2016

Analysis of Insect Pest Reports at LSU Residential Life

Namoona Acharya
Louisiana State University and Agricultural and Mechanical College, nachar1@lsu.edu

ANALYSIS OF INSECT PEST REPORTS AT LSU RESIDENTIAL LIFE

A Thesis

Submitted to the Graduate Faculty of the
Louisiana State University and
Agricultural and Mechanical College
in partial fulfillment of the
requirements for the degree of
Master of Science

in

The Department of Entomology

by
Namoona Acharya
B.S., Tribhuvan University, 2010
August 2016

ACKNOWLEDGMENTS

I would like to express my special appreciation to my major advisor Professor Dr. Gregg Henderson for his support and effort for my research so that I can grow as a research scientist in the future. I appreciate Ms. Celena Trahan, my supervisor while working at the LSU Residential Life for providing a platform to work in the field of applied entomology. I want to thank the collaborated project between Department of Residential Life and Department of Entomology for providing me funds for my study as well my research and considering me as the 1st student working in such a wonderful project. I would like to appreciate my committee member, Dr. Melissa Cater, Dr. Rodrigo Diaz and Dr. Fangneng Huang for their incredible help for research and data analysis. I would like to thank Dr. Bal K. Gautam, our former Postdoctoral Research Associate, labmates: Dependra Bhatta, Scott Nacko and all of my friends from Department of Entomology for their help and support. I would like to thank all the staff and faculty from Department of Entomology, all the staff from Department of Residential Life, all students living on campus, Student Voice and Department of Experimental Statistics.

I am very appreciative to my parents Mr. Bishnu Kumar Acharya and Mrs. Rama Ghimire Acharya, my husband, Jagannath Upadhyay, and my dear sister, Ranjana Acharya, for their support. I want to appreciate my family members and host family members for their positive support. I want to appreciate all those people who have benevolent feeling towards me. Finally, I am very thankful to all those people who helped me directly or indirectly to complete this project.

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

ABSTRACT

Urban insect pests are adversely affecting student living on campus at LSU. Insect pest reporting was started systematically in 2000 at LSU Residential Life after introducing Maximo database. To analyze the insect pest reports, complaints from students on ants, bed bugs and cockroaches were selected from the database. From the 16-year data set, the growth trend of reports of ants, bed bugs and cockroaches was found to be increasing. The highest reported month and year for ants was September 2004. In August 2008, cockroaches were most reported on. Bed bug reports peaked in October 2009. Based on the reports, the highest degree of infestation was found in Highland Hall for ants and West Nicholson for bed bugs and cockroaches. To calculate the degree of infestation for each 20 dorms, 2 single student apartments and 2 family apartments, total reports of a particular insect group was divided by 16 years to calculate the averages and then divided by the number of students residing in that dorm/apartment and then multiplied by hundred to convert the value to a percentage. All halls/apartments were divided into 3 age groups (< 30 years, 30-60 years, and > 60 years) to determine the relationship between the degree of infestation and the age of halls/apartments. The oldest halls/apartments had significantly higher ant infestations/students, while halls/apartments age was not significant for bed bugs and cockroaches. A negative slope was found between the degree of infestation and the number of floors among all dorms and apartments which was linearly significant with bed bugs and cockroaches. From our visual inspections of 21 apartments/halls with bed bug reports, only 3 actually had bed bugs. Most of the reports were possibly related other insect bites/stings, allergies and a negative perception toward bed bugs.

A web survey “Residential Life Entomology Survey” was also developed and sent to students living on campus. From this study, the LSU Residential Life came to know the present

situation of insects among all halls and apartments. From 392 respondents, mosquitoes, cockroaches, long horn crazy ants, gnats, bees and wasps were found as the most common insects reported. Students were positive toward the use of preventative chemicals measure. More than half of the students were satisfied with the insect pest control. In this case, the pest management team of Residential Life as well as the Pest Control Company (PCO) should work better and while using pest control strategies, students should be advised about the prevention procedure. Linearly significant relationship was observed between the number of insects observed and the level of satisfaction, in which for every one unit increase of insects observed, the satisfaction level decreases by -1.61.

From this overall study, LSU Residential Life's insect problem is minor with 2.64% of reports while comparing all reports in Maximo Database. Although this percentage is low, insects should be considered important. Residential Life has been working with different PCOs and students consider that PCOs and Residential Life are responsible for insect control in their living areas. However, students could also prevent many insects in their halls and apartments. As for ants and cockroaches, students can prevent these insects by improving their habits. As sanitation is the key to prevent many insects, students can protect themselves from many allergic reactions after insects' bites/stings. Similarly, disease vectors could be prevented along with the clean environment in dorms and apartments. To prevent and control insect pests at the LSU Residential Life, PCOs working as contractors, pest management team of LSU Residential Life and students collaborate together to make LSU Residential Life a great place.

CHAPTER 1. INTRODUCTION

1.1 Urban pests

Urban pests affect man and his surrounding environment. These pests are present both inside and outside a home. Those pests involved in injuring, disabling human lives, damaging properties and sharing human resources are the urban pests (Dhang 2011). Blood feeders such as mosquitoes and bed bugs, insects stinging with venom such as ants, bees and wasps, insects causing allergies, contamination and phobias such as cockroaches and dust mites, structural pests such as termites, power post beetles and ants are common urban pests world-wide (Dhang 2011). Urban environments are severely affected especially by social insect pests such as ants, termites and yellowjackets (Rust and Su 2012). Urban insects are responsible for the destruction of structures, transferring of disease organisms, and biting and stinging humans as well as pets (Rust and Su 2012). Cockroaches, house dust mites, bed bugs, fleas, human body lice, ticks, mosquitoes, rodents and birds are common urban pests with public health significance (Bonnefoy et al. 2008).

1.2 Public and medical importance of ants, bed bugs and cockroaches

Insects have public health and medical significance. Human disease organisms such as *Pseudomonas aeruginosa, Staphylococus* spp., *Salmonella* spp., and *Clostrium* spp., were found on the exoskeleton of worker pharaoh ants, *Monomorium pharaonis* (Linnaeus) foraging in hospitals in England and USA (Beatson 1972, Rupp and Forni 1972, Beatson 1973, Granovsky and Howell 1983). The poison gland is located in the abdomen which provides a defense for many ants (Attygalle and Morgan 1984). Some ants can eject this poison up to 20 inches (50 cm) (Mallis 1969). In Oklahoma, a child died because of Texas harvester ant stings, *Pogonomyrmex barbatus* Smith (Brett 1950) and in Mississippi, a child of eight months was dead by the sting of

Southern fire ant, *Solenopsis xyloni* McCook (Coarsey 1952). Similarly, the red imported fire ant, *Solenopsis invicta* Buren, another stinging ant, ejects venom inside the human body that results in the development of many symptoms such as nausea, vomiting, dizziness, perspiration, cyanosis, and asthma, leading to anaphylactic shock in sensitive individuals (Harwood and James 1979). If the patient does not receive timely treatment in such a condition, he/she can die (Harwood and James 1979). As of today, bed bugs, *Cimex lactularius* Latreille are not regarded as human disease vectors but they can cause discomfort, nervousness, insomnia, and isolation which reduces the quality of life (Hwang et al. 2005). An Indian study on infants refers to the fact that they can cause iron deficiency by multiple blood feeding (Venkatachalam and Belavady 1962) and also mechanically transmit hepatitis B virus and human immunodeficiency virus in the laboratory (Jupp et al. 1983, Jupp and Lyons 1987). Cockroaches are important human diseases vectors. More than 100 bacterial species were found from schools, restaurants, hospitals, pet shops, and home dwellings due to cockroaches (Roth and Willis 1957). Many reports show that cockroaches are potential mechanical human diseases vectors (Anuar and Paran 1976, Bajomi and Elek 1979, Rampal et al. 1983, Oothuman et al. 1985, Oothuman et al. 1989, Lee 1997). Reports also show that cockroaches cause household allergies and entomophobia (Lee 1997).

1.3 Distribution

1.3.1 Distribution of ants

Ants are classified into 21 subfamilies, 283 genera (http://www.antweb.org/world.jsp) and 14,095 species (http://www.antweb.org/antblog/2010/04/how-many-kinds-of-ants-are-there.html). Almost 150 species of ants have been transported to non-native habitats around the world (McGlynn 1999). In Louisiana, 132 species of ants were found during research conducted in 2007 and 19 of them were non-native (Dash and Hooper 2008). Three of the non-native

species in Louisiana are the red imported fire ants, Argentine ants, *Linepithema humile* (Mayr) and tawny crazy ants, *Nylanderia fluva* Mayr. Red imported fire ants are urban pests that nest in playgrounds, under pavements, nearby structures, and gardens (Benedict 2007). Similarly, tawny crazy ants are a new, invasive and aggressive pest in households and agricultural lands in Louisiana, Mississippi, Texas and Florida (MacGown and Layton 2010, Aguillard et al. 2011). All of these insects are native to South America and are successfully established as economically important pests in Louisiana. Most invasive ant species come from South America (Suarez et al. 2010). Besides these, the common crazy ant, *Paratrechina longicornis* (Latreille) also known as the longhorn crazy ant, native to India and Southeast Asia (Wasmann 1905b, Wheeler 1910,Wheeler 1919) has been an urban pest in Louisiana since 1943 (Wetterer 2008).

1.3.2 Distribution of bed bugs

Bed bugs (*Cimex lectularius*) are hematophagous bugs, living near human beings. They mainly feed on human blood during the night but also suck blood from other animals such as bats, chickens, other birds and pets. Since ancient times, bed bugs have been parasites to humans (Usinger 1966). According to some experts, bed bugs used to feed on bat blood in the Mediterranean region, as they lived together in caves (Sailer 1952, Usinger and Povolny 1966). At some point, humans started occupying bat caves and some bat bugs adapted and speciated to specialize on humans. Bed bugs were spread all over Europe and Asia; they reached Italy in 77 Common Era, China in 600 Common Era, Germany in the 11th century and France in the 13th century, mainly with trade (Usinger 1966). Because of the widespread use of synthetic insecticides, bed bug control was effective in many developed countries after World War II. In the United States, bed bugs were infrequent specimens for college entomology class collections up to 1997 (Snetsinger 1997). Resurgence of bed bugs occurred within the past 24 years in

Australia, Europe and North America (Boase 2001, Doggett et al. 2004). Today bed bug infestations can be found in many areas as they are transported via travelers. Bed bug infestations are common in urban areas which include apartments, hotels, college dormitories, and other public places (Hwang et al. 2005).

1.3.3 Distribution of cockroaches

Cockroaches are considered important household insect pests. Out of about 4000 species, only 1% are considered pests (Cochran 1999). As these insects are omnivorous insects, they use their chewing mouthparts to feed on various food stuffs as well as waste materials, garbage and sewage (Roth and Will 1957, James and Harwood 1969). In the genus *Periplaneta,* 47 species are found in the US in which the common American cockroach, *Periplanata americana* (Linnaeus) is native to Africa and came to the United States in 17th Century (Bell and Adiyodi 1981). These cockroaches are found both indoors and outdoors. The common indoor places are basements, sewers, steam tunnel and drainage systems (Rust et. al. 1991) and in Florida, these insects were found outdoors places such as trees, woodpiles, garbage facilities, and accumulations of organic debris around homes which provide sufficient food and water for their growth and development (Hagenbuch et al. 1988). In the genus *Blattella,* 45 species are found all round the world and 3 different species occur in North America (Benson and Zungoli 1997). Because of worldwide distribution (Cornwell 1968), these can be found everywhere from home to cruise ship (Benson and Zungoli 1997). Another type of African cockroach which was introduced to the US from Cuba is the brownbanded cockroach, *Supella longipalpa* Fabricius (Rehn 1945), is common all over the US except Vermont (Cornnwell 1968). Oriental cockroach, *Blatta orientalis* L., native to North America (Cornwell 1968), is also a pest in different regions of the US with 29° C temperature (Cornwell 1968).

1.4 Economic importance of ants, bed bugs and cockroaches

Ants are categorized as the most economically important insects by the Structural Pest Control Industry, with an annual expense of 1.7 billion dollars in the United States (Curl 2005). The red important fire ant is one of the economically invasive ants in the US. Damage caused by red imported fire ant was forecasted in the range of $3 to $9 billion by researchers at the University of California, if the ants were left unchecked (Jetter et al. 2002). In private houses, the cost of treatment for bed bugs ranges from $500-$1000 while using standard pesticide as well as additional cost raises to $2000 while changing the infested items such as furniture and beddings (MacDonald and Zavys 2009). According to a survey among 225 Pest Management Industries, in addition to insecticides, 77% of pest management professionals throw away furniture and mattresses, 70% use a vacuum, 64% use sticky traps, 37% encase mattresses, 25% use sticky barriers, 17% use steam, 13% use cold treatments, 10% use heat treatments, and 15% of industries use other methods (Gangloff- Kaufmann et al. 2006). Buying these above mentioned tools and equipment for treatment also increases the victim's costs. Bed bugs have developed resistance to pesticides such as DDT, malathion and diazinon long ago (Busvine 1958, Lofgren et. al. 1958, Feroz 1968). Because of pesticide resistance and the lack of other active control tactics, bed bugs are economically important as well as difficult to eradicate (Romero et al. 2007). Similarly, cockroach control is not cheap. In a study conducted by North Carolina State University in Raleigh, North Carolina, a total cost of $281 per 12 months was found once the cockroach control was done by professional entomologists and 12 month contract with commercial pest control raised up to $475 (Sever et al. 2007).

1.5 Pest control

Most urban pests causing problems are found inside the house. Ants especially may become a pest outside as well. Pesticides that are too toxic are not good for inside treatments since they can affect human beings as well as pets. Chemical treatment approaches are not the only solution for household insects. Sanitation is the most important factor for controlling them (Sherron et al. 1982, Write and Dupree 1984, Sachal 1988, Hedges 1997). For most insects, an integrated pest management (IPM) approach should be used. In IPM many methods such as biological, cultural and chemical methods are combined together which results in low pest infestation and pest populations below a threshold level (Gianessi et. al. 1992). According to William H Robinson, in a Handbook of Urban Entomology, possible damage, individual injury and emotional distress can be considered as the decision making point for treatment for medically important insects (Robinson 2005). According to Hedges (1997), in the case of ants, an IPM approach includes:

- Proper food storage and waste management.
- Sanitation of the surroundings by removing all ant attractants.
- Different baits can be used to kill the foraging worker ants.
- Hot water can be used as a drench the individual colony or mound.
- Barrier treatment of residual insecticides.
- Drenches of residual pesticides on ant nests.
- Contact insecticide treatment.

According to Arrow Termite and Pest Control, D-FENSE SC (4.75% deltamethrin, Control Solutions Inc. Genoa- Red Bluff Pasadena, TX 77507) at the rate of 2 ml per liter is used for ant treatment inside a residential area (J. Cohn, personal communication, Arrow Termite and Pest Control, Baton Rouge Louisiana).

For bed bugs, many non-chemical tactics can be used. Non-chemical technologies are of great significance to decrease bed bug populations (Kells 2006). They include sanitation, such as physical removal and vacuuming, infested mattress and furniture disposal, heat treatments, steaming, cold treatments, sticky traps, sticky barriers which prevent bed bugs from climbing on furniture, and mattress encasements. But using non-chemical methods may not be cost effective and an IPM strategy usually includes the use of chemical pesticides.

For cockroach control, sanitation and preventive measures play a very important role. Monitoring is another method to determine the level and infestation. Traps are very useful to monitor cockroaches. Traps give the most accurate data of population presence and is less disruptive for monitoring German cockroaches (Owens 1980, Owens and Bennett 1983) and Oriental cockroaches (Baker and Southam 1977) compared to other methods. Baited banana malt can be used as the attractant for cockroach along the trap (Benson and Zungoli 1997). With the result of monitoring, an IPM approach helps in deciding the best method to control cockroaches (Benson and Zungoli 1997).

1.6 Database

Databases are used for collecting data. A database can be a very useful source for insect management since different information can be gathered for many years and evaluated in a short amount of time. Maximo Database is being used by Residential Life at LSU to record everyday problems being reported by students (Celena Trahan, personal communication), using the link (https://rhmax.lsu.edu/maximo/webclient/login/login.jsp?appservauth=true). This has been active since 1998 and insect pest cases have been reported since 2000. For this thesis, the insect cases reported to LSU Residential Life's Maximo Database include these benefits:

- Store and keep records of all potential insect pest problems allowing data to be analyzed for most common pest, pest in particular month and year, pest population, growth rate, most vulnerable residential area, etc.
- Determine how research and pest management can minimize the effects of pests.
- Create a safe and clean environment at LSU Residential Life as more research and development towards urban pest management are implemented.

1.7 Survey

Collection of insect related data through a questionnaire survey is a common procedure. Gangloff-Kaufmann et al. (2006) used a questionnaire survey with 15 questions to collect data on the status of bed bugs which are considered a significant urban pests in the United States. Similarly, Morgan et al. (2004) developed a questionnaire survey to determine the participants' knowledge and opinion about the efficiency of the French Quarter Formosan Termite Program which was started in 1998 as a large area pilot test in New Orleans, Louisiana. From January to April 2010, the National Pest Management Association (NPMA) and University of Kentucky surveyed national and international pest management companies to find the status of bed bug resurgence and this project was completed by Potter et al. (2011). Two different online surveys with 34 questions in each were developed for national and international companies separately (Potter et al. 2011). Similar surveys were conducted in 2011, 2013 and 2015 (Potter et al. 2015). To determine the relative occurrence and frequency of urban pest ants and other information related to infestations by ants, a questionnaire survey was conducted by Klotz et al. (1995) with structural pest control employees of Florida. A similar survey was conducted in New Jersey the year before (Klotz et al. 1994).

In Florida, 8 most common species of ants were found as key urban pests including red imported fire ants, carpenter ants, pharaoh ants, and long horn crazy ants (Klotz et al. 1995). More than 25 species of ants except the above are also encountered as occasional pest while surveying (Klotz et al. 1995). While inspecting inside and outside locations, most ants were found inside and most of the complaints reported to pest control employees (PCEs) with ants were because ants were a nuisance in which crazy ant had the highest percentage (Klotz et al. 1995). Spraying with insecticides was found the common treatment used by PCEs for controlling urban ant pests (Klotz et al. 1995).

Concerning the effects of insects at LSU Residential Life for hygiene, comfort, and safety for students' academic progress, specific objectives of the research included:

A. Analysis of data from Maximo Database

1. To determine the yearly growth trend.
2. To determine the monthly reporting pattern.
3. To determine the degree of infestation reports according to specifics about the buildings.
    a. Degree of infestation with the age of building.
    b. Degree of infestation with the number of floors.
4. To evaluate the relationship between bed bug reporting and bed bug presence after inspection and monitoring from September 2014 to December 2015 (reality versus perception).

B. Survey data analysis

1. To find out the most common insects.

2. To determine whether ant presence inside the building and multiple stings are being problematic to students.
3. To determine whether students think bed bugs are a problem.
4. To measure the students' awareness on bed bug transportation.
5. To determine what strategy students are applying to prevent and control insects.
6. To determine students' opinion regarding quarterly preventive pesticide measures.
7. To determine the satisfaction level regarding insect control.
8. To explain the variance in level of satisfaction with insect control accounted for by the number of insects observed.

1.8 References

Aguillard, D., R. M. Strecker, and L. M. Hooper-Bui. 2011. Extraction of super colonies of crazy ants from soil and wood. Midsouth. Entomol. 4: 53-56. Online available at (http://midsouthentomologist.org.msstate.edu/pdfs/Vol4_2/Vol4_2_004.pdf).

Anonymous 2015a. Ant web. (http://www.antweb.org/antblog/2010/04/how-many-kinds-of-ants-are-there.html). Last accessed 06/15/2015.

