INTEGRATED PEST MANAGEMENT (IPM) IN URBAN ENTOMOLOGY: TRAINING, REGULATION AND EDUCATION

by

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(Under the Direction of Brian T. Forschler)

ABSTRACT

Integrated Pest Management (IPM) is a site-specific decision-making process that includes accountability (record-keeping) aimed at sustainable reductions in pest damage. For over 60 years, IPM has been identified as the calling card to reduce the use of pesticides. IPM has its genesis in agriculture, this philosophy was developed due to the insecticide resistance problems farmers faced using DDT and other pesticides. Urban entomology, concerns the management of pests in and around structural habitats. This dissertation focuses on the training, education and regulation of urban entomology as it relates to IPM.

The Structural Pest Control Section (SPCS) in the Georgia Department of Agriculture (GDA) regulates pesticide use in schools and residential areas. In 2007, SPCS inspectors began reviewing the pesticide use records (PURs) in Georgia schools. Over the course of two years, the SPCS collected over $800,000 in fines and several companies lost licensure due to violations associated with the PUR review program. I analyzed the PURs to find areas of training needs for the pest management industry. Results indicate that the Specific Areas Treated (spa) proved to be

largest area of concern. Overall 66% of pesticides used were pyrethroids and less than 1% of PUR's were in compliance.

My second project included developing a training tool for the eight steps of IPM. I incorporated eight steps that outline the process of IPM into a dichotomous key format for introducing practitioners to the concept of urban IPM. The key is intended to be a practical guide for instructors, property owners and practitioners interested in understanding and implementing the IPM process.

The third project included creating IPM lesson plans for Georgia schools. Focusing on the pesticide users of tomorrow, I developed eight kid-friendly activities that describe the foundational lessons needed to implement IPM, identify pests and reduce pesticides.

The fourth project involved development of an IPM plan for the Chattahoochee River National Recreational Area. Information from site inspections conducted in the park were compiled into a guide that can be used to implement IPM within the 14 land-units that make up the park management area.

INDEX WORDS: School; IPM, Integrated Pest Management; Pests; Regulation; Lesson Plans; Pesticides

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DEDICATION

I would like to dedicate this to my daughter Courtney Michelle Thomas.

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I would like to thank my major professor Brian Forschler for introducing me to the world of urban entomology. The places we have traveled and the people I have met along the way will stay with me forever! I would also like to thank my committee members Dr. Nancy Hinkle, and Dr. Paul Guillebeau for guiding me through this process. Your knowledge of Entomology continues to amaze me!

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CHAPTER 1

INTRODUCTION AND LITERATURE REVIEW

Pests and humans have interacted since the beginning of time, and in response to this, various pesticidal agents have been used to manage pests for centuries (Ebeling 1975, Flint and van den Bosch 1981, Bennett and Owens 1986, Robinson 1996b, Pedigo and Rice 2008). Sulfur was used by the Sumerians to manage mite pests as early as 2500 BC (Kogan and Prokopy 2003), and lead arsenate was used in the 1800s to manage Colorado potato beetle infestations and other agricultural pests (Metcalf 1994). In 1910, the Insecticide Act was created to protect farmers and users from pesticide misbranding, and in 1947 the Federal Insecticide Fungicide and Rodenticide Act (FIFRA) was developed to regulate pesticide registration (Lewis 1985).

In 1874, the chlorinated hydrocarbon dichloro-diphenyl-trichloroethane, also known as DDT, was synthesized (US EPA 2011). The insecticidal properties of DDT were not discovered and patented until 1939 by a Swiss chemist named Paul Mueller (US EPA 2011). Although originally intended to eradicate vector-borne diseases such as typhus and malaria during and after World War II (Pedigo and Rice 2008), the quick kill of arthropods made this chemical very desirable to practitioners (Wright *et al.* 1972, Ebeling 1975, Luck *et al*. 1977). These pesticides increased crop yield and saved millions from insect-vectored diseases such as malaria, Chagas disease, and typhus (Wright *et al.* 1972, Ebeling 1975, Pedigo and Rice 2008).

Continued resistance stemming from excessive use of DDT and other pesticides (CPEAP 1980) caused some scientists (Stern *et al*. 1959) and practitioners (Owens 1986) to express concerns (van den Bosch and Hintz 1973, US EPA 1975). Faced with insecticide resistance and non-target effects on wildlife and humans, farmers, scientists and pest management professionals began to question the excessive use of DDT and other chlorinated hydrocarbons (van den Bosch and Hintz 1973, Ebeling 1975, Pedigo and Rice 2008).

In 1959, Stern *et al.* published a paper addressing the issues of insecticide resistance, pesticide residuals and economic injury levels in agricultural crops. In an article describing what earlier authors (Hoskins *et al.* 1939, Michelbacher and Bacon 1952, Smith and Hagen 1959) termed "Integrated Control", known today as Integrated Pest Management (IPM), Stern *et al.* (1959) defined integrated control as "applied pest control which combines and integrates biological and chemical control" (Stern *et al.* 1959). This seminal paper would be the beginning of a movement towards combining pesticides with earlier strategies that were used before the introduction of pesticides, to manage pests.

Fueled by non-target effects on wildlife and other environmental concerns, Rachel Carson published a book entitled Silent Spring (Carson 1962). Carson's book increased public awareness of pesticides and the need to reduce pesticide use due to their environmental persistence and potential to infiltrate the food web (Carson 1962, US EPA 2010). It has been argued that this book influenced policy makers, resulting in the formation of the Environmental Protection Agency (EPA) in 1970, which banned the use of DDT in 1972 (Ebeling 1975, US

EPA 1975, Lewis 1985, US EPA 2010b). In 1972, President Nixon addressed the US Congress, urging the agricultural community to adopt Integrated Pest Management (Gray *et al.* 2009), and later that year the Council on Environmental Quality (CEQ) published a report entitled *Integrated Pest Management,* and thus the term IPM was established (CEQ 1972).

Federal agencies were advised, in a later Presidential Memorandum, to "support and adopt IPM practices wherever possible" (Carter 1979). Environmental awareness increased the implementation of IPM by the pest management industry, extension, farmers, researchers, government and the public (Feldman and Lewis 1995, Benbrook *et al.* 1996, US EPA 2010b). However, it was not until 1996, when the Food Quality Protection Act (FQPA) was passed that federal agencies were mandated to implement IPM (Greene and Breisch 2002, US EPA 2010b).

IPM

Since 1972, agencies, researchers and practitioners have developed their own definitions of IPM (Kogan 1998, Bajwa and Kogan 2002). The Environmental Protection Agency defined IPM as "the coordinated use of pest and environmental information with available pest control methods to prevent unacceptable levels of pest damage by the most economical means and with the least possible hazard to people, property, and the environment" (US EPA 2010a).

Implementing urban IPM involves a process usually described as steps that are implemented by the practitioner. The steps vary in order and applicability and can range from 1 to 9 or more, depending on the authors' assessment of the pest treated (Bennett *et al.* 1988, Olkowski *et al.*1991, Robinson 1996a, US EPA 2010a). The AIL or Aesthetic Injury Level, a term defined as the clients' tolerance level of a single pest (Robinson and Zungoli 1995), for

example, it can range from 0 to 1 cockroaches for one client or more than 3 cockroaches for another (Wood *et al.* 1981). Descriptions of the urban IPM process usually list steps that include educating the client through an information transfer process (Frankie *et al*. 1986); identification of the pest (Mallis 2004, Kells 2009); inspection (Kramer 2004, AFPMB 2009); developing and enacting action plans (Kramer 2004); establishing the AIL (Frankie et al. 1986, Robinson 1996b, Kramer 2004, Kells 2009); and monitoring/evaluations (Ball 1987, Granovsky 1997, Kells 2009, Frankie *et al.* 1986).

Studies have shown that IPM can be more efficient and successful than conventional pest control (Greene and Breisch 2002, Williams *et al.* 2005, Gouge *et al*. 2006). The overall goal of urban IPM is to reduce pests while avoiding excessive and ineffective pesticide use (Ebeling 1975, Robinson and Zungoli 1995, Granovsky 1997, Kells 2009). However, if an IPM program is not successful the client and practitioner may lose interest, reject the strategy and return to previous control methods (Robinson 1996a, Kells 2009). IPM is a decision-making process; therefore, practitioners should have the training to identify issues relative to potential impediments to successful implementation (Ebeling 1975, Frankie *et al.* 1986, Robinson 1996a, Kramer 2004, Pedigo and Rice 2008).

Structural IPM

Structural IPM as defined by the Georgia Department of Agriculture (GDA) is "a philosophy of pest management outlining a decision-making process aimed at achieving sustainable reductions in pest populations and their potential for growth. Successful IPM programs incorporate judicious application of control methods including, but not limited to, sanitation, habitat modification, exclusion, repellents and pesticides" (GSPCC 2009). In addition,

the “structural space” as defined by RGSPCA (2005) is defined as any area indoors and adjacent outside areas.

Structural IPM has developed into an area of concern within the last 25 years due to the number of pesticides used in and around the structural space (Sawyer and Casagrande 1982, Ebeling 1995, Pedigo and Rice 2008) and the increase in urban populations (Robinson 1996b). Individual States, such as Florida in 1992, California in 2008 and Georgia in 2009, chose to include a definition of IPM in the urban – not agricultural - habitat within their statutes or laws (SCDPR 2008; GSPCC 2009; Oi, personal communication, 2011).

Implementing structural IPM is complex due to the varied sensitivity of the urban clientele. The structural space can be spiritual, personal, public and sometimes emotional (Byrne *et al.* 1984, Robinson 1996b). People spend roughly 90% of their lives in this space, and when pests move into these areas tolerance levels can be low (Robinson 1996b). The urban habitat is an area that can be an assemblage of many different pest ecosystems (Racke 1993, Ebeling 1995, Robinson 1996a), consisting of the surrounding landscape, ornamental plants, gardens, or structural components (Racke 1993). These structures contain microhabitats (under sinks, in between walls, etc.) that are almost entirely predator/competition free, providing favorable conditions for pests to become established (Frankie and Ehler 1978, Robinson 1996b). Strategies to remove pests, such as German cockroaches, have relied on thresholds or AILs set by the inhabitant or specific target audiences such as hospitals, nursing homes, food-service environments, and schools (Robinson and Zungoli 1995). Studies have proven that educating clients about IPM principles, pest biology and pesticides reduced client requests/need for

repeated pesticide interventions (Klinnert *et al*. 2005, Krieger *et al*. 2005, McConnell *et al*. 2005, Kass *et al.* 2009).

Training in Structural IPM

In its genesis, training in urban IPM primarily focused on ornamental and turf-grass pests (Ebeling 1975, Hellman *et al.* 1982). Training in structural IPM, as stated by Kells (2009), "is often underestimated, underutilized or completely ignored". The federal guidelines listed under FIFRA for pest control license and continuing education credits, require practitioners to maintain a license. Training of practitioners is administered by the states with the majority of training available from industry (product training, conferences etc.) and academic (college courses, extension) personnel. Pest control operators, in the past commonly entered the business with little if any training (Frankie *et al.*1986). Today, pest control companies may provide formal training; however, this is at a cost that is too expensive for smaller companies and is commonly supplemented by "on the job" training (Kells 2009).

Texts (Ebeling 1975, Mallis 2004, Radcliff *et al.* 2009) are available for instruction on pest identification and intervention tactics, but few actually *teach* the mindset required to implement the IPM process. This mindset includes understanding pest biology and site specifics. Several venues attempt to bridge that gap and groups such as the National Pest Management Association, state pest control associations and technical directors employed by the pest control companies, and Extension, all provide training information with the intent of reaching the practitioner. If structural IPM trainings are to be effective, pest control operators must communicate their needs to the educators, and educators in return should develop trainings that

are applicable to the real world, economically feasible and appropriate to the client (Frankie *et al.* 1986).

School IPM

Facilities, such as daycare centers and schools, are the current "proving ground" for the formalized implementation of urban IPM (NRC 1993, Bearer 1995, Rambo 1999, US EPA 2002). Administrators have little tolerance for pest infestations and, because students spend 80% of their time indoors, the goal is to reduce exposure to pesticides, pests, and diseases, such as asthma, associated with pests through the use of IPM (Rambo 1999, US EPA 2010, Owens 2009). Not only do children risk pesticide exposure inside, outside exposure in turf grasses and playgrounds has also been of concern (Arkin 2008). Attempts to establish federal laws such as the School Environment Protection Act (SEPA) have not been successful (Owens 2009). However, state laws pertaining to pesticide use can be more restrictive than federal restrictions, so, 35 states have adopted laws that restrict pesticide use in schools, with 21 of those states requiring or recommending schools to adopt IPM (Owens 2009). Georgia is listed as a state that has laws restricting pesticide use in schools (Owens 2009, GSPCC 2005).

School IPM Curricula

Establishing IPM curricula in Georgia begins with following the Georgia Performance Standards in Science (GPSS) and approval by the school administrator (NRC 2000, Barab and Leuhmann 2003, GPSS 2010). The Georgia Performance Standards in Science (GPSS) requires that students reach certain "Bench Marks" outlined for each grade level (GPSS 2010). In response to the need of entomological and IPM education in Georgia, IPM lessons for grades K-

12 should cover identification, pests biology, recognition of IPM vocabulary, and inquiry-based learning that addresses the IPM process.

Dissertation Objectives:

1). Develop a training tool for instructors and practitioners illustrative of the flow of the thought process inherent in the IPM philosophy.

2). Identify areas of training needs for Georgia pest management professionals through analysis of GDA pesticide use records.

3). Develop IPM lesson plans for grades K-12 in Georgia schools.

4).Develop an IPM plan for the Chattahoochee River National Recreational Area.

CHAPTER 2

Dichotomous Key for the eight steps of Urban IPM

The eight steps of urban IPM are introduced in a dichotomous key design that can be used by practitioners and instructors interested in understanding and implementing the IPM process. This key highlights the flow of the IPM process and methodology required to implement IPM.

CHAPTER 3

Analysis of Pesticide Use Records in Georgia Schools

Pesticide use records (PURs) collected by the GDA from schools from April 2007 and April 2009, were sorted and analyzed with the goal of identifying potential areas for training pest management professionals. Out of twelve categories, the specific areas treated category was

identified as an area of potential training. These results will aid regulatory officials and pest management professionals toward the goal of improving pest management in Georgia schools.

CHAPTER 4

Urban IPM lesson plans for Georgia schools

Georgia standards currently require agricultural IPM as a teaching component (GPSS 2010). However, urban IPM is not addressed in the Georgia standards. Due to the unavailability and need of urban IPM curricula for teachers, eight lesson plans were developed for grades K-12 in Georgia. These lesson plans were designed to introduce students and teachers to pest biology, pesticides and the process of urban IPM.

CHAPTER 5

Integrated Pest Management Plan for the Chattahoochee River National Recreational Area (CRNRA)

An IPM plan for the CRNRA was developed as a response to federal mandates advising all national parks to implement IPM whenever possible (Carter 1979). This plan outlines information specific to CRNRA that is essential to implementation of an IPM program.

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CHAPTER 2

DICOTOMOUS KEY FOR THE EIGHT STEPS OF URBAN INTEGRATED PEST MANAGEMENT (IPM)[1]

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Dichotomous Key for the Eight Steps of Urban Integrated Pest Management (IPM)

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Abstract

IPM is a site-specific decision-making process supported by record keeping that is aimed at sustainable reductions in pest sightings. We describe eight steps; identification, inspection, communication, action plan development, action plan implementation, action plan monitoring, action plan revision, and continued monitoring that illustrate the main components of the process of IPM and incorporate them into a dichotomous key. The key is intended to illustrate the flow of the thought process involved in IPM decision-making and is aimed at introducing instructors, property owners and practitioners to the philosophy of urban pest management.

Keywords: Urban IPM, Dichotomous Key, Pest Management

2.1 Introduction

The practice of Integrated Pest Management (IPM) has its genesis in agricultural entomology (Hoskins *et al.* 1939, Stern *et al.* 1959, Jones 1973, Smith 1973, Ebeling 1975, Flint and van den Bosch 1981, Kogan 1998, Pedigo and Rice 2008, Gray *et al*. 2009). The discipline of IPM in the urban habitat has been discussed and defined by various authors in the past 20 years (Kramer 2004, Ehler 2006, US EPA 2010). Practical implementation of structural IPM has been slower, as indicated by only three states having defined IPM for their structural clientele; the Florida Department of Agriculture (FDA) in 1992, California Department of Agriculture in 2008 and the Georgia Department of Agriculture (GDA) in 2009 (F. Oi, Personal Communication, SCDPR 2008, GSPCC 2009). Despite decades of academic discussions, urban pest management practitioners often utilize the same tactic(s) to remove a pest whether the site is a hospital, school or household due to implied or real client urgency (Robinson and Zungoli 1995, Ingram *et al.* 2008). Clientele insistence on a 'quick-fix' to pest issues often results in the use of broad-spectrum pesticides. The quick-fix approach forces practitioners to address symptoms (pest sightings) and not the underlying issues (site conditions related to pest population holding capacity) linked to the problem (Ehler 2006). The bankruptcy of such an approach is highlighted by the phenomenon of pesticide resistance (Stern *et al.*1959, Barfield and Swisher 1994, Romero *et al.* 2007).

School IPM, an important area of interest, has focused on training school administrators, industry and other interested parties simultaneously to reduce pests and pesticide use in schools (IPM Institute 2011, US EPA 2010). IPM implementation has been slow due to the inability of school districts to grasp the IPM philosophy (Lame 2005). This is true not only for schools but

for other urban areas. The IPM process is commonly introduced in training manuals (Koehler and Kern 1994, Corrigan *et al.* 1997, EcoWise 2007) that provide the trainee with the foundational knowledge needed to fully implement IPM. IPM training websites (IPM Institute 2004, NPMA 2009, AFPMB 2009, US EPA 2010) and peer-reviewed literature assume the practitioner is well versed in the concept of urban IPM and does not need guidance on the mindset or process. As described by Greene and Breisch (2002), the academic or methodological approach to evaluating pest interventions considers IPM a set of "principles, practices, and procedures applied to the task of pest control". The majority of training guides, (Bennett *et al.* 2010, Hedges 1998, Kramer 2004) were developed by authors with research or extension backgrounds well grounded in the methodological approach. However, this pest-centric methodology does not factor in the practical or ideological perspective (Greene and Breisch 2002). In an effort to highlight the flow-of-thought involved in implementing urban IPM we present a tool, in the form of a dichotomous key, to address practical components of the IPM process to assist the practitioner in understanding the mindset required to solve a pest problem.

Process of Integrated Pest Management

In 2007, the GDA began inspections of pesticide use records in Georgia schools (Harron 2009). Our involvement in analyzing the pesticide use record violations associated with those GDA inspections, along with the United States Environmental Protection Agency's (US EPA) initiative on "verifiable IPM" (Matthews 2011) encouraged us to look at new approaches to training.

Wearing (1998) stated, over 14 years ago that the thought processes involved in implementing IPM are not often addressed in the scientific literature. That condition holds true today as instruction (Bennett and Owens 1986, Pedigo and Rice 2008) in urban IPM continues to focus on a single pest or a particular site with no overview aimed at instructing the neophyte practitioner on the flow of thought required to implement IPM. Ten years after Wearing's (1998) comments, Rosenheim and Coll (2008) stated, "the process-centric approach in agricultural entomology promotes a broader sharing of insights across different systems" with the goal of identifying "underlying issues" surrounding a pest problem. In the urban habitat, addressing the "underlying issues" (balancing the risks associated with pests as well as those associated with pesticide use) through stakeholder/Pest Management Professional (PMP) communication should be a focal point of IPM that begins with the recognition that the "quick-fix" approach is but one choice within the toolbox of possible interventions. Descriptions on how to conduct IPM are, by necessity, outlined as a series of three or more "steps" most often in association with a particular pest (Olkowski *et al.*1991, Robinson 1996, Bennett *et al.* 2010, US EPA 2010). The steps usually mention the importance of pest identification, inspection, education, and monitoring (Frankie *et al.* 1986, Granovsky 1997, Kramer 2004,).

Our goal was to develop a stepwise tool that can be used in or out of a classroom as a guide for practitioners to assist in understanding the flow and mindset involved in conducting IPM independent of the context of the pest or urban habitat.

We chose to define IPM, for the urban habitat, in a broad sense to accommodate the variety of potential pest scenarios and emphasize the site-specific nature of action thresholds. We define, for the purposes of this discussion, IPM as a biology-centric, site-specific decision-

making process that includes accountability (record-keeping and communication) for planning and implementing interventions aimed at a sustainable reduction in pest damage. The emphasis is on proper identification and knowledge of pest biology that are matched with the unique features of the infested area to develop a set of interventions. IPM is therefore a process founded in a thorough inspection, supported by knowledge of pest biology. Recommendations are made for biological, ecological and economically justifiable interventions that start with attempts to reduce sources of food, water and harborage for pests. Pesticides are used in a like-minded knowledge-based approach aimed at reducing non-target impacts as part of an ongoing program. Communication between the practitioner who conducts the inspection, identifies the pest, develops and enacts an action plan and the building/property owners/managers is essential to the success of any IPM program. The practitioner must understand the mindset of the knowledge-based portion to effectively communicate the essential elements of an action plan before implementation because urban IPM action plans generally involve interventions enabled by the property occupants/managers. The IPM 'way of thinking' is aimed at problem solving through investigation of clues and piecing those 'data' into a coherent (and from the IPM perspective – biologically relevant) scenario not unlike crime scene investigation, solving a crossword puzzle, or psychoanalysis. The IPM dichotomous key presented in this manuscript was developed to assist in reinforcing the practitioner thought processes to illustrate the logical flow from one component to the next… and perhaps back again.

2.2 Introduction to the Eight Steps of Urban IPM

The eight steps of IPM used in the dichotomous key are: (1) Identification, (2) Inspection, (3) Communication, (4) Action Plan Development, (5) Action Plan Implementation, (6) Action Plan Monitoring, (7) Action Plan Revision, and (8) Continued Monitoring. The steps are provided as an outline and not intended to be a strict, linear procedure to be followed in sequence. For example, the first two steps, identification and inspection, are not necessarily in sequence because an inspection can and should identify pests found during that part of the process but in certain instances a pest sighting provokes an inspection. It is important for the instructor and practitioner to recognize that the practice of urban IPM involves a way of thinking or mindset toward conducting a knowledge-based process of gathering information to integrate into a site-specific action plan involving interventions aimed at mitigating a pest-related issue. A brief explanation of the importance of each step follows as an instructional guide to using the key.

Step One: Identification.

All texts on urban IPM discuss the importance of proper pest identification (Frankie *et al.*1986, Kramer 2004, VanRychkeghem 2004). The level of pest identification required, whether to order, family or species, depends on the pest and the situation, but this step is the basis of the biological knowledge portion of the IPM process. Identification affords the practitioner access to the body of knowledge on a particular pest to narrow the focus of an inspection and identify areas amenable to potential site-specific interventions.

Step Two: Inspection

Inspection is the foundation of any urban IPM program and an integral part of the communication/educational component. Numerous publications (Kramer 2004, Smith and Whitman 2007) have addressed the details and equipment required to conduct an IPM inspection which is beyond the scope of this presentation but important to the training required for any practitioner.

Step Three: Communication

The facts surrounding implementation of each step of the IPM process are recorded and reported to the appropriate stakeholders. Stakeholders would include business owners, residents or groups of people that hold an interest in site operations (Kramer 2004). A report should be generated that would include inspection findings, pest identification, action plan details (because plans might involve multiple participants) and what, when, and where interventions were conducted/concluded/attempted (Frankie *et al*. 1986). The report should include referenced illustrations (diagrams, photographs) that are updated after each site visit (Kramer 2004) and information explaining the IPM process as well as the biology, and habitats of the pest(s) (Robinson and Zungoli 1995). Operational report forms can be developed to individualize the process, but they should provide leeway for listing the site-specific information that must be collected on each visit, thereby establishing a running record of visits, interventions and all communication with stakeholders. Proper record-keeping is an essential part of the communication required for IPM to be effective (Wearing 1998).

Step Four: Action Plan Development

The information gathered during the inspection combined with knowledge on pest biology and site conditions afforded by the local landscape and construction to formulate interventions appropriate for the situation. The literature (Hedges 1998, Kramer 2004, Smith and Whitman 2007) provides ample guidance on the ever-changing set of pest management interventions available to the IPM practitioner. Interventions should be identified in an order ranging from no action to biologically relevant sanitation and habitat modification schemes — not normally the purview of the PMP – to employment of pesticides (Robinson and Zungoli 1995, US EPA 2010).

Step Five: Action Plan Implementation

Enact the action plan while paying attention to the details of proper preparation, application, and maintenance of each intervention. The facts surrounding implementation of an intervention should be recorded for future reference and communicated with all involved stakeholders.

Step Six: Action Plan Monitoring

Selection of the most appropriate monitoring program for a particular pest and stakeholder is a critical component of any IPM program (Greene and Breisch 2002). The variety of options available to the practitioner range from elaborate schemes aimed at recording insect numbers to simple reports of sighting by building inhabitants (Owens 1995, Kramer 2004). The choice of monitoring program will vary by pest, stakeholder (because of the wide variance in pest tolerance) and site. Successful IPM programs use a monitoring program tailored – as are interventions – to the situation.

Step Seven: Action Plan Revision

Results from the monitoring program are reviewed, at some point, and the original action plan evaluated and revised as required to affect the overall goal of pest population management. This step highlights the fluid, changeable aspect of the IPM philosophy.

Step Eight: Continued Monitoring

This last step illustrates the ongoing permanence of the IPM process and the need for communication.

2.3. Dichotomous Key for the 8 Steps of Urban IPM

1. **Identify the pest--**The first step in pest management is to properly identify the pest.

   1a. *When the pest is properly identified, proceed to step*……..…….....3a
   1b. *If pest previously identified and biology and site history known proceed to step* ……2

2. **Inspection--**Identifying those unique biological, ecological and environmental factors for a particular pest that are present at a particular site (where the pest was sighted) is the first step in developing a sustainable action plan and must be the focus of any inspection.

   2a. *Following an inspection and identification of site features conducive to target pests proceed to step*…..……..…….....…..…..…3b
   2b. *If an inspection reveals a new pest return to step* ……..……...…….. 1

3. **Communication--** Collection and distribution of relevant information to stakeholders (clients, maintenance workers, management etc) is essential to the urban IPM process. Communication includes development of and updating a report that identifies site-specific concerns addressed by any action plan. Informing stakeholders throughout the process is essential.

   3a. **Develop identification report**. *Following identification of pest(s) a report must be generated and presented to stakeholders, proceed to step*……..……..…..…2
   3b. **Develop inspection report**. *Site inspection findings must be included in a report and presented to stakeholders. Once inspections are reported, proceed to step*……..…..…….. 4
   3c. ***Action plan dissemination*** *–The action plan developed from the identification and inspection reports must be presented to stakeholders. Once completed, proceed to step* ……..……..… 5
   3d. ***Action plan implementation report*** *– Once an intervention is implemented a report is disseminated to stakeholders, proceed to step*……..……..……6
   3e. Development of a pest population-monitoring schedule -*Once a monitoring program is developed, agreed to and presented to stakeholders, proceed to step*…….……..…..…6b

4. **Action Plan Development--**If a pre-determined threshold is exceeded, pest biology should determine the when, how, and type of intervention(s) needed to manage a pest population given the site specifics identified during the inspection.

   4a. *When a final action plan is developed, proceed to step*……..……3c

5. **Action Plan Implementation**--The action plan is implemented by conducting appropriate, agreed to interventions given the known facts according to site specifics (described in the inspection report) and pest biology (as reported in the Action Plan). Interventions can involve the actions/cooperation of several stakeholders at any given site.

5a. *Once the action plan is implemented, proceed to step*…..…..3d
5b. *If no action is taken (no interventions conducted) this is noted in the records, proceed to step*…….……..…6

6. **Action Plan Monitoring**--Appropriate monitoring techniques will vary for each pest. Techniques include (but are not limited to) sticky traps, seasonal surveys, visual inspections, and pest complaint logs. Communication between appropriate personnel/departments is a key component of any monitoring program.

6a. *Once an appropriate monitoring program is identified, proceed to step*……..3e
6b. *The monitoring program is enacted and if a predetermined threshold is reached, proceed to step* …….……....…….....7
6c. *The monitoring program is enacted and if data are below predetermined threshold, proceed to step* …….……....……...8

7. **Action Plan Revision**--Data from the monitoring program and observations from site visits indicating a change in conditions will determine if modifications to the original action plan are needed to manage pests.

7a. *If the current action plan is not effective a revision should proceed only after another inspection aimed at identifying site specifics relative to new pests or conditions. If revision is needed return to step*…….....…….…..…..2

8. **Continue Monitoring**--Monitoring is an exercise in communication and record-keeping involving all stakeholders. Appropriate monitoring includes reporting and recording pest sightings or building/landscape changes that may require additional inspection.

8a. *If action thresholds are not exceeded* …….…….....Continue Monitoring
8b. *If a new pest is identified during the monitoring program, return to step...*……..….1
8c. *If pest populations increase, or site conditions change, return to step*…….……..…….2

2.4 Discussion

Urban IPM is a knowledge-based, site-specific process that is difficult to explain in a single, simple one-size-fits-all lesson plan (Tucker 1997). The training literature (Norton and Mumford 1993, Koehler and Kern 1994, Bennett *et al*. 2010, US EPA 2010) typically recites a pest-centric list of relevant biological attributes followed by another list of appropriate interventions. This approach fails to explain the pragmatic flow of the mindset required to conduct the IPM process which can leave practitioners confused on how and when to implement an 'IPM service' (Kells 2009).

The dichotomous key presented in this manuscript is designed to be an introduction to the flow of the IPM mindset and intended as a training tool for practitioners toward practicing the process. It outlines a series of eight steps, but it should be remembered that these do not have to be followed in any particular sequence in every pest-related situation. Managing a pest problem is often not as straightforward as following a series of steps and the dichotomous key is intended to illustrate the logical flow of information from the practitioner to client based on the variety of site-specifics involved in urban pest management. The dichotomous key represents a practical adjunct to the available body of knowledge on urban IPM and is intended to introduce practitioners to the logical stepwise progression inherent to the process.

2.5 Acknowledgements

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CHAPTER 3

ASSESSMENT OF PESTICIE USE RECORD VIOLATIONS IN PUBLIC SCHOLS ISSUED TO PEST CONTROL OPERATORS BY THE GEORGIA DEPARTMENT OF AGRICULTURE

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Abstract

In 2007, Georgia Department of Agriculture Regulatory Field Agents, began auditing pesticide use records (PURs) from pest control companies servicing schools. Pest control companies not in compliance with the Rules of the Georgia Structural Pest Control Act (RGSPCA) were issued citations. We reviewed 1,926 PURs sequestered between April 2007 and April 2009 that involved 58 different companies. Twelve categories were evaluated including time in and time out during service, method of application, amount and percent of chemical used, specific areas treated, possible label violations, posting and re-entry violations, targeted pest, type of chemical applied, school or company altered PURs and no name/address. The majority (63%) of violations were attributed to 10 technicians and over half of the violations were issued to four of the 58 companies. Less than 1% of the PURs analyzed were in complete compliance. Ants and cockroaches were the insect pests most often listed as the targets for pesticide applications. Pyrethroid-based pesticides were used in over 66% of the records, with 'Borax' a distant second. Results of our analysis are discussed in relation to IPM implementation and lessons learned for regulators, the pest management community, and school boards.

Key Words: Pest Control, Regulatory, Schools, Integrated Pest Management, IPM, Pesticides

3.1 Introduction

Children's exposure to pesticides in public areas, particularly schools, has been a topic of concern for over 20 years (Bearer 1990; USGAO 1999; Fenske *et al.* 2000). Implementation of Integrated Pest Management (IPM) programs coupled with regulations aimed at decreasing pesticide use in schools are believed to be important in reducing risk of pesticide exposure to children (Owens 2010). Currently there is no unified federal policy or mandate for IPM in schools in the United States. Sixteen states, Massachusetts, New Jersey, Maryland, Texas, Pennsylvania, Illinois, Indiana, Kentucky, Louisiana, Maine, New York, North Carolina, Florida, Michigan, Minnesota, and West Virginia require or volunteer implementation of IPM in schools and 21 states recommend the adoption of IPM (Owens 2010).

In 2007, the Georgia Department of Agriculture (GDA) directed field agents to begin inspections of daycare facilities as well as primary and secondary schools to assess compliance with local, state and federal regulations (Harron 2009). These inspections were prompted by an incident of non-compliance in a Georgia school that resulted in fines of $96,000 (USD) and revocation of the company and certified operator licenses (Harron 2009). In response, the Georgia Structural Pest Control Commission (GSPCC) amended the Rules of Georgia Structural Pest Control Act to include chapter 620-7-.03 entitled "Treatment of Schools" (Harron 2009). Georgia Department of Agriculture school PUR inspections were announced in 2007 with a latency period giving pest control companies time to organize their PUR records and self-report violations to allow Designated Certified Operators (DCOs) to avoid penalties and maintain compliance with the rules (Harron 2009).

Rules of the Georgia Structural Pest Control Act (RGSPCA): DCO, as defined by the RGSPCA (2005), refers to the "person who is currently certified in one or more of the Structural Pest Control categories and who has been designated by a licensee as being responsible for the pest control and reporting activities of said licensee in the category(ies) in which he is certified." Certified operators are practitioners that are certified in a chosen area of pest control and are deemed "competent" in that pest control category (RGSPCA 2005). Pest control actions taken on school grounds must be in compliance with the section labeled "Treatment of Schools" (chapter 620-7-.03) (RGSPCA 2005). A requirement of 620-7-0.3 includes leaving a 'service ticket' or PUR at the school and a copy in the company records. Pesticide Use Records (PUR) provide information on pesticide use and includes attention to any precautions required attendant with said use. The RGSPCA (chapter 620-3-.02) requires that all DCOs and certified operators keep true and accurate PURs for two years, and upon request these should be made available for GDA review (RGSPCA 2005).

This research project reviewed PURs collected by GDA field agents, with the aim of organizing the data to examine industry practices in Georgia schools. There were two objectives for this study. First was to identify trends in PUR violations that could be targeted to develop training resources toward improving pest management practices in schools. The second objective was to illustrate pest management practices in Georgia schools as indicated by the records kept by pest management professionals.

3.2 Materials and Methods

The GDA headquarters is located in Atlanta, Georgia. The Structural Pest Control Section (SPCS) licenses and regulates Georgia's pest management professionals as a section within the Plant Industry Division of the GDA. The SPCS included one director, two agricultural managers, and field agents serving nineteen (19) districts with one field agent assigned to each district (Figure 3.0). At the time of our survey, three districts (6, 16, 19) did not have an assigned field agent and district 15 did not contain any PURs available for review (Figure 3.0). However field agents did inspect PURs from neighboring districts

In 2007, GDA field agents began requesting PURs from individual schools and the pest management company under contract with each school as part of a protocol to examine compliance with RGSPCA section 620-7-.03. The "Code Sheet for School Violations" was developed from the RGSPCA and used by each field agent when evaluating PUR's(Table 3.0 and 3.1).The GDA categorized violations as "minor" or "significant" before issuing fines or revoking licensure (Harron 2009)

Violations survey-- PURs examined for this study were dated between April 1, 2007 and April 31, 2009. There was no standardized PUR format, therefore each PUR was unique to each pest control company. This lack of consistency required repeated identification of categories between companies/PURs while organizing the data during the review process. All PURs were kept on file at the GDA Atlanta headquarters as paper copies, which required examination of each hard copy prior to data entry into a spreadsheet. The city of the servicing company, company registration number, technician initials and GDA district were recorded from each PUR to serve as identification during analysis. The length of time each technician spent

servicing a school along with the chemical (Chem) used during application and the target pest (Listed Pest) were also recorded. Twelve violation categories were selected from the code sheet (Table 3.0 and 3.1). Those categories were Time (T); No or Inadequate Percent (INAD); No or Inadequate Amount (AMT) of pesticide; Specific Areas Treated (SPA); Target Pest (TP); Tickets Altered (TA); Method of application (M); Possible Re-entry Violation (PRV1); Precautionary Violation (PRV2); Post re-entry violation (PRV3); Possible Label Violations (PLV), and No Name and address violations (MISC) (Table 3.0 and 3.1). The data were entered into an Excel file with categories tabulated as either "V" for violation or "N" for no violation. Violations were later separated by small (1-5 technicians), medium (6-11 technicians) and large (11+ technicians) companies.

Data Analysis – The categorical data was analyzed using Excel 2007 and Sigma Plot for Windows® 11.0 (descriptive statistics). Correlations between categories were analyzed using Sigma Plot 11.0 (one way analysis of variance) ANOVA, and Linear Regressions (Excel 2007, Sigma Plot 2008). Significance within categories (Company or Technician) were analyzed using Sigma Plot 11.0 (One-Sample t-test) (Sigma Plot 2008) at the $P < 0.050$ level of significance.

Self-Reporting – Pest control companies were encouraged to self-report violations to the RGSPCA (620-7-.03) in accordance with the EPA "Incentives for Self Policing" established in 1995 (US EPA 2009). Companies that self-reported were offered the chance to correct violations that might have otherwise resulted in penalties (GSPCC 2010b). The process involved PMPs delivering PURs to GDA for review. The GDA followed three steps when assessing self-reported PURs: discovery, correction or prevention, and disclosure. During the discovery phase the PMPs

reviewed their records including service records, inspection records and contracts. If a problem was discovered during the discovery phase by the PMP they were required to take immediate corrective and preventive action. All discovered issues were referred to the GDA and a meeting scheduled to discuss compliance. The agricultural manager worked with the designated certified operator (DCO) through the disclosure process to prevent further violations and to correct existing problems (GSPCC 2010b) before issuing a warning letter stating a date for full compliance with the rules (Harron 2009).

3.3 Results

Self-Reporting-- When self-reporting began in 2007, 125 companies reported, with the highest monthly count (28) occurring in July (Figure 3.1). January, February and March of 2008 received the highest (45) number of self-reporting audits, with no reports in May, August, November and December (Figure 3.2). The information from the self-reporting process was not included in the analysis of violations data because the PURs involved in that process were not made available for data entry although we assume the type and frequency of violations was reflected in the PUR's examined for this study.

Violations-- From April 2007 to April 2009, GDA issued 9,011 PUR violations, to 58 companies and 72 technicians. Over half (55%) of the 9,011 violations were attributable to four (4) companies, and these companies received over 10 violations per PUR, with a maximum of 12 violations on one PUR (Figure 3.3). There was an average of 4.61 companies per district and an average of 4 technicians per district. Districts one 1and 13 provided 34.5% of the PURs

contained in our data set (Figure 3.4). Examination of the data by GDA district showed that districts 1, 13, and 16 provided the highest numbers of PURs. Districts 1, 13 and 16 also provided the highest percentage of the violations per PUR (19.6%, 17.5%, and 16.6 %, respectively). Districts 17, 18 and 7 provided the lowest percentages of violations per PUR (1.0%, 1.2%, and 1.2% respectively).

Examination of the data by violation category showed that the target pest and tickets altered categories had the lowest numbers of violations, 321 and 219 respectively (Figure 3.5). The highest number (1,508) of violations occurred in the specific areas treated category, which was not in compliance on 21% of the PURs (Figure 3.5). The remaining nine categories beginning with time, method, and possible label violations received 715, 867 and 841 violations, respectively. The amount, possible re-entry violations, and percent inadequate received 505, 830, and 947 violations while the no name/address category, 3 hour posting violation and the precautionary violation provided 892, 631 and 735, violations respectively (Figure 3.5).

Twenty-five percent of the 58 companies in the data set received 20 or fewer violations per company, and 55.3% of the companies received fewer than 200 violations (Figure 3.3). Seven Compared to the Georgia Pest Control Association company size demographics (Figure 3.7), there was no difference between the numbers of violations per company based on company size (Figure 3.6).

The number of violations per service technician ranged from 0 to 400, with over 50% of the technicians having fewer than 20 violations (N=36). The percentage of technicians that received 21 to 80 violations accounted for 33% (N=24) of the total number violations, while those receiving 81 to 400 violations accounted for 16% (N=12) (Figure 3.8). The time a

technician spent on site, as indicated by the PURs, at each school (Service time) averaged 34 (± 2.06 SEM) minutes per visit. There was no correlation between time spent on school property and number of violations received by that technician *(DF=1; P>=0.050).* Technicians with the lowest and highest numbers of violations spent an average of 28 minutes on school grounds (Figure 3.9).

Chemicals – The Insecticide Resistance Action Committee's (IRAC) chemical classification guidelines divides pesticides into chemical classes based on mode of action (IRAC 2006). We used the IRAC classification system to group pesticides (IRAC 2006). Seventy-five percent of the chemicals listed on PURs were appropriate as per label use instructions for the intended pest target. There were 64 brand names listed, with over 66% of the PURs identifying a pyrethroid- or borax-based pesticide (Figure 3.10). Over 60% of the pyrethroids were applied as liquid spray formulation (Figure 3.12). A sticky trap was listed on 36 (1.8%) of the 1,926 PURs and three PURs contained unknown active ingredients while189 PURs failed to list a pesticide (Figure 3.10). Indoxacarb and phenylpyrazoles constituted 9% of the pesticides listed, with insect growth regulators, hydramethylnon, pyrroles, avermectin, coumadin and organophosphates listed on less than 4% of the remaining records (Figure 3.10).

Pests: Figure 3.10 shows that 203 PURs failed to list the target pest. Cockroaches and ants were named as target pests on 1,564 (80%) and 1,215 (63%) of the PURs respectively (Figure 3.11). The remainder of the list in descending order, included spiders 23% (447), mice 9% (167), perimeter pests/occasional invaders 8% (145), rats 4% (72) and termites 1% (23) (Figure 3.11). Perimeter pests or occasional invaders are described as insects or arthropods such

as; centipedes, millipedes, scorpions, flies, crickets and silverfish that temporarily or occasionally enter structures (Hedges 2004).

3.4 Discussion

This study represents the first examination of pest management practices in schools as indicated by the PURs required by regulations in the United States. The findings have relevance for understanding the state of the art as practiced by pest management professionals in Georgia and provide lessons for anyone interested in pesticide use patterns in the urban habitat. The review of PURs indicated 99% of technicians committed one or more violations per PUR. This level of non-compliance with regulatory requirements signifies a lack of attention to the details of record keeping required by state and federal statutes.

Pesticide use records are a record of pesticides used during a service call represent one of the core principles of IPM (record keeping) that informs the client of all pesticides used during the service as well as precautions that must be taken as per label instructions or state regulations (RGSPCA 2005Kramer 2004, US EPA 2011). Our data showed that 68% of the violations stemmed from PMPs' lack of attention to the details of compliance with the record keeping requirements implicit with a PUR. Out of the 12 categories analyzed the specific areas treated contained the highest number and percent of violations within the entire data set 21% (1,508) (Figure 3.5). The significant violations comprised 32% of all violations issued by the GDA. These categories were; possible label violation, possible re-entry violations, tickets altered posting violation, precautionary statement violation, method, percent inadequate, and amount of chemical used (Table 3.1). Any violation received in the significant category was the result of

not following the label. The exception to this list was the tickets altered a category more focused on the moral obligation a DCO has to uphold when servicing schools.

Based on recent literature , or data review indicates that many PMPs in Georgia are not using IPM (Greene and Breisch 2002, Miller and Meek 2004) . When comparing the time each technician spent servicing schools in Georgia (34 min/visit) versus the time it takes to implement/maintain IPM (45 ± 3.2 min) and the time it takes to perform conventional pest control (71±30min at induction and 29±2.5 min for maintenance) (Williams *et al.* 2005), PMPs' use of IPM cannot be determined by the time data.

Greene and Breisch (2002) indicated that over the course of 11 years during the initial phase of IPM induction in federal buildings, chemicals mainly consisted of pyrethroids, organophosphates, carbamates and boric acid. Greene and Breisch (2002) stated that by 1999 these chemicals were reduced by over 97%, in part due to IPM. Our data show that PMPs are using high volumes of pyrethroid-based liquid formulations. The extensive use of pyrethroids is similar to the use of pyrethroids as reported in the induction phase of IPM by Greene and Breisch (2002).

Wang and Bennett (2006) found that when baits were used in conjunction with IPM principles to control cockroaches, not only were pests reduced by 97%, but pesticide applications were reduced as well. Literature states that the use of baits to control cockroaches is very effective Wang and Bennett (2006); however our data show that cockroaches and ants were the pests consistently listed on the PURs. If PMPs were performing IPM and educating clients about sanitation and exclusion we would have expected this number to be greatly reduced, as shown in

studies using IPM for cockroaches and ants (Green and Breisch 2002, Gouge *et al.* 2006, Wang and Bennett 2006, Nalyana *et al*. 2009).

The GDA, GPCA, researchers and industry professionals gathered in 2008 to address the school violations (Harron 2009). PMPs discussed their concerns about the most frequently violated categories. Identical to our findings, the specific areas treated was the main point of concern for PMPs. In response to this meeting, the GDA initiated several significant innovations that included a special seminar on IPM in schools that was filmed and the video posted on the GDA website as a training tool. In addition, the GSPCC endorsed a definition of IPM specifically for structural and household pest management and provided guidance documents on a standardized PUR format. The standardized PUR format addressed the area (specific areas treated) identified in our analysis as the most frequently violated category. The Georgia Pest Control Association, in 2010, developed a PUR format, accepted but not endorsed by the GDA, that adheres to the RGSPCA. These actions were aimed at providing congruence between regulatory oversight and industry understanding of record keeping requirements.

Analysis of the PUR data also provided insights into pest management practices employed by pest control companies in schools. The EPA defines IPM in schools as a program that uses common sense strategies to reduce sources of food, water and shelter for pests, including the judicious and careful use of pesticides when necessary along with the use of spot treatments instead of broad scale spraying (EPA 2011). Sixty-six percent of the PURs we examined listed use of pyrethroid pesticides that are typically applied as a liquid spray thus while only 24% listed pesticides generally formulated in baits (Figure 3.12).

Initially when we viewed the PURs, we believed that company operations were to blame for outstanding violations. This may be the case in smaller one-man operations, however in the majority of the companies analyzed a few ill-informed or bad technicians were the reason companies incurred these violations. The results also indicated that violations did not increase when service time decreased. Furthermore, the PURs did not list whether the technician was performing a routine visit or what they list as a callback. Callbacks can increase or decrease average service time at a school depending on the nature of the pest problem. Callbacks occur when a client requests a retreatment for an existing pest problem.

The GDA developed self-reporting as a way to help pest control companies resolve noncompliance mistakes or issues with few or no penalties (Harron 2009). This rule allowed many companies to come into compliance without the threat of an investigation; however only 125 out of the 1,032 registered companies self-reported in 2007 and 2008.

Lastly, our data shows that Georgia PMPs are not in line with EPA's definition of verifiable IPM. According to Lame (2005), few school districts understand the IPM philosophy and know how to implement IPM into their schools. Adding to this our data suggests that PMPs are far from implementing IPM in schools in Georgia. There are a few monitoring devices in place, as our data show that 10% (6) of companies used glue boards often paired with baseboard spraying. These data demonstrate the importance of proper training and education. Simple mistakes such as not listing the client address or filling out the PUR improperly have contributed to 68% of violations. Emphases on where the pesticides are placed (*specific areas treated*) and how they are used (*possible label violations*) are areas for future training. In a recent survey of 180 school districts in Georgia with a 93% (168) response rate, we found that 7% (13) of school

districts use in-house staff to manage pests. Educating school administrators on proper pesticide use and IPM could be an area of future focus, whether by academia or regulators.

Since this study was implemented, the GDA developed a form that can be used in conjunction with the company's PUR (GSPCC 2010a). This form will help alleviate some of the problems with the *specific areas treated* by listing major areas within a structure, allowing pest management professionals to record pesticide applications. Several educational tools and trainings are available to the industry, and literature focusing on IPM in schools is continuously available online and through various training courses. However, further training should involve increasing pesticide use accountability and the implementation of IPM in schools.

3.5 Acknowledgments

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Williams GM, Linker HM, Waldvogel MG Leidy RB, Schal C (2005)
Comparison of conventional and integrated pest management programs in public schools.
J. Econ. Entomol. 98: 1275-1283.

