



## **Pest Control Practices for the German Cockroach (Blattodea: Blattellidae): A Survey of Rural Residents in North Carolina**

Authors: Dingha, Beatrice, Jackai, Louis, Monteverdi, Rachel H., and Ibrahim, Jimo

Source: Florida Entomologist, 96(3) : 1009-1015

Published By: Florida Entomological Society

URL: <https://doi.org/10.1653/024.096.0339>

---

BioOne Complete (complete.BioOne.org) is a full-text database of 200 subscribed and open-access titles in the biological, ecological, and environmental sciences published by nonprofit societies, associations, museums, institutions, and presses.

Your use of this PDF, the BioOne Complete website, and all posted and associated content indicates your acceptance of BioOne's Terms of Use, available at [www.bioone.org/terms-of-use](http://www.bioone.org/terms-of-use).

Usage of BioOne Complete content is strictly limited to personal, educational, and non - commercial use. Commercial inquiries or rights and permissions requests should be directed to the individual publisher as copyright holder.

---

BioOne sees sustainable scholarly publishing as an inherently collaborative enterprise connecting authors, nonprofit publishers, academic institutions, research libraries, and research funders in the common goal of maximizing access to critical research.

## PEST CONTROL PRACTICES FOR THE GERMAN COCKROACH (BLATTODEA: BLATTELLIDAE): A SURVEY OF RURAL RESIDENTS IN NORTH CAROLINA

BEATRICE DINGHA<sup>1,\*</sup>, LOUIS JACKAI<sup>2</sup>, RACHEL H. MONTEVERDI<sup>3</sup> AND JIMO IBRAHIM<sup>4</sup>

<sup>1</sup>Department of Family and Consumer Sciences, North Carolina A&T State University, Greensboro, NC 27411, USA

<sup>2</sup>Department of Natural Resource and Environmental Design, North Carolina A&T State University, Greensboro, NC 27411, USA

<sup>3</sup>North Carolina Cooperative Extension, North Carolina State University, Louisburg, NC, USA

<sup>4</sup>Coperative Extension, North Carolina A&T State University, Greensboro, NC 27411, USA

\*Corresponding author; E-mail: bndingha@ncat.edu

### ABSTRACT

The German cockroach, *Blattella germanica* (L.) (Blattodea: Blattellidae), is a serious pest in rural and urban housing. The aim of this study was to ascertain the pest control practice used by home residents to control the German cockroach and to assess the level of residents' awareness and knowledge of integrated pest management. A face-to-face survey of 100 participants was carried out in 3 rural counties in NC. Only individuals who acknowledged that the German cockroach was a pest in their homes were selected for the survey. Of these participants only 23% indicated that the German cockroach was a major indoor pest, while 48% indicated that mosquitoes and 50% indicated that ants were major pests in their homes. The majority (71%) of survey respondents reported that to cope with domestic pest problems, they or a member of their household applied pesticides, and 16% worked with a contractor to do so. Pesticides were the main control measure used in homes and most (65%) respondents indicated these were applied routinely irrespective of need. The majority (93%) of residents surveyed were unfamiliar with the strategy of integrated pest management (IPM) and associated measures of control and prevention. Based on our findings, we believe that organizing an educational IPM program would increase awareness among residents of the economic, human health and environmental costs and benefits of each control measure and make sustainable IPM implementation more likely to succeed.

Key Words: *Blattella germanica*, residential IPM, integrated pest management

### RESUMEN

La cucaracha alemana, *Blattella germanica* (L.) (Blattodea: Blattellidae), es una plaga seria en las viviendas rurales y urbanas. El objetivo de este estudio fue determinar las estrategias de control de plagas utilizadas por los residentes de hogares para controlar la cucaracha alemana y el nivel de conciencia y conocimiento de los residentes sobre el manejo integrado de las plagas. Se realizó una encuesta hecha cara a cara con 100 participantes en 3 condados rurales de Carolina del Norte. Veintitrés por ciento de los encuestados indicó que las cucarachas son plagas de mayor importancia dentro sus hogares, 48% indicó mosquitos y 50% las hormigas. La mayoría (71%) de los encuestados informaron que ellos o un miembro de su hogar aplicaron plaguicidas por sí mismos y el 16% utilizaron una combinación de un contratista y ellos mismos. En general, los pesticidas fueron la medida de control principal utilizada para los hogares y la mayoría (65%) de los encuestados indicaron que se aplicaron pesticidas rutinariamente independientemente de la necesidad. La mayoría (93%) de los residentes no fueron familiarizados con las estrategias de manejo integrado de plagas. En base a nuestros resultados, creemos que la organización de un programa de MIP educativo aumentará la conciencia entre los residentes e incrementaría la implementación sostenible de un programa MIP tenga éxito.

