INTEGRATED PEST MANAGEMENT

IN FOOD WAREHOUSES

By

RAYMOND R. PLATT JR.

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Southwestern Oklahoma State University

Weatherford, Oklahoma

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Thesis Advisor

Thomas C. Collins

Dean of the Graduate College

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Chapter I

Literature Review

IPM

Integrated Pest Management (IPM) is defined as a systematic approach to commodity protection that emphasizes increased information for improved decision making in order to reduce purchased inputs and optimize social, economic, and environmental consequences (Rajotte, et al., 1987). A simpler definition would be an interdisciplinary approach that integrates all biotic and abiotic components within a system to help make sound management decisions (Cuperus and Krischik, 1995).

The concept of IPM emphasizes the integration of disciplines into a total management system, including cultural practices, sanitation, monitoring, and the judicious use of pesticides. Increasing information, including identification of the pest, knowledge of its biology and habits, and knowledge of infestation sites is very important. Presenting the information is often a team effort between pest control operators, supervisors, managers and owners.

Making better management decisions entails knowledge of strategies that optimize economic outcomes. Strategies could be as simple as removing infested product from a storage area before the insects spread to uninfested product to setting up a housekeeping/sanitation, inspection, and insecticide application schedule. Above all, pest management systems must be site specific. Many pest management programs call for a generic insecticide application for every insect problem, regardless of population. This approach must change in order to implement sound IPM systems. Reducing purchased inputs of insecticides, rodenticides, and other inputs can occur if a pest problem can be remedied by an alternate practice such as proper sanitation and housekeeping, thus reducing possible problems. Spraying an unclean area will kill the insects on the surface, but may have little to no effect on insects within the conditions or the problems that harbor the insects.

IPM implies that pests are "managed" and not eradicated. In the milling and food industry, pests must be managed at extremely low levels. The ultimate objective of a pest management program in food processing industries must be to consistently maintain these low populations. However, this is sometimes beyond the reach of even processors with excellent pest management programs (Mills and Pedersen, 1990). Because of the need to maintain low pest populations, warehouse managers often employ professional consultants such as pest control operators, university personnel, or state officials to conduct training and or handle pest management within a facility. Traditionally these consultants used management techniques such as scheduled pesticide applications and limited alternative recommendations. These consultants also face extreme competition from other consultants (Cuperus, personal communication).

The literature dealing with pest management practices in grocery stores is limited. However, there have been significant studies done in the grain storage and food processing industries, including but not limited to: Mills and Pedersen's *A Flour Sanitation Manual,* Oklahoma Cooperative Extension Service's *Current Management Practices and Impact of Pesticide Loss in the Hard Red Wheat Post Harvest System (E-930)*, and Oklahoma Cooperative Extension Service's *Stored Product Management (E-*

912). Therefore, much is known about post-harvest storage and processing pest management, yet when food products leave the processors and are transported to grocery stores for consumers, limited information is available.

Stored Product Pest Management

Several agencies are involved in the inspection of stored grain and food products. The Federal Grain Inspection Service (FGIS) is responsible for administering a national inspection and weighing program for grain, oilseeds, pulses, rice, and related commodities. The mission of the FGIS is to facilitate the marketing of these products by: 1) establishing descriptive standards and terms, 2) accurately and consistently certifying quality, 3) providing for uniform official inspection and weighing, 4) carrying out assigned regulatory and service responsibilities, and 5) providing the framework for commodity quality improvement incentives to both domestic and foreign buyers (Giler and Eustrom, 1995).

The Food and Drug Administration (FDA) has the authority given by the Federal Food, Drug, and Cosmetic Act to inspect grain, bulk commodities, and bagged products when introduced into and while in interstate commerce. The primary purpose of inspection is to determine the degree of health hazard, especially from chemical odors or evidence of insect, bird, or rodent contamination. The act is enforced by inspection of facilities that hold, distribute, and process commodities. It may also include microscopic examination and chemical residue analysis of the product and its containers to determine the products' fitness for human or animal consumption (Dowdy and Rahto, 1995).