Anonymous 2015b. Ant web. (http://www.antweb.org/world.jsp). Last accessed 06/15/2015.

Anuar, K. A., and T. P. Paran. 1976. *Periplaneta americana* L. as intermediate host of *Moniliformis moniliformis* Bremser in Penang, Malaysia. Southeast Asian J. Trop. Med. Public Health. 7: 415-416.

Attygalle, A. B., and E. D. Morgan. 1984. Chemicals from the glands of ants. Department of Chemistry, University of Keele, Staffordshire. Chem. Soc. Rev. 13: 245-278. DOI: 10.1039/CS9841300245. Online available on (http://pubs.rsc.org/en/content/articlepdf/1984/cs/cs9841300245). Last accessed 07/02/2015.

Bajomi, D., and S. Elek. 1979. The importance of cockroaches and methods of their control. Int. Pest. Con. l21: 31-38.

Baker, L. F., and N. D. Southam. 1977. Detection of *Blattella germanica* and *Blatta orientalis* by trapping. Int. Pest Con. 45: 14-20.

Beatson, S. H. 1972. Pharaoh's ant as pathogen vectors in hospitals. The Lancet. Feb. 19:1: 425-427.

Beatson, S. H. 1973. Pharaoh's ants entering giving-sets. The Lancet. March. 17. 606.

Bell, W. J., and K. G. Adiyodi. 1981. The American Cockroach. Chapman and Hall, London.

Benedict, L. F. 2007. Urban Entomology: Its value and impact in Louisiana. Louisiana Ag. 50; 6-11.

Benson, E. P., and P. A. Zungoli. 1997. Cockroaches, pp. 122- 203. *In* S. Hedges and D. Moreland [eds.], 8th ed. Mallis' handbook of pest control. Mallis Handbook and Technical Training Company. GIE Publishing, Cleveland.

Boase, C. J. 2001. Bedbugs-back from the brink. Pestic. Outlook 12: 159-162.

Bonnefoy, X., H. Kampen, and K. Sweeney. 2008. Public Health Significance of Urban Pests. World Health Organization-Regional Office for Europe (http://www.euro.who.int/__data/assets/pdf_file/0011/98426/E91435.pdf). Last accessed 06/24/2016.

Brett, C. H. 1950. The Texas harvester ant. Okla. Agr. Expt. Sta. Bull. No. B-353. July.

Busvine, J. R. 1958. Insecticide-resistant strains of insects of public health importance. Trans. Royal Soc. Trop. Med. Hyg. 51: 11-31.

Coarsey, J. M. 1952. Southern Fire ant, *Solenopsis xyloni* (Death of a child in Mississippi). Coop. Econ. Insect Report. Sept. 19, 1952.

Cochran, D. G. 1999. Cockroaches - Their biology, distribution and control. World Health Organization, Switzerland. WHO/CDS/CPS/WHOPES/ 99: 3-83.

Cornwell, P. B. 1986. The cockroach. Vol. I. Hutchinson, London. 391 pp. The cockroach. Vol. II. Hutchinson, London. 557 pp. The cockroach. Vol. II: Insecticides and Cockroach Control. London: Associated Business Programs. 557 pp. *In* S. Hedges and D. Moreland [eds.], 8th ed. Mallis' handbook of pest control. Mallis Handbook and Technical Training Company. GIE Publishing, Cleveland.

Curl, G. 2005. A strategic analysis of the U.S. structural pest control industry-the 2005 season. A survey of PMP's in the U.S., Gary Curl Specialty Products Consultants, LLC. *In* Field, H. B., W. E. Evans Sr., R. Hartley, L. D. Hansen, and J. H. Klotz. 2007. [eds.], A survey of structural ant pests in the southwestern USA (Hymenoptera: Formicidae). Sociobiol. 49: 1-14.

Dhang, P. 2011. Urban Pest Management: An Environmental Prospective. CAB International (https://books.google.com/books?hl=en&lr=&id=4r4OQQxCXRIC&oi=fnd&pg=PR5&d

q=Dhang,+P.+2011.+Urban+Pest+Management:+An+Environmental+Perspective.+CAB+International.&ots=apQgQA3dua&sig=FRpC2A4D1f0h6s23zJqLq9wkPUc#v=onepage&q=Dhang%2C%20P.%202011.%20Urban%20Pest%20Management%3A%20An%20Environmental%20Perspective.%20CAB%20International.&f=false). Last accessed 06/24/2016.

Dash, S. T., and L. M. Hooper. 2008. Species diversity of ants (Hymenoptera: Formicidae) in Louisiana. Ann. Entomol. Soc. Am. 101: 1056-1066.

Doggett, S. L., M. J. Geary and R. C. Russell. 2004. The resurgence of bed bugs in Australia: with notes on their ecology and control. Environ. Health 4: 30-38.

Feroz, M. 1968. Toxicological and genetical studies of organophosphorus-resistance in *Cimex lectularius* L. Bull. Entomol. Res. 59: 377-382.

Gangloff-Kaufmann, J., C. Hollingsworth, J. Hahn, L. Hansen, B. Kard and M. Waldvogel. 2006. Bed bugs in America: a pest management industry survey. Am. Entomol. 52: 105 - 106.

Gianessi, L. P., and C. A. Puffer. 1992. Reregistration of Minor Pesticides: Some observations and implications. Input situation outlook report. US Dept. of Agr., Econ. Research Service, February: 52-60.

Granovsky, T. A., and H. H. Howell. 1983. Texas A&M research team develops new pharaoh's ant control technique. Pest Cont. Tech. 11: 30-34.

Hagenbuch, B. E., P. G. Koehler, R. S. Patterson, and R. J. Brenner. 1988. Peridomestic cockroaches (Orthoptera: Blattidae) of Florida: their species composition and suppression. J. Med. Entomol. 25: 377-380.

Harwood, F. R., and M. T. James. 1979. Entomology in human and animal health. MacMillan Publishing Co., Inc., New York. 548 pp.

Hedges, S. A. 1997. Ants, pp. 502- 589. *In* S. Hedges and D. Moreland [eds.], 8th ed. Mallis' handbook of pest control. Mallis Handbook and Technical Training Company. GIE Publishing, Cleveland.

Hwang, S., T. Svoboda, L. D. Jong, K. Kabasele, and E. Gogosis. 2005. Bed bug infestations in an urban environment. Emerg. Infect. Dis. 11:533-538.

James, M. T., R. F. Harwood. 1969. Herm's medical entomology. The MacMillan Co., New York; Collier-MacMillan Ltd., London.

Jetter, K. M., J. Hamilton, and J. H. Klotz. 2002. Eradication costs calculated: Red imported fire ants threaten agriculture, wildlife and homes. Calif. Agr. 56: 26-34.

Jupp, P. G., S. E. McElligott, G. Lecatas. 1983. The mechanical transmission of hepatitis B virus by the common bed bug (*Cimex Lectularius* L.*)* in South Africa. S.A. Med. J. 63: 77-81.

Jupp, P. G., and S. F. Lyons. 1987. Experimental assessment of bed bugs *(Cimex lectularius* and *Cimex hemipterus*) and mosquitoes (*Aedes aegypti formosus*) as vectors of Human Immuno deficiency Virus. AIDS. London, England. 1: 171-174.

Kells, S. A. 2006. Nonchemical control of bed bugs. Am. Entomol. 52: 109-110.

Klotz, J. H., G. Goveia, L. Davis and B. L. Reid. 1994. Surgical strikes. Pest Con. Tec. 22: 32-42.

Klotz, J. H., J. R. Mangold, K. M. Vail, L. R. Davis, and R. S. Patterson. 1995. A survey of urban pest ants (Hymenoptera: Formicidae) of peninsular Florida. Fla. Entomol. 78: 109-118.

Lee, C. Y. 1997. Medical importance of domiciliary cockroaches. Singapore Microbiol. 11: 14 - 17.

Lofgren, C. S., J. C. Keller, and G. S. Burden. 1958. Resistance tests with the bed bug and evaluation of insecticides for its control. J. Econ. Entomol. 51: 241–244.

McDonald, L. and R. Zavys, R. 2009. Bedbugs are back: are we ready? Woodgreen Community Services, Toronto (http://www.woodgreen.org/Portals/0/PDFs/WG_BBresearchReport-web.pdf). Last accessed 06/24/2016.

MacGown, J. A., and B. Layton. 2010. The invasive Rasberry crazy ant, *Nylanderia* sp. near *pubens* (Hymenoptera: Formicidae) reported from Mississippi. Midsouth. Entomol. 3: 44-47.

McGlynn, T. P. 1999. The worldwide transfer of ants: geographical distribution and ecological invasions**.** J. Biogeo. 26: 535-548.

Mallis, A. 1969. Handbook of pest control. 5th Ed. *In* S. Hedges and D. Moreland [eds.], 8th ed. Mallis' handbook of pest control**.** Mallis Handbook and Technical Training Company. GIE Publishing, Cleveland.

Maximo Order LSU Residential Life (https://rhmax.lsu.edu/maximo/webclient/login/login.jsp?appservauth=true.)

Morgan, A. L., K. L. Machtmes and E. Johnson. 2004. Evaluating the effectiveness of the French Quarter Formosan Termite Project: A survey of participants' knowledge and perceptions. J. Ag. Urban. Entomol. 21:185-194.

Oothuman, P., J. Jeffery, M. Z. Daud, L. Rampal, and C. Shekhar. 1985. On a collection of acanthocephalan cystacanths in domiciliary cockroaches from the district of Kelang, Selangor and the Kuala Lumpur Federal Territory. J. Malaysian Soc. Health 5: 81.

Oothuman, P., J. Jeffery, A. H. A. Aziz, E. A. Bakar, and M. Jegathesan. 1989. Bacterial pathogens isolated from cockroaches trapped from pediatric wards in peninsular Malaysia. Trans. Royal Soc. Trop. Med. and Hygiene 83: 133 - 135.

Owens, J. M. 1980. Some aspects of German cockroach population ecology in urban apartments. PhD dissertation, Purdue Univ., West Lafayette, Ind. 1116 pp.

Owens, J. M. and G. W. Bennett. 1983. Comparative study of German cockroach population sampling techniques. Environ. Entomol. 12: 1040-1046.

Potter, M. F., B. Rosenberg and M. Henriksen. 2011. Bugs without borders-executive summary. Defining the global bed bug resurgence. Online in https://npmapestworld.org/default/assets/File/publicpolicy/executivesummaryreleasetomembersFINAL.pdf. Last accessed 06/10/2015.

Potter, M. F., J. Fredericks and M. Henriksen. 2015. Bugs without borders-executive summary. Online in http://www.pestworld.org/news-hub/pest-articles/2015-bugs-without-borders-executive-summary/. Last accessed 04/19/2016.

Rampal, L., P. Oothuman, J. Jeffery, M. Z. Daud, C. Shekhar, P. Senan, K. E. Lim, Y. Suboh, and Z. Ahmad. 1983. Bacterial pathogens from the intestinal tracts of various species of cockroaches. Med. J. of Malaysia 38: 104-107.

Rehn, J. A. G. 1945. Man's uninvited fellow traveler. The cockroach Sci. Mo. 61: 265-278. *In* Hedges, S.A.1997. Ants, pp. 502- 589. *In* S. Hedges and D. Moreland [eds.], 8th ed. Mallis' handbook of pest control. Mallis Handbook and Technical Training Company. GIE Publishing, Cleveland.

Robinson, W. H. 2005. Urban Insects and Arachnids. A handbook of Urban Entomology. Cambridge University Press, New York.

Romero, A., M. F. Potter, D. A. Potter, and K. F. Haynes. 2007. Insecticide resistance in the bed bug: a factor in the pest's sudden resurgence? J. Med. Entomol. 44: 175-178.

Roth, L. M., and E. R. Willis. 1957. The medical and veterinary importance of cockroaches. Smithson. Misc. Collect. 1 34:1-147.

Rupp, C. A., and P. Forni. 1972. Formic I.V. therapy. The Eng. J. Med. 286: 894-895.

Rust, M. K., D. A. Reierson, and K. H. Hansgen. 1991. Control of American cockroaches (Dictyoptera: Blattidae) in sewers. J. Med. Entomol. 28: 210-213.

Rust, M. K., N. Y. Su. 2012. Managing social insects of urban importance. Annu. Rev. Entomol. 57: 355–75.

Sailer, R. 1952. The bed bug: an old bedfellow that's still with us. Pest Cont. 20: 22-24, 70, 72.

Schal, C. 1988. Relation among efficacy of insecticides, resistance levels, and sanitation in the control of the German cockroach (Dictyoptera: Balttellidae). J. Econ. Entomol. 81: 536-544.

Sever, M. L., S. J. Arbes Jr., J. C. Gore, R. G. Santangelo, B. Vaughn, H. Mitchell, C. Schal, and D. C. Zeldin. 2007. Cockroach allergen reduction by cockroach control alone in low-income urban homes: A randomized control trial. J. Allergy. Clin. Immunol. 120: 849-855.

Sherron D. A, C. G. Write, M. H. Ross, and M. H. Farrier. 1982. Density, fecundity, homogeneity and embryonic development of German cockroach (*Blattella germanica* (L.)) populations in kitchens of varying degree of sanitation (Dictyoptera: Balttellidae). Proc. Entomol. Soc. Wash. 84: 376- 390.

Snetsinger, R. 1997. Bed bugs & other bugs, pp. 392–424. *In* S. Hedges and D. Moreland [eds.], 8th ed. Mallis' handbook of pest control. Mallis Handbook and Technical Training Company. GIE Publishing, Cleveland.

Suarez, A. V., T. P. McGlynn, and N. D. Tsutsui. 2010. Biogeographic and taxonomic patterns of introduced ants. pp. 233-244. *In* L. Lach, and K. Abbott (eds.), Ant Ecology. Oxford University Press. New York, NY.

Usinger, R. L. 1966. Monograph of Cimicidae (Hemiptera-Heteroptera). The Thomas Say Foundation, Vol. VII. Entomol. Soc. Am., College Park, MD.

Usinger, R. L., and D. Povolny. 1966. The discovery of a possibly aboriginal population of the bed bug (*Cimex lectularius*) Linnaeus. Acta. Musei. Moroviae. 51: 237-242.

Venkatachalam, P. S. and B. Belavady. 1962. Loss of haemoglobin iron due to excessive bitting by bed bugs. Trans. R. Soc. Trop. Med. Hyg. 56: 218-221.

Wasmann, E. 1905b: Zur Lebensweise einiger in- und ausländischer Ameisengäste (148. Beitrag zur Kenntnis der Myrmecophilen und Termitophilen). – Zeitschrift für Wissenschaftliche Insektenbiologie 11: 384-390. *In* Wetterer, J. K. 2008. [eds.], Worldwide spread of the longhorn crazy ant, *Paratrechina longicornis* (Hymenoptera: Formicidae. Myrmecological News 11: 137-149.

Wetterer, J. K. 2008. Worldwide spread of the longhorn crazy ant, *Paratrechina longicornis* (Hymenoptera: Formicidae). Myrmecological News 11: 137-149.

Wheeler, W. M. 1910. Ants: their structure, development and behavior. Harvard Columbia University Press, New York, 663 pp.

Wheeler, W. M. 1919. Expedition of the California Academy of Sciences to the Galapagos Islands, 1905-1906. Part 14. The ants of the Galapagos Islands. Proceedings of the California Academy of Sciences. 2: 259-297.

Write, C. G and H. E. Jr. Dupree. 1984. Evaluation of German cockroach mortality with several insecticidal dust formulations. J. Ga. Entomol. Soc. 19: 223-228.

CHAPTER 2. WORKING WITH THE INSECT REPORTS FROM 2000 TO 2015 FROM MAXIMO DATABASE SYSTEM OF LSU RESIDENTIAL LIFE

2.1 Introduction

Some urban insect pests dwelling inside and outside buildings are adversely affecting students living on campus at LSU. Students report insect problems to their custodial staff working in their halls and apartments. All reports have been recorded in Maximo database since 2000 in which different insect problems are noted.

For the structural pest control industry, ants are ranked as the most common urban pest for which annually 1.7 billion dollars are spent in the United States (Curl 2005). Similarly, ants were also considered as the number one urban pest problematic to households by the National Home and Garden Pesticide Use Survey (Whitmore et al. 1992). Both native and non-native ants affect urban environments. Approximately, 150 different species of ants were already transported to the non-native areas worldwide (McGlynn 1999). Some species of pest ants have been studied; such as fire ants which are medically and agriculturally important (Banks 1990), pharaoh ants as a major household ant and disease vector (Williams 1990) and carpenter ants as an important wood destroying pest (Akre & Hansen 1990). Some invasive ants such as red imported fire ants, and Argentine ants are problematic not only in the United States but other countries as well (McGrath 2005). Though fire ants prefer sunny areas for nesting, they have been found nesting indoors in wall voids, under rugs, in boxes, and drawers with clothes which causes additional problems to the people living in homes, apartments, condominiums and business stores (Vinson 1997). The major problem caused by red imported fire ants is contact frequency which increases the chance of being stung (Vinson 1997).

Bed bugs are hematophagous bugs, living near human beings. They mainly feed on human blood during the night but also suck blood from other animals such as bats, chickens, other birds

and pets. Since ancient times, bed bugs have been parasites to humans (Usinger 1966). According to some experts, bed bugs used to feed on bats' blood in the Mediterranean region, as they lived together in caves (Sailer 1952, Usinger and Povolny 1966). At some point, humans started occupying bat caves and some bat bugs adapted to specialize on humans. Today bed bug infestations can be found in many areas, as they are transported via travelers. Bed bug infestations are common in urban areas which include apartments, hotels, college dormitories, and other public places (Hwang et al. 2005). Once a student in Residential Life reports a bed bug problem, inspections are made with the aid of a flashlight looking in locations such as pillows, bed sheets, mattresses, bed frames, headboards, along the walls and floors, cracks and crevices, furniture, night stands, shoes, clothes and other material found. Evidence of blood fecal spots, exoskeletons, egg cases, live or dead bed bugs indicates the presence of bed bugs (Doggett 2004, King et al. 1989, Snetsiger 1997, Usinger 1966). Collected bed bugs were examined under a microscope using a key (Usinger 1966) in the Urban Entomology Lab, LSU.

Out of many cockroach species, some invasive species are common indoor pests in the United States (Schweid 1999). Among them, German cockroach is the most commonly found domestic cockroach which is prevalent in kitchens, bathrooms and areas with daily access of water (Schweid 1999, Benson and Zungoli 1997). The second common domestic cockroach is the American cockroach which prefers to live in drains, basements and other dark and moist places (Schweid 1999). These cockroaches eat a variety human food which are starchy and sugary (Mohamed et al. 2014). The third common domestic cockroach is the Oriental cockroaches, which are common outdoors in garbage (Schweid 1999). Another common cockroach is the brown-banded cockroach which prefers to live on shelves of closets, behind

pictures and picture moldings and lays eggs in kitchen sinks, desks, tables, other furniture, and beddings (Benson and Zungoli 1997).

In this study, we analyzed insect data from 2000 to 2015. The objectives of this study were:

1. To determine the yearly growth trend.
2. To determine the monthly reporting pattern.
3. To determine the degree of infestation reports according to specifics about the buildings.
    a. Degree of infestation with the age of building.
    b. Degree of infestation with the number of floor.
4. To evaluate the relationship between bed bug reporting and bed bug presence after inspection and monitoring from September 2014 to December 2015 (reality versus perception).

2.2 Materials and methods

2.2.1. Description of study area

In 2015, all the halls and apartments with their established date, number of floors, number of rooms, number of students and gender residing in halls or apartments are in the Table 2.01. Out of 24 different structures, 20 are halls. In these halls, 2 or 3 students share a single room with a bathroom suite or hall bathrooms. At least a kitchen is located in each halls. The next 2 are senior class or single student apartments where 2, 3 or 4 students share a kitchen, one or 2 bathrooms and a living room but each student has a separate bedroom. Another 2 are family apartments. Here, students have single bedroom, two bedrooms, or three bedrooms. Each apartment unit has its own kitchen. These apartments are for the graduate students who live on

campus with their families. Students of age 21 and above can stay with their friends of the same sex. All halls and apartments are located on campus at 4 different sites (Figure 2.01).

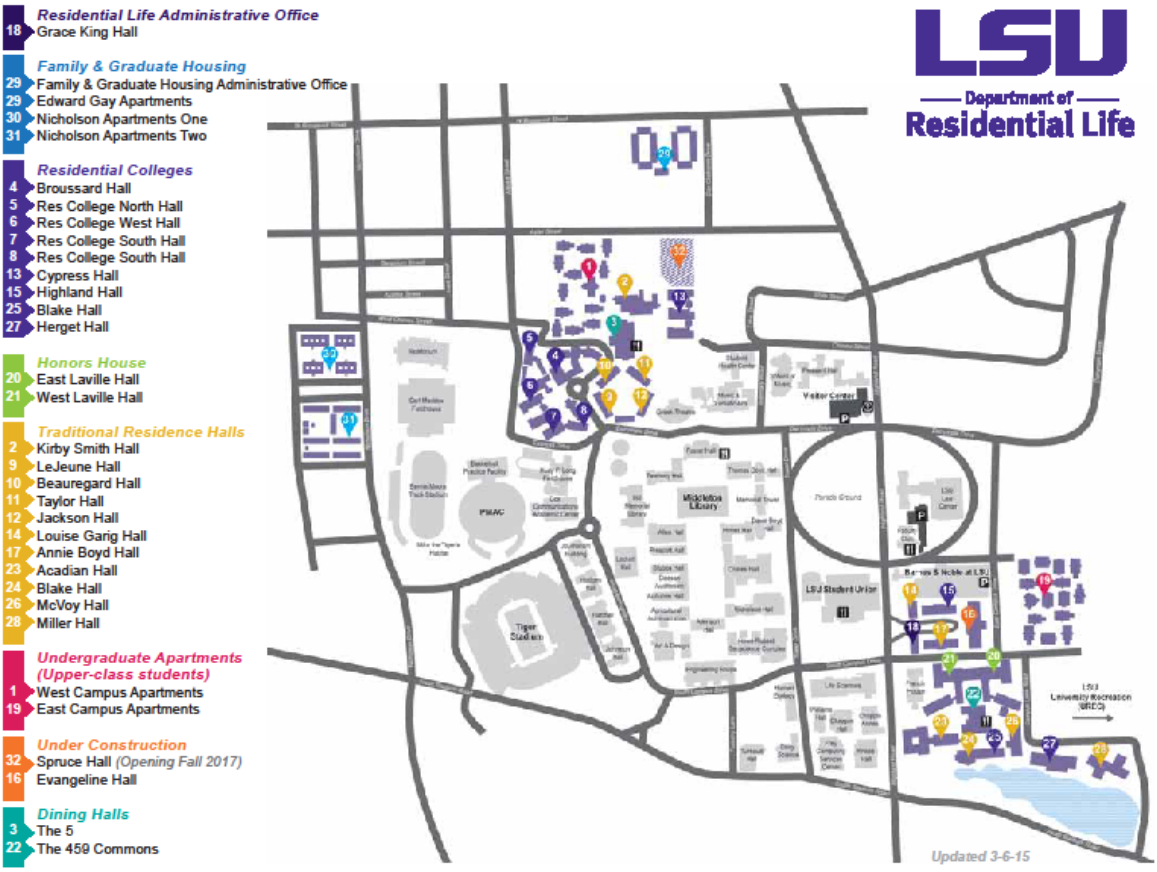


Figure 2.01. Map of LSU Residential Life with location of all residential halls and apartments

2.2.2 Pest control

Most household insect pests such as cockroaches, bed bugs, ants, termites, and occasional arthropod invaders are treated under a pragmatic pest control program at LSU Residential Life (Living on Campus Handbook 2014-2015). All residential halls and apartments are treated quarterly as a precautionary method. Presently the product of choice by Arrow Termite and Pest Control is D-FENSE SC (4.75% deltamethrin, Control Solutions Inc. Genoa- Red Bluff Pasadena, TX 77507) at the rate of 2 ml per liter. As a rule of thumb, 1 liter of the mixture is

sufficient for 13 apartments (Arrow Termite and Pest Control Co., personal communication). For bed bugs, inspections and follow ups are done. ClimbUp insect inspectors (Susan McKnight, Inc., Memphis, Tennessee) are installed under each bed legs after the first inspection. These climbUp insect inspectors were found to be very effective in low bed bug infestation areas (Wang et al. 2011, Cooper et al. 2015a). If bed bug presence is confirmed in the apartment then four different pesticides are used. Tekko Pro (Pyriproxyfen Control Solutions, Inc. Genoa-Red Bluff Pasadena, TX 77507) and D-FENSE SC are mixed together at the rate of each 2 ml per a liter of water. In addition, an aerosol pesticide, CB-80 (pyrethrins 0.50% and piperonyl butoxide 4.00%. FMC Corporation Agricultural Products Group, Philadelphia, PA) is also used in the corners of the apartment units. For water damageable items, D-FENSE Dust with deltamethrin 0.05% is used. For ant and cockroach treatment, D-FENSE SC is used at the rate of 2 ml per liter of water inside units (Arrow Termite and Pest Control Co., personal communication). Students are suggested to clean their apartments by removing waste, and neatly organizing all their belongings. They are also suggested to report any pests found to the front desk office of that apartment using the Maximo Database. For termites, Louisiana Pest Control is the present contractor which only uses termite baits outside halls/apartments.

2.2.3 Database maintenance

Cases are registered via Maximo Database Software (https://rhmax.lsu.edu/maximo/webclient/login/login.jsp?appservauth=true) manufactured by International Business Machines Corporation (IBM), New York, US. Maximo Database has been used to record all insect reports in Residential Life since September 2000. Maximo Database is accessible to staff and students working at LSU Residential Life. Table 2.02 is a sample of Maximo database.

Table 2.01. General background of residential halls and apartments at LSU

Hall/Apt	Establish date	Age of halls/apt	No. of floors	No. of rooms	No. of students	Gender
Annie Boyd Hall (ABH)	1937	78	4	61	112	Co-ed
Acadian Hall (ACD)	1941	74	5	106	212	Co-ed
Beauregard Hall (BEA)	1923	92	3	54	108	Co-ed
Blake Hall (BLA)	1961	54	4	135	270	Co-ed
Broussard Hall (BRO)	1951	64	3	84	165	Co-ed
Kirby Smith Hall (EKS)	1967	48	12	299	577	Co-ed
East Laville Hall (ELV)	1949	66	4	165	330	Co-ed
Evangeline Hall (EVG)	1936	79	5	100	237	Co-ed
Highland Hall (HGH)	1933	82	4	64	127	Co-ed
Herget Hall (HGT)	1964	51	6	219	456	Co-ed
Jackson Hall (JAC)	1923	92	3	54	108	Co-ed
LeJeune Hall (LEJ)	1923	92	3	54	108	Co-ed
Louise Garig Hall (LGH)	1936	79	3	30	57	Male
McVoy Hall (MCV)	1962	53	4	102	203	Co-ed
Miller Hall (MLR)	1968	47	7	241	547	Female
Residential College 1 (RC1)	2008	7	4	104	201	Co-ed
Residential College 2 (RC2)	2008	7	4	117	227	Co-ed
Residential College 3 (RC3)	2013	2	4	183	354	Co-ed
Taylor Hall (TAY)	1923	92	3	54	108	Co-ed
West Laville Hall (WLV)	1948	67	4	135	281	Co-ed
East Campus Apartment (ECA)	1998	17	3	184	692	Co-ed
West Campus Apartment (WCA)	2003	12	3	168	500	Co-ed
Edward Gay Apartment (EDG)	1966	49	3	138	300	Co-ed
West Nicholson Apartment (WN)	1958	57	2	244	384	Co-ed

Table 2.02. Sample of Maximo Database

Work Order	Description	Location	Asset	Status	Work type	Priority	Reported Date	Supervisor	Lead	Site
Serial number	Actual problem	Hall/Apt	Item number	Approved Called Completed Cancel Close	CS-Custodian service SC-Service Contract	0-Lowest priority 10-Highest priority	Time of report of particular problem	Head of particular hall/apt at reporting time.	Pest control company	Department of Residential Life

2.2.4 Data collection

All data were collected from Maximo database after log in with a LSU paws username and password. “Work order tracking” was selected in the first page of the website which takes you to another page. Among the categories of different types of work order, “all records” was selected. As the table 2.02, under description, insect names such as ants, bed bugs, cockroaches and so on were cataloged to find the reports of every insect reported. Every hall and apartment for each report was accessed using location data. For the status of work order, “close status” was selected. The report has “close” status once the problem has been investigated. “Reported Date” was selected and cataloged in different years and months. Thus, all the necessary data for this analysis were found in Maximo database.

2.2.5 Insect inspection

After reporting a bed bug infestation, the apartments or rooms were inspected by myself, Professor Dr. Gregg Henderson, Ms. Celena Trahan and other entomology graduate students along with the custodial staff. Using a flash light, inspections were done mainly on the mattress, comforter, bed sheets, pillows and other materials found around the bed, followed by other items present in that particular room where the bed bugs were reported. In the case of apartments, all rooms were inspected.

2.2.6. Statistical analysis

2.2.6.1 Yearly growth trend

Using Simple Linear Regression method, year was considered the independent variable and report was considered the dependent variable. A Simple Linear model “Report=B0+B1*Year” was used for three different groups of insects. Data was analyzed using SAS 9.4 version with PROC REG with alpha 0.05.

2.2.6.2 Monthly reporting pattern

The month was considered as a treatments and data from each month were collected from 16 years to start the process of One-Way ANOVA. SAS 9.4 with PROC GLM was used for the data analysis for 3 groups of insect. Tukey's honestly significant difference was used for their mean comparison. Alpha was considered 0.05.

2.2.6.3 Degree of infestation of all halls and apartments

The total number of reports of three different groups of insect (see Table 2.03) were divided by 16 years. Each year report of the 3 groups of insects were divided by the number of students living in a particular halls/apartments. The report per student number was again multiplied by 100% to calculate the degree of infestation of each hall/apartment. The formula for degree of infestation is:

$$\text{Degree of Infestation with ants} = \frac{\text{no.of total ant reports}}{16*\text{students living in that apartment}}\text{X}100\%$$

$$\text{Degree of Infestation with bed bugs} = \frac{\text{no.of total bed bug reports}}{16*\text{students living in that apartment}}\text{X}100\%$$

$$\text{Degree of Infestation with cockroaches} = \frac{\text{no.of total cockroach reports}}{16*\text{students living in that apartment}}\text{X}100\%$$

After calculating the degree of infestation of all buildings with 3 types of insects differently, One-Way ANOVA was performed. SAS 9.4 with Proc GLM and Tukey's honestly significant difference were used for this test. Alpha was considered 0.05.

2.2.6.3.1. Relationship between degree of infestation and age of halls/apartments

All the halls/apartments were divided into 3 age groups according to their age; were below 30 years, 30 to 60 years and above 60 years, which were considered as treatments. In the relationship between degree of infestation and age for the 3 groups of insects, degree of infestation of all halls/apartments was used as a variable. Then a One-Way ANOVA, SAS 9.4

with PROC GLM and Tukey's honestly significant difference were used. Alpha was considered 0.05.

2.2.6.3.2. Relation between degree of infestation and number of floors in halls/apartments

Using Simple Linear Regression method between number of floors as the independent variable and degree of infestation as the dependent variable, analysis was performed for all 3 groups of insects (y =B0+B1XNumber of floors). Data was analyzed by using SAS 9.4 version with PROC REG and alpha as 0.05. One building with 12 floor was eliminated in this analysis.

2.3 Results

Out of all reports in Maximo database, only 2.64% were of insect problems from 2000 to 2015 (Figure 2.01).

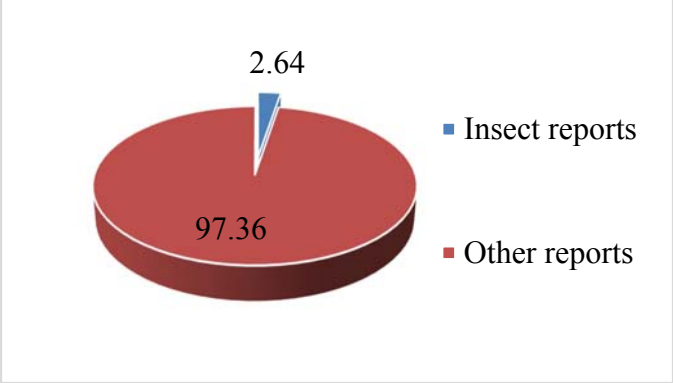


Figure 2.02. Percentage of insect reports in Maximo Database from 2000 to 2015 at LSU Residential Life

Some students used the term “bugs” or “insects” instead of a specific name. So, we were unable to distinguish those 729 reports in Table 2.03 for the exact pest, but we considered those as “insects” problematic to students living on campus. Table 2.03 represents the frequency of reports and percentage for different insects. Table 2.04 represents per year reports for ants, bed bugs and cockroaches respectively. Ant reports were the highest in 2004, bed bug reports in 2009 and cockroach reports in 2008.

Table 2.03. Frequency and percentage of insects reported in Maximo Database from 2000 to 2015 at LSU Residential Life

Insect	Reports	Percentage of reports
Ants	4627	54.4
Cockroaches	1644	19.3
wasps	603	7.0
Bed Bugs	181	2.1
fleas	153	1.9
termites	111	1.3
bees	93	1.1
mosquitoes	92	1.1
beetles	83	1
gnats	61	0.7
flies	50	0.6
fruit flies	16	0.2
silverfish	16	0.2
caterpillars	16	0.2
crickets	9	0.1
moths	9	0.1
stink bugs	3	0.04
grasshoppers	3	0.04
horse flies	2	0.02
drain flies	1	0.01
unidentified insects	729	8.6
Total Insects	8502	100

2.3.1 Yearly growth trend

Ant reports yearly growth trend was not significant (F= 0.34; df =1, 14; p = 0.57) (Table 2.05) with an R^2 value of 0.023 (Figure 2.03). The residual mean square error was 22243 (Table 2.05). The slope was positive (Slope= 4.69). Bed bug reports yearly growth trend was significant (F= 7.54; df =1, 14; p = 0.015) (Table 2.06) and an R^2 was 0.35 (Figure 2.04). The slope was positive with a value of 1.59. The residual mean square was 114.36 (Table 2.06). Cockroach reports yearly growth trend was not significant (F= 1.77; df =1, 14; p = 4.35) (Table 2.07) with

an R^2 value of 0.112. The slope was positive with a value of 4.36 (Figure 2.05). The residual mean square was 3648.1 (Table 2.07).

Table 2.04. Yearly reports of insects in Maximo Database from 2000 to 2015 at LSU Residential Life

Year	Ant Reports	Bed bug Reports	Cockroach Reports
2000	35	1	2
2001	126	0	45
2002	327	1	63
2003	268	0	52
2004	580	2	104
2005	476	2	126
2006	328	2	110
2007	195	0	107
2008	235	27	292
2009	203	37	127
2010	187	35	119
2011	391	12	135
2012	361	13	104
2013	491	22	88
2014	271	11	66
2015	153	16	104
Total	4627	181	1644

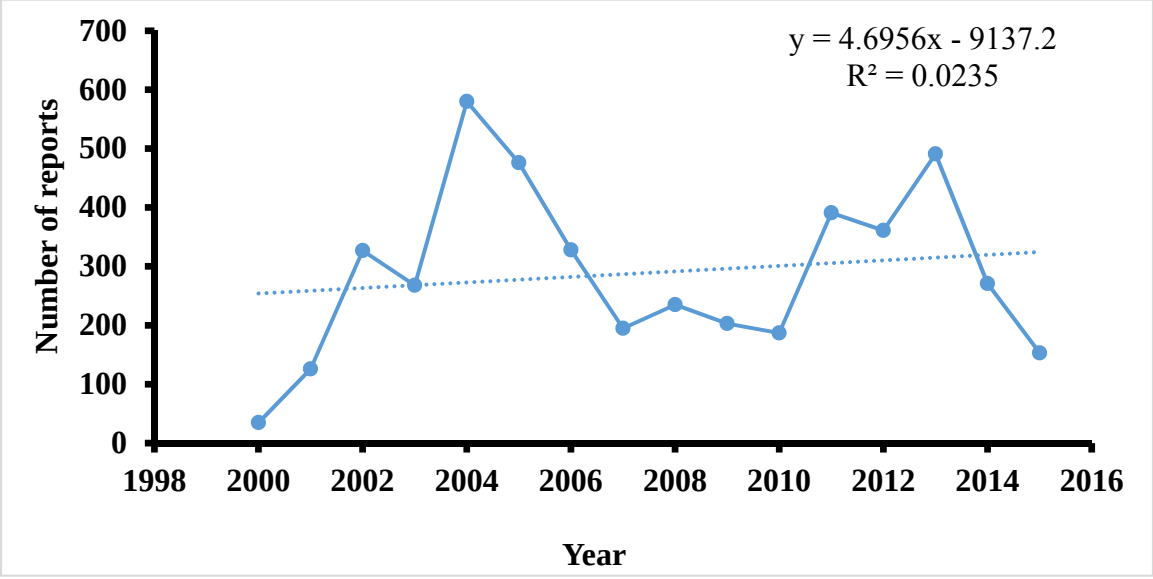


Figure 2.03: Growth trend of ant reports from 2000 to 2015 at LSU Residential Life

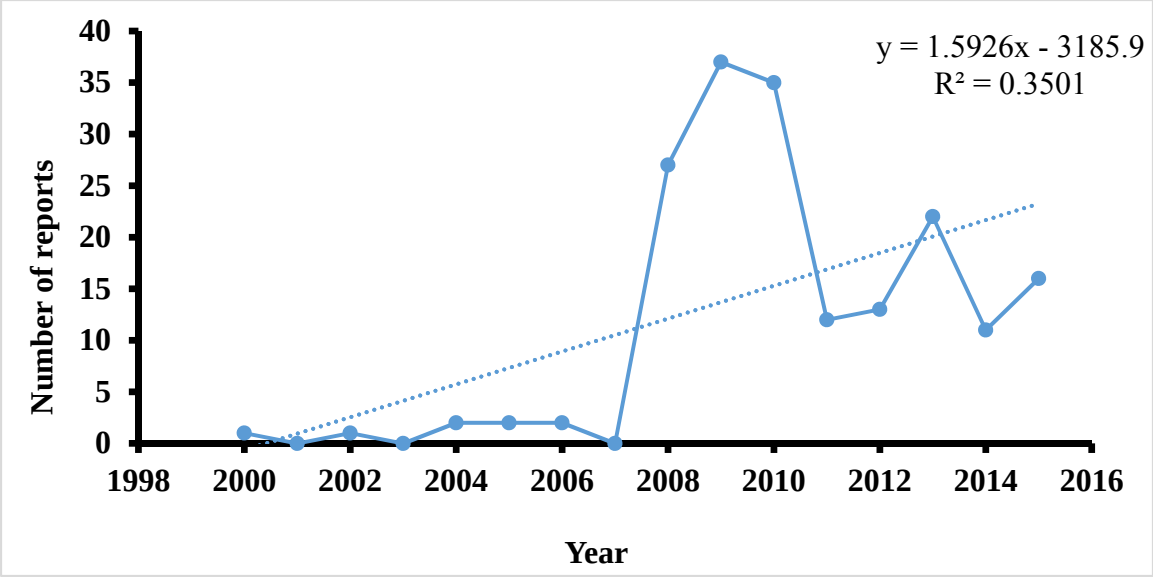


Figure 2.04: Growth trend of bed bug reports from 2000 to 2015 at LSU Residential Life