Palabras Clave: *Blattella germanica*, MIP residencial, manejo integrado de plagas

The German cockroach, *Blattella germanica* (L.) (Blattodea: Blattellidae), is a common indoor pest in residential housing. Their filthy habits and indiscriminate movement between filth and

food make them very efficient vectors of human pathogens (Alcamo & Frishman 1980; Brenner et al. 1987). Beside causing disgust and stress their feces and shed body parts are sources of allergens

that trigger asthmatic symptoms in sensitized individuals and may increase the risk of allergic sensitization (Rosenstreich et al. 1997; Huss et al. 2001; Leaderer et al. 2002; Chew et al. 2005). These allergens are proteins found in cockroach feces, saliva, eggs and shed cuticles, which become incorporated into household dust and surfaces (Potera 1997).

In the United States residential pesticide usage is widespread; 85% of households store at least 1 pesticide in their home, and approximately 10% of the conventional pesticides used annually in the US are applied in and around the home (Adgate et al. 2000; Kiely et al. 2004). The traditional approach to the control of cockroaches and other residential pests has been regular spraying of pesticides by professional pest control companies and in certain cases by residents themselves (Koehler et al. 1995). These chemicals are often applied routinely whether needed or not, sometimes driven by entomophobia rather than a true need for pesticide application. This practice has been largely unsuccessful and has led to increased frequency of pesticide application resulting in the use of large quantities of insecticide to increase cockroach kill (Benson & Zungoli 1997). Such high frequency and routine applications are associated with high levels of pesticide residues and this often leads to pesticide resistance by the insect (Robinson & Zungoli 1985). More importantly, the practice creates health risks particularly among children from exposure through inhalation, ingestion, or absorption through the skin from both initial applications and lingering pesticide residues on surfaces.

Integrated Pest Management (IPM) relies on the use of control tactics that are ecologically sound and uses pesticides only when other tactics provide inadequate control. Traditionally, control of cockroaches relies solely on pesticide application. In IPM overall pesticide usage is reduced and insecticides with low toxicity are recommended for use as needed rather than on a calendar regimen. Also the use of non-spray formulations such as baits and gels in confined areas further reduces the likelihood of human exposure. The underlying concept in IPM practice for cockroach is that pest populations can be controlled by removing their basic survival elements such as moisture, food, and air and by sealing cracks and crevices to prevent access to homes, and educational program through which a reduction in the pest status can be achieved and maintained. An understanding of the attitudes and knowledge of residential occupants towards the insect pests in their homes should be the basic starting point for implementing an effective pest management program for household pests (Woods et al. 1981). Survey reports on residents' attitudes, knowledge and pesticide usage for cockroach control have focused on urban communities (Woods et al. 1981; Bennett et al. 1983; Byrne et al. 1984; Levenson & Frankie 1983; Hahn & Ascerno 1991). It is unclear whether

their findings can be extrapolated to all rural areas of the country (Byrne et al. 1984). Moreover, several studies conducted in urban communities have reported significant reduction in cockroach populations and cockroach allergen levels after implementing an IPM intervention (Wood et al. 2001; Arbes et al. 2003; Brenner et al. 2003; Arbes et al. 2004; Wang & Bennett 2006; Server et al. 2007).

Despite the success of these investigations, little attention has been paid to families in rural areas, particularly those adjacent to farm lands where the potential for exposure to pesticide is greater than it is for the general population (Shalat et al. 2002). Of even greater concern is the likelihood that non-approved farm chemicals will be used for household pest control by farm families or other rural residents. Given this backdrop, the main objective of this study was to determine the pest control strategies used by residents of rural counties in North Carolina for the control of German cockroach and residents' awareness and knowledge of integrated pest management. Information obtained from the survey will help determine the direction and approach of an IPM program suitable for rural homes in NC and beyond.

#### MATERIALS AND METHODS

The survey was conducted in 3 rural counties in Central North Carolina-Franklin, Warren and Vance. Data were collected using a modified version of the questionnaires developed by Toxic Free NC (2009). The Institutional Review Board (IRB) of North Carolina Agricultural and Technical State University (NCA & TSU) approved the study, and we obtained informed consent from all participants. Participants attending the 2010 and 2011 Strawberry Festival held in Franklin County in NC were shown electronic and hardcopy photos of the German cockroach, and an insect collection, which included the German cockroach. We inquired from participants if they had seen the cockroach in their homes and those who responded affirmatively were further asked if they would be interested in participating in a German cockroach survey. Questionnaires were administered face to face. Data collected included information on demographics (age, sex and educational level), number of children living with respondents and the number of children/adults who have been diagnosed by physician with asthma/or respiratory allergies. Each participant was asked if they considered the German cockroach to be a major pest in their home, but if not, which other insects (ants, flies and mosquitoes) were considered to be a major pest problems in their home. For questions relating to pest management approaches and pesticides used against the German cockroach, respondents were asked if any pest control measures for German cockroach were used or applied in their homes by themselves, or by a member of the household, by a contractor or a com-