The Animal and Plant Health Inspection Service (APHIS) is responsible for phytosanitary (phyto=plant, sanitary=health) certification and is performed under the authority of the Organic Act of 1944, as amended. A phytosanitary certificate is a document that provides essential information to the importing country's plant protection service. The certificate informs the country of destination that the agricultural commodity has been officially inspected and is considered to be free from quarantine pests and practically free from other injurious pests (Crawford, et al., 1995).

Where these agencies set and enforce the guidelines for grain safety, it is the responsibility of the owner or manager of the storage facility, be it on farm or commercial, to make sure that the conditions set forth in these guidelines for stored grain management are met.

Temperature

Grain temperature is the major management tool that regulates insects and mold. Temperatures below 65°F are unfavorable for insects and mold as are temperatures above 95°F. Insects are especially sensitive to high temperatures and temperature has been used as a disinfestation and management practice for centuries. Keeping the commodity at a sub-obtimal temperature for insects is important to reduce insect population development and minimize damage and cosmetic concerns (Cuperus, et al., 1995).

Trapping Systems

There are several trap types available as well as several types of attractants for pests. Traps have been shown to be excellent monitoring tools in stored grain. It is important to realize that there is not always one type of trap that is best to use in a pest monitoring program. Trap types should be matched to the environmental conditions in each particular situation. Some examples are: 1) dusty areas, 2) hot vs. cold areas, and 3) indoors or outdoors use (Mueller, 1995). There are several traps available with the two basic designs being pitfall or flight traps. Research on trapping has been developed and available for over 20 years, yet a limited number of operators presently use trapping systems (Kenkel, et al., 1993). Traps can be used to determine what insect pests are present, where they are located, and give some estimate of population density. The key to interpreting trap catch is to look for increases in insect numbers from one trapping period to the next (Mueller, 1995), which includes good record keeping and comparisons of previous trap catches.

Much research has been done on trap types and pheromones in the detection of stored product insect pests (Fleurat-Lessard, et al., 1994). Traps are an invaluable tool for monitoring insect pest populations and are especially important in determining when to use chemical control.

Sampling

It is important to distinguish between species of stored product pests since each insect species has different damage potential, biology, temperature preference, moisture requirement, and reproductive potential. Insect species create different types of damage and have different activity periods (Krischik and Burkholder, 1995). Accurate and reliable detection and monitoring of insects is an essential part of pest management systems (Fleurat-Lessard, et al., 1994). This can be accomplished by implementing a sampling program within the facility. A sampling program may be designed to determine species and numbers of insects infesting a commodity, or in accurately determining changes in insect numbers with an increase or decrease in product temperature or moisture.

Sampling is the process of taking various characteristics of the population, such as density or number of a species occupying a given area, dispersion or the arrangement of individuals in space, changes in birth and death rates, relative number of various insect stages, and changes in insect numbers over time (Subramanyam and Hagstrum, 1996).

Areas in which sampling should be concentrated can be enhanced by first conducting inspections. Inspections can be formal and/or informal. Informal inspections are made by a number of people in a facility on a continual basis. This can include employees at the start of their work shift who check their work area for situations that may lead to pest activity. Formal inspections are more rigorous and performed by personnel trained to observe and pinpoint problem areas. These are usually conducted on a regular (i.e. monthly) basis. Proper equipment is important to the success of an inspection. The inspector should be equipped with a good quality flashlight, equipment opening tools (screwdrivers, pliers, etc.) a spatula or thin bladed knife, sample containers, labels, etc. (Mills and Pedersen, 1990). Inspectors look for product damage, unsanitary conditions, structural defects which could aid an infestation, insect, bird, and rodent feces, unusual odors such as mold or decay, and numerous other signs which indicate potential or ongoing infestations.

Sanitation

Sanitation is essential to eliminating existing and potential pest attractants inside and outside a facility. Standards of cleanliness and cleaning schedules must be established, along with direct accountability for cleaning activity (Mills and Pedersen, 1990). The proper placement of stored items is essential for proper sanitation. This allows for proper cleaning and inspection. As a guide, at least 18 inches should be allowed between equipment or pallets and walls, ceilings, or other major obstructions. At least 4-6 inches should be provided beneath equipment or pallets (Mills and Pedersen, 1990). When restocking items such as flour or pet foods, time should be taken to clean spilled product from the shelves.

Pedersen, et al. (1994) recommends the following sanitation practices:

1) Regular maintenance of the area surrounding the facility.

2) Periodic cleaning of floors, ledges, walls, and the exterior and interior of equipment in order to remove accumulations of material that sustain pest growth and attract pests to the area.

3) Storage and maintenance of equipment such that it does not provide harborage for pests or complicate cleaning.

Pesticides

Pesticides are an important tool to reduce populations of insects that have escaped other management tools. Insects are susceptible to many different types of insecticides if applied to their habitats. It is especially important to apply insecticides in areas where insects are most likely to come in contact with the chemical (Subramanyam, et al., 1993).

Many residual products such as malathion, chlorpyrifos-methyl (Reldan®), pirimiphos-methyl (Actellic®), synergised pyrethrins (Tempo®), methoprene, *Bacillus thuringiensis* (Dipel®), and diatomaceous earth are currently labeled as residuals for stored products in the United States (Arthur and Pitts, 1995). It should be realized that residuals for grain and other stored products are designed to suppress populations and reduce migration, but they are not designed to control an infestation that exists at the time the grain or stored product is loaded into storage. Food processors are currently in the process of losing their number one product, dichlorvos, a pesticide favored because of low residual and fast knockdown of insects (Kenkel, et al., 1993).

Fumigants are pesticides that kill in the gaseous form. As toxic gases, fumigants penetrate into cracks and crevices, the commodity, and throughout the area to be treated (Leesch, et al., 1995). Only two fumigants remain for treating stored products as registered by the Environmental Protection Agency, Phosphine producing materials and methyl bromide. Two other fumigants, chlorpicrin and sulfuryl bromide (Vikane®) are used for structural fumigation but are not allowed as fumigants for food or animal feed (Leesch, et al., 1995). Methyl bromide is the product of choice in food processing because of speed of action and concerns regarding electrical currents.

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Chapter II

A Survey of Grocers in Oklahoma, Arkansas, and Texas

Introduction

Consumer Concerns

Consumer concerns regarding the contamination of food products, ground and surface water, and the environment by pesticide residues have increased over the past 20 years (Collins, et al., 1992). This, in addition to worker safety concerns that pesticides contain known carcinogenic compounds, the absence of efficient governmental control on production treatments such as fertilizer and pesticide applications, and scientific uncertainty of the long term effects of fertilizers and pesticides on the environment create consumer concerns (Collins, et al., 1992). Consumers generally expect the food they purchase to be safe, wholesome, and nutritious. However, as recent media events have illustrated, consumer confidence in the safety of the food supply is easily shaken (Norris, et al., 1991). Several studies have been conducted to determine consumer attitudes regarding pesticide residues on food products. National surveys in 1992 revealed that 82% of consumers in the U.S. were either concerned or very concerned about the safety of their food and in 1995, 64% of consumers were concerned or very concerned (Collins, et al., 1992; Fresh Trends, 1995). When given the treatment history of fresh produce, the primary factor influencing selection was the presence of pesticide residues which indicates a great concern regarding residual pesticides on food (OCES, 1991). Shoppers have indicated that they would be willing to pay slightly higher prices for produce which was free of pesticide residues (Norris, et al., 1991).

Pest Management Programs

When developing a grocery store pest management program, a detailed store assessment should be performed to identify pest problems and conditions which might contribute to pest population development. The assessment should include questioning of store employees about previous pest infestations. The store history may uncover seasonal pest problems that require attention in the overall IPM program (NPCA, 1994).

Historically, producers and elevator operators are often characterized with high implementation of IPM principles such as sanitation, stock rotation, utilization of pesticides, and inspection (Kenkel, et al., 1994). Regardless of whether insect damage and other losses occur during harvesting, storage, processing, or distribution, they impact the entire system and, ultimately, the consumer (Kenkel, et al., 1994). While food processors implement sound IPM programs, they have limited control on their products after they leave their processing facilities, yet product complaints are often forwarded to them. Generally the final point of contact between processors and consumers is the grocery store.

At the grocer level, key elements that should be integrated into IPM programs include inspection, sanitation, rapid stock movement, record keeping, improved packaging, building design, lighting, and temperature management (Pinkston, 1995; Mullen, 1995). Although much is known about the food processing industry, including pest management practices, prevalent insect species, and proper IPM practices, little is known about the problems and practices within grocery stores.

The National Pest Control Association guidelines indicate that grocery store service calls should be made at least twice per month for an effective IPM program. Steps include surveying the store to identify pest problems, creating a diagram of the facility to map out where control areas would be deemed highest priority, determining high risk areas, and maintaining a log book of pest activity in the store. These steps are necessary for inspection and service of the account so that previously reported high risk areas of high pest activity can be monitored effectively (NPCA, 1994).

The most problematic insects reported by grocers were cockroaches, flies, weevils, and ants, with no indications of any of the major stored grain and grain product insects such as the Indianmeal moth, *Plodia interpunctella* (Hubner), the confused flour beetle, *Tribolium confusum* (Jacquelin du Val), the red flour beetle, *Tribolium castaneum* (Herbst), the sawtoothed grain beetle, *Oryzaephilus surinamensis* (L.), or the merchant grain beetle, *Oryzaephilus mercator* (Fauvel) (Davis, 1986).

Objectives

The subject of servicing food-processing accounts has been widely discussed at meetings and in publications, but food processors are separate and distinct from food service facilities such as retail businesses and restaurants (Baumann, 1994). To make decisions regarding sound IPM, present IPM practices implemented by grocery stores and frequency of implementation must be quantified. Objectives of this research were to:

1. Document present grocery store stored product IPM practices in Oklahoma, Arkansas, and Texas.

2. Document perceptions of stored product pest occurrence and distribution within grocery stores.

3. Document the role of pest control operators in present pest management systems within grocery stores.

Materials and Methods

A list of grocery stores in Oklahoma, Arkansas, and Texas was purchased from the Grocery Manufacturers of America (Washington D.C.). A survey was developed and administered, from this list of 841 grocery stores, to 327 grocery store personnel, including 122 from Arkansas, 100 from Texas, and 105 from Oklahoma. Grocery stores were called in each state until 327 had completed the survey. The survey was conducted via telephone, consisted of 28 questions, and took approximately 15 minutes to complete. The survey was administered by three female employees that had been trained to administer the survey. Grocers were assured of anonymity. Data were analyzed using SYSTAT (SYSTAT Inc., 1992).

Results

When asked who handled their pest management program, 278 grocery stores used a pest control company, grocers in 48 stores did their own pest control and one grocer used no pest control. Of the ones using a pest control company, the average time between service calls was 30.62 days (S.D. = 32.97). However, the range was large and nearly 25% of the service calls occurred more than 45 days apart. This is much longer than recommended by the National Pest Control Association and is ample time for a generation of stored product insects to develop.

Factors that grocers considered when selecting a pest control program included effectiveness, safety requirements, application costs, chemical costs, and alternatives to pesticides. Effectiveness and safety requirements were the two most important factors and alternatives to pesticides were least important (Table 2.1). Grocers were more concerned with controlling the pest by the most rapid, economical and effective means

The majority of grocers (307) indicated that there were no insect pest problems in their stores, 13 indicated that there were insect problems in the store and 7 were unsure. This perception shows that store managers either did not understand what was occurring, or believed that the pest control operator was handling the insect problems in the store. When questioned about financial losses, 250 grocers claimed not to have lost money in the past year due to insect or rodent activity while 41 stated they had lost money. A total of 288 grocers claimed to have five or fewer complaints from customers about infested products, while one grocer claimed to have over 20 complaints in one year. When questioned about perceived consequences of not having a pest control program, the grocers indicated that a loss of product and customers were the greatest concern (Table 2.2). . The majority of grocers (297) indicated that they used visual observation to routinely monitor for insect pests and 287 used visual inspection to monitor for rodent pests. Trapping systems were rated very low, with only four grocers indicating they use insect traps. Monitoring is a cornerstone for an IPM program. Sampling need to occur regularly, with adequate sample numbers, and by a competent user to be effective.

Insecticides and sanitation were the two most widely used pest management practices, while temperature control and screens were the least used, although usage varied between states (Table 2.3). Oklahoma grocers need significant educational training as indicated by a low use of sanitation, stock rotation, and other IPM practices. Overall, insecticides, sanitation, and stock rotation were relied upon as management practices. Present pest management systems appear to be pesticide-based with limited integration of other components such as traps, exclusion practices, or temperature. For rodents, sanitation and quick stock rotation were more widely used, with exclusion screens and humane traps least used (Table 2.4). Again, significant variation occurred between states with Oklahoma having the lowest utilization of IPM practices.

The most troublesome areas for insects were reported as the back storage room and the trash areas, while the least troublesome areas were spices and canned goods (Table 2.5), although managers did not feel that any area was actually a problem area. Grocers reported that sources for insect infestations in the store were coming from the outside, the warehouse, and delivery trucks (Table 2.6). This is probably the reason why they rated back room storage and trash areas as key trouble spots for insects.

IPM Perceptions

After they received a definition of IPM, the majority of grocery stores (297) indicated they were not familiar with IPM while 18 claimed to have some familiarity with IPM. When asked if they would like to learn more about IPM, 53.8% of the grocers were interested, 34.3% were not interested, and 11.9% were unsure. Although this indicated grocers have a limited knowledge of IPM, it did show a willingness to learn more about IPM. When asked about ways to learn more about IPM, and given choices of literature, workshops, or other, all grocers who indicated they would like to learn more about IPM chose literature. Grocers were equally divided over whether or not they would pay more for a pest control program that used IPM (Yes-21.1%, No-27.8%), while a large group (51.1%) were unsure, probably since most grocers did not understand IPM.

Grocers were asked about their perceptions of customer concerns regarding pesticide residues. Approximately one fourth (25.4%) indicated that they felt customers were concerned, 54.1% indicated that customers were not concerned, and 20.5% indicated that they were unsure of customer concerns about the use of pesticides in the store. A majority of grocers in Arkansas and Texas indicated that they have some concerns about pesticides being potential contaminants of food products in the store (Table 2.7). This was surprising considering that grocers felt customers were not concerned about pesticide residues in the store. When grocers were asked if they thought customers would pay a premium for pesticide free products, 96 believed they would, 153 believed they would not, and 78 were unsure. The majority of grocery stores (214) did not have contracts with brokers, distributors or processors regarding pesticide use or IPM, yet many food processors do have these stipulations (Dunaif and Krysinski, 1992). Pesticides used in insect control was ranked least important whereas taste and appearance were most important when grocers were asked what they perceive customer concerns were for products or baked goods (Table 2.8). Cosmetics were also a central element of importance as shown by Collins, et al. (1992).

The majority of grocery store employees surveyed were either store managers, owners, or assistant managers (Table 2.9). Most of their information about pesticides and pesticide safety were received from pest control operators, media, and their main offices

(Table 2.10). The floor space of the stores ranged from 120-80,000 square feet with 17,391 square feet being the mean (S.D. = 18,719). The number of checkstands ranged from 1-60 with a mean of 4.7 (S.D. = 4.9). The number of employees ranged from 1-3,000 with a mean of 47.4 (S.D. = 195.5).

Conclusions and Discussion

When compared to surveys conducted with consumers, producers, and processors (Collins, et al., 1992; Kenkel, et al., 1993 and 1994) it appeared that grocers are not aware of customer concerns regarding pesticides. The survey results also showed a lack of knowledge about IPM programs compared to producers and processors as evidenced by such a low number of grocers having even heard about IPM. Almost half of the grocers expressed an interest in learning more about IPM. This, in conjunction with the large number of grocers who are undecided about IPM, leaves a very large number of these surveyed who may be more interested in IPM if proper educational and training materials were made available to them. With the majority of knowledge gained about pesticides and pesticide safety received from pest control firms and corporate offices, it would appear that an appropriate plan would be to target pest control operators and grocery store corporate offices when distributing IPM literature and training materials. Personal communication with several pest control firms showed a lack of knowledge about IPM in grocery store settings. The most common method of treatment in a store was to spray insecticides around the prepared food areas and checkstands and to leave the rest of the store alone. There appeared to be no monitoring of insect pests other than what the grocer indicated as problem areas. The grocers relied on the pest control firm to find and control the insects, yet the pest control firms were relying on the grocers to find the insects to control. Therefore, no one was actually monitoring the store or trying to find the insects or the areas of highest infestation.

There was a large difference between states. One theory was that there are more corporate owned grocery stores in Arkansas and Texas and more privately owned stores in Oklahoma. This is supported by Table 2.10, as only two Oklahoma grocers received information from corporate offices compared to 24 in Arkansas and 10 in Texas. This would provide an answer for the question of why Oklahoma grocers appear to know less about IPM or pest control practices since they do not have a corporation to provide them with any training in even basic IPM practices such as sanitation and stock rotation.

IPM should be a cooperative effort between the pest control professional and the store's management. If the store is unwilling to cooperate completely in addressing sanitation issues and any other contributing conditions, then more pesticide use may be necessary to correct or prevent pest infestations. The concept of IPM and the store's role in the program must be communicated to the store's management and its employees. Without their cooperation, the goals of IPM are easily undermined (NPCA, 1994).

Table 2.1, Factors Considered by Grocers When Selecting a Pest Control Program.*

Factors	Mean	S.D.
Effectiveness	1.197	0.773
Safety Requirements	1.296	0.841
Application Costs	2.565	1.578
Chemical Costs	2.705	1.655
Alternatives to Pesticides	3.051	1.551

* 1= Very Important, 5= Not Considered Important

Table 2.2, Perceived Consequences of No Pest Control Program.

Consequence	OK	AR	TX
Closed for health reasons	30%	80%	77%
Fined	19%	72%	73%
Fired Manager	11%	71%	73%
Loss of Product	70%	80%	85%
Decrease in Customers	58%	82%	85%

Table 2.3, Currently Used Pest Management Practices For Insects

Practice	OK	AR	TX
Sanitation	26%	92%	90%
Insecticides	68%	86%	88%
Traps	30%	50%	49%
Baits	23%	54%	48%
Temperature Control	14%	27%	17%
Dusts	10%	26%	26%
Screens	7%	29%	5%
Quick Stock Rotation	25%	82%	70%

Table 2.4, Currently Used Pest Management Practices For Rodents

Practice	OK	AR	TX
Sanitation	25%	86%	84%
Traps	34%	55%	49%
Baits	35%	59%	53%
Glue Boards	16%	40%	34%
Humane Traps	7%	2%	3%
Screens	5%	20%	4%
Quick Stock Rotation	21%	71%	67%

Table 2.5, Perceived Trouble Spots For Insects in Grocery Stores*

Area	Mean	S.D.
Deli	3.785	1.569
Canned Goods	4.889	0.515
Produce	3.867	1.375
Bakery	3.523	1.570
Dried Pet Food	3.408	1.606
Back Room (storage)	3.112	1.612
Trash Areas	3.273	1.718
Cereals	4.085	1.296
Flour, Sugar, Cake Mixes	3.507	1.498
Spices	4.623	0.906
Pasta	4.378	1.119
Popcorn	4.439	1.098

* 1= Most Troublesome, 5= Least Troublesome

Table 2.6, Grocer Perceptions of Where Insect Pests Come From

Where	OK	AR	TX
Customer Homes	4%	8%	10%
Migrate From Outside	50%	48%	63%
Warehouse	49%	53%	36%
Delivery Truck	47%	52%	47%

Table 2.7, Grocer Concerns For Pesticides Used in Store

Concern	OK	AR	TX
Very	13%	36%	26%
Concerned	10%	18%	29%
Somewhat	27%	14%	12%
Not At All	51%	33%	33%

Table 2.8, Grocer Perceptions of Customer Concerns for Products or Baked Goods*

Concern	Mean	S.D.
Pesticides Used In Insect Control	3.259	1.623
Taste	1.438	0.910
Price	1.681	1.127
Appearance	1.619	0.993
Potential Risks From Pesticides	2.900	1.601

* 1= Most Important, 5= Least Important

Table 2.9, Person Completing Survey, Position in the Company (Actual Count)

OK	AR	TX
50-Store Manager	46-Store Manager	39-Store Manager
36-Owner	33-Owner	21-Asst. Manager
3-Asst. Manager	25-Asst. Manager	11-Owner
3-President	4-Co-Owner	1-Butcher
2-Produce Manager	2-Co-Manager	1-Clerk
2-Co-Owner	1-Head	1-Co-Manager
1-Director of Operations	1-Night Manager	1-Co-Owner
1-Employee	1-Office Manager	
1-Grocery Manager	1-Safety Manager	
1-Main Manager	1-Third Manager	

Table 2.10, Where Do You Get Information About Pesticides and Pesticide Safety (Actual Count)

OK	AR	TX
43-PCO	30-PCO	17-PCO
19-Media	24-Corporate Office	10-Corporate Office
3-Health Department	8-Media	5-Media
2-Corporate Office	6-Word of Mouth	5-None
2-OSU	4-Safety Program	5-Trade Journals
2-Word of Mouth	4-Trade Journal	3-Company
1-CEO/Media/W.O.M	4-Warehouse	2-Boss
1-Fleming	2-Common Sense	2-Common Sense
1-Grocery	2-County Health	2-Health Department
1-Labels	2-Literature	2-Main Office
1-MSDS	2-Scientific Journal	2-Management
1-Main Store	2-State	1-Ag Extension
1-None	1-Back of Can	1-Back of Can
1-Product Label	1-Boss	1-CEO
1-Scientific Journals	1-Division Manager	1-Common Knowledge
1-Warehouse	1-Food Sanitation Manual	1-County Extension
	1-Husband	1-Johnson/Johnson
	1-Lumber Company	1-Literature
	1-Main Office	1-Personal Knowledge
	1-None	1-State
	1-OCEA	1-Warehouse
	1-Pesticide Label	1-Wholesale
	1-School	1-Word of Mouth
	1-Self	
	1-Supervisor	

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Chapter III

Abundance and Distribution of Stored Product Insects in Oklahoma Grocery Stores

Introduction

Most studies on stored product insects have been performed in either the stored grain or processing industry and have dealt with a single commodity. A grocery store is unique in that it contains a variety of processed products including, but not limited to, baked goods, fresh and prepared meat, wheat products, rice products, corn products, raw beans, pet foods, and confectioneries. This variety, combined with a constant temperature favorable for stored product insects, makes grocery stores a perfect ecosystem for stored product pests.

Inspection and sampling are preventative management measures that require time and effort. Stored product insect management relies on effective sampling (Fargo, et al., 1994). Sampling is a critical component of any management program for stored-product insects, and the use of traps to sample stored product insects has been studied extensively during the past 2-3 decades (Cuperus, et al., 1990). Monitoring includes such factors as location, proper trap selection, and proper trap placement. If the wrong trap type is chosen, or the trap is placed improperly, low captures of pest insects can give the individuals monitoring the traps a false sense of security.

A well designed monitoring program can offer the food industry manager a relatively precise method for determining the need for control and also serves as an evaluation tool after a control procedure has been administered to a food facility (Mueller and Pierce, 1992). With regulatory requirements for reduced or near zero tolerance of insect infestation, damage, and contamination, the use of traps for the early detection, monitoring and control of food product insects has proven to be valuable in the effort to protect food and fiber from insect damage or loss (Barak, 1995).

Five primary pests cause most of the insect damage to stored grain and grain products. These are the granary weevil, *Sitophilus granarius* (Linnaeus), rice weevil, *Sitophilus oryzae* (Linnaeus), maize weevil, *Sitophilus zeamaise* (Motschulsky), lesser grain borer, *Rhyzopertha dominica* (Fabricius), and Angoumois grain moth, *Sitotroga cerealella* (Olivier) (USDA, 1991). Some insect pests common to processed foods are the cigarette beetle, *Lasioderma serricorne (*Fabricius), drugstore beetle, *Stegobium paniceum* (L.), sawtoothed grain beetle, *Oryzaephilus surinamensis* (L.), merchant grain beetle, *Oryzaephilus mercator* (Fauvel), confused flour beetle, *Tribolium confusum* (du Val), red flour beetle, *Tribolium castaneum* (Herbst), and Indianmeal moth, *Plodia interpunctella* (Hubner) (Pinkston and Cuperus, 1995). Insect pests have also been identified in flour mills, bakeries, chocolate factories, breweries, slaughterhouses, fish packing plants, dairies, soup factories, canneries, distilleries, wine cellars, and seed-oil refineries (Zuska, 1983). To date, little is known about insects found or population dynamics in grocery stores, the final link between food processors/producers and the consumer.

Traps

All insect traps depend on insect movement. Any factor that influences insect movement will also affect trap capture. The size of this effect depends primarily on insect species, temperature, product type, and product condition (Cuperus, et al., 1990). Insect traps are effective and sensitive tools for detecting stored product insects (Fargo, et al., 1989). Traps can be used to determine which insect species are present, help determine the potential for pest infestation, help determine the extent of a pest problem, and help with the evaluation of a particular treatment or control method (Mueller, 1995).

Traps exploit insect behavior to detect insect populations with less effort than more absolute sampling methods such as actively looking for and capturing insects. However, this exploitation of behavior may result in large variations in trap catch. Much of this variation in trap catch may be attributed to variation in the trap's efficiency in response to environmental factors. One of the first considerations in planning a trapping program is the estimation of trap efficiency so that the number of insects caught can be converted to absolute density of insects in or around stored commodities or storage facilities. Detection implies some measure of population density in that lower densities are detected with increases in the number of traps, with longer trapping periods, or with environmental conditions more favorable for insect activity (Hagstrum, et al., 1990).

Based on use, traps for stored product insects fall into four general categories: 1) light traps; 2) aerial traps, including sticky and funnel types; 3) surface deployed traps for crawling insects, including harborage, sticky, and pitfall types, and food or bag-bait traps; and 4) bulk grain and commodity traps, which include perforated probe traps. These traps may use pheromones, food attractants, or both, or may remain unbaited (Barak, 1995).

Sampling for insects is a very critical component of any management program for stored product insects (Cuperus, et al., 1990), yet the sampling must be done effectively for appropriate management decisions to be made (Fargo, et al., 1994). Since residual populations of stored product insects tend to seek refuge in crack and crevices of grain stores and warehouses, populations are usually difficult to detect until populations reach densities often considered unacceptable in food processing systems (Subramanyam, et al., 1992). A food processing monitoring tool needs to effectively sample low insect populations since detection implies some measure of population density.

A well designed trap must satisfy many conditions: sample insects either by random movement or by the use of food baits or pheromones; provide insects with a place to hide; prevent insects from escaping; be resistant to dust and dirt; discourage humans or animals from disturbing the trap; and be able to be placed so that normal warehouse traffic and commodity movement are not hindered or otherwise affected (Mullen, 1994). Once these conditions have been met, researchers can then use the traps to detect insect populations, determine insect species present, and estimate abundance.

Objectives

The objectives of this study were to:

1. Determine which insect pests are most prevalent in grocery store stored product areas.
2. Quantify population dynamics within grocery stores.
3. Perform preliminary studies in insect distribution within grocery stores.

Materials and Methods

Four grocery stores were selected in Oklahoma City, OK and 4 in Stillwater, OK. In each store, three areas of the store were used as potential trapping sites: 1) pet food, 2) cake mix and flour, and 3) back storage areas. Insecticides were not used in sampled areas during this study nor were areas sampled by grocery employees. One store was selected for a three week period of intense trapping to determine overall distribution of key insects within the store.

Insect populations were sampled using two trap types. The Trece' M2 Flit-Trak pitfall trap (Trece' Inc., Salinas CA., USA), originally called the Savannah trap (Mullen, 1994), was baited with an oil based food attractant formulated and supplied by Trece'. A pheromone was not used in these traps because we were attempting to quantify all insects present, not just a particular species. The other trap was the Trece' Pherocon® