypoponera	3
				Paratrechina faisonensis	1
				Phidole	12
				Phidole crassicornis	12
				Solenopsis invicta	370
t052022a	28	2112-2122	C	*Apheanogaster rudis*	51
				Camponotus americanus	7
				Crematogaster cerasi	6
				Crematogaster lineolata	4
				Formica schaufussi	2
				Lasius	176
				Paratrechina faisonensis	2
				Phidole denata	14
				Solenopsis invicta	5
t052911b	6	2167-2177	C	*Apheanogaster picea*	24
				Apheanogaster rudis	16
				Lasius alienus	22
				Phidole denata	6
				Tapinoma sessile	14
t052914b	18	2200-2210	C	*Apheanogaster rudis*	32
				Lasius alienus	11
				Phidole denata	5
				Solenopsis invicta	2
t053011a	11	2211-2221	C	*Dorymyrmex bureni*	205
				Formica schaufussi	4
				Solenopsis invicta	56

File Name	Research Classification	Pitfall #s	Region	Species	number
t053122a	16	2244-2254	C	*Brachymyrmex*	1
				Camponotus floridanus	1
				Hypoponera	8
				Lasius	3
				Myrmecina americana	2
				Paratrechina concinna	1
				Paratrechina faisonensis	5
				Solenopsis invicta	153
t053123a	16	2255-2265	C	*Camponotus floridanus*	9
				Cyphomyrmex rimosus	5
				Hypoponera	8
				Paratrechina concinna	17
				Paratrechina faisonensis	1
				Paratrechina flavipes	11
				Paratrechina parvula	3
				Solenopsis invicta	415
				Tapinoma sessile	1
t053123b	16	2266-2276	C	*Camponotus floridanus*	7
				Cyphomyrmex rimosus	1
				Formica schaufussi	3
				Hypoponera	2
				Paratrechina concinna	44
				Solenopsis invicta	512
t060513a	6	2332-2342	C	*Apheanogaster rudis*	
				Camponotus americanus	9
				Camponotus	4
				pennsylvanicus	23
				Formica schaufussi	5
				Hypoponera	49
				Phidole	7
				Phidole denata	7
				Solenopsis invicta	32
t060514a	21	2343-2353	C	*Aphaenogaster*	
				tennesseensis	1
				Dolichoderous mariae	3
				Leptothorax	4
				Solenopsis carolinensis	4
				Solenopsis invicta	683

File Name	Research Classification	Pitfall #s	Region	Species	number
t060516a	28	2365-2375	C	*Apheanogaster*	
				ashmeadi	
				Apheanogaster rudis	
				Camponotus americanus	5
				Camponotus	7
				pennsylvanicus	4
				Crematogaster lineolata	5
				Formica schaufussi	4
				Neivamyrmex	1
				opacithorax	1
				Phidole	49
				Phidole crassicornis	18
				Phidole denata	35
t061410a	6	2387-2397	C	*Apheanogaster picea*	
				Camponotus americanus	6
				Camponotus	1
				pennsylvanicus	37
				Crematogaster cerasi	6
				Lasius	5
				Paratrechina concinna	1
				Paratrechina faisonensis	5
t061413a	14	2398-2408	C	*Apheanogaster rudis*	2
				Camponotus americanus	2
				Crematogaster atkinsoni	1
				Crematogaster lineolata	2
				Hypoponera	1
				Paratrechina faisonensis	3
				Paratrechina vividula	1
				Solenopsis invicta	132
t061511a	21	2409-2419	C	*Apheanogaster rudis*	2
				Dorymyrmex bureni	105
				Leptothorax	38
				Paratrechina vividula	11
				Phidole	10
				Phidole crassicornis	1
				Phidole denata	5
				Phidole vinelandica	4
				Tapinoma sessile	15

File Name	Research Classification	Pitfall #s	Region	Species	number
t061513a	18	2431-2441	C	*Apheanogaster rudis*	20
				Camponotus americanus	8
				Crematogaster cerasi	5
				Crematogaster lineolata	1
				Dorymyrmex bureni	119
				Myrmecina americana	2
				Phidole	65
				Phidole crassicornis	67
				Solenopsis invicta	54
t061523a	6	2442-2452	C	*Apheanogaster fulva*	3
				Apheanogaster rudis	28
				Camponotus americanus	2
				Hypoponera	2
				Myrmecina americana	2
				Phidole	2
				Phidole crassicornis	2
				Solenopsis invicta	18
				Tapinoma sessile	1
t061615a	16	2464-2474	C	*Crematogaster lineolata*	12
				Myrmecina americana	1
				Paratrechina faisonensis	14
				Solenopsis invicta	329
t061622b	6	2475-2485	C	*Apheanogaster fulva*	
				Apheanogaster rudis	1
				Aphaenogaster	9
				tennesseensis	15
				Camponotus americanus	2
				Crematogaster cerasi	1
				Solenopsis invicta	109
				Tapinoma sessile	4
t062014a	21	2541-2551	C	*Solenopsis invicta*	237
t062022a	11	2508-2518	C	*Apheanogaster rudis*	1
				Formica schaufussi	4
				Solenopsis invicta	72
t062113a	6	2519-2529	C	*Apheanogaster rudis*	
				Camponotus	1
				pennsylvanicus	4
				Crematogaster cerasi	3
				Hypoponera	1
				Tapinoma sessile	5

File Name	Research Classification	Pitfall #s	Region	Species	number
t062114a	14	2552-2562	C	*Dorymyrmex bureni*	10
				Hypoponera opacior	1
				Paratrechina concinna	2
				Phidole crassicornis	19
				Solenopsis invicta	71
t062122a	18	2563-2573	C	*Apheanogaster rudis*	
				Camponotus americanus	22
				Camonotus casteneus	1
				Lasius alienus	2
				Leptothorax	1
				Myrmecina americana	1
				Neivamyrmex	5
				opacithorax	1
				Paratrechina faisonensis	3
				Phidole crassicornis	8
				Phidole denata	24
				Strumigenys	1
t062123a	11	2574-2584	C	*Apheanogaster rudis*	2
				Camonotus casteneus	1
				Dorymyrmex bureni	12
				Dorymyrmex medeis	4
				Forelius mccooki	12
				Formica dolosa	2
				Phidole crassicornis	33
				Phidole denata	7
				Pogonomyrmex badius	2
				Solenopsis invicta	30
				Tapinoma sessile	3
t062813a	3	2596-2606	C	*Apheanogaster rudis*	
				Aphaenogaster	
				tennesseensis	9
				Camonotus casteneus	1
				Camponotus	2
				pennsylvanicus	10
				Crematogaster lineolata	20
				Dolichoderous pustulatus	1
				Hypoponera opaciceps	4
				Hypoponera opacior	1
				Linepithema humile	1
				Paratrechina faisonensis	3
				Solenopsis invicta	115

File Name	Research Classification	Pitfall #s	Region	Species	number
t062912a	16	2607-	C	*Apheanogaster rudis*	
		2617		*Camonotus casteneus*	3
				Camponotus	1
				chromaiodes	1
				Crematogaster lineolata	1
				Formica dolosa	3
				Myrmecina americana	1
				Solenopsis invicta	49
t062914a	18	2618-	C	*Apheanogaster rudis*	14
		2628		*Camonotus casteneus*	1
				Hypoponera opaciceps	1
				Lasius alienus	2
				Phidole denata	2
t063011b	11	2651-	C	*Apheanogaster rudis*	2
		2661		*Hypoponera opaciceps*	1
				Paratrechina faisonensis	3
				Solenopsis invicta	90
t063023a	21	2662-	C	*Hypoponera opaciceps*	3
		2672		*Paratrechina concinna*	12
				Paratrechina faisonensis	1
				Solenopsis invicta	611
t070112a	28	2673-	C	*Apheanogaster*	
		2683		*ashmeadi*	
				Apheanogaster rudis	
				Crematogaster lineolata	3
				Myrmecina americana	8
				Neivamyrmex	2
				opacithorax	1
				Phidole crassicornis	19
				Phidole denata	21
				Phidole vinelandica	1
				Solenopsis carolinensis	5
				Tracymyrmex	1
				septentrionalis	1

File Name	Research Classification	Pitfall #s	Region	Species	number
t070122a	16	2684-2694	C	*Apheanogaster rudis*	7
				Camonotus casteneus	1
				Crematogaster lineolata	5
				Cyphomyrmex rimosus	2
				Formica dolosa	1
				Hypoponera opaciceps	6
				Myrmecina americana	1
				Paratrechina wojciki	3
				Solenopsis carolinensis	5
				Solenopsis invicta	254
t070123a	28	2695-2705	C	*Apheanogaster*	
				ashmaedi	
				Apheanogaster	
				ashmeadi	
				Apheanogaster	13
				lamellidens	14
				Apheanogaster rudis	1
				Crematogaster cerasi	21
				Hypoponera opaciceps	2
				Phidole crassicornis	1
				Phidole denata	9
				Tracymyrmex	10
				septentrionalis	16
t070213a	14	2706-2716	C	*Apheanogaster*	
				ashmeadi	1
				Apheanogaster rudis	6
				Formica dolosa	6
				Solenopsis invicta	28
t070511a	16	2728-2738	C	*Apheanogaster rudis*	
				Camonotus casteneus	3
				Crematogaster lineolata	7
				Neivamyrmex	103
				opacithorax	45
				Paratrechina concinna	16
				Paratrechina terricola	1
				Solenopsis invicta	164
t070513a	18	2739-2749	C	*Hypoponera opaciceps*	1
				Myrmecina americana	1
				Paratrechina faisonensis	1
				Solenopsis invicta	510
t070823a	21	2860-2870	C	*Hypoponera opaciceps*	1
				Solenopsis invicta	371

File Name	Research Classification	Pitfall #s	Region	Species	number
t071013a	16	2871-2881	C	*Apheanogaster ashmeadi*	1
				Aphaenogaster flemingi	1
				Apheanogaster rudis	2
				Camonotus casteneus	4
				Crematogaster lineolata	36
				Dolichoderous pustulatus	2
				Dorymyrmex bureni	25
				Forelius mccooki	9
				Hypoponera opacior	1
				Leptothorax	1
				Neivamyrmex texanus	1
				Paratrechina concinna	6
				Phidole dentigula	1
				Solenopsis invicta	179
t071114a	18	2882-2892	C	*Apheanogaster rudis*	
				Camponotus pennsylvanicus	20
				Myrmecina americana	1
				Neivamyrmex	1
				opacithorax	3
				Solenopsis invicta	1
t071122a	16	2893-2903	C	*Apheanogaster ashmeadi*	2
				Apheanogaster floridana	2
				Crematogaster lineolata	10
				Dorymyrmex bureni	30
				Forelius mccooki	23
				Paratrechina concinna	1
				Paratrechina faisonensis	2
				Phidole denata	13
				Phidole vinelandica	2
				Solenopsis invicta	5
t072023b	21	2794-2804	C	*Cyphomyrmex rimosus*	1
				Solenopsis invicta	752
t072111a	11	2805-2815	C	*Camonotus casteneus*	1
				Crematogaster lineolata	1
				Myrmecina americana	1
				Paratrechina concinna	2
				Paratrechina faisonensis	3
				Solenopsis invicta	39

File Name	Research Classification	Pitfall #s	Region	Species	number
t072122a	28	2838- 2848	C	*Apheanogaster*	1
				ashmaedi	18
				Apheanogaster rudis	1
				Camonotus casteneus	3
				Myrmecina americana	3
				Neivamyrmex texanus	4
				Solenopsis invicta	
t072125a	28	2915- 2925	C	*Apheanogaster rudis*	24
				Camonotus casteneus	11
				Camponotus	1
				pennsylvanicus	2
				Cyphomyrmex rimosus	1
				Hypoponera opacior	1
				Myrmecina americana	6
				Phidole denata	6
				Solenopsis invicta	
t072212a	16	2926- 2936	C	*Apheanogaster floridana*	6
				Forelius mccooki	1
				Formica dolosa	1
				Solenopsis invicta	9
t072213a	11	2937- 2947	C	*Solenopsis invicta*	29
t072312a	18	2959- 2969	C	*Apheanogaster rudis*	4
				Paratrechina faisonensis	2
				Phidole denata	14
t080214a	21	298- 308	M	*Formica nitidiventris*	3
				Paratrechina arenivaga	386
t080308a	6	3036- 3046	S	*Apheanogaster rudis*	12
				Lasius alienus	2
				Linepithema humile	1
				Myrmecina americana	1
				Paratrechina faisonensis	1
				Phidole dentigula	4

File Name	Research Classification	Pitfall #s	Region	Species	number
t080314a	4	3047-	S	*Apheanogaster*	4
		3057		*ashmaedi*	4
				Apheanogaster	19
				ashmeadi	1
				Apheanogaster rudis	37
				Camonotus casteneus	2
				Crematogaster lineolata	5
				Myrmecina americana	1
				Phidole denata	
				Phidole dentigula	
t080315a	4	3069-	S	*Apheanogaster*	1
		3079		*ashmeadi*	53
				Apheanogaster rudis	1
				Camonotus casteneus	14
				Camponotus	1
				chromaiodes	1
				Formica dolosa	23
				Lasius umbratus	2
				Myrmica	
				Phidole crassicornis	
t080318a	4	3080-	S	*Apheanogaster rudis*	31
		3090		*Crematogaster cerasi*	1
				Crematogaster lineolata	5
				Lasius umbratus	8
				Phidole crassicornis	4
				Phidole denata	11
				Solenopsis carolinensis	1
				Solenopsis invicta	28
t080408a	19	309-	M	*Apheanogaster fulva*	
		319		*Apheanogaster picea*	
				Apheanogaster rudis	1
				Camponotus americanus	2
				Camponotus	10
				chromaiodes	1
				Camponotus	1
				pennsylvanicus	10
				Lasius neoniger	1
				Paratrechina concinna	1
				Paratrechina faisonensis	1
				Paratrechina terricola	1
				Prenolepis imparis	65

File Name	Research Classification	Pitfall #s	Region	Species	number
t080409a	17	3102-3112	S	*Aphaenogaster flemingi*	
				Apheanogaster rudis	1
				Camonotus casteneus	1
				Crematogaster lineolata	2
				Neivamyrmex	10
				opacithorax	3
				Phidole crassicornis	9
				Phidole denata	2
t080413a	17	3124-3134	S	*Apheanogaster*	
				ashmaedi	
				Apheanogaster	17
				ashmeadi	2
				Apheanogaster rudis	34
				Camponotus americanus	2
				Camonotus casteneus	6
				Crematogaster lineolata	33
				Formica argentea	11
				Formica dolosa	1
				Myrmecina americana	1
				Phidole denata	34
t080414a	15	3135-3145	S	*Apheanogaster*	
				ashmaedi	7
				Apheanogaster rudis	19
				Aphaenogaster treatae	1
				Camonotus casteneus	4
				Crematogaster lineolata	46
				Myrmecina americana	1
				Paratrechina faisonensis	1
				Phidole crassicornis	45
				Phidole denata	6
				Solenopsis carolinensis	5
				Solenopsis invicta	3

File Name	Research Classification	Pitfall #s	Region	Species	number
t080512a	15	3113-3123	S	*Apheanogaster*	
				ashmaedi	1
				Apheanogaster rudis	20
				Aphaenogaster treatae	3
				Camponotus	1
				chromaiodes	2
				Crematogaster lineolata	51
				Dorymyrmex bureni	2
				Myrmecina americana	1
				Phidole crassicornis	12
				Phidole denata	32
				Solenopsis invicta	126
t080514a	15	3146-3156	S	*Apheanogaster*	
				ashmaedi	1
				Apheanogaster rudis	1
				Aphaenogaster treatae	6
				Camponotus floridanus	1
				Crematogaster cerasi	1
				Crematogaster lineolata	1
				Forelius pruinosus	1
				Formica dolosa	1
				Hypoponera opacior	1
				Phidole denata	4
				Pogonomyrmex badius	1
				Solenopsis invicta	24
t080613a	6	3212-3222	S	*Crematogaster cerasi*	1
				Crematogaster lineolata	1
				Lasius alienus	3
				Paratrechina faisonensis	1
				Solenopsis invicta	46
				Tapinoma sessile	7
t080614a	17	3157-3167	S	*Apheanogaster*	
				ashmaedi	
				Aphaenogaster treatae	8
				Camponotus americanus	1
				Camonotus casteneus	1
				Crematogaster atkinsoni	2
				Crematogaster lineolata	1
				Neivamyrmex	12
				opacithorax	1
				Phidole denata	8
				Solenopsis carolinensis	1

File Name	Research Classification	Pitfall #s	Region	Species	number
t080615a	4	3179-3189	S	*Apheanogaster fulva*	
				Apheanogaster rudis	11
				Camponotus	35
				chromaiodes	7
				Crematogaster lineolata	12
				Lasius alienus	200
				Paratrechina concinna	3
				Paratrechina faisonensis	3
				Phidole denata	79
				Solenopsis invicta	1
				Tapinoma sessile	3
t080923a	20	320-330	M	*Apheanogaster fulva*	2
				Apheanogaster picea	12
				Apheanogaster rudis	4
				Formica subsericea	20
				Myrmecina americana	1
				Paratrechina faisonensis	1
				Prenolepis imparis	8
				Strumigenys	2
t081112a	4	3234-3244	S	*Apheanogaster*	
				ashmaedi	2
				Apheanogaster rudis	60
				Aphaenogaster treatae	1
				Camonotus casteneus	2
				Camponotus	7
				chromaiodes	25
				Crematogaster lineolata	1
				Formica dolosa	2
				Paratrechina concinna	2
				Phidole denata	4
				Phidole vinelandica	1

File Name	Research Classification	Pitfall #s	Region	Species	number
t081113a	15	3245-3255	S	*Apheanogaster fulva*	
				Aphaenogaster	
				tennesseensis	1
				Aphaenogaster treatae	6
				Dolichoderous mariae	6
				Dolichoderous pustulatus	1
				Dorymyrmex bureni	34
				Dorymyrmex medeis	71
				Forelius pruinosus	14
				Neivamyrmex	8
				opacithorax	23
				Paratrechina wojciki	4
				Phidole morrisii	26
				Pogonomyrmex badius	2
				Tapinoma sessile	9
t081612a	11	3256-3266	S	*Apheanogaster*	
				ashmaedi	
				Apheanogaster picea	1
				Apheanogaster rudis	6
				Camponotus americanus	1
				Crematogaster atkinsoni	2
				Dorymyrmex bureni	1
				Dorymyrmex medeis	1
				Lasius neoniger	1
				Lasius umbratus	2
				Myrmecina americana	7
				Paratrechina faisonensis	6
				Solenopsis carolinensis	4
				Tapinoma sessile	1
				Tetramorium	10
				Tracymyrmex	5
				septentrionalis	1
t081613a	20	33-43	M	*Apheanogaster fulva*	3
				Apheanogaster picea	17
				Lasius alienus	2
				Myrmecina americana	2
				Stenamma schmittii	4

File Name	Research Classification	Pitfall #s	Region	Species	number
t081712a	21	3366-3376	S	*Crematogaster lineolata*	
				Dorymyrmex bureni	
				Forelius pruinosus	1
				Hypoponera opacior	108
				Neivamyrmex	1
				opacithorax	1
				Paratrechina concinna	19
				Paratrechina faisonensis	1
				Phidole crassicornis	2
				Phidole denata	1
				Phidole vinelandica	2
				Solenopsis invicta	1
				Tapinoma sessile	426
				Tracymyrmex	1
				septentrionalis	4
t081713a	17	3377-3387	S	*Apheanogaster fulva*	
				Apheanogaster rudis	
				Camponotus	
				chromaiodes	4
				Camponotus	19
				pennsylvanicus	2
				Lasius umbratus	7
				Leptothorax	21
				Tracymyrmex	1
				septentrionalis	5
t081812a	21	3388-3398	S	*Aphaenogaster flemingi*	
				Dorymyrmex bureni	1
				Dorymyrmex medeis	108
				Paratrechina faisonensis	4
				Pogonomyrmex badius	3
				Solenopsis invicta	28
				Tracymyrmex	148
				septentrionalis	9
t081813a	6	3399-3409	S	*Crematogaster lineolata*	1
				Dorymyrmex bureni	2
				Solenopsis invicta	40

File Name	Research Classification	Pitfall #s	Region	Species	number
t082215a	19	342-352	M	*Apheanogaster rudis*	
				Camponotus	9
				pennsylvanicus	3
				Crematogaster lineolata	1
				Crematogaster pilosa	2
				Formica schaufussi	4
				Leptothorax	1
				Myrmecina americana	1
				Paratrechina faisonensis	6
				Prenolepis imparis	262
				Solenopsis carolinensis	5
				Tapinoma sessile	4
t082223a	17	3432-3442	S	*Apheanogaster rudis*	
				Camonotus casteneus	5
				Camponotus	2
				chromaiodes	13
				Crematogaster lineolata	5
				Paratrechina concinna	2
				Phidole crassicornis	1
				Solenopsis invicta	16
t082312a	17	3443-3453	S	*Apheanogaster rudis*	
				Camonotus casteneus	20
				Camponotus	7
				chromaiodes	9
				Hypoponera opacior	1
				Myrmecina americana	2
				Paratrechina faisonensis	4
				Phidole crassicornis	1
				Solenopsis invicta	45

File Name	Research Classification	Pitfall #s	Region	Species	number
t082812a	15	3454-3464	S	*Apheanogaster ashmaedi*	3
				Apheanogaster floridana	2
				Apheanogaster rudis	9
				Aphaenogaster treatae	1
				Camonotus casteneus	1
				Crematogaster lineolata	4
				Dorymyrmex bureni	8
				Myrmecina americana	1
				Paratrechina concinna	1
				Phidole crassicornis	1
				Solenopsis invicta	11
t082813a	17	3487-3497	S	*Apheanogaster ashmaedi*	
				Apheanogaster rudis	1
				Camonotus casteneus	15
				Camponotus	5
				chromaiodes	1
				Formica argentea	30
				Myrmecina americana	1
				Solenopsis invicta	450
t082913a	11	3498-3508	S	*Dorymyrmex bureni*	
				Hypoponera opaciceps	12
				Neivamyrmex	1
				opacithorax	9
				Paratrechina faisonensis	1
				Solenopsis invicta	287
t083013b	17	3564-3574	S	*Apheanogaster rudis*	
				Camponotus	14
				chromaiodes	2
				Crematogaster lineolata	4
				Dorymyrmex bureni	1
				Paratrechina concinna	2
				Paratrechina faisonensis	1
				Solenopsis invicta	18
t083021a	6	3597-3607	S	*Apheanogaster rudis*	3
				Paratrechina faisonensis	1

File Name	Research Classification	Pitfall #s	Region	Species	number
t090721a	19	353-363	M	*Apheanogaster rudis*	11
				Camponotus	5
				chromaiodes	8
				Camponotus	6
				pennsylvanicus	3
				Formica subsericea	1
				Hypoponera	2
				Myrmecina americana	1
				Myrmica	1
				Paratrechina faisonensis	
t090722a	6	3608-3618	S	*Apheanogaster fulva*	1
				Camponotus	3
				pennsylvanicus	2
				Dorymyrmex bureni	9
				Phidole morrisii	89
				Solenopsis invicta	
t090822a	17	3619-3629	S	*Camonotus casteneus*	3
				Camponotus	9
				chromaiodes	1
				Hypoponera opacior	2
				Myrmecina americana	59
				Neivamyrmex	282
				opacithorax	1
				Solenopsis invicta	
				Strumigenys	
t090913a	18	364-374	M	*Apheanogaster rudis*	25
				Camponotus americanus	1
				Camponotus	5
				pennsylvanicus	15
				Formica subsericea	5
				Myrmecina americana	2
				Paratrechina faisonensis	9
				Prenolepis imparis	2
				Strumigenys gundlachi	

File Name	Research Classification	Pitfall #s	Region	Species	number
t090914b	4	3740- 3750	S	*Apheanogaster rudis* *Camponotus* *chromaiodes* *Camponotus* *pennsylvanicus* *Crematogaster cerasi* *Crematogaster lineolata* *Crematogaster pilosa* *Hypoponera opacior* *Solenopsis invicta*	2 3 2 1 1 1 5 41
t090922a	17	375- 385	M	*Apheanogaster rudis* *Crematogaster ashmeadi* *Myrmecina americana* *Myrmica* *Paratrechina faisonensis* *Prenolepis imparis* *Tapinoma sessile*	30 1 7 3 3 40 2
t091013a	21	3783- 3793	S	*Dorymyrmex medeis* *Lasius neoniger* *Phidole crassicornis* *Phidole denata* *Phidole morrisii* *Pogonomyrmex badius*	144 13 3 2 3 9 6
t091014a	15	3794- 3804	S	*Apheanogaster* *ashmaedi* *Apheanogaster rudis* *Camonotus casteneus* *Crematogaster lineolata* *Formica dolosa* *Hypoponera opaciceps* *Phidole crassicornis* *Tapinoma sessile*	3 2 11 14 1 1 2 1
t091122a	15	3805- 3815	S	*Apheanogaster* *ashmaedi* *Apheanogaster rudis* *Camonotus casteneus* *Dorymyrmex bureni* *Phidole morrisii* *Tapinoma sessile*	4 1 2 1 25 1

File Name	Research Classification	Pitfall #s	Region	Species	number
t091222a	11	3848-3858	S	*Dorymyrmex medeis*	
				Neivamyrmex	1762
				opacithorax	8
				Solenopsis invicta	115

Appendix C

Miscellaneous Publications

During the course of my program I have also been employed as a county extension agent, as well as the state imported fire ant specialist. During my tenure in the above positions I have had occasional need to understand treatments and recommendations of the past. Finding such information has often allowed me to have a deeper understanding of our current methods and how they evolved. Historical records of treatments and recommendations are often difficult to find as such recommendations were and are often placed in ephemeral publications such as annual publications of pest management handbooks. Such publications are usually discarded once they are deemed out of date. I have had the opportunity to write and publish numerous fact sheets. Most of these are published in the ephemeral forms listed above, or on the internet. In the interest of preserving these fact sheets for historical reference I have included some of them within this appendix. As future technologies are developed and the current technologies are forgotten perhaps these will one day help a new researcher understand what once was.

I also had the privilege of being invited to Taiwan to participate in a symposium on fire ant management. At the time Taiwan had just discovered red imported fire ant occurring in their country as an invasive species. Most of my duties while there consisted of consulting with the Bureau of Animal and Plant Health Inspection and Quarantine (BAPHIQ) on the development of a strategy for the eradication of RIFA in their country. As part of this experience I wrote two pieces that I have also included in this appendix.

The first was used as a basis for a talk on fire ant management in the United States. The second was written after the visit and is a summary of the discussions that took place while there.

I have since had a great deal of contact with the fire ant researchers in Taiwan. We have conducted several training sessions here in the United States for their field personnel. So many things that we do were much easier to show using hands on techniques rather than trying to explain what was happening – especially with the language barrier

As stated above I have included them in my appendix in the hope that some future student may have need of the information regarding the recommendations that were made with regard to eradication efforts in our day and time. Comparisons between what was done and what was recommended my help a future researcher discover and implement a program that is ultimately successful in stopping an incursion and invasion of the red imported fire ant.

I am very grateful to have had the opportunity to work with the Taiwanese as well as extension. It is my hope that the work that I have done with people, bringing researched based knowledge to the real world will have a more lasting impact than any dissertation or other publications that I might write.

THE EXCLUSION OF THE RED IMPORTED FIRE ANT (FORMICIDAE: *SOLENOPSIS INVICTA* BUREN) TO PREVENT PREDATION ON THE EASTERN BLUEBIRD *SIALIA SIALIS*

INTRODUCTION

The Red Imported Fire Ant (RIFA), *Solenopsis invicata* Buren (Hymenoptera: Formicidae) was first introduced into North America in the 1930" (Buren 1972, Buren et al. 1974). Since that introduction they have spread to cover more than 290 million acres in the Southeastern United States, Puerto Rico, and Southern California. In 2001 (McCubbin and Weiner 2002) infestations were discovered in Australia. In 2004 infestations of this pest were confirmed in Taiwan, Hong Kong, and Mainland China. Infestations of individual mounds have been discovered and destroyed in New Zealand. These newer infestations on the Pacific Rim have given this pest global status.

The impacts on human health of this invasive pest are well documented and understood even by the general public within infested zones. About 15% of the human population can have a localized allergic reaction to the proteins found in the fire ant's venom. About 1 – 2% of the population can have a severe systemic reaction that results anaphylaxis (Caldwell et al. 1999).

Fire ants have been known to damage electrical equipment such as switches, well pumps, air conditioners, and even runway approach lights. Their mounds damage equipment such as mowers, combines, and vehicles. Significant amounts of money is spent each year to manage fire ant populations (Miller et al. 2000). The impacts of RIFA on vertebrates and invertebrate species have also been a focus of much research (Allen et al. 2004).

RIFA are opportunistic and omnivorous predators. Their primary targets are other invertebrate species. As invasive competitors they are often capable of displacing and excluding other ant species (Porter and Savignano 1990, Vinson and Scarborough 1991, Morris and Steigman 1993) This role as dominate predators can place RIFA in the position of direct competitors with vertebrate insectivores such as northern bob white quail and the Eastern bluebird.

The eastern bluebird was once very common, but began to decline during the mid-1800's (Janetatos 2007). Changes in land use patterns and competition of exotic vertebrate species such as European starlings and the house sparrow contributed to a reduction in suitable nesting sites for the birds. The establishment of Bluebird Nestboxes is widely attributed with the recovery of the species from near extinction.

This study evaluated the predation of RIFA on eastern bluebird nestlings in nest boxes located Northeastern Richland County, and the efficacy of a baffle device to exclude the RIFA from the boxes. Tests were conducted both in the field and in a controlled laboratory experiment testing uncoated baffles, baffles coated with Fluon AD-1™ (Northern Products Inc153 Hamlet Avenue P.O.Box 1175 Woonsocket RI, 02895), and baffles coated with Tanglefoot™ (The Tanglefoot Company, 314 Straight Avenue, S.W.Grand Rapids, MI 49504-6485 USA).

In 2000, bluebird nest boxes were established in the Midlands area of South Carolina by the Department of Natural Resources as an educational community outreach program. The number of boxes has ranged from 72 during the first year to a total of 246

boxes in 2006. Boxes were monitored by volunteers for a number of factors including predation.

MATERIALS AND METHODS

Field Study

In 2000, bluebird nest boxes were established in the Midlands area of South Carolina by the Department of Natural Resources as an educational community outreach program. The number of boxes has ranged from 72 during the first year to a total of 246 boxes in 2006. Boxes were monitored by volunteers for a number of factors including predation.

Volunteers collecting data on the bluebird nestlings often complained about the impacts of RIFA predation on the nestlings. RIFA predation is particularly noticeable and upsetting to the volunteers because the RIFA are usually still in the box and predating the nestlings when the volunteers check the box.

Baffles have been widely used in the past to exclude predators such as raccoons, squirrels and snakes. They have been largely ineffective for protecting nestlings from RIFA. Due to the small size of RIFA and their ability to crawl on inverted surfaces they have are able to go around the baffle or take advantage of small openings between the baffle and the pole

Fluon AD-1™ is often used to contain laboratory colonies of RIFA in plastic trays. It was hypothesized that if a baffle was treated with Fluon AD-1™ and was tightly sealed it might prevent RIFA from predating the nestlings.

Starting with the 2004 season 49 bluebird nestboxes at Sandhill REC were protected using baffles constructed from the top half of a 1 liter Pepsi bottle. Half of the baffles were coated with Fluon AD-1™ the other half were coated with Tanglefoot™. During this initial season none of the nestboxes that were protected with baffles were predated by RIFA.

At the Sandhill Research and Education Center, the forty-nine bluebird nest boxes were equipped with baffles constructed by cutting a 1 liter plastic Pepsi bottle in half. Approximately half of the resulting cones were coated with Fluon AD-1™ and the other half with Tanglefoot™. The baffles were attached to the poles supporting the nest boxes using electrical tape. Electrical tape was used because we were able to get a complete seal and the material is very weather proof.

Throughout the nesting season RIFA predation was noted and compared between baffle protected nest boxes and unprotected nest boxes. Results are reported in this study for 2004 – 2006.

Figure 5.1: Photograph of baffle deployed in the field.

Lab Study

The initiation of the field experiment was not designed as a scientific experiment, and was implemented based upon the educated guess that such a device might have potential. After noting the high level efficacy of the baffles in the field it was determined that a more comprehensive and rigorous experiment was needed to test the efficacy of the baffle.

An experiment was designed using 5 replications of a completely randomized block design using three common pole types: metal, pvc, and wood. Three types of baffles were used: uncoated, Tanglefoot™ coated, and Fluon AD-1™ coated. A pole of each type without a baffle was used as the untreated control (UTC).

Peanut butter is a well known attractant for RIFA and was used at the top of each pole to simulate the nestlings. A matrix with all of the combinations was constructed and place in a laboratory reared colony.

Data were recorded as an hit (1) if fire ants were found feeding feeding on peanut butter bait at intervals of one hour, two hours, four hours, and six hours, or miss (0) if fire ants were not found feeding on the peanutbutter at the specified intervals. Initial tests extended to data points as far out as 72 hours, but showed that if RIFA were going to breach the barrier this would happen within the six hour time frame. Using SAS software Fisher's Exact Test was used to determine if the protection provided by the baffle was significantly different.

RESULTS

Field study results

The total number of nest boxes has ranged from a low of 72 boxes in 2001 to a high of 246 in 2004. The mean RIFA predation of the nestboxes was 15.4 ± 3.0 during the study. The mean total predation (predation by RIFA and other predators) recorded was 38.3 ± 6.2 (See Table 5.1). RIFA predation accounted for 40.3% of the total predation throughout the duration of this study.

Nestboxes protected by the baffles deployed during the 2004 – 2006 seasons provided 100% protection from RIFA predation. This protection was consistent without regard to the type of coating i.e. Tanglefoot™ or Fluon AD-1™. Due to the results obtained in the laboratory tests below with uncoated baffles we deployed some uncoated baffles in the spring of 2006. This uncoated baffle provided equal protection during the season as baffles with either Tanglefoot™ or Fluon AD-1™ coating. See table 4.1.

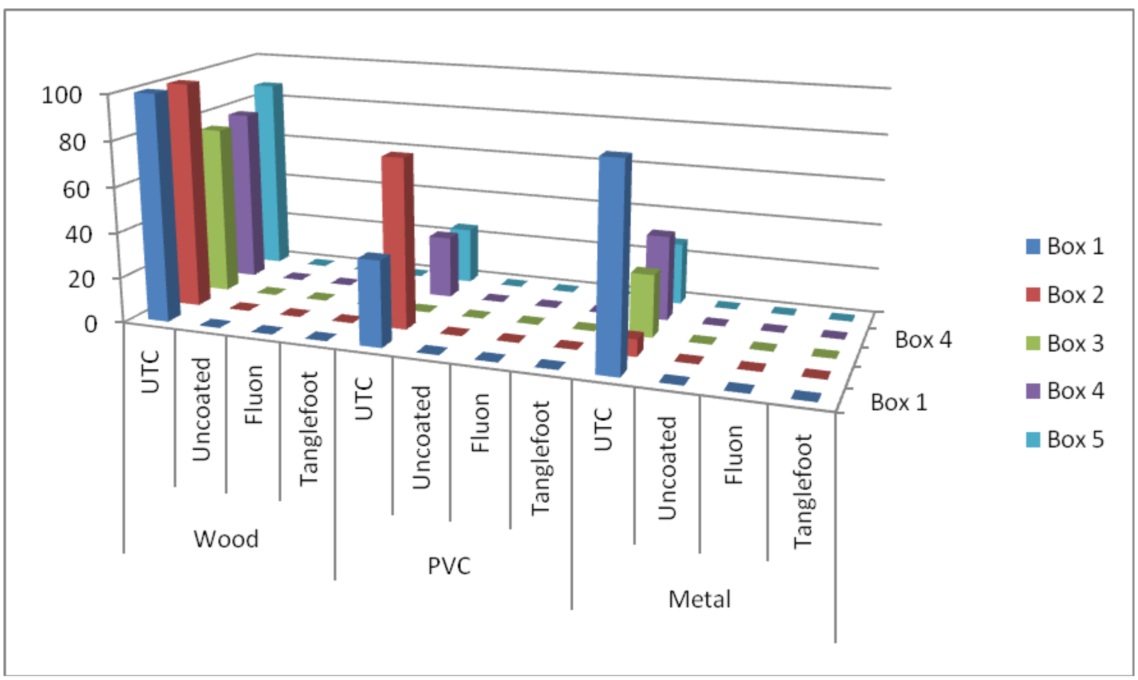
Table 5.1: Field Study Summary Table: Baffles were initiated in the field in 2004. RIFA accounted for 40.3% of the total bluebird predation. Nestboxes protected by the baffle were 100% effective at eliminating RIFA predation regardless of baffle coating.

Year	Total number of boxes	Number of protected boxes	Number of unprotected boxes	Number of nestboxes with RIFA predations	Total number of nestboxes with predation (RIFA and other predators)	Number of RIFA predations on protected boxes
2000	139	0	139	5	21	-
2001	72	0	72	12	16	-
2002	170	0	170	9	33	-
2003	214	0	214	13	40	-
2004	249	48	201	23	61	0
2005	233	48	185	27	53	0
2006	248	48	200	19	44	0
Total				108	268	0
Mean				15.4±3.0	38.3±6.2	0±0

<u>Lab results</u>

The results obtained the laboratory experiment are shown in Figure 5.1. The UTC in all replications and pole types found RIFA attacking the baits within one hour after the experiment was initiated. The baits that were protected with the baffles on the other had showed zero RIFA attacking the baits at the conclusion of the experiments. These results were held without regard to the baffle coating. Thus the uncoated baffle provided equal protection to the baffles that were coated with Fluon AD-1™ and Tanglefoot™. The estimated number of ants found on the baits were converted to hit or miss (1 or 0) since the estimated number of ants was the same for all of the treatment categories. These results found the baffle treatments were statistically different from the UTC $p = 4.13 \times 10^{-12}$ Fisher's Exact Test.

Figure 5.2: The average estimated number of ants (0 – 100+) reaching bait at 1, 2, 4, and 6 hour intervals in each attack box and for each baffle coating and pole type.



CONCLUSIONS/DISCUSSION

This study demonstrates that RIFA can be and probably are a significant portion of the predation of nestlings in field populations. In spite of this, the bluebird population continues to thrive thanks to the nest box programs throughout the range of this bird.

When examining the field data the actual level of RIFA predation presented is lower than would be predicted from the complaints of the volunteers. It doesn't take long when speaking with participants to realize the enthusiasm and attachment they have for the nestlings. A quotation from a listserve sums up the feelings of responsibility shared by the many volunteers, "*I will guarantee that there is not a bluebirder . . . that has not shed a tear or two either for the joy these birds bring or the heart ache we occasionally feel depending on what we find or learn about these birds over the course of our lives! It hurts just as much to lose that first nest as it will the last next only you feel more guilty the longer you put up nestboxes because we "believe" we have learned enough to be able to prevent ALL losses!" – (Kridler 2005)*

Predation is a natural part of the life cycle, and most of the participants recognize this fact. Most of the natural predators of the bluebird nestlings, however, do not present the negative visual and visceral impact of RIFA preying upon the nestlings. Predation is a necessary and important part of the natural process. It is possible that ants in general may have always been one of the predators of Eastern Bluebird nestlings. RIFA, however, are a non-native and invasive species with reduced competition and are not a part of the natural predator-prey ecology.

The annual variation of the RIFA predation is likely due to normal variations in the RIFA population and/or activity. Factors such as temperature and moisture play a role in the level of RIFA activity.

It is probable, though not tested in this study, that RIFA impacts the bluebird population in other ways. Both species primary food sources are small arthropods and competition for this food source could be impacting the bluebird populations or behavior in ways that have not yet been measured or tested.

A number of solutions to fire ant predation have been suggested, most of these recommendations have had very little replicated testing to prove their efficacy (Sialis). Most commonly coating the poles with grease, petroleum jelly, or Tanglefoot™ is recommended. Personal experiences with these suggest that they may give some temporary protection for fire ant predation, but over time, debris such as dirt, leaves, and even dead ants can allow the fire ants to bridge the barrier. Another disadvantage, at least for the use of grease or petroleum jelly is the potential for polluting the environment as these coatings are washed off and into the soil.

A number of studies have looked at the use of chemical barriers to serve as a barrier to RIFA. Reports of the efficacy of chemical barriers are mixed Pranschke (Pranschke et al. 2003) found a barrier of bifenthrin was effective. Hooper-Bui (Hooper-Bui 2005) however concluded that barriers of fipronil or bifenthrin did not significantly reduce fire ant foraging activity. With any insecticide treatment for fire ants there are a lot of variables that can impact the ultimate results. This likely leads to the varied results reported in the literature. If researchers are obtaining such mixed results it is unlikely that the untrained general population can hope to get consistent results

The baffle is inexpensive compared to chemical treatment and more effective. These treatments do not reach the high levels of efficacy found with this baffle device. They are also more expensive and must be repeated on a regular basis to maintain a reduction in the RIFA population.

Originally we thought that the use of coatings such as Tanglefoot™ or Fluon AD-1™ be necessary for the baffles to be effective, since baffles used to prevent squirrel or snake predation had proved ineffective against RIFA. These coatings carried with them some disadvantages. Tanglefoot™ is unpleasant and difficult to work with and debris can stick to the coating rendering it ineffective. Fluon AD-1™ is expensive and difficult to obtain. Further, under humid conditions it becomes ineffective at containing RIFA. The thin layer is easily damaged again rendering it ineffective.

In our laboratory experiments we decided to try the baffle without these coatings for the sake of comparison. We were surprised to learn that this was as effective as either coating preventing 100% of RIFA in the test boxes from reaching the attractant. While uncoated a baffles have only been tested for a single season in the field our data suggest once again they performed as well as their coated counterparts.

Data for preliminary tests are not included, but a number of brands of bottles were tested. We found that bottles with a smooth surface and a vertical slope were effective. Bottles with any type of texturing were not effective (data not included in this report).

Another important property in the success was that all gaps between the tape and the pole substrate must be closed. The RIFA were able to exploit any small opening.

We have not tested this method against other species of ants besides RIFA. We would hypothesize that it may not be effective against all ant species. Species such as *Technomyrmex albipes* are notoriously difficult to contain in laboratory situations thus we would surmise this device would also not be effective against *T. albipes* or other species that are similarly difficult to contain.

These data do suggest that the baffles are as effective in the field as they are in the laboratory test thus we feel that the baffle is a very effective means of protecting bluebird nestlings from RIFA predation. It is simple, inexpensive and effective. It carries the added benefit of reusing a product that has a very long decay half life.

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Hints for Effective RIFA Bait Treatment (Fact Sheet)

Bait treatments for fire ants are frequently recommended and are often a great choice for controlling fire ant populations. Fire ant baits rely upon the fire ants to pick the material up and take it back to their mounds. Once in the colony the bait is incorporated into the food system where the active ingredient is passed to all members of the colony. The following tips should allow the applicator to obtain the highest level of control.

1. *Baits must be applied while RIFA are actively foraging.* Technically, this is determined by the surface temperature. Temperatures between 70º and 90º F are ideal. The easiest way to detemine if RIFA are actively foraging is the use of a test bait. Place a small amount of bait in the area to be treated. RIFA should hit the bait within 30 minutes.

2. *Use fresh bait.* Most baits are formulated with three components, an active ingredient, soybean oil as a carrier, and defatted corn grit as a matrix. If the soybean oil goes rancid it is not attractive to the fire ants and they won't pick it up. Baits usually do not store well so should be purchased in one time use quantities. They should be stored in a cool dry place until used.

3. *Baits need to be applied when it is dry*. A 12 hour window is recommended before rain or irrigation.

4. *1—1.5 lbs of bait is not a lot of product.* This comes to about 30 granules per square foot. A good starting point for calibration is 1/8 inch opening at 6—8 miles per hour. The speed can be slowed by skipping a swath.

5. *RIFA can forage a long distance from their colonies*. When baiting difficult or sensitive areas this can be used. For example, a 30 foot buffer can be used around a pond to effectively treat mounds close to the pond, or another example might be RIFA invading homes. Treatment around the outside perimeter is frequently effective against the home invaders.

Managing the Red Imported Fire Ant in Pastures

This question of how to manage RIFA in pastures is occurring up more and frequently. Generally the $20 or more per acre, per year cost of treating pastures for RIFA is prohibitive for those desiring to make a profit from their pastures and hayfields.

For those still interested in treating, the principles of RIFA management stay the same as with any other environment or habitat.

Two basic choices are available individual mound treatments (IMT) or broadcast bait treatments.

The only products currently labeled for pastures contain the active ingredients Hydromethylnon, Methoprene, Pyrproxyfen, Spinosad and Sevin.

Hydromethylnon, Pyrproxifen, and Methoprene are baits suitable and labeled for broadcast treatments. Spinosad is a bait labeled for IMT, and Sevin is an IMT drench.

There are, of course, numerous formulations of Sevin on the market. Charles Barr with Texas A&M did some tests with several and found them all to be effective on mounds treated. There have been label changes recently and the only one I found with pastures still on the label was the 80S as an Individual Mound Treatment (IMT). The label reads 8.4 grams per gallon, and a "drench of 2 gallons per mound or at least a quart per six inches of mound diameter . . ." IMT's do effectively kill individual mounds that are treated. IMTs are rarely practical in an area the size of most pastures. IMTs may be worthwhile to take out the pesky ones around the fences and gates. It is unlikely to reduce the population to an acceptable level since any mound you don't treat is unaffected.

Spinosad is labeled as Justice™. In pastures it is labeled for IMT only. It would carry the same advantages and disadvantages as Sevin. Very effective on the mounds that are treated, labor intensive (though you don't need to mix it with water), and kills only mounds that are treated.

<u>Now to the baits where this gets complicated</u>

Methoprene and Pyrproxyfen are insect growth regulators. They have very broad labels to include pastures. It is labeled for broadcast applications. Generally, the research shows this to act very slowly, but may provide suppression for up to a year. In the Areawide program I began to see differences in mounds within four weeks, but the colonies were not dead. Colonies began to produce primarily alate larvae. They have a supplemental label that allows the product to be mixed with other baits at a 1:1 ratio and a total application of 1.5 lbs per acre i.e. 0.75lbs Extinguish™ and 0.75 lbs "other bait". The reasoning is when combined with a faster acting bait you will get a faster effect and a longer suppression.

Hydromethylnon is sold under several labels Amdro™, Amdro Pro™, Siege Pro™, and Probait™ (to name a few). The formulation is 0.73% active ingredient on all of these, however, the label varies considerably regarding pastures. Probait does not have pastures on the label at all. Amdro has it for "non-grazed and companion animals (horses and llamas) that are not intended for food." For example, this would mean that if I have a goat intended for mowing purposes Amdro™ is acceptable. If the goat is intended for meat or milk then Amdro™ is ***not*** acceptable. Amdro Pro™ and Siege Pro™ both have pastures on the label. They are not to be applied directly to the animal and there is a 12 hour Reentry Interval (REI) on them. There are also restrictions regarding frequency and total product applied per year.

An alternative to mixing the baits might be to treat with the IGR in the fall (Sep/Oct) and the toxin in the spring (Mid April - June).

So let's boil this down to a recommendation.

First, you need to evaluate the situation and determine if treatment is necessary or viable. Cost may be an issue, particularly in larger areas. Cost of bait applications including equipment, labor and material is probably going to get close to $15 - $20 per acre depending upon products and methods. You may need to treat more than once a year to obtain satisfactory levels.

Second, where is the greatest impact? Examine the cost to equipment, personnel, and animal. While it may not be profitable to treat the entire pasture it may be worthwhile to treat areas where the risks are concentrated such as corrals, stock yards etc. It may be worthwhile to treat those colonies at the gates where workers are likely to have a fire ant encounter or areas where equipment is maintained, or electric fences that may be disabled due to fire ants etc. Hence, an evaluation may lead to the conclusion that the greatest impact may be obtained by a partial treatment.

Third, once one decides to treat I would go to the Two Step approach - Bait for larger areas, IMT for individual mounds that create a problem. ***When choosing a bait check the label carefully for the intended use before you purchase!*** This includes the area to be treated as well as mixing the baits. As you know there are frequent changes so the only conclusive means is to read the label on the stuff you are purchasing.

For broadcast treatments seeder type spreaders such as the “Herd seeder” work well. Several models are available at http://www.herdseeder.com/ The opening should be a minimum 1/8 inch. A speed of 6—9 miles per hour is necessary to reach the proper calibration. The speed can be reduced by treating every other swath a.k.a. skip swath treatments.

For areas greater than 100 acres aerial treatments may be practical and cost effective. The cost varies depending upon the vendor and area to be treated, but in general the cost is $17 – $19 per acre based upon 2008 prices.

Amdro™ Hydromethylnon	Broadcast BaitCompanion animals and animals not intended for food or food product.
Amdro Pro™ Hydromethylnon	Broadcast BaitLabeled for Pastures and Hayfields. 12 hour REI
Seige Pro™ Hydromethylnon	Broadcast BaitLabeled for Pastures and Hayfields. 12 hour REI
Extinguish™ Methoprene (IGR)	Broadcast Bait, Slow acting, may give longer suppression of population. Can be "tank" mixed with other baits.
Extinguish Plus™ Hydromethylnon and Methoprene	In the bag mix of toxicant and IGR
Esteem™ Pyrproxifen	IGR
Justice™ Spinosad	IMT only in pastures
Sevin 80S™ Carbaryl	IMT drench only

Management of the Red Imported Fire Ant – Theory and Practice in the United States

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I appreciate the opportunity to stand here with some of my colleagues and share our experiences with the Red Imported Fire Ant. I bring greetings from the U.S and would like to welcome you to the Fire Ant family – it is my hope that your program will be successful and that your membership in our family will be short lived. I would also like to thank Bayer Environmental Sciences for their kind hospitality and for sponsoring my participation in this workshop.

Introduction

Without a doubt, the Red Imported Fire Ant (RIFA), *Solenopsis invicta,* needs little introduction to this assembled group. By now I'm sure most of you have not only seen much of the news media coverage, but also spent some time delving into the resources available from Australia and the United States. The impacts of RIFA are well studied and there is a mountain of information available.

I will not spend a lot of time telling some of the scary stories about what fire ants do, have done, or even what they have been accused of doing. I would like to cite two studies conducted in South Carolina. The first is a survey conducted in 1998 that found 660,000 out of about 4 million people in our state were stung by fire ants. Of those, 33,000 sought medical attention for the fire ant stings. About 15 % of the population can have a severe localized allergic reaction, and about 1 – 2% can have a severe systemic allergic reaction up to and including anaphylaxis. In that year two deaths attributed directly to fire ant stings were documented (Caldwell 1999).

In the same year, 1998, another survey found that South Carolina homeowners expected to spend about $124.7 million treating fire ants around their homes (Miller 2000). This number does not include any commercial management or impacts. Since that time I have talked to thousands of these people and have come to realize that most are not obtaining satisfactory results from these efforts because they fail to adequately understand the pest with which they are dealing, nor do they understand the products they are using.

My plan today is to spend some time providing the background information that is necessary for RIFA management success as well as discuss the products and tools at the disposal of the RIFA manager.

So why is the RIFA so difficult to control? In truth fire ants are pretty easy to kill. In fact, individual colonies are not difficult to eliminate. They are susceptible to almost any pesticide one might choose. What *is* difficult is to achieve a reduction in the RIFA population. There are a number of reasons for this.

- ❑ Colonies and newly mated queen move easily from one location to another as well as vertically in soil profile
- ❑ RIFA are omnivorous and will choose numerous food sources.

- Their life cycle ensures survivability and dispersal.
- They have a high reproductive potential.
- The large number of colonies. It is not uncommon to find 480 – 1200 mounds per hectare.
- Colonies can have a large number of individuals.
- Colonies are capable of very rapid growth.
- Biological traits such as hybridization, multiple queen colonies and queen replacementIt is an invasive species with reduced competition in the absence of natural enemies.

Any RIFA management program must systematically take each of these factors into account in order to achieve the goal of population reduction or elimination.

Identification

Pest management programs must start with proper identification. This is true with any pest management program whether we are talking about RIFA or any other pest. I believe this to be especially true with ant pests.

In most cases, when I get calls about treatment failures, and everything appears to have been done correctly, a little investigation frequently reveals the usual problem - misidentification of the target pest. RIFA are first on most people's mind, but it shouldn't be forgotten that other ants are present and some of these are also pests. Some are even similar in size and color to fire ants. These ants could be easily mistaken for RIFA by the casual observer.

RIFA are distinguished by the following combination of characters: they are a "two humped" ant, posses ten antennal segments, the terminal antennal segments form a two-segmented club. *S. invicta* is further distinguished from other *Solenopsis* species by the presence of a third median clypeal tooth. This is especially useful in distinguishing *S. invicta* from *S. geminata*. Distinguishing other species in the *Solenopsis* genus such as *S. richteri* and *S. xyloni* is very problematic using morphological characters and is largely unnecessary with regard to management techniques.

Biology as it relates to management

Fire ants are one of the most studied ants in the world today. While much of the work has focused upon management a significant body of knowledge about the biology and ecology of the species has been accrued. A clear understanding of RIFA biology is necessary to obtain management success. It is particularly imperative when special situations arise that are out of the ordinary, or when evaluating a treatment failure. For this reason we will discuss some of the biological traits that directly affect management decisions.

Life Cycle

Mating flights can occur when the air temperature is between 21°C and 38°C, with wind speeds less than 24 kilometers per hour, low humidity, and usually within 24 hours of a rain. In the Southeast U.S. this can occur almost any time of the year. Mating takes place in the air. After mating, queens are capable of flying as far as 3 kilometers.

In some studies they have been found as far away as 19 kilometers with the help of a tail wind.

What does this mean to management? Suppose for a moment, that a treatment is completely successful and all of the colonies in a given area are destroyed, reinfestation can occur at any time of year when a mating flight occurs. Reinfestation can also occur from a relatively great distance.

After mating a queen lands, burrows underground and forms a small capsule of soil and saliva where she will lay 75 to 150 eggs. She will rear these young to adults in about 20 – 45 days depending upon the temperature. During this time she is essentially invulnerable to management treatments. So once again, if a treatment is completely successful and all of the mature colonies are destroyed these incipient colonies remain untouched and reinfestation will soon be apparent.

Once the queen rears her young to adults they begin to take care of the queen. They groom her, feed her, and care for the young. In short the queen's only "job" from this point on is to lay eggs. At her peak she can lay as many as 1500 eggs per day or about 250,000 eggs per year. This means any management plan must destroy the queen or she can quickly replace any workers that are lost to a pesticide treatment.

The Mound

The mound has rightly been called a "castle in the ground." Each mound in general has as much volume above ground as below. The mound can also be raised or lowered to control both temperature and moisture. This means that mounds can often be difficult to find during hot or dry times of the year.

Another feature of the mound are the foraging tunnels that radiate out from the mound in all directions. The tunnels can have numerous openings and can range as far as 100 meters from the mound itself. This means that fire ants foragers may not necessarily be from a nearby mound and could be coming from a long distance.

Fire ants forage in the U.S. when the substrate temperatures are between 21°C and 38°C. When the temperatures are too warm or too cold, activity decreases or takes place primarily underground where the temperatures are suitable.

Feeding

RIFA are omnivorous and feed on numerous food sources that may be available. They will feed on plants that produce oil or from plant nectaries. They also will tend Homopteran insects for honeydew. Their primary food source, however, is other small insects. From a management perspective a strategy that reduces or removes the food source is not a practical option for RIFA.

It is important to understand that adult RIFA are incapable of ingesting solid food. Instead they feed by a process called tropholaxis. When foragers return with a solid food source they place it in a structure of the fourth instar larvae called a bucal pouch. This larvae will excrete digestive juices that externally liquefy the food source.

During grooming, a nurse ant will stroke the larvae with her antennae, stimulating the larvae to regurgitate a liquid that the nurse ant ingests. That ant in turn is stimulated by another ant to produce some of the liquid to be ingested, and so on and so forth throughout the entire colony.

This process serves as a food filter to protect the queen from toxins and disease. Tropholaxis is the reason most of the RIFA baits must act slowly. The active ingredient must be spread through all of the individuals in the colony before the toxic properties are evident or the colony may survive the treatment. It also means that the brood plays an important role in the survival of a colony.

Management options

In the U.S.A. more than 150 products are labeled for fire ant treatment. Most are relatively effective if they are properly used. This means choices for management can get complicated.

Essentially the treatments can be broken down into three categories: Individual mound treatments (IMT), baits, and granular broadcast treatments. Let's examine the advantages and disadvantages of each of these options.

IMT – These products are applied directly to individual mounds. They include products such as Acephate (Orthene), Bifenthrin, Triazicide, Sevin, or Cyfluthrin. These treatments are very effective on the treated mounds. Most research demonstrates a >98% mound mortality. Unfortunately, these treatments do not kill any mounds that are not treated. In most cases, even experts will miss as many mounds as they find so this method is great for killing individual mounds, but is rarely effective at reducing the RIFA population overall.

Baits – Many active ingredients that have been formulated into baits. Most RIFA baits consist of a soybean oil, which serves as an attractant and carrier for the active ingredient, and defatted corn gel as a carrier. Baits are applied by a broadcast application, usually at a rate of 1 – 1.5 lbs per acre (1.0Kg – 1.6Kg/Hectare). In general, all of the available baits will give between 85 and 95% control that will last from 3 – 12 months.

They have several advantages. First they are relatively inexpensive. Second, because they rely upon the foraging behavior of the ants they are self dosing and able to control mounds that are difficult to find. Third they are effective at controlling ants in some sensitive areas such as near water or home gardens.

Baits can be broken into two different groups: Toxicants and Insect Growth Regulators (IGR). The active ingredient in toxicants obviously kills the ants and queen directly. Insect Growth Regulators on the other hand attack the development of the ants. Some may prevent larvae from developing normally. Others cause the queen to lay non-viable eggs. Still others cause only reproductive stages to develop.

The mode of action means that toxicants tend to work a faster (four to six weeks) and will provide population reduction for 3 to 5 months. IGR's are slower (12 – 25 weeks), but will provide population reductions for longer periods of time. (6 – 12 months).

Baits: Active Ingredients

The following are some of the most common active ingredients found in baits and some comments based upon personal experiences both as a Clemson County Extension Agent and field trials conducted during my research and demonstration projects.

Hydramethylnon – is a toxicant in the U.S. it is sold under a number of names:

Amdro™, Probait™, Amdro Pro™ etc.

Spinosad – Is a toxicant. The main advantage to this product is that it is considered "organic" because it is derived from a bacterial fermentation process. Unfortunately, it is also very toxic to the ants and has been shown to kill foragers before they get back to the colony and incorporate the product into the food system. For this reason it does not work well as a broadcast bait, but it does have some uses as an individual mound treatment.

Fipronil – Is a toxicant sold as Ceasefire™. This product uses "Tast-e-bait™", as the carrier rather than the standard soybean oil/grits carrier. One of the main advantages is the very low amount of active ingredient used. In field tests this product has shown some mixed results. Some of my earlier tests have failed, but in my most recent tests the product has performed well.

Indoxacarb – Is a toxicant bait sold as Advion™. This product has just recently been labeled for fire ants in the U.S. Field trials over the last two years have shown this product to work very quickly. Usually foraging activity stops within 24 hours. Colonies are completely dead within 72 hours.

Methoprene – is an Insect Growth Regulator (IGR) sold as Extinguish™. Methoprene has a broad range of uses and has been around as an insecticide for a long time. The main advantage to this product is that it also is labeled for the broadest range of sites. The main disadvantage is that it may take as long as six months before the fire ant population is affected by the treatment.

Fenoxycarb- is an IGR sold as Award™. This product is primarily marketed to and used by professional turfgrass managers such as golf courses and athletic fields.

Pyriproxyfen – is an IGR sold as Distance™. In South Carolina this product has been difficult to find. It seems there are few vendors. It is one of the products that has been used in the Australian program. (note: this product is now widely available as Esteem Fire Ant Bait™)

Mixtures – Extinguish Plus™ is a product that contains a methoprene and hydromethylnon mixture. In most tests this mixture seems to give more reduction than either product alone, however, to my knowledge this difference is not statistically significant. Likely, a test with a greater number of replications would yield a difference, but such a test would also be too labor intensive to be practical.

Getting Baits to work

RIFA baits can be somewhat tricky to use and obtain the desired results. I have many people call me each week to tell me that fire ant baits don't work. Most often, after talking with them, I find that some errors in the use or application of the baits have occurred. The following is a compilation of the most common problems that lead to bait treatment failures.

Fresh bait must be used – Most of the fire ant baits are formulated using defatted corn grit, with soybean oil as both a carrier and attractant. If the soybean oil becomes rancid the bait is not attractive to the ants hence they don't pick the bait up and return it to the colony.

Baits cannot get wet – Again these baits are formulated using defatted corn grit. If the product gets wet the grits swell, the oil separates and the product is unattractive to the ants.

Bait breaks down quickly in UV radiation i.e. sunlight. A few hours in sunlight and most of the active ingredients, and the soybean oil breakdown and they become ineffective.

Timing of bait application is most critical. For the above reasons fire ant bait products must be applied while fire ants are actively foraging. In my opinion, this is the most important key to successful baiting of RIFA. In the U.S. this is when the substrate surface is between 21°C and 38°C. In Australia researchers found there was often a shift in foraging activity attributed to competition with other ants species. Hence, some experimentation may be required to determine a predictable time for fire ant foraging in Taiwan. In general, I recommend a pre-bait test. Simply, put a small amount of bait out and wait for about 30 minutes. If fire ants hit the bait it is a good time, if not it is better to wait before making an application.

Granular Broadcast Treatments

Granular broadcast treatments include fipronil (sold as TopChoice™) and bifenthrin (sold as Talstar™). These products have several advantages: They give nearly 100% control for 12 – 18 months, they can be used any time of the year without regard to foraging activities of RIFA, they can control RIFA in small areas, and they are very stable. Of course there are several disadvantages. They have a strong edge effect i.e. RIFA can establish in a missed swath or between soil and pavement. They also require water for activation. They are also very expensive (approximately $230 per acre)

These products are best used in areas with zero tolerance for RIFA such as around children's playgrounds and hospitals. They are also a good choice to protect small areas such as electrical equipment. At Clemson we have effectively used fipronil to protect runway approach lights, air conditioners, and transformers, all of which commonly are attacked by RIFA.

Combinations

Combining common control methods such as baits and IMT treatments has proven to be an effective strategy for RIFA management. Of course, there are several possibilities that have been used.

The most common recommendation is known as the "Texas Two Step". Broadcast fire ant bait while the ants are foraging, after 7 – 10 days IMT treatments are used on the mounds that continue to be a problem.

Another combination I call the "Clemson Two Step". After analyzing a site, areas with zero or low tolerance for RIFA are treated with a broadcast granular. The rest of the property is treated with a broadcast bait treatment while RIFA are foraging. This reduces the area where the high priced product is used, but gives the advantage in the area where it is most needed.

Bayer recommends the use of TopChoice™ followed immediately by a bait treatment. This will give the advantage of the broadcast granular and clean up mounds along the hard edges such as pavement or sidewalks. Another researcher has suggested adding IMT treatments to this regime for persistent mounds.

Regardless of the combination that is chosen it is likely to be more effective than any single method. Further, each of these combinations are only effective if the products are applied correctly.

Application Techniques

The rate for most of the baits is 1 – 1.5 lbs product per acre (1.0Kg – 1.6Kg/Hectare). This is not a lot of product so it is often difficult to spread at this low rate. Most applications are made either aerially or with spreaders and ground equipment. Undoubtedly, aerial applications are the most efficient for large areas. Of course, obstacles such as power lines and skyscrapers can be problematic. It is also difficult to target areas smaller than 40.hectares.

Ground applications can be made with a variety of equipment. The most common equipment is a low volume seeder such as the Herd® seeder. Such a seeder can be attached to a tractor, All Terrain Vehicle (ATV), or even a truck. The seeder needs to have a minimum opening of 1/8 inch to allow flow of the product. To get the product out at the proper rate the equipment will need to be calibrated. Usually, a speed of 12 – 16 kilometers per hour will be needed to get the application rate into the proper range.

Conclusions

In the U.S eradication is not a practical option. Fire ants have spread to cover too great an area for success to be a likely outcome. The cost to control fire ants over such a large area is prohibitive. Lastly, the logistics of such a program would require an overwhelming bureaucracy.

We do however have effective tools to manage fire ants, but these tools require a deep knowledge of the pest and pesticide to be effective.

If you miss everything else I say today do not miss this: ***The most important tool in the box is the knowledge of the individual or individuals doing the applications!***

Understanding these intricate interactions between the environment, ecology, biology, chemistry, and people will be the key to a successful RIFA management program. A successful program in Taiwan will require cooperation between the government agencies, scientists, private industry, and maybe most importantly the public.

I know I speak for my colleagues in wishing your program and country luck with your RIFA program.

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Summary of Observations and Thoughts Regarding the Incursion of the Red Imported Fire Ant *Solenopsis invicta* Buren (HYMENOPTERA: FORMICIDAE) in Taiwan.

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I would first like to express my appreciation for the kind hospitality shown to me during my recent visit to Taiwan. I look forward to the day that I can return and see all the places that no longer have fire ants.

At Clemson Extension we report the success of our programs on three levels. The first is how many people attended the program. The second is how many people increased knowledge at the program. The last is how many people adopted new practices at the program. To be sure the most important tool for managing fire ants is not the chemicals, but rather the knowledge of the people applying those chemicals. I am encouraged by the desire of the Taiwan fire ant program to absorb as much knowledge as possible. I am most encouraged, however, that during my short stay we began to see the adoption of new practices for the management of the Red Imported Fire Ant (RIFA).

It is clear that the Taiwan program has chosen eradication of the RIFA as their ultimate goal. Eradication is without a doubt the toughest goal to achieve, but success in such a program is truly the most rewarding. . Eradication has never been successfully demonstrated, however, ongoing efforts in Australia suggest that such a goal may be possible.

Observations and Recommendations Regarding Eradication of RIFA - An eradication program means that 100% elimination of the entire fire ant population is the goal of the program. The following points are a summary of the steps necessary to achieve the eradication of a RIFA population based upon the current technologies.

Clearly define the infested area. Currently, the Taiwan infestation is believed to cover about 7000 ha. It is likely the area is larger than is accounted for by early estimates. If the Australian experience is taken as a model, they found their infestation to be about three times the size of their early estimates. Transferring that figure to Taiwan I would not be surprised to learn that after an intensive survey the area infested was found to be closer to 21,000 ha. Before serious treatment efforts can begin the area to be treated must be defined and mapped.

Both passive and active means of surveillance should be employed to determine the extent of the infested area. Public awareness and involvement can play a large role in finding infested sites that were previously unknown. With that in mind an aggressive public awareness campaign should be conducted.

GIS mapping and modeling of the infestation will help with the visualization of the infestation and the allocation of resources to surveillance. As an individual that has built models of ant distributions I would caution that such models need to be used within their prescribed limitations. Among modelers there is a mantra "If you model long enough you will begin to believe they are real" – How true it is.

Pitfall traps are time consuming and analysis requires a fairly high degree of knowledge, but pitfalls can also be effective for finding populations as well as inferring information about population densities. The development of an ELISA test can greatly help with the analysis of these trap type methods.

Add a buffer zone of 3 – 5 km to contain the infestation. During mating flights queens are capable of flying up to 5 km without a tailwind. Early studies in the Southeastern United States found IFA to be spreading at about 10 km per year without the aid of human movement. This spread was due mostly to the movement of queens over relatively large distances during mating flights.

The buffer zone also plays an important role in limiting human movement of RIFA colonies. Movement of soil that can potentially harbor RIFA colonies must be regulated, treated and inspected to prevent the movement of the colonies outside of the treatment and buffer zones. As treatments progress and the populations are reduced it is equally important to limit movement within the treated zone to lessen reinfestation of treated sites. Movement control recommendations will be addressed later in this document.

Treat 100% of the infested area a minimum of three times a year with an Insect Growth Regulator Bait (IGR). It is possible to substitute a toxicant bait for the middle treatment to give a faster visible result. In theory, the use of IGR baits will sterilize female alates and limit their reproductive and range expansion potential during mating flights.

These treatments need to be broadcast treatments aimed at reducing the population over the entire infested area. During my tours I noticed a great deal of effort being placed into individual mound treatments (IMT). It should be remembered that the goal of any fire ant management program is the reduction of fire ants on the population level.

Due to the large number of mounds and the ability of RIFA to establish mounds in a variety of places, it is difficult to find every mound that needs to be treated. For an eradication program, any mound that is left untreated will provide the reproductives to reinvade the treated areas.

It should be remembered that in the United States we do recommend the use of IMT, but we are also not attempting to eradicate RIFA in the U.S. at this time. IMT are largely used to eliminate mounds that are in problem locations. IMTs may have a place in an overall program, but they do very little to reduce fire ants at the population level and are not suitable for a fire ant eradication program.

Extensive surveillance system of 100% of the infested zone. This includes both passive and active surveillance systems. Surveillance will serve to document the success of the program and define the extent of the infestation. The standard recommendation is that surveillance must continue for at least two years after the last RIFA colony is eliminated to demonstrate eradication.

Active methods of surveillance include visual inspection of the infested areas and the buffer zones. It can also include trap methods such as pitfall traps, or collections of swimming pool skimmer debris.

Passive methods largely rely upon public reports. Passive methods can be very effective, but require a high level of public education. Such education must also keep the topic of RIFA a high priority in the public eye. As the program progresses, experiences successes, and the RIFA population is reduced it is difficult to keep the program high in the minds of the public. The RIFA program will need to develop methods to counter this tendency.

Eliminate human assisted movement of RIFA. Both the U.S. and Australia have strict regulations in place to limit and/or eliminate human assisted movement of RIFA colonies. The regulations of both countries should be looked at carefully and adapted for use in Taiwan. The heart of each of these programs is three fold: first, treatment of soils in pots, second sanitation of equipment used for soil movement, and third inspection of all items susceptible to movement of RIFA colonies.

The sites in Jungpu, Chiai County are especially vulnerable as there are a number of nurseries producing potted plants for the ornamental horticulture industry. The other sites are especially susceptible to movement due to construction.

Other observations and recommendations

Clean up Treatments – While the eradication program dictates the treatment with IGR baits there may be some use for other strategies in highly sensitive areas. For example, National Taipei University is very concerned about the effect of RIFA upon the student population and quality of life. In such an area it may be appropriate to conduct the broadcast IGR treatment as planned, but follow the treatment with a highly effective toxicant treatment such as TopChoice (Fipronil) or Advion (Indoxacarb). Such treatments would serve to greatly reduce the RIFA population in this sensitive area. It would also give the RIFA program some high visibility successes early in the program.

Opportunities for Research – Due to the need to quickly limit the spread and begin the eradication program in Taiwan efforts to develop new products is probably not a practical nor profitable use of time. The greatest effort should be aimed at learning to optimize the products that are already available for the conditions in Taiwan.

There are still some questions that should be addressed through research. Most of these questions can be addressed cooperatively with other RIFA researchers. For example, determining the origin of the infestation may be useful in developing a plan to prevent reinfestation. Also information about the population such as monogyne vs polygyne would be interesting. We have found the microsporidian *Thelohania solenopsae* in the U.S. Screening for this and other disease organisms may also be productive. So little is known about ant pathology it is even possible that disease organism unique to Taiwan could come into play. Such a unique discovery could have tremendous implications for other countries with RIFA infestations.

Questions regarding the impact of RIFA on native ant populations are difficult to address in the U.S. due to the saturation of the infestation. The situation in Taiwan and Australia present some interesting opportunities. The ability to compare the ant fauna in both uninfested and infested sites as well as the potential to document the affects post eradication should not be missed.

I was impressed with the work to develop an ELISA test for RIFA. The perfection of such a test could be very useful. Surveillance methods such as pitfalls traditionally have require a high level of expertise and time investment to separate and identify the various ants. An ELISA test that could distinguish the presence of RIFA in such samples would increase the speed and reduce the difficulty of analysis.

Application Methods – Due to the variety of habitats, ground covers, land-use patterns, and terrain a single method of bait application is virtually impossible. Several methods will need to be developed and perfected to completely cover the area that needs to be treated.

RIFA bait applications are difficult and require a relatively high level of applicator knowledge to be successful. For this reason, I would suggest that manual applications be conducted by a set of trained crews rather than individual landowners.

Due to the large size of the area to be treated mechanization should be pursued where possible. Mechanization can take several forms. The use of All Terrain Vehicles (ATVs), equipped with electric seeders such as the Herdseeder will save considerable time and money. Aerial treatments, where possible, are very effective and probably the best way to treat large areas. In the U.S. surplus military aircraft were refitted to apply fire ant baits. When properly fitted, these applications can be made from a sufficient altitude to deal with variation in terrain and land-use.

Education – Education will be a critical aspect of the program. In fact the success or failure of the program will likely hinge upon the quality of the education program. There are at least three populations that will need intensive education: the public, the applicators, and the government sponsors.

The public plays a very large role in the eradication program. If they are well educated they will be responsible for passive surveillance. The public needs to understand the importance of their participation in the program. They will also be important when it comes to government funding of the program. The programs most important to the public inevitably find the greatest funding.

The application of RIFA baits is a fairly tricky business. The education of the applicators is critical to success. In the end, the public opinion will hinge on whether or not the treatments work or not. These people can also play a key role in educating the public and the government officials. Like the County Extension Agents they will be on the front line meeting the public in the "real world". Their conduct and conversation will play an important role in public opinion.

The government will be responsible for oversight and funding of the program. They must understand the cost of failure. They must also have realistic expectations. The learning curve for this program is very steep there will be failures and successes, this is to be expected. With experience the successes will soon outnumber the failures. Failures should not mean the end of the program.

One of the more difficult aspects of RIFA management to grasp is the difference between perception and reality. For example, when using IGR baits it may take 18 weeks or longer for the average person to see a difference in the RIFA population. Early in the treatment regime the perception will be that the treatments have failed. The reality may be that the treatments were very successful, but it may be too late for the program. Education of all involved will reduce the number of complaints against the program. People must have a realistic understanding of the complexity of an eradication program, the length of time for the treatments to take effect, the level of control that can be expected from each treatment, and the level of individual involvement each of them must have for the overall program to be successful

Bait Choices – The U.S. experience has found that virtually all of the RIFA baits will give from 80 – 95% reduction in the RIFA population when broadcast while the RIFA are foraging. The only exception to this is Spinosad which has not proven effective for broadcast applications. For this reason, the choice of product should hinge upon three factors: supply, cost of the product, and labeling of the product.

RIFA baits rely upon the ants to find and recruit to the bait product. Most of the baits use soybean oil as the carrier and attractant. If the oil turns rancid the efficacy of the treatment can be affected. I would suggest that the choice of which bait will be used should hinge upon the ability of the company to provide fresh bait. It may require the purchase of the individual components then assembling the bait locally.

Cost for each of the products varies considerably. The size of this program will require an economy of bait costs. While the supply and labeling should be primary factors the costs of the various choices should be comparable.

The last factor will be labeling. The infestation in Taiwan inhabits a large variety of habitats and landcovers. This will present some problems since some of these products have application limitations.

Formulations - The following are some of the most common active ingredients found in baits and some comments based upon personal experiences both as a Clemson County Extension Agent and field trials conducted during my research and demonstration projects. This list is modified from my symposium comments with additions based upon observations in Taiwan.

Hydramethylnon – is a toxicant in the U.S. it is sold under a number of names: Amdro™, Probait™, Amdro Pro™ etc. It is probably the most widely used bait in the U.S. this is probably due to availability and name recognition rather than any efficacy advantage.

Spinosad – Is a toxicant. The main advantage to this product is that it is considered “organic” because it is derived from a bacterial fermentation process. Unfortunately, it is also very toxic to the ants and has been shown to kill foragers before they get back to the colony and incorporate the product into the food system. For this reason it does not work well as a broadcast bait, but it does have some uses as an individual mound treatment.

Fipronil – Is a toxicant sold as Ceasefire. This product uses “Taste-e-bait™”, as the carrier rather than the standard soybean oil/grits carrier. One of the main advantages is the very low amount of active ingredient used. In field tests this product has shown some mixed results. Some of my earlier tests have failed, but in my most recent tests the product has performed well. The main disadvantage of this product is the formulation on Taste-e-bait. It would require a different calibration of the spreading equipment and retraining of the personnel conducting the applications. If Bayer is willing to reformulate the product for eradication programs it may have a place in some of the clean up programs or in toxicant bait treatments.

Indoxacarb – Is a toxicant bait sold as Advion™. This product has just recently been labeled for fire ants in the U.S. Field trials over the last two years have shown this product to work very quickly. Usually foraging activity stops within 24 hours. Colonies are completely dead within 72 hours. This may be a good choice in some of the clean up treatments where a quick reduction of RIFA would be advantageous.

Methoprene – is an Insect Growth Regulator (IGR) sold as Extinguish™. Methoprene has a broad range of uses and has been around as an insecticide for a long time. The main advantage to this product is that it also is labeled for the broadest range of sites. The main disadvantage is that it may take as long as six months before the fire ant population is affected by the treatment. This product should definitely be in the “toolbox” because of the many areas that it can be used, but it will also require patience and realistic expectations while waiting for it to affect the RIFA population.

Fenoxycarb- is an IGR sold as Award™. This product is primarily marketed to and used by professional turfgrass managers such as golf courses and athletic fields. As an IGR this product could be used, but label restrictions may make this use difficult.

Pyriproxyfen – is an IGR sold as Distance™. In South Carolina this product has been difficult to find. It seems there are few vendors. It is one of the products that has been used in the Australian program. One of the major driving forces for this product was the availability with a local company manufacturing this bait in Australia.

Mixtures – Extinguish Plus™ is a product that contains a methoprene and hydromethylnon mixture. Some products may have labels that allow "tank mixture" of an IGR and a toxicant. In most tests this mixture seems to give more reduction than either product alone, however, to my knowledge this difference is not statistically significant. Likely, a test with a greater number of replications would yield a difference, but such a test would also be too labor intensive to be practical.

The role of fipronil formulations – Several times during my visit the efficacy of various formulations of fipronil was raised. The formulations that have been tested for RIFA management are sold as Ceasefire™,TopChoice™, and Over 'n Out™. TopChoice™ is sold to the commercial applicators and is a broadcast granular formulation. Over 'n Out™ is also a broadcast granular formulation sold to consumer applicators. Ceasefire™ is a bait. The efficacy and uses of each are discussed in the proceedings of my symposium presentation.

A third formulation for agricultural uses is available in Taiwan. This is the formulation in question. Without research based information the efficacy of this formulation cannot be known. It may worth the effort to conduct a structured trial to determine the efficacy of this product in agricultural areas. Such a trial, will need to be conducted quickly since the results will be mixed if eradication treatments commence. Indeed there is some evidence to hypothesize that the product may be effective. While visiting site in Jungpu, Chiai County RIFA were found along the levies of the rice field, but none were found in the fields themselves. With TopChoice we often see similar results with RIFA occurring very near the treated edges.

If the product is found to be effective in a scientific test it will have to be labeled for RIFA. Under those circumstances it may work well in agricultural situations. Such sites will still need to be treated with an IGR under the eradication protocol that has been recommended.

Conclusions

It is very easy for me to write recommendations about a RIFA eradication program in Taiwan. The reality of implementing a RIFA eradication program is far more complex and difficult. Such a program must deal with the technical aspects of treating a RIFA infestation, preventing movement of RIFA outside of the infested area, and preventing any new incursions into the country. It must also deal with more subjective aspects such as education of the various stakeholders, the political machine, and funding. The progress of the program in Australia, however, should lend a measure of confidence to any country interested in the eradication of RIFA. It cannot be forgotten, however, that the Australian program is still in progress and has not yet achieved the goal of eradication.

One of the aspects of the Australian program that has greatly impressed me and I believe helped their program in the subjective areas is the external oversight and transparency of the program. I would suggest to any country interested in an eradication program to follow the lead Australia has set in the technical aspects as well as the outside oversight and transparency of the program.

Lastly, with reports of RIFA in Singapore and Malaysia, Taiwan can serve as a leader in Southeast Asia with regard to their RIFA program. The implementation of the Pacific Ant Prevention Plan will serve to protect your neighbors from RIFA invasion. Your influence as neighbors can promote the participation of other Southeast Asian countries. The knowledge and experience you gain through this program will undoubted be invaluable toward dealing with future incursions throughout the world.

There are significant differences between the United States, Australia, and Taiwan. I have every confidence the community of RIFA scientists are willing to lend their minds and expertise to this problem. I am equally confident that you have the begun to assemble the knowledge and expertise necessary to tackle this problem in your country. I wish you luck and look forward to seeing you progress toward your goals.