bination of contractor and self, or none. If pest control measures were used, respondents were asked which of the following 8 specific types of methods were employed: sticky traps, baits, spray-aerosols, pump sprayer with diluted spray concentrates, fogs or bombs, dusts or powders, building maintenance and cleaning/sanitation. Respondents were asked specifically how frequently the following approaches were applied in their homes: applying pesticides, deploying insect baits, deploying traps, vacuuming, reducing food/water sources, habitat modification, monitoring pest population densities, sanitation and education of household members. The questionnaire also collected information on how and by whom pest management decisions were made, and if persons who applied pesticides were licensed. If application was done by a contractor or by a contractor in combination with self, respondents were further asked whether the contractor inquired about the presence of German cockroaches in the home, inspected the home before applying pesticides, provided the names of the chemicals that were applied, provided a pesticide label, posted warning signs indoors, left a written receipt of everything done during the visit, or provided other control options for the German cockroach. When pesticides were applied respondents were asked if children's toys were either removed or covered before application, if the home was treated only when children and household members were absent, and if the area was cleaned or decontaminated following treatment. Data was also obtained on the effectiveness of respondent's pest control program, where the pesticides were stored, and their source of information about pest control. Additionally, the questionnaire asked respondents if they kept a written policy or maintained records of pesticides used in their home. They were also asked if they were aware of integrated pest management (IPM), and whether they would be willing to participate in an IPM program for German cockroach control. A total of 100 questionnaires were given out and a \$10 Wal-Mart gift card was provided as incentive to each participant. Data were coded and analyzed by using SPSS version 20 (SPSS Inc., Chicago, Illinois, USA).

## RESULTS

Of the 100 respondents 66 were from Franklin, 18 from Warren and 16 from Vance County. Thirty four percent of respondents were between 20 to 39 years, 35% between 40 to 59 years and 31% were over 60 years. Most respondents (58%) had a college education and 42% had high school level education. Eighty-one percent of respondents were female and 47% had one or more children living with them (total of 97 children). Thirty five percent of respondents indicated that either a child or an adult in the family had been diagnosed with asthma and/or respiratory allergies by a physician. A clinical follow-up was not part of the survey. Among those

responding to questions on the prevalence of major indoor pests, 50% said ants and 48% indicated mosquitoes were the major indoor pests followed by flies (37%) and cockroaches (23%). Most survey respondents (71%) indicated cockroach control was done by them or a member of their household, with only a small number using a combination of contractor and self (16%), contractor only (7%) and no pesticide application (6%) in their homes.

In the presence of German cockroach, pesticides used in the form of aerosol sprays (61%) was by far the most commonly practiced pest management strategy by the respondents or a member of their household; building maintenance such as sealing cracks and crevices was the least approach practiced (Table 1). Of the 23 respondents who used contractor services alone or in combination with self, the use of pump sprayer (41%) with diluted pesticide concentrate was the most commonly used method for cockroach control, and building maintenance or improvement was the least used (Table 1). When pesticides were applied in homes, only a handful (1%) of residents who used a contractor alone or in combination with self reported that the contractor posted warning signs indoors. In some cases (7%) contractors left a receipt indicating everything they had done; 7% reported the home was thoroughly inspected for pests, and only 6% indicated contractors provided other pest control options and told them the names of the chemicals that had been applied. When asked if the contractor provided a copy of the pesticide label, only 6% indicated in the affirmative. Only 8% reported that contractors asked if pests had been seen in the residence prior to applying insecticides. Few respondents (6%) maintained written records of pesticides applied in their homes and most (88%) did not have a policy for pesticide use. More than half of the respondents stored pesticides in their homes, and 61% believed their current practices were ineffective compared to 34% who thought they were very effective.

The frequencies of use of the various German cockroach control strategies varied widely. With regard to information aimed at preventing German cockroach infestations very few respondents (21%) indicated they often monitored infestation levels, 15% made home modifications to prevent pests from entering their home, and only 14% often educated family members about preventive measures to avoid pest infestations (Fig. 1). Majority of respondents (61%) indicated they never educated family members about preventive measures, 54% never monitored their homes for cockroach infestations, while 59% never made any modifications to their homes to prevent pest entry (Fig. 1). For strategies adopted in response to the presence of German cockroaches in homes, 51% of respondents sprayed quite often only 16% used insect baits and traps and 22% often vacuumed their homes to get rid of pests (Fig. 1).

TABLE 1. PROPORTION OF RESPONDENTS IN THREE RURAL COUNTIES IN NORTH CAROLINA USING VARIOUS PEST MANAGEMENT PRACTICES FOR THE CONTROL OF THE GERMAN COCKROACH.

Management practices used for German cockroach control	Self or member of household (%)	Self and contractor (%)
Cleaning/sanitation	35	3
Building maintenance	11	1
Sticky traps	26	2
Baiting	20	3
Spray-aerosol	61	5
Pump Sprayer with concentrated spray	20	41
Fog or bomb	12	3
Dust or powder	24	3

In making decisions regarding when to apply a pesticide, majority of respondents (81%) indicated that these decisions were made by the head of the household, while in 12% of the cases the contractor made the decision. The same people who decided when to apply pesticides were also responsible for applying the pesticides. Among those who applied pesticides, only 18% were licensed. It has to be assumed that licenses were for commercial applications, because no license is required for over the counter pesticides applications in the home. Twenty three percent of survey respondents indicated that pesticides were applied whenever they saw a pest while majority (65%) applied pesticides on a routine basis, either daily (6%), weekly (14%), monthly (15%) and yearly (30%) irrespective of the presence of pests. When pesticides were used 24% reported that they treated their homes only when children or others in the home were away, while 76% indicated they applied pesticides in the presence of household members including children. As to whether children's toys were covered or removed from space being treated 85% of the respondents

said they did, but only 29% cleaned or decontaminated the area treated after pesticides had been applied.

Regarding knowledge of IPM, and preferred educational sources, respondents received information about pest management from multiple sources. Friends and colleagues (38%) comprised the most common source of cockroach management information, while 30% were informed via the internet, 19% by pest control companies and 16% by the Cooperative Extension Service. An overwhelming majority of the respondents (93%) indicated they were not familiar with IPM as a strategy to manage German cockroaches. Despite the lack of awareness with IPM, only 38% of respondents were willing to participate in an IPM program on cockroaches.

DISCUSSION

The presence of cockroaches and other insects in residential homes is a potential source of health related problems because they transmit diseases, contaminate food and surrounding ar-

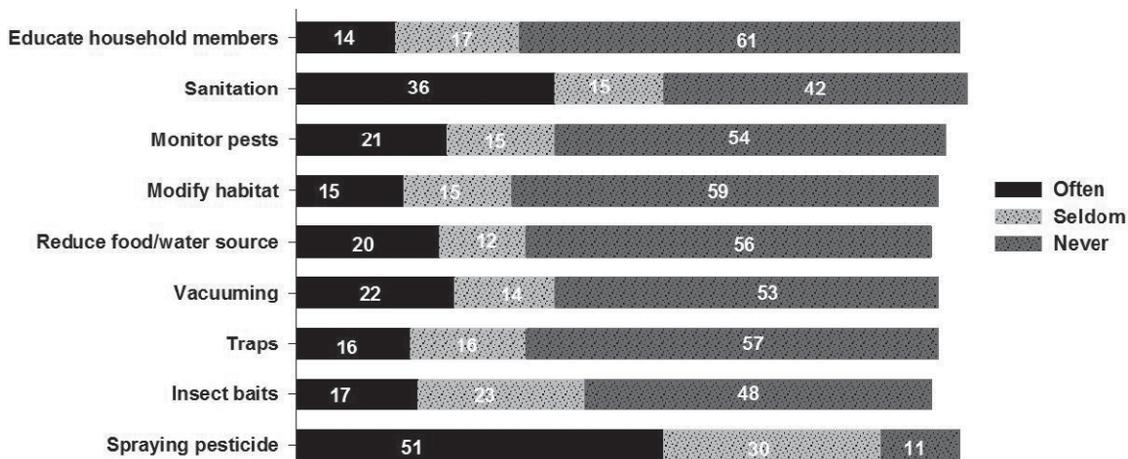


Fig. 1. Frequency (%) of use of various pest management practices by residents in 3 rural counties in NC for control of the German cockroach.