Figure 3.0 Georgia Department of Agriculture inspection districts for pest control compliance inspections. Between April 2007 and April 2009 no field agents assigned to districts 6, 16, and 19. PURs were not available for district 15**.**

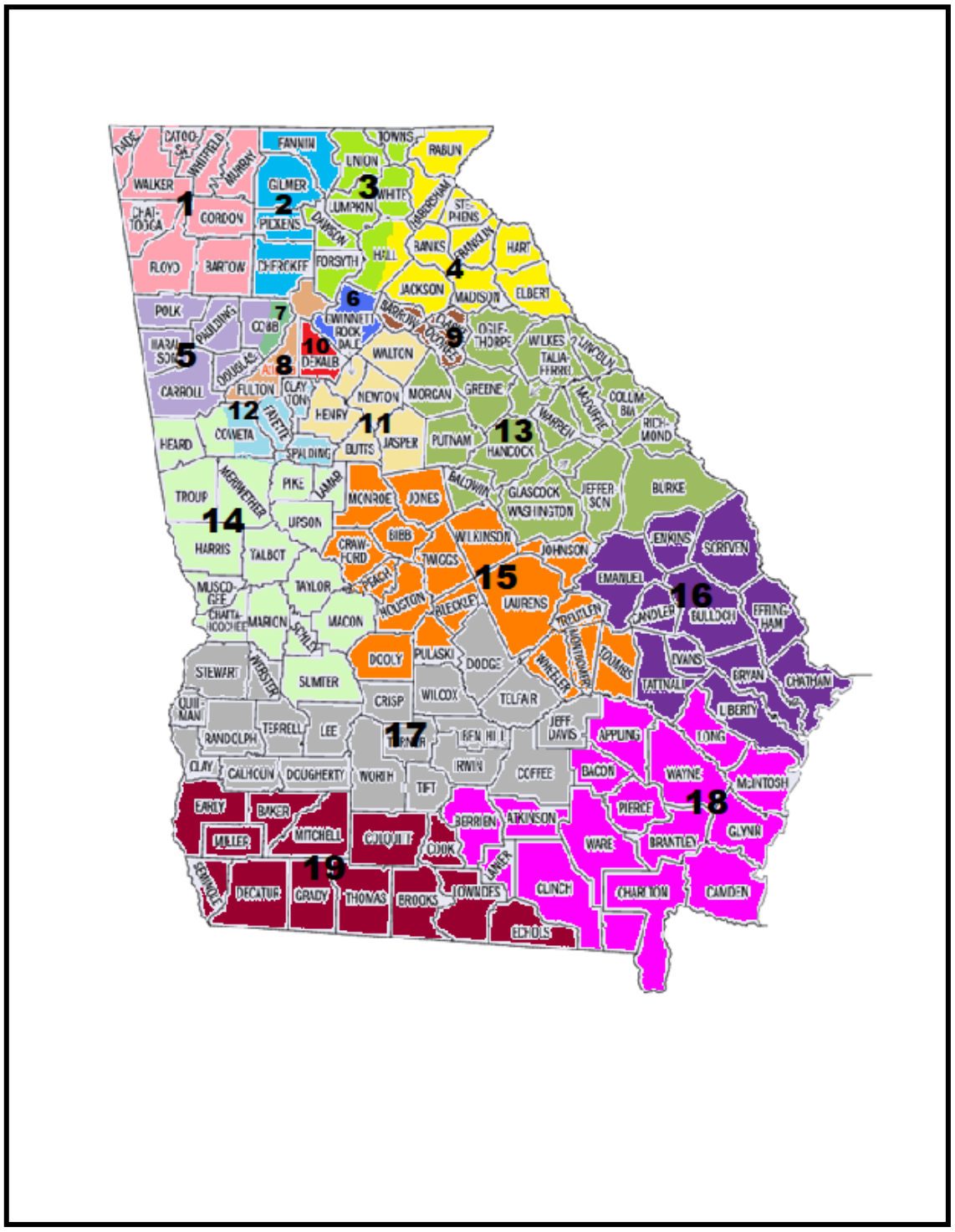


Table 3.0. Code sheet for the pesticide use record violations inspected by the Georgia Department of Agriculture. "Minor Violations" (Harron 2009).

Minor Violations	Code	Definition
Amount	AMT	No or inadequate amount of pesticide applied
Name and Address	Misc	No technician name, no customer address or zip code
Specific Areas Treated	SPA	Specific areas treated in- and outside of the building
Target Pest	TP	Pest targeted during site visit
Time	T	Improper notation of time-in -out of service.

Table 3.1. Code sheet for the pesticide use record violations inspected by the Georgia Department of Agriculture. "Significant Violations" (Harron 2009).

Significant Violations	Code	Definition
Method	M	No or inadequate method of application
Percent Inadequate	%INAD	No or Inadequate Percent of pesticide formulation listed or used
Possible Label Violations	PLV	Possible label violation
Possible Re-entry Violation	PRV1	No or improper re-entry statement listed
Post entry Interval	PRV3	Not following or posting notice of the three hour window required after pesticide application
Precautionary Violation	PRV2	No precautionary statement listed on record or in school area after treatment
Tickets Altered	TA	Changes noted between company and school PUR's

Figure 3.1 Number of Georgia pest control companies that self-reported (monthly) improper pesticide use to the Georgia Department of Agriculture in 2007.

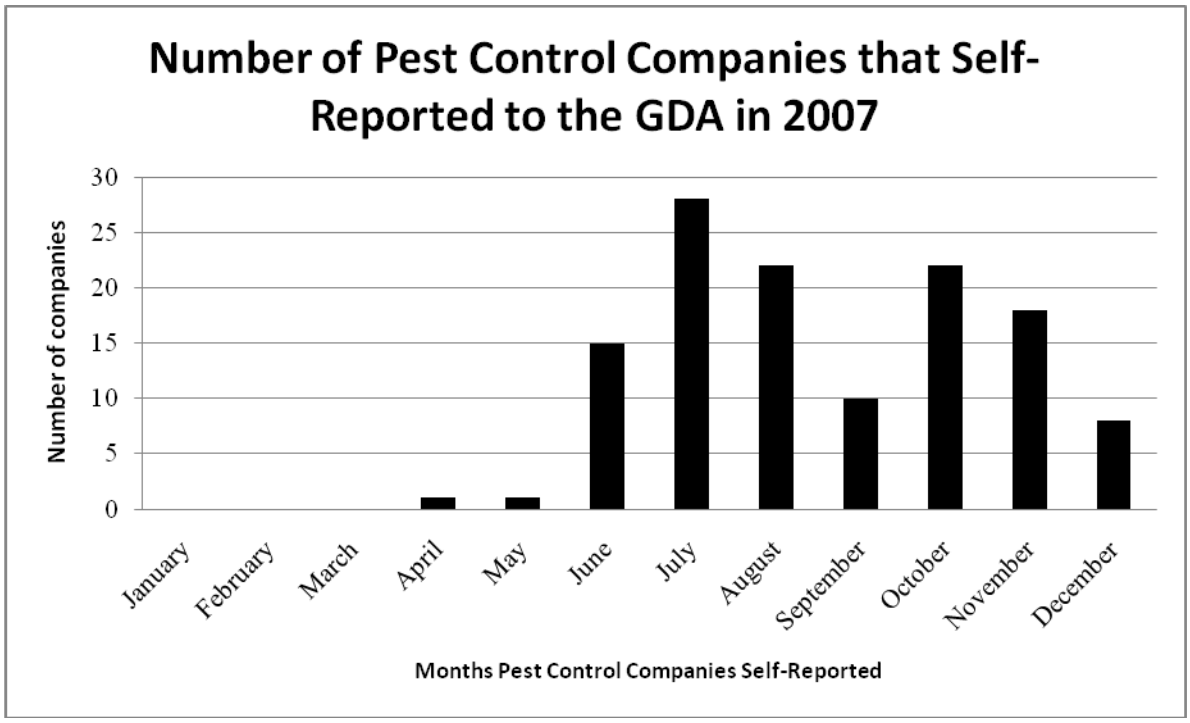


Figure 3.2 Number of Georgia pest control companies that self-reported (monthly) improper pesticide use to the Georgia Department of Agriculture in 2008.

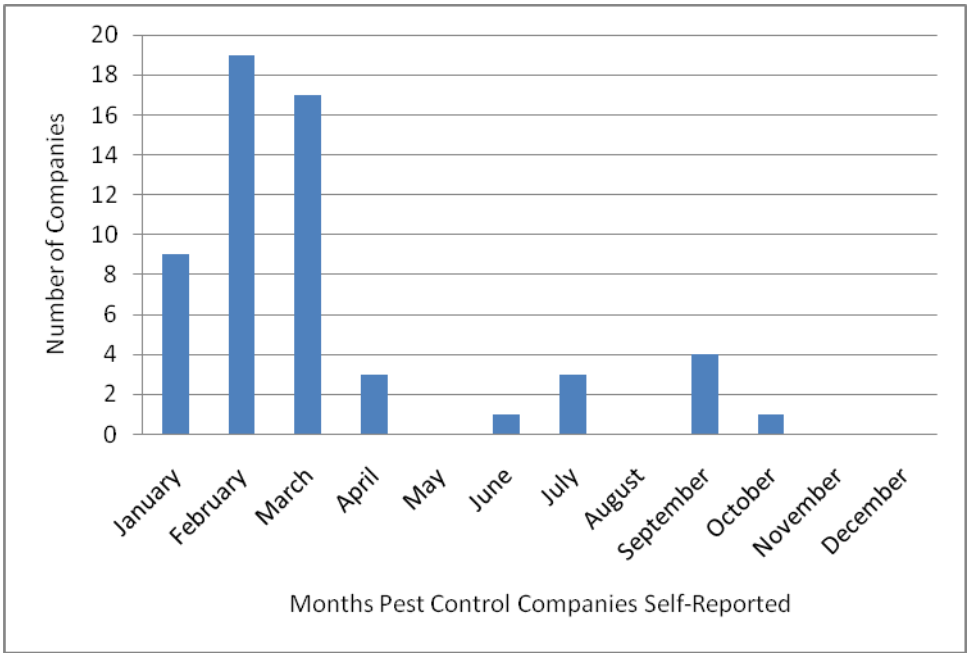


Figure 3.3. Breakdown of the number of violations companies received on pesticide use record issued by the Georgia Department of Agriculture between April 2007 and April 2009.

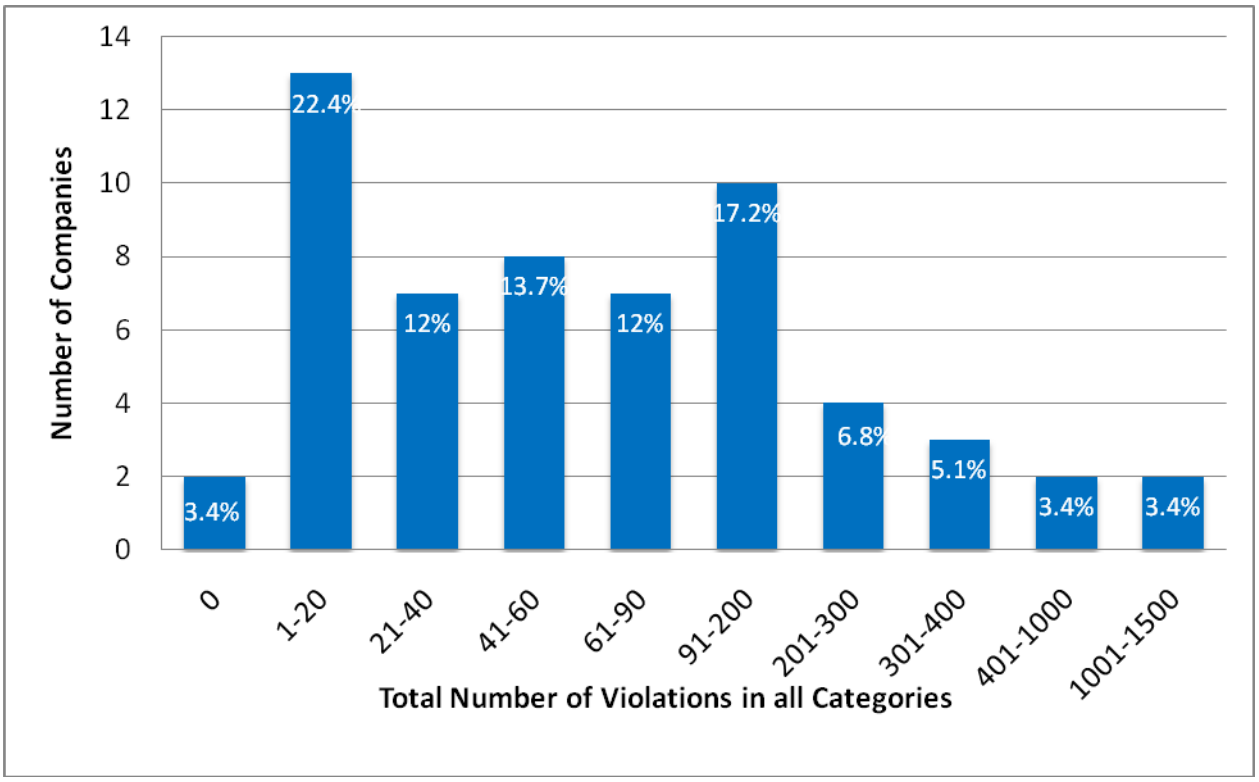


Figure 3.4. Percentage of total reviewed pesticide use records by district in Georgia schools between April 2007 to April 2009. No pesticide use records analyzed for district 15. Districts 1, 13 and 16 accounted for the largest percentages of PURs in the data set.

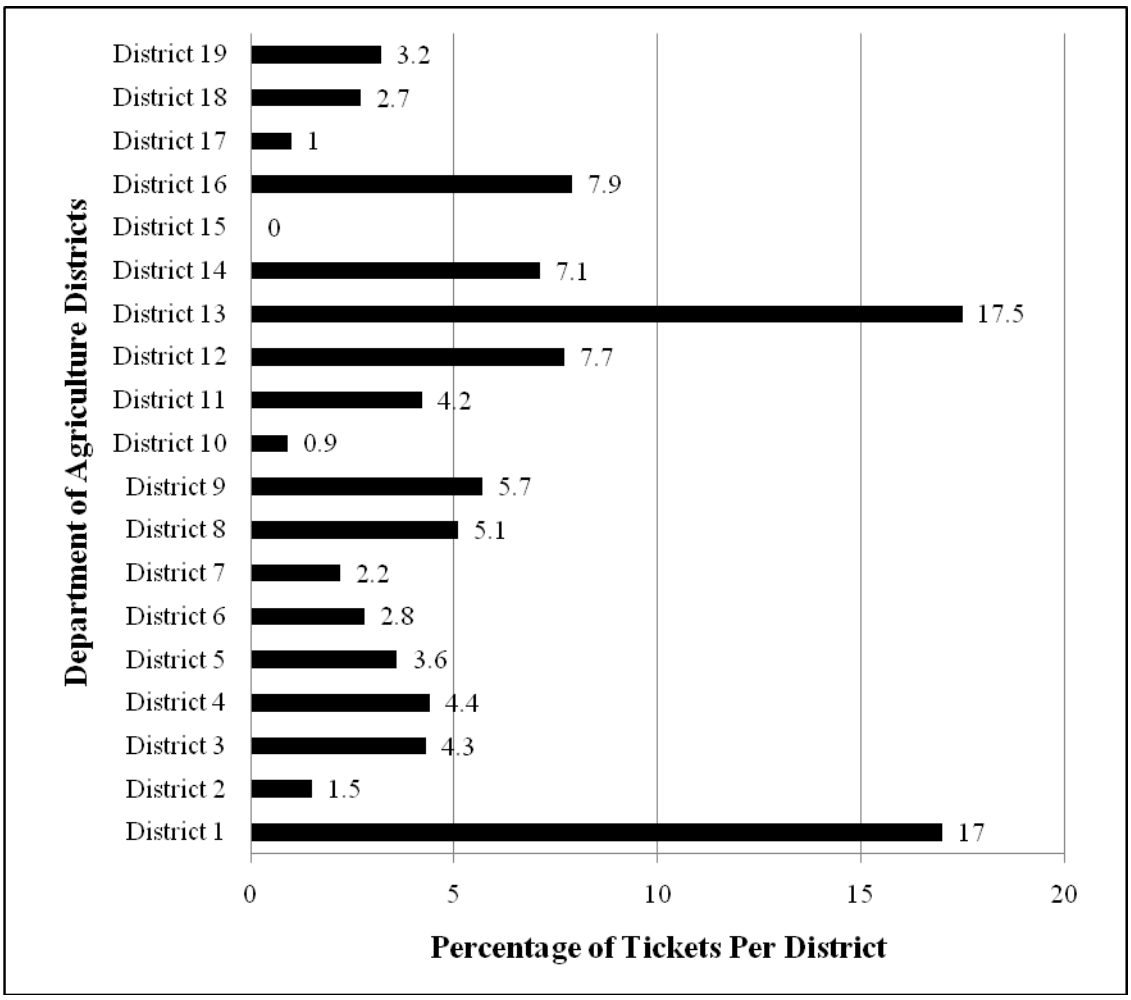


Figure 3.5. Total number of pesticide use record violations issued to pest control operators in Georgia schools from April 2007 to April 2009. Listed by Georgia Department of Agriculture pesticide violation category.

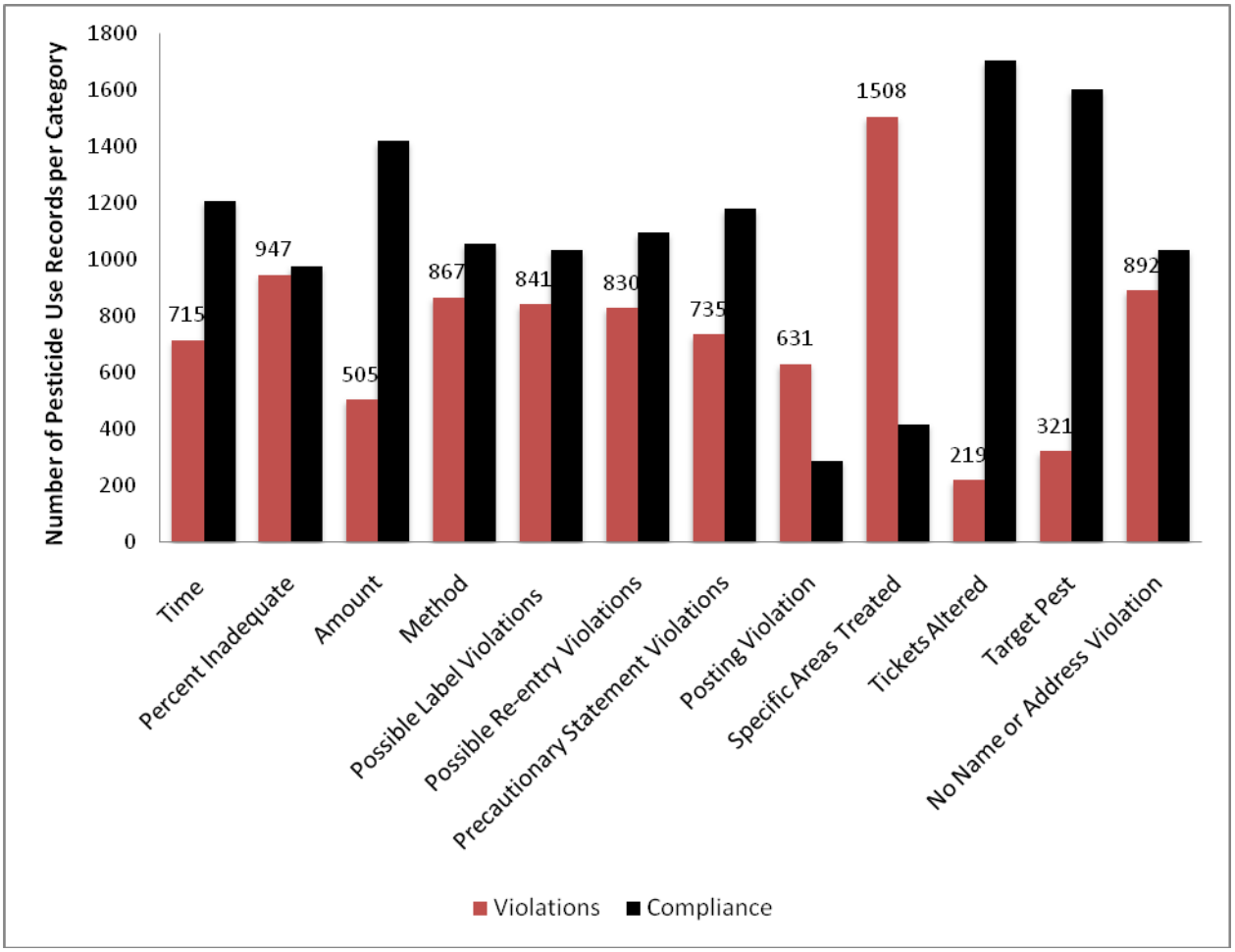


Figure 3.6. Percentage of PUR violations issued to small medium and large companies by the GDA between April 2007 to April 2009. Total number of unrepresented violations from companies not registered (2,927).

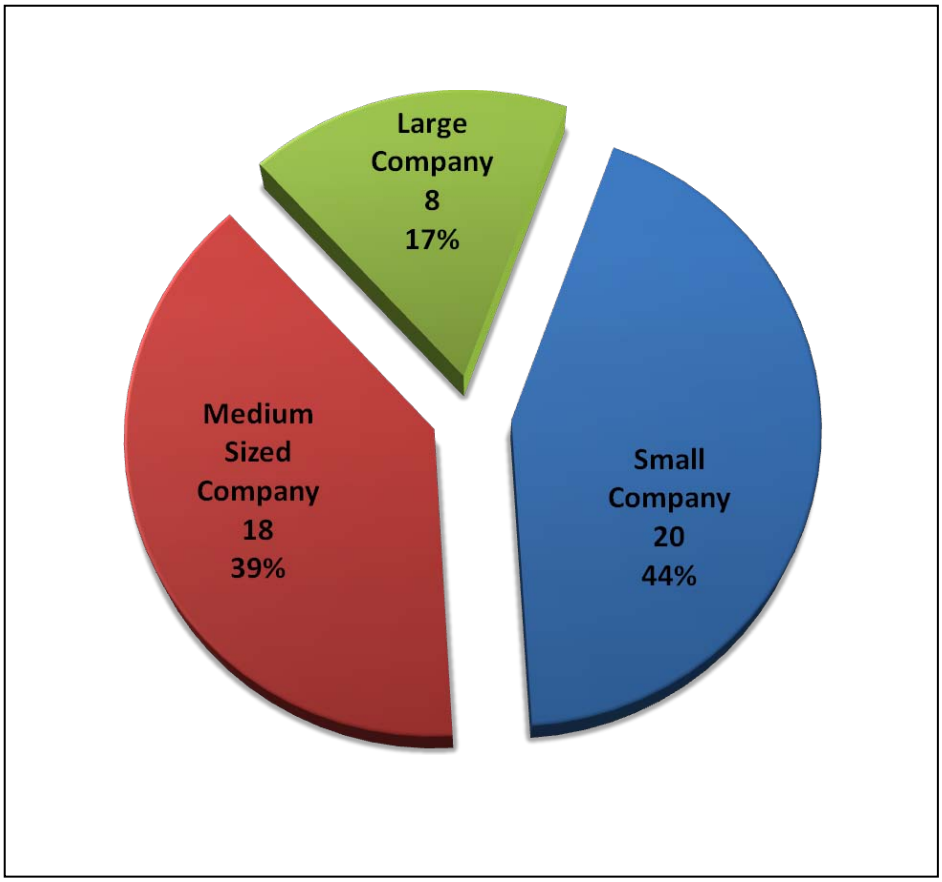


Fig. 3.7. Distribution of small, medium and large pest control companies in Georgia. Data received in 2011 from the Georgia Pest Control Association.

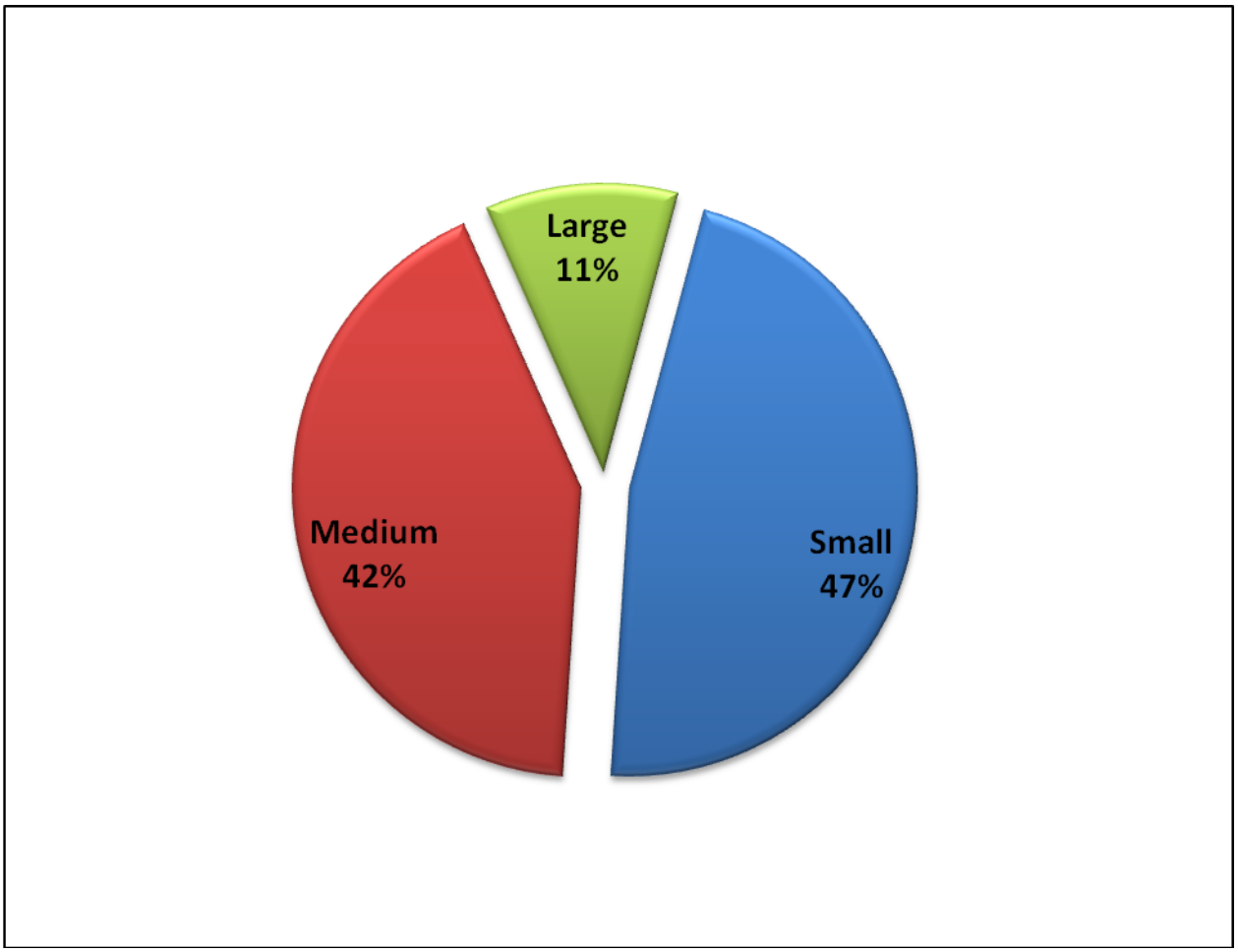


Figure 3.8. Number of PUR violations by service technician between April 2007 and April 2009. N=72

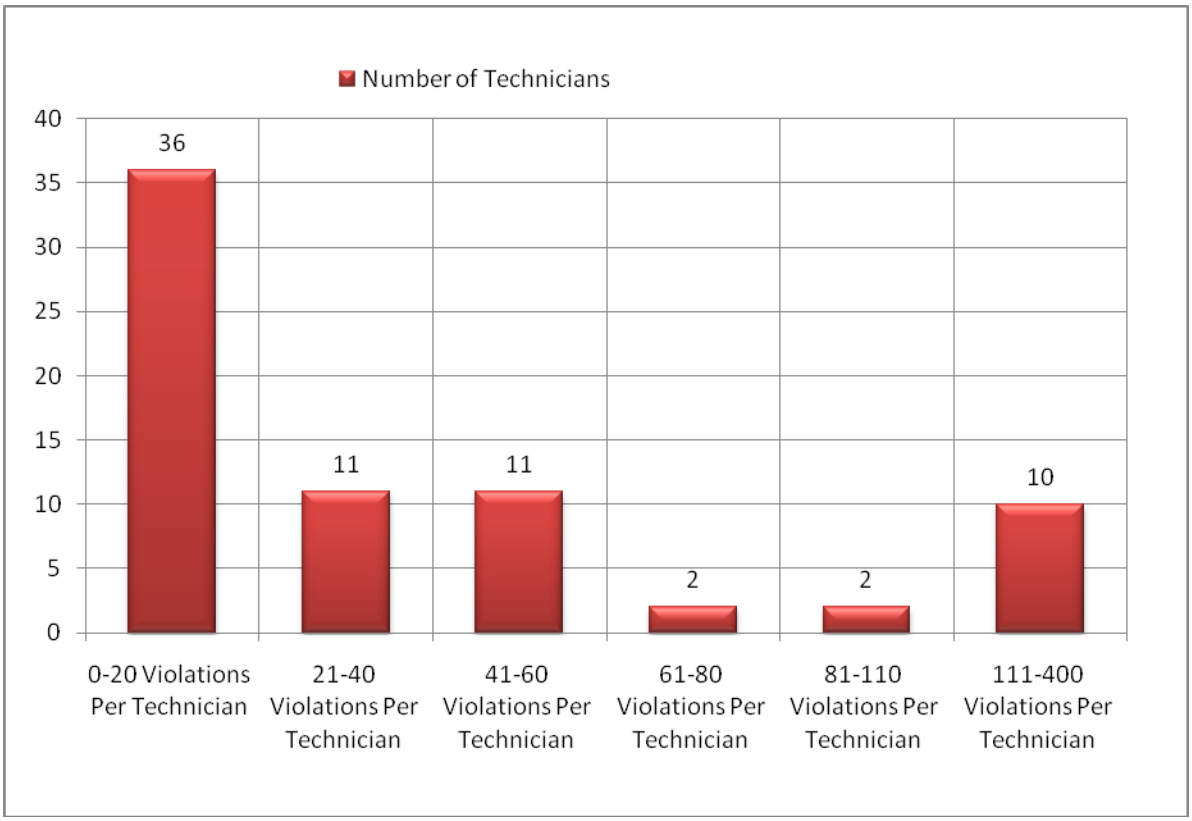


Figure 3.9 Scatter plot of average technician service time and average number of violations received by technician on pesticide use records in Georgia schools between April 2007 and April 2009. (ANOVA DF=1 F = 0.002, P>.050) n=58

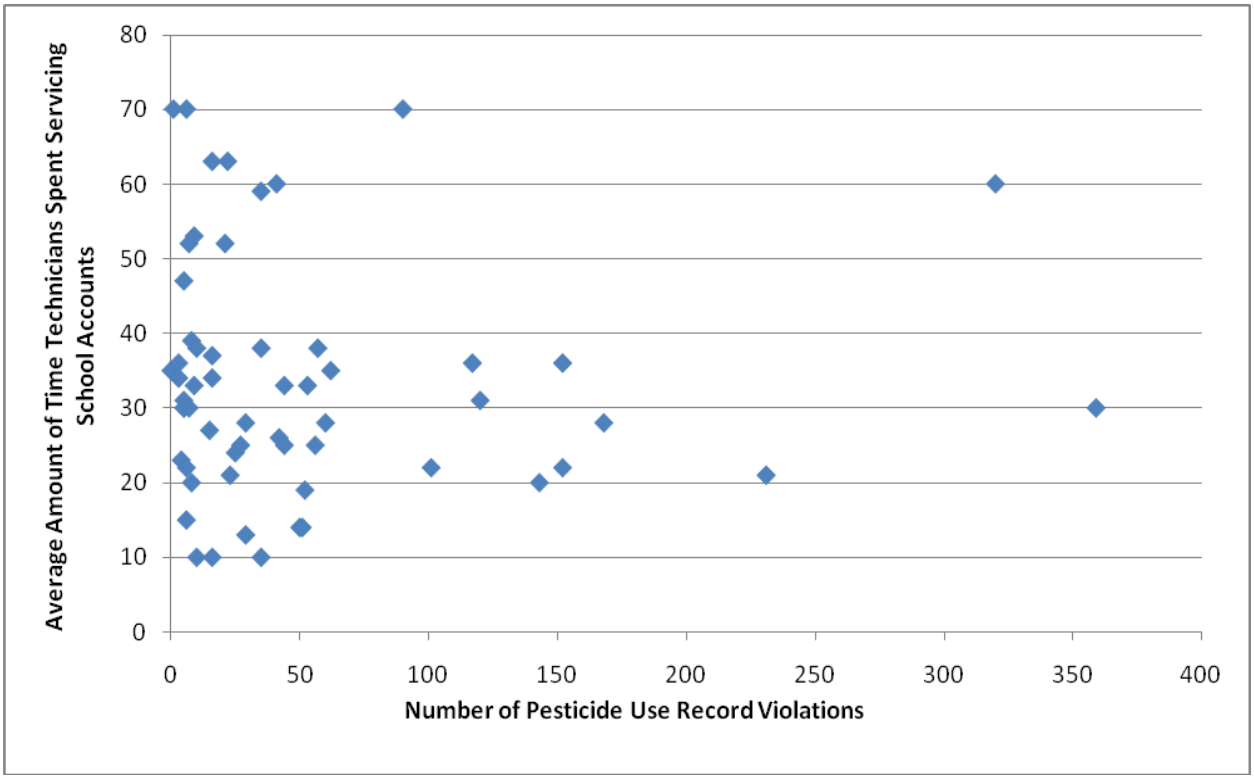


Figure 3.10. Number pesticides listed on pesticide use records in Georgia schools from April 2007 to April 2009. Sorted by IRAC mode of action (version 2009).

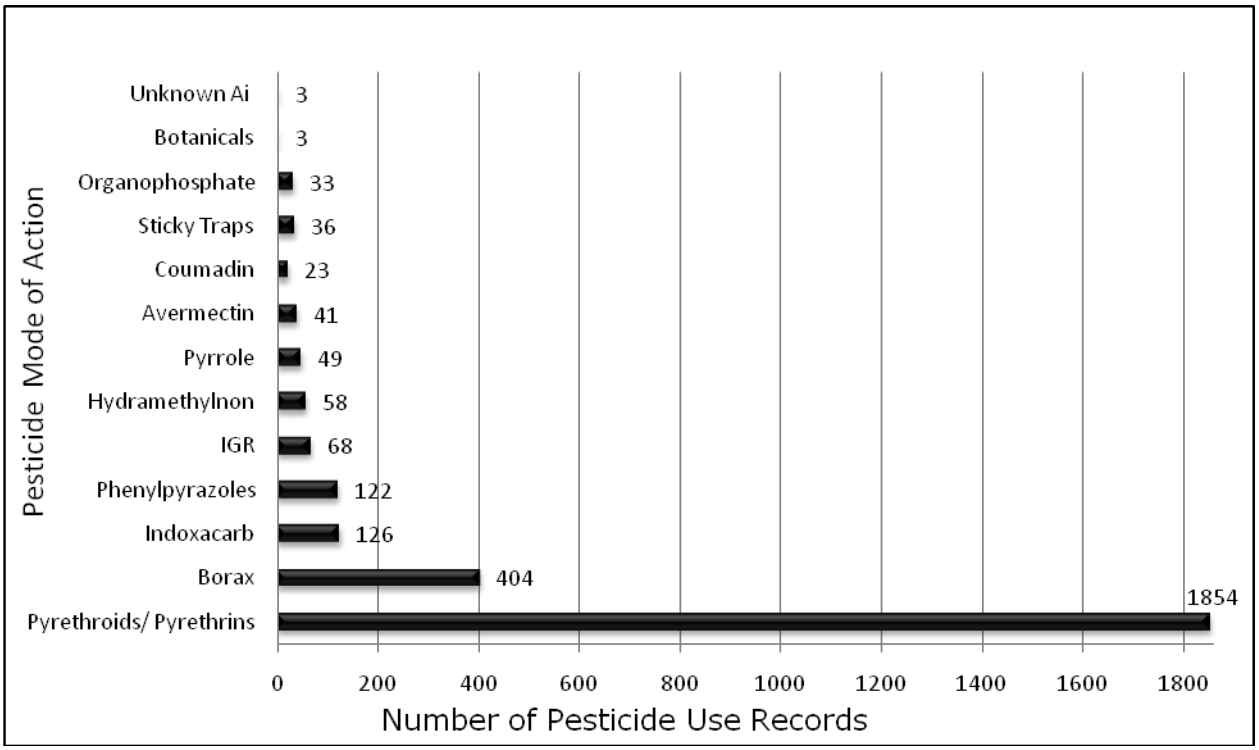


Figure 3.11 Pests commonly listed on PUR's in Georgia Schools between April 2007 and April 2009**.**

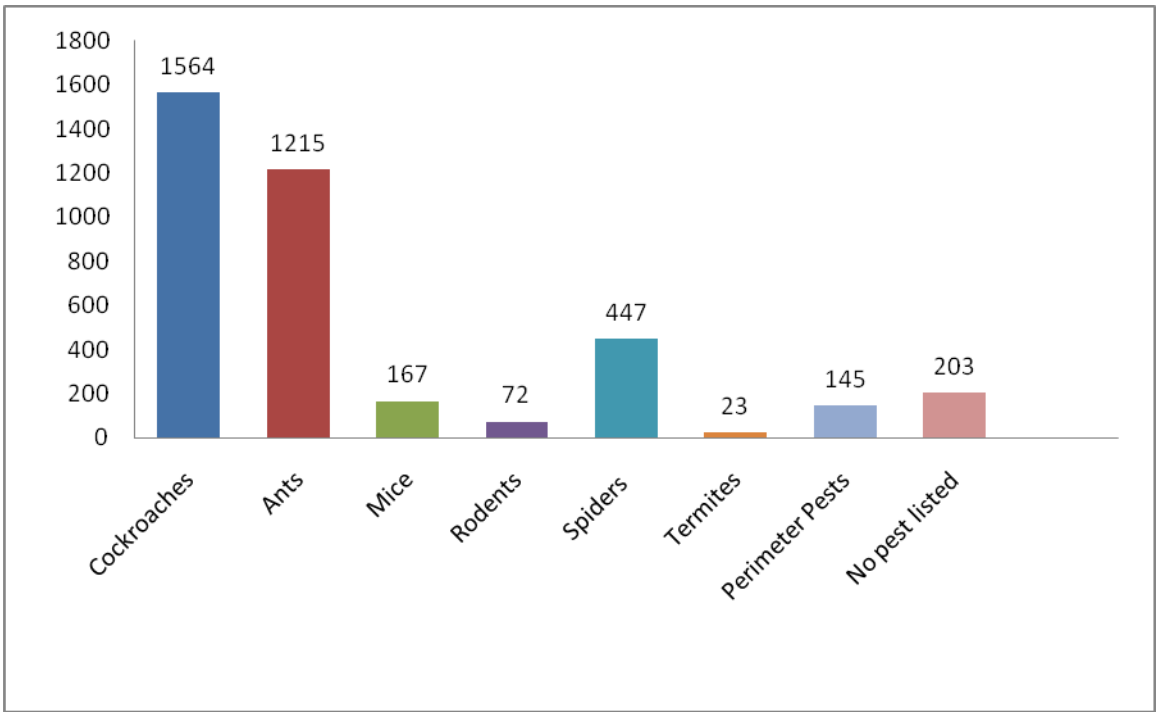
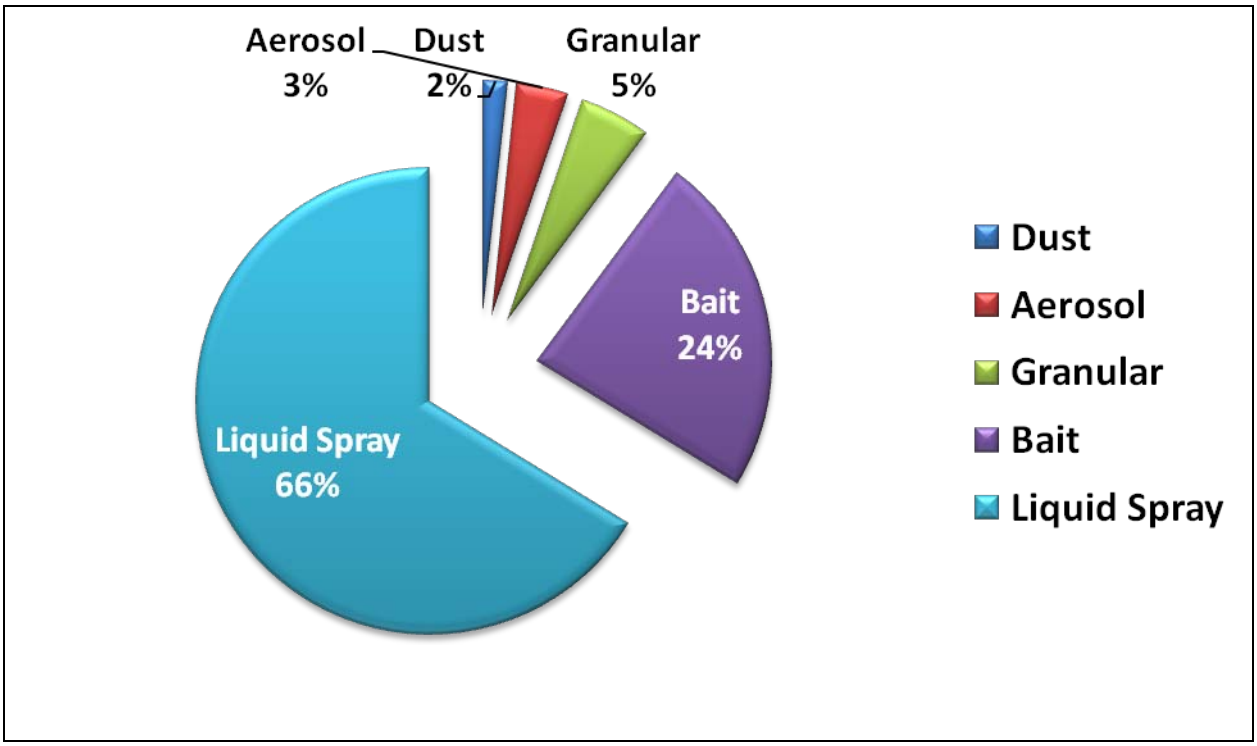


Fig. 3.12. Distribution of the insecticide formulations listed on PUR's between April 2007 and April 2009.



CHAPTER 4

DEVELOPMENT OF URBAN IPM LESSON PLANS FOR GEORGIA SCHOOLS

INTRODUCTION

Incorporating science curricula into a school begins with understanding the performance standards set by the National Science Education Standards (NSES), and set within each state (AAAS 1993, NRC 2000, Barab and Leuhmann 2003, GPSS 2010b). Georgia's Performance Standards in Science (GPSS) require that students reach certain "Benchmarks" outlined for each grade level (GPSS 2010a). Benchmarks are defined as any outcome that can be measured or observed (GPSS 2010b). Benchmarks for Integrated Pest Management (IPM) lesson plans and pest control lesson plans in grades 9-12 are outlined in the agricultural and science standards section on the GPSS website (Figure 4.1). IPM standards for grades K-8 are not required however, the science standards reference insect biology and environmental awareness (Table 4.2 and 4.3).

National Science Education Standards defines inquiry based learning through five essential features; students are engaged through developed scientifically oriented questions; students give priority to evidence; students formulate explanations from available evidence; and students analyze their explanations in reference to alternative explanations and students communicate through verbal or written methods their proposed explanations (NRC 2000).

IPM Lesson Plans – States that enforce or suggest urban IPM in schools (MSU 2009, ISU 2010, PSU 2011) also provide lesson plans for educators and students. These lesson plans are designed to educate the teacher and students about urban IPM with resources available on the internet as well as books and other digital media. Our goal was to create lesson plans that follow the Georgia standards and that can be incorporated into schools with little or no entomology background required by the educator.

Following the requirements for inquiry-based learning is one of the objectives of this project. Our hopes is that IPM lesson plans can increases student awareness of urban pests and pesticides through inquiry-based learning. The goal of this project will be to develop lesson plans that address IPM at a fundamental level for students and educators, presented in a format that teachers can access and immediately utilize.

4.2 Materials and Methods

The IPM lesson plans cover elementary, middle and high school and follow the Georgia Performance Science Standards (GPSS) for each grade. The teacher section includes information for the teacher such as title, summary of lesson, grade level for activity, subject(s) covered, learning objective(s), standards, length of activity, materials needed, and directions. The student section includes handouts necessary to perform the activity as well as directions implementation.

Teacher Section

The "Title" is descriptive of the lesson plan that would guide the teacher to make an informed decision whether the lesson would interest the students or fit into their teaching curriculum.

The “Summary” contains key points as well as key words that guide the teacher toward introducing the lesson plan.

The “Grade Level” indicator helps teachers properly select or modify the activity according to their class learning level. When a teacher needs to incorporate various activities into the curriculum, lessons can be selected based on the “Subjects Covered” section, which lists various key subjects such as biology, entomology and physical or environmental science. The “Learning Objectives” section explains how the lesson addresses the GPSS standards. The “Time” section assists the teacher in his or her selection of time sensitive activities. The information in the “Materials Needed” and “Activity” section enables the teacher to plan the lesson ahead of time by gathering needed items along with detailed directions for setting up and performing the activity.

Student Section

This section varies depending on activity and grade level. Each student section will have detailed directions with guiding thoughts on the activity a short summary, and possible outcomes. The “Summary Section” consists of conclusion and discussion questions geared toward inquiry-based learning. Eight urban IPM lessons were developed.

4.3 Results

Adopt a Pest – This lesson is designed to help with researching skills as well as working with the student’s ability to gain and present knowledge. Depending on the size of the class this could either be a single student project or a small (2-4) group effort. Once students choose their insect, the second day students will gather pest information. The third day students will present

their findings to the class. This lesson plan will introduce students to insect pests in an attempt to expand their basic knowledge of insects.

Insect collection – Students are divided into groups of two and each group is asked to bring one large shoebox from home. The shoebox, laced with Styrofoam will be used to make an insect collection. The students are directed to collect insects that they consider beneficial or pests (depending on their group) and include them in their collection. Insects collected by students will be discussed with the class, and a graph comparing pest versus beneficial or non-pest. The teacher can graph the results to help students gain an understanding of the meaning of a pest and how that differs from one person to the next.

Take a Closer Look – Students will receive an already preserved American Cockroach or a Grasshopper. Students will be directed to dissect the insect, label and draw its body parts. Students will be required to answer a set of questions pertaining to the anatomy of the selected insect. Handouts describing the various parts of the insect and internet resources will be available to assist each teacher during the activity.

Pest Detective – The teacher will set up arenas in the classroom labeled bathroom, kitchen and bedroom. Pictures of food, water and trash will be placed in the, bathroom, kitchen and bedroom area. Pests such as cockroaches, ants, spiders along with insects considered beneficial will be placed in the kitchen and bathroom. The teacher will then place pictures of clothes and trash in the bedroom and bathroom. These rooms will simulate a family's home.

Students should be divided into three groups. Each group is required to investigate their area and identify the pests, ways to control the pest and what they could change about their room

to keep pests from re-entering. A set of “pest detective” questions guide each student through their selected crime scene during the lesson plan. Finally, students will compare their findings with the other groups and graph the number of pests and beneficial insects found during the inspection.

Ants Ants Everywhere – The teacher will begin by reading to the class, “Are you an Ant” written by Judy Allen and Tudor Humphries. This book will introduce students to various ant species and their biology (Allen and Humphries 2002). Using the pictures of ants provided in the information handouts, the teacher explains how some ants, (red imported fire ants) can bite or sting and how some ants (Argentine) usually are just searching for food and shelter. Guided by the teacher, the students are instructed to cut out the pieces needed to make an ant. The teacher is instructed to perform the activity with the children while describing each body part. Once all of the insect pieces are combined, each student explains will share information about his ant. This will allow for discussion of various ant species. Students will further describe a location they observed an ant and its behavior during that sighting. The intended outcome of this lesson is to increase student knowledge of pests.

Build a Bug – This project is designed as an independent thinking project that can be completed as homework or in class. The objective of this project is to introduce the various morphological, behavioral and physiological traits of insects. Teachers will describe various types of pests to the class and students are challenged with making their own perfect pest. A perfect pest can be any insect that is capable of avoiding, through resistance or behavior, predators and pesticides while searching for the basic requirements (shelter, food and water)

needed to survive. The goal is to learn the attributes of a pest, resulting in a new pest species, complete with its food, habitat and natural enemies.

Time to Eat – This project is designed as a collaborative class project. The teacher gives each student a plate with a small amount of water along with a sponge, a drink box, and small napkin with cheerios or something that can be "chewed". The teacher proceeds to demonstrate how various insects acquire food. The sponge and plate of water demonstrate how a fly would pick up liquid food by soaking up the water and then releasing the water only to suck it up again. The drink boxes demonstrate how a mosquito would pierce the skin of the host and remove the nutrients. The straws in the drink box demonstrate how butterflies remove liquid from a flower by siphoning nectar and the chewing gum demonstrates chewing mouthparts. This activity demonstrates the characteristics of each and the feeding behavior of insects.

All about Bugs – This is a crossword puzzle use to boost the students' entomology and IPM vocabulary. The words students will have to define are; beneficial, pupa, adult, holometabolous, egg, pest, IPM and immature. Students are asked match the vocabulary with the definition and place it within the crossword grid.

4.4 Discussion

A report from Owens (2009) identified 21 states that recommend or required the use of Integrated Pest Management (IPM) and 16 other states have developed laws that restrict when and where pesticides can be used in schools. The School IPM Report Card for the Southern Region Meeting in (2007) further revealed that Georgia has failed to develop an IPM curriculum for schools (Southern Regional School IPM Meeting 2007).

Creating entomology lesson plans for areas not traditionally covered in the classroom can be difficult. However, utilizing experts such as entomologists that specialize in the area of educational interest can help develop lesson plans that fulfill these requirements (Earle 1994). Entomology lesson plans are often not included in science lesson plans due to the lack of training, education and available sources for teachers (Barbosa 1974). Basic entomology lesson plans generally cover insects such as butterflies, bees and ants, while needed; incorporating urban entomology into those lesson plans will increase student's knowledge of common pests.

Studies have shown that entomology lesson plans rarely cover urban insects (Acre and Hansen 1992). Future plans with this project are to incorporate these plans in to an already established science or agriculture curriculum. These set of lesson plans are designed to help students understand Integrated Pest Management (IPM) by introducing them to common pest biology and methods of control. Through these lesson plans Georgia teachers have available lesson plans that will satisfy the Georgia Standards for agriculture, science and environmental awareness.

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Southern Regional IPM Center. 2007. School IPM Report Card for Southern Region Meeting.

Table 4.1 Benchmark Science Standards for Grades 9-12.

AG-BAS-10: The student identifies major pests of agriculture, their damage and prescribed control methods.

a. Explains five major kinds of agricultural pests.
b. Explains three conditions needed for pest problems to exist and thrive.
c. Describes how pests are prevented and methods used to control them after infestation.
d. Explains integrated pest management (IPM) in pest control.
e. Describes how pests affect plants and cause losses.
f. Identifies important factors to consider for correct chemical storage.
g. Applies correct procedures used to properly dispose of chemicals and their containers.
h. Demonstrates safe practices in pest control.

Table 4.2. Benchmark Science Standards for Grades 6-8.

Students will investigate the characteristics and basic needs of plants and animals.

a. Identify the basic needs of a plant.
   1. Air
   2. Water
   3. Light
   4. Nutrients

b. Identify the basic needs of an animal.
   1. Air
   2. Water
   3. Food
   4. Shelter

c. Identify the parts of a plant—root, stem, leaf, and flower.

d. Compare and describe various animals—appearance, motion, growth, basic needs.

Table 4.3. Benchmark Science Standards Grades K-5.

Students will investigate the life cycles of different living organisms.

a. Determine the sequence of the life cycle of common animals in your area: a mammal such as a cat or dog or classroom pet, a bird such as a chicken, an amphibian such as a frog, and an insect such as a butterfly.

CHAPTER 5

INTRODUCTION TO THE INTEGRATED PEST MANAGEMENT PLAN FOR THE CHATTAHOOCHEE RVER NATIONAL RECREATIONAL AREA

INTRODUCTION

A memorandum imposed by President Nixon in 1972, stated that "The Secretary of Agriculture in cooperation with the administrator shall implement research, demonstration, and education programs to support adoption of Integrated Pest Management Plan IPM and make information on IPM widely available to pesticide users, including federal agencies (Council on Environmental Quality 1972). Furthermore, this memorandum stated that federal agencies shall use Integrated Pest Management techniques when carrying out pest management activities and shall promote IPM through procurement and regulatory policies and other activities (FIFRA, 7 U.S. C. 136 r-1)". This IPM plan is a result of that memorandum imposed in 1972 by President Nixon. The National Park Service, a federal agency under the Bureau of Land Management is required, too implement IPM into their park system, this includes offices, classrooms, living quarters and visitor areas (Carter 1979).

The Chattahoochee River National Recreation (CRNRA) area consists of a 48-mile stretch of the Chattahoochee River and 14 land units. This park has many urban and rural stretches of land. The 14 land units stretch from Lake Lanier down through Peachtree Creek in Atlanta, Georgia. The CRNRA encompasses various flora and fauna, as well as hiking trails, horseback trails, streams, lakes and picnic areas. Residential homes that surround the park are

not required to adhere to federal IPM mandates and pose a threat to the waterways and trails in the parks. This diversity and proximity to urban areas make CRNRA a candidate for IPM.

The (IPM) for the CRNRA is designed to serve as a guide to the park coordinator, maintenance personnel, rangers and residents. The plan focuses on the proper intervention and management of common pests within the park facilities and visitor related areas. The plan for CRNRA will adhere to federal, state and local laws pertinent to pest management and pesticides. The final plan shall list existing information relevant to CRNRA and incorporates best management practices that is utilized by park personnel and visitors.

5.1 References

Carter, J. 1979. Presidential memorandum of August 2, 1979, Washington, DC

Council on Environmental Quality. 1972. Integrated pest management. Executive Office of the President, Washington, DC

CHAPTER 6

CONCLUSIONS

We used eight steps inherent to the IPM process to develop a dichotomous key. Kells (2009), stated that a “structural IPM program must have a plan or strategy of operation”. This key allows instructors and practitioners to follow the process of urban IPM and introduces users to the mindset needed for implementation. This key originally was developed for an IPM plan however; this plan can be used as a training or field guide for practitioners. In terms of current urban IPM literature, the process of urban IPM can be found with references to case studies or definitions for each step (Kramer 2004, AFPMB 2009). However, most practitioners lack the assistance needed to move from one-step to the next within the process. Each step in our key highlights the decisions that guide practitioners during the IPM process. The key demonstrates the cyclic nature that is IPM and philosophy therein. Further testing of this model will determine the efficacy of a dichotomous key.

The Georgia Department of Agriculture (GDA) provides training courses, websites and literature for pest management professionals PMPs. Pesticide use records (PURs) collected by the GDA from schools, between April 2007 and April 2009 carried over 9,000 violations indicating that more training for pesticide use in Georgia schools is needed. Out of thirteen categories, the specific areas treated category was identified as an area of potential training. Since the study began, the Georgia Structural Pest Control Commission has developed a specific

areas treated form for PMPs (GSPCC 2010). Comparison of future PURs with this data set will determine if training and paperwork issues are improved.

Georgia standards currently require agricultural and urban IPM as teaching component (GPSS 2010). However, lesson plans covering these topics are not available. Due to the unavailability and need of urban IPM curricula for teachers, eight lesson plans were developed for grades K-12 in Georgia. These lesson plans were designed to introduce students and teachers to pest biology, pesticides and the process of urban IPM. The lesson plans cover pest control, morphology, identification, biology and insect behavior. Determining the efficacy of these lesson plans will require further testing.

Legislation developed under the Food Quality Protection act in 1996, required that federal agencies implement IPM techniques through regulatory policies and other activities (US Congress 1996). Before this mandate was issued federal memorandums were developed in 1979 advising all national parks to implement IPM whenever possible (Carter 1979). This plan outlines information specific to CRNRA that is essential to implementation of an IPM program. The IPM plan covers 14 land units and 48 miles of urban and rural land units. Information in the plan covers regulations, pesticide usage, pesticide safety, and insect and plant identification. Further details of the IPM plan include geospatial data of four land units not commonly included in IPM plans.

6.0 References

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APPENDIX A

INTEGRATED PEST MANAGEMENT LESSON PLANS

TAKE A CLOSER LOOK

Grade level: Ninth to twelfth grade

Time: Set Up 15-min, Activity 30-45min

Subjects/Topics Covered: Biology, Environmental Science, Chemistry, Human Health, Anatomy

Objectives:

Students will learn how to identify common pests.
Students will learn how properly collect field specimens
Students will gain an in-depth perception of insect body parts.

Materials:

Several differential grasshoppers (can be purchased or caught in the field). Or large American cockroaches that have been raised in a laboratory (to prevent bacteria transmission). Other options include virtual insect guides:

Grasshopper: http://www.ent.iastate.edu/ref/anatomy/ihop/

Roach: http://www.ent.uga.edu/mchugh/Virtual_Roach.htm

Tweezers
Plastic knives
Petri Dishes or hard plastic plates
Jar full of alcohol (for teacher use only to store insects)
Gloves
Pen
Paper

Activity

Students will each be given either an American Cockroach or a Grasshopper. Each child will be allowed to dissect the insect and label and draw its body parts. Students will be given a set of questions pertaining to the anatomy of the insect as well as the comparing the insects to each other.

Georgia Performance Science Standard learning objective:

SCS3.Students identify and investigate problems scientifically
SCSh6. Students will communicate scientific investigations and information clearly.

Teachers Notes:

What to cover in class:

Anatomy of an insect

Variability in insect structures

Purpose of insect structures

Use the insect anatomy diagrams listed in this packet as a visual aid.

Grasshopper

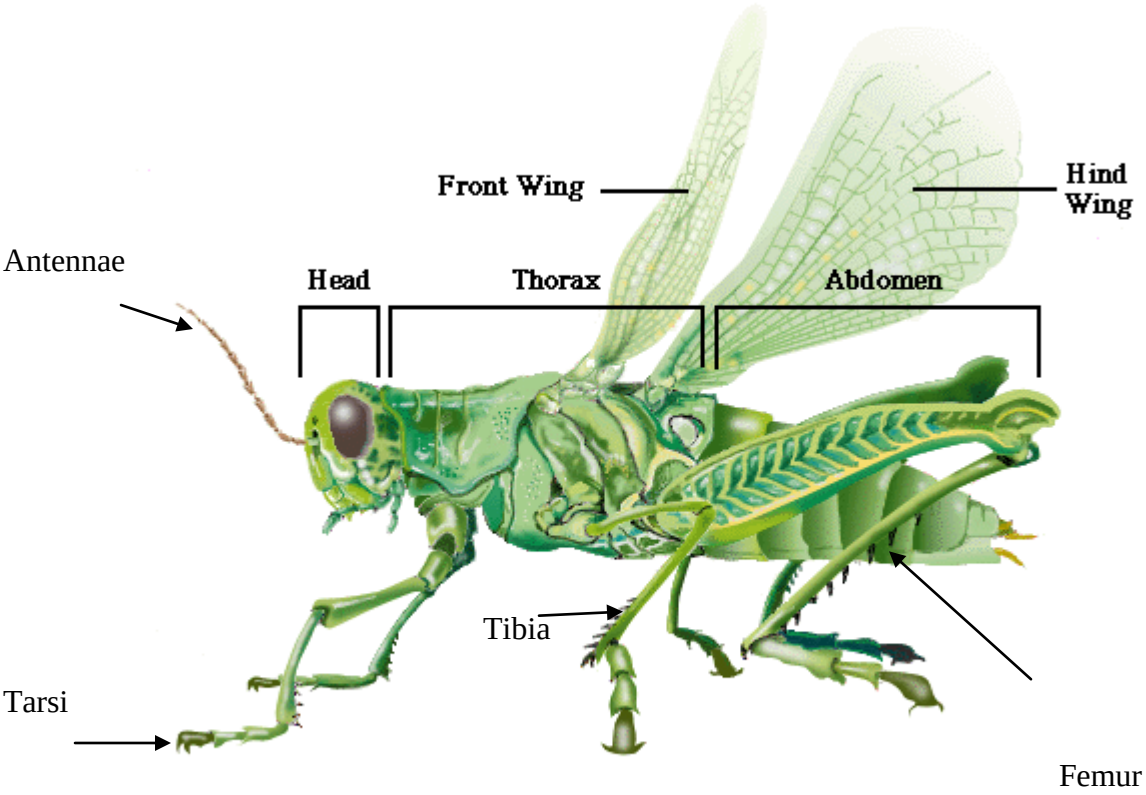


Photo: “Class Insecta” http://biology.unm.edu/ccouncil/Biology_203/Summaries/Protostomes.htm.

American Cockroach

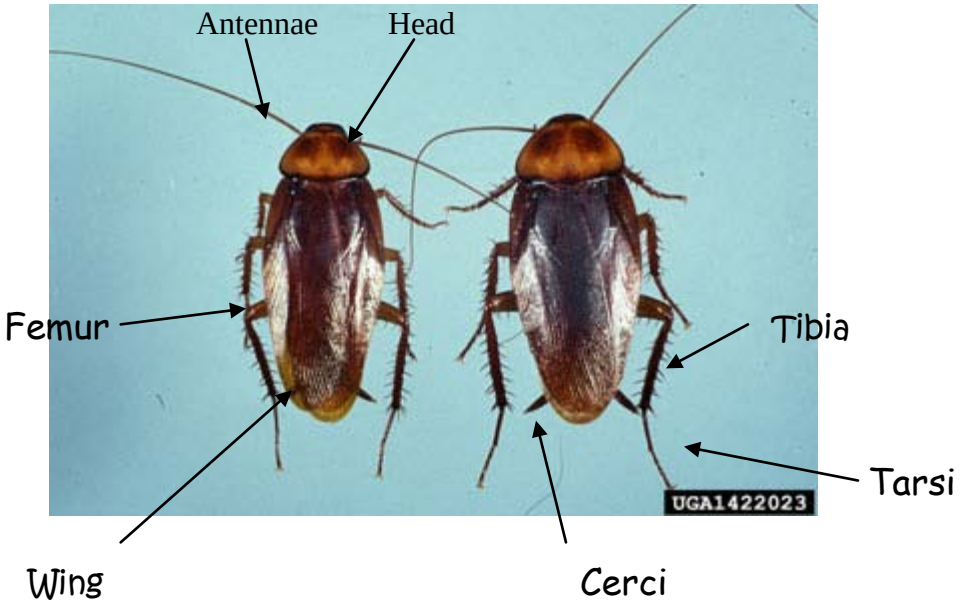


Photo: Daniel R. Suiter, University of Georgia, www.Bugwood.org

Take a Closer Look

1. Locate the head
    a. Remove the head using a scalpel
        i. Look at the eyes. What type of eyes does this insect have?
        ii. Locate the antennae. What type of antennae is shown?

2. Find the mouthparts
        i. Look for the mandible, labrum, maxillae and labium
        ii. What are these used for?
3. Find the thorax,
    a. Locate the hearing structure or tympanum
4. Find the abdomen.
    a. Count the abdominal segments. How many? ____
    b. Find the circular structures along the abdomen. These are for breathing.
        i. Count the number of spiracles

4. Locate the tympanum, or eardrums, on the thorax.

5. All insects have six legs. Locate:

Front Legs Middle Legs Back Legs

6. Draw these structures of the legs

Tibia

Femur

Tarsi

6. Locate the two pairs of wings.

Lesson

Pest Detective

The super sleuth is back!

Grade level: Nine-twelve

Time: Set Up 15-min, Activity 30-min

Subjects/Topics Covered: Biology, Environmental Science, Human Health, Risk and

Benefits of Insect Control

Objectives:

Students will learn how to identify common pests.
Students will learn how to control pests without pesticides through early detection.
Students will learn about food webs and humans' roles in them.
Students will be able to incorporate the activity into their home life.

Materials:

- Fake food or pictures of food (flour, bread, crumbs (broken up foam) protein items
- 5 of each item; Index cards labeled or replicated items if available
- Water, cockroaches, crickets, spiders, ants, beetles, flies, mouse
- Beneficial insects: butterflies, caterpillar, preying mantis, ladybugs
- Three cans with paper wrapped around them. Label the cans to show they are pesticides for insects, rodents, and spiders.
- Cut pieces of cloth or paper to represent clothes
- Four areas of the room labeled Kitchen, Bedroom, Dining Room and Bathroom

Activity

1. Set up areas in your classroom labeled Kitchen, Bedroom, Dining Room and Bathroom.

2. In the Kitchen and Dining Room areas scatter food, water, and crumbs all around. Then place pests in those areas along with beneficial insects. Do the same in the Bedroom and Bathroom except place crumbled up paper and clothes on the floor as well.

3. Break students into four teams. Each team is required to investigate their area and determine what pests they have, how to control the pests, and what they could change about their area to keep pests from re-entering.

Georgia Performance Science Standard Learning Objectives:

SCS3. Students identify and investigate problems scientifically.
SCS1. Students will evaluate the importance of curiosity, honesty, openness, and skepticism in science.
SCSh6. Students will communicate scientific investigations and information clearly.
SEN4. Students will investigate the impact of insects on human health and history.
SEN5. Students will evaluate the risks and benefits of various methods used to control insect pests of human and agriculture.

Teacher Notes: Prior to this activity discuss with the class the differences between beneficial and harmful insects. Discuss that sometimes beneficial insects can be pests as well (i.e. lady bugs).

Key words: Pests, Insects, Beneficials, pesticides

Pest Detective

A family comes home from the movies and realizes that their home has been invaded by pests! They quickly call you, a super sleuth investigator, to help find and remove the critters *without* hurting their family pets. Did you know…Pets or other insects sometimes like the same foods as pests.
Luckily for you, you have a team of super sleuths to help you solve this problem. What steps does your team need to take to tackle this job? Write out your steps and check them with your teacher before you begin. Then use the data sheets below to help you collect information.
KEY:

Step 1. Identify the pests

Step 2. Figure out why and how they got into the home.

Step 3. Remove pests without hurting pets.

Step 4. Help the family understand how to prevent this problem.

What room in the house did your team investigate? _____

Pest Inventory

	Insect	**Is it a pest? y/n**	**Location**
1.			
2.			
3.			
4.			
5.			
6.			
7.			
8.			
9.			
10.			

Investigative Report

How can the family change their habitat to reduce pests?

_____

_____

_____

How do you think the items listed below attracted the pests?

Clothes_____

Water_____

Food_____

The family used pesticides to remove many pests; can you think of other ways they can remove pests.

_____

_____

_____

Ants! Ants! Everywhere!

Grade Level: Kindergarten to First grade

Objectives:

1. Learn the different body parts of an Ant.
2. Distinguishing characteristics of an Ant that make them unique to other insects.
3. Role of ants in society and how they are beneficial.
4. Life cycle of an ant.

Duration: 30-45mintues

Background:

There are many different types of insects all belonging to different orders. Young children most likely will encounter an Ant during their childhood time. Ants, order Hymenoptera, are very different from other insects. Their bodies are very strong and they can lift up to a 100 times their weight. The Ants body consists of six legs and three body parts. Uniquely, the ant can be an interesting creature that often has huge colonies and sometimes travel indoors. Explain to the students why an Ant may come indoors and why.

Materials:

- Yellow, brown and black, construction paper cut into three circles.
- Scissors
- Glue
- Pipe cleaners at least 10 inches long
- Book “Are you an Ant” by Judy Allen
- Containers with at least three different types of ants

Procedure:

1. Start by reading “Are you an Ant” to the class. This will help the children have a better understanding of what an Ant is and its role in society, as well as its life cycle.
2. Have the children cut out the pieces needed to make an ant.
3. Do the activity with the children and explain to them what each part is.
4. Glue the eyes to the head. Add the legs to the thorax by bending one pipe cleaner into two pieces for each set of legs.
5. Next, have the children glue the antenna onto the head of the ant drawing eyes and a mouth. The ant is complete.
6. Next, have each student stand up and tell of one place they saw an ant and what it was doing at that time. Also, have each student say what kind of ant they have, a worker, queen or soldier.
7. Explain how some ants (Red Imported Fire ants) can bite or sting people and animals and how some ants (Argentine) usually are just looking for food and will not harm people or animals.

Teacher Tips:

1. It is helpful to read a story to younger children, which help them visualize. This activity is good for all types of children because it applies listening, visualizing, and doing the activity themselves, depending on the type of learners they are.
2. The activity gives the children a better understanding of what an Ant is. It is also helpful to do the activity along with the children and talk them through as they do the activity so they can understand the different body parts.
3. You may also want to bring in live Ants for the children to view at the end, after they have finished the activity.

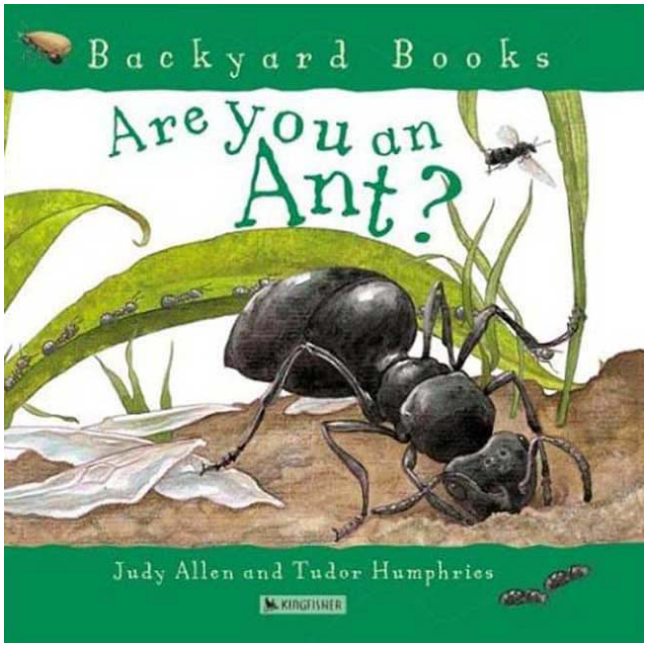
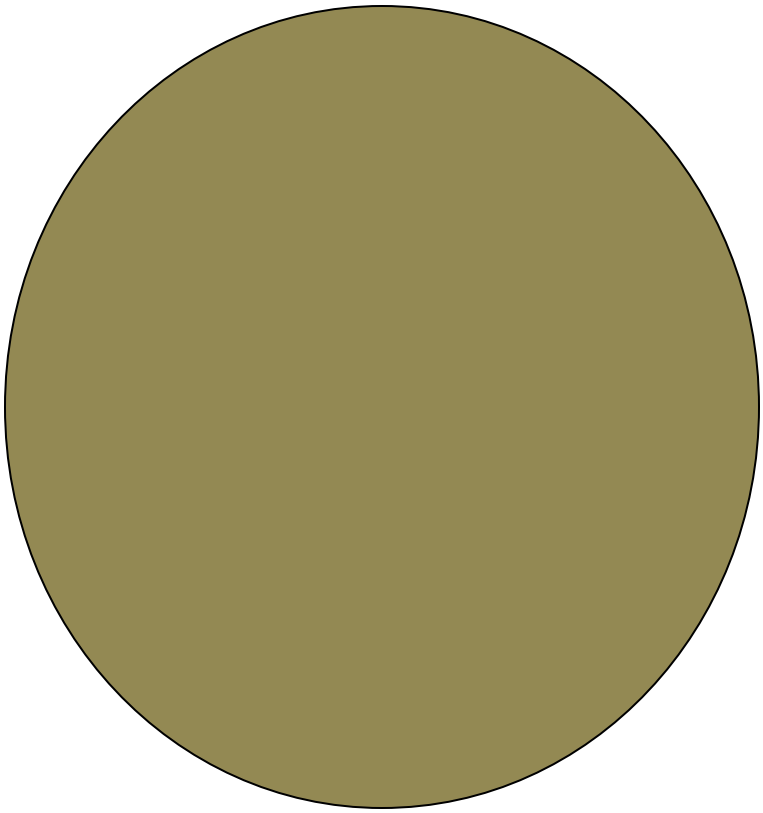


Figure 1.1 Are You an Ant. By Judy Allen Tudor Humphries

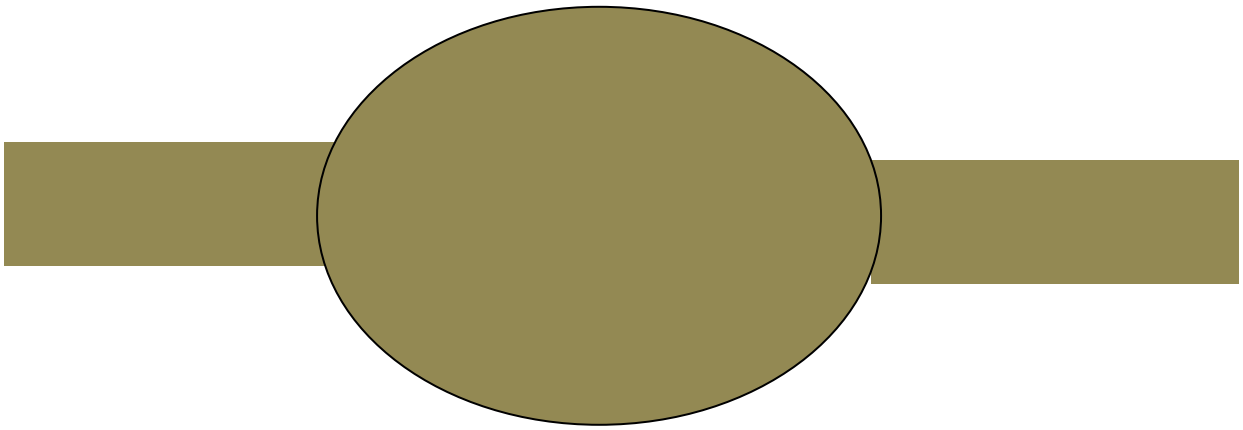
Resources

Facts and handouts about ants	http://www.pestworldforkids.org/ants.html
Pictures of Ants	www.bugwood.org
	www.bugguide.net

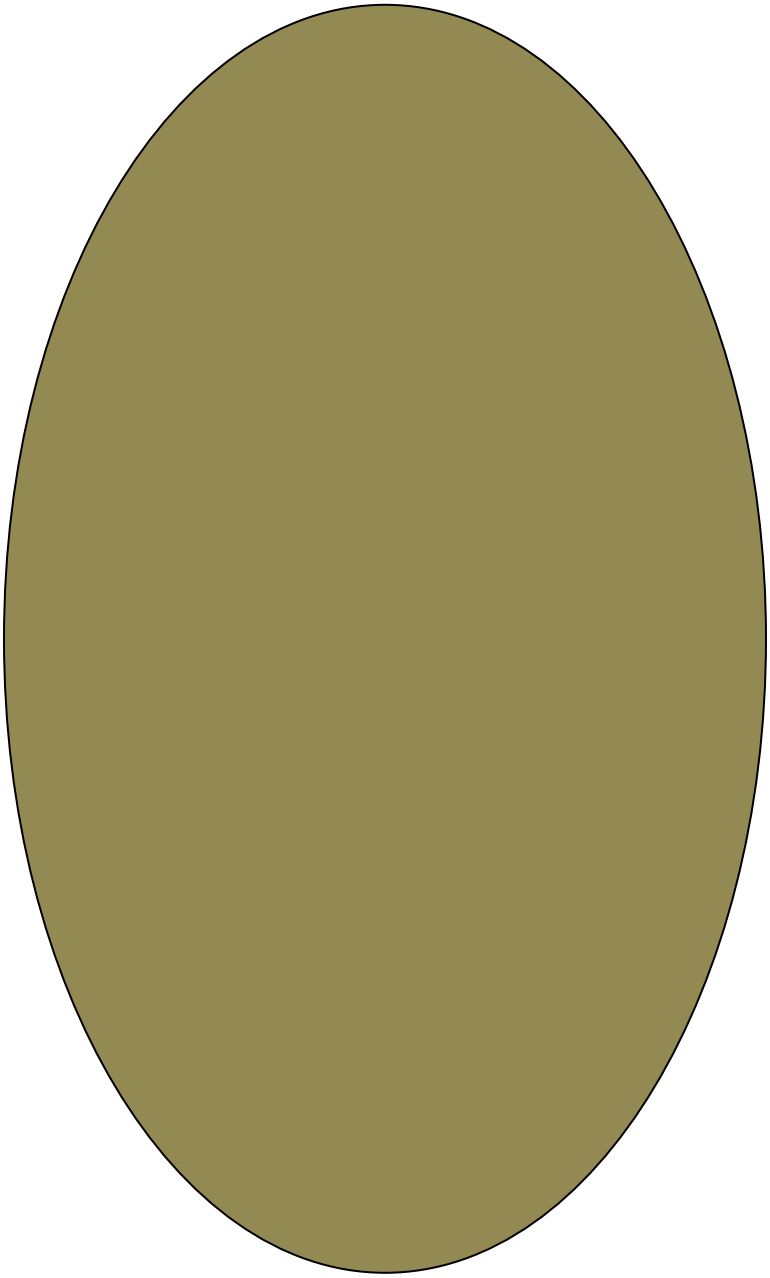
Head



Thorax



ABDOMEN



Adopt an Insect

Grade level: Sixth to Eighth Grade

Time: Set Up 15-min, Activity broken into 1-2 Weeks (lag time not actual activity time) or 30 minutes if teacher provides supplies.

Subjects/Topics Covered: Biology, Environmental Science, Human Health, Agriculture

Objectives:

Students will learn how to identify common pests.
Students will learn about the food web and what role humans play
Students will learn about various insect species
Students will learn about the biology of insects.

Materials
Students need

Poster board or several 8 ½ x 11 sheets of paper
Students can make a poster or book
Camera for pictures or drawings and cut outs or print outs from
Magazines, books, internet etc.
Scissors
Glue

Activity

This lesson is designed to help with researching skills as well as working with the student's ability to gain and present knowledge. Depending on the size of the class this could either be a single student project or a small (2-4) group effort. This is also a great homework project. Allow the students to choose their own native insect. Sign their group up for that particular insect as to not have duplicate presentations. After the students

choose their insect, the second day will mainly be about gathering information, and the third day will be for setting up or arranging the information to be able to present it to the class. Giving the students some freedom with how they present their information this gives the project a little variety. The end result will be that the entire class should have at least a basic knowledge of the insects that live around them and detailed knowledge about the insect presented.

Georgia Performance Science Standard learning objective:

SCS3.Students identifies and investigates problems scientifically
SCS1. Students will evaluate the importance of curiosity, honesty, openness, and skepticism in science.
SCS6. Students will communicate scientific investigations and information clearly.

Teacher Notes: Prior to the activity discuss with the class the many ways insects impact our lives. Discuss the good and the negative. By the end of your lecture students should be able to gain an understanding that not all insects are harmful and that they play a vital role in our life.

Websites that can be used.

National Geographic

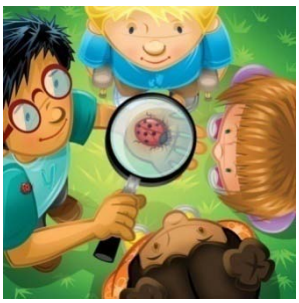
Bugwood www.bugwood.org

Bug Guide www.bugguide.net

What's that Bug www.whatsthatbug.com

Magazines

National Geographic
Bug Club Magazine for Amateur Entomologists



Adopt a Pest

Have you ever stopped to look a at pests eyes, or count his tarsi? Tarsi are like our toes. How many insects have you seen? Discovering insects can be fun. There are millions of insects and many more to be discovered!

Your task: Find one insect you want to adopt. As any great parent would, you have to figure out what makes this insect happy. You can use many tools to find out about insects.

Tools: Library, Books, Internet, Bug Magazines, Observation (watching the bug to see what it likes) and Microscope

Presentation:

Using the tools above, make a poster or a book displaying your adopted pest. Add cool features such as different colors of the same insect, places the insect lives, food it eats and what time of the year you can find this pest. Answer the questions below for your presentation.

Presentation Requirements:

1. What is the name of your insect?
    a. Scientific name
    b. Common name (is there more than one?)

2. Where's your insect commonly found?
    a. Where did it originally come from?
    b. Is it in the same place all around the world?

3. What kind of food does it eat?
    a. Does it like live food or decaying food?
    b. Can you show the types of food it likes?

4. What type of mouth parts does this insect have?

5. How does this insect spend the winter?

6. Does the female look identical to the male?

7. Are there any cool facts about this insect that you want to share with the class?

8. Where does this insect lay its eggs? How many does the female lay?

9. Is this insect a pest or a beneficial?

Place all of this information on a poster or make a book. You can also bring in live specimens to share with the class.

Insect Collection: Pest vs. Beneficial

Grade level: Sixth to Eighth Grades

Time: Set Up/ Introduction 45 min, Activity 1-2 weeks

Subjects/Topics Covered: Biology, Environmental Science, Risk and Benefits of Insect Control

Objectives:

Students will learn how to identify common pests.
Students will learn how properly collect field specimens
Students will gain an understanding of the ecosystem and food web.
Students will learn the difference between pests and beneficial insects.

Materials:

Shoe Box
Jar with tissues or plaster placed in ¼ of jar.
Fingernail polish remover (Acetone)
Styrofoam ½ inches thick
Insect pins for pinning insects
Containers and plastic bags for holding insects
Paper for labels
Pest ID book or you can use the internet (see list of websites)

Activity

Students are divided into groups of two. Each group will bring two large shoe boxes from home. The teacher or the students can purchase a couple of sheets of Styrofoam from the store. Each group of students will be chosen to collect either beneficial or pests. Explain to the students that any insect they find can be placed into a freezer to relax the insect before pinning. Demonstrate with the students showing them how to properly pin the insects.

Depending on their maturity level you may want to designate a group leader. Students should include on labels: Date, location collected and insect name. Over the course of two weeks students are to collect insects and include them in their collection. At the end of two weeks each group will discuss their findings, and share their collections with the class.

Georgia Performance Science Standard learning objective:

SCS3.Students identify and investigate problems scientifically
SCS1. Students will evaluate the importance of curiosity, honesty, openness, and skepticism in science.
SCSh6. Students will communicate scientific investigations and information clearly.
SEN4. Students will investigate the impact of insects on human health and history.

Teacher Notes: Prior to the activity discuss with the class the different orders of insects. Include many visually different varieties of insects. Hand out insect identification guide and instructions of how to collect insects. Use websites below to explain orders of insects.

Helpful Websites

Introduction to insect orders

http://www.entomology.umn.edu/cues/4015/handouts/Orders.htm

http://www.sci.sdsu.edu/classes/bio462/easykey.html

http://www.utahbugclub.org/collection.html

Other websites that can be used.

National Geographic
Bugwood www.bugwood.org
Bug Guide www.bugguide.net
What's that Bug www.whatsthatbug.com

Other Resources

Petersons field guide to insects

Pest Insect Collection:

Key Words: *Pest, Nuisance, Beneficial, Habitat*

Pest: A pest can be anything that causes harm to any person, place or thing. A pest can be an insect that eats your home. Or any insect that infests your food (Ants, Flies), or anything that enters the wrong place at the wrong time can be considered a pest.

Collecting and identifying insects is how scientists learn about new species. Scientists often travel around the world looking for different types of insects. However some of the best insects are right in your backyard.

What are insects?

Insects are part of the phylum Arthropoda and part of the class insecta. Arthropoda includes animals such as mites, scorpions, insects, spiders and millipedes among others. What separates insects out from other classes of Arthropods is that insects have six legs and a head, abdomen and thorax. Insects can live in almost any environment. You can find them in homes, trees, ocean, Antarctica, on people as well as animals.

Use your knowledge about insects to start your own insect collection with your group but remember you are to collect Pests only. Therefore, anything that is considered a pest you can place it in your collection. For each insect you need to answer several questions. So let's get started!

My Insect collection: (Pests)

One way scientists keep track of insects is to place them in a categorical table. A table can share a lot of important information about an insect and especially whether or not it is harmful. With your collection of insects we are going to place them into categories to learn more about the insects in our area.

Instructions: Collect 10 insects and pin them in your box. Using your insect guide try to determine their order (what group of insects do they belong to). Once you have figured out their order answer the graph below.

Number	What kind of Insect?	Habitat Where did you find this insect?	Is it a pest? Yes/no	Why do you think it is a pest?
1	Roach Blattodea	Kitchen Sink	Yes	Because it was in our kitchen…
2				
3				
4				
5				
6				
7				
8				
9				
10				

Wrap up Questions:

1. Did you see any similarity with your collection and the other (Beneficial) groups' collection?

2. Can a pest be beneficial too?

3. Which insects were the hardest to collect?

4. Where did you find the most insects?

5. How many insects were Pests?

6. How many were not pests?

7. Create a Graph displaying your answers.

Pests vs Beneficial

Insect Collection: (Beneficial)

One way scientists keep track of insects is to place them in a categorical table. A table can share a lot of important information about an insect and especially whether or not it is harmful. With your collection of insects we are going to place them into categories to learn more about the insects in our area. ***Instructions:*** Collect 10 insects and pin them in your box. Using your insect guide try to determine their order (what group of insects do they belong to)? Once you have figured out their order answer the table below.

Number	What kind of Insect did you find?	Habitat Where did you find this insect?	Is it a pest? Yes/no	Why do you think it is a Beneficial?
1				
2				
3				
4				
5				
6				
7				
8				
9				

Wrap up Questions:

1. Did you see any similarity with your collection and the other (Pest) groups' collection?

2. Can beneficial insect be a pest?

3. Which insects were the hardest to collect?

4. Where did you find the most insects?

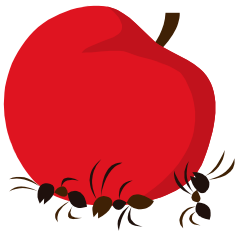
5. How many insects were Pests?

6. How many were not pests?

7. Create a Graph displaying your answers.

Pests vs Beneficial

Time to Eat!!



Grade level: Kindergarten through Second Grade

Time: Set Up 15-min, Activity 30-min

Subjects/Topics Covered: Biology, Environmental Science, Physiology, Anatomy

Objectives:

Students learn about basic insect mouth parts.
Students will be able to incorporate the activity into their home life.
Students gain an understanding of how insects affect human life.
Students learn morphology and physiology of insects.
Students learn about plant and insect interactions.

Materials

Sponges
Capri Sun Drinks or juice boxes with straws
Chewing Gum
Paper plates

Activity

This can be a project that the students can perform as a class project. Give each student a plate with a small amount of water, sponge, drink box, sucker and chewing gum. Using these items demonstrate how insects acquire food. Using the sponge and plate of water demonstrate how a fly would pick up liquid food by soaking up the water and then releasing the water only to suck it up again. With the box drinks demonstrate how a mosquito would pierce the skin of the host and remove the nutrients. Use the straws to demonstrate how a butterfly removes liquid from a flower by sucking nectar. Use the chewing gum or some other food to demonstrate chewing. Show the students each mouth part that correlates to the feeding behavior. Then allow them to use their tools to mimic insect feeding behavior.

Student Activity

Have each student draw his or her favorite mouthpart.

Have them find an insect with their favorite mouthpart

Have the student write a report on how, where and what this insect eats to survive.

Create a graph of everyone's answers and see what mouth parts are the class favorite.

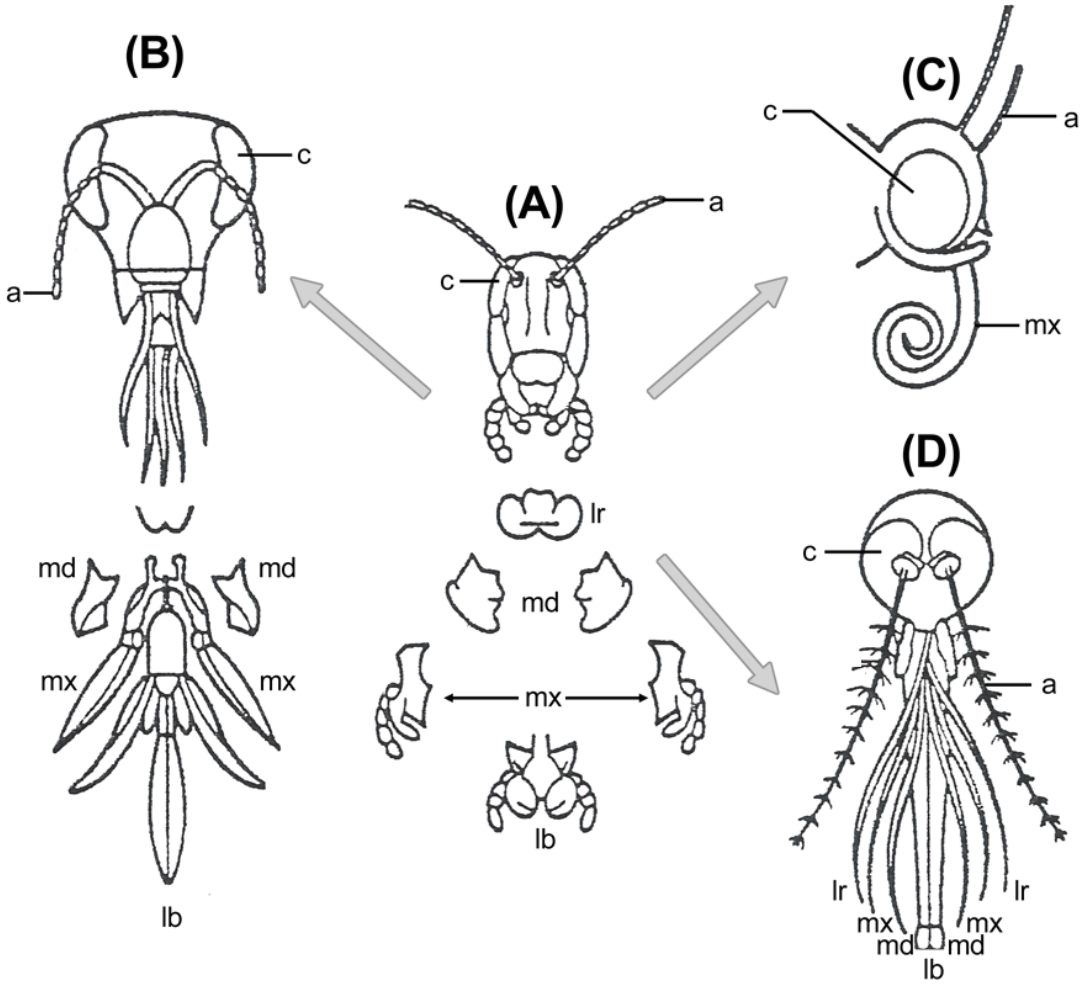
Georgia Performance Science Standard learning objective:

SCS3.Students identifies and investigates problems scientifically
SCS1. Students will evaluate the importance of curiosity

Teacher Notes: Discuss how insects use the structures on their head for protection, eating, mating, and to find prey. A great interactive website that can be use to demonstrate mouth parts is the website listed below.
http://www.cals.ncsu.edu/course/ent425/library/labs/external_anatomy/anatomy_mouthparts.html

Insect Mouth Parts

(Wilkepedia.com 2011)



A. Chewing
B. Sponging
C. Siphoning
D. Piercing Sucking
a=antennae
c= ocelli
mx= maxilliary palps
lb= labium
lr= labrum
md=mandible

Build a Bug

Grade level: Sixth to Eighth Grade

Time: Set Up 15-min, Activity 30-min

Subjects/Topics Covered: Biology, Environmental Science, Chemistry, Human Health

Objectives:

Students will learn about insect, biology.
Students will gain an understanding of insect habitats.
Students will learn the life cycle of insects
Student will learn why an insect is a pest.

Materials

Craft supplies: tissue paper, sand, glitter, colored paper, feathers, glue, markers, scissors, magazines, craft eyes, pipe cleaners, etc

Activity

This can be a project that the students can perform as a homework project or a class project. Students are to design their own bug. Using the tools above students will create what they believe to be an indestructible insect. The product is a new bug complete with the food it consumes, its habitat and its natural enemies.

Georgia Performance Science Standard learning objective:

SCS3.Students identifies and investigates problems scientifically
SCS1. Students will evaluate the importance of curiosity, honesty, openness, and skepticism in science.
SCSh6. Students will communicate scientific investigations and information clearly.

Teacher Notes:

Discuss various insects their habitats, including their natural enemies and what they eat. This will give the students a foundation to build their bug. Ask the students to imagine they could create the perfect insect. Discuss what insects need to survive (light, temperature, water, food etc). Show them an example and challenge them to create one of their own. Essential concepts: IPM habitat modification to control insect pests. This will teach students about insects and how they survive in the right habitats. At the end of the project ask the students to figure out who's bug is the most resilient, beneficial and a pest.

Build a Bug

Have you ever wondered where insects live and what they eat? If you were a bug where would you live? What kind of food would you eat? There are many animals that feed on insects, what kind of insect would you eat?

Create your own insect and tell us about him or her. Does she live in buildings, trees, water or the sewer? What about living on another animal? Does this insect eat pizza, plastic, or glue? Does this insect have any natural enemies? How is this insect protected from natural enemies? Your insect should be indestructible and free from predators!! Good luck!

Project:	Design a bug (shape, size, color etc)
Bug Name:	Think of a name that describes the habitat or its food be creative
What it needs:	Create its habitat. Where does it live?
What does your insect eat:	What type of food?
What eats this bug:	Another insect? Animal? Create a natural predator
Tell us about your bug:	A day in the life of _____. When is he active?

How does he find his food?

Does he live by himself or with other bugs etc?

All About Bugs Crossword Puzzle

Grade: Sixth through Eighth

Time: 5-15 min

Ga. Standards:

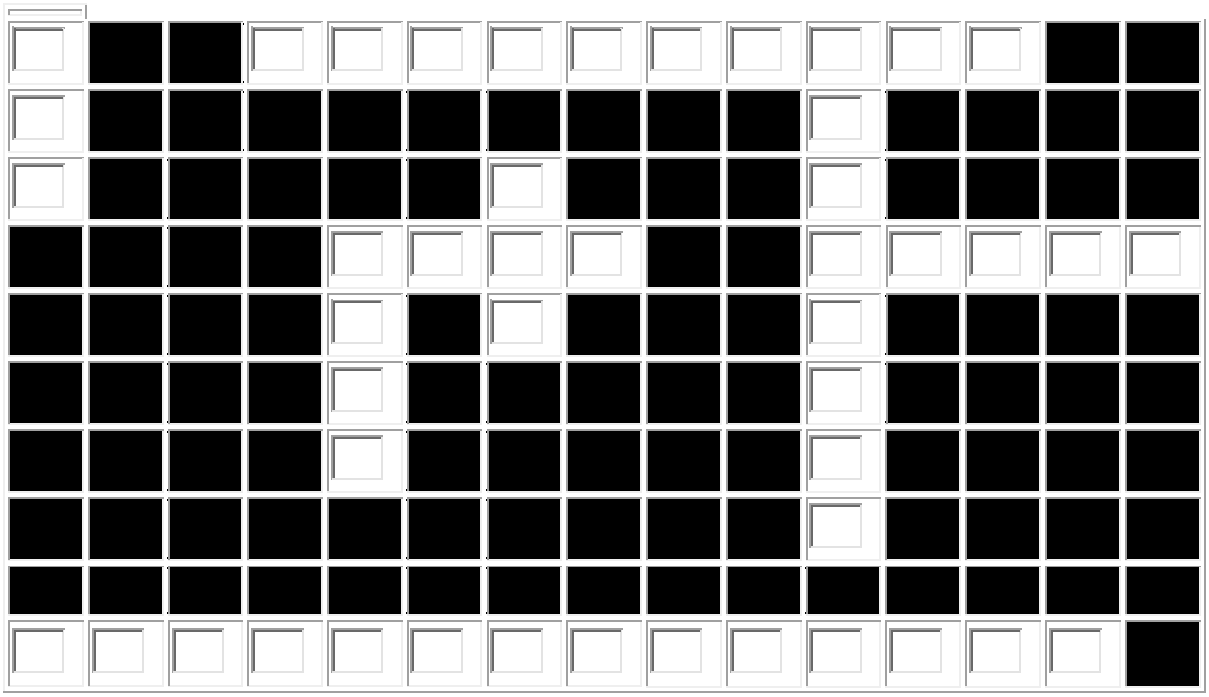
S8CS10. Students will enhance reading in all curriculum areas by:

- *Building vocabulary knowledge*
- *Demonstrate an understanding of contextual vocabulary in various subjects.*
- *Use content vocabulary in writing and speaking.*
- *Explore understanding of new words found in subject area texts.*

Activity

This is a crossword puzzle use to boost the students' entomology and IPM vocabulary. The words students will have to define are; Beneficial, Pupa, Adult, Holometabolous, Egg, Pest, IPM and Immature. Students are asked match the vocabulary with the definition and place it within the crossword grid.

All About IPM



	ACROSS	**DOWN**
	1.A GOOD BUG	1.THE FIRST STAGE
	2.BEFORE THE ADULT STAGE	2.A BAD BUG
	3.HAS WINGS	3.INTEGRATED PEST MANAGEMENT
	4.HAS FOUR STAGES	4.AFTER THE EGG STAGE

Answers to “All about IPM” cross word puzzle.

Grade Level-6-8

Across

1. Beneficial

2. Pupa

3. Adult

4. Holometabolous

Down

1. Egg

2. Pest

3. IPM

4. Immature

APPENDIX B

INTEGRATED PEST MANAGEMENT PLAN FOR THE CHATTAHOOCHEE RIVER NATIONAL RECREATION AREA

Integrated Pest Management Plan
Chattahoochee River
National Recreation Area

University of Georgia
Department of Entomology

Sonja L. Brannon, Dr. Brian T. Forschler

Chattahoochee River National Recreation Area Integrated Pest Management Plan

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Integrated Pest Management Plan

Chattahoochee River National Recreation Area

Atlanta, Georgia

I. Introduction

The Integrated Pest Management Plan (IPM) for the Chattahoochee River National Recreation Area (CRNRA) is designed to serve as a guide to the park coordinator, maintenance personnel, rangers and residents. It focuses on the proper intervention and management of common pests concerning the park facilities and visitor related areas.

IPM PLAN OBJECTIVE:

The plan for CRNRA will determine Federal, state and local laws pertinent to pest management and pesticides. It will include storage, transportation, registration, application, business/facility licensing, certification fees, reporting and all other relevant requirements for CRNRA installations and pest-management businesses that might provide local services. The final plan also shall list existing information relevant to CRNRA that incorporates best management practices and follows all federal, state and local laws.

Chattahoochee River National Recreation Area

The Chattahoochee River National Recreation area consists of a 48-mile stretch of the Chattahoochee River and 14 land units. It stretches from Lake Lanier and ends at Peachtree Creek in Atlanta, Georgia. The CRNRA encompasses various flora and fauna, as well as hiking trails, horseback trails, streams, lakes and picnic areas. This great diversity and proximity to urban areas make CRNRA a great candidate for IPM.

II. Laws Governing Integrated Pest Management

The Federal Insecticide Fungicide and Rodenticide Act (FIFRA), directs federal agencies to use an IPM approach to manage pests. FIFRA states “The Secretary of Agriculture in cooperation with the Administrator shall implement research, demonstration, and education programs to support adoption of IPM….The Secretary of Agriculture and the Administrator shall make information on IPM widely available to pesticide users, including federal agencies. Furthermore Federal agencies shall use Integrated Pest Management techniques in carrying out pest management activities and shall promote IPM through procurement and regulatory policies and other activities (FIFRA, 7 U.S. C. 136 r-1)”.

Federal Regulations and Executive Orders Governing IPM

Executive Orders:

Animal Damage Control Order 11870
Exotic Organisms Order 11870
Greening the environment through leadership in environmental management Order 13148 Section 601 (a)
Invasive Species Order 13112 February 3, 1999
Pollution Control Order 12088
Protection and enhancement of environmental quality Order 11541

Federal Acts:

Carlson-Foley Act; Public Law 90-583
Clean Water Act 1977
Endangered Species Act, Public Law 93-205
Federal Insecticide, Fungicide, and Rodenticide Act
Federal Land Policy and Management Act of 1976
Federal Noxious Weed Act of 1974
Federal Water Pollution Control Act 1972
Migratory Bird Treaty Act of 1918
National Environmental Policy Act (NEPA)
National Invasive Species Act of 1996, 16 U.S. C. 4701
National Park Service Organic Act 39 Stat. 535
Non-indigenous Aquatic Nuisance Prevention and Control Act of 1990, 16 USC
Occupational Health and Safety Hazard Communication Standard Act of 1970
Plant Protection Act of 1996, 7 U.S.C. 136 (amends FIFRA and FDA)

Reclamation Act of 1902

Other Regulations and Laws:

Departmental Manual, Pesticide Use Policy, 517 DM 1
National Park Service Management Policies 2006
Noxious Weed Regulations, 7 CFR Part 360
Pesticide Programs, 40 CFR Subchapter E
President Carter's Presidential Memorandum 1979

Federal Laws Governing Pesticide application.

It is the Bureau of Land Managements' (BLM) policy that any BLM employee applying pesticides, signing pesticide use proposals, or supervising projects where pesticide applications occur, attend and pass the BLM course Integrated Pest Management Pesticide Applications. The U.S. Environmental Protection Agency (EPA) approved this course, and passing the course certifies you as a pesticide applicator on federal lands.

State and Local Laws

Rules of Georgia Pesticide use and Application Act of 1976

Record-keeping

Any pesticides used or stored for later use should be recorded and be kept on file for five (5) years. This includes the M.S.D.S. folder containing all chemical fact sheets. This information should be organized in one format and kept near the pesticide storage facility as well as the main office.

State Laws for record-keeping: Ga-40-21-5-.02
Content of Records states: All records of pesticide application required by these regulations shall include the following information: Appendix -2

A. Date and time of application
B. Name of person/company etc. for whom applied
C. Location of application site
D. Crop or target to which applied
E. Acreage, size of area treated or total amount of pesticide applied
F. Target pest for which applied

G. Pesticide used and application rate
H. Type of equipment used
I. Name of applicator
J. Notation of any unexpected occurrence at or during application, such as spillage, exposure of humans or non-target animals, or drift, and any corrective or emergency action taken.

Persons required to keep records 40-21-5-.01 (Ga. L. 1976, p. 369)

Georgia law states that every licensed pesticide handler shall maintain true and accurate records of all pesticide applications performed as a part of his business operations. Every licensed commercial pesticide applicator not employed by or otherwise acting for a licensed pesticide applicator shall maintain true and accurate records of all restricted use pesticides and pesticides with State restricted uses, whether applied by him or persons under his supervision. Licensed private pesticide applicators shall not be required to maintain records of pesticide application.

Private Applicators Georgia 40-21-2-.02 states

Any category includes any certified applicator who uses or supervises the use of any restricted use pesticide or state restricted pesticide used in the production of an agricultural or forestry commodity on property owned, rented or otherwise under the control of him or his employer or (if applied without compensation other than trading of personal services between producers of such commodities) on the property of another person.

III. Roles and Responsibilities

Park Superintendent:

The responsibility of the Park Superintendent is to make sure all new and existing federal, state and local laws are being conveyed to the park coordinator and other involved parties including but not limited to:

- Acquire funding, staff and materials required for IPM projects.
- Continue to monitor, and perform regular meetings concerning the park IPM efforts as mandated by the federal, state and local laws.
- He/she should also designate an IPM coordinator to implement pest management programs and monitor pests and arising issues.

Park Coordinator:

His/her duties are to make certain that each division follows proper IPM guidelines and laws through quarterly reports from the superintendent. He/she will help identify procedures including appropriate monitoring techniques, evaluations, and action plans for pest management that involve the type, source and number of pests and recommended treatment methods. Treatment methods may involve nonchemical or chemical options.

The coordinator:

- Will gain proper identification for all pests that detrimentally affect park resources or pose health or safety concerns. When arthropods or small animals can not be identified in the park, specimens will be properly preserved and sent to specialists. Identifications of larger animals will be made by specialists from clear photographs.
- Will inspect facilities and monitor for seasonal changes in pest populations, document potential and actual damage caused by pests, and recommend least toxic methods for managing pests.
- Will identify and monitor cultural and/or environmental conditions in the park that encourage or support pests and will develop programs for remedial action plans.
- Will evaluate all available physical, mechanical, and cultural pest management options for acceptability and feasibility before using chemical pesticides.
- Will assure required NPS approvals are obtained (via P.U.P.S.) before any pesticide is used in the park. The coordinator will inform pesticide applicators, whether in-house or contracted, about NPS pesticide use policies: monitor applicators for safety considerations and assure applicators follow label precautions and application guidelines.
- Will establish techniques to measure relative efficacy of pest management success and keep the Chief of Maintenance informed about inspection and evaluation results/records.
- Will consult with the cultural resources specialists before initiating any structural modifications, landscape changes or other pest management activities that might affect cultural resources.
- Will make information on pesticides used or areas treated in the park available to both the public and employees.
- Will prepare appropriate forms and maps for recording data from monitoring and inspections activities. Inspection and monitoring reports will list deficiencies found and “flag” them for repair by the Maintenance division or Landscape division. The coordinator will establish and maintain permanent files of inspection and monitoring results.

- Will train the park staff, to enable them to complement the IPM effort in the park.

The Museum Curator:

Pest management duties for the Museum Curator are important to the park IPM program. The curator will:

- At least semi-annually (preferably, monthly) physically inspect the entire museum and museum storage areas making notes on harborage available to pests, pest evidence, damage to historical artifacts, and structural defects or conditions that encourage pests. Inspections will record defects or needed repairs on maps or floor plans. Additional "spot inspections" may be made at other times during the year, as dictated by needs. Inspection results will be recorded on Museum inspection reports and permanently filed for future reference.
- Thoroughly clean museum storage exteriors and interiors at least weekly.
- Will utilize proper monitoring devices such as sticky traps, identification resources outlined in the NPS IPM manual as well as other records needed to detect pests.

Chief of Maintenance:

- Maintenance crews, because they usually visit places not seen by most employees and visitors, serve as a vital component of monitoring and management of pests.
- Chief of Maintenance shall report any sightings of fecal matter, arthropod or rodent remains or damage to structures that indicate possible pest activity in addition to structural damage caused by man or nature should to be reported to the IPM coordinator to ensure timely repair of potential pest entry points or harborage.
- Custodians will also maintain proper sanitation in park facilities including trails, classrooms, including daily attention to high traffic areas.
- Installation of proper door sweeps doors, windows and window screens to keep out pests.

- Maintenance will also report any leaks, water damage or floor damage to the Chief of Maintenance as soon as noticed.
- Chief of Maintenance will ensure quick response to any damage, leaks or potential problems in the park and any other conditions that support pests.
- Any debris; including piles of construction materials, wood, metal or chemical containers used and unused should be properly removed.
- Landscapers, ground maintenance and any other related employees, will coordinate with the IPM Coordinator regarding best management practices including but not limited to:
- Planting appropriate shrubbery around and near structures
- Reduction of ground cover to keep out perimeter pests
- Trimming hedges, trees and other plants that may contribute to a pest infestation and to encourage proper air flow around structures
- Timing and application of pesticides
- Notification of application and supporting laws/ordinances for pesticide usage.

Park Rangers:

Rangers that patrol the park areas will report illegal dumping or chemical disposal on park properties. They also should report to the IPM coordinator any complaints from guests concerning pests near public areas, as well as, other wildlife issues.

Chief of Resource Management:

Scientists and any other employees (biologists, laboratory technicians including volunteers and interpretation guides) should report any sightings around the park involving new species that could become invasive as well as animals that have moved into new areas. They should report to the IPM coordinator any potential harborage for pests. They will coordinate, with the IPM coordinator, training for staff regarding new and invasive species management.

IV. Integrated Pest Management at Chattahoochee River National Recreation Area

Integrated pest management:
(as defined in FIFRA) is a sustainable approach to managing pests by combining biological, cultural, physical and chemical tools in a way that minimizes economic, health and environmental risks. A pest is defined as: Any insect, rodent, nematode, fungus, weed or any form of terrestrial or aquatic plant or animal life or virus, bacteria or other microorganism (not on living animals or man) which the administrator declares to be a pest (see NPS Management 2006). This policy also states pest are living organisms that may interfere with the site-specific purposes, operations or management objectives or that jeopardize human health or safety.

Developing an IPM strategy to manage pests.
Deciding when and what method to use to manage a pest depends on several factors. One should only control pests when an established threshold has been met. Thresholds are the minimum or maximum number of pests in a certain area. Establishing thresholds is very important in a successful IPM plan. Thresholds dictate the type and timing of an action aimed at managing a pest according to the biology of that pest. The IPM coordinator should determine the proper thresholds for CRNRA facilities. It is important to remember that one threshold may not fit the same pest in every situation.
An example of a threshold: A rat is found in a stack of wood along a trail. The sighting could be noted and ignored or the wood stacked properly to discourage harborage for rats. However if this same rat were sighted inside a kitchen area it would need to be eradicated starting with a thorough cleaning of the area, removal of all harborage and sealing all entry points.

Implementing IPM to manage pests:
Once a threshold has been met or exceeded it is time to employ an IPM approach for managing that pest. Descriptions of how to conduct IPM are, by necessity, outlined as a series of “steps”. However, it is important to remember that IPM is a site-specific philosophy or way of thinking that includes accountability (record-keeping) and is aimed at sustainable reductions in pest sightings – therefore the emphasis on knowledge of pest biology and the unique features of any area where the pest was observed/sighted/recorded. This document will outline IPM as a series of seven steps but it should be remembered that these steps do not have to be followed in any particular sequence in each and every pest-related situation. Often times controlling a pest problem will not be as straightforward as following a series of steps; however the seven steps are

provided as guidance for understanding the process of IPM. The IPM coordinator is responsible for confirming these steps are utilized in any effort to manage pests.

The steps are:

1. Identify the Pest
2. Inspect the area
3. Develop an Action Plan
4. Take Action
5. Monitor pest population
6. Revisit Action Plan and make modifications
7. Continue Monitoring

Pest Management Matrix for the Seven IPM steps.

1. **Identify the pest.** The first step in pest management is to properly identify the pest. A proper identification is necessary to understanding the pests' biology. Preservation and collection of common arthropods encountered in the CRNRA can be useful for current and future identification of these pests. Digital or pinned specimens can be used. Pest biology is key to proper management. There are several biological factors that should be identified for any pest before proceeding to the next step in the IPM process. All animal pests need food, water and harborage (a place to rest, hide, or nest). All plant pests need sunlight, water and nutrients (soil conditions). These biological life-support requirements are unique for each pest and can vary within a pest group. For example identifying a pest as an ant or roach does not provide the level of biological detail required to describe the food, water and harborage requirements for a particular species of ant – a fire ant has different life-support requirements from a carpenter ant. In contrast, identifying a pest as a millipede or scorpion is sufficient to implementing an appropriate intervention.

Identification Resources

Cooperative Extension
NPMA Field Guide
Resources section XI
In House collection
Appendix 3 & 6

When the pest is properly identified proceed to step ……2

2. **Inspection.** All pests have a unique set of life support requirements. Plant pests require a range of sun, water and nutrient conditions; animal pests, likewise, have food, water, and harborage needs. Identifying those unique biological factors for a particular pest at a particular site (where the pest was sighted) is the first step toward developing a sustainable action plan and should be the focus of any inspection.

Following an inspection and identification of site features conducive to pests proceed to step……3

3. **Action Plan.** In this step the first consideration is whether the pest population, as determined by monitoring, sightings or damage, has reached or exceeded the threshold for action. Thresholds will vary by pest and situation. No action - if the threshold is not reached - is a viable IPM option. If the threshold is exceeded, pest biology should determine the when, how, and type of intervention needed to manage the pest population given the site specifics identified during the inspection. Identifying those aspects for a particular site that allow pest numbers/sighting given that pests' life support requirements is the first step toward developing a sustainable action plan. Plant pests, for example, may be managed by altering the amount of sun reaching a site or by amending soil nutrients. Animal pests may be excluded from buildings by modification of the structure or pest numbers reduced by removing harborage sites or a moisture source from the landscape or building.

Questions to ask given knowledge of pest biology and site specifics:

Is there an aspect of the landscape that can be changed to impact this pest?

Is there an aspect of the building that can be changed to impact this pest?

Is there a moisture source that can be eliminated to impact this pest?

Is there a food source that can be eliminated to impact this pest?

Is there a harborage site that can be eliminated to impact this pest?

Types of Intervention:

No Action

When an infestation calls for no intervention a specific monitoring regime is often utilized.

Cultural

Is modification of a pests' habitat. Examples would be sanitation, crop rotation, removing harborages (includes reducing clutter inside & outside buildings), and reducing moisture in the habitat or access to water (includes building maintenance such as keeping gutters cleaned, fixing leaks or redirecting AC condensation runoff).

Mechanical/Physical

Picking bugs off of plants, weeding, trapping, burlap on trees, flyswatter, vacuuming, installation of door sweeps, window screen, closing access to harborages (caulking and vent screens).

Biological Control

Any organism used to manage populations of another organism. Importation, augmentation or conservation of parasitic insects, nematodes, predators, disease (bacteria, viruses, fungi) to manage pests.

Chemical

Chemical pest management involves the use of toxic active ingredients to kill or disrupt the lifecycle of a pest. Chemical management can be in the form of pheromones, pesticides, and repellants. Some commonly used pesticides are herbicides (plants), insecticides (insects), molluscicides (snails), avicides (birds), piscicides (fish), rodenticides (rodents), fungicides (fungi and bacteria). Pesticide formulations vary and the form used in any action plan must be appropriate for the specific pests' biology and site conditions.

For a guide on various pesticides and usage see the Georgia Pesticide Handbook

Selecting a Pesticide:

Consult P.U.P.S. for approved list of pesticides and their registered uses. If the pesticide needed is not present, a request must be made in accordance with the P.U.P.S Guidelines. Always read and apply pesticides in a manner that is consistent with the label.

For a key to reading labels see appendix 4.
(ALWAYS READ THE LABEL BEFORE USING ANY PESTICIDE!)

Formulation of an action plan based on site and pest specifics requires record keeping and communication with all appropriate NPS personnel from landscape managers, building supervisors, custodians, and rangers. An action plan using pesticides should be considered only after the aforementioned non-pesticide based intervention options are considered and/or implemented without successful reduction in pest complaints or damage. Pesticides must be applied according to the label in a manner that targets the intended pest to minimize non-target exposure.

Proceed to step ……..……4

4. **Take Action.** The action plan is implemented by conducting those interventions deemed appropriate given the known facts according to the site specifics (as described by the inspection) and pest biology (as determined from a proper identification).

Proceed to step……..5

5. **Monitor Pest Population**: Appropriate monitoring techniques will vary for each specific pest. Techniques include (but are not limited to) sticky traps, seasonal surveys, visual inspections of hot spots, and pest complaint logs. Communication between appropriate personnel/departments is a key component of any monitoring program.

Once an appropriate monitoring system is identified and implemented;
Proceed to step…….……..6

6. **Revisit Action plan and make adjustments (if needed)**: Data from the monitoring program should determine if modifications to the original action plan are needed to manage the pest. This step is required because even the best inspections do not always identify features of a particular site that are capable of supporting a particular pest population. If the original action plan is not effective - as determined by the monitoring program - the revision should only proceed after another inspection. The follow-up inspection must be aimed at identifying areas that were 'missed' in the first inspection and pest specimens should be sent to experts for definitive identification (in other words proceed to STEP 2 and start again).

Proceed to step…….7

7. **Continue Monitoring**: Monitoring is a record-keeping requirement and a group effort involving all concerned parties. Maintenance, staff, volunteers and other employees should report and record any sightings or changes in the park to the IPM coordinator for consideration of preventative interventions and immediate attention.

V. Common Pests at CRNRA and suggested management.

This list is a summary of common pests around the CRNRA. The list is by no means inclusive of all pests and potential threats to the park. The information listed below can be supplemented with the NPS IPM Manual, Georgia Pesticide Handbook, National Pest Management Guide and other information listed in the common links and reference section of this manual.

Rats/ Mice:

Principle pest rat species consist of roof and norway rats associated with attics, walls and woodpiles. These animals usually enter buildings via openings found around roofs, foundations as well as utility access points -pipes or electrical conduit penetrations. Mice can enter through the same access points however they can use smaller-sized openings.. Sealing around utility access points, roofs, and foundations can prove helpful in managing these animals. Also removing any debris (potential harborage) around the exterior of buildings, fixing leaking pipes and removing potential food can facilitate managing these rodents. Traps used in conjunction with cultural efforts are often effective and rodenticide use must be in accordance with label instructions. (See appendix 6 for Identification)

Ticks:

Lone Star Tick American Dog Tick

Ticks are blood-feeding external parasites commonly found around places frequented by their host(s). In the CRNRA the major hosts of tick populations are small rodents, lizards, and deer. Ticks require areas of dense vegetation to complete their most vulnerable life stage - the egg - and reducing areas where high humidity exists at ground level (by cutting brush and tall grass) will reduce tick populations. To avoid these pests stay out of areas with dense vegetation, use repellents (preferably products containing DEET or permethrin) according to label directions, and conduct a "tick check" (visual examination of the entire body) after every outdoor experience in a tick-prone area. Ticks require 24-hr to beginning exchanging their saliva (which could be infected with Lyme disease) so a "tick check" within 24-hr of exposure to tick habitat will reduce the probability of problems. Tick identification and information on disease problems can be found in the NPS IPM manual, Appendix 6 as well as the Georgia Pest Management Handbook.

Scorpions:

Scorpions are predators of insects that tend to frequent areas of high humidity like basements and bathrooms. Fixing leaky pipes, removing harborage places (old storage places, piles of leaves surrounding exterior etc.) and reducing the number of potential prey of this animal, will aid in managing these pests. - Also, reducing the use of outdoor lights around buildings or using sodium vapor lights and removing areas of heavy mulch from near the building foundation. Excluding ground-dwelling scorpions by using door sweeps and sealing window and door frames with caulk will also reduce the indoor appearance of these pests. (See appendix 6 for Identification)

Weeds:

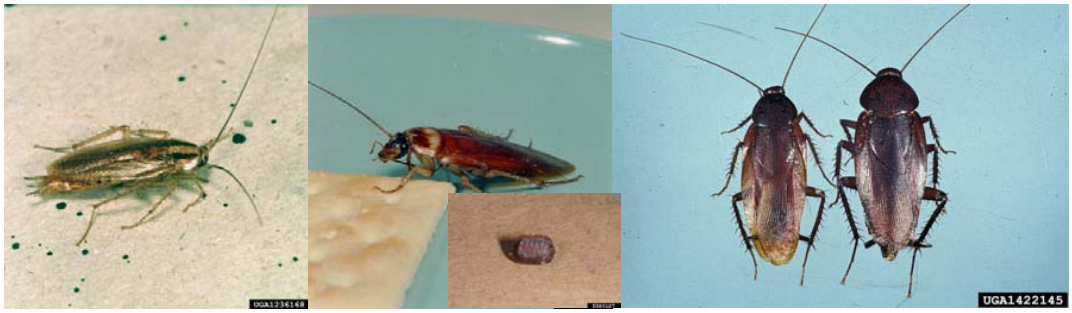
The definition of a weed is “any plant that is out of place” therefore when selecting to manage a certain plant you should always consider the conditions of the surrounding area. Sunlight, water, and soil conditions foster certain plants. Modify the habitat if possible to eradicate unwanted plants and physical removal (weeding or tillage) from certain areas may be an appropriate intervention, however a plant is never really removed if living roots are still present. Attacking weeds using herbicides during their dormant stage or before they develop a flower may require more than one product. Check the herbicide label to determine if it is a pre- or post emergence pesticide. Do not apply herbicides during a drought unless the label guarantees control. Most plants “shut down” their sites targeted by herbicides during droughts. See the Georgia Pest Control Handbook for selected weeds and herbicides recommended for their control.

Common weeds found in the Chattahoochee River National Recreation Area and some that are on the Invasive species watch list can be found in Appendix 3.

Spiders:

There are several species of spiders that inhabit the CRNRA facilities. A majority of these are aesthetic problems usually not harmful to humans. However there are two spiders that should be a concern. The Black and Brown Widow's and the Brown Recluse are found in this area and although they rarely cause serious problems can make a person ill if they happen to bite. These spiders harbor in dark places, such as woodpiles, rock piles, attics, crawlspaces, storage areas or any location subjected to little disturbance. Management would include removing harborages by eliminating 'clutter' both indoors and outdoors. Mechanical methods such as physical crushing and/or vacuuming webs, spiders and egg sacs around buildings on a regular schedule are effective. Reducing lighting that attracts insects (spiders food) can also assist in reducing spider populations. Furthermore, monitoring tools such as sticky traps can be used to find "hot spots" of spider activity or entry points into structures. (See appendix 6 for Identification)

Roaches:



German Cockroach American Cockroach/w egg case Smokey Brown Cockroach

Brown Banded Cockroach

There are several types of roaches that can inhabit common areas around the park. It is well documented that roaches may mechanically vector diseases and their fecal matter and cast skins can cause respiratory illness. Proper identification to species is critical. Roaches include species that display a diversity of biological attributes; therefore, management has to be specifically targeted for that species. Roaches require harborages that provide darkness, high humidity and no air movement to reproduce and build their populations. Kitchen, bathrooms, and storage areas are places that can provide roaches the necessary harborage that is close to a water and food source. Utilize sticky traps to monitor for 'hot spots' of activity and insecticidal baits to manage this pest inside buildings. Bait placement will be dictated by the species and site specifics determined through inspection and monitoring. (See appendix 6 for Identification)

Two examples of commonly encountered species are the Smoky Brown and German Cockroaches. These two insects vary in identity and biology. The Smoky Brown is commonly known to inhabit sewage areas. However, the German cockroach inhabits homes with a likeness to areas where food and other perishable items are stored. Management of these insects differs due to their biological attributes. The Smokey Brown can be managed by exclusion methods such as covering drains, pipes and other

openings with a fine metal mesh. This method requires maintenance of drainage areas along with periodical cleaning of mesh coverings. The German cockroach can be managed via a baiting system placed near harborage sites. Use sticky traps to determine harborage sites and application sites. Inspection of items brought into the park can also reduce the incidence of bringing in new roaches.

Termites:

Subterranean Termites *Workers* *Adults*

The most common species in Georgia are the subterranean termites including the eastern subterranean and Formosan termite. Identifying swarms of termites verses ants is critical to proper management. Termites have wings that fold neatly onto their backs, both wings are the same size, and antennae that are straight. Ants on the other hand have wings that stand out in an “A” position over their back, have a larger front wing with a small back wing, and antennae that are 'elbowed' or bent. Insects cause damage to structures because they feed on dead wood. Termites are transparent, soft bodied insects that are sensitive to desiccation. To manage these pests reduce moisture around the foundation of a building, remove any wood touching the soil (wood-to-ground contact) and keep the grade (soil

level around the foundation) below the last two elements of construction that support the building. Always consult a professional to ensure proper treatment using chemical methods. (See appendix 6 for Identification)

Snakes:

Snake management is best accomplished by reducing their food sources. Removal of rodents and other animals usually assists in reducing snake sightings. Common areas near bodies of water such as lakes or ponds should have nearby brush and tall weeds removed to reduce harborages. Modifying the habitat and removing food sources is the best way to control snakes along with knowledge of potentially harmful snakes in the area. This information should be available to park employees as well as park guests. (See appendix 6 for Identification)

Birds:

Birds are a problem when they roost in and around structures. There are several birds that live in the park boundaries and many are protected species making identification important. There are several tactics that can be used to make roosting sites undesirable including bird spikes, noise devices or “dummy” birds of prey. (See appendix 6 for Identification)

Ants:

Red Imported Fire Ant *Odorous House Ant* *Argentine Ants*

There are numerous species of ants in CRNRA and species identification is critical to designing an appropriate action plan because of the diversity of biological needs for the various species. See the NPS IPM manual for keys and tips to identify pest ants. In general, ants are social insects that live in colonies and display species specific life-history traits important to understanding their management. The life of an ant revolves around the queen who is always found in a nest along with 90% of the ant population that includes the "brood" (eggs, larvae and pupae). Therefore, those ants that leave the nest to forage for food and water represent a small percentage of the colony. Foraging ants cannot swallow solid foods so they carry this back to the nest and feed it to the larval ants that digest and then share the food back to the workers in the nest. This food flow has been described as a social stomach and is the reason why baiting for ants is the most appropriate insecticidal intervention for managing most pest ants. (See appendix 6 for identification)

- Fire Ants: The red imported fire ant, *Solenopsis invicta,* a common pest in natural settings as well as urban areas similar to the CRNRA. These ants are a threat due to their aggressive behavior making them more likely to sting when disturbed. The fire ant sting has been compared to wasps or bee stings. The medical threat arises due to the venom that is injected into the host. This venom can cause serious reactions in individuals that are allergic to the venom. Fire ant mounds can harbor thousands of ants below-ground in chambers that can extend several feet below ground. These ants will feed on various food sources (such as waste, dead and alive animals) and will come indoors. Management of these pests will vary by location, pest density and level and proximity to human activity. Mounds in high traffic areas can be treated with baits or application of approved liquid solution of insecticide. Bait treatment of mounds should involve making a small hole in the mound

surface and depositing of no more than 1/8 teaspoon of bait into the hole. Baits or dusts applied to the surface of an undisturbed mound are not effective.

Squirrels:

Exclusion is the only practical method for managing squirrels around building - which is the only time they are afforded pest status. Seal all entry points using appropriate and approved rodent proofing tactics after making certain during the breeding season (Dec &Jan., June& July) that no young are left inside. Remove or cut back any trees within 10 feet of a building. (See appendix 6 for identification)

Yellowjackets, wasps, Bees, and Hornets:

Bald-faced hornet Carpenter Bee

Stinging insects in the order Hymenoptera are generally not aggressive but will sting if provoked or disturbed. As social they have a lifestyle centered on a nest and most serious encounters with stinging insects involve human traffic in proximity to a nest site. Yellow jacket usually nest in the soil and those identified near buildings or on trails should be treated with an approved insecticide at night when all the colony members are inside. Yellowjackets can be a problem in public areas in the late summer or fall when their

natural prey items are less common and the colony populations are at their peak (having increased all summer long). Sanitation around public areas in the fall is a practical intervention that should include garbage cans with tight fitting lids. Sanitation is important because these animals will communicate the source of food to their nest mates and regular sources of food can accumulate high number of foraging yellowjackets. Yellowjackets and wasps are omnivorous insect predators that in the fall will switch, as their nocturnal prey diminish, in the fall to other sources of sugar and proteins. Yellowjacket traps placed near (but not in) areas of human activity can help reduce encounters with park visitors however, these must be placed in early spring/ summer before insect activity begins. Paper wasp nests are found in areas protected from the sun and rain - usually under the eaves of buildings. Those nests in areas of heavy human traffic can be treated with an approved insecticide. Identified honeybee hives, yellowjackets and hornet nests in or around structures should be referred to a licensed professional for treatment. (See appendix 6 for identification).

Aquatic Weeds/Fish:

There are thousands of weeds and invasive aquatic animals that invade lakes and ponds each year. Performing surveys of plant and aquatic species yearly will reduce the "surprise" of invasive organisms. Check with the park biologists quarterly to see if any new sightings have been detected. Compile an aquatic life survey complete with plants, invertebrates and other animals that would potentially be harmed or cause problems.

Interventions for aquatic pests must follow established procedures to reduce the risk of unintended non-target impacts.

VI. Other suggestions towards a successful IPM program:

Island Ford

***Offices/Buildings*:**

Place sticky traps in bathrooms, eating areas and storage rooms to monitor common pests. These should be checked bi-weekly for pest maintenance. Stored books, informational etc, should be properly sealed and sticky traps or other monitoring devices should be placed in storage areas to monitor potential pests. Employees should remove any debris (clothing, food, empty containers etc.) that will attract pests. Repair/install door sweeps window screens and leaks to keep out pests seeking shelter or food. Replace rotten wood as soon as possible to reduce carpenter ants and termites. Gutters should be cleaned seasonally or after a heavy storm and water should flow away from the building.

Kitchen:

Areas that contain food items should be cleaned on a monthly/weekly (minimum-major cleaning) and quarterly schedule (major). The quarterly cleaning should remove any unused food items and potential harborage places. Fix any leaky faucets and create a daily checklist for custodians. Place monitoring devices for rodents and insects under cabinets, refrigerators and other potential harborage places Use the pest identification keys in section (6) to identify new pests and properly manage current pests. Report any new sightings to the IPM coordinator.

***Bookstore*:**

Vacuum daily for commonly used rooms. Place sticky traps near bookshelves to monitor for pests such as carpet beetles, silverfish, roaches or other pests. Any items brought in for displays or educational purposes should be thoroughly inspected to reduce introduction of new pests.

Storage Facilities:

Storage facilities are a potential harborage place for insects, rodents and other pests. Always properly secure boxes to prevent pest infestation. Place monitoring stations and check bi weekly for signs of pest. Organize storage rooms quarterly or as needed and report any sightings to the IPM Coordinator.

Maintenance Facility:

Place sticky traps in bathrooms, eating areas and storage rooms to monitor common pests. These should be checked bi-weekly for pest maintenance. Stored items should be properly sealed and sticky traps or other monitoring devices should be placed in storage areas to monitor potential pests. Employees should remove any debris (stacks of paper, food, containers etc) that will attract pests. Repair/install door sweeps window screens and leaks to keep out pests seeking shelter or food. Any chemicals used should be properly stored and clothing used should be cleaned according to label directions. Remove piles of wood, scrap metal and old equipment from working areas to reduce wildlife and pest infestations.

***Housing*:**

Seal any openings that can serve as rodent/pest entry way. Clean eating areas daily, place monitoring devices for rodents and insects under cabinets, refrigerators and other potential harborage places. Place sticky traps in bathrooms, eating areas and storage rooms to monitor common pests. These should be checked bi-weekly for pest maintenance. Stored items should be properly sealed and sticky traps or other monitoring devices should be placed in storage areas to monitor potential pests. Employees should remove any debris (stacks of paper, food, containers etc) that will attract pests. Repair/install door sweeps window screens and leaks to keep out pests seeking shelter or food.

Restroom:

Cover sockets and open pipes to keep out pests. Create a daily cleaning checklist for custodians. This can include a section for pest sightings and key items listed to recognize various pests. Fix any leaking pipes to reduce pests. Report any pest sightings to the IPM Coordinator.

Vickery Creek

Pavilion*:*

Move trash cans away from buildings to reduce yellow jackets and other flying/biting or crawling pests. Clean pavilions quarterly/monthly, removing any wildlife, insect nests or other potential harborage places. Any new or potential sites should be identified and treated BEFORE the pest becomes a nuisance. Utility closets and storage areas should be cleaned twice per year or as needed to remove any harborage places for spiders and rodents. Surrounding grasses should be kept below 3 inches to reduce ticks, snakes and other harmful pests.

Restroom:

Cover sockets and open pipes to keep out pests. Create a daily cleaning checklist for custodians. This can include a section for pest sightings and key items listed to recognize various pests. Fix any leaking pipes to reduce pests. Report any pest sightings to the IPM Coordinator.

Jones Bridge

Pavilion*:*

Move trash cans away from buildings to reduce yellow jackets and other flying/biting or crawling pests. Clean pavilions quarterly/monthly, removing any wildlife, insect nests or other potential harborage places. Any new or potential sites should be identified and treated BEFORE the pest becomes a nuisance. Utility closets and storage areas should be cleaned twice per year or as needed to remove any harborage places for wildlife and spiders. Surrounding grasses should be kept below 3 inches to reduce ticks, snakes and other harmful pests.

Restroom:

Cover sockets and open pipes to keep out pests. Create a daily cleaning checklist for custodians. This can include a section for pest sightings and key items listed to recognize various pests. Fix any leaking pipes to reduce pests. Report any pest sightings to the IPM Coordinator.

Education Center

Cover sockets and open pipes to keep out pests. Vacuum daily for commonly used rooms, and weekly for rarely used spaces, to reduce pests. Create a daily cleaning checklist for custodians. This can include a section for pest sightings and key items listed to recognize various pests. Areas that contain food items should be cleaned on a monthly/weekly (minimum-major cleaning) and quarterly schedule (major). The quarterly cleaning should remove any unused food items and potential harborage places. Store items in secure containers and report any new sightings to the IPM coordinator. Repair/install door sweeps window screens and leaks to keep out pests seeking shelter or food. Any items brought in for displays or educational purposes should be thoroughly inspected to reduce introduction of new pests. Also any chemical used to treat pests should be labeled for use around children and should be placed out of reach in a secure location along with MSDS sheets for easy access to emergency information.

Bowmans Island

Pavilion*:*

Move trash cans away from buildings to reduce yellow jackets and other flying/biting or crawling pests. Clean pavilions quarterly/monthly, removing any wildlife, insect nests or other potential harborage places. Any new or potential sites should be identified and treated BEFORE the pest becomes a nuisance. Utility closets and storage areas should be cleaned twice per year or as needed to

remove any harborage places for wildlife and spiders. Surrounding grasses should be kept below 3 inches to reduce ticks, snakes and other harmful pests.

Restroom:

Cover sockets and open pipes to keep out pests. Create a daily cleaning checklist for custodians. This can include a section for pest sightings and key items listed to recognize various pests. Fix any leaking pipes to reduce pests. Report any pest sightings to the IPM Coordinator.

Palisades

Pavilion:

Move trash cans away from buildings to reduce yellow jackets and other flying/biting or crawling pests. Clean pavilions quarterly/monthly, removing any wildlife, insect nests or other potential harborage places. Any new or potential sites should be identified and treated BEFORE the pest becomes a nuisance. Utility closets and storage areas, should be cleaned twice per year or as needed to remove any harborage places for wildlife and spiders. Surrounding grasses should be kept below 3 inches to reduce ticks, snakes and other harmful pests.

Restroom:

Cover sockets and open pipes to keep out pests. Create a daily cleaning checklist for custodians. This can include a section for pest sightings and key items listed to recognize various pests. Fix any leaking pipes to reduce pests. Report any pest sightings to the IPM Coordinator.

The Rock

Cover sockets and open pipes to keep out pests. Vacuum daily for commonly used rooms, and weekly for rarely used spaces to reduce pests. Create a daily cleaning checklist for custodians. This can include a section for pest sightings and key items listed to recognize various pests. Areas that contain food items should be cleaned on a monthly/weekly (minimum-major cleaning) and quarterly schedule (major). The quarterly cleaning should remove any unused food items and potential harborage places. Store items in secure containers and report any new sightings to the IPM coordinator. Repair/install door sweeps window screens and leaks to keep out pests seeking shelter or food.

Any locations with mold (dispatchers' office) should be cleaned and humidity problems identified. Piles of wood, scrap metal and other storage locations should be

cleared/removed and properly disposed. Utility closets and attics should be cleaned twice per year or as needed to remove any harborage places for spiders and rodents. Attics can be inhabited by bats and various types of rodents, these animals leave fecal matter that can cause respiratory diseases and illnesses. If any are detected these areas should be properly cleaned by a trained professional.

Gutters need to be periodically checked for damage that can lead to water leaking into or close to buildings. Gutters should be cleaned seasonally or after a heavy storm and water should flow away from the building. Excavate any dirt mound or shrubbery up against buildings. Replace rotten wood as soon as possible to reduce carpenter ants and termites.

Allen Brook

Gutters need to be periodically checked for damage that can lead to water leaking into or close to buildings. Gutters should be cleaned seasonally or after a heavy storm and water should flow away from the building. Cover sockets and open pipes to keep out pests. Excavate any dirt mound or shrubbery up against buildings. Replace rotten wood as soon as possible to reduce carpenter ants and termites. Utilize sticky traps and other devices to monitor pest population. Paint peeling from walls is an indicator of humidity and potentially mold. Any location with mold should be cleaned and humidity problems corrected see mold and humidity suggestions in section VII.

VII. Moisture and Mold Prevention and Control Tips (EPA)

- When water leaks or spills occur indoors - **ACT QUICKLY**. If wet or damp materials or areas are dried 24-48 hours after a leak or spill happens, in most cases mold will not grow.
- Clean and repair roof gutters regularly.
- Make sure the ground slopes away from the building foundation, so that water does not enter or collect around the foundation.
- Keep air conditioning drip pans clean and the drain lines unobstructed and flowing properly.
- Keep indoor humidity low. If possible, keep indoor humidity below 60 percent (ideally between 30 and 50 percent) relative humidity. Relative humidity can be measured with a moisture or humidity meter, a small, inexpensive ($10-$50) instrument available at many hardware stores.
- If you see condensation or moisture collecting on windows, walls or pipes ACT QUICKLY to dry the wet surface and reduce the moisture/water source. Condensation can be a sign of high humidity.

Actions that will help to reduce humidity

- Vent appliances that produce moisture, such as clothes dryers, stoves, and kerosene heaters to the outside where possible. (Combustion appliances such as stoves and kerosene heaters produce water vapor and will increase the humidity unless vented to the outside.)
- Use air conditioners and/or de-humidifiers when needed.
- Run the bathroom fan or open the window when showering.

Actions that will help prevent condensation

- Reduce the humidity.
- Increase ventilation or air movement by opening doors and/or windows, when practical. Use fans as needed.
- Cover cold surfaces, such as cold water pipes, with insulation.
- Increase air temperature.

VIII. Human Health Protection and Guidelines:

Personal Protective Equipment (PPE)

The purpose of personal protective clothing and equipment is to shield or isolate individuals from the chemical, physical, and biological hazards that may be encountered. Careful selection and use of adequate PPE should protect the respiratory system, skin, eyes, face, hands, feet, head, body, and hearing. No single combination of protective equipment and clothing is capable of protecting against all hazards. Thus PPE should be used in conjunction with other protective methods. The use of PPE can itself create significant worker hazards, such as heat stress, physical or psychological stress, and impaired vision, mobility, and communication. In general, the greater the level of PPE protection, the greater the associated risks. For any given situation, equipment and clothing should be selected that provide an adequate level of protection. Overprotection as well as under-protection can be hazardous and should be avoided. Bear in mind that 85

of PPE failed to protect when studied in a recent survey of PPE effectiveness. As equipment ages, it may not work as well.

Note: *Employees must have medical clearance from a licensed physician to wear a respirator or personal protective equipment. The body incurs extra physical stress during the wearing of this protective equipment and it is important that employees be cleared by a licensed physician to undertake this additional stress.*

The use of PPE is required by OSHA regulations in 29 CFR part 1910 and reinforced by U.S. EPA regulations in 40 CFR part 300. www.osha-slc.gov

Storage and Disposal of Pesticides:

- Improper pesticide storage and disposal can be hazardous to human health and the environment. Follow these safety recommendations recommended by the EPA.
- Do not stockpile. Reduce storage needs by buying only the amount of pesticide that you will need in the near future or during the current season when the pest is active.
- Follow all storage instructions on the pesticide label.
- Store pesticides high enough so that they are out of reach of children and pests. This includes common pesticides such as wasp sprays and other common chemicals that may be in classrooms. If possible, keep all pesticides in a locked cabinet in a well-ventilated utility area or shed.
- Never store pesticides in cabinets with or near food, animal feed or medical supplies.
- Store flammable liquids outside your living/office area and far away from an ignition source such as a furnace, a car and outdoor grill, or a power lawn.
- Label with proper hazmat warning labels on the chemical (if mixed in container) and the entry ways of storage facilities. (Fig 1.)

Figure 1. Various warning labels for chemical storage facilities

Transportation of Pesticides (Environmental Safety Division)

- Always inspect your vehicle for sharp objects, and ensure vehicle stability for transportation of chemicals
- Place safety equipment needed application inside the vehicle
- Protective clothing as needed
- Absorbent materials such as kitty litter or spill kit (fig. 2)
- Goggles
- Soap and water to remove any chemicals from skin
- Respirator for fumes
- Shovel to build dirt dikes if needed
- MSDS sheets incase a spill occurs
- Never transport pesticides in the passenger seat of a vehicle
- Never load edible food or feed into the same cargo as chemicals
- Do not stack chemical containers
- Always drive with extreme caution
- In the case of a spill follow the MSDS sheets

Material Safety Data Sheets (MSDS)

All MSDS sheets should be kept bound in a folder and copies should be available in the pesticide storage facility as well as the office of the IPM coordinator. In the event of a chemical spill or injury due to pesticide mishandling, easy access to these is impertinent.

For further information or to locate a MSDS sheet visit the chemical manufacturer website.

Cleaning a Spill

- Large or small, cleaning a chemical spill can be hazardous to your health. The Center for Disease Control outlines several suggestions for proper cleaning a chemical spill.
- When spills occur immediately alert area occupants and evacuate the area where necessary. Attend to any people who may be contaminated, without endangering yourself.
- Contaminated clothing must be removed immediately and the skin flushed for no less than 15 minutes with water.
- Contaminated clothing must be laundered before reuse.
- Do not clean up spills if the material is mixed with other articles such as grass, paper etc. or if the material is reacting, i.e. hissing bubbling, smoking, gassing or burning.
- If there is any sign that a chemical reaction is happening evacuate the area immediately and call your local fire department for help.
- Put on Personal protective equipment as appropriate to the hazard before proceeding to control the spill.
- Stop the spill as quickly as possible by restoring the container to its upright position, closing a leaking valve or hose or putting a secondary container in place to catch the leaking solution.
- Begin clean up promptly. On pavement or concrete, use absorbent materials to capture the spilled liquids. Non-chlorinated pet litter is an inexpensive absorbent material for such purposes.
- Loose spill absorbent materials should be distributed over the entire spill area, working from the outside, circling to the inside. This reduces the chance of splash or spread of the chemical.

Figure 2. Spill kit used to control chemical spills.

- Once the spilled materials have been absorbed, use a brush and scoop to place materials in, a polyethylene bag for small spills, and a reusable screw top plastic container with polyethylene liners for larger quantities.
- If a spill occurs on soil, it may be necessary to dig up the contaminated soil.
- Keep an eye on the material once it has been picked up because there may be a delayed reaction.
- Affix a label to the chemical waste, identifying the material as spill debris involving XYZ chemical.
- Decontaminate the surface areas after cleanup where the spill occurred using a mild detergent and water, when appropriate.
- Dispose of all contaminated materials according to the manufacturer's instructions and the local regulations.

Trainings:

Trainings executed by the IPM Coordinator should include:

- Pesticide application training for all applicators
- Updates concerning new species and pests.
- Extension related trainings scheduled for Park Employees
- Trainings mandated by NPS
- Trainings on laws and new regulations (eg. droughts, flooding etc)

Herbicides **Common Name**	**Trade Name**	**Registration Number**	**Uses**
Renovate	Triclopyr	62719-37-67690	Control of submersed and floating aquatic plants
Clearcast	Imazamox	241-379	Floating and emersed weeds.
Hardball	2-4-D	5905-549	Floating weeds, emersed weeds and submersed weeds
Habitat	Imazapyr	241-426	Emergent and floating aquatic plants. As well as terrestrial plants.
Earth-tech/ Agritech	Copper Sulfate	64962- 1-ZG	Algae
Galleon	Penoxsulam	62719-546-67690	Floating and immersed weeds.
Sonar A.S.	fluridone	67690-4	Submersed weeds, immersed weeds, and floating weeds.
Stingray	Carfentrazone	128639-00-1-21	Floating weeds
Insecticides and Rodenticides **Common Name**	**Trade Name**		**Uses**
Coumadin	Warfarin		Control of rodents (Norway rat, Roof rat and house mouse)
Bromfenacoum	Brodifacoum		Control of rodents (Norway rat, Roof rat and house mouse)
Deet	Delphene, Detamide etc.		Repellant for biting midges, mosquitoes and mites
Pyrethroid	Various		Repellant and control for biting midges, mosquitoes and other organisms

X. Suggested Pesticides (See Georgia Pest Management handbook for detail uses and optional pesticides not listed). Note any pesticides other than listed must be preapproved via the NPS Pesticide Use Proposal System (P.U.P)

Herbicides Common Name	Trade Name	Registration Number	Uses
Credit Extra	Glyphosate	71368-20	Herbicide for control of Privet, Autumn-olive, English Ivey and other exotic plants
Fulsade Dx	Fluazifop P-Burly	100-1070	Herbicide for control of weeds on trails and parking lots.
Garlon 3A	Triclopyr	62719-37	Herbicide for control of Privet, Autumn-olive, Mimosa on roads and trails.
Garlon 4 Ultra	Triclopyr	62719-527	Herbicide for control of Privet, English Ivey and Vinca Major. In recreation areas.
Imazapur 28	Isopropyl amine	744-774	Herbicide for control of vegetation in forests.
Poast	Sethoxydim	7969-58-51036	Herbicide for Japanese Stilt grass on roads, trails and parking lots.
Razor Pro	Glyphosate	228-366	Herbicide non-selective, for control of weeds on roads and pavement.
Reward	Diquat	82542-14-84237	Herbicide (Aquatic) weed control only. See Label. See P.U.P.S. for detailed uses.
Transline	Clopyralid	464-m11	Herbicide for control of Kudzu, privet and other exotic plants
Insecticides Common Name	Trade Name	Registration Number	Uses
Amdro Fire Ant Bait	Hydramethylnon	73342-1	Insecticide for fire ants on picnic grounds and recreational areas
Bifen-LP	Bifenthrin	53883-124	Insecticide for control of ants, roaches and scorpions.
Borid, Borax, Boric Acid	Orthoboric Acid	9444-129	Insecticide for control of ants, roaches, Carpet Beetles and silverfish. Apply in cracks, crevices or entry points.
Max Force	Fipronil	432-1460	Insecticide bait for roaches inside offices and kitchen
Niban	Orthorbic Acid	644-052	Insecticide for control of roaches inside and outside of buildings.
Ortho Home Defense Max	Bifenthrin	239-2663	Insecticide for control of Cockroaches, Scorpions, Carpet Beetles, silverfish and Fire ants. Apply via crack and crevice in buildings and visitor center.
Ortho Hornet and Wasp Killer	Tetramethrin	42697-42-239	Insecticide for control of Yellowjackets and wasps in pavilions, and visitor sites.
Talstar	Bifenthrin	279-3168	Insecticide for control of ants, roaches and mole crickets
Termidor	Fipronil	7969-210	Insecticide for control of termites and ants outside perimeter of building.

IX. CRNRA Approved Pesticides: (See Georgia Pest Management handbook for detail uses and optional pesticides not listed). Note any pesticides other than listed must be preapproved via the NPS Pesticide Use Proposal System (P.U.P.)

X. Helpful Links and Phone Numbers (active links available on CD version)

Integrated Pest Management Links

NPS IPM Management Manual 2006
www.nature.nps.gov/biology/ipm/manual/ipmmanual.cfm

UC Davis IPM Website
http://www.ipm.ucdavis.edu/

Ga. Integrated Pest Management (IPM)
http://ipm.ent.uga.edu

Georgia Pest Management Handbook
www.ent.uga.edu/pmh/

Environmental Protection Agency
http://www.epa.gov/

Cooperative Extension Service
www.caes.uga.edu/extension

Human Health Protection and Safety

National Response Center (spills and chemical violations)
http://www.nrc.uscg.mil/nrchp.html 1-800-424-8802

Center for Disease Control
www.cdc.gov

Occupational Standard Health
www.osha-slc.gov

Materials Safety Data Sheets
www.MSDSonline.com

NIOSH Pocket Guide to Chemical Hazards
http://www.cdc.gov/niosh/npg/default.html

Pesticide Risks
http://extoxnet.orst.edu

Pesticide labels/MSDS from a range of companies.
http://www.CDMS.net

EPA Pesticide Safety Programs/Worker Protection Standard
http://www.epa.gov/agriculture

Environmental Safety Division
http://www.esd.uga.edu/

Pesticide Regulatory and Licensing Information

Georgia Department of Agriculture - Pesticide Division
http://agr.georgia.gov - click on Divisions and Plant Industry

Pesticide licensing
http://agr.georgia.gov - click on Divisions and Plant Industry

EPA Pesticide Product Information
http://ppis.ceris.purdue.edu

EPA List of Restricted-Use Pesticides
http://www.epa.gov/opprd001/rup

U.S. Fish & Wildlife Service: Endangered Species
http://www.fws.gov

EPA Office of Pesticide Programs
http://www.epa.gov/pesticides/

Pesticide Action Network North America
http://www.panna.org

National Pesticide Telecommunications Network
http://npic.orst.edu

EPA Agriculture Compliance Center
http://www.epa.gov/agriculture

Plant Insect and Animal Identification Links

UGA Plant Identification Service
http://www.plantbio.uga.edu/herbarium/policies/plidpolicy.html

UGA Insect Identification
http://www.ent.uga.edu/insectid.htm

USDA Plant Identification website
http://plants.usda.gov/index.html

Pictorial Dichotomous Plant key
http://www.cnr.vt.edu/DENDRO/DENDROLOGY/idit.htm

Forest Pests of North America
http://www.bugwood.org/ipmcd/

Invasive Plants of the Eastern United States: Identification and Control
http://www.invasive.org/eastern/

Key to Wildlife and Invertebrates
http://www.forestryimages.org/wildlife.cfm

Bugwood (Plant, Insect, Wildlife and Aquatic information)
http://www.bugwood.org/publications.html

Centers for Disease Control Pests of Human Health Concern
http://www.cdc.gov/nceh/ehs/Docs/Pictorial_Keys/Introduction.pdf

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* Indicates article is on file in catalog section of CD.

XII Appendices

Appendix 1. Pesticide record keeping form.

Name	Date	Brand or Product Name	EPA Registration #	Size of Area Treated	Total Amount Applied	Location	Pest

Site Application Area			
Living Areas	Offices/Visitor Areas	Exterior/Grounds	Method
1. Bedroom 1 2. Bedroom 2 3. Bedroom 3 4. Bedroom 4 5. Living area 6. Kitchen 7. Bathroom 1 8. Bathroom 2 9. Bathroom 3 10.Laundry Room 11.Storage Room 12.Garage 13. Crawl Space	14. Bookstore 15.Bathroom1 16.Bathroom 2 17.Bathroom 3 18.Meeting Room 19.Conference Rm 20.Storge Room 21. Craft Room 22. Employee Break Rm 23. Common Areas 24. Windows 25. Animal Displays 26. Service Desk 27. Attic 28. Classrooms 29. Dumpster Area	30. Trails 31. Pavilion Restrooms 32. Trash Cans near Pavilion 33. Right of Ways 34. Roads 35. Parking Lot 36. Sidewalk 37. Eves 38. Window sills 39. Ponds 40. Soil/Mulch 41. Deck 42. Foundation 43. Storage facility 44._____ 45._____ 46._____ 47._____	AE. Aerosol BP Bait Placement BR Broadcast CC Crack and Crevice EA Exterior Application FO Fog GS General Surface Spray IO Inspection MP Monitoring Placement PE Perimeter SP Spot (2 square feet or less) SS Space Spray VT Void Treatment ST Stump Treatment SO Soil Treatment
			Target Pest 1. Roaches 2. Termites 3. Weeds 4. Aquatic Weeds 5. Ants 6. Scorpions 7. Fleas 8. Ticks 9. Mosquitoes 10. Beetles 11. Caterpillars 12. Rats/ Mice 13.Spiders 14._____ 15._____

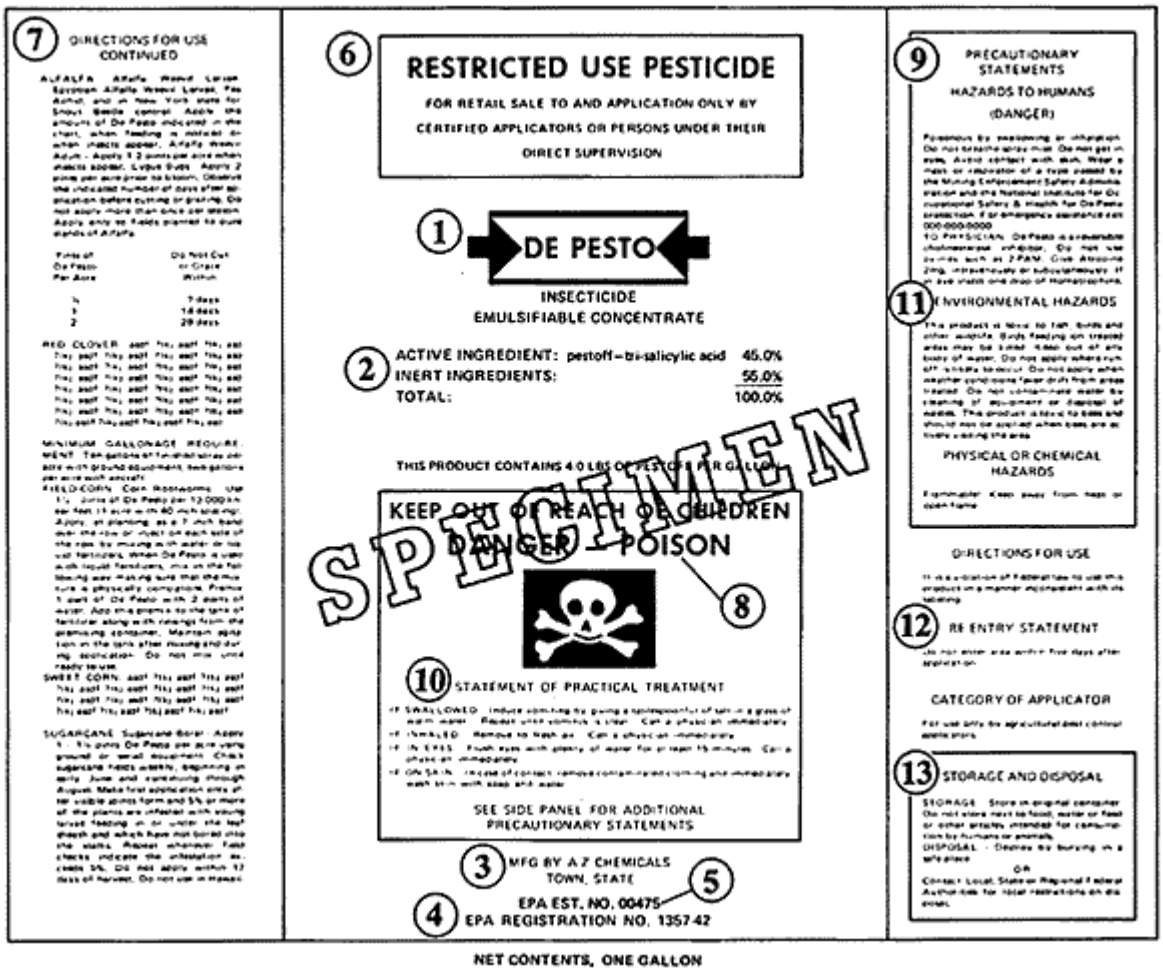
Appendix 2 B-25's Organic Pesticides

Active Ingredients Exempted Under 25(b) of the Federal Insecticide, Fungicide, & Rodenticide Act

* indicates exempt active ingredients that are also exempt from pesticide residue tolerance requirements

CASTOR OIL (U.S.P. OR EQUIVALENT)*
CEDAR OIL
CINNAMON AND CINNAMON OIL*
CITRIC ACID*
CITRONELLA AND CITRONELLA OIL
CLOVES AND CLOVE OIL*
CORN GLUTEN MEAL*
CORN OIL*
COTTONSEED OIL*
DRIED BLOOD
EUGENOL
GARLIC AND GARLIC OIL*
GERANIOL*
GERANIUM OIL
LAURYL SULFATE
LEMONGRASS OIL
LINSEED OIL
MALIC ACID
MINT AND MINT OIL
PEPPERMINT AND PEPPERMINT OIL*
2-PHENETHYL PROPIONATE (2-PHENYLETHYL PROPIONATE)
POTASSIUM SORBATE
PUTRESCENT WHOLE EGG SOLIDS
ROSEMARY AND ROSEMARY OIL*
SESAME (INCLUDES GROUND SESAME PLANT) AND SESAME OIL*
SODIUM CHLORIDE (COMMON SALT) *
SODIUM LAURYL SULFATE
SOYBEAN OIL
THYME AND THYME OIL*
WHITE PEPPER
ZINC METAL STRIPS (CONSISTING SOLELY OF ZINC METAL AND IMPURITIES)

Appendix 3. Sample Pesticide Label (Pesticide Education Resources; University of Nebraska – Lincoln)



Parts of a label:

1. Brand Name
2. Type of Pesticide
3. Ingredient Statement
4. Common Name
5. Chemical Name
6. Net Contents
7. EPA Registration Number
8. EPA Establishment Number
9. Classification Statement
10. Signal Words and Symbol
11. Reentry Statement
12. Pre-harvest Interval
13. Precautionary Statements
    - Route of Entry Statement
    - Specific Action Statement
    - Protective Clothing/Equipment
14. Statement of Practical Treatment
15. Environmental Hazards
    - Special Toxicity Statements
    - Environmental Statements
16. Physical or Chemical Hazards
17. Storage and Disposal
18. Manufacturer
19. Directions For Use

Appendix 4. List of current plant species of concern in the CRNRA. For updated control of these plants see the **"IPM Matrix"** and the **Georgia Pesticide Handbook**. For more detailed pictures of aquatic plants see the CRNA Survey of aquatic plants, and identification links in the resources section.

Aquatic Plants:

Parrot Feather Water Milfoil

Scientific name*:* *Myriophyllum aquaticum* Common names: parrotfeather, watermilfoil

Alligator Weed

Scientific name: *Alternanthera philoxeroides*
Common names: Alligator weed, pigweed

Brazilian Waterweed

Scientific name: *Egeria densa*
Common names: Brazilian elodea, Brazilian waterweed

Wartremoving Herb

Scientific name: *Murdannia keisak*

Common names: Wartremoving herb

Water Hyacinth

Scientific name*: Eichhornia* Kunth
Common name: Water hyacinth

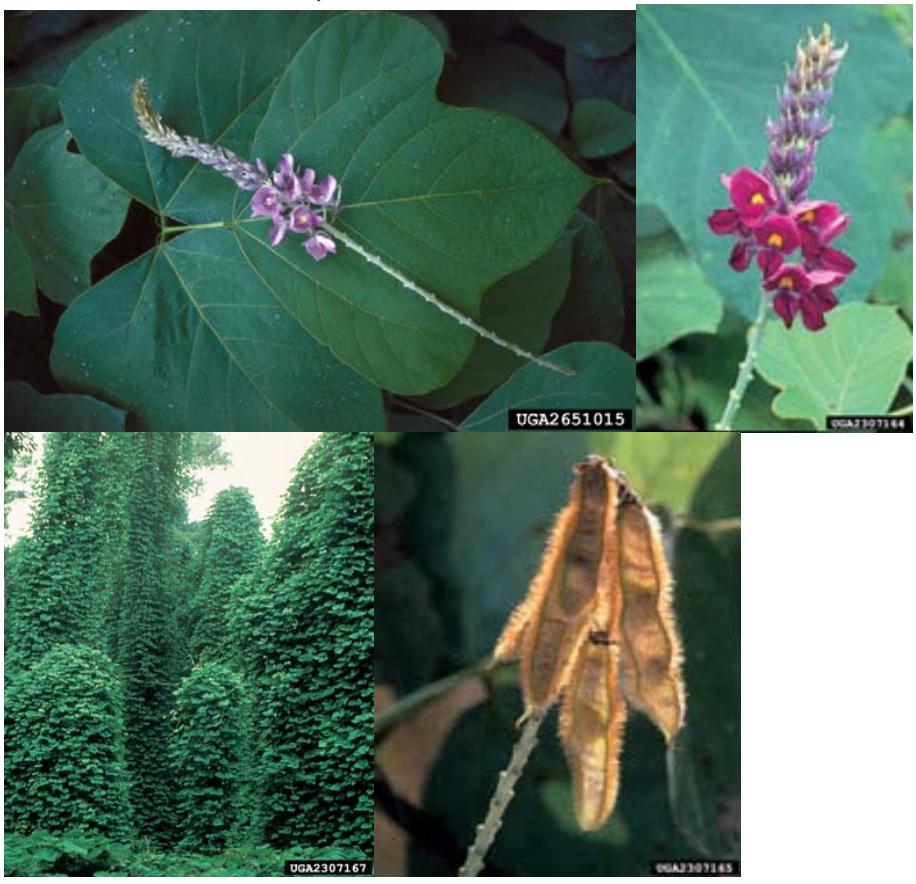
Giant Salvinia

Common names: Giant salvinia
Scientific name: *Salvinia molesta*

Terrestrial Plants

Kudzu

Scientific name: *Pueraria montana*
Common names: Kudzu, Kudzu-vine



Japanese Honeysuckle

Scientific name: *Lonicera japonica*
Common names: Japanese honeysuckle, madreselva

Russian Olive

Scientific name: *Elaeagnus angustifolia* L.
Common names: Russian olive, Oleaster

Autumn Olive

Scientific name: *Elaeagnus umbellata* .
Common names: Autumn olive, Elaeagnus, Oleaster, Japanese Silverberry


Chinese Privet

Scientific name*: Ligustrum sinense*
Common names: Chinese Privet

Mimosa

Scientific name*: Mimosa quadrivalvis*
Common names: Mimosa

Wisteria

Scientific name: *Wisteria frutescens*
Common names: American wisteria

Japanese Stilt Grass

Scientific name: *Microstegium vimineum*
Common names: Japanese stiltgrass, Nepalese browntop, Chinese packing grass, Asian stilt grass, annual jewgrass, bamboograss, Nepal microstegium, eulalia, Mary's grass

English Ivey

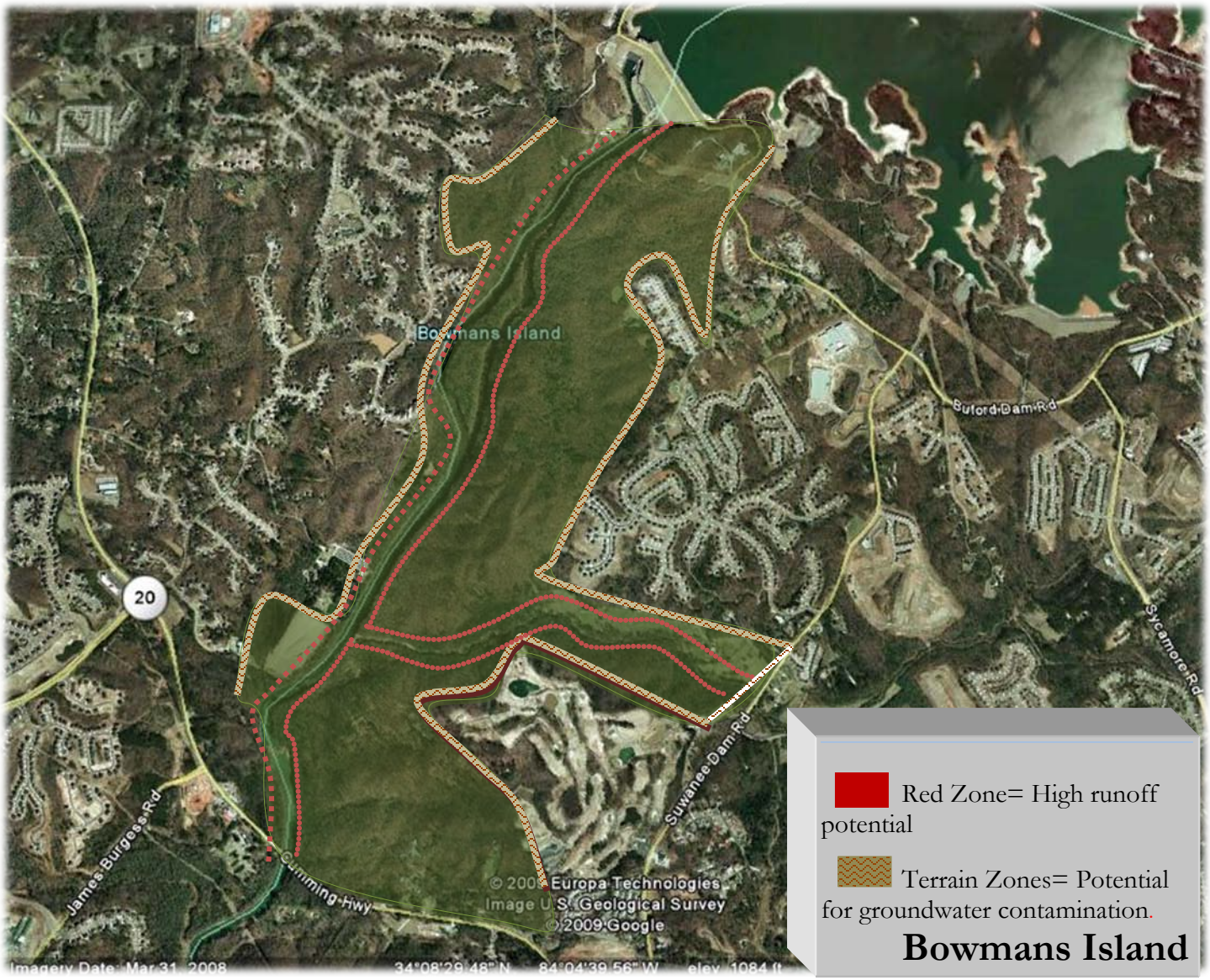
Common names: English Ivey
Scientific name: *Hedera helix*

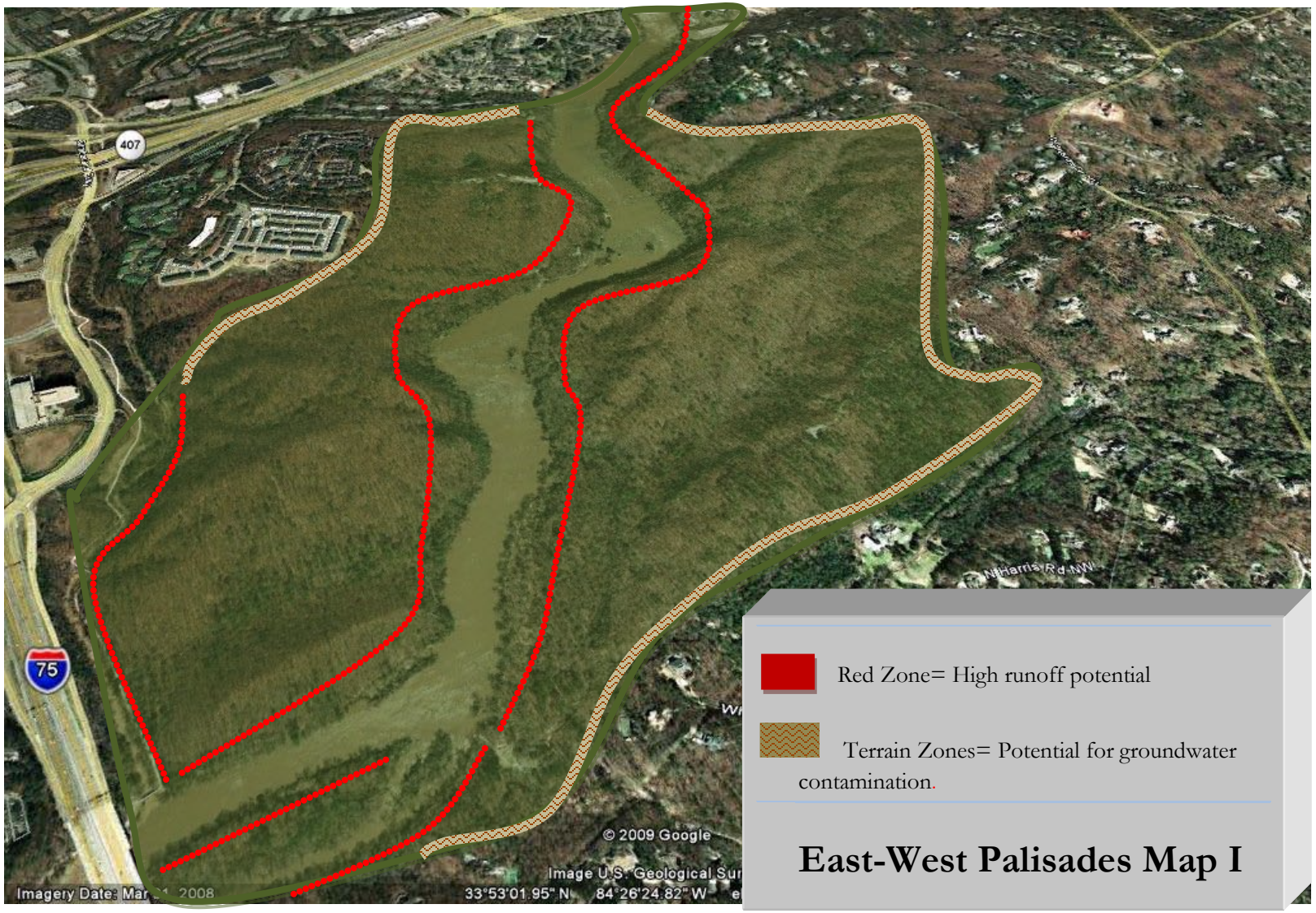
Chinese Lespedeza

Common names: Chinese Lespedeza
Scientific name*: Lespedeza cuneata*

Appendix 5. Geospatial Data.

CRNRA, is positioned among five areas of connecting watersheds. Because the CRNRA is also located in a Riverine habitat all areas of the park are subject to off-site movement of pesticides. Watershed in an urban area is five times that of natural settings due to run off from buildings, parking lots and roads. To decrease polluted runoff from paved surfaces alternatives can be developed to areas traditionally covered by impervious surfaces. Porous pavement materials are available for driveways and sidewalks, and native vegetation and mulch can boarder roads, pavilions, standing structures and trails. Use geospatial data to determine the proper location to apply pesticides. A red zone denotes potential for high run off and should be avoided at all times. A “terrain zone” indicates low-moderate potential for ground water contamination and pesticide applications should be use only when extremely necessary. Any chemical applications surrounding other portions of the park area should follow label directions for proper management.


Bowmans Island
Buford Dam Rd
Sycamore Rd
Suwanee Dam Rd
James Burgess Rd
Cumming Hwy
20
© 2009 Europa Technologies
Image U.S. Geological Survey
© 2009 Google
Imagery Date: Mar 31, 2008
34°08'29.48" N 84°04'39.56" W elev 1084 ft
Red Zone= High runoff potential
Terrain Zones= Potential for groundwater contamination.
Bowmans Island


407
75
N Harris Rd NW
© 2009 Google
Image U.S. Geological Sur
Imagery Date: Mar 21, 2008
33°53'01.95" N 84°26'24.82" W
Red Zone= High runoff potential
Terrain Zones= Potential for groundwater contamination.
East-West Palisades Map I


Island Ferry Rd
Martins Trail
Watergate Dr
Watergate Way
Applegate Ln
Roberts Dr
Summer Lake Dr
Cliffchase Close
Northcliff Trc
Natchez Trc
Gettysburg Pl
Summer Brook Dr
Riverside D
Huntingdon Trail
Island Ford Pkwy
Ridge Farm
Valley Tarn NE
Berkley Ridge NE
Red Zone= High runoff potential
Terrain Zones= Potential for groundwater contamination.
Island Ford
© 2009 Europa Technologies
© 2009 Google
Image U.S. Geological Survey
Image City of Roswell
Imagery Dates: Feb 17, 2007 - Mar 31, 2008
33°59'28.03" N 84°19'35.00" W elev 916 ft


Oxbo Dr
Vickery St
Walnut St
Sloan St
River Lake Ct
River Lake Dr
N Shore Ct
Over Land Dr
9
River Mill Ct
S Atlanta St
Church Cir
Jones
River Glen Dr
Chattahoochee Ct
Riverwalk Dr
© 2009 Europa Technologies
© 2009 Google
Image U.S. Geological Survey
Image City of Roswell
Imagery Dates: Feb 17, 2007 - Mar 31, 2008
34°00'40.54" N
84°21'07.45" W
elev 102
Red Zone= High runoff potential
Terrain Zones= Potential for groundwater contamination.
Vickery Creek

Appendix 6. Keys to Arthropods of Public Health Importance**.**

ARTHROPODS OF PUBLIC HEALTH IMPORTANCE: KEY TO COMMON CLASSES AND ORDERS

Harold George Scott and Chester J. Stojanovich

1. Three or 4 pairs of walking legs (Fig. 1 A & B).....2

   Five or more pairs of walking legs (Fig. 1 C & D).....33

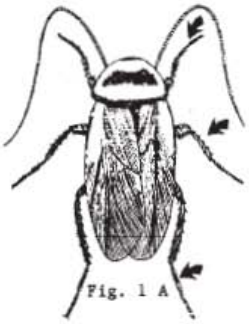


Fig. 1 A

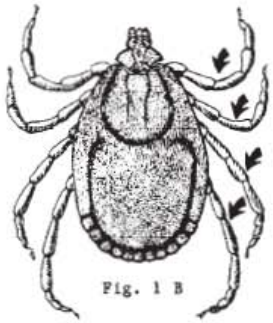


Fig. 1 B

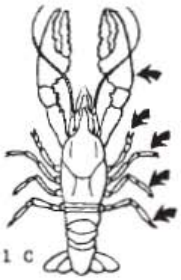


Fig. 1 C

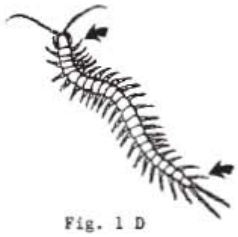


Fig. 1 D

2. Three pairs of walking legs (Fig. 2 A).....3

   Four pairs of walking legs (Fig. 2 B).....25

Fig. 2 A

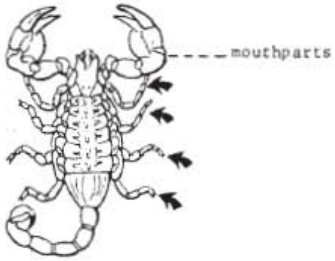


Fig. 2 B

3. Wings present, well developed (Fig. 3 A).....4

   Wings absent or rudimentary (Fig. 3 B & C).....13

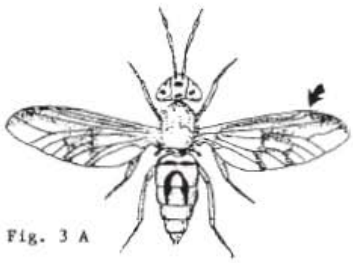


Fig. 3 A

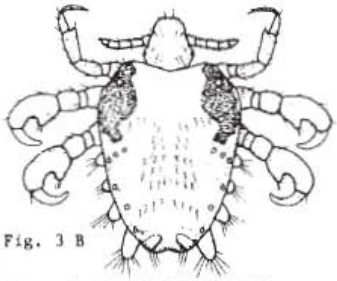


Fig. 3 B

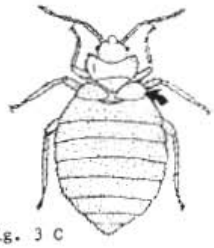


Fig. 3 C

4. With one pair of membranous wings (Fig. 4 A). ORDER DIPTERA.....5

   With two pairs of wings (Fig. 4 B & C).....6

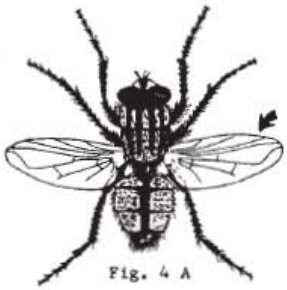


Fig. 4 A

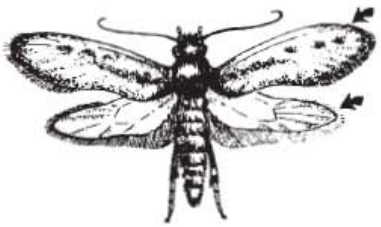


Fig. 4 B

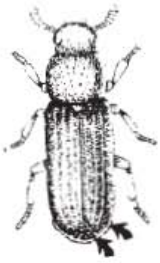


Fig. 4 C

5. Wings with scales (Fig. 5 A). FAMILY CULICIDAE.....MOSQUITO

   Wings without scales (Fig. 5 B). DIPTERA OTHER THAN MOSQUITOES.....FLY

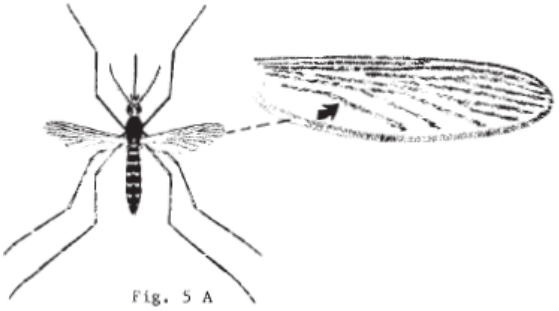


Fig. 5 A

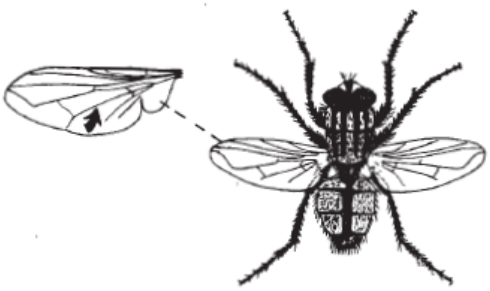


Fig. 5 B

6. Mouthparts adapted for sucking, with elongate proboscis (Fig. 6 A).....7

   Mouthparts adapted for chewing, without elongate proboscis (Fig. 6 B).....9

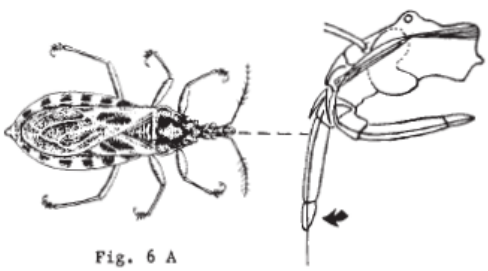


Fig. 6 A

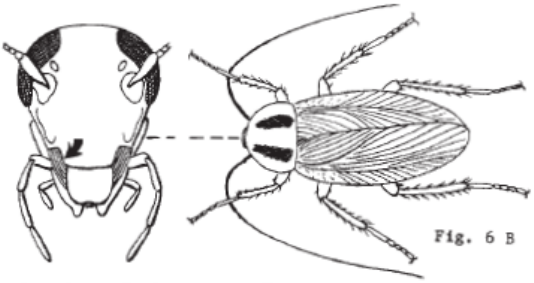


Fig. 6 B

7. Wings densely covered with scales; proboscis coiled (Fig. 7 A). ORDER LEPIDOPTERA.....
   .....MOTH OR BUTTERFLY

   Wings not covered with scales; proboscis not coiled (Fig. 7 B).....8

Fig. 7 A

Fig. 7 B

8. Wing with fringe of long hair (Fig. 8 A). ORDER THYSANOPTERA.....THRIPS

   Wing without long hair (Fig. 8 B). ORDER HEMIPTERA.....KISSING BUG

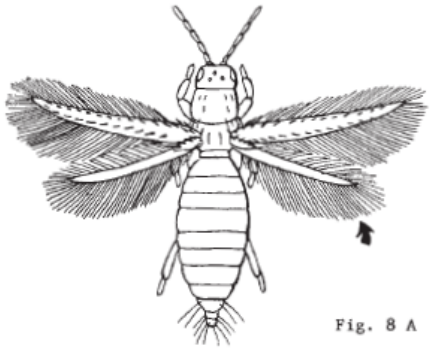


Fig. 8 A

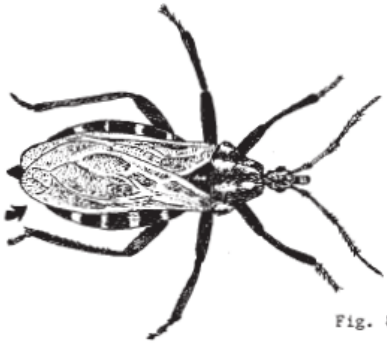


Fig. 8 B

9. Both pair of wings membranous and similar in structure (Fig. 9 A).....10

Front pair of wings shell-like or leathery, serving as covers for the second pair (Fig. 9 B).....11

Fig. 9 A

Fig. 9 B

10. Both pairs of wings similar in size (Fig. 10 A). ORDER ISOPTERA.....TERMITE

Hind wing much smaller than front wing (Fig. 10 B). ORDER HYMENOPTERA.....
.....BEE, HORNET, WASP, YELLOW JACKET, OR ANT

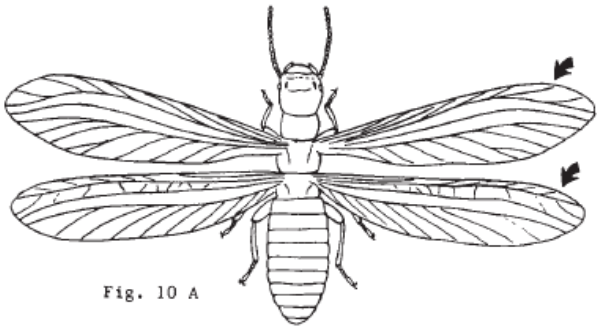


Fig. 10 A

Fig. 10 B

11. Front wings horny or leathery, without distinct veins (Fig. 11 A).....12

Front wings leathery or paper-like, with distinct veins (Fig. 11 B). ORDER ORTHOPTERA.....COCKROACH

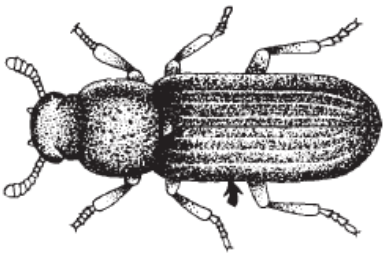


Fig. 11 A

Fig. 11 B

12. Abdomen with prominent cerci; wings shorter than abdomen (Fig. 12 A). ORDER DERMAPTERA.....EARWIG

Abdomen without prominent cerci; wings covering abdomen (Fig. 12 B). ORDER COLEOPTERA.....BEETLE

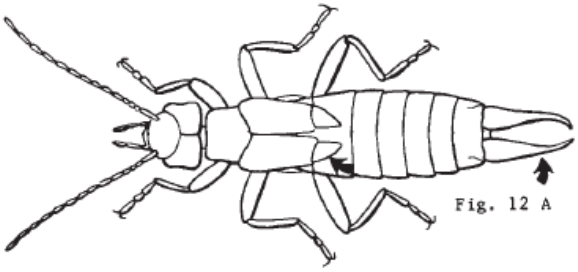


Fig. 12 A

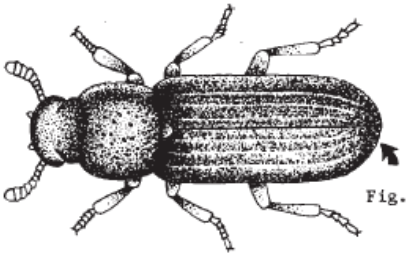


Fig. 12 B

13. Mouthparts with jaws for chewing (Fig. 13 A).....14

Mouthparts with a long beak or stylets for sucking up food (Fig. 13 B).....21

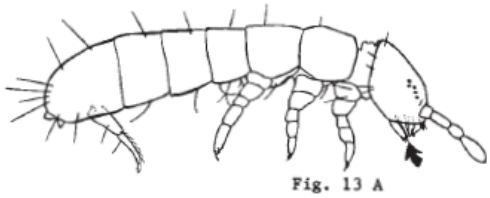


Fig. 13 A

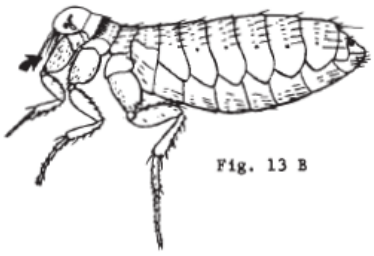


Fig. 13 B

14. With three long terminal tails (Fig. 14 A). ORDER THYSANURA.....SILVERFISH AND FIREBRAT

Without three long terminal tails (Fig. 14 B).....15

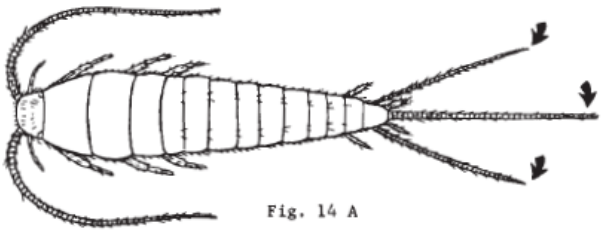


Fig. 14 A

Fig. 14 B

15. Abdomen with prominent pair of cerci (Fig. 15 A). ORDER DERMAPTERA.....EARWIG

Abdomen without prominent pair of cerci (Fig. 15 B).....16

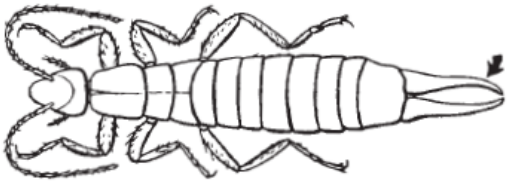


Fig. 15 A

Fig. 15 B

16. With narrow waist (Fig. 16 A). ORDER HYMENOPTERA.....ANT

Without narrow waist (Fig. 16 B).....17

Fig. 16 A

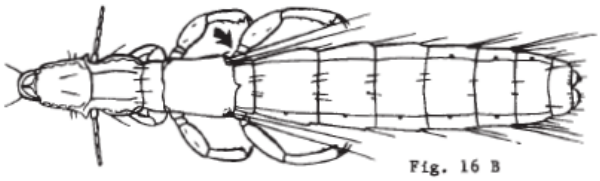


Fig. 16 B

17. Antenna with fewer than 8 segments (Fig. 17 A).....18

Antenna with more than 8 segments (Fig. 17 B).....19

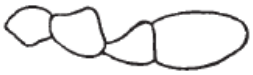


Fig. 17 A

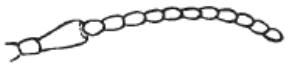


Fig. 17 B

18. Abdomen with 6 or fewer segments (Fig. 18 A). ORDER COLLEMBOLA.....SPRINGTAIL

Abdomen with more than 6 segments (Fig. 18 B). ORDER MALLOPHAGA.....CHEWING LOUSE

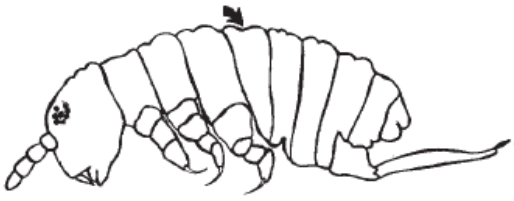


Fig. 18 A

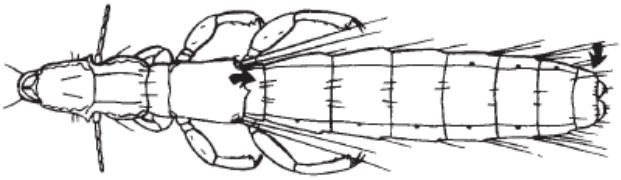


Fig. 18 B

19. Tarsus with 4-5 segments (Fig. 19 A).....20

Tarsus with 1-3 segments (fig. 19 B). ORDER PSOCOPTERA.....BOOK LOUSE OR PSOCID

Fig. 19 A

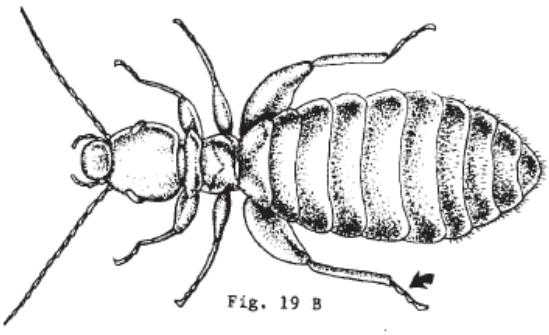


Fig. 19 B

20. Pronotum narrower than head, never covering head (Fig. 20 A). ORDER ISOPTERA.....TERMITE

Pronotum broader than head, often covering head (Fig. 20 B). ORDER ORTHOPTERA.....COCKROACH

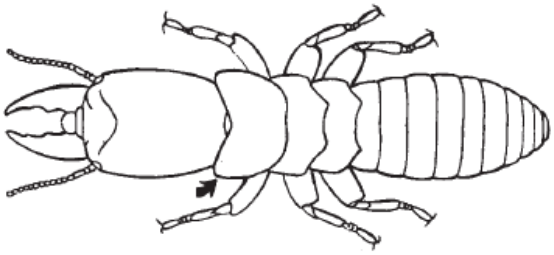


Fig. 20 A

Fig. 20 B

21. Flattened laterally (Fig. 21 A). ORDER SIPHONATERA.....FLEA

Flattened dorso-ventrally (Fig. 21 B).....22

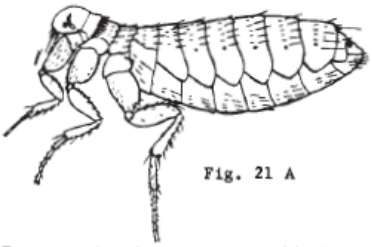


Fig. 21 A

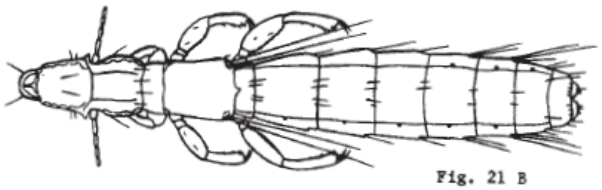


Fig. 21 B

22. Foot terminating in protrusible bladder (Fig. 22 A). ORDER THYSANOPTERA.....THRIPS

Foot not terminating in protrusible bladder (Fig. 22 B).....23

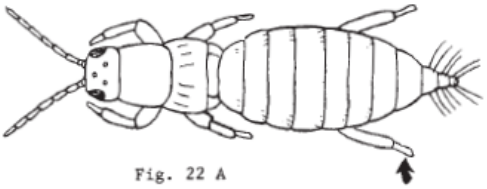


Fig. 22 A

Fig. 22 B

23. Beak jointed (Fig. 23 A). ORDER HEMIPTERA.....BEDBUG

Beak not jointed (Fig. 23 B).....24

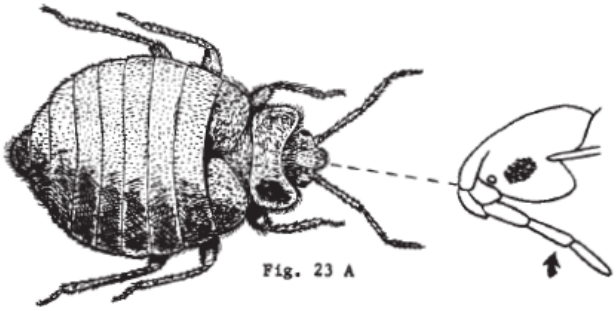


Fig. 23 A

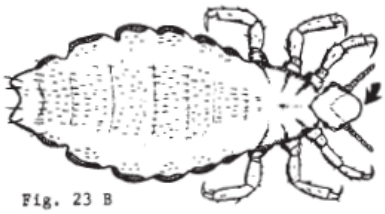


Fig. 23 B

24. Mouthparts retracted into head (Fig. 24 A). ORDER ANOPLURA.....SUCKING LOUSE

Mouthparts not retracted into head (Fig. 24 B). ORDER DIPTERA.....KED OR LOUSE FLY

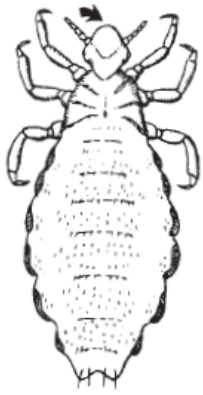


Fig. 24 A

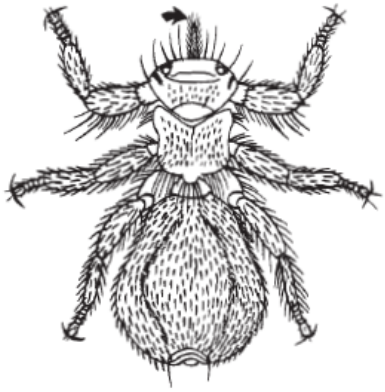


Fig. 24 B

25. Abdomen well-developed (Fig. 25 A). CLASS ARACHNIDA.....26

Abdomen peg-like (Fig. 25 B). CLASS PYCNOGONIDA.....SEA SPIDER

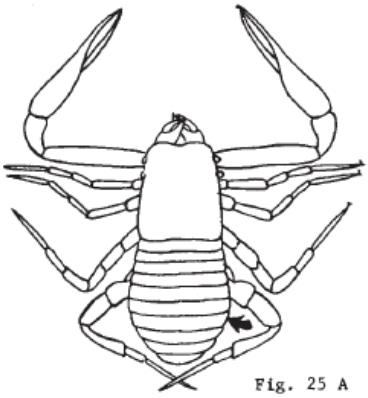


Fig. 25 A

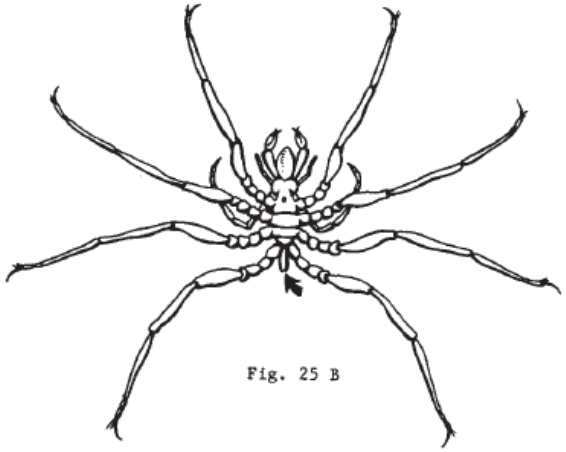


Fig. 25 B

26. Abdomen distinctly segmented (Fig. 26 A).....27

Abdomen not distinctly segmented (Fig. 26 B).....31

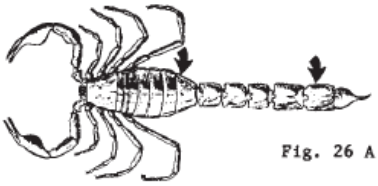


Fig. 26 A

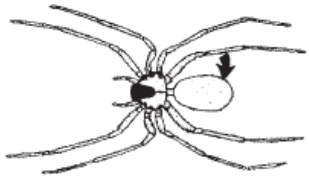


Fig. 26 B

27. Abdomen lengthened to form a long tail (Fig. 27 A).....28

Abdomen not lengthened to form a long tail (Fig. 27 B).....29

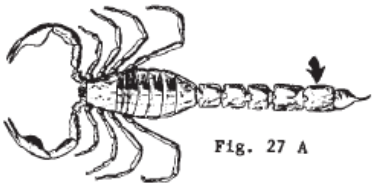


Fig. 27 A

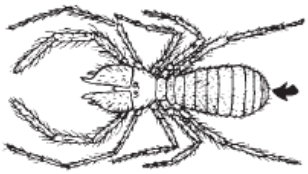


Fig. 27 B

28. Tail with stinger (Fig. 28 A). ORDER SCORPIONIDA.....SCORPION

Tail without stinger (Fig. 28 B). ORDER PEDIPALPIDA.....WHIP SCORPION

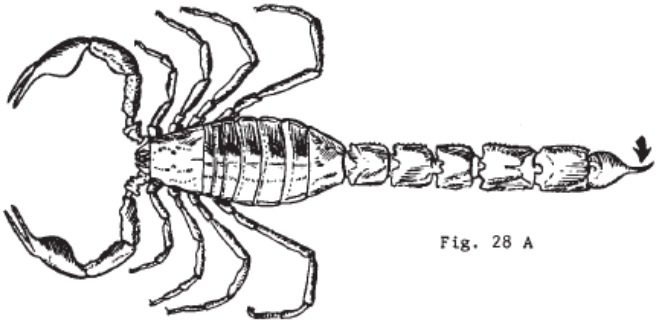


Fig. 28 A

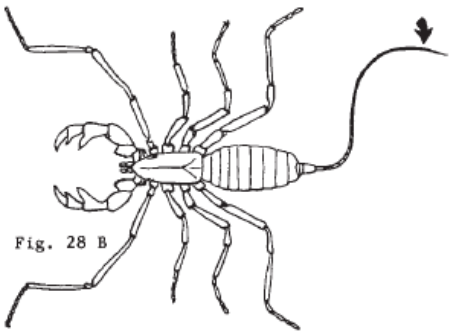


Fig. 28 B

29. With large pincer-like claws (Fig. 29 A). ORDER PSEUDOSCORPIONIDA.....PSEUDOSCORPION

Without large pincer-like claws (Fig. 29 B).....30

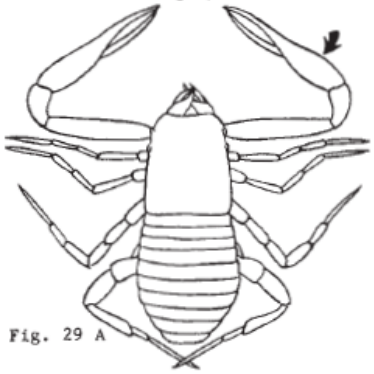


Fig. 29 A

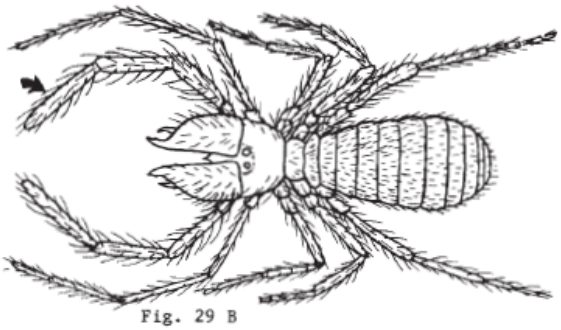


Fig. 29 B

30. Legs not longer than body (Fig. 30 A). ORDER SOLPUGIDA.....SUN SPIDER

Legs much longer than body (Fig. 30 B). ORDER PHALANGIDA.....DADDY LONG-LEG SPIDER

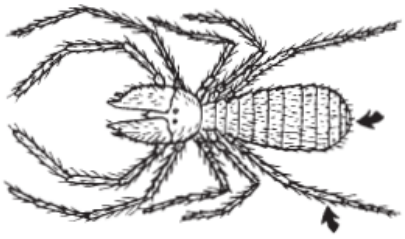


Fig. 30 A

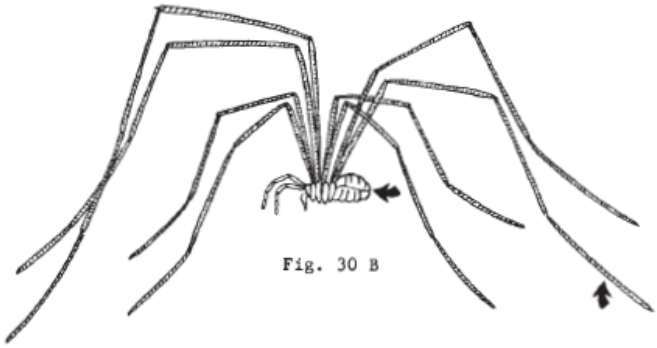


Fig. 30 B

31. Abdomen constricted to form a narrow waist (Fig. 31 A). ORDER ARANEIDA.....SPIDER

Abdomen not constricted (Fig. 31 B).....32

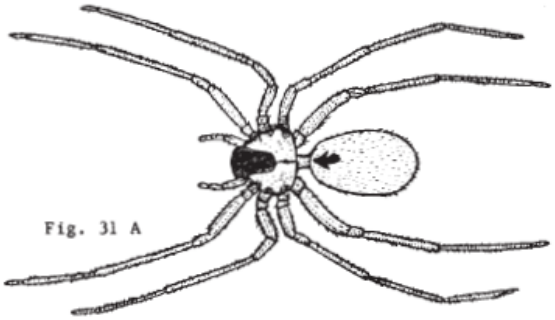
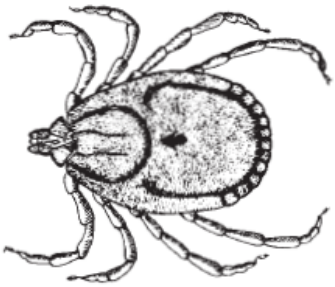


Fig. 31 A

Fig. 31 B



32. Body with long hair; Haller's organ absent (Fig. 32 A). ORDER ACARINA.....MITE

Body without hair or short hair; Haller's organ present (Fig. 32 B). ORDER ACARINA.....TICK

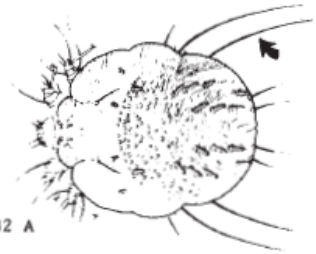


Fig. 32 A

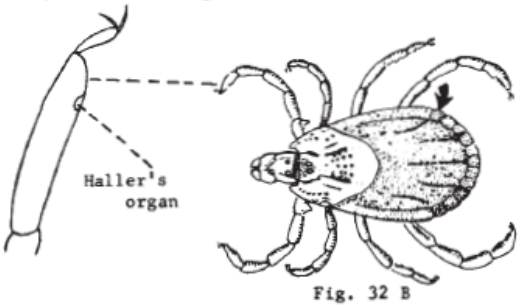


Fig. 32 B

33. Five to 7 pairs of walking legs (Fig. 33 A). CLASS CRUSTACEA.....34

More than 14 pairs of walking legs (Fig. 33 B).....36

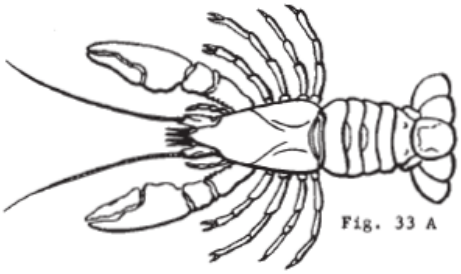


Fig. 33 A

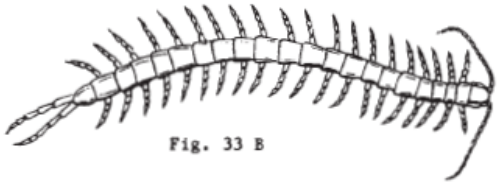


Fig. 33 B

34. Abdomen without appendages (Fig. 34 A). ORDER COPEPODA.....COPEPOD

Abdomen with appendages (Fig. 34 B).....35

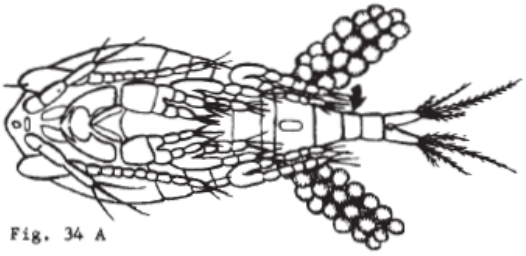


Fig. 34 A

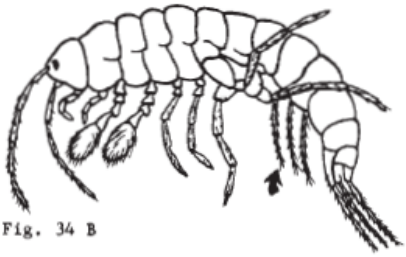


Fig. 34 B

35. Thorax covered with a fused plate; eyes, when present, on movable stalks (Fig. 35 A & B).....
ORDER DECAPODA.....LOBSTER, CRAB, CRAYFISH, SHRIMP, ETC.

Thorax not covered with a fused plate; eyes, when present, not on movable stalks (Fig. 35 C & D)...
ORDER ISOPODA.....SOWBUG, PILLBUG

Fig. 35 A

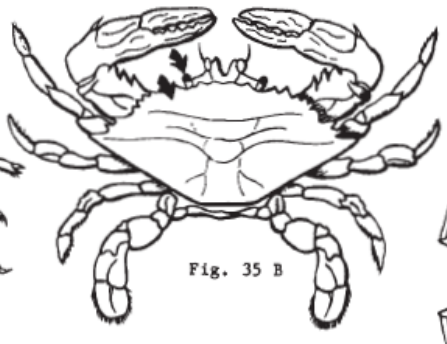


Fig. 35 B

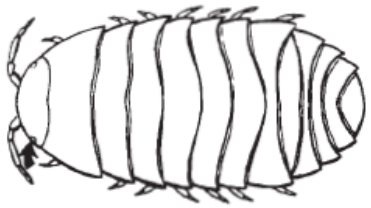


Fig. 35 C

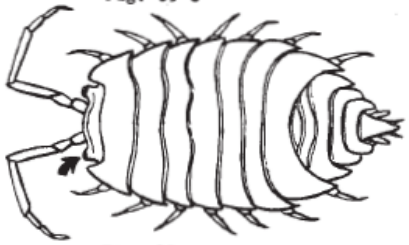


Fig. 35 D

36. One pair of legs per body segment (Fig. 36 A). CLASS CHILOPODA.....CENTIPEDE

Two pairs of legs per body segment (Fig. 36 B). CLASS DIPLOPODA.....MILLIPEDE

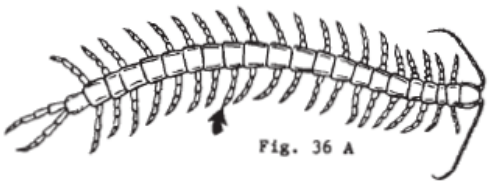


Fig. 36 A

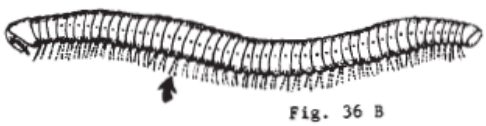


Fig. 36 B

BUGS: PICTORIAL KEY TO SOME SPECIES THAT MAY BITE MAN

Harry D. Pratt and Chester J. Stojanovich

wings usually well-developed; body elongate-oval

ASSASSIN AND KISSING BUGS–FAMILY REDUVIIDAE

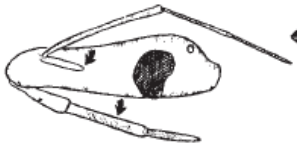
thorax with cog-wheel crest

WHEEL BUG
Arilus cristatus

fore-wing with 2 yellow spots

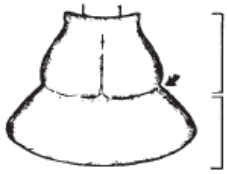
CORSAIR
Rasahus biguttatus

antenna inserted midway between eye and tip of head; beak slender, straight



KISSING BUG
Triatoma spp

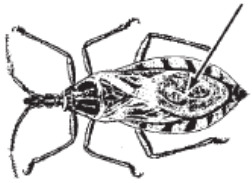
pronotum constricted behind middle



BLACK BUG
Melanolestes picipes

thorax without crest

fore-wing dark in U. S. species



antenna inserted near eye; beak stout, curved

pronotum constricted before middle

MASKED HUNTER
Reduvius personatus

wings reduced; body broadly-oval

BED BUGS–FAMILY CIMICIDAE

middle coxae nearly touching beak reaching 2nd coxa

POULTRY BUG
Haematosiphon inodorus

3rd and 4th antennal segments equal

BARN SWALLOW BUG
Oeciacus vicarius

fringe hairs on pronotum longer than, or equal to, width of eye

BAT BUGS
Cimex adjunctus E. N. AM.
Cimex pilosellus W. N. AM.

pronotum with anterior margin moderately excavated

TROPICAL BED BUG
Cimex hemipterus
SO. U.S. & TROPICS

middle coxae widely separated beak not reaching 2nd coxa

4th antennal segment shorter than 3rd

fringe hairs on pronotum shorter than width of eye

pronotum with anterior margin deeply excavated

BED BUG
Cimex lectularius
TEMPERATE AREAS

COCKROACHES: PICTORIAL KEY TO SOME COMMON SPECIES

Harry D. Pratt

SMALL, ABOUT 5/8" OR SHORTER

PRONOTUM WITH 2 LONGITUDINAL BLACK BARS

GERMAN COCKROACH
(Blattella germanica)

PRONOTUM WITHOUT LONGITUDINAL BLACK BARS

WINGS COVERING ABOUT HALF OF ABDOMEN PRONOTUM ABOUT 1/4 INCH WIDE

WOOD ROACH
(Parcoblatta spp.)

WINGS COVERING NEARLY ALL OF ABDOMEN OR EXTENDING BEYOND. PRONOTUM NARROWER

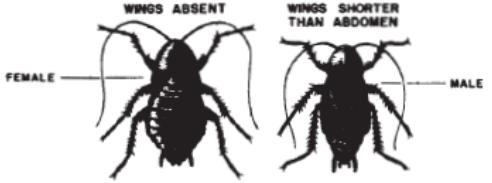
BROWN-BANDED COCKROACH
(Supella supellectilium)

MEDIUM TO LARGE, LONGER THAN 5/8 INCH

WINGS ABSENT, OR SHORTER THAN ABDOMEN

WINGS ABSENT

WINGS SHORTER THAN ABDOMEN



ORIENTAL COCKROACH
(Blatta orientalis)

WINGS COVERING ABDOMEN, OFTEN EXTENDING BEYOND

PRONOTUM MORE THAN 1/4 INCH WIDE

PRONOTUM ABOUT 1/4 INCH WIDE WITH PALE BORDER

WOOD ROACH
(Parcoblatta spp.)

FRONT WING WITHOUT PALE STREAK. PRONOTUM SOLID COLOR, OR WITH PALE DESIGN ONLY MODERATELY CONSPICUOUS

PRONOTUM SOLID DARK COLOR. GENERAL COLOR VERY DARK BROWN TO BLACK.

SMOKY BROWN COCKROACH
(Periplaneta fuliginosa)

PRONOTUM USUALLY WITH SOME PALE AREA. GENERAL COLOR SELDOM DARKER THAN REDDISH CHESTNUT

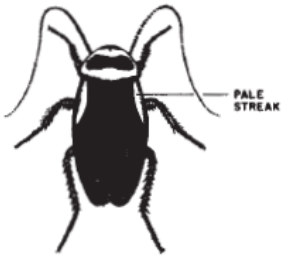
LAST SEGMENT OF CERCUS NOT TWICE AS LONG AS WIDE

BROWN COCKROACH
(Periplaneta brunnea)

LAST SEGMENT OF CERCUS TWICE AS LONG AS WIDE

AMERICAN COCKROACH
(Periplaneta americana)

FRONT WING WITH OUTER PALE STREAK AT BASE. PRONOTUM STRIKINGLY MARKED



AUSTRALIAN COCKROACH
(Periplaneta australasiae)

COCKROACHES: KEY TO EGG CASES OF COMMON DOMESTIC SPECIES

Harold George Scott, Ph.D. and Margery R. Borom

less than ¼" long subsegments apparent

more than ¼" long subsegments inapparent

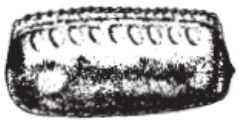
with about 16 subsegments length more than twice width

Blatella germanica
GERMAN COCKROACH

with about 8 subsegments length less than twice width

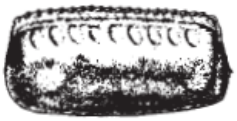
Supella supellectilium
BROWN-BANDED COCKROACH

with lateral indentations



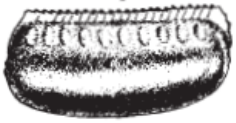
without lateral indentations

terminal point strong



Periplaneta brunnea
BROWN COCKROACH

terminal point weak



Periplaneta fuliginosa
SMOKY-BROWN COCKROACH

not symmetrical

Blatta orientalis
ORIENTAL COCKROACH

symmetrical

length more than twice width

Periplaneta australasiae
AUSTRALIAN COCKROACH

length less than twice width

Periplaneta americana
AMERICAN COCKROACH

COCKROACHES: KEY TO SOME COMMON SPECIES FOUND IN THE UNITED STATES

Harry D. Pratt & Chester J. Stojanovich

1. Middle and hind femora both with numerous strong spines along the ventral margin (Fig. 1 A)..2

   Middle and hind femora without strong spines along the ventral margin (Fig. 1 B).....12

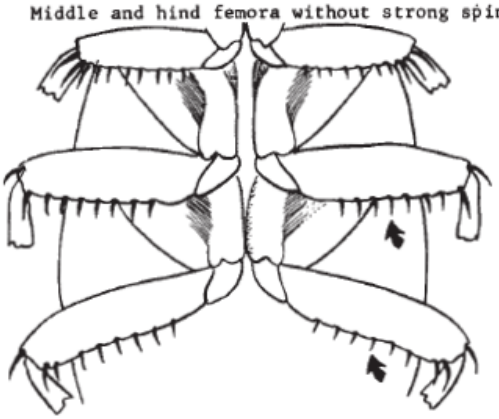


Fig. 1 A

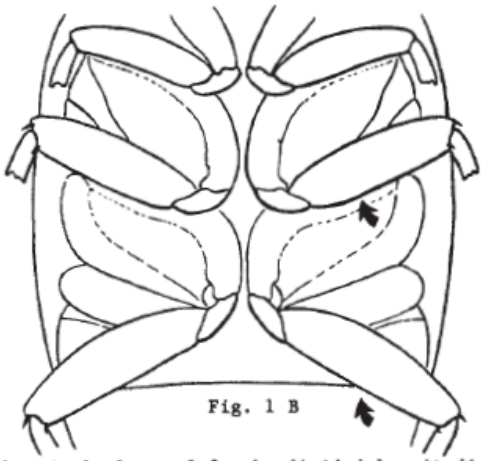


Fig. 1 B

2. Comparatively large species 18 mm. or longer; subgenital plate of female divided longitudinally, valvular (Fig. 2 A); male styli similar, slender, elongate and straight (Fig. 2 B).....3

   Species usually less than 18 mm. long; or, if longer, anterior-ventral margin of front femur with several large stout spines on basal portion, followed by a row of smaller spines (Fig. 2 C); female subgenital plate simple, not divided (Fig. 2 D); male styli variable, frequently modified, asymmetrical, or unequal in size (Fig. 2 E).....8

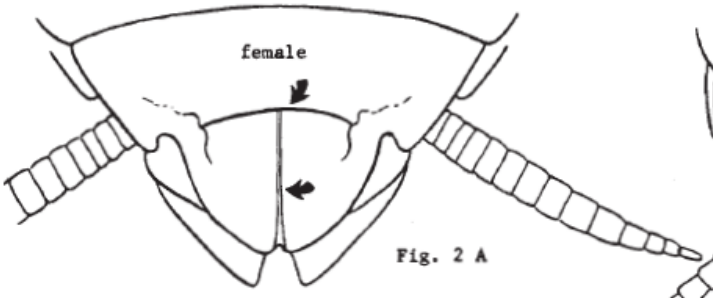


Fig. 2 A

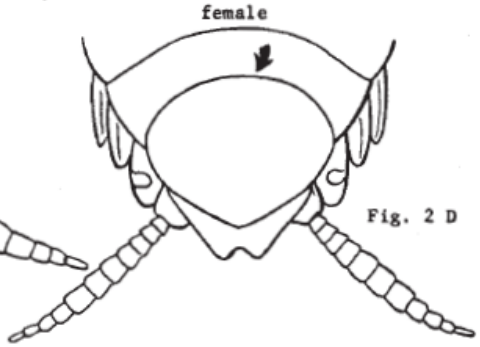


Fig. 2 D

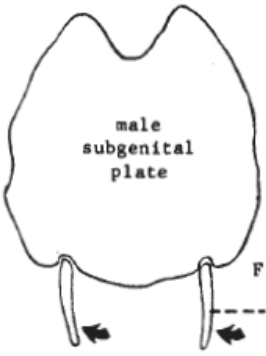


Fig. 2 B

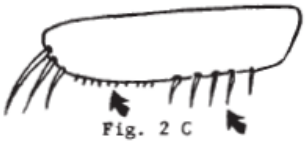


Fig. 2 C

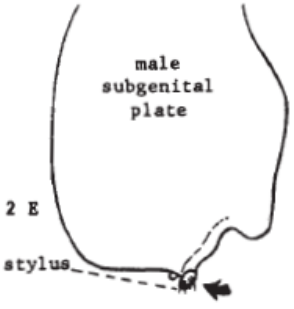


Fig. 2 E

3. Front wing in both sexes extending beyond tip of abdomen (Fig. 3 A).....4

Front wing in both sexes not reaching tip of abdomen (Fig. 3 B).....7

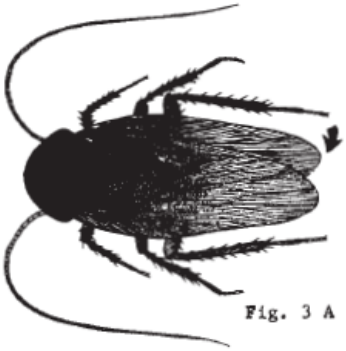


Fig. 3 A

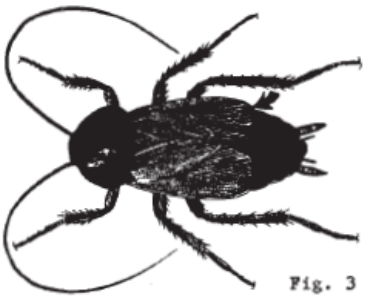


Fig. 3 B

4. Uniformly dark blackish-brown, shining species (Fig. 4 A).....
.....(Periplaneta fuliginosa) SMOKY BROWN COCKROACH

Species with some yellowish markings on pronotum or front wing or both (Fig. 4 B).....5

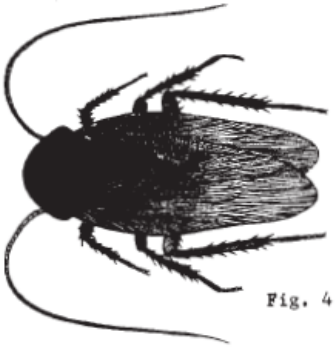


Fig. 4 A

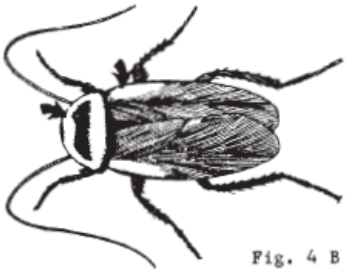


Fig. 4 B

5. Front wing with yellowish stripe; pronotum with yellowish and darker areas very contrastingly marked (Fig. 5 A).....(Periplaneta australasiae) AUSTRALIAN COCKROACH

Front wing entirely brownish; pronotum with yellowish and darker areas less contrastingly marked (Fig. 5 B).....6

Fig. 5 A

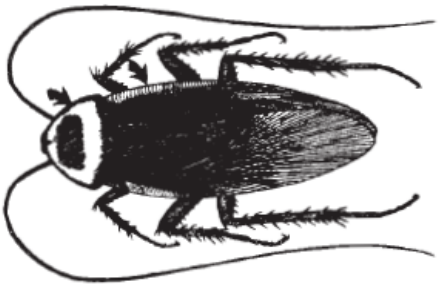


Fig. 5 B

6. Styli very long and slender, longer than space between their bases (Fig. 6 A); cercus long and slender particularly in the male; male supra-anal plate deeply notched (Fig. 6 B).....
.....(Periplaneta americana) AMERICAN COCKROACH

Styli shorter, not as long as space between their bases (Fig. 6 C); cercus stouter and more evenly spindle-shaped; male supra-anal plate truncate or feebly notched (Fig. 6 D).....
.....(Periplaneta brunnea) BROWN COCKROACH

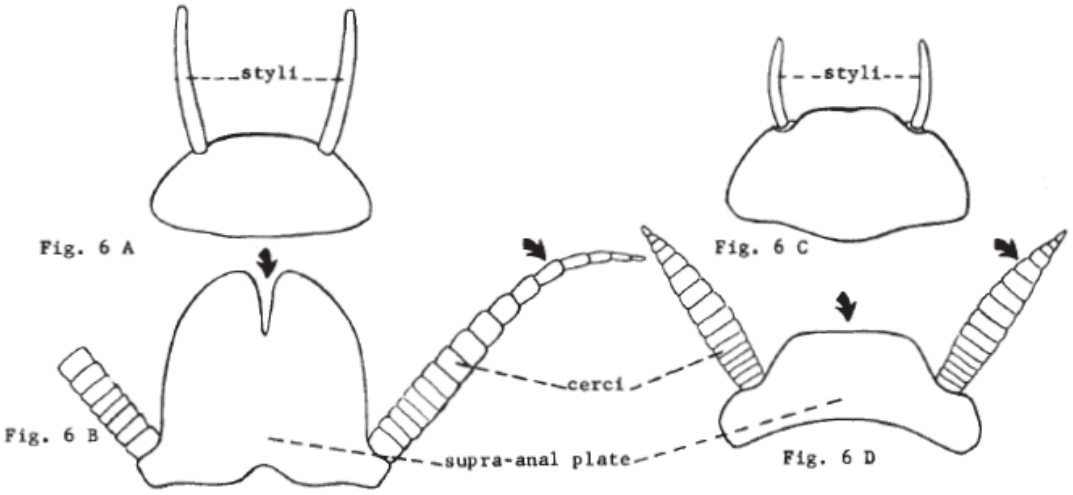


Fig. 6 A

Fig. 6 C

Fig. 6 B

Fig. 6 D

7. Blackish species, 15-27 mm. long; male front wings covering two-thirds of abdomen (Fig. 7 A); female front wings widely separated pads (Fig. 7 B); first segment of hind tarsus longer than segments 2-5 combined, pulvilli of second and third segments small (Fig. 7 C).....
.....(Blatta orientalis) ORIENTAL COCKROACH

Mahogany brownish species, 30-40 mm. long; front wings reduced to short pads, not widely separated (Fig. 7 D); first segment of hind tarsus shorter than segments 2-5 combined, pulvilli of second and third segments large (Fig. 7 E)....(Eurycotis floridana) LARGE FLORIDA COCKROACH

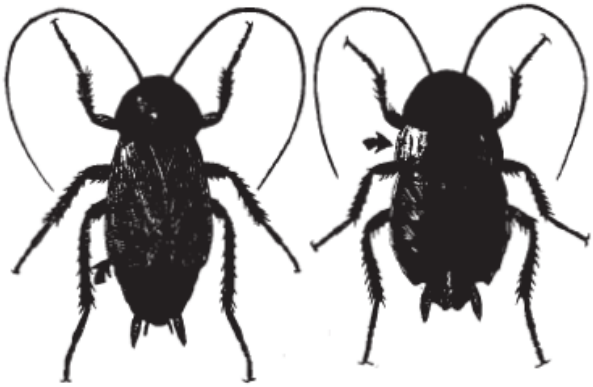


Fig. 7 A

Fig. 7 B

Fig. 7 D

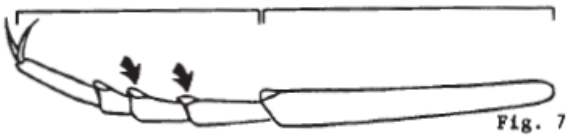


Fig. 7 C

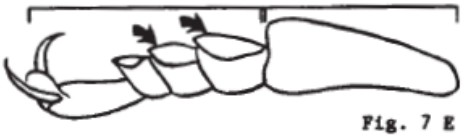


Fig. 7 E

8. Pronotum with two conspicuous longitudinal dark bars on a pale background (Fig. 8 A).....9

Pronotum variously marked, but without two conspicuous dark longitudinal bars (Fig. 8 B)....10

Fig. 8 A

Fig. 8 B

9. Face pale (Fig. 9 A); male subgenital plate asymmetrical, styli very unequal, short and rounded (Fig. 9 B).....(Blattella germanica) GERMAN COCKROACH

Face dark; male subgenital plate almost symmetrical, styli somewhat elongate and subequal in size (Fig. 9 C).....(Blattella vaga) FIELD COCKROACH

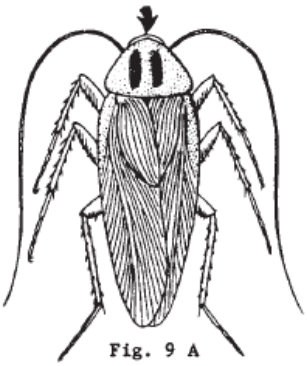


Fig. 9 A

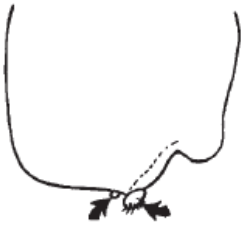


Fig. 9 B

Fig. 9 C

10. Pronotum with a broad dark central stripe; front wings of both sexes appearing to have two transverse brownish bars, some pale specimens showing bars poorly (Fig. 10 A). Width of pronotum usually not exceeding 4.5 mm.....(Supella supellectilium) BROWN-BANDED COCKROACH

Pronotum and front wings otherwise, or, if pronotum is so marked, its width exceeding 4.5 mm. (Fig. 10 B).....11

Fig. 10 A

Fig. 10 B

11. Larger species 9-25 mm. or more in length; front wing without small dark spots in winged specimens (Fig. 11 A); claws equal (Fig. 11 B); ventral anterior margin of front femur with 3 long apical spines (Fig. 11 C).....(Parcoblatta species) WOOD COCKROACHES

Small species, 8-9 mm. long; front wing with small dark spots (Fig. 11 D); claws unequal (Fig. 11 E); ventral anterior margin of front femur with 2 long apical spines (Fig. 11 F)... .....(Ectobius pallidus) SPOTTED MEDITERRANEAN COCKROACH

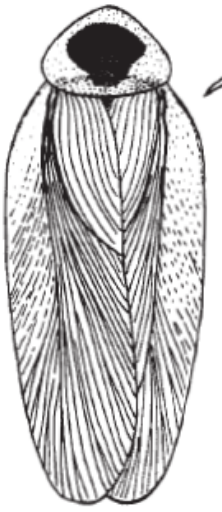


Fig. 11 A

Fig. 11 B

Fig. 11 C

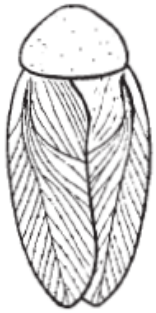


Fig. 11 D

Fig. 11 E

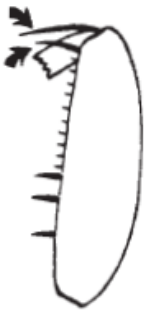


Fig. 11 F

12. Top of eyes close together (Fig. 12 A); general color a nearly uniform greenish; posterior margin of pronotum somewhat angularly produced (Fig. 12 B) (Panchlora nivea) CUBAN COCKROACH

Top of eyes sometimes distant (Fig. 12 C); general color various shades of brown and gray; pronotum usually not angularly produced posteriorly (Fig. 12 D).....13

Fig. 12 A

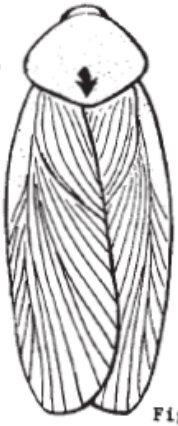


Fig. 12 B

Fig. 12 C

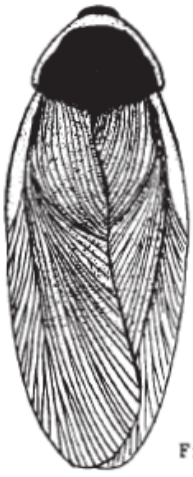


Fig. 12 D

13. Medium sized species, 30 mm. or less in length, including folded wings (Fig. 14 A & B).....14

Large species 40 mm. or more in length, including folded wings (Fig. 15 A & C).....15

14. Pronotum uniformly blackish except a narrow yellowish band along anterior and lateral margins (Fig. 14 A).....(Pycnoscelus surinamensis) SURINAM COCKROACH

Pronotum pale with a narrow dark longitudinal submarginal band on each side and irregular brownish blotches on disc (Fig. 14 B).....(Nauphoeta cinerea) CINEREOUS COCKROACH

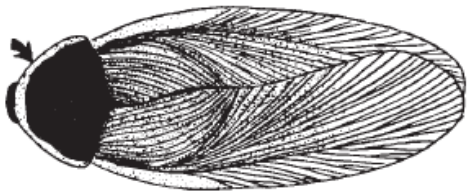


Fig. 14 A

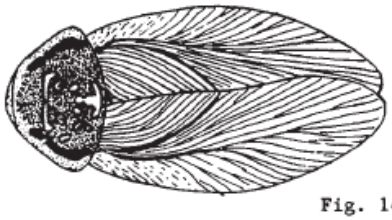


Fig. 14 B

15. Disc or pronotum with shield-like design, sometimes skull-like design (Fig. 15 A); front femur with one or more stout spurs on underside (Fig. 15 B).....
.....(Blaberus giganteus; Blaberus craniifer) GIANT COCKROACH

Disc of pronotum with shield-like design darkened in outline only, not solid black (Fig. 15 C); front femur with a line of stiff hairs on anterior-ventral margin (Fig. 15 D).....
.....(Leucophaea maderae) MADEIRA COCKROACH

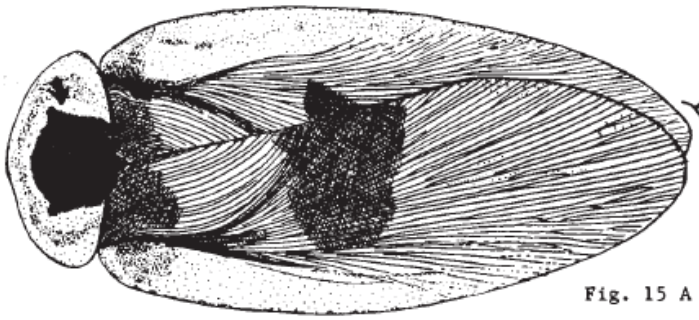


Fig. 15 A

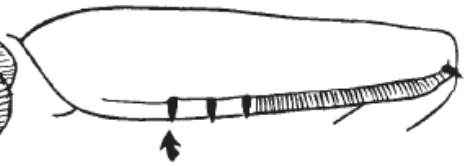


Fig. 15 B

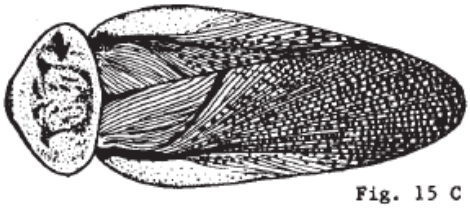
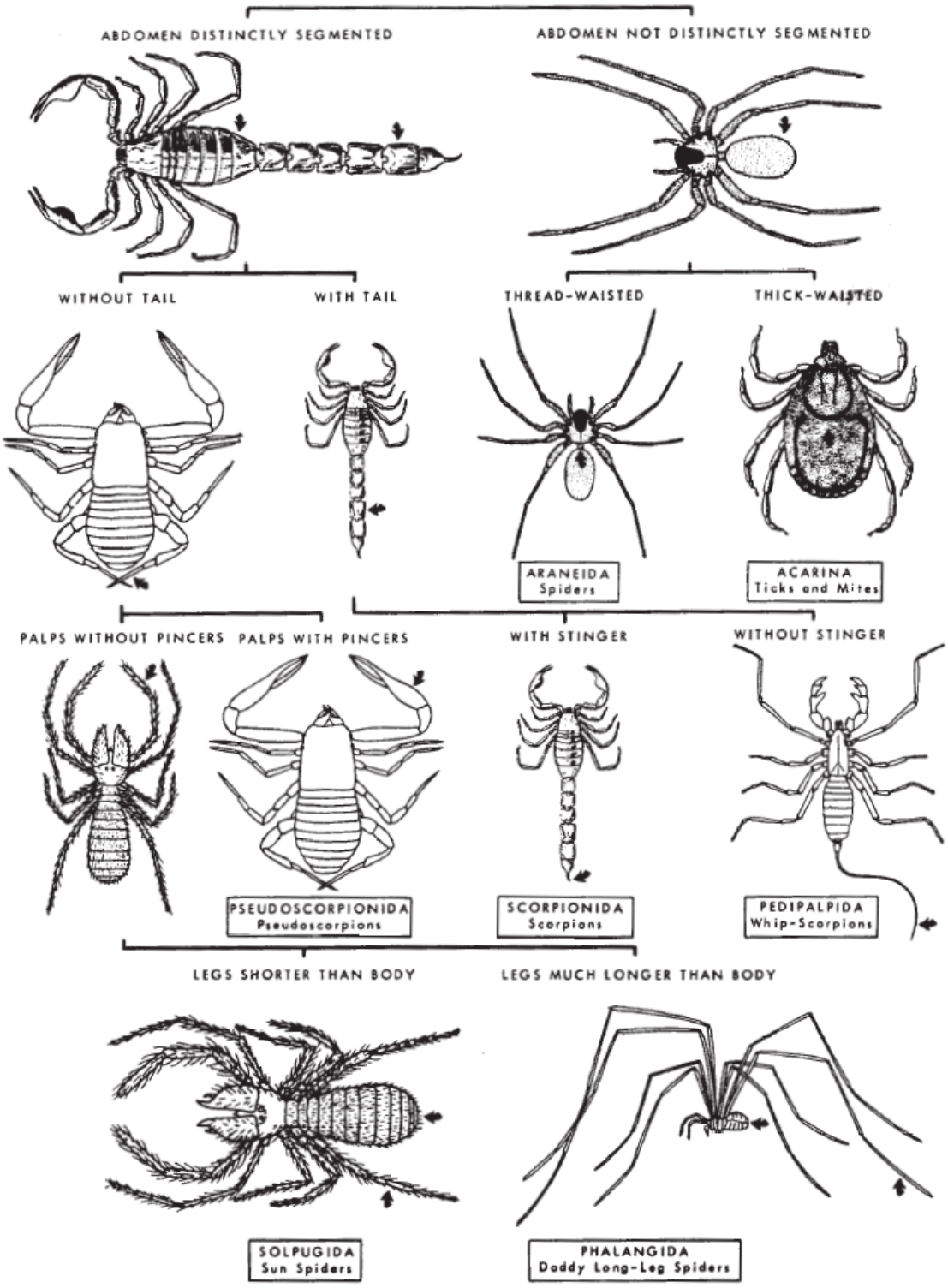


Fig. 15 C

Fig. 15 D

ARACHNIDA: KEY TO COMMON ORDERS OF PUBLIC HEALTH IMPORTANCE
Harold George Scott & Chester J. Stojanovich



SPIDERS: KEY TO SOME IMPORTANT UNITED STATES SPECIES

Harold George Scott & Chester J. Stojanovich

1. Fangs projecting horizontally (Fig. 1 A). (abdomen without tergites; tarsus with claw tufts and 2 claws) ..... *Dugesiella hentzi* and others, TARANTULAS

   Fangs projecting vertically (Fig. 1 B) 2

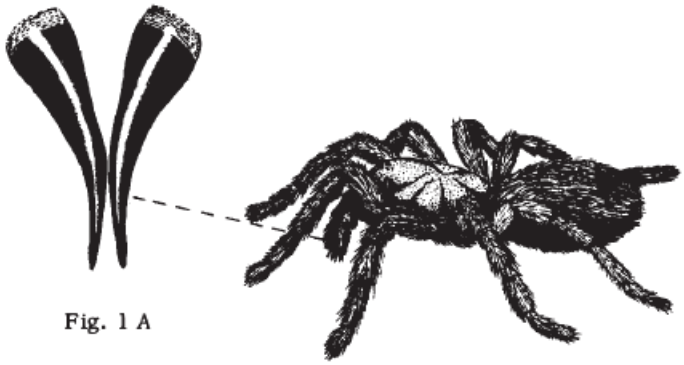


Fig. 1 A

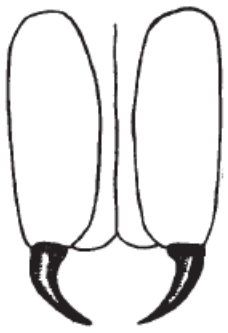


Fig. 1 B

2. Six eyes in 3 pairs; fiddle-shaped marking on cephalothorax (Fig. 2 A) .....
   Loxosceles reclusa ..... BROWN RECLUSE SPIDERS

   Eight eyes (shiny black with red spots; usually with red hourglass on underside of abdomen) (Fig. 2 B).
   Latrodectus mactans ..... BLACK WIDOW SPIDER

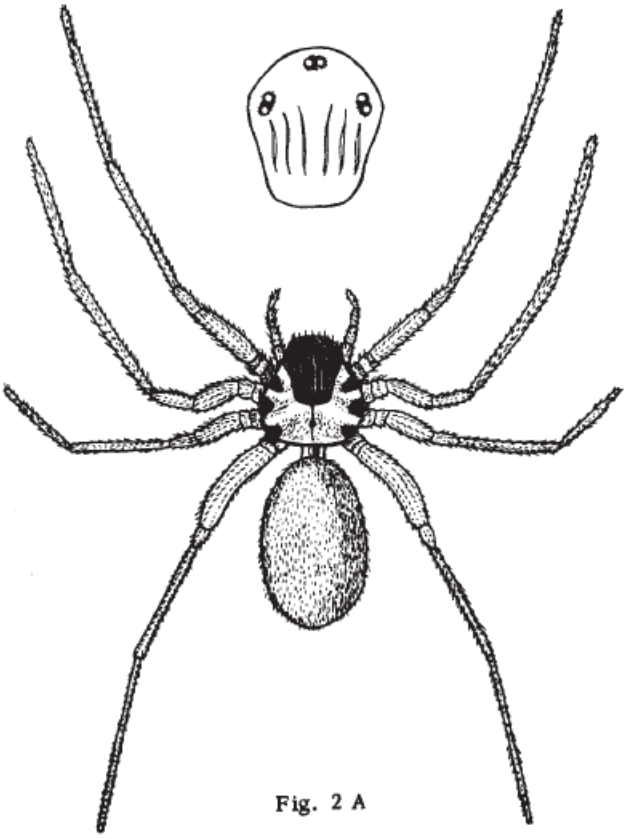


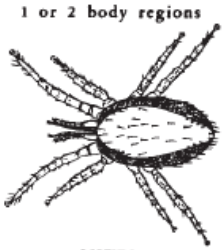
Fig. 2 A

Fig. 2 B

HOUSEHOLD AND STORED-FOOD PESTS: KEY TO COMMON ADULTS

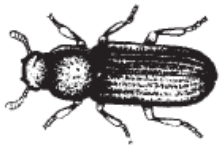
Harold George Scott & Chester J. Stojanovich

1 or 2 body regions



MITES

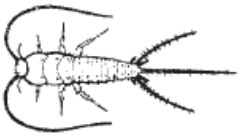
3 body regions



wings well developed

wings reduced or absent

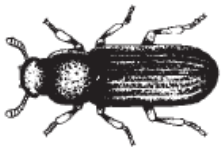
with 3 long tails



SILVERFISH

without 3 long tails

front wings shell-like



front wings not shell-like

BEETLES—WEEVILS—
BORERS—MEALWORMS

antenna 4-7 segmented

SPRINGTAILS

antenna more than 7 segmented

1 pair wings

FLIES

2 pair wings

tarsus 4-5 segmented

PSOCIDS

tarsus 1-3 segmented

wings with scales

MOTHS

wings without scales

COCKROACHES

with narrow waist

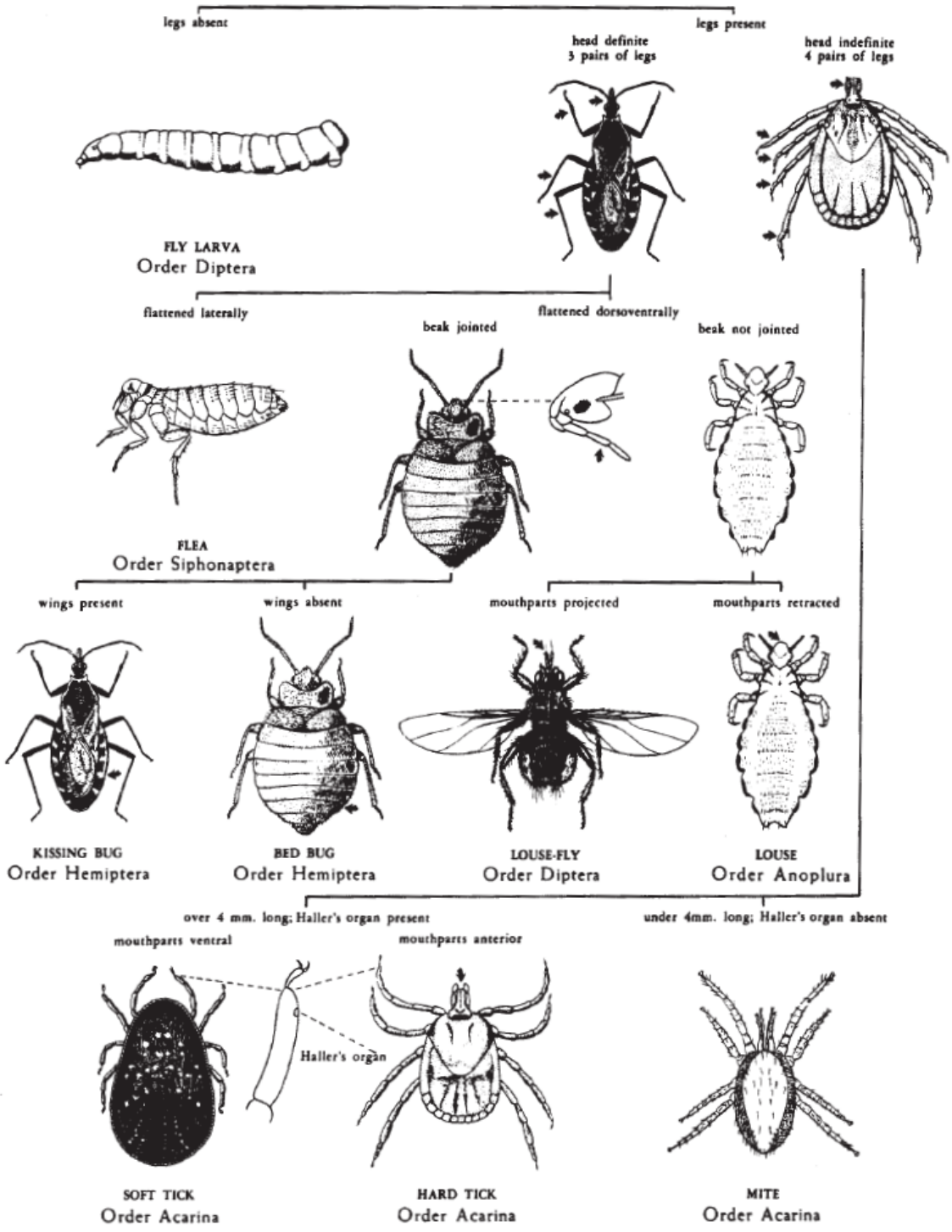
ANTS

without waist

COCKROACHES

HUMAN ECTOPARASITES: KEY TO COMMON GROUPS

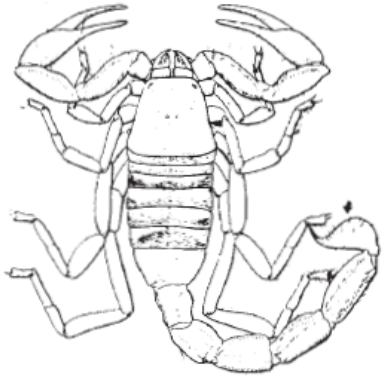
Chester J. Stojanovich and Harold George Scott



SCORPIONS: PICTORIAL KEY TO SOME COMMON UNITED STATES SPECIES

Chester J. Stojanovich and Harold George Scott

stinger with many setae



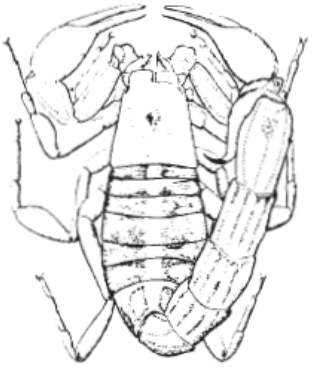
Hadrurus arizonensis
OLIVE HAIRY SCORPION

stinger with few setae

stinger without subaculear tooth

stinger with subaculear tooth

body striped dorsally

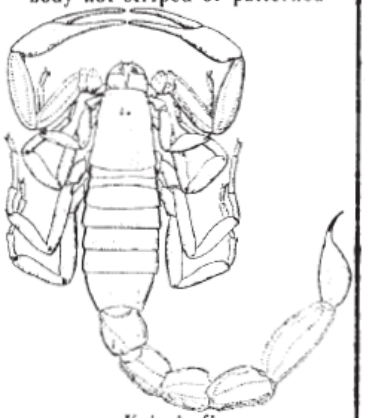


Vejovis spinigerus
STRIPE-TAIL DEVIL SCORPION

body patterned dorsally

Vejovis carolinianus
SOUTHERN DEVIL SCORPION

body not striped or patterned

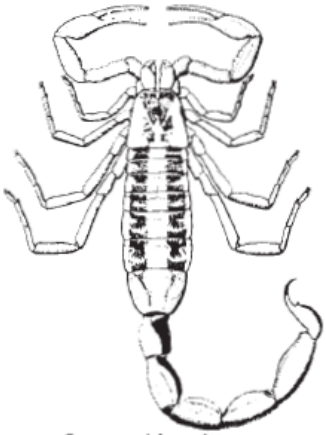


Vejovis flavus
SLENDER DEVIL SCORPION

body black dorsally

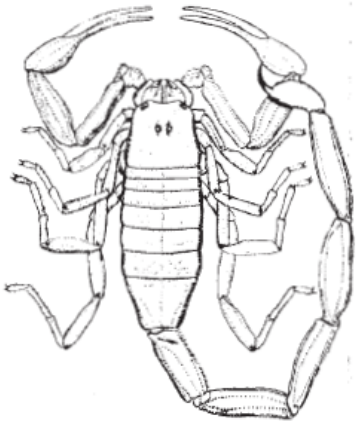
Centruroides gracilis
MARGARITE SCORPION

body striped dorsally



Centruroides vittatus
STRIPE-BACK SCORPION

body yellow dorsally



Centruroides sculpturatus
DEADLY SCULPTURED SCORPION

RODENTS: PICTORIAL KEY TO SOME COMMON UNITED STATES GENERA

Harold George Scott and Margery R. Borom

tail almost naked, scaly

large (9-17"long) — small (5-7"long)

Rattus
DOMESTIC
RATS

Mus
HOUSE
MICE

tail almost naked, annulate

tail long — tail short

Oryzomys
RICE
RATS

Sigmodon
COTTON
RATS

tail hairy

hair short — hair long

tail bones longer than 1/2 body

large (about 16"long) — small (7-9"long)

Neotoma
WOOD
RATS

Peromyscus
WHITE-FOOTED
MICE

tail bones shorter than 1/2 body

front feet enlarged — front feet not enlarged

Geomys-East
Thomomys-West
POCKET GOPHERS

Microtus
MEADOW
MICE

tail bones longer than body

tail bushy — tail not bushy

Sciurus
TREE
SQUIRRELS

Dipodomys
KANGAROO
RATS

tail bones shorter than body

large (about 15"long) — small (about 9" long) — very large (about 26"long)

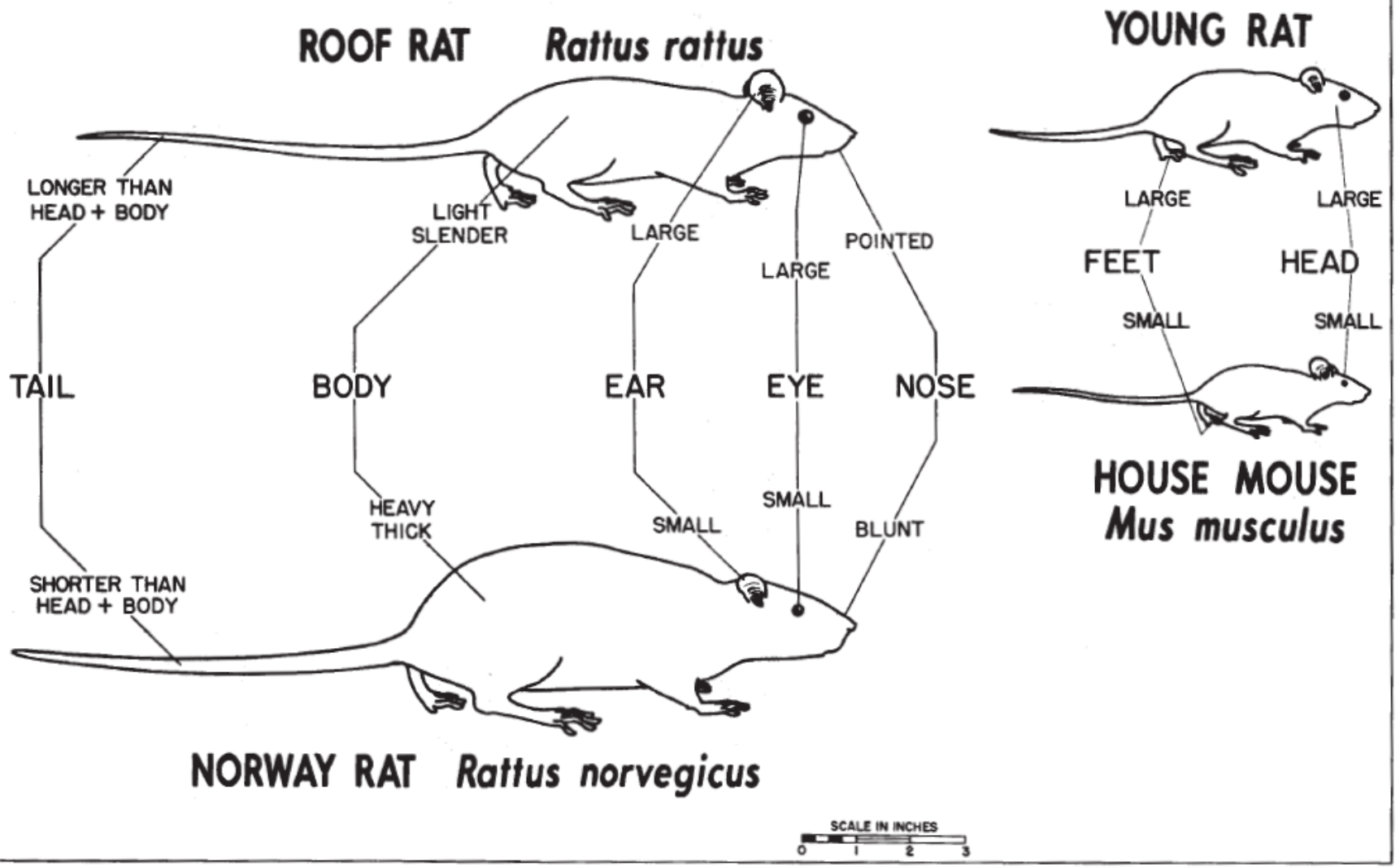
Citellus
GROUND
SQUIRRELS

Tamias-East
Eutamias-West
CHIPMUNKS

Marmota
WOODCHUCKS

DOMESTIC RODENT FIELD IDENTIFICATION

Robert Z. Brown

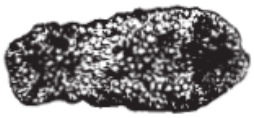


DOMESTIC RODENTS AND COCKROACHES: PICTORIAL KEY TO DROPPINGS

Harold George Scott and Margery R. Borom

length over 1/3-inch*

rectangular, blunt



Rattus norvegicus
NORWAY RAT

elongate, pointed

Rattus rattus
ROOF RAT

length under 1/4-inch*

elongate, pointed

without ridges
length about 1/4-inch

Mus musculus
HOUSE MOUSE

with ridges
length about 1/16-inch

Blatella germanica
GERMAN COCKROACH

rectangular, blunt
with ridges

ovoid, pointed
with ridges

length about 1/8-inch

Periplaneta americana
AMERICAN COCKROACH

length about 1/16-inch

Blatta orientalis — ORIENTAL COCKROACH or
Periplaneta fuliginosa — SMOKY BROWN COCKROACH

length about 1/8-inch

Periplaneta australasiae
AUSTRALIAN COCKROACH

length about 1/16-inch

Periplaneta brunnea
BROWN COCKROACH

length about 1/32-inch

Supella supellectilium
BROWN-BANDED COCKROACH

*All characteristics for average, dry, adult droppings. Study groups, not individual droppings.

ACARINA: ILLUSTRATED KEY TO SOME COMMON ADULT FEMALE MITES AND ADULT TICKS

Harry D. Pratt and Chester J. Stojanovich

1. Last segment of first leg with a depression known as Haller's organ; most species with a toothed hypostome on capitulum; size usually over 4 mm. (Fig. 1 A). Ticks 21

   Last segment of first leg without such a depression known as Haller's organ; hypostome not toothed; most species less than 4 mm. long (Fig. 1 B). Mites.....2

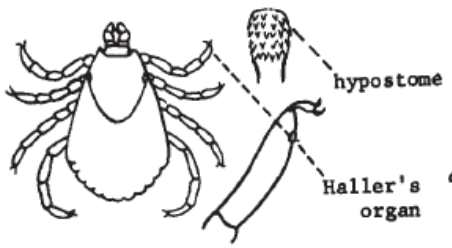


Fig. 1 A

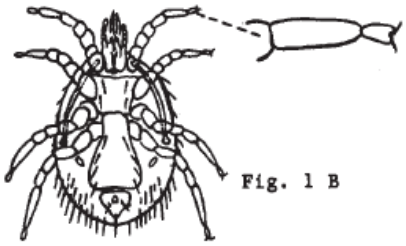


Fig. 1 B

2. Respiratory system with a spiracle on each side opening lateral to the bases of the 3rd or 4th pair of legs, frequently spiracles leading into slender tubes that extend forward laterally to the bases of the 1st or 2nd pairs of legs Fig. 2 A). Mesostigmatid Mites. 3

   Respiratory system without spiracles, or with spiracles opening near bases of the chelicerae (Fig. 2 B).....13

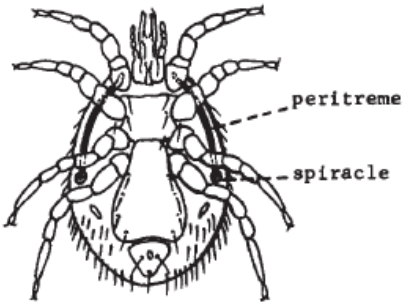


Fig. 2 A

Fig. 2 B

3. Anus surrounded by a plate bearing only 3 setae, one on each side and one behind the anal opening; first tarsus bearing caruncle and claws at tip (Fig. 3 A).....4

   Anus surrounded by a plate bearing more than 3 setae; first tarsus without caruncle and claws (Fig. 3 B)..... Many species of Macrocheles

Fig. 3 A

Fig. 3 B

4. Anal opening more than its length behind anterior margin of anal plate; chelicerae strongly narrowed apically, needle-like, movable chela absent or extremely small (Fig. 4 A). Genus Dermanyssus 5

   Anal opening less than its length or about its length, behind anterior margin of anal plate; chelicerae not narrowed apically and needle-like, shear-like, bearing conspicuous shear-like chelae at tip which may or may not bear teeth (Fig. 4 B)..... 7

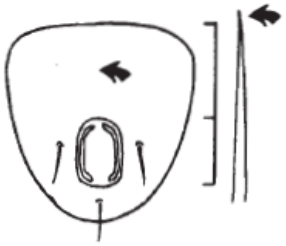


Fig. 4 A

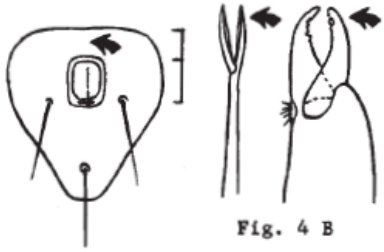


Fig. 4 B

5. Dorsal surface of body with a single plate (Fig. 5 A).....6

   Dorsal surface of body with two plates, a large anterior plate and a small posterior plate (Fig. 5 B). Dermanyssus sanguineus..... HOUSE MOUSE MITE

Fig. 5 A

Fig. 5 B

6. Peritreme tube somewhat sinuous and extending anteriorly to a point opposite coxa 2 (Fig. 6 A). Dermanyssus gallinae..... CHICKEN MITE

   Peritreme tube short, extending forward for a distance less than half the diameter of coxa 3 (Fig. 6 B). Dermanyssus americanus..... AMERICAN BIRD MITE

Fig. 6 A

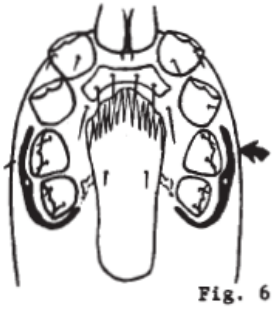


Fig. 6 B

7. Dorsal plate not covering entire dorsal surface of mite; genito-ventral plate typically narrowed posteriorly behind 4th coxae; chelae on chelicerae without teeth or setae (Fig. 7 A). Genus Ornithonyssus 8

Dorsal plate almost covering entire dorsal surface of mite; genito-ventral plate typically expanded posterior to 4th coxae; one or both chelae of chelicerae with teeth and a seta (Fig. 7 B). Family Laelaptidae 10

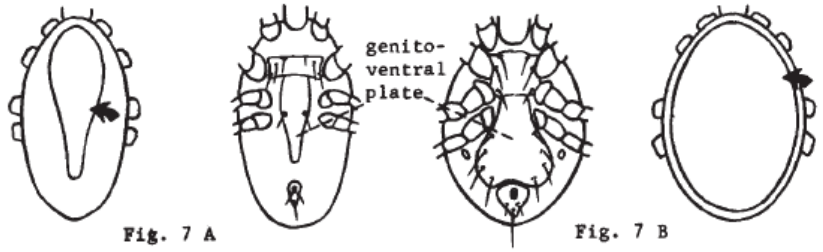


Fig. 7 A Fig. 7 B

8. Sternal plate with anterior and middle pairs of sternal setae on the plate, posterior pair usually just off the plate (Fig. 8 A). On Birds... Ornithonyssus sylviarum..... ..... NORTHERN FOWL MITE

Sternal plate with the usual three pairs of setae on the plate (Fig. 8 B)..... 9

Fig. 8 A Fig. 8 B

9. Dorsal plate narrowed posteriorly; setae in middle dorsal row of plate longer than the distance between their bases (Fig. 9 A). Normally on mammals or man..... Ornithonyssus bacoti ..... TROPICAL RAT MITE

Dorsal plate broader posteriorly; setae in middle dorsal row of plate much shorter than the distance between their bases (Fig. 9 B). Normally on birds..... Ornithonyssus bursa..... TROPICAL BIRD MITE

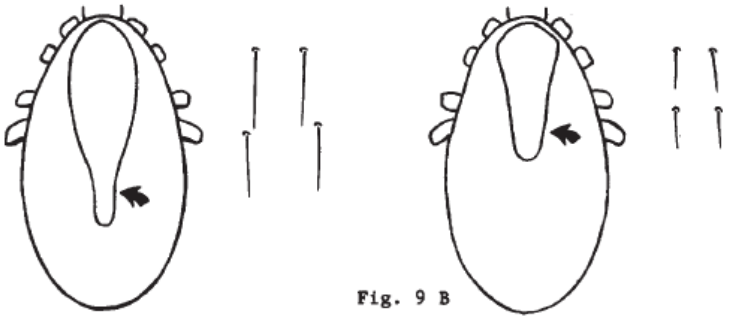


Fig. 9 A Fig. 9 B

10. Genito-ventral plate with many fine setae; anal plate transverse, wider than long (Fig. 10 A). On domestic rats and a wide variety of wild mammals..... Eulaelaps stabularis

Genito-ventral plate with one to four pairs of setae; anal plate longer than wide (Fig. 10 B).....11

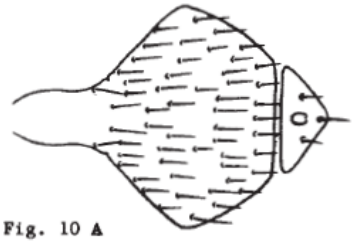


Fig. 10 A

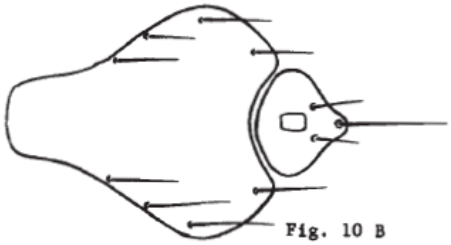


Fig. 10 B

11. Genito-ventral plate with only a single pair of setae (Fig. 11 A). On domestic rats and mice and a wide variety of mammals and birds.....
Haemolaelaps glasgowi.....COMMON RODENT MITE

Genito-ventral plate with four pairs of setae (Fig. 11 B). Normally on domestic rats..12

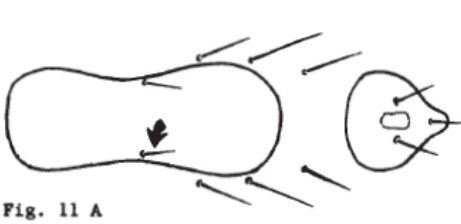


Fig. 11 A

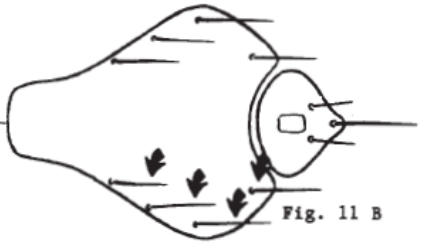


Fig. 11 B

12. Anal plate contiguous with the genito-ventral plate, anterior margin rounded and fitting into a strong concavity in genito-vental plate; larger species averaging 1-2 mm. long. (Fig. 12 A). Echinolaelaps echidninus.....SPINY RAT MITE

Anal plate somewhat separated from genito-ventral plat, anterior margin almost straight with definite anterior-lateral corners; small species averaging 0.5-1 mm long (Fig. 12 B). Laelaps nuttalli.....DOMESTIC RAT MITE

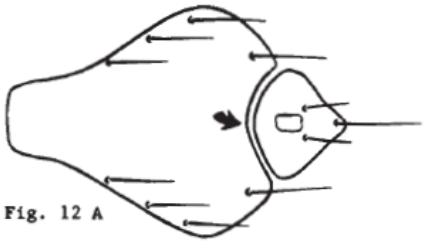


Fig. 12 A

Fig. 12 B

13. First pair of legs very long, much longer than other three pairs; anterior margin of body with four distinct flattened scales and somewhat flattened scales on other dorsal surfaces of body (Fig. 13 A). Plant feeders which invade buildings but do not bite man. Bryobia praetiosa.....CLOVER MITE

First pair of legs not markedly longer than the other three pairs of legs; no flattened scales on body (Fig. 13 B).....14

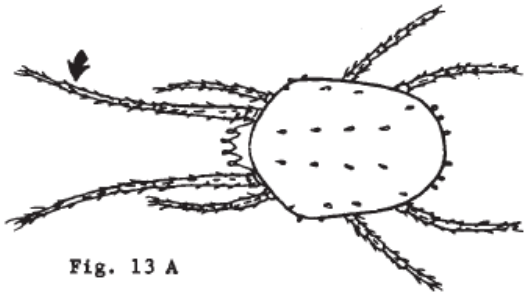


Fig. 13 A

Fig. 13 B

14. Surface of body without fine parallel lines or folds; tarsi without stalked suckers (Fig. 14 A). Adults never true parasites (Cheese or Flour mites).....15

Surface of body with fine parallel lines or folds; tarsi often provided with stalked suckers (Fig. 14 B). Scabies or mange mites parasitic in all stages, chiefly on vertebrates 16

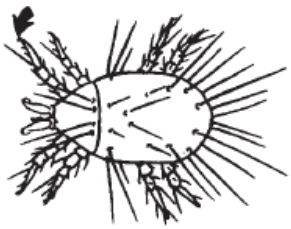


Fig. 14 A

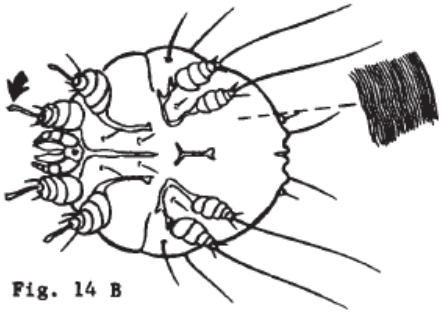


Fig. 14 B

15. Tarsi tapering markedly to tip (Fig. 15 A).....Glycyphagus prunorum

Tarsi not tapering markedly to tip (Fig. 15 B). Many cheese and flour mites which are difficult to separate except with very specialized literature and a reference collection. ..... Genus Tyrophagus, Genus Caloglyphus, Etc.

Fig. 15 A

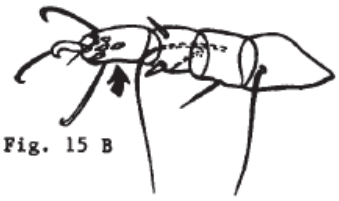


Fig. 15 B

16. Body elongate, somewhat cigar-shaped and prolonged behind; the abdomen somewhat ringed; legs very short, apparently three-segmented; tiny species less than 1 mm. (Fig. 16 A). In hair follicles or sebaceous glands of mammals..... Demodex folliculorum.....PORE OR FOLLICLE MITE

Body not prolonged behind and cigar-shaped (Fig. 16 B). Occasionally female grain itch somewhat balloon-shaped; larger species not found in hair follicle or sebaceous glands of mammals..... 17

Fig. 16 A

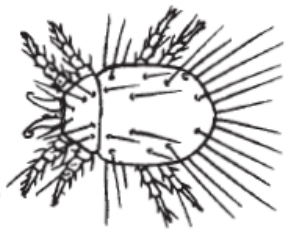


Fig. 16 B

17. A club-shaped or clavate hair between bases of first and second pairs of legs, body divided into cephalothorax and abdomen, the latter often enormously enlarged (Fig. 17 A) Pyemotes ventricosus formerly Pediculoides ventricosus.....STRAW ITCH MITE

Setae on cephalothorax normal, no club-shaped or clavate hair between bases of first and second pairs of legs; no distinct division into cephalothorax and abdomen (Fig. 17 B) 18

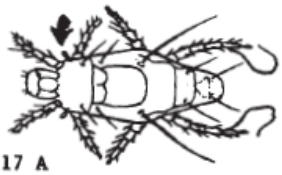


Fig. 17 A

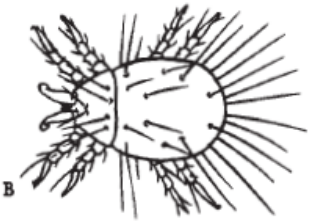


Fig. 17 B

18. Legs short and stubby (Fig. 18 A).....20

Legs longer and more slender (Fig. 18 B).....19

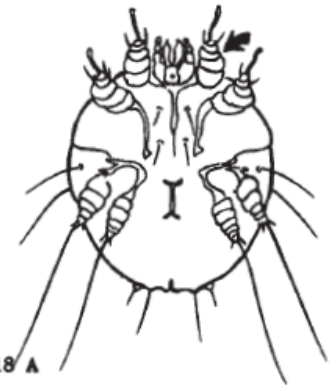


Fig. 18 A

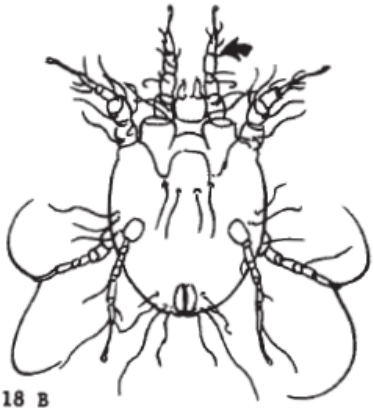


Fig. 18 B

19. Suckers of tarsi with segmented pedicels (Fig. 19 A). Non-burrowing itch mites on mammals in the genus Psoroptes, a common species causing scabs and crusts in the ears of rabbits is the Psoroptes cuniculi ..... RABBIT EAR MITE

Suckers of tarsi without segmented pedicels (Fig. 19 B)..... ..... Dermatophagoides scheremetewskyi

Fig. 19 A

Fig. 19 B

20. Anal opening on the dorsal surface of the body; dorsal surface of the body with only short, sharp setae (Fig. 20 A).....Notoedres

Anal opening at tip of body or slightly on ventral side; dorsal surface of body with pointed scales and blunt stout spines (Fig. 20 B). Sarcoptes scabiei..... ..... SCABIES OR MANGE MITE

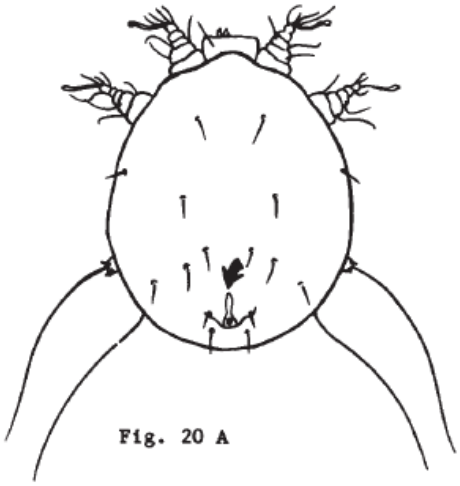


Fig. 20 A

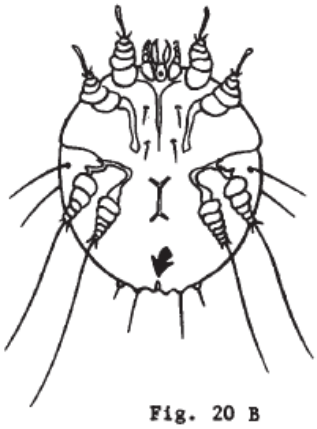


Fig. 20 B

21. Capitulum at anterior end of body, visible from above and below; scutum or dorsal shield present, short in female, long in male (Fig. 21 A & B). Family Ixodidae..HARD TICKS...22

Capitulum on under side of body, hidden by body when seen from above though palpi may project anteriorly; scutum absent (Fig. 21 C & D). Family Argasidae.....SOFT TICKS....31

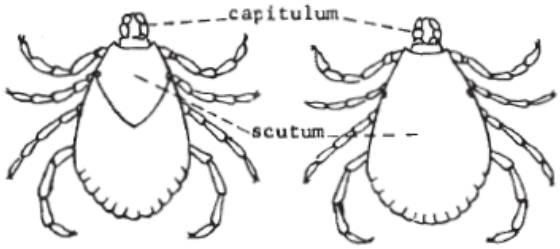


Fig. 21 A

Fig. 21 B

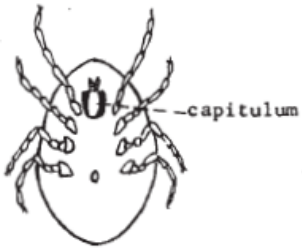


Fig. 21 C

Fig. 21 D

FAMILY IXODIDAE - HARD TICKS

22. Ornate ticks, with some white markings on dorsal shield (Fig. 22 A).....23

Inornate ticks, without white markings on dorsal shield (Fig. 22 B).....28

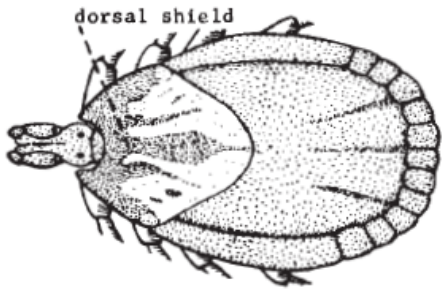


Fig. 2 A

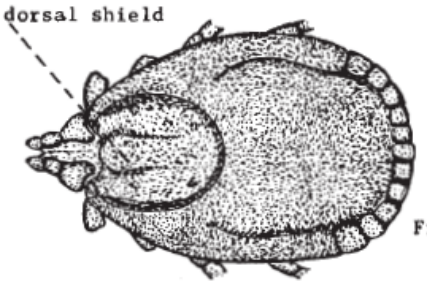


Fig. 2 B

23. Palpi long, much longer than basis capituli; second segment of palpus about twice as long as wide (Fig. 23A). Genus Amblyomma.....24

Palpi short, about as long as basis capituli; second segment of palpus about as long as wide (Fig. 23 B). Genus Dermacentor.....25

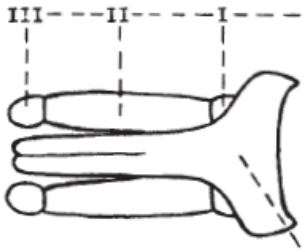


Fig. 23A

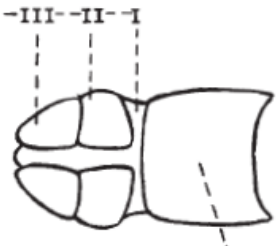


Fig. 23 B

24. Next to last segment of second, third, and fourth pairs of legs without paired terminal spurs; female with a distinct pale marking near posterior end of dorsal shield (Fig. 24 A). Amblyomma americanum.....LONE STAR TICK

Next to last segment of second, third, and fourth pairs of legs with long, paired terminal spurs; female with more diffuse markings on dorsal shield (Fig. 24 B)..... Amblyomma maculatum.....GULF COAST TICK

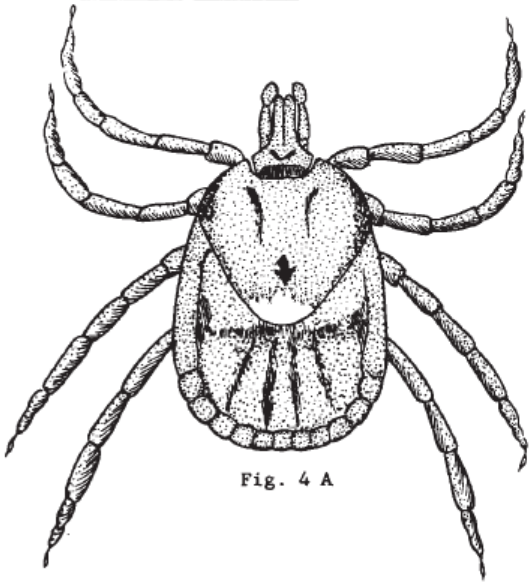


Fig. 4 A

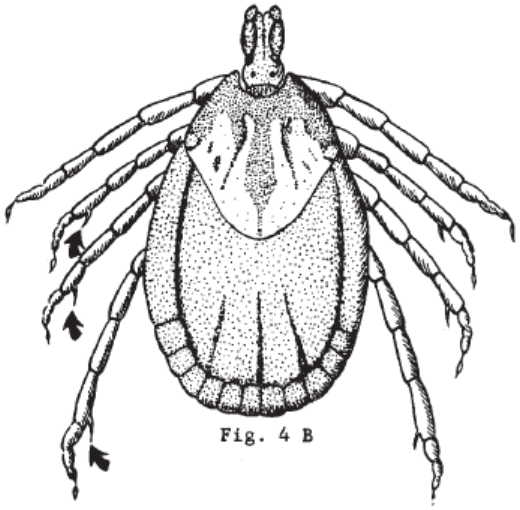


Fig. 4 B

25. Spiracular plate without dorsal prolongation (Fig. 25 A). Dermacentor albipictus..... .....WINTER TICK

Spiracular plate with dorsal prolongation (Fig. 25 B).....26

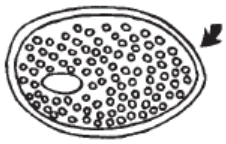


Fig. 25 A

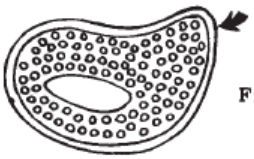


Fig. 25 B

26. Basis capituli with long cornua (Fig. 26 A). Dermacentor occidentalis.PACIFIC COAST TICK

Basis capituli with short cornua (Fig. 26 B)..... 27

Fig. 26 A

Fig. 26 B

27. Goblets of spiracular plate large and less numerous; Rocky Mountain species. (Fig. 27 A) Dermacentor andersoni.....ROCKY MOUNTAIN WOOD TICK

Goblets of spiracular plate very small and numerous; east of the Rocky Mountains and on the Pacific coast. (Fig. 27 B). Dermacentor variabilis.....AMERICAN DOG TICK

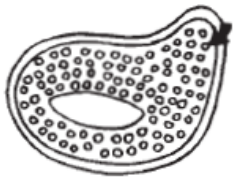


Fig. 27 A

Fig. 27 B

28. Sides of basis capituli laterally produced; distinctly angulate; eyes present on sides of scutum (Fig. 28 A & B).....29

Sides of basis capituli not laterally produced; more or less parallel (Fig. 28 C); eyes absent.....30

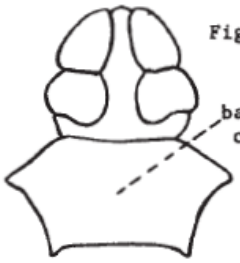


Fig. 28 A

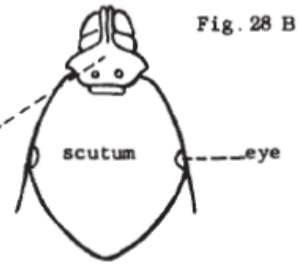


Fig. 28 B

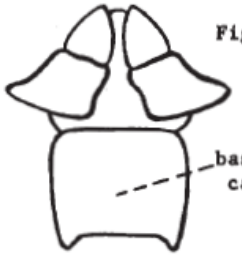


Fig. 28 C

29. Fore coxa deeply cleft; festoons present; easily seen in unengorged specimens; anal groove distinct in unengorged specimens (Fig. 29 A). (principally on dogs or in houses) Rhipicephalus sanguineus.....BROWN DOG TICK

Fore coxa not deeply cleft; festoons absent; anal groove indistinct (Fig. 29 B). (On cattle and deer). Boophilus annulatus.....CATTLE TICK

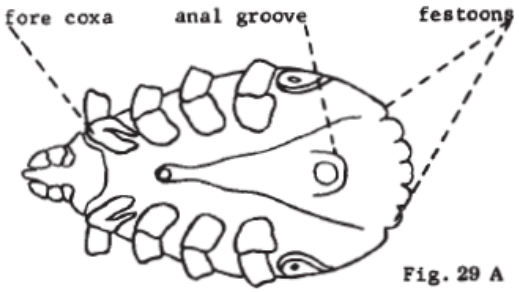


Fig. 29 A

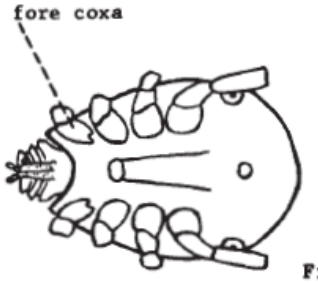


Fig. 29 B

30. Second segment of palpus laterally produced; anal groove behind anus, not attaining posterior margins of body (Fig. 30 A & B). Haemaphysalis leporispalustris.....RABBIT TICK

Second segment of palpus not laterally produced; anal groove extending as an inverted U from in front of anus to posterior margins of body (Fig. 30 C).....Genus Ixodes

Fig. 30 A

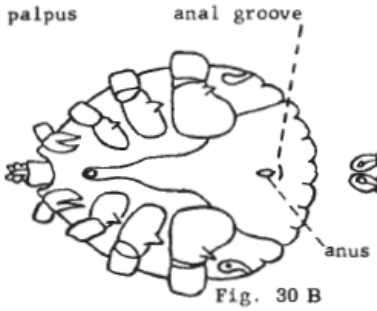


Fig. 30 B

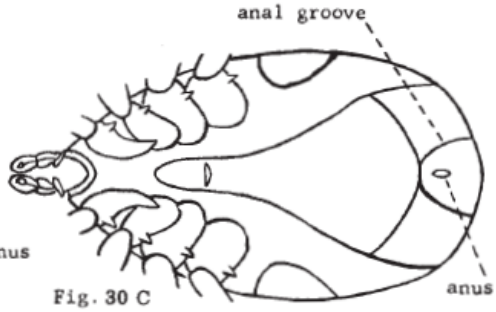


Fig. 30 C

FAMILY ARGASIDAE - SOFT TICKS

31. Margin of body with a definite sutural line separating dorsal and ventral surfaces; dorsal surface with conspicuous "discs" arranged somewhat in radiating lines (Fig. 31 A) Argas persicus.....FOWL TICK

Margin of body lacking definite sutural line, thick and rounded (Fig. 31 B).....32

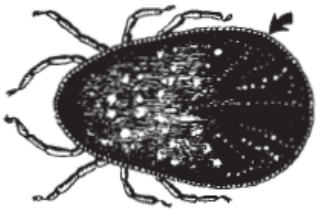


Fig. 31 A

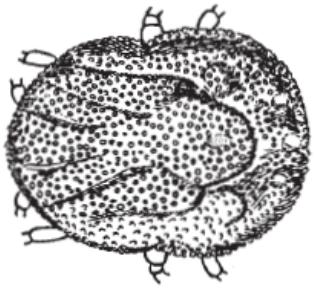


Fig 31 B

32. Hypostome with well-developed teeth (Fig. 32 A); integument not spinose..... Genus Ornithodoros.....33

Hypostome of adult vestigial or without effective teeth; integument of nymph (stage usually seen) spinose (Fig. 32 B). Usually on cattle and horses..... Otobius megnini.....SPINOSE EAR TICK


Fig. 32 A

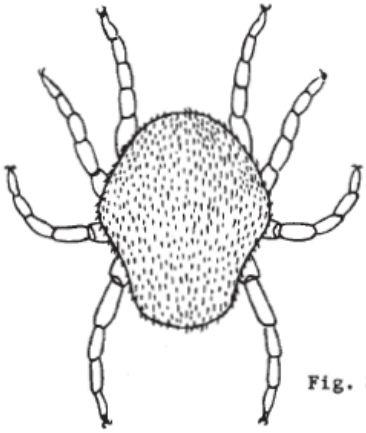


Fig. 32 B

33. Strong dorsal humps absent on all tarsi (Fig. 33 A).....34

Strong dorsal humps present on tarsi of first, second and third legs (Fig. 33 B).....35

Fig. 33

Fig. 33 B

34. Cheeks absent (Fig. 34 A). Ornithodoros hermsi.....HERMS' RELAPSING FEVER TICK

Cheeks present (Fig. 34 B).....Ornithodoros talaje

Fig. 34 A

Fig. 34 B

35. Eyes present on sides of body above second and third coxae (Fig. 35 A); tarsus of fourth leg with a prominent, pointed subterminal spur (Fig. 35 B)..... Ornithodoros coriaceus.....PAJAROELLO TICK

Eyes absent; tarsus of fourth leg without such subterminal spur (Fig. 35 C).....15

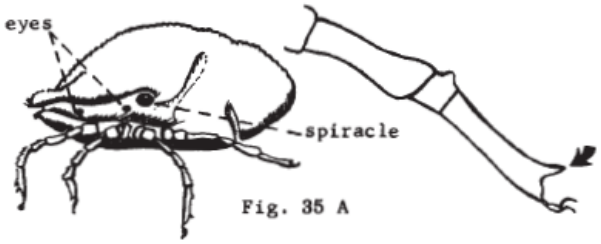


Fig. 35 A

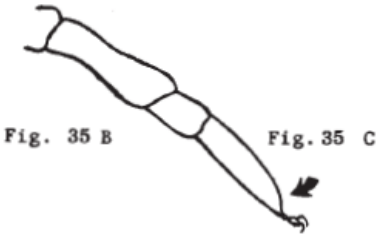


Fig. 35 B

Fig. 35 C

36. Mammillae large, relatively few and not crowded; in mid-dorsal region about 10 per linear mm.; hypostome over 1/2 mm. long. Southeastern United States and Mexico north to Kansas and Florida. Ornithodoros turicata.....RELAPSING FEVER TICK

Mammillae small, crowded, and numerous; in mid-dorsal region about 18 per linear mm.; hypostome less than 1/2 mm. long. Pacific coast and Rocky Mountain states..... Ornithodoros parkeri.....PARKER'S RELAPSING FEVER TICK

BLISTER BEETLES: KEY TO SOME COMMON UNITED STATES SPECIES

Harold George Scott and Chester J. Stojanovich

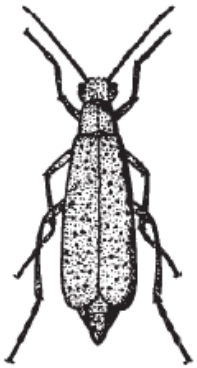
striped

Epicauta vittata
STRIPED BLISTER BEETLE

margined

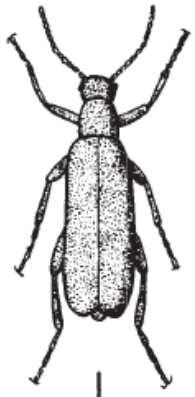
Epicauta pestifera
MARGINED BLISTER BEETLE

spotted



Epicauta cinerea maculata
SPOTTED BLISTER BEETLE

essentially unicolorous



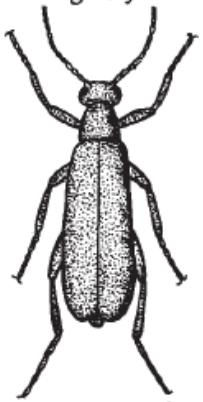
black

Epicauta pennsylvanica
BLACK BLISTER BEETLE

black with gray pubescense

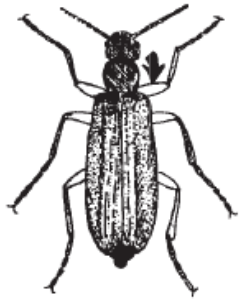
Epicauta cinerea cinerea
CLEMATIS BLISTER BEETLE

gray



Epicauta fabrici
ASH-GRAY BLISTER BEETLE

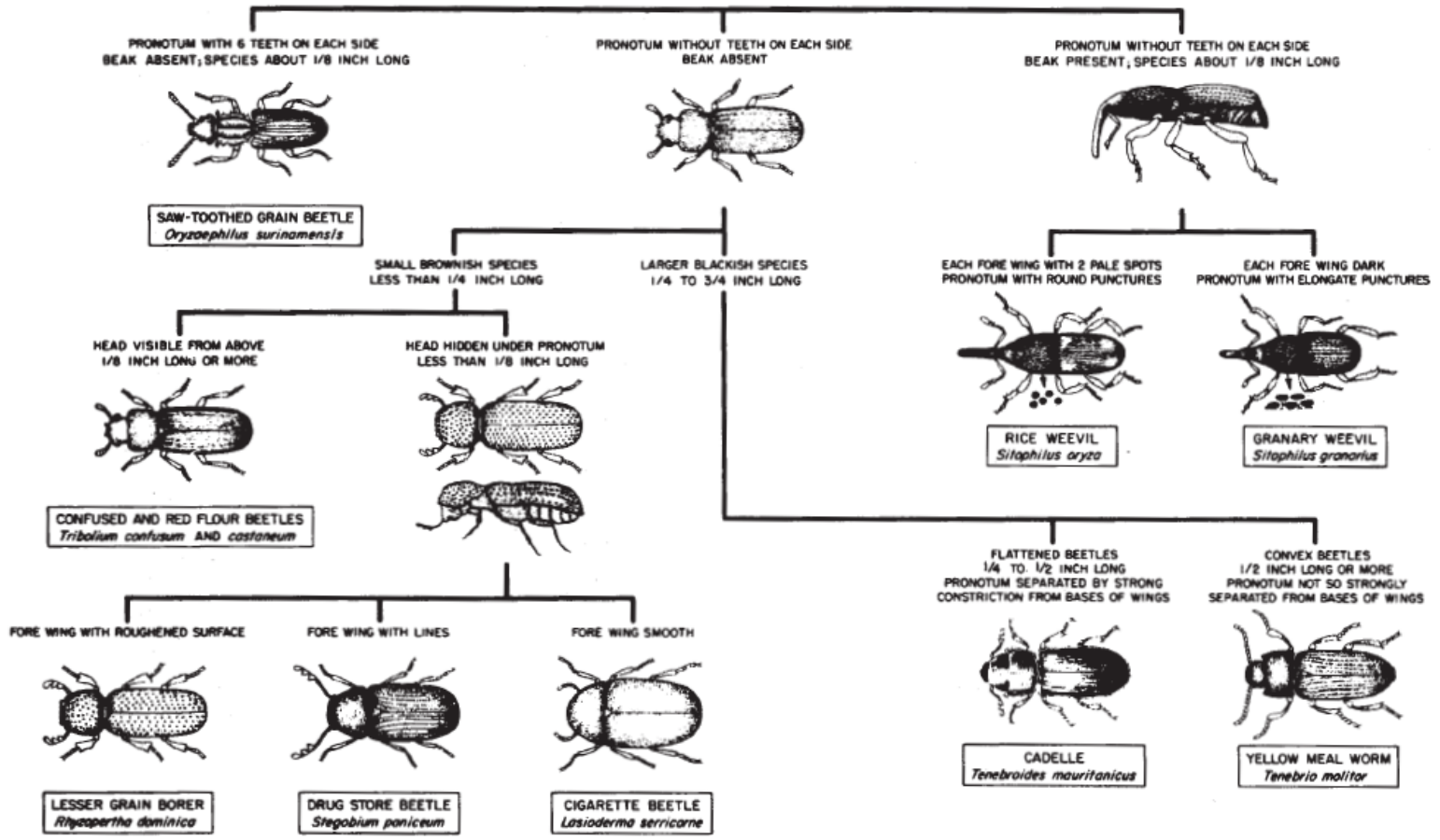
metallic blue with red-yellow leg bases



Pomphopoea sayi
SAY BLISTER BEETLE

BEETLES: PICTORIAL KEY TO SOME SPECIES COMMONLY ASSOCIATED WITH STORED FOODS

Harry D. Pratt



DOMESTIC FLIES: PICTORIAL KEY TO COMMON SPECIES

Harold George Scott and Margery R. Borom

thorax dull, abdomen dull

thorax dull, abdomen shiny

Calliphora spp. and *Cynomyopsis* spp.
BLUE BOTTLE FLIES

thorax shiny, abdomen shiny

small (about 1/5-inch long)
4 thoracic stripes, indistinct

Fannia spp.
LESSER HOUSE FLIES

medium-size (about ¼-inch long)
4 thoracic stripes, often indistinct

large (usually over 1/3-inch long)
3 distinct thoracic stripes
abdomen with red tip

Sarcophaga spp.
FLESH FLIES

thoracic stripes distinct
sides of abdomen pale
erect when resting
thorax without pale spots

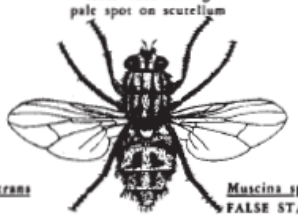
Musca domestica
HOUSE FLY

thoracic stripes indistinct
sides of abdomen dark

"squats" when resting
pale spot behind head

Stomoxys calcitrans
STABLE FLY

erect when resting
pale spot on scutellum



Muscina spp.
FALSE STABLE FLIES

color black
medium-size (¼-inch long)

Ophyra spp.
DUMP FLIES

color dark blue
large (1/3-inch long)

Phormia regina
BLACK BLOW FLY

color green to bronze

color green

3 thoracic stripes

Cochliomyia macellaria
SECONDARY
SCREW WORM FLY

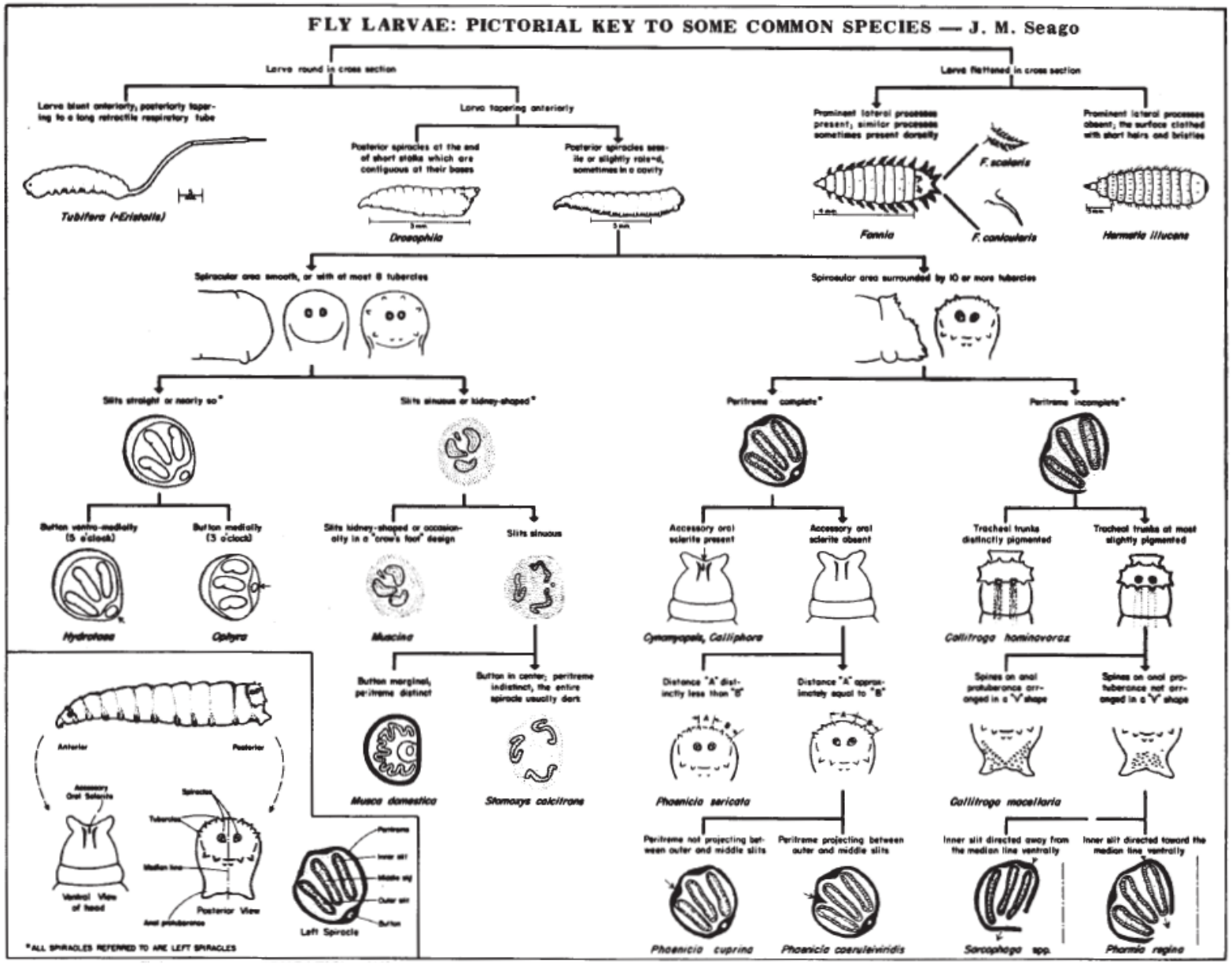
without thoracic stripes

Phaenicia sericata
GREEN
BOTTLE FLY

color bronze
without thoracic stripes

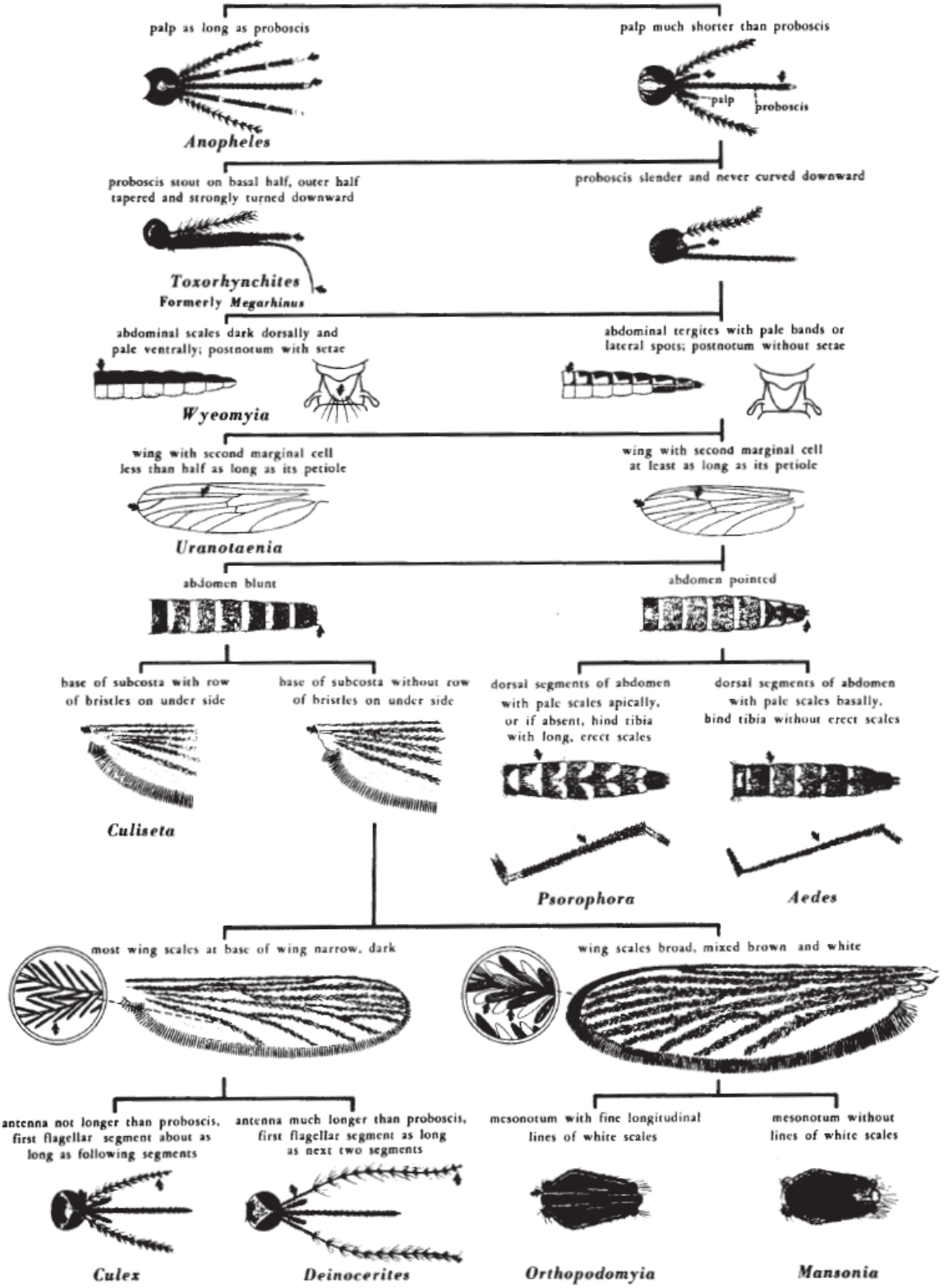
Phaenicia cuprina
BRONZE
BOTTLE FLY

FLY LARVAE: PICTORIAL KEY TO SOME COMMON SPECIES — J. M. Seago



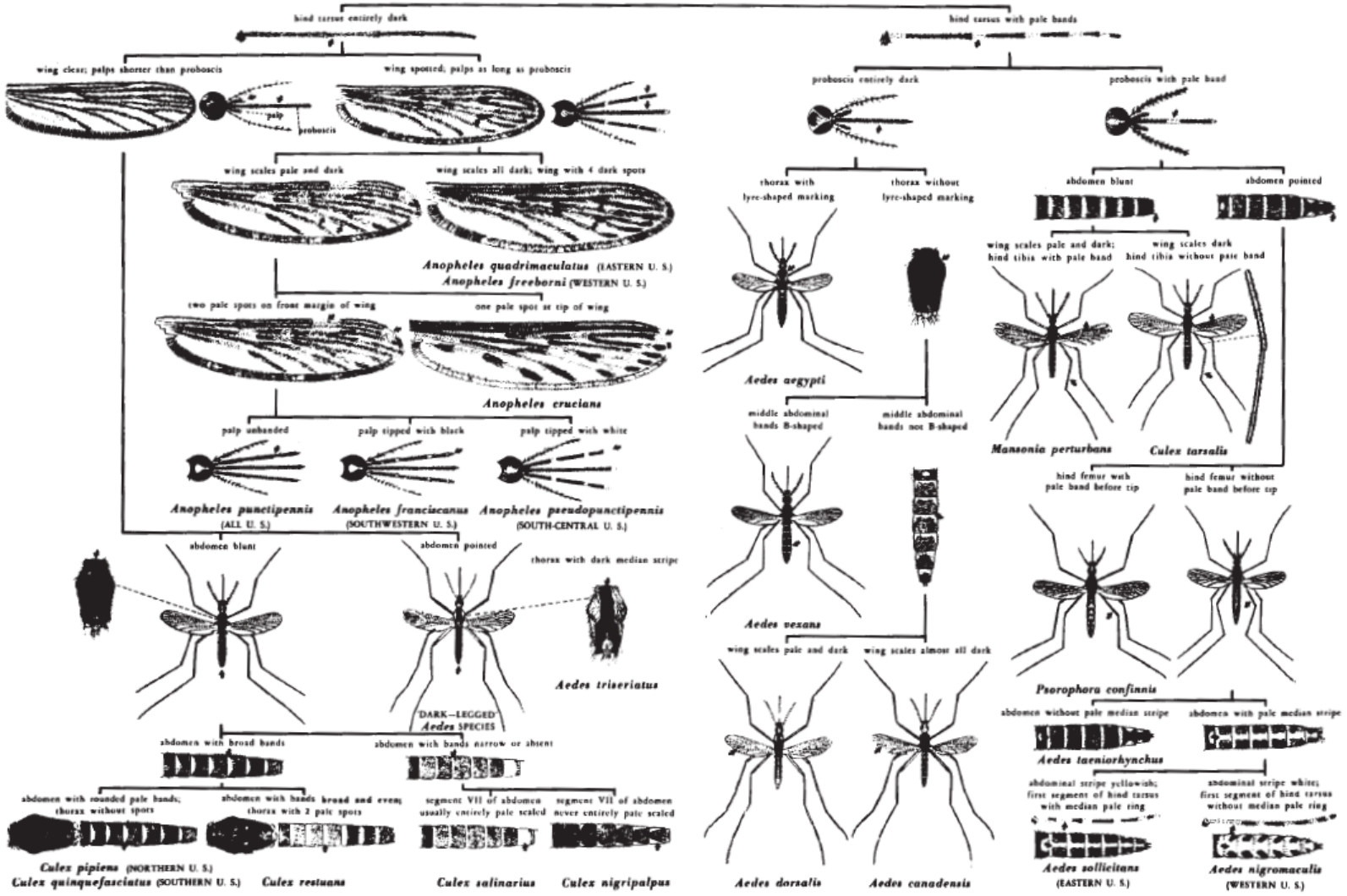
MOSQUITOES: PICTORIAL KEY TO UNITED STATES GENERA OF ADULTS (FEMALE)

Harry D. Pratt and Chester J. Stojanovich



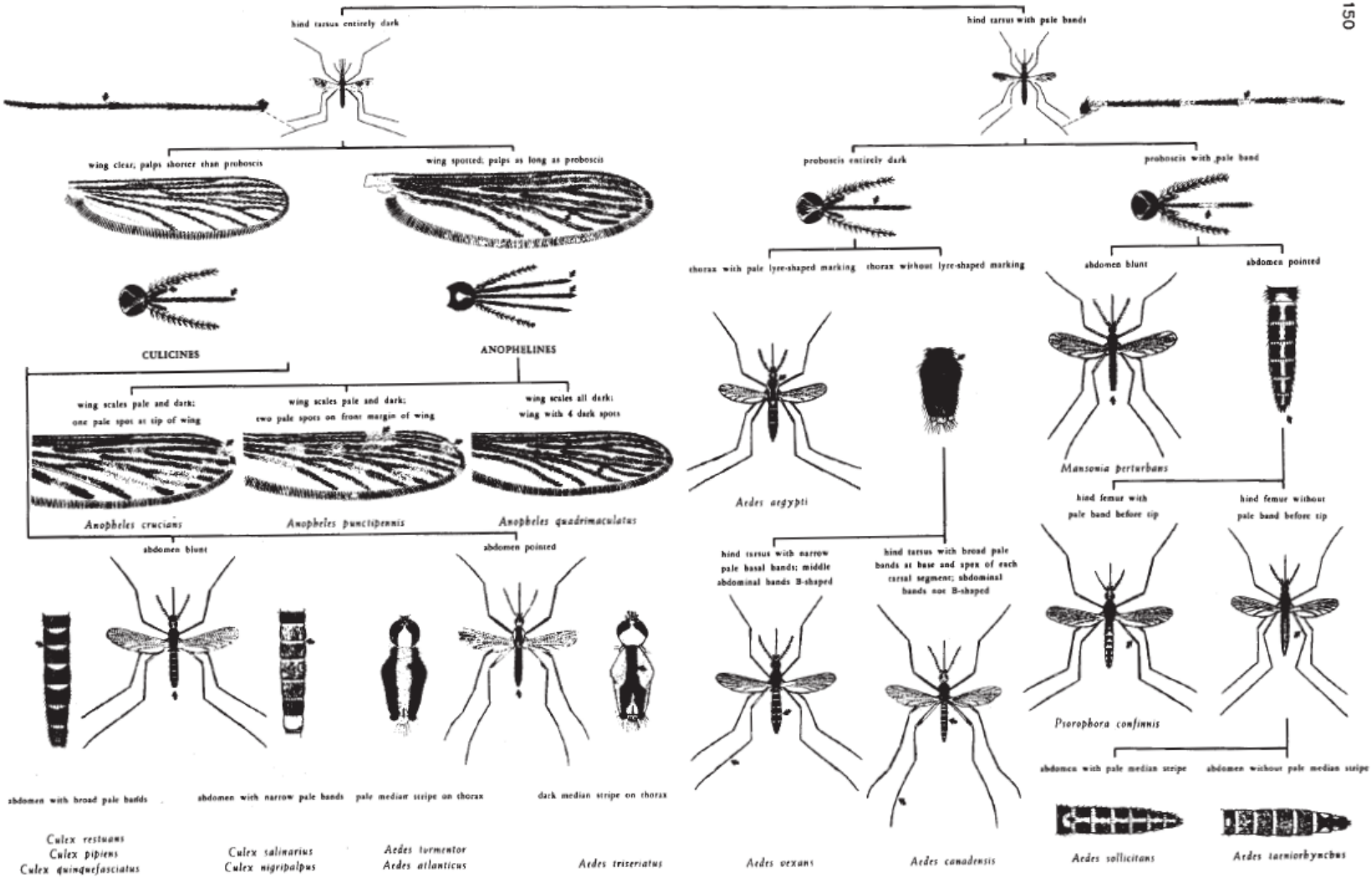
MOSQUITOES: PICTORIAL KEY TO SOME COMMON ADULTS (FEMALE) OF THE UNITED STATES

Harry D. Pratt and Chester J. Stojanovich



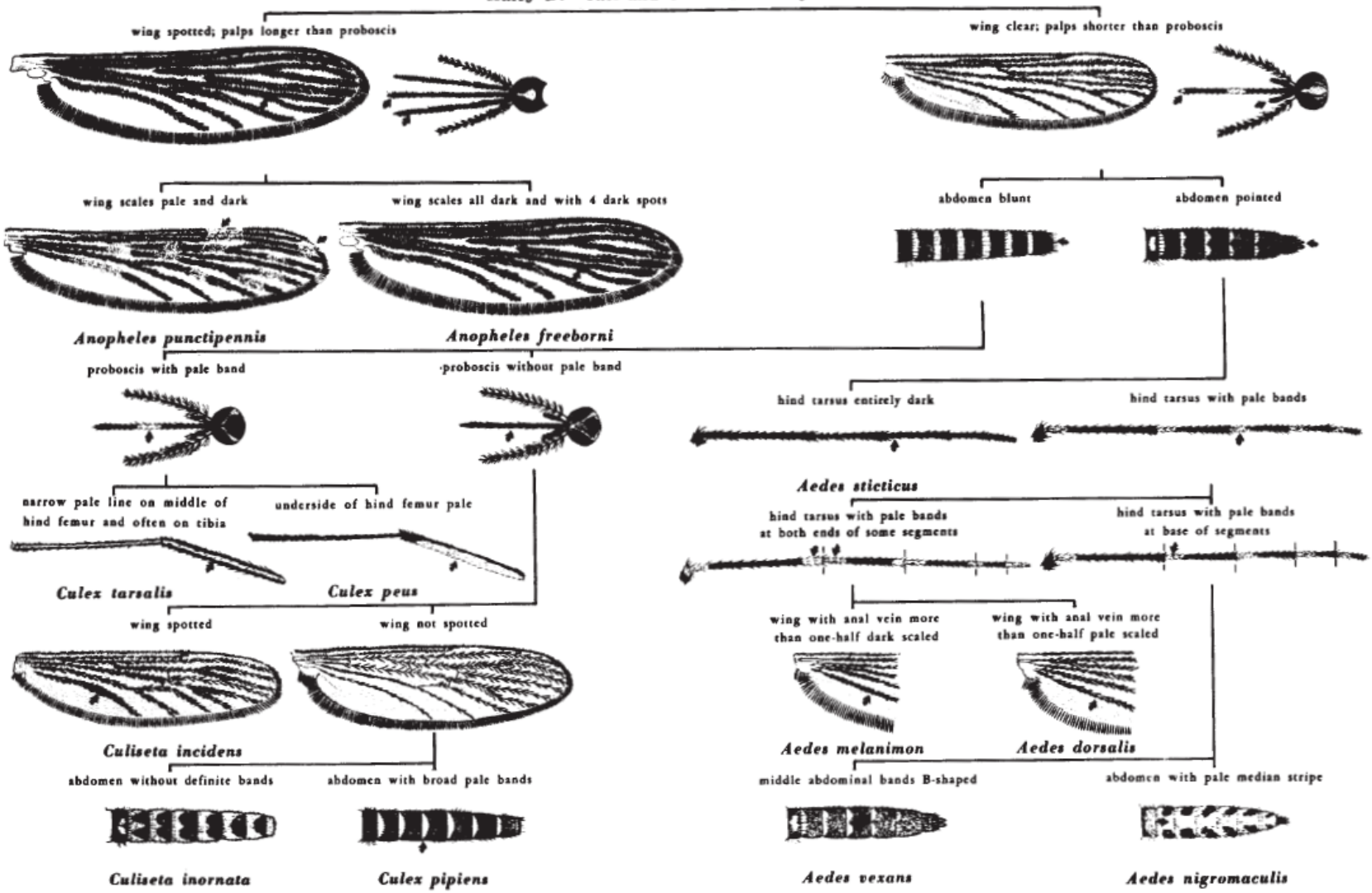
MOSQUITOES: PICTORIAL KEY TO SOME ADULTS (FEMALE) IN EASTERN UNITED STATES

Harry D. Pratt and Chester J. Stojanovich



MOSQUITOES: PICTORIAL KEY TO SOME COMMON ADULTS (FEMALE) OF WESTERN UNITED STATES

Harry D. Pratt and Chester J. Stojanovich



TERMITES: KEY TO SOME COMMON NORTH AMERICAN SPECIES

Harold George Scott

Fig. A - Winged Adult

Fig. B - Soldier

Fig. C - Worker

Key to Winged Adults

1. Radius without branches; fontanel (fig. E) usually present 2
   Radius (fig. D)-with branches; fontanel absent 4

2. Tibia (fig. F) slightly to plainly blackish 3
   Tibia entirely pale; Ontario to Guatemala, west to Utah and Arizona
   (*Reticulitermes flavipes*) ..... EASTERN SUBTERRANEAN TERMITE

3. Tibia slightly darkened; length 9 mm.; British Columbia to Baja California, east to Idaho and Sonora
   (*Reticulitermes hesperus*) ..... WESTERN SUBTERRANEAN TERMITE
   Tibia generally darkened; length 9.5- 10 mm.; Oregon and Montana to western Mexico, Missouri, and Texas
   (*Reticulitermes tibialis*) ..... ARID SUBTERRANEAN TERMITE

4. Ocelli (fig. E) present 5
   Ocelli absent; western Canada to Baja California
   (*Zootermopsis angusticollis*) ..... WESTERN ROTTEN-WOOD TERMITE

5. Body yellow to light brown 6
   Body blackish; California to Baja California, east to Arizona and Utah
   (*Kalotermes minor*) ..... WESTERN DRY-WOOD TERMITE

6. Transverse rows of long hairs on tergites; South Carolina to Florida, west to eastern Texas (*Kalotermes snyderi*) ..... EASTERN DRY-WOOD TERMITE
   No transverse rows of hairs on tergites; Arizona and California
   (*Procryptotermes hubbardi*) ..... ARID DRY-WOOD TERMITE

Fig. D - Wing

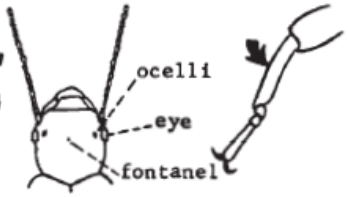


Fig. E - Head

Fig. F - Leg

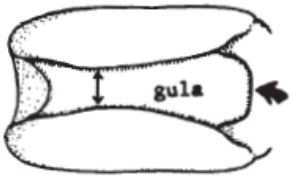


Fig. G - Throat

Key to Soldiers

1. Fontanel (fig. E) present; eyes usually absent 2
   Fontanel absent; eyes (fig. E) present 4

2. Gula (fig. G) not twice as broad in front as in middle ..... ARID SUBTERRANEAN TERMITE
   Gula twice as broad in front as in middle 3

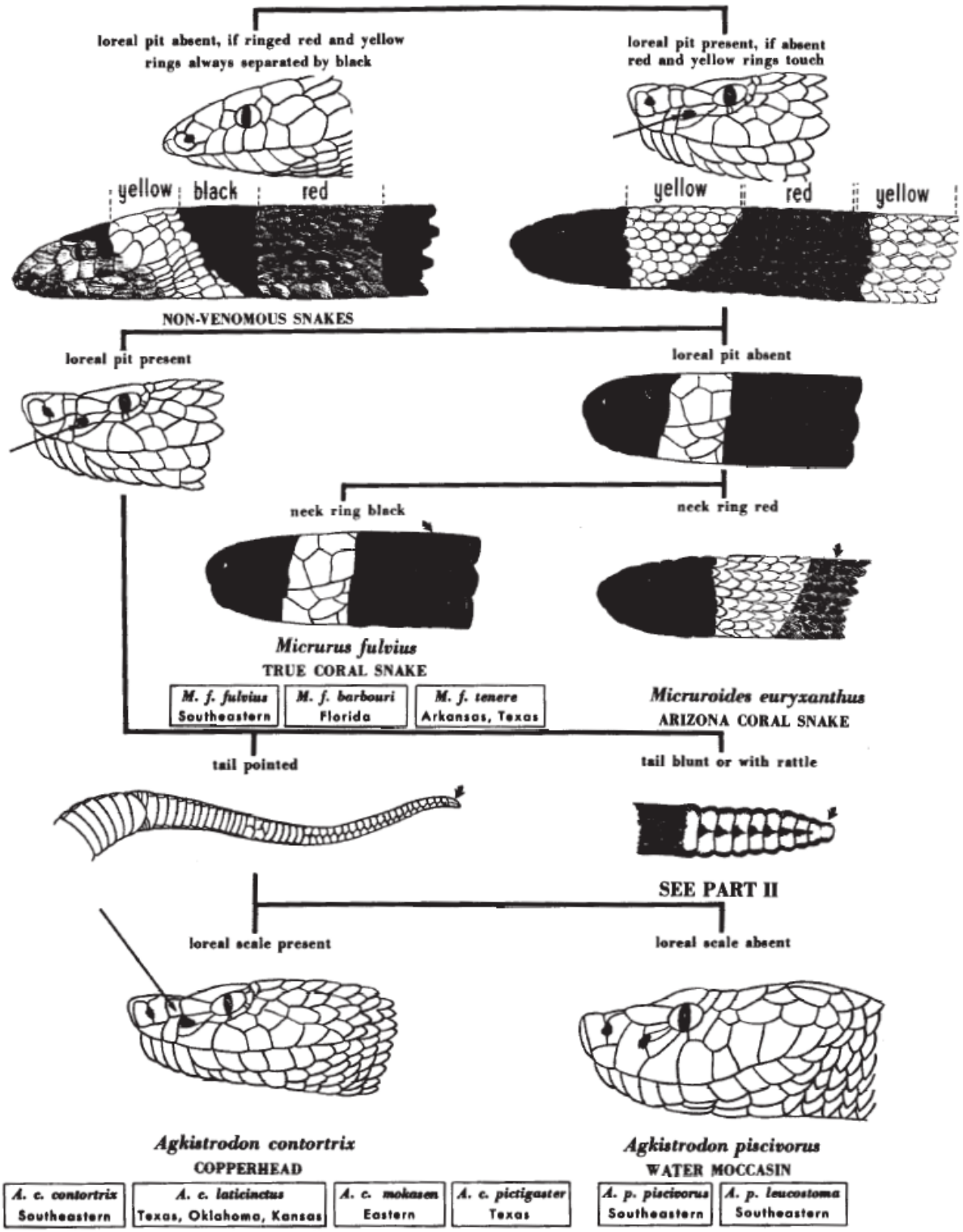
3. Head twice as long as broad ..... WESTERN SUBTERRANEAN TERMITE
   Head less than twice as long as broad ..... EASTERN SUBTERRANEAN TERMITE

4. Antenna (fig. E) with 23-31 segments 5
   Antenna with 10-20 segments ..... WESTERN ROTTEN-WOOD TERMITE

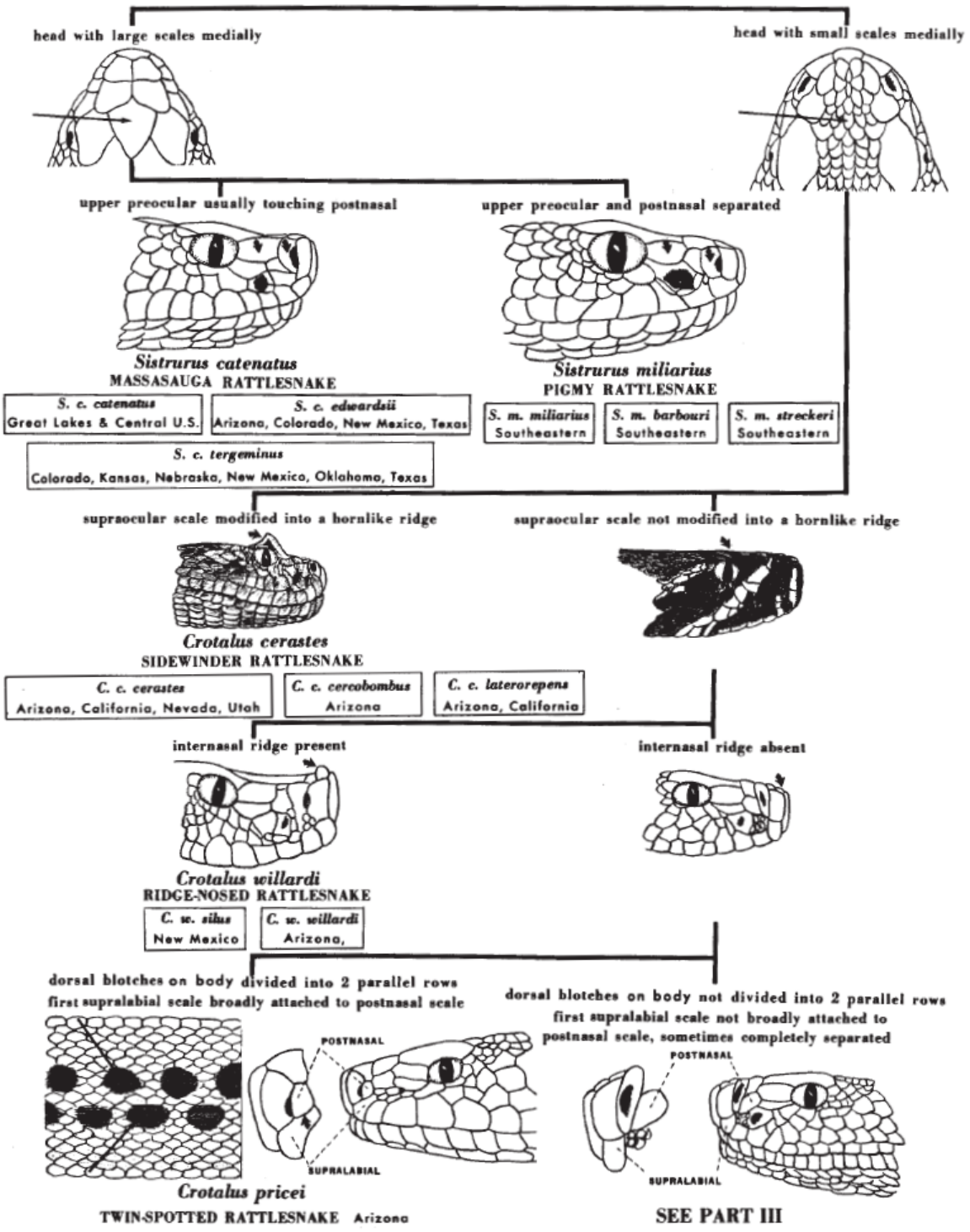
5. Third antennal segment as long as next 3 combined ..... EASTERN DRY-WOOD TERMITE
   Third antennal segment shorter than next 3 combined ..... WESTERN DRY-WOOD TERMITE
   Third antennal segment as long as next 4 combined ..... ARID DRY-WOOD TERMITE

SNAKES: PICTORIAL KEY TO VENOMOUS SPECIES IN UNITED STATES
PART I

Chester J. Stojanovich and Margaret A. Parsons

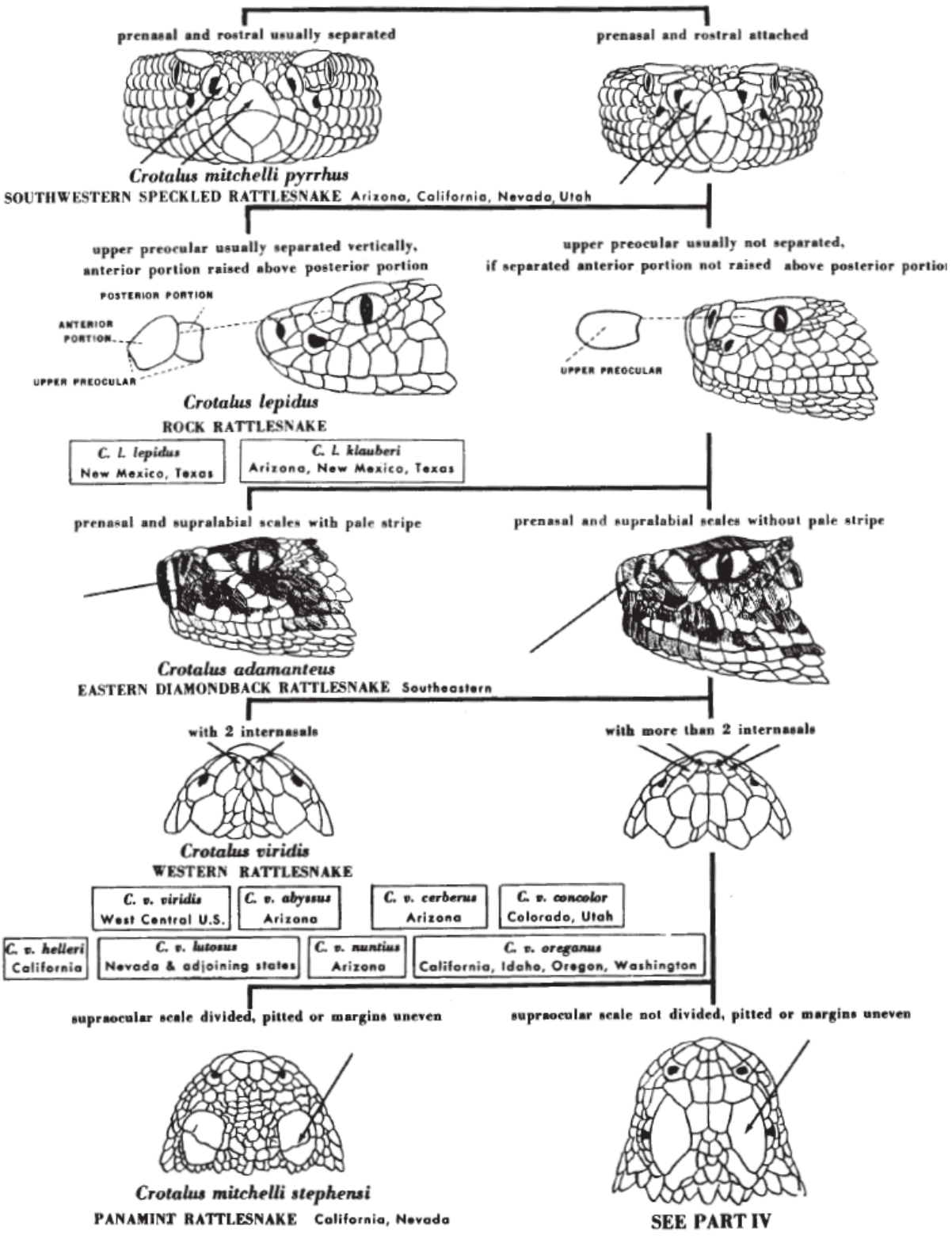


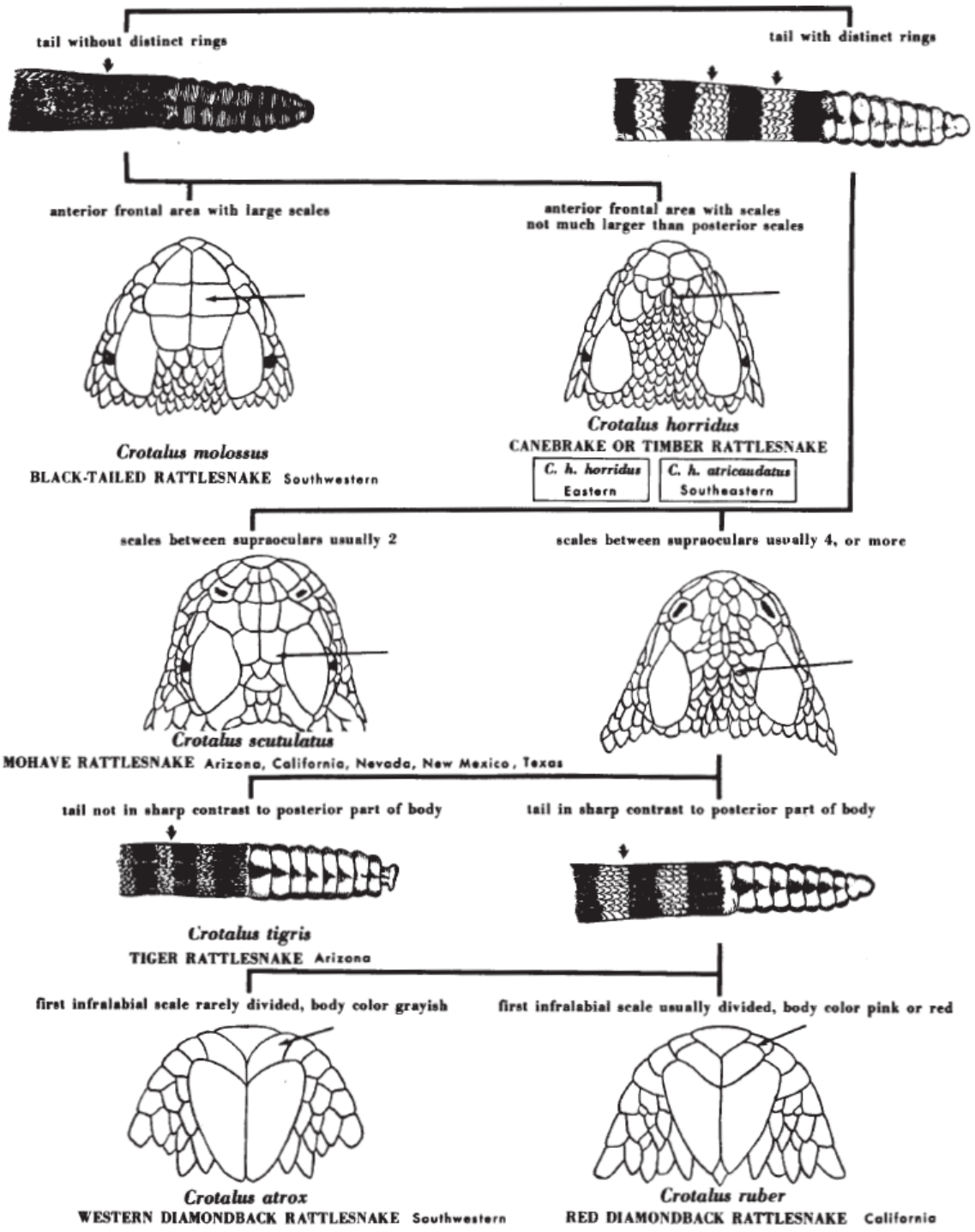
PART II



SEE PART III

PART III


prenasal and rostral usually separated
prenasal and rostral attached
Crotalus mitchelli pyrrhus
SOUTHWESTERN SPECKLED RATTLESNAKE Arizona, California, Nevada, Utah
upper preocular usually separated vertically, anterior portion raised above posterior portion
upper preocular usually not separated, if separated anterior portion not raised above posterior portion
POSTERIOR PORTION
ANTERIOR PORTION
UPPER PREOCULAR
UPPER PREOCULAR
Crotalus lepidus
ROCK RATTLESNAKE
C. l. lepidus
New Mexico, Texas
C. l. klauberi
Arizona, New Mexico, Texas
prenasal and supralabial scales with pale stripe
prenasal and supralabial scales without pale stripe
Crotalus adamanteus
EASTERN DIAMONDBACK RATTLESNAKE Southeastern
with 2 internasals
with more than 2 internasals
Crotalus viridis
WESTERN RATTLESNAKE
C. v. viridis
West Central U.S.
C. v. abyssus
Arizona
C. v. cerberus
Arizona
C. v. concolor
Colorado, Utah
C. v. helleri
California
C. v. lutosus
Nevada & adjoining states
C. v. nuntius
Arizona
C. v. oreganus
California, Idaho, Oregon, Washington
supraocular scale divided, pitted or margins uneven
supraocular scale not divided, pitted or margins uneven
Crotalus mitchelli stephensi
PANAMINT RATTLESNAKE California, Nevada
SEE PART IV


tail without distinct rings
tail with distinct rings
anterior frontal area with large scales
anterior frontal area with scales not much larger than posterior scales
Crotalus molossus
BLACK-TAILED RATTLESNAKE Southwestern
Crotalus horridus
CANEBRAKE OR TIMBER RATTLESNAKE
C. h. horridus Eastern
C. h. atricaudatus Southeastern
scales between supraoculars usually 2
scales between supraoculars usually 4, or more
Crotalus scutulatus
MOHAVE RATTLESNAKE Arizona, California, Nevada, New Mexico, Texas
tail not in sharp contrast to posterior part of body
tail in sharp contrast to posterior part of body
Crotalus tigris
TIGER RATTLESNAKE Arizona
first infralabial scale rarely divided, body color grayish
first infralabial scale usually divided, body color pink or red
Crotalus atrox
WESTERN DIAMONDBACK RATTLESNAKE Southwestern
Crotalus ruber
RED DIAMONDBACK RATTLESNAKE California

BIRDS: PICTORIAL KEY TO SOME COMMON PEST SPECIES OF PUBLIC HEALTH IMPORTANCE

Margaret A. Parsons and Chester J. Stojanovich

bill short

bill long

male and female. body plump, tail fan-like

body trim, tail not fan-like

COMMON PIGEON

male. body black, head brown
female. overall dull grey color

male. black throat, grey crown
female. whitish throat, dull eye stripe

male female

female male

COMMON COWBIRD

HOUSE SPARROW

male. wing with red 'epaulettes'
female. breast heavily striped, light eye stripe

wing without 'epaulettes'
breast not heavily striped

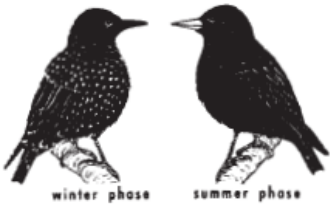
female male

RED-WINGED BLACKBIRD

males. plain bronze or
dull purple back, tail long
females: less iridescent, smaller size

winter. bill dark, body heavily speckled with light dots
spring. bill yellow, color purple and green

male and female.
very large size, coal
black color, tail flat



winter phase summer phase

GRACKLES

STARLING

CROWS

APPENDIX C

SURVEY OF GEORGIA SCHOOLS

Pest Control Survey Questions for Georgia Schools

(All surveys conducted by phone in 2010)

Instructions: *Please answer the following questions to the best of your knowledge.*

1. Who is responsible for pest control decision in this district? _____

2. Is pest control a district wide decision or left up to the individual school? _____

3. How many schools are in your district? _____

4. Of these schools how many use a licensed pest control service to physically apply pesticides.

_____

Thank you for taking the time to respond to this survey. If you have any questions please contact

Sonja Brannon at the University of Georgia, Department of Entomology

Thank you

Sonja Brannon

Sonjab@uga.edu

706-224-7371

Figure A 1. The percentage of Georgia school districts that use a licensed pest control company to manage pests. 2010

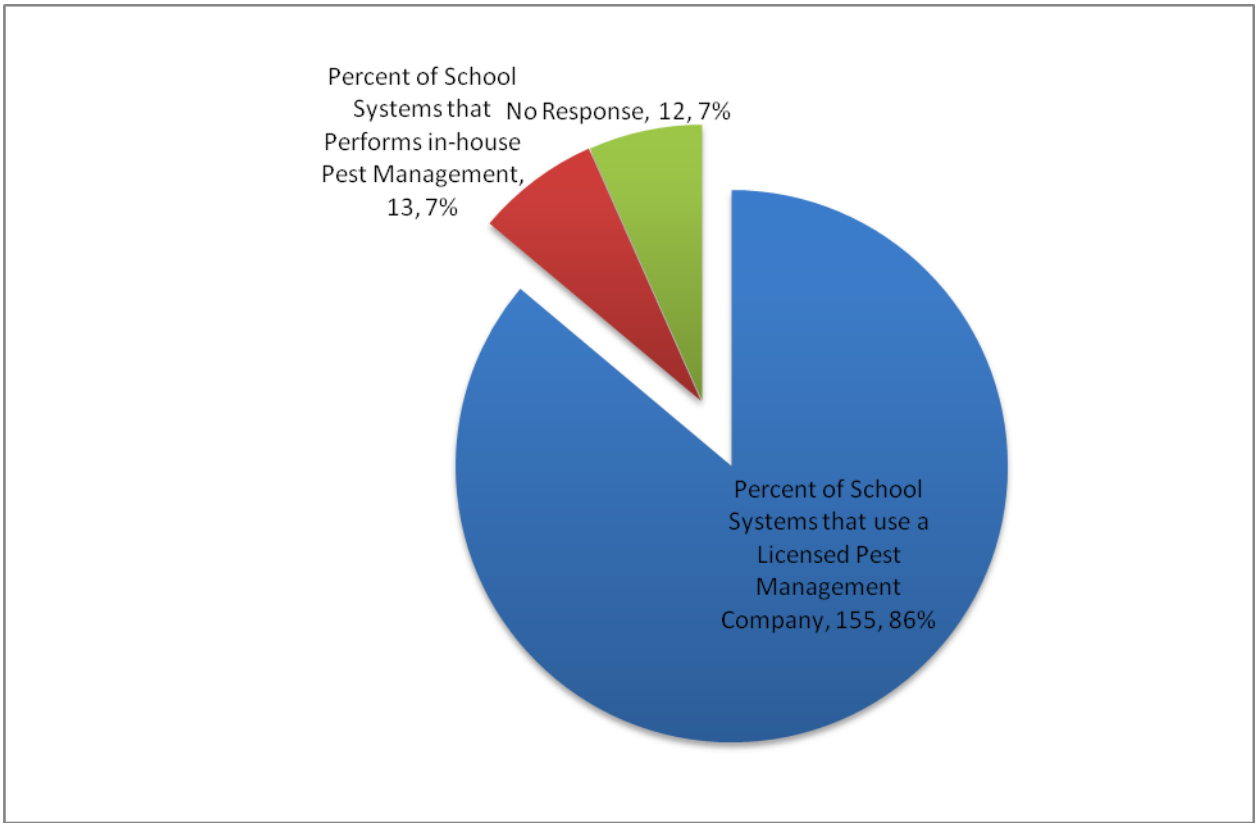


Figure A-2. Distribution of school districts in Georgia that use a licensed pest control company to manage pests. Each county represents a district. A red dot inside a county represents a city district.