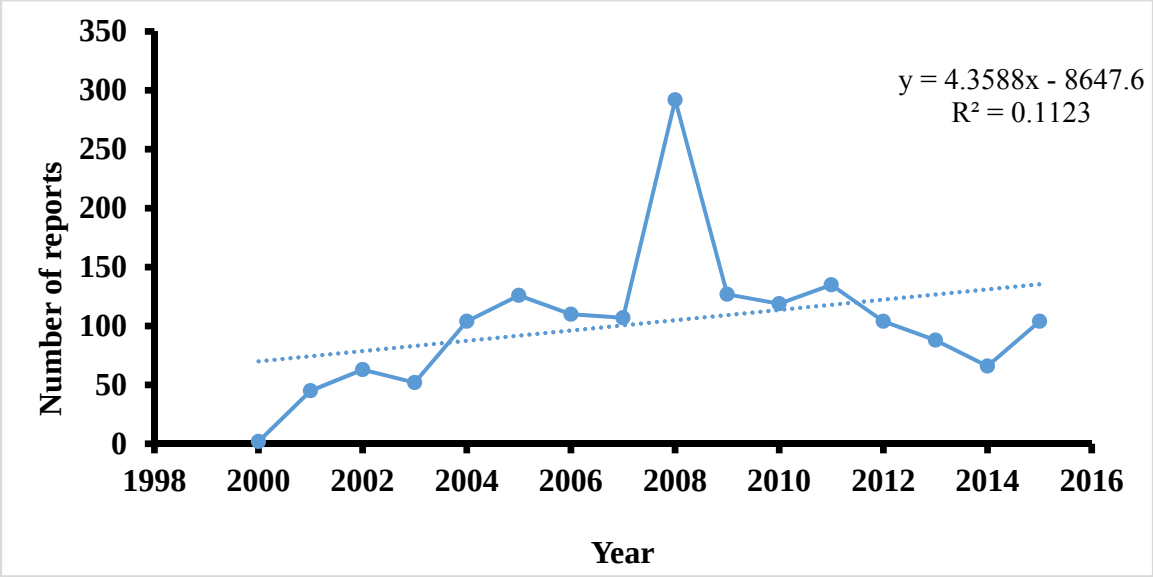


Figure 2.05. Growth trend of cockroach reports from 2000 to 2015 at LSU Residential Life

Table 2.05. Analysis of Variance for growth trend of ant reports from 2000 to 2015 at LSU Residential Life

Source of variance	*df*	Sum of squares	Mean Squares	*F*	*P>F*
Model	1	7496.50	7496.50	0.34	0.5708
Residual	14	311408	22243		
Total	15	318904			

Table 2.06: Analysis of Variance for growth trend of bed bug reports from 2000 to 2015 at LSU Residential Life

Source of variance	*df*	Sum of squares	Mean Squares	*F*	*P>F*
Model	1	862.42	862.42	7.54	0.0158
Residual	14	1601.02	114.36		
Total	15	2463.44			

Table 2.07: Analysis of Variance for growth trend of cockroach reports from 2000 to 2015 at LSU Residential Life

Source of variance	*df*	Sum of squares	Mean Squares	*F*	*P>F*
Model	1	6459.78	6459.78	1.77	0.2046
Residual	14	51073	3648.1		
Total	15	57533			

2.3.2. Monthly reporting pattern

Monthly reporting pattern for ants was significantly different (F= 12.84; df =11, 180; p < 0.001) (Figure 2.06). Monthly reporting pattern for bed bugs was not significant (F= 0.54; df =11, 180; p = 0.8727) (Figure 2.07). Monthly reporting pattern for cockroaches was significantly different (F= 2.45; df =11, 180; p= 0.007) (Figure 2.08).

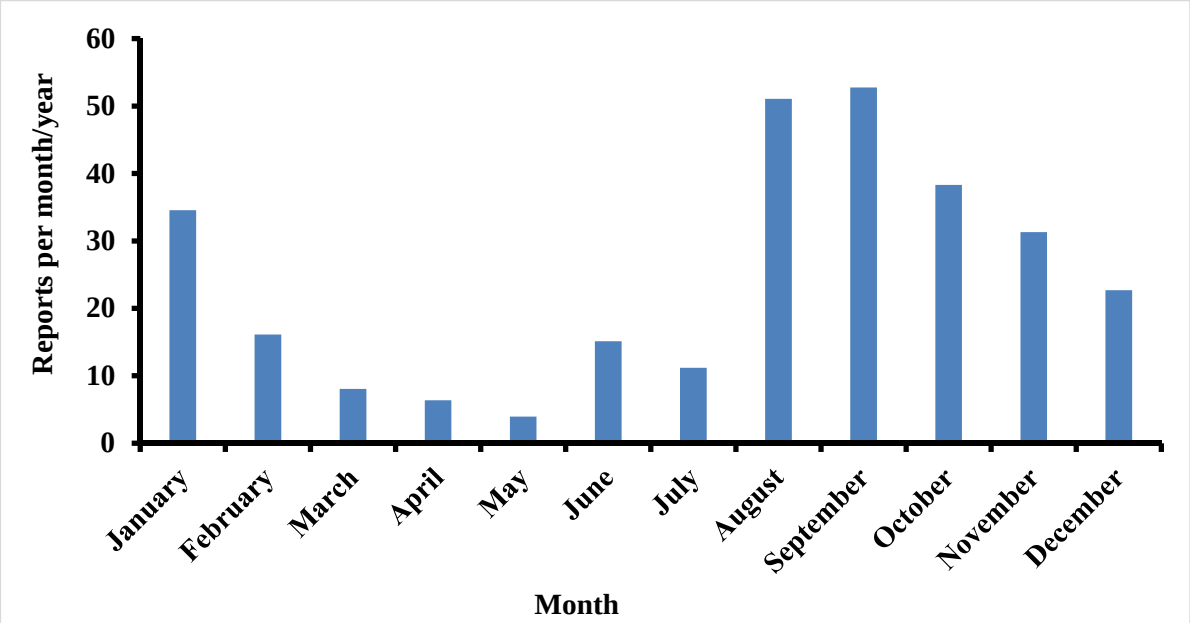


Figure 2.06. Monthly reporting pattern on ants from 2000 to 2015 at LSU Residential Life

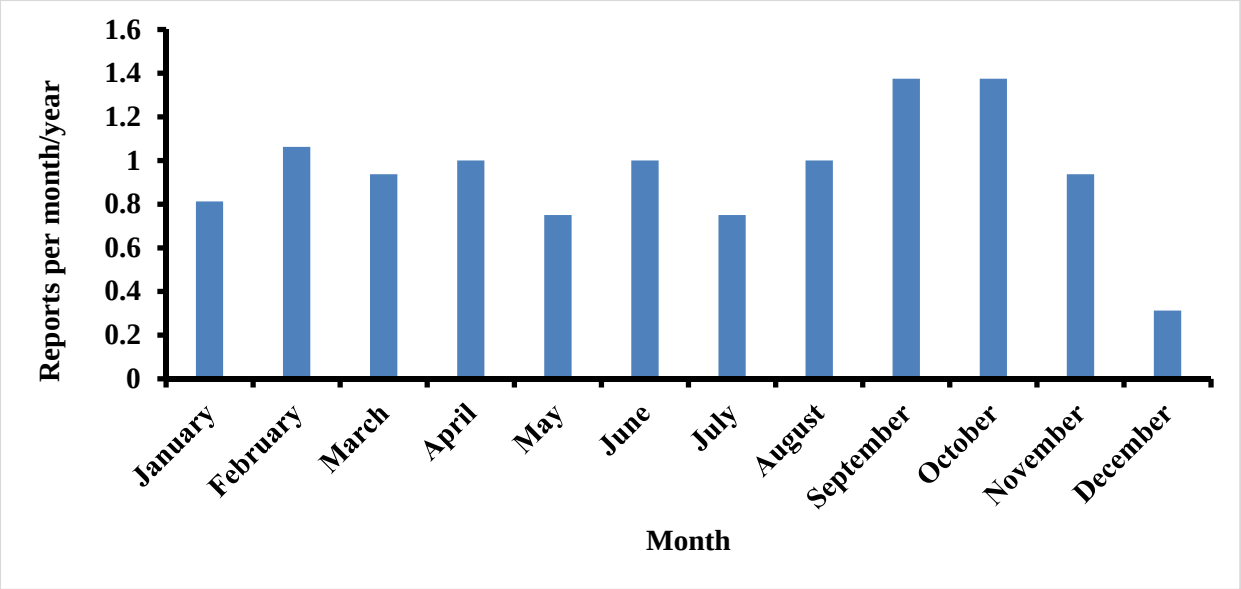


Figure 2.07. Monthly reporting pattern on bed bugs from 2000 to 2015 at LSU Residential Life

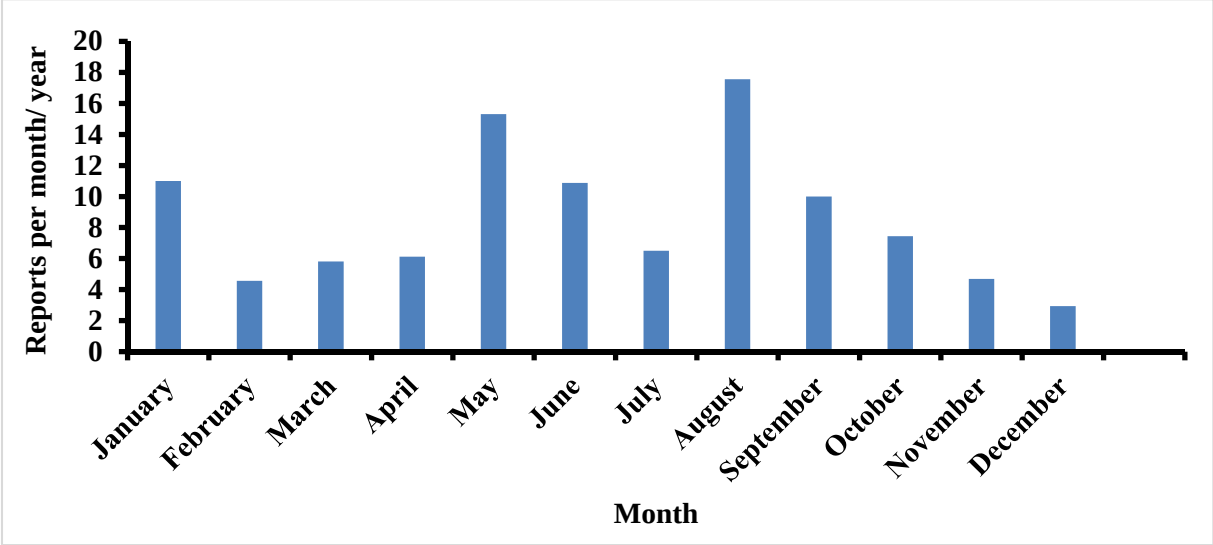


Figure 2.08. Monthly reporting pattern on cockroaches from 2000 to 2015 at LSU Residential Life

2.3.3 Degree of infestation of all halls and apartments

Based on the reports, the degree of infestation with ants was significantly different based on location (F= 4.81; df =23,360; $p < 0.0001$) (Figure 2.09). Degree of infestation with bed bugs was also significantly different based on the location (F= 4.57; df =23,360; $p < 0.0001$) (Figure

2.10), as was the degree of infestation of cockroaches (F= 14.19; df =23,360; $p < 0.0001$) (Figure 2.11).

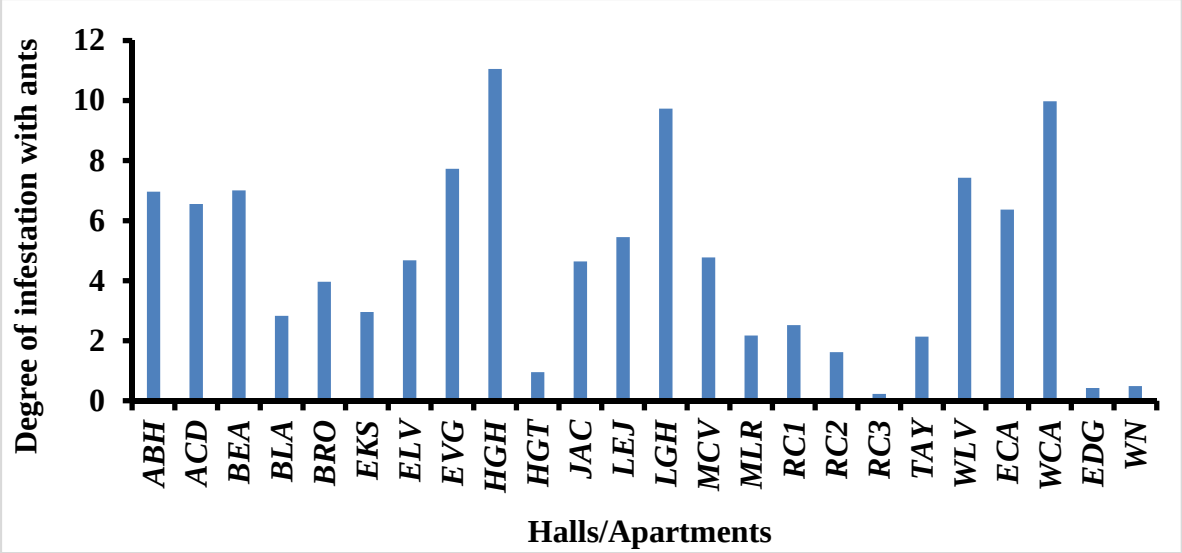


Figure 2.09. Degree of infestation of all halls and apartments with ants from 2000 to 2015 at LSU Residential Life

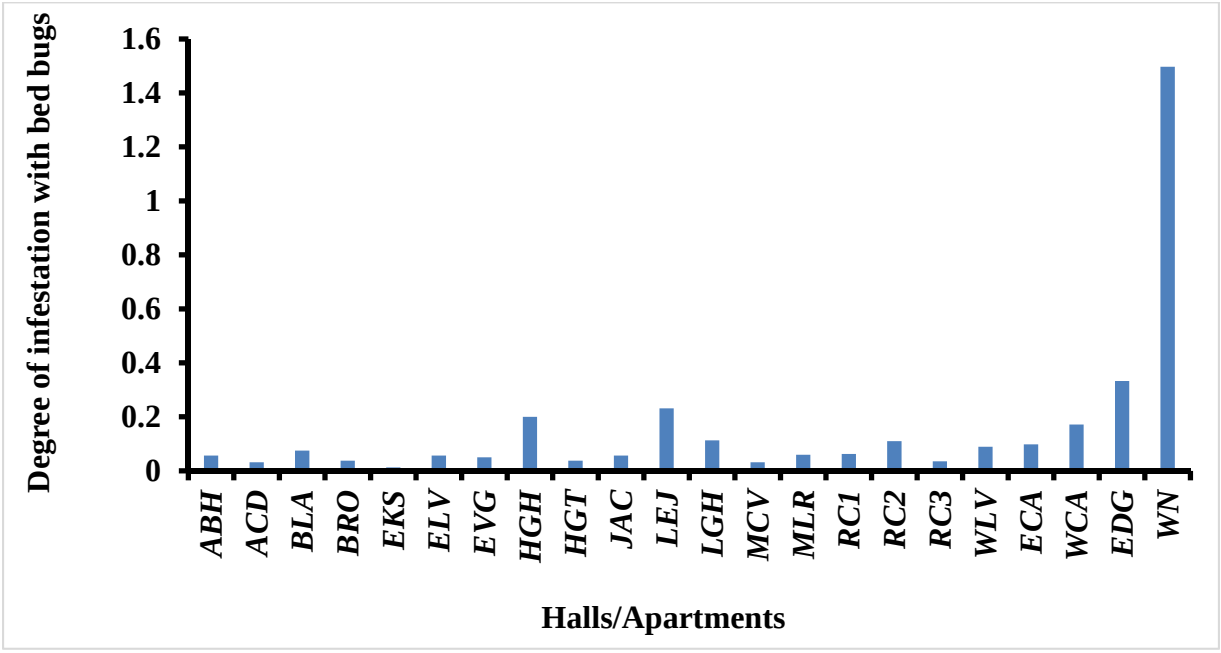


Figure 2.10. Degree of infestation of all halls and apartments with bed bugs from 2000 to 2015 at LSU Residential Life

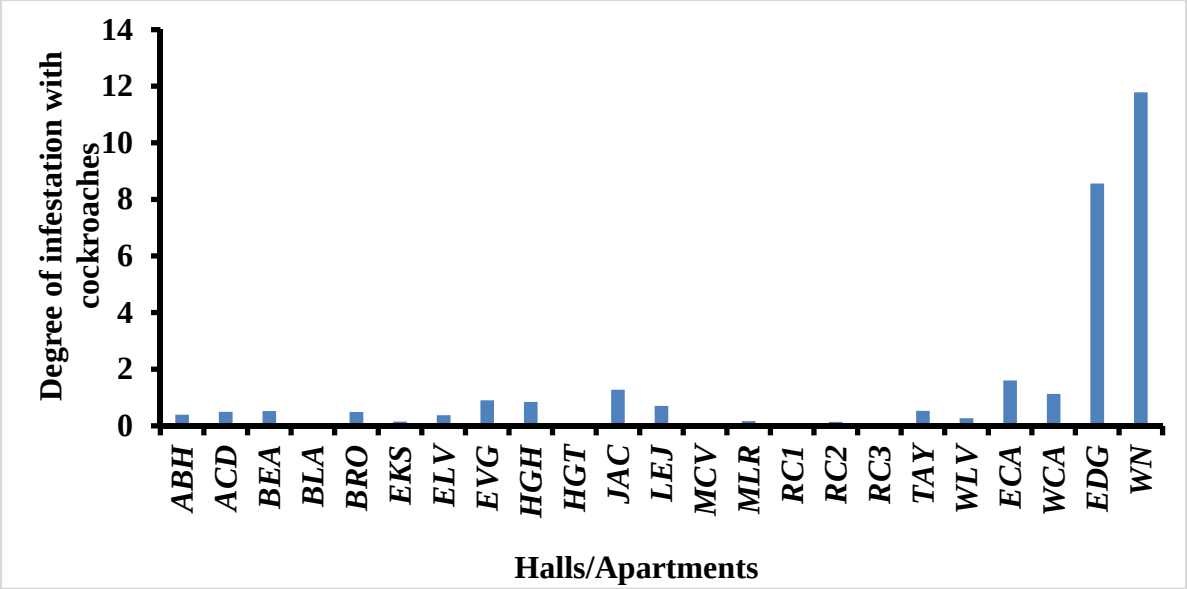


Figure 2.11. Degree of infestation of all halls and apartments with cockroaches from 2000 to 2015 at LSU Residential Life

2.3.3.1. Relationship between degree of infestation with the age of halls and apartments

The relationship between degree of infestation with ants and age halls/apartments was significantly different (F= 6.19; df =2, 21; p = 0.008) (Figure 2.12), but not significantly different for bed bugs and cockroaches, respectively (F= 1.26; df =2, 21; p = 0.3) (Figure 2.13) and (F= 1.96; df =2, 21; p = 0.17) (Figure 2.14).

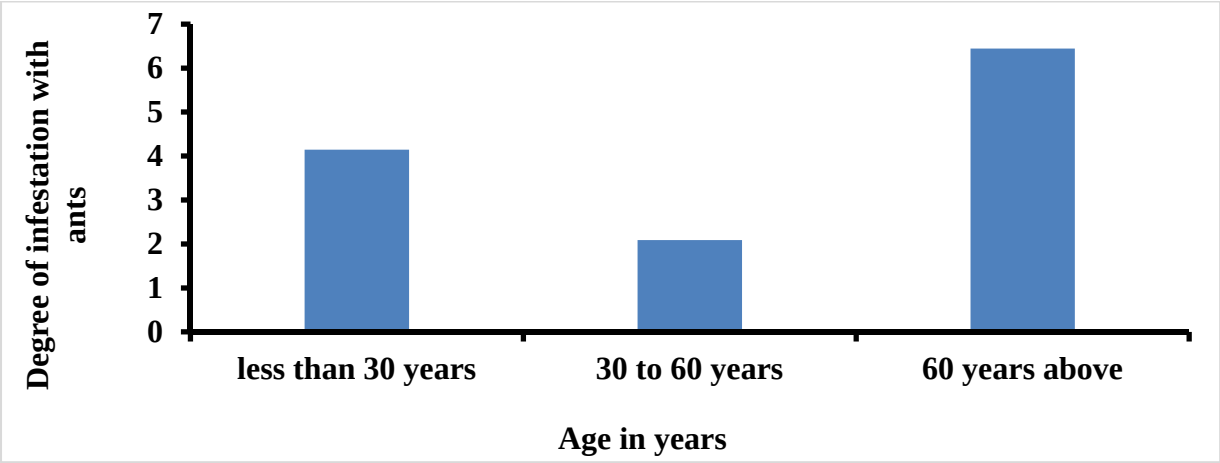


Figure 2.12. Relationship between degree of infestation with ants and age of halls and apartments from 2000 to 2015 at LSU Residential Life

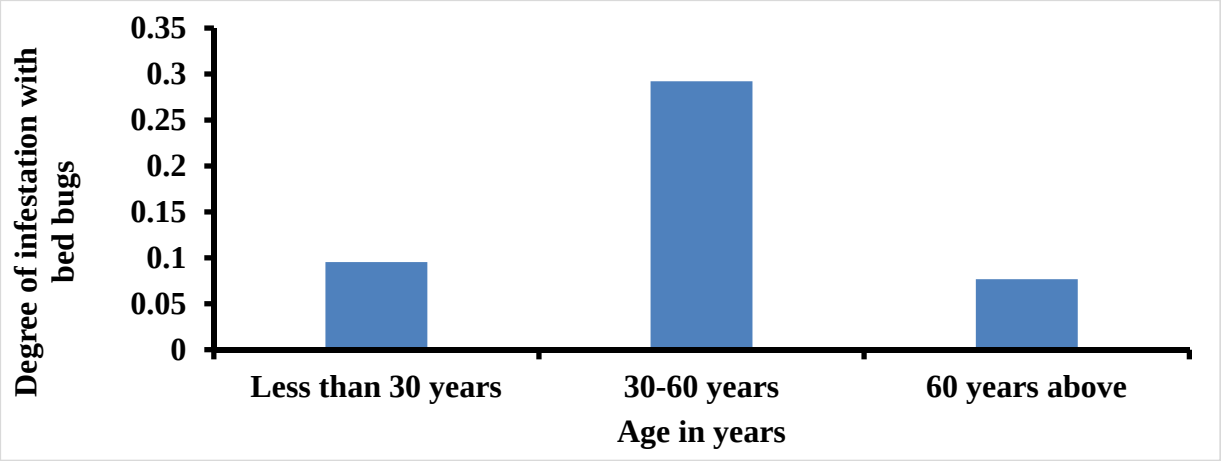


Figure 2.13. Relationship between degree of infestation with bed bugs and age of halls and apartments from 2000 to 2015 at LSU Residential Life

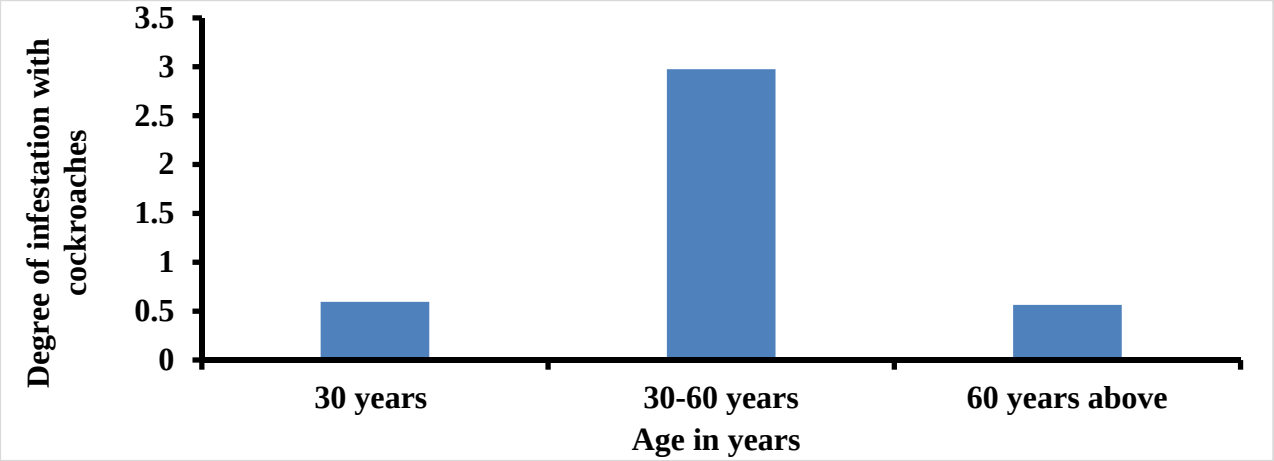


Figure 2.14. Relationship between degree of infestation with bed bugs and age of halls/apartments from 2000 to 2015 at LSU Residential Life

2.3.3.2. Relationship between the degree of infestation with the number of floors in halls and apartments

The result for ants was not significant (F= 0.26; df =1, 21; p = 0.6131) (Table 2.08) with an R^2 of 0.0124 (Figure 2.15). The residual mean square error was 11.17414 (Table 2.08). A negative slope with -0.328 was observed between the degree of infestation of ants with number of floors in the buildings. The result for bed bug was significant (F= 4.40; df =1, 21; p= *0.0483*) (Table 2.09) and R^2 was 0.17 (Figure 2.16). The residual mean square error was 0.08016 (Table

2.09). In bed bug reports a negative slope of -0.046 was observed. The result for cockroach was significant (F= 5.63; df =1, 21; p= 0.0273 (Table 2.10) with R^2 value of 0.21 (Figure 2.17). The residual mean square error was 6.78929 (Table 2.10).The slope for cockroach reports was -1.198.

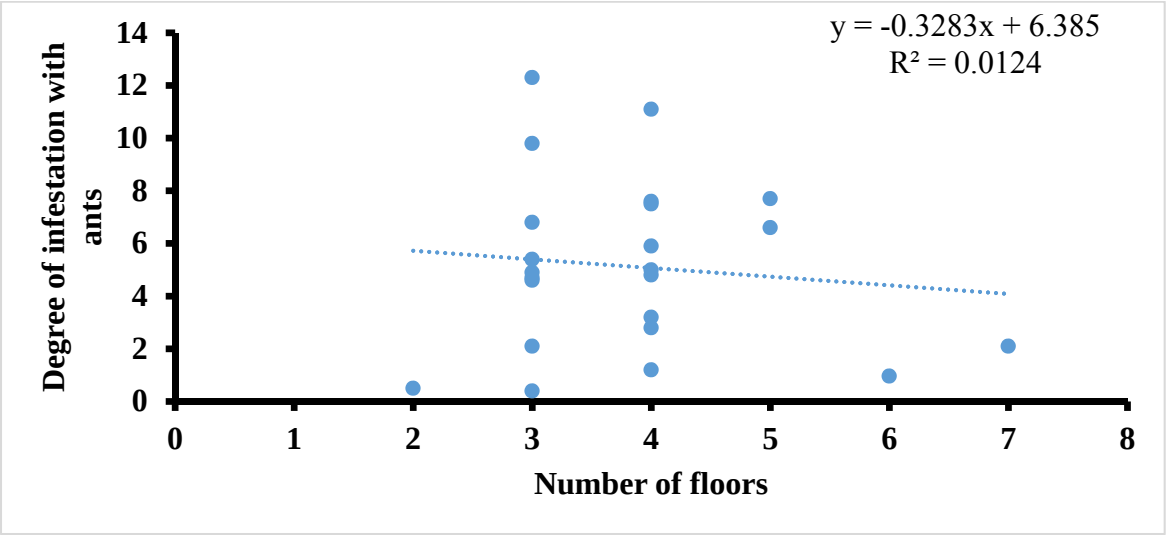


Figure 2.15. Relationship between degree of infestation with ants and number of floors in halls and apartments from 2000 to 2015 at LSU Residential Life

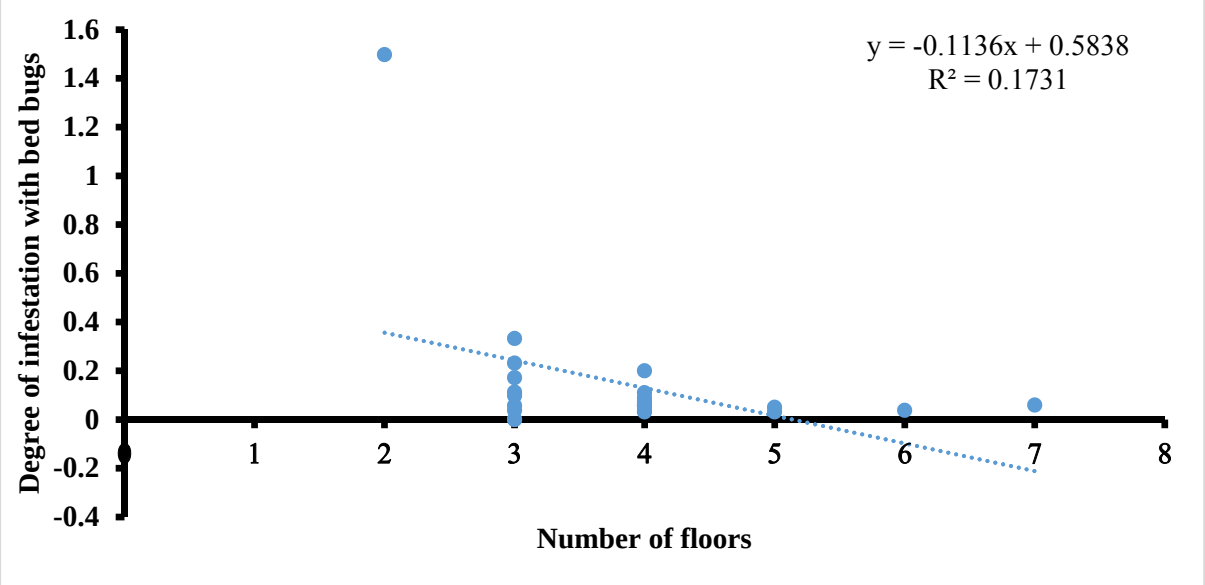


Figure 2.16. Relationship between degree of infestation with bed bugs and number of floors in halls and apartments from 2000 to 2015 at LSU Residential Life

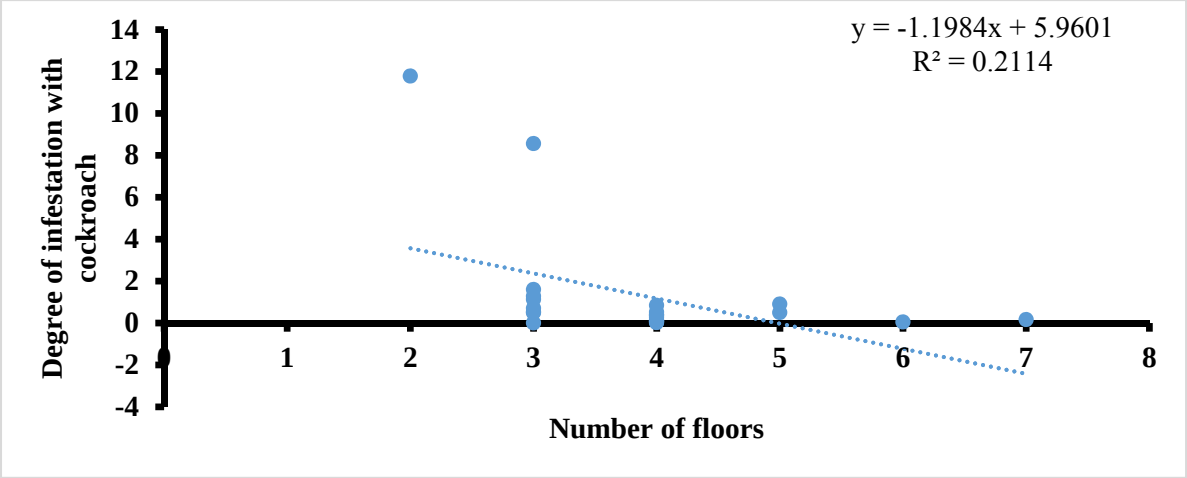


Figure 2.17. Relationship between degree of infestation with cockroach and number of floors in halls and apartments from 2000 to 2015 at LSU Residential Life

Table 2.08. Analysis of Variance for simple linear regression between degree of infestation with ants and number of floors from 2000 to 2015 at LSU Residential Life

Source	*df*	Sum of Squares	Mean Squares	*F*	*Pr > F*
Model	1	2.94367	2.94367	0.26	0.6131
Error	21	234.65699	11.17414		
Total	22	237.60066			

Table 2.09. Analysis of Variance for simple linear regression between degree of infestation with bed bugs and number of floors from 2000 to 2015 at LSU Residential Life

Source	*df*	Sum of Squares	Mean Square	*F*	*Pr > F*
Model	1	0.35247	0.35247	4.40	0.0483
Error	21	1.68344	0.08016		
Total	22	2.03591			

Table 2.10. Analysis of Variance for simple linear regression between degree of infestation with cockroaches and number of floors from 2000 to 2015 at LSU Residential Life

Source	*df*	Sum of Squares	Mean Square	*F*	*Pr > F*
Model	1	38.21266	38.21266	5.63	0.0273
Error	21	142.57503	6.78929		
Total	22	180.78769			

2.3.4 Relationship between bed bug reporting and bed bug presence after inspection and monitoring from September 2014 to December 2015 (reality versus perception)

During the 15 month period, 21 different bed bugs reports were reported in Maximo.

Only 3 times was a bed bug found after inspections and follow ups. Only 14.3% of all the reports

were “reality” whereas the rest were found only as “perceptions” of having bed bugs (Figure 2.18). The bed bugs found during inspections are in shown Figure 2.19 a-e.

Figure 2.18. Percentage of reports for comparison of reality versus perception of having bed bugs from September 2014 to December 2015 at LSU Residential Life

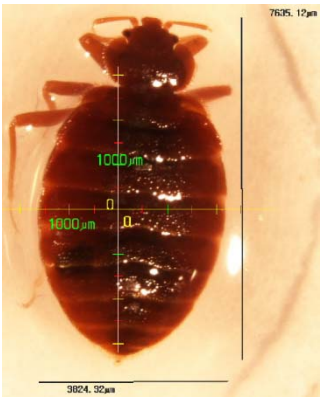


Figure 2.19.a: Adult female bed bug

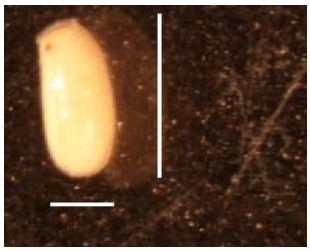


Figure 2.19.b: Egg before hatching

Figure 2.19.c: Eggs after hatching

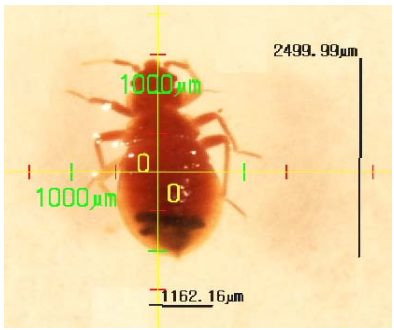


Figure 2.19.d: Blood-fed nymph

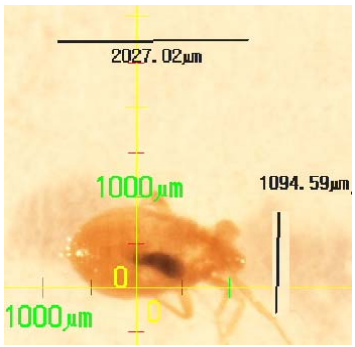


Figure 2.19.e: Unfed nymph

Figure 2.19. Pictures of bed bugs found at LSU Residential Life from September 2014 to December 2015
(Photos by Namoona Acharya from Nikon Digital Sight DS- Fi1 microscope and Nikon DS Camera Control Unit DS-L2 Version 4.0, Japan at Urban Entomology Lab, LSU)

2.4. Discussion

Household insect pests are of great importance because some are vectors of diseases, some sting and some are a nuisance to humans. Urban insects are responsible for the destruction of structures, transferring of disease organisms, and biting and stinging humans as well as pets (Rust and Su 2012). Some insects are considered pests although they don't have any negative effects. People are intolerable to their presence in the living area (Hahn and Ascerno 1991). For these reasons, many people want to get rid of urban insects. The main way to get rid of such insect pests for the students living in LSU Residential Life is to report their problems in Maximo Database. In the 16 years, a diverse group of household insect reports were filed in which certainly most of the students were not entomology professionals. In a survey of household insects inside 50 houses in Raleigh, North Carolina, USA, a diverse group of insects were found including flies, beetles, wasps, ants, bugs, cockroaches, springtails, moths, butterflies, silverfish, crickets and grasshoppers (Bertone et al. 2016). In addition to these insects, we have reports for bed bugs, bees, fleas, mosquitoes and termites. Other insects found with a focus on medical and economic importance include bed bugs, termites, fleas, mosquitoes, and cockroaches (Robinson 2005).

At LSU Residential Life, one single student apartment and 3 halls were established after the Maximo Database started functioning. The number of students living on campus increased by 9.3% after the establishment of West Campus Apartment in 2003. In 2008, 7.3% more students were added after the Residential College 1 and 2 were constructed. In 2013, Residential College 3 was built, which has a capacity of 354 students and increased by 5.6% the number of students living on campus at that time. During the 10 years period from 2003 to 2013, there was a total increase of 1282 students. The positive trend for all 3 insects reports (although not significant for

ant reports and cockroach reports) are probably related to the increased number of students. For bed bug reports, a sharp increase in number of reports from 2008 and the following years was observed. During that time, bed bugs were common in other places as well. In 2008, Cornell University also came up with a "Guidelines for Prevention and Management of Bed Bugs in Shelters and Group Living Facilities" as a state IPM Program (Gangloff-Kaufmann and Pichler 2008). At the same time, 2006-2008, bed bug infestations were found in multistory apartments in Indianapolis, IN (Wang et al. 2010). The resurgences of bed bugs occurred some years before in the US and other parts of world. Bed bugs were thought to have disappeared after the Second World War but they were not eliminated; that is the reason they are back again in North America, Europe, and Australia (Boase 2001, Doggett et al. 2004, Potter 2005). The global resurgence of bed bugs through North America, Eastern Asia, Australia and Europe has increased the bed bug population by 100-500% in the past 10 years (Dogget et al. 2004, Ter Poorten and Prose 2005, Potter 2005, Anderson and Leffler 2008, Lee et al. 2008, Reinhardt et al. 2009).

The highest degree of infestation with ants was from the halls near a cafeteria, Barnes and Nobel, the 2nd highest near a dining hall and the third near Barnes and Nobel over other locations. The food sources availability from these food stations probably helped ant populations to grow. Two halls nearby the Barnes and Nobel also have non-centralized air conditioning systems. Most of the windows have separate air cooling systems, where cracks and cervices are found that can allow insects to enter rooms. Cracks and cervices should be caulked to stop entry of ants (Drees and Summerlin 1983). Some ants nest in soil, lawns, gardens, plant beds, leaf litter, tree cavities, and sidewalk pavements (Drees and Summerlin 1983). These 2 halls and

WCA single student apartments also landscaping with have plants and mulch in their area which provide nesting sites for ants.

Residential Life at LSU provides all the furniture and mattresses to the students who are living in halls and senior student apartments, but students living in family students' apartments are responsible to get their own furniture and bedding. Thus, those students either buy new furniture or get used furniture. Those students who cannot afford new furniture often collect them from their friends, relatives or other donating organizations. Some even take them from the trash (C. Trahan, personal communication). Bed bugs are common in many places. The students who get these used items may be getting more than they bargained for-they may have bed bugs. Bed bugs are found in single-family dwellings, apartments, rooming houses, hotels, health care facilities, and college dormitories (Hwang et al. 2005). The reason for the rapid spread of bed bug infestation during 2006-2008 in Indianapolis, IN is suspected to be related to used furniture, and the high cost for laundry and professional bed bug control (Wang et al. 2010). According the management office of an apartment with 223 units in Indianapolis, IN, the first infestation was caused in a single unit once a resident moved into that unit with a bed bug infestation and later other units were infested (Wang et al. 2010). When single units get infested, other units are likely to also have bed bugs. Bed bugs can move from one apartment to another in multi-unit buildings. This was shown by installing inspectors (ClimbUp Insect Interceptors, Susan McKnight, Inc., Memphis, TN) baited with a lure (Bedoukian Research Inc. Danbury, CT) in hallways in which 3 out of 5 pairs of inspectors trapped some bed bugs near entrance doors in hallways (Wang et al. 2010). LSU Residential Life has a multi-unit family apartments from where degree of infestation with bed bug is highest. As the main reasons of bed bug transportation and spread are scientifically proven, LSU Residential Life and students living on campus should work in a

better way to prevent bed bugs first in family apartments as well as other apartments and halls. As furniture transportation is the major reason, LSU Residential Life could provide furnished apartments for graduate students also. It can also provide or develop a mandatory rule to use bed bug mattress protector to all the students in halls and apartments. If bed bugs are already present, the best work from Residential Life should be preventing their spread to all other adjoining apartments while controlling the bed bugs in the infested apartments.

Cockroaches are important indoor pests with public health and medical concern whose movement is often between human food materials and sewers (Schal and Hamilton, 1990). Some laboratory studies suggest that cockroaches are attracted to common foodstuffs such as soft drinks, bananas, apples, oranges, pineapples, brown sugar and molasses (Rust 1986). Similar kind of foods are available in family apartments more than halls and single student apartments at LSU Residential Life. Kitchen availability and sanitation are other factors which distinguish family apartments from halls. A positive correlation was found between the reduction of cockroach numbers and improved sanitation (Sherron et al. 1982, Write and Dupree 1984, Sachal 1988). So, in the handbook of LSU Residential Life Family-Graduate Resident Handbook, cockroach control is emphasized which is not found in handbook for students living in halls and senior student apartments. Students are suggested to employ sanitation measures and should not have such things as standing water, greasy stove burners, stacked newspapers, paper bags or dirty laundry.

As buildings age, they become weak. This may be a factor for structural insect infestation as well. In our study, the old buildings 60 years and above were found more prone to ant infestation. Penetration through cracks and cervices might be easier in old buildings compared to new ones. In addition, out of 12 buildings, whose ages are more than 60 years, 7 are located on

the east side of campus, nearest to LSU lakes. The water availability from the lakes is another reason for aggregation of ants. In a study done in Kleberg and Kenedy counties in Texas, red imported fire ants were found more in wet areas than dry areas (LeBrun et al. 2012).

Bed bugs are important human ectoparasites whose bite causes itching and other dermatitis problems such as erythematous or urticarial papules and secondary infections such as impetigo, ecthyma and lymphanigites (Stibich et al. 2001, Abdel-Naser et al. 2006, Leverkus et al. 2006, Scarupa and Economides 2006, Stucki and Ludwig 2008, Rossi and Jennings 2010). All of the bed bug reports we investigated were based on the bite and skin symptoms. Even with medical knowledge, it is difficult to identify dermal symptoms of bites on human skin. But as entomologists, we inspected the rooms or apartments from where bed bugs were reported from September 2014 to December 2015 with the help of a flash light and magnifying glass. We put ClimbUp inspectors under the 4 legs of the bed in the rooms after visual inspection. These tools were found very effective for low level bed bug infestations (Wang et al. 2011, Cooper et al. 2015a). We got 2 different doctor reports indicating that the bite on students' bodies were from bed bugs. But our inspection did not detect the presence of bed bugs from those two places. If those bites were from bed bugs, they were from a different place rather than their rooms or apartments at LSU Residential Life. In our study, very few people had actual bed bugs in their rooms and apartments as compared to the number of reports of having bed bugs. In a study in 2015 in Indianapolis, many residents also suspected bed bugs, but after inspection it was found that a significant number of residents did not have any bed bugs (Gibb 2015). It was suggested from that bed bugs were "in their heads" (psychological) rather than in homes and beds, which only increases depression as well as socially separating behavior in humans (Gibb 2015).

2.5 References

Abdel-Naser, M. B., R. A. Lotfy, M. N. Al-Sherbiny, and A. N. M. Sayed. 2006. Patients with papular urticaria have IgG antibodies to bed bug (*Cimex lectularius*) antigens. Parasitol Res. 98: 550–556.

Akre, R. D. and L. D. Hansen. 1990. Management of carpenter ants. *In:* R.K. Vander Meer, K. Jaffe, and A. Cedeno, [eds.], Applied Myrmecology: a World Perspective. Boulder: Colo. Westview Press. 693–700.

Anderson, A. L., and K. Leffler. 2008. Bed bug infestations in the news: a picture of an emerging public health problem in the United States. J. Environ. Health 70: 24–27.

Banks, W. A. 1990. Chemical control of the imported fire ants. *In* R.K. Vander Meer, K. Jaffe, and A. Cedeno, eds., Applied Myrmecology: a World Perspective. Boulder: Colo. Westview Press. 596-603.

Benson, E. P. and P. A. Zungoli. 1997. Cockroaches. *In* S. Hedges and D. Moreland [eds.], 8th ed. Mallis' handbook of pest control. Mallis Handbook and Technical Training Company. GIE Publishing, Cleveland.

Bertone, M. A., M. Leong, K. M. Bayless, T. L. F. Malow, R. R. Dunn, and M. D. Trautwein. 2016. Arthropods of great indoors: characterizing diversity inside urban and suburban homes. Peer J 4: e1852; DOI10.7717/peerj.1582.

Boase, C. J. 2001. Bedbugs-back from the brink. Pestic. Outlook 12: 159-162.

Cooper R., C. Wang, and N. Singh. 2015. Evaluation of a model community-wide bed bug management program in affordable housing. Pest. Manag. Sci. 72*:* 45-56.

Curl, G. 2005. A strategic analysis of the U.S. structural pest control industry – the 2005 season. A survey of PMP's in the U.S., Gary Curl Specialty Products Consultants, LLC. *In* Field, H.B., W.E.E. Sr., R. Hartley, L.D. Hansen and J.H. Klotz, [eds.], 2007. A survey of structural ant pests in the southwestern USA (Hymenoptera: Formicidae). Sociobiol. 49: 1-14.

Doggett, S. L., M. J. Geary, and R. C. Russell. 2004. The resurgence of bed bugs in Australia: with notes on their ecology and control. Environ. Health. 4: 30-38.

Drees, B. M., and B. Summerlin. 1983. House-infestating ants and their management. Texas Agricultural Extension Service. The Texas A&M University system. (http://colorado.agrilife.org/files/2011/08/houseinfestingantmanagement_15.pdf.) Last accessed 04/28/2016.

Gangloff-Kaufmann, J. L., and C. Pichler. 2008. Guidelines for prevention and management of bed bugs in shelters and group living facilities. New York State IPM Program, Cornell

University Cooperative Extension. (http://health.baltimorecity.gov/sites/default/files/BedBugs_Guidelines_for_Shelters_Group_Living_Facilities.pdf). Last accessed June 15th 2016.

Gibb, T. 2015. Study: bed bugs in your head space. Pest Management Professional. 83: 20.

Hahn, J. D., M. E. Ascerno. 1991. Public attitudes toward urban arthropods in Minnesota. Am. Entomol. 37: 179-185.

Hwang, S., T. Svoboda, L. D. Jong, K. Kabasele, and E. Gogosis. 2005. Bed bug infestations in an urban environment. Emerg. Infect. Dis. 11:533-538.

King, F., I. Dick, and P. Evans. 1989. Bed bugs in Britain. Parasitol. Today. 5: 100–102.

LeBrun E. G., R. M. Plowes, and L. E. Gilbert. 2012. Imported fire ants near the edge of their range: disturbance and moisture determine prevalence and impact of an invasive social insect. J. Anim. Ecol. 81: 884-895.

Lee, I. Y., H. I. Ree, S. J. An, J. A. Linton, and T. S. Yong. 2008. Reemergence of the bed bug *Cimex lectularius* in Seoul, Korea. Korean. J. Parasitol. 46: 269–271.

Leverkus, M., R. C. Jochim, S. Schad, E. B. Brocker, J. F. Anderson, J. G. Valenzuela, and A. Trautmann. 2006. Bullous allergic hypersensitivity to bed bug bites mediated by IgE against salivary nitrophorin. J. Invest. Dermatol. 126: 91–96.

Living on campus handbook, 2015-2016. (https://sites01.lsu.edu/wp/reslife/files/2013/06/LivingOnCampusHandbook.pdf). Last accessed 01/05/2016.

LSU Residential Life family and graduate housing handbook. 2015-2016. (https://sites01.lsu.edu/wp/reslife/files/2014/03/Family-Graduate-Resident-Handbook.pdf). Last accessed 01/05/2016.

Maximo Order LSU Residential Life (https://rhmax.lsu.edu/maximo/webclient/login/login.jsp?appservauth=true).

McGlynn, T. P. 1999. The worldwide transfer of ants: geographical distribution and ecological invasions. J. Biogeogr. 26: 535-548.

McGrath, S. 2005. Alien Invaders. Natl. Geographic 207: 92-117.

Mohamed H. A. E., F. A. E. Mohamed, and R. M. H. Baleela. 2014. Control of *Periplaneta americana* using boric acid & neem tree leaflets powder. Sudan Journal of Science. 1: 59-68.

Potter, M. F. 2005. A bed bug state of mind: emerging issues in bed bug management. Pest. Con. Technol. 33: 82-97.

Reinhardt, D., R. A. Kempke, L. O. R. Nay, and M. T. Siva-Jothy. 2009. Sensitivity to bites by the bed bug, *Cimex lectularius.* Med. Vet. Entomol. 23: 163-166.

Robinson W. H. 2005. Urban insects and arachnids: a handbook of urban entomology. Cambridge: Cambridge University Press.

Rossi, L., and S. Jennings. 2010. Bed bugs: a public health problem in need of a collaborative solution. J. Environ. Health. 72: 34-35.

Rust, M. K., N. Y. Su. 2012. Managing social insects of urban importance. Annu. Rev. Entomol. 57: 355-75.

Rust M. R. 1986. Managing household pests. Sec. Ref. 64: 335-368. *In* Schal, C., and R. L. Hamilton. [eds.], 1990. Integrated suppression of synanthropic cockroaches. Annu. Rev. Entomol. 35: 521-551.

Sailer, R. 1952. The bedbug: an old bedfellow that's still with us. Pest. Control. 20: 22-24, 70, 72.

Scarupa, M. D., and A. Economides. 2006. Bed bug bites masquerading as urticarial. J. Allergy. Clin. Immunol. 117: 1508-1509.

Schal, C. 1988. Relation among efficacy of insecticides, resistance levels, and sanitation in the control of the German cockroach (Dictyoptera: Balttellidae). J. Econ. Entomol. 81: 536-544.

Schal, C., and R. L. Hamilton. 1990. Integrated suppression of synanthropic cockroaches. Annu. Rev. Entomol. 35: 521-551.

Schweid, R. 1999. The cockroach papers: a compendium of history and lore. The University of Chicago Press.

Sherron D. A., C. G. Write, M. H. Ross, and M. H. Farrier. 1982. Density, fecundity, homogeneity and embryonic development of German cockroach (*Blattella germanica* (L.)) populations in kitchens of varying degree of sanitation (Dictyoptera: Balttellidae). Proc. Entomol. Soc. Wash. 84: 376- 390.

Stibich, A. S., P. A. Carbonaro, and R. A. Schwartz. 2001. Insect bite reactions: an update. J. Dermatol. 202: 193-197.

Stucki, A., and R. Ludwig. 2008. Images in clinical medicine: bed bug bites. New Engl. J. Med. 359: 1047.

Ter Poorten, M. C., and N. S. Prose. 2005. The return of the common bedbug. Pediatr. Dermatol. 22: 183-187.

Usinger, R. L. 1966. Monograph of Cimicidae (Hemiptera-Heteroptera). The Thomas Say Foundation, Vol. VII. Entomological Society of America, College Park, MD.

Usinger, R. L., and D. Povolny. 1966. The discovery of a possibly aboriginal population of the bed bug (*Cimex lectularius* Linnaeus, 1758). Acta. Musei. Moroviae. 51: 237-242.

Vinson, S. B. 1997. Invasion of the red imported fire ant (Hymenoptera: Formicidae) spread, biology, and impact. Am. Entomol. Spring: 23-39.

Wang, C., K. Saltzmann, E. Chin, G.A. Bennett, and T. Gibb. 2010. Characteristics of *Cimex lectularius* (Hemiptera: Cimicidae), infestation and dispersal in a high-rise apartment building. J. Econ. Entomol. 103: 172-177.

Wang C., W. Tsai, R. Cooper, and J. White. 2011. Effectiveness of bed bug monitors for detecting and trapping bed bugs in apartments. J. Econ. Entomol. 104: 274-278.

Whitmore, R. W., J. E. Kelly and P. L. Reading. 1992. National home and garden pesticide use survey, final report, Volume 1: executive summary, results, and recommendations. U.S. Environmental Protection Agency. Research Triangle Park NC: Research Triangle Institute.

Williams, D. F. 1990. Effects of fenoxycarb baits on laboratory colonies of the Pharaoh's ant, *Monomorium pharaonic*. pp. 676-683. *In* R. K. Vander Meer, K. Jaffe, and A. Cedeno, [eds.], Applied Myrmecology: a World Perspective. Boulder: Colo. Westview Press.

Write, C. G., and H. E. Dupree Jr. 1984. Evaluation of German cockroach mortality with several insecticidal dust formulations. J. Ga. Entomol. Soc. 19: 223-228.

CHAPTER 3. QUESTIONNAIRE SURVEY OF INSECT PEST PROBLEMS AMONG THE STUDENTS LIVING ON CAMPUS

3.1 Introduction

Having other creatures living with humans is not a new story. Since the beginning of time humans are found living, and evolving with insects and their relatives. Kissing bugs and bed bugs (blood feeders) are examples of those arthropods that share human structures from cave to buildings (Balvin et al. 2012, Araujo et al. 2009). In a study by Bertone et al. (2016), 4 subphyla (Chelicerata, Myriapoda, Crustacea, and Hexapoda) and 6 classes, 34 orders, and 304 different families were found indoors while sampling 554 rooms in 50 homes in North Carolina, USA. Out of 34 orders, 16 were from the class Insecta.

Urban insects dwelling inside and outside of structures are reported by the students at LSU Residential Life since 2000 in the Maximo database. Simply considering the results in Table 2.03 does not precisely reflect the prevailing situation, another method of data collection was developed, a questionnaire survey. The survey was available for 44 days.

A questionnaire survey is a common procedure to collect data. Gangloff-Kaufmann et al. (2006) used a questionnaire survey with 15 questions to collect data on the status of bed bugs, which are considered one of the significant urban pest in the United States. Similarly, Morgan et al. (2004) also a developed questionnaire survey to determine the participants' knowledge and opinion about the efficiency of the French Quarter Formosan Termite Program, which was started in 1998 as a large area pilot test in New Orleans. From January to April 2010, the National Pest Management Association (NPMA) and University of Kentucky surveyed national and international pest management companies on the status of bed bug resurgence and the project was completed by Potter et al. (2010). Two different online surveys with 34 questions in each were developed for national and international companies separately (Potter et al. 2010). Similar

surveys were also conducted in 2011, 2013 and 2015 (Potter et al. 2015). To determine the relative occurrence frequency of urban pest ants, and other information related to infestations by ants, a questionnaire survey was conducted by Klotz et al. (1995) with structural pest control employees in Florida. A similar survey was also conducted in New Jersey the year before (Klotz et al. 1994).

In Florida, 8 species of ants were found as key urban pests including red important fire ant (Klotz et al. 1995). More than 25 species of ant species, besides these 8 species of key urban pests, were also encountered as occasional pests (Klotz et al. 1995). While inspecting inside and outside locations, more ants were found inside as were more of the complaints reported to pest control employees (PCEs) because ants were a nuisance in which the crazy ant had the highest percentage among all ants (Klotz et al. 1995). Insecticide spraying was found as common treatment used by PCEs for controlling urban ant pests (Klotz et al. 1995).

In this study, we conducted a questionnaire survey with students living on campus about the commonly encountered insects and problems due to those insects, their prevention and control. Our objectives for this study were:

1. To find out the most common insects.
2. To determine whether ant presence inside the building and multiple stings are being problematic to students.
3. To determine whether students think bed bugs are a problem.
4. To measure the students' awareness on bed bug transportation.
5. To determine what strategy students are applying to prevent and control insects.
6. To determine students' opinion regarding quarterly preventive pesticide measures.
7. To determine the satisfaction level regarding insect control.

8. To explain the variance in level of satisfaction with insect control accounted for by the number of insects observed.

3.2. Materials and methods

3.2.1 Survey design

Before starting data collection from the students of LSU Residential Life, a letter for approval was submitted to the Assistant Vice President of LSU Residential Life (Appendix A). The survey was then sent to students living on campus. A cover letter was also provided and sent to those students (Appendix B). Then the survey questionnaire with 10 questions and 1 additional request for a recommendation was developed to collect students' views of insect problems (Appendix C). Questions were categorized as yes/no, check box, close ended, partially close ended and Likert-type questions. Yes/no type questions were provided with only 2 options to select. In the check box type questions, students were provided with more than one option to select. Close ended type of questions were the multiple choice questions from which students were requested to choose their best answer. In partially close ended questions, students were requested to choose among given options first and then give their opinion. Likert type questions were invented by psychologist Rensis Likert (1932) and are commonly used in questionnaire surveys from which the respondents provide their level of agreement or disagreement on agree-disagree scale of symmetric pattern reflecting their intensity of feelings for a particular item (Burns and Burns, 2008). Yes/no questions were asked of students for ants' stings, prevention and control strategies for bed bugs, and further recommendations. Check box questions also were designed to collect information on common insects, students' knowledge on bed bug transportation methods and measures for cockroach prevention and control. Close ended questions included location of insects, accuracy on bed bug presence in apartments, awareness of

bed bug infestations, and views toward the quarterly preventive insecticide spraying. A procedure of quarterly preventative pesticide spraying was started once LSU Residential Life switched its contractor from Bayou Cajun Pest Control to Arrow Termite and Pest Control Company in the fall of 2014. Partially close ended questions included common insects encountered, prevention and control strategies, and recommendations for Residential Life. A Likert- type question was asked to find the satisfaction level of students for insect control in their apartments and dorms.

3.2.2 Student selection

Out of all students living on campus, only students from sophomore year, junior year and senior years were selected. The list of 1760 students were collected under the supervision of Associate Director- Information and Security Services, Department of Residential Life at LSU. That list consisting names and email addresses of 1760 students was used for the survey distribution.

3.2.3 Survey distribution

The survey questionnaire was submitted to the Student Voice Office LSU, located at the Student Union Building, through email and the survey was created on the LSU Student Voice website and titled as "Residential Life Entomology Survey". This survey was then placed in active status from 10/5/2015 in the given link below: http://www.studentvoice.com/p/?uuid=8a1c7d6cf73445f9b895a85e7f653b1b&p=1. The link was sent to all 1760 students on 11/17/2015 9:00 AM (CT) along with a cover letter. A reminder email was sent to all students on 12/11/2015 2:00 PM (CT). The survey was closed on December 31st, 2015.

3.2.4 Data collection

All the partially and completely answered survey were collected from Baseline (Campus Labs) which is another name for Student Voice from the given link: https://lsu.campuslabs.com/app/ClientWeb/GetStarted.aspx. All the data were collected on Excel for further analysis.

3.2.5 Statistical analysis

All collected data were analyzed using a Statistical Package for the Social Sciences (SPSS) version 23 (International Business Machines Corporation, Armonk, New York). As a very first step of analysis, frequency and percentages were analyzed for each variable. Considering level of satisfaction as dependent variable and number of insect encountered as independent variable, simple linear regression was also used.

3.3 Results

Out of 1760 students, 392 students (22.27%), participated in the "Residential Life Entomology Survey". The date and number of participation is shown in Figure 3.01.

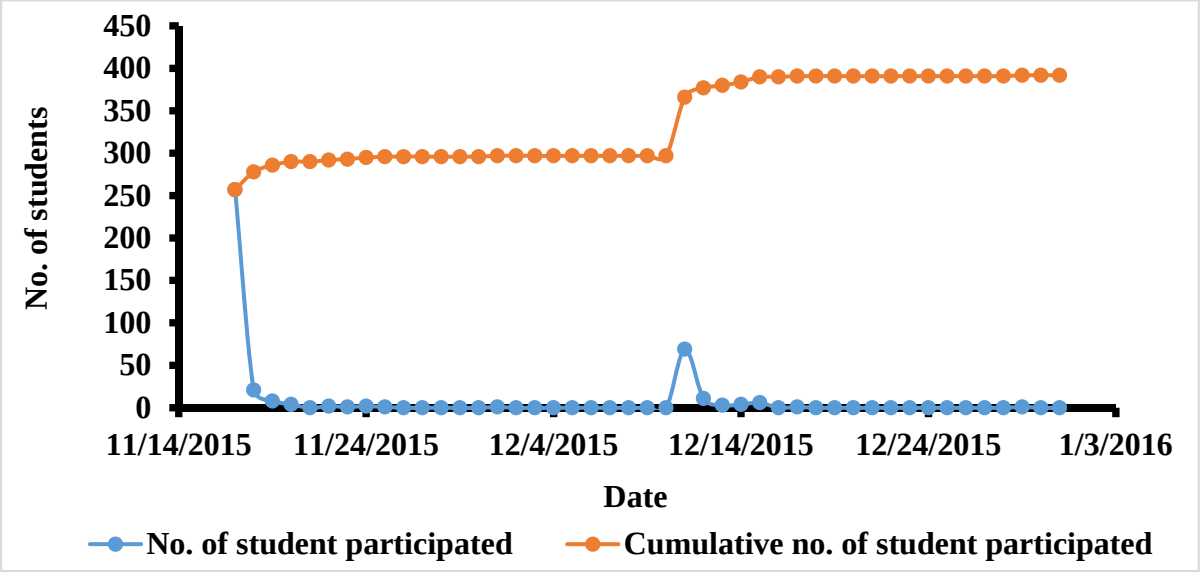


Figure: 3.01. Number of student participants in the Residential Life Entomology Survey from October 17th 2015 to December 31st 2015.

3.3.1 Most common insects

From the survey reports, mosquitoes were found the most common insect which was selected by 69.1% of students that participated in the survey (Table 3.01). All the common insects with their rankings are presented in Table 3.01. Some students named spiders and some other pests which are shown in bold letters in Table 3.01 while the survey asked only about insects.

Table 3.01. Frequency and percentage of students observing insect in different halls and apartments at LSU Residential Life from Residential Life Entomology Survey.

Insects	Number of students	Percentage of students
Mosquitoes	271	69.1
Cockroaches	257	65.6
Long horn crazy ants	175	44.6
Gnats	166	42.3
Bees and wasps	124	31.6
House flies	112	28.6
Silverfish	110	28.1
Beetles	106	27.0
Red imported fire ants	82	20.9
Drain flies	72	18.4
Carpenter ants	40	10.2
Unidentified ants	40	10.2
Bed bugs	7	1.8
Fruit flies	5	1.3
Fleas	3	0.8
Termites	2	0.5
Caterpillars	2	0.5
Moths	2	0.5
Stink bugs	1	0.3
Dragonflies	1	0.3
Crane flies	1	0.3
Crickets	1	0.3
Worms	1	0.3
Spiders	16	4.1
Centipedes/Millipedes	2	0.5
Unknown	2	0.5

Note: All 392 students responded to this question. This is a multi-select item. Percentages do not add up to 100%.

3.3.2 Whether ant presence inside the building and multiple stings are being problematic to students

While conducting a survey among students regarding the location of the ants found in their dorms and apartments, 47.1% of students reported finding ants outside the buildings, 40% encountered ants both outside and inside the buildings, and 12.9% inside the buildings (Table 3.02). Of all the students that participated in this question, 51.2% were not stung by red imported fire ants (Table 3.03).

Table 3.02. Frequency and percentage of students encountering ants in different location from Residential Life Entomology Survey

Location	Frequency of students	Percentage of students
Outside	113	47.1
Both	96	40.0
Inside	31	12.9
Total	240	100

Note: 152 students did not respond to this item.

Table 3.03. Frequency and percentage of students stung by red imported fire ant at LSU Residential Life from Residential Life Entomology Survey

Stings by red important fire ants	Frequency of students	Percentage of students
No sting	42	51.2
Multiple stings	25	30.5
Single Sting	15	18.3
Total	82	100

Note: 310 students did not respond to this item.

3.3.3 Bed bug problem

Only 5 students responded to this question considering bed bugs a problem at Residential Life (Table 3.04). In this objective, we did not analyzed their awareness toward bed bug infestation in their rooms and apartments (Question 5 Appendix C), few students responded to this question and we considered that the question was confusing and was a replication of the previous question, which was asking about the extent of bed bugs present at LSU Residential Life.

Table 3.04 Frequency and percentage of students considering bed bug as a problem from Residential Life Entomology Survey.

Bed bug a as problem	Frequency of students	Percentage of students
Slight problem	3	60
Moderate problem	1	20
Considerable problem	1	20
Total	5	100

Note: 387 students did not respond to this item.

3.3.4 Students' awareness on bed bug transportation

When conducting the survey, students were asked about their knowledge regarding methods of bed bugs transportation, and only 5 students responded (Table 3.05).

Table 3.05. Frequency and percentage of students who are awareness of bed bug transportation from Residential Life Entomology Survey.

Awareness of bed bug transportation	Frequency of students	Percentage of students
I am not aware of bed bug transportation	3	23.1
Staying in infested hotel	3	23.1
Visiting a friend who may have infestation	3	23.1
Buying used mattress and furniture	2	15.4
Having guest overnight who might from infested area	2	15.4

Note: 387 students did not respond to this item. This is a multi-select item. Percentages do not add up to 100%.

3.3.5 Strategies that students are applying to prevent and control insects

For bed bugs preventative and control strategies were on occasion applied by the students. Out of participated students, 18.4% are applying different strategies for bed bugs prevention and control where as 81.6% are not applying any strategies (Table 3.06, Figure 3.02). For cockroach prevention and control, 82.1% of students were found towards sanitation in which they took out their trash in a regular fashion, 70.9% of the students were found to be keeping their food in sealed containers, 22.9% of students purchased cockroach spray (Table 3.07.a).

Out of 71 students reporting use of bed bug prevention and control methods (Table 3.06), 62 students provided a written response for different strategies used as shown in Figure 3.02. Use

of a mattress cover was the most commonly cited different strategy used. Nine students did not provide a written response.

Table 3.06: Frequency and percentage of students who are using bed bug prevention and control strategy from Residential Life Entomology Survey

Bed bug prevention and control	Frequency of students	Percentage of students
No	314	81.6
Yes	71	18.4
Total	385	100

Note: 7 people did not respond to this item.

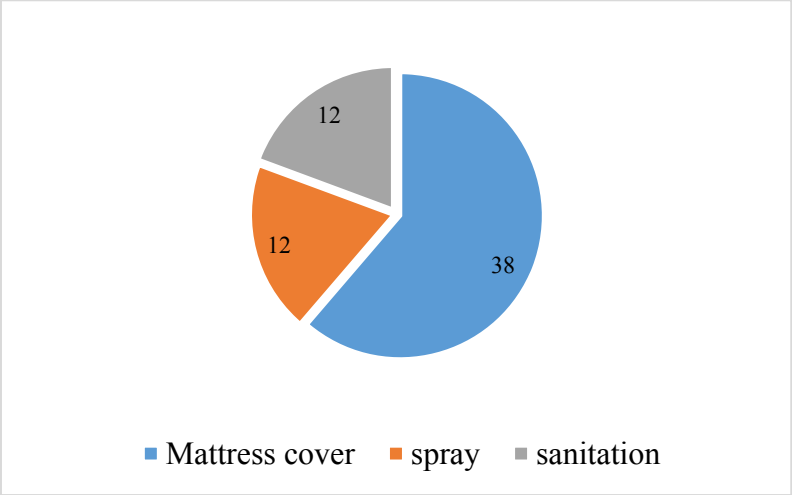


Figure 3.02. Students applying different strategies to prevent and control bed bugs.

Table 3.07.a. Frequency and percentage of students using prevention and control strategies for cockroaches.

Cockroaches prevention and control strategies	Frequency of students	Percentage of students
Take out trash regularly	316	82.1
Keep food in sealed container	273	70.9
Purchase of cockroach spray	88	22.9
None of the above	49	12.7
Other strategies	28	7.3

Note: 7 students did not respond to this item. This is a multi-select item. Percentages do not add up to 100%.

Out of 28 students who provided a written response, 15 came with their own strategies for preventing and controlling cockroaches, 10 gave reactions (Table 3.07.b), and 3 students

responded that they have Residential Life to spray their apartments. The students who came with their own strategies used traps most frequently (Figure 3.03).

Table 3.07.b. Students' Reaction towards cockroaches

Students' Reactions
"I kill the ones I find"
"I killed them"
"I only saw one"
"I pray to the mighty goddess Isis"
"My shoe"
"Scream"
"Just to be clear: I do all the above, but my roommates are incredibly disgusting and leave massive messes all over the apartment which I attribute to being the reason for the roaches"
"Squish 'em when I see 'em"
"They became very intimately acquainted with my largest pair of shoes. I leave their corpses outside my door to scare off their kind"
"Only outside"

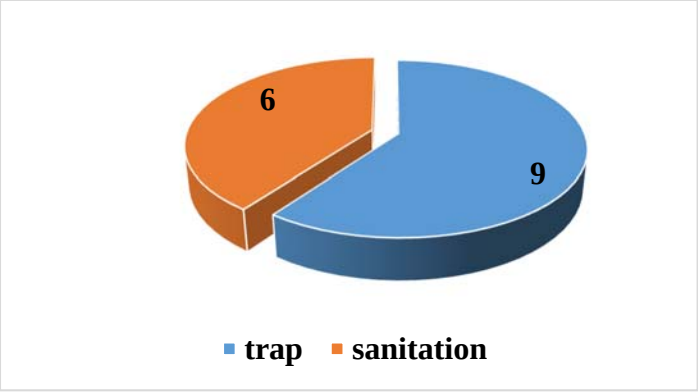


Figure 3.03. Students applying different strategies for cockroach control.

3.3.6 Students' opinions regarding quarterly preventive pesticide measures

Out of students responding about the awareness of the preventative measures, 84.9% positively viewed the quarterly spraying application (Table 3.08).

Table 3.08. Frequency and percentage of students with an opinion about quarterly preventive pesticide measure from Residential Life Entomology Survey

View of Quarterly preventative measure	Frequency of students	Percentage of students
Kills current and prevents future infestation	155	41.1
Kills only the current infestation	150	39.8
It does not work	57	15.1
Prevents only the future infestation	15	4.0
Total	377	100

Note: 15 students did not respond to this item.

3.3.7 Satisfaction level regarding insect control

In the LSU Residential Life Entomology Survey 24.1% of students were found to be very satisfied with Residential Life in insect control measures (Table 3.09).

Table 3.09. Frequency and percentage of students with their satisfaction level regarding to the insect pest control from Residential Life Entomology Survey

Satisfaction level of insect control	Frequency of students	Percentage of students
Moderately satisfied	147	39.0
Very satisfied	91	24.1
Moderately dissatisfied	61	16.2
Neither satisfied nor dissatisfied	60	15.9
Very dissatisfied	18	4.8
Total	377	100

Note: 15 students did not respond to this item.

3.3.8 To explain the variance in level of satisfaction with insect control accounted for by the number of insects observed

The purpose of objective 8 was to determine how much of the variance in level of satisfaction with insect control was accounted by the number of insects observed (Table 3.10). The simple linear model was used for the analysis. The independent variable was insects observed and the dependent variable was level of satisfaction with insect control. For every one unit increase of insects observed, the satisfaction level decreases by -1.61 (Table 3.11). This was a significant linear relationship. The linear relationship is shown in Table 3.11 in which the adj. R^2 is 0.105. Adj. R^2 suggests that the amount of change from sample to population is minimal. Residual mean square error for this model is 1.194 (Table 3.12).

Table 3.10: Cross tabulation of number of insects reported and satisfaction level with insect control from Residential Life Entomology Survey

Number of insects observed	Number of very satisfied students	Number of moderately satisfied students	Number of neither satisfied nor dissatisfied students	Number of moderately dissatisfied students	Number of very dissatisfied students
0	9	2	2	0	0
1	17	15	3	1	1
2	17	20	5	9	1
3	15	23	11	6	3
4	12	23	11	10	3
5	14	30	12	8	1
6	4	11	7	13	2
7	1	11	2	6	2
8	1	7	4	2	2
9	1	4	0	3	1
10	0	1	2	2	2
11	0	0	0	1	0
12	0	0	1	0	0
Total	91	147	60	61	18

Table 3.11: Simple Linear relationship between numbers of insects observed and the satisfaction level with insect control.

Model	β0	Standard Error	β1	*t*	*p*	R^2	*Adj.* R^2
Number of insects observed	-0.161	0.024	-0.327	-6.704	0.000	0.107	0.105

Table 3.12: ANOVA table for Residual mean square error of Simple Linear relationship between numbers of insects observed and the satisfaction level with insect control

Model	Sum of squares	*df*	Mean squares	*F*	*p*
Regression	53.648	1	53.648	44.948	0.000
Residual	447.583	375	1.194		
Total	501.231	376			

3.4 Discussion

In this study, mosquitoes were the most common insect identified by students of Residential Life although mosquito reports from 16 years of data was in the 8th position (Table

2.03). For determining mosquitoes as the most common insects for students living in campus, time had played a very important role. Dr. Todd Walker, the director of the East Baton Rouge Mosquito Abatement and Rodent Control Center said that in the time period of 100 years, October 2015 was the wettest October. So, this could be the reason of waxing in mosquito population all-round the Baton Rouge, but within a week, light traps captured 2000 mosquitoes within a week in those traps located in the Baton Rouge Zoo (Frey 2015). The National Pest Management Association also published news in which mosquitoes were above normal population in two thirds of the United States in the month of September (Janssen 2015).

In our study, cockroaches were the second most common insects. Food availability and sanitation status might be the reasons for cockroach populations in LSU Residential Life. Students living in halls have some food such as soft drinks and fruits in their room which are some of the attractants to cockroaches (Rust 1986). Students often trash food items improperly and sometimes leave them open in their rooms. Senior student apartments have a kitchen in every unit where students can prepare their own food. Once the food and utensils are not properly managed, the cockroach populations grow. The greasy stove burner resulting from cooking food in kitchens also attracts cockroaches. Better sanitation was found positively correlated with cockroach reduction (Sachal 1988, Sherron et al. 1982, Write and Dupree 1984). In multi-unit halls and apartments, cockroaches can move from one unit to another. Within a time period of 3 years, reporting of cockroach problems increased by 65% in a multi-unit residential area in California (Slater et al. 1979).

In our study, students encountered most of the ants outside the building. Some ants such as red imported fire ants build their nests in the soil. Some ants' nests are difficult to find. But when foraging, ants are found in different places inside and outside the house. Different ants

have different foraging strategies. Our study showed that most of the ants were found outside the building. A similar study was done by Koltz et al., and found carpenter ants in both locations, outside and inside a building (Klotz et al. 1995). Similarly, other ants such as long horn crazy ants and red imported fire ants were found in both location (Klotz et al. 1995). Pharaoh ants and ghost ants were found inside most often and sometimes were found outside as well (Klotz et al. 1995).

In our study, almost half of the students that participating in the study had gotten stings from red imported fire ants. Red imported fire ants are stingers to human in the United States, and 2-3% people are allergic to their venom which can cause anaphylactic shock (Shute 2013). Urban dwelling people getting stings from red imported fire ant was 30-60% (Klotz et al.1994, Clemmer and Serfling, 1975, Adams and Lofgren 1981). Similarly, New Orleans, has a sting rate of 58% (Desforges et al. 1990).

In our study, few students responded to the bed bug questions. Bed bugs are cosmopolitan human pests and have been reported in 3 different apartment units in LSU Residential Life in the time period between September 2014 to December 2015. It might be because those students who did not respond have not experienced any bed bug bites in their halls and apartments. Bed bugs are hiders and sometimes human beings do not feel their presence despite sharing the most private thing, a bed. The good part is that students considering bed bug as not problematic, the less chance they will be isolated feelings and depressed. As human beings are the important factor in bed bug transportation and resurgence of these mysterious bugs all over the world, the more people should be aware of their transportation. Bed bug presence in bus stands, taxi stands, luggage racks, lockers and cargo are considered temporary sites, and homes, apartments and condominiums known as permanent sites (Kells, 2006). The students' awareness

in bed bug transportation may reduce the probability of having bed bugs transported from other places to LSU Residential halls and apartments. Preventing bed bugs before welcoming them and controlling them if already established are both very important measures. So, as more students follow preventative strategies, the less chance for them to be victims. As only one fifth of students are using such strategies, other students may be prone to have bed bug problems in the future. Most students who were involved with the protective measures were found to be using mattress covers or mattress protectors. In a laboratory study on bed bugs, they were incapable of feeding through the mattress protector (products registered by the EPA) (Todd, 2006). Proper inspection, vacuuming and mattress protectors were mentioned as the means of bed bug control (Kells, 2006).

In our study, many students were found to be aware of cockroach prevention and control. To control the cockroach population in the living area, cleanliness is very important. Since the movement of cockroaches is between trash and human food materials, food protection is one of the most effective measures to prevent health issues. Cockroaches collected from schools, restaurants, hospitals, pet shops, and homes carry at least 100 species of bacteria (Roth and Willis, 1957) thus preventing and controlling cockroaches is vital in living areas. Students who were found controlling cockroaches in their halls and apartments were using methods to have a hygienic areas in their halls and apartments. Some students chose traps as the control measure of cockroaches which is effective in cockroach population control (Piper et al. 1975, Piper and Frankie 1978, Ballard and Gold 1984).

In our study, the fewer number of insects encountered by students the more students were satisfied regarding insect control. Insect control is a service provided to the students by Residential Life. Every student has his or her own opinion or attitude toward the service

provided. As more students have a positive attitude for pest control process, the relationship between service provider and service receiver can become stronger. Once a service receiver develops the positive attitude from the repeated services from a service provider, a different kind of bond is established, known as relationship (Liljander and Strandvik 1995). And this relationship becomes stronger once the service receiver feels some optimistic commitment to the service provider (Liljander and Strandvik 1995).

Along with the determination of the common urban insect pests in LSU Residential Life, this survey was found useful to determine the perception of students toward different insects. This survey was also helpful to collect data on the location of ants found, stinging status of red imported fire ant and current status of bed bugs.

3.5 References

Adams, C. T. and C. S. Lofgren. 1981. Red imported fire ants (Hymenoptera: Formicidae): frequency of sting attacks on residents of Sumter County, Georgia. J. Med. Entomol.; 18:378-382.

Araujo, A., A. M. J ansen, K. Reinhard, and L. F. Ferreira. 2009. Paleoparasitology of Chagas disease: a review. Memórias do Instituto Oswaldo Cruz*;* 104:9-16. *In* Bertone, M. A., M. Leong, K. M. Bayless, T. L. F. Malow, R. R. Dunn, and M. D. Trautwein. [eds.], 2016. Arthopods of great indoors: characterizing diversity inside urban and suburban homes. Peer J. 4: e1852; DOI10.7717/peerj.1582.

Ballard, J. B., and R. E. Gold. 1984. Laboratory and field evaluation of German cockroach traps. J. Econ. Entomol. 77: 661-65.

Balvin, O., P. Munclinger, L. Kratochvil and J. Vilimova. 2012. Mitochondrial DNA and morphology show independent evolutionary histories of bedbug *Cimex lectularius* (Heteroptera: Cimicidae) on bats and humans. Parasitol. Res. 111:457-469

Bertone, M. A., M. Leong, K. M. Bayless, T. L. F. Malow, R. R. Dunn, and M. D. Trautwein. 2016. Arthopods of great indoors: characterizing diversity inside urban and suburban homes. Peer J 4: e1852; DOI10.7717/peerj.1582.

Burns, A., and R. Burns. 2008. Basic marketing research. 2nd Ed. New Jersey: Pearson Education. p. 245. In Likert scale Wikipedia? (https://en.wikipedia.org/wiki/Likert_scale). Last accessed 16th May 2016.

Clemmer D. I., and R. E. Serfling. 1975. The imported fire ant: dimensions of the urban problem. South Med. J. 68:1113 -1118.

Desforges, J. F., R. D. deShazo, B. T. Butcher, and W. A. Banks. 1990. Review Article: Reactions to the Stings of the Imported Fire Ant. The New Eng. J. of Med. 323: 462-66.

Frey, K. 2015. Mosquitoes swarm in south Louisiana after a wet October. (http://www.wafb.com/story/30460469/mosquitos-swarm-in-south-louisiana-after-a-wet-october). Last accessed 05/01/2016.

Gangloff-Kaufmann, J., C. Hollingsworth, J. Hahn, L. Hansen, B. Kard, and M. Waldvogel. 2006. Bed bugs in America: a pest management industry survey. Am. Entomol. 52: 105 - 106.

Janssen, H. 2015. 2015 fall pest forecast: above-normal mosquito populations to agitate more than two-thirds of US. Online available at http://www.accuweather.com/en/weather-news/2015-fall-pest-forecast-bug-populations-stink-bug-mosquito-ants/52537613. Last accessed 05/01/2016.

Kells, S.A. 2006. Bed bugs: A systemic pest within society. Am. Entomol. 52: 107-108.

Klotz, J. H., G. Goveia, L. Davis and B. L. Reid. 1994. Surgical strikes. Pest. Control. Tech. 22: 32-42.

Klotz, J. H., J. R. Mangold, K. M. Vail, L. R. Davis and R. S. Patterson. 1995. A survey of Urban Pest Ants (Hymenoptera: Formicidae) of peninsular Florida. The Fla. Entomol. 78: 109-118.

Likert, R. 1932. A technique for the measurement of attitudes. Archives of Psychology 140: 1–55. In Likert scale Wikipedia? (https://en.wikipedia.org/wiki/Likert_scale). Last accessed 16th May 2016.

Liljander, V., and T. Strandvik. 1995. The nature of customer relationships in services. Advances in Service Marketing and Management. JAI Press Inc. London. 4: 1-35.

Morgan, A. L., K. L. Machtmes, and E. Johnson. 2004. Evaluating the effectiveness of the French Quarter Formosan Termite Project: A survey of participants' knowledge and perceptions. J. Agr. Urban. Entomol. 21:185-194.

Piper, G. L., R. R. Fleet, G. W. Frankie and R. E. Frisbie. 1975. Controlling cockroaches without synthetic organic insecticides. Tex. Agric. Exp. Stn. Ext. Service. Leafl. 1373.

Piper, G. L., R. R. Fleet, and G. W. Frankie. 1978. Integrated management of urban cockroach populations. *In* G. W. Frankie, C. S. Koehler, [eds.], Perspectives in Urban Entomology. New York: Academic. pp. 249–266.

Potter, M. F., B. Rosenberg, and M. Henriksen. 2010. Bugs without borders- executive summary. Defining the global bed bug resurgence. (https://npmapestworld.org/default/assets/File/publicpolicy/executivesummaryreleasetomembersFINAL.pdf). Last accessed 06/10/2015.

Potter, M. F., J. Fredericks, and M. Henriksen. 2015. Bugs without borders executive summary. (http://www.pestworld.org/news-hub/pest-articles/2015-bugs-without-borders-executive-summary/). Last accessed 04/19/2016.

Roth, L. M., and E. R. Willis. 1957. The medical and veterinary importance of cockroaches. Smithson. Misc. Collect. 134: 1-147.

Rust, M. R. 1986. Managing household pests. Sec Ref. 64: 335-368. *In* Schal, C., and R. L. Hamilton. [eds.], 1990. Integrated suppression of synanthropic cockroaches. Annu. Rev. Entomol. 35: 521-551.

Schal, C. 1988. Relation among efficacy of insecticides, resistance levels, and sanitation in the control of the German cockroach (Dictyoptera: Balttellidae). J. Econ. Entomol. 81: 536-544.

Sherron D. A, C. G. Write, M. H. Ross, and M. H. Farrier. 1982. Density, fecundity, homogeneity and embryonic development of German cockroach (*Blattella germanica* L.) populations in kitchens of varying degree of sanitation (Dictyoptera: Balttellidae). Proc. Entomol. Soc. Wash. 84: 376-390.

Shute, N. 2013. Best defense against fire ants may be allergy shot offense. (http://www.npr.org/sections/health-shots/2013/03/04/173424247/best-defense-against-fire-ants-may-be-allergy-shot-offense). Last accessed 05/01.2016.

Slater, A. J., L. Mclntosh, R. B. Coleman, and M. Hurlbert. 1979. German cockroach management in student housing. J. of Environ. Health. 42: 21-24.

Todd, R. G. 2006. Efficacy of bed bug control products in lab bioassays: Do they make it past the starting gate? Am. Entomol. 52; 113-116.

Wright, C. G., and H. E. Jr. Dupree. 1984. Evaluation of German cockroach mortality with several insecticidal dust formulations. J. Ga. Entomol. Soc. 19: 223-228.

CHAPTER 4. SUMMARY AND CONCLUSION

Urban insects such as ants, bed bugs, cockroaches, mosquitoes, wasps, flies and many others are problematic to human world. Urban insects are responsible for the destruction of structures, transferring disease organisms, and biting and stinging humans as well as pets. Students living at Louisiana State University Residential Life are also having problems with the insects in and around their halls and apartments. LSU Residential Life has been recording all insect reports in Maximo database since 2000. Insect related data in Maximo Database were collected from 2000 to 2015 for our study. All these data were collected from 22 halls and apartments whose age ranges from 2 years to 92 years. These all halls and apartments are located in 4 different sites inside LSU. For preventing insects and other pests, quarterly pesticide spraying is done in all halls and apartments. Graduate entomology students are helping to identify the insects which are problematical to LSU Residential Life. For controlling the existing insect problems, LSU Residential Life has contracted with pest control and the staff from that company comes once they get some information of students having problem with insects.

In our study, out of all problems reported in this database, insects made up 2.64%. Ants, cockroaches, wasps, and bed bugs were the 4 most frequently encountered insects during the 16-year period. While analyzing the data of ants, bed bugs and cockroaches, ants reports were the highest in 2004, bed bugs in 2009 and cockroaches in 2008. Reports of these 3 insects have increasing model with positive slope. Ants were found the highest in September, bed bugs in October and cockroaches in August. The highest degree of infestation with ants were found from those halls and apartment which are located near the cafeteria and dining halls. The highest degree of infestation for bed bugs and cockroaches were from the family apartments. The buildings whose age were 60 years above have more degree of infestation with ants. More

reports were from the lower floors and negative slope was found between the relationship of degree of infestation and number of floors. Many students reported bed bugs but less than 15% of the reports were actual bed bug cases. Students might be confused with other insect bites and report bed bug though they did not find any bed bug evidence in their rooms and apartments. Surveys are one of the popular methods to collect data. Many scientists have conducted questionnaire survey to collect insect data. In our study, we also conducted a questionnaire survey among the students living on campus. In this web survey, "Residential Life Entomology survey" which was conducted from October to December 2015, 392 students living in campus were participated. From the survey, mosquitoes were the most common insects followed by cockroaches, long horn crazy ants and gnats. Altogether 21 different types of insects were encountered by these students while living in LSU Residential Life. Some ants being problematic to students because of their presence inside and their stings. Some students were stung by red imported fire ants too which is almost similar to the other studies in New Orleans. As few students were found concerned about bed bugs and their transportation from one place to another, LSU Residential Life has a risk to be infested by bed bugs in near future. As compared to cockroach prevention and control, one fifth of students were found preventing and controlling bed bugs in their rooms and apartments. Almost all students were found focused in sanitation for cockroach prevention and control whereas for bed bugs, some students were using mattress cover or mattress protector. If Residential Life at LSU can make a mandatory rule to use mattress cover in all halls and apartments, bed bugs will be easily prevented. Along with this, if Residential Life can provide furnished family apartments, students may not collect their requirements from trash, other donating organizations or buy used items. Many students were found positive towards the quarterly preventative pesticide spraying measure. But some students believed that this was not

working. LSU Residential Life as well as students should understand that treating buildings with chemical pesticides alone does not work well. The first step should be initiated by students to have a clean living condition. More than half students were happy with the insect control. To have almost all students happy with insect control, there should be a strong team work among Residential Life, students living on campus and pest control company working as a contractor. All the team should be responsible to decrease the existing pest population and prevent other insect pests. In our study, the less number of insects encountered by student the more students were satisfied regarding to insect control. Insect control is the service provided to the students by Residential Life. Every student has their own opinion or attitude toward the service provided. As more students have a positive attitude for pest control process, relationships between service provider and service receiver becomes stronger.

RECOMMENDATION FOR LSU RESIDENTIAL LIFE

Students living on campus send their recommendation to the LSU Residential Life for pest control in different halls and apartments. Most of the students complained about the mosquito problem and requested Residential Life to control them. They were more concerned with frequently, careful and meticulous spraying of pesticides. A student complained that pesticide spraying in minimal quantity does not have a good result. It should be sprayed all-round the room and all the corners should be more focused. Some students who believe that quarterly preventative spraying only works for current infestation recommended to spray as soon as possible once the student reports. Some students came up with renovation of old buildings and sealing of cracks and cervices found on doors and windows. They complained that the sealing was done poorly and it was the main way for insects entering inside. The other recommendation from them was the halls and apartments with non-central air cooling systems were more prone for the insects. According to the survey, students recommended LSU Residential Life to spray chemical pesticides in a meticulous way in those infested buildings rather than just spraying in a quarterly basis. Some students suggested to focus more on the first floor, as lights in front of doors, and crawling insects can enter inside. Some students suggested to pay more attention to Maximo order and take an immediate action once insects are reported. Students who were from apartments suggested to control cockroaches. Some halls had bad drain fly infestation and those students requested to control the drain flies.

With a year experience working with Residential Life as an entomology graduate student, I have gone through different reports of insects. My first recommendation for Residential Life to decrease insect problems in different halls and apartments is to educate staff and students regarding the prevention of insects inside the buildings. Most of the common insects have a

common preventative measure which is sanitation. Change in habits can also support a lot for insect pest prevention.

The procedure of insect control is quite long and complicated. Once the report is done, first inspection is done by custodial staff with no entomological background. An entomology graduate student cannot provide his/her full time for the inspection. Once the insect presence is confirmed, then another person contact the pest control company. As of now, the procedure is lengthy and take so much manpower. If a full time staff with entomology background take the responsibilities regarding insect reports in Maximo Order up to the follow up after pesticide spray (if necessary), then it would be easier to solve insect problems. If one staff can work on that particular problem, time, energy and money can be saved. Along with that, entomologist would work in a preventative way. As example if that entomologist finds bed bugs in an apartment, he/she will start preventing the infestation in other adjoining apartments with different strategies. Along with this, he/she can monitor insect pests outside and inside the building and develop a scientific project to control and prevent them.

APPENDIX

A. Approval Letter from Assistant Vice President of LSU Residential Life

Dear Department Chair,

Department of Residential Life

Date: 11/13/2015

I am Namoona Acharya, a graduate student of Department of Entomology. I have worked as a graduate assistant in Department of Residential Life since October 2014 to June 2015. During my working period in this Department, I went through most of the insect pest problems. I went through all the insect pest related reports in Maximo Order as well. At the meantime, I planned to study the effects of insect pests among the students.

For my MS thesis, I choose 2 ways of information collection. One from survey and another from Maximo reports. For this I need to send the survey questionnaire so that I can collect at least 200 data set.

This survey is important for Department of Residential Life too. After analysis of data, many information regarding common insects, problematic insects, students' knowledge about insect transportation, their view in chemical treatment and so on will originate. With this reports, new technology for insect pest prevention and control strategy can be establish in coming years. Department of Entomology will be also benefited since it will get connected to other departments. Students from this department will get more area for research and study too.

From Maximo Order, the data analysis will help to figure out the important insect pests, common insect pests, month and year with highest infestation, apartments with highest infestation, multiple insect pest infestation in same apartment and multiple reports for same insect pest from same apartment. This analysis will work as the basis of many further research in this field.

So, I have a humble request with you for the approval of survey as well as analysis of Maximo Order data related to insect pests in Residential Life.

After your approval, I will start for survey with current students till December 2015.

11.13.15

Thank you so much.

Sincerely,

Namoona Acharya

approved
Steven Dekalb
Assist Vice Presider
Residential Life & Hous

B. Cover Letter for Students

Greeting Tigers!

My name is Namoona Acharya. I am a Master's Student in the Department of Entomology at LSU. The Department of Entomology and the Department of Residential Life are working together to help identify and control insect problems as they may arise in Residential Life facilities. As part of my thesis research, I am attempting to determine what kind of insects you encounter within your residential space. I am requesting that you fill out a quick survey to better understand your experience as an upperclassmen living on campus. Your participation is greatly appreciated, as it will not only fulfill my thesis requirements, but also provide valuable feedback to the Department of Residential Life. The survey has 10 questions and should only take one to two minutes of your time. You can access the survey at:

http://www.studentvoice.com/p/?uuid=8a1c7d6cf73445f9b895a85e7f653b1b&p=1.

Thank you for your time and participation in my research.

Sincerely,

Namoona Acharya

C. **Survey Questionnaire**

1. Have you ever found any of the insects at your residential hall/apartment? **Check all that apply.**

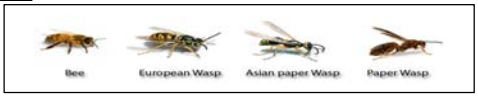
------Crazy ants which are found inside building, small in size, run like crazy when disturbed and found near sweet food.  http://www.license-to-kill.com/ant-control-san-diego.php

------Red imported fire ants which are found outside most of the time and make soil mounds.  http://www.desertmuseum.org/programs/images/RIFA_mound_freshtilledlook.jpg

------Carpenter ants which are found usually outside, black in color and the biggest ants in Louisiana----------  http://www.flyfishusa.com/flies/ants.ht

------Unidentified ants

------Bed bugs  http://www.abchomeandcommercial.com/houston/pest-control/bed-bugs

------Bees and Wasps 

http://www.tams.act.gov.au/parks-recreation/plants_and_animals/Biosecurity/vertebrate_pest_management/pest_animals/insect/wasps

------Beetles  http://blocs.xtec.cat/hortetdelturonet/

------Cockroaches----------  http://en.wikipedia.org/wiki/American_cockroach

------Drain flies  http://www.familyhandyman.com/pest-control/do-your-own-pest-control/view-all

------ Fleas  http://www.planetnatural.com/pest-problem-solver/household-pests/flea-control/

------Gnats----------  http://en.wikipedia.org/wiki/Gnat

------House flies  http://entnemdept.ufl.edu/creatures/urban/flies/house_fly.HTM

------Mosquitoes  http://npic.orst.edu/pest/mosquito/

------Silverfish----------  http://www.owlpestcontrol.ie/pest-guide/crawling-insects/silverfish

------Termites  http://www.progressivepestcontrollasvegas.com/termite_inspection.html

------Others (specify) ----------

Ants

2. Where do you most often encounter ants at Residential Life?

------Outside the building

------Inside the building

------Both a and b

3. Have you been stung by red imported fire ants?

------Yes

------Yes once

------Yes multiple times

------No

Bed Bugs

4. To what extent are the presence of beg bugs in LSU Residential Life a problem?

-----A great deal

------ Considerably

------ Moderately

------ Slightly

------ Not at all

5. How aware are you of a bed bug infestation in your apartment or residential hall room?

-----Extremely aware

----- Very aware

-----Moderately aware

----- Slightly aware

----- Not at all aware

6. Which of the following methods of bed bug transportation are you aware? (Check all that apply)

-----I am unware of a bed bug transportation.

------Staying in infested hotel and carrying a bed bug in clothes/bags.

------Buying used mattress and furniture.

-------Having guests stay overnight who may have come from an infested location.

------Visiting a friend who may have an infestation.

7. Are you applying any preventative strategy for bed bugs in your apartment at present?

   If yes, what strategy are you applying in your apartment? Please be specific.

   ------No

   ------Yes

   ……

   ……

   ……

Cockroaches

8. Which of the following measures of cockroach control have you tried in your

   room/apartment? (Check all that apply)

   ------ I purchased cockroach spray.

   ------I made sure to keep food in sealed containers.

   ------ I took out my trash regularly.

   ------Other, please explain

   ------None of the above

……

……

……

……

Treatments

9. The department of Residential Life contracts quarterly sprays of all Residential hall rooms, apartments, and building exteriors. Do you feel these sprays work?

------Yes, it kills current and prevents future insect infestation.

------Yes, but only kills current infestations.

------Yes, but only prevents future infestation

------No, it does not work.

Feedback

10. How satisfied are you with Residential Life with respect to control of insects?

------Very Satisfied

------Moderately satisfied

------Neither satisfied nor dissatisfied

------Moderately satisfied

------Very dissatisfied

11. Do you have any additional recommendations?

------Yes (please explain),

------No

……

……

……

…….

VITA

Namoona Acharya was born and raised in Dang, Nepal. She pursue her bachelor degree in agriculture with a major in plant pathology in 2010 from the Institute of Agriculture and Animal Sciences, Tribhuvan University, Nepal. She worked as a field officer, documentation officer and project officer for different agriculture projects. In the fall of 2014, she started her master's degree in entomology at Louisiana State University (LSU), Baton Rouge, Louisiana under the supervision of Dr. Gregg Henderson. She worked as an Entomology Graduate Student in Louisiana State University Residential Life for a year under the supervision of Ms. Celena Trahan. Her research was based on the insect reports in Residential Life and the topic was Analysis of Insect Reports in LSU Residential Life.