eas with pathogenic micro-organisms, and are a source of allergens, which may trigger asthma; the bites of mosquitoes and stings of ants, bees and wasps are especially concerning to sensitive individuals. The German cockroach is a widely distributed pest and the most common indoor species (Miller 1998). All survey respondents reported the presence of the German cockroach in their homes, however, in our study half of the respondents considered ants to be the major indoor pest and only 23% cited cockroaches to be a major concern. A similar trend was observed in North Central Indiana and Minnesota where less than 5% of respondents indicated cockroaches as the major pest and more than 30% specified ants (Bennett et al. 1983; Hahn & Ascerno 1991). The low numbers obtained for cockroaches could be partially attributed to the social stigma associated with the presence of cockroaches and hence, to reluctance of respondents to admit to them as a significant problem. Another reason could be that the German cockroach is considered an aesthetic pest, and many respondents may have a high tolerance of living in an infested home. An ongoing study will determine the actual levels of German cockroach infestation over time in participants' homes. Furthermore, given that German cockroaches are associated with dirty or fitly conditions most people do not want to be identified with their infestations and consequently, occasional cockroach infestations prompt the routine preventive use of pesticides.

The standard approach for pest control is to use pesticides (Koehler et al. 1995). Our study reveals an alarming proportion (94%) of respondents applied pesticides in some form (including dust, bait, aerosols, traps and fog) to control cockroaches. This could be another reason for the decreased response (23%) obtained from respondents citing cockroach as a major indoor pest. Most of the pest management strategies were directed at killing the pest with pesticides with little attention paid to preventive measures such as sanitation and building maintenance that would avoid pest entrance into homes. The public concerns about health and environmental risk associated with pesticides usage is increasing. Therefore, people who make pest control decisions should be aware of the pest control management options available. Our study reveals that head of households and contracted pest management personnel were mostly responsible for decisions pertaining to when to apply pesticides and the time of application. Pesticide application was carried out mainly by residents or a member of their household in approximately three-fourths of those surveyed in this study. Similar findings (78%) of respondents were reported for the study on urban residents in Indiana by Bennett et al. (1983).

The present study also raises some concerns in that residents did not appear to rely on their Extension Service Agents for information on pest control. This brings up an interesting question as to whether

extension services pay enough attention to non-crop pest management issues. An even greater uneasiness involves pesticide application on a pre-determined or calendar schedule rather than application based on need. Given this, it is therefore no surprise that a staggering 93% of the respondents were unfamiliar with IPM. This mirrors other reports, for example the study in San Diego County, California, in which 95% of single family residents surveyed in 2006 had not heard the term IPM (Wilens et al. 2011). However, results from surveys examining consumer and limited resource farmers' awareness of IPM were considerably different. Consumer response as regards IPM knowledge ranged from 19% in Eastern Massachusetts (Anderson et al. 1996), 27% in New York (Burgess et al. 1989) and 31% in New Jersey (Govindasamy et al. 1998) of respondents who were unaware of IPM. In Alabama, 31% of limited resource farmers were unfamiliar with IPM (Tackie et al. 2009). Despite the statistics from our survey, only 38% of respondents were willing to participate in an IPM program or become educated on IPM control strategies.

Our study reveals that households and contracted pest management personnel in rural North Carolina may not be adequately informed, or are in complete disregard of pesticide application regulations especially in regard to safe use practices and the tenets IPM. Residents should not wait to get an infestation and then apply pesticides as the first line of attack as is often the case. They need to be educated on prevention practices that would minimize the occurrence of an infestation and reduce the need for pesticide application. It is clear from this survey that many chemicals are used in homes without taking the necessary precautions to ensure safety of home occupants, especially children. From the data obtained in this survey, a high percentage of respondents did not protect children's toys or home surfaces after treatment. Many pesticides are persistent and should not be used in the presence of children (Owens & Feldman 2000; Wilson et al. 2001; Lewis et al. 1994), or around areas accessible to children. Some of these pesticides leave residues above the recommended tolerance level on toys and hard surfaces (Gurunathan et al. 1998; Wilson et al. 2001). This is of great concern because several factors increase children's exposure and vulnerability more than those of adults. For instance children spend more time on the floor, where residues can easily be transferred to their skin and be absorbed; in addition they frequently touch things and surfaces and place their hands and objects (toys) in their mouth leading to ingestion of pesticides (Cohen et al. 2000; Lo et al. 2005). Children are less developed neurologically, immunologically and physiologically and are therefore more vulnerable to the adverse effects of chemicals (Eskenazi et al. 2007, 2008). Even though cockroach infestation can lead to health problems such as asthma, the chemicals used to eliminate them may pose even

greater or additional health risks. Exposure to residential pesticides or inappropriate use of pesticides in homes has been associated with many health effects, which include immediate effects such as headache and nausea, (Titlic et al. 2008), skin and eye irritations (Graham et al. 2005), and delayed effects like immune toxicity (Banerjee 1999), intrauterine growth retardation (Levario-Carrillo et al. 2004), birth defects (Shaw et al. 1999), nervous system disorders (Eskenazi et al. 2008; Rosas & Eskenazi 2008), cancers (Davis et al. 1993). Unless homeowners are made aware of these dangers, "the pest-medical condition continuum" will never be broken.

Rural residents are faced with additional challenges as many live close to farmlands and are farm families who work with various farm chemicals. It is likely that when faced with high cockroach infestations (as is the case in some of the sites being studied in a follow-up project) there is great temptation to use farm chemicals in the home environment. This survey results indicate the need to expand the role of Extension Service Agents to include residential IPM issues and to stress the importance of prevention of pest infestations and the adoption of pest control tactics that are environmental and health friendly. One way to do this would be to target both home residents and individuals responsible for pest management in homes for IPM education. The program would consist of demonstrations through workshops by extension personnel trained in this discipline and dissemination of educational materials illustrating an array of tactics such as sanitation, pest monitoring and need-based pesticide application and others. We recommend the use of IPM practice because it has been shown to reduce cockroach infestation, pesticide use (Robinson & Zungoli 1985; Green & Breicsh 2002; Brenner et al. 2003; Wang & Bennett 2006), and reduction in allergen and human exposure (Wood et al. 2001; Arbes et al. 2003; Arbes et al. 2004; McConnell et al. 2005; Server et al. 2007; Nalyanya et al. 2009).

#### CONFLICT OF INTEREST STATEMENT

The authors have no conflicts of interest concerning the work reported in this paper.

#### ACKNOWLEDGMENTS

Funding for this project was granted by the National Institute of Food and Agriculture of the US Department of Agriculture Evans-Allen Project # NCX-257-5-11-170-1 in the Agricultural Research Program North Carolina Agricultural and Technical State University. The authors would like to thank the undergraduate students, Carmen Young and Roshenea Bristow who helped in data entry.

#### REFERENCES CITED

ADGATE, J. L., KUKOWSKI, A., STROEBEL, C., SHUBAT, P. J., MORRELL, S., AND QUACKENBOSS, J. J. 2000. Pesti-

- cide storage and use patterns in Minnesota households with children. *J. Expo. Anal. Environ. Epidemiol.* 10: 159-167.
- ALCAMO, I. E., AND FRISHMAN, A. M. 1980. The microbial flora of field collected cockroaches and other arthropods. *J. Environ. Health* 42: 263-266.
- ANDERSON, M. D., HOLLINGSWORTH, C. S., VAN ZEE, V., COLI, W. M., AND RHODES, M. 1996. Consumer response to Integrated Pest Management and certification. *Agr. Ecosys. Environ.* 60: 97-106.
- ARBES, S. J. JR., SEVER, M., ARCHER, J., LONG, E. H., GORE, J. C., SCHAL, C., AND ET AL. 2003. Abatement of cockroach allergen (Bla g 1 and Bla g 2) in low-income, urban housing: a randomized controlled trial. *J. Allergy Clin. Immunol.* 112: 339-345.
- ARBES, S. J. JR., SEVER, M., MEHTA, J., GORE, J. C., SCHAL, C., VAUGHN, B., AND ET AL. 2004. Abatement of cockroach allergens (Bla g 1 and Bla g 2) in low-income, urban housing: month 12 continuation results. *J. Allergy Clin. Immunol.* 113: 109-114.
- BANERJEE, B. D. 1999. The influence of various factors on immune toxicity assessment of pesticide chemicals. *Toxicol. Letters* 107: 21-31.
- BENNETT, G. W., RUNSTROM, E. S., AND WIELAND, J. A. 1983. Pesticide use in homes. *Bull. Entomol. Soc. Am.* 29: 31-38.
- BENSON, E. P., AND ZUNGOLI, P. A., 1997. Cockroaches, pp. 123-202 *In* A. Mallis [ed.], *Handbook of pest control, Mallis Handbook and Technical Training Co., Cleveland, OH, USA.*
- BRENNER, B. L., MARKOWITZ, S., RIVERA, M., ROMERO, H., WEEKS, M., SANCHEZ, E., AND ET AL. 2003. Integrated pest management in an urban community: a successful partnership for prevention. *Environ. Health Perspect.* 111: 1649-1653.
- BRENNER, R. J., KOEHLER, P. G., AND PATTERSON, R. S., 1987. Health implications of cockroach infestations. *Infect. Med.* 4(8): 349-358.
- BURGESS, R., KOVACH, J., PETZOLDT, C., SHELTON, A., AND TETTE, J. 1989. Results of IPM marketing survey: New York State IPM Program, New York State Department of Agriculture and Markets, New York State Agricultural Experiment Station, Geneva, NY.
- BYRNE, D.N., CARPENTER, E. H., THOMS, E. M., AND COTTY, S. T. 1984. Public attitudes toward urban arthropods. *Bull. Entomol. Soc. Am.* 30: 40-44.
- CHEW, G. L., CORREA, J. C., AND PERZANOWSKI, M. S., 2005. Mouse and cockroach allergens in the dust and air in northeastern United States inner-city public schools. *Indoor Air* 15: 228-34.
- COHEN HUBAL, E. S., SHELTON, L. S., BURKE, M. J., ET AL. 2000. Children's exposure assessment: a review of factors influencing children's exposure, and the data available to characterize and assess that exposure. *Environ. Health Perspect.* 108: 475-486.
- DAVIS, J., BROWNSON, R., GARCIA, R., BENTZ, B., AND TURNER A. 1993. Family pesticide use and childhood brain cancer. *Arch. of Environ. Contam. Toxicol.* 24: 87-92.
- ESKENAZI, B. AND ROSAS L. G., ET AL. 2008. Cons Pesticide toxicity and the developing brain. *Basic Clin. Pharmacol. Toxicol.* 102: 228-236.
- GOVINDASAMY, R., ITALIA J., THATCH, D., AND ADELAJA, A. 1998. Consumer response to IPM-grown produce. *J. Extension* 36: 1-4.
- GRAHAM, J. P., CORELLA, B. V., AVITIA, D. R., AND GURIAN, P. 2005. The In-home environment and household health: a cross-sectional study of informal urban settle-

- ments in northern Mexico. *Int. J. Environ. Res. Public Health* 2: 394-402.
- GREENE, A., AND BREISCH, N. L. 2002. Measuring integrated pest management programs for public buildings. *J. Econ. Entomol.* 95: 1-13.
- GURUNATHAN, S., ROBSON, M., FREEMAN, N., BUCKLEY, B., ROY, A., MEYER, R., BUKOWSKI, J., AND LIOY, P. J. 1998. Accumulation of chlorpyrifos on residential surfaces and toys accessible to children. *Environ. Health Perspect.* 106: 9-16.
- HAHN, J. D., AND ASCERNO, M. E. 1991. Public attitudes towards urban arthropods in Minnesota. *American Entomol.* 179-183.
- HUSS, K., ADKINSON, N. F. JR., EGGLESTON, P. A., DAWSON, C., VAN NATTA, M. L., AND HAMILTON R. G. 2001. House dust mite and cockroach exposure are strong risk factors for positive allergy skin test responses in the Childhood Asthma Management Program. *J. Allergy Clin. Immunol.* 107: 48-54.
- KIELY, T., DONALDSON, D., AND GRUBE, A. 2004. Pesticide industry sales and usage: 2000 and 2001 market estimates. Washington, DC: U.S. Environmental Protection Agency, Office of Pesticide Programs. <http://www.epa.gov/oppbead1/pestsales/index.htm>.
- KOEHLER, P. G., PATTERSON, R. S., AND OWENS, J. M. 1995. Chemical systems approach to German cockroach control, pp. 287-323 *In* M. K. Rust, J. M. Owens and D. A. Reiersen [eds.], *Understanding and controlling the German cockroach*. Oxford University Press, New York.
- LEADERER, B. P., BELANGER, K., TRICHE, E., HOLFORD, T., GOLD, D. R., AND KIM, Y. 2002. Dust mite, cockroach, cat, and dog allergen concentrations in homes of asthmatic children in the northeastern United States: Impact of socioeconomic factors and population density. *Environ. Health Perspect.* 110: 419-425.
- LEVARIO-CARRILLO, M., AMATO, D., OSTROSKY-WEGMAN, P., GONZALEZ-HORTA, C., CORONA, Y., AND SANIN, L. H. 2004. Relation between pesticide exposure and intrauterine growth retardation *Chemosphere* 55: 1421-1427.
- LEVENSON, H., AND FRANKIE, G. W. 1983. A study of home owner attitudes and practice toward arthropod pests and pesticides in three U.S. metropolitan areas, pp. 67-106 *In* G. W. Frankie and C. S. Koehler [eds.], *Urban Entomology: Interdisciplinary Perspectives*. Praeger, New York.
- LEWIS, R. G., FORTMANN, R. C., AND CAMANN, D. E. 1994. Evaluation of methods for monitoring the potential exposure of small children to pesticides in the residential environment. *Arch. Environ. Contam. Toxicol.* 26: 37-46.
- LO, B., AND O'CONNELL, M. 2005. National Research Council and Institute of Medicine: Ethical considerations for research on housing-related health hazards involving children: Washington, DC. The National Academy Press.
- MCCONNELL, R., MILAM, J., RICHARDSON, J., GALVAN, J., JONES, C., AND THORNE, P. S. 2005. Educational intervention to control cockroach allergen exposure in the homes of Hispanic children in Los Angeles: Results of the La Casa study. *Clin. Exper. Allergy* 35: 426-433.
- MILLER, D. 1998. IPM for Cockroaches in Schools. School Integrated Pest Management. <http://schoolipm.ifas.ufl.edu/tp4.htm> (March 1998).
- NALYANYA, G., GORE, J. C., LINKER, H. M., AND SCHAL, C. 2009. German cockroach allergen levels in North Carolina schools: comparison of Integrated Pest Management and conventional cockroach control. *J. Med. Entomol.* 46: 420-427.
- OWENS, K., AND FELDMAN, J. 2000. The Schooling of State Pesticide laws Beyond Pesticides/National Coalition against the Misuse of Pesticides. *Pesticides and You* 20: 1-24.
- POTERA, C., 1997. Working the bugs out of asthma. *Environ. Health Perspect.* 105(11): 1192-1195.
- ROBINSON, W. H., AND ZUNGOLI, P. A. 1985. Integrated control program for German cockroaches (Dictyoptera: Blattellidae) in multiple-unit dwellings. *J. Econ. Entomol.* 78: 595-598.
- ROSENSTREICH, D. L., EGGLESTON, P., KATTAN, M., BAKER, D., SLAVIN, R. G., AND GERGEN, P. 1997. The role of cockroach allergy and exposure to cockroach allergen in causing morbidity among inner city children with asthma. *The New England J. Med.* 336: 1356-1363.
- ROSAS, L. G., AND ESKENAZI, B. 2008. Pesticides and child neurodevelopment. *Current Opinion Pediatrics* 20: 191-197.
- SEVER, M. L., ARBES, S. J. JR., GORE, J. C., SANTANGELO, R. G., VAUGHN, B., MITCHELL, H., AND ET AL. 2007. Cockroach allergen reduction by cockroach control alone in low-income urban homes: a randomized control trial. *J. Allergy Clin. Immunol.* 120: 849-855.
- SHALAT, S. L., ROBSON, M. G., AND MOHR, S. N. 2002. Agricultural workers *In* L. Rosenstock, M. R. Cullen, C. D. Brodtkin and C. Redlich [eds.], *Textbook of Clinical Occupational and Environmental Medicine*. W B Saunders, Philadelphia PA.
- SHAW, G. M., WASSERMAN, C. R., O'MALLEY, C. R., NELSON, V., AND JACKSON, R. J. 1999. Maternal pesticide exposure from multiple sources and selected congenital anomalies. *Epidemiol.* 10: 60-66.
- TACKIE, N., JACKAI, L., ANKUMAH, R., DINGHA, B., SALIFU, A., AND OJUMU, O. 2009. Integrated pest management and protection practices by limited resource farmers. *J. Extension* 47(1).
- TITLI, M., JOSIPOVI-JELI, Z., AND PUNDA, A. 2008. Headache caused by pesticides-a review of the literature. *Acta Medica Croatica* 62: 233-236.
- TOXIC FREE NC. 2009. Avoiding big risks for small kids. Retrieved from <http://www.toxicfreenc.org/involved/actionalerts/bigrisksforsmallkids.htm>
- WANG, C., AND BENNETT, G. W. 2006. Comparative study of integrated pest management and baiting for German cockroach management in public housing. *J. Econ. Entomol.* 99: 879-885.
- WILEN, C. A., LAZANEO, V. F., AND PARKER, S. 2011. Does the general public relate to the term "Integrated Pest Management"? *J. Extension* 49: 1-8.
- WILSON, N. K., CHUANG, J. C., AND LYU, C. 2001. Levels of persistent organic pollutants in several child care centers. *J. Expo. Anal. Environ. Epidemiol.* 11: 449-458
- WOOD, F. E., ROBINSON, W. H., KRAFT, S. K., AND ZUNGOLI, P. A. 1981. Survey of attitudes and knowledge of public housing residents toward cockroaches. *Bull. Entomol. Soc. Am.* 27: 9-13.
- WOOD, R. A., EGGLESTON, P. A., RAND, C., NIXON, W. J., AND KANCHANARAKSA, S. 2001. Cockroach allergen abatement with extermination and sodium hypochlorite cleaning in inner-city homes. *Ann. Allergy Asthma Immunol.* 87: 60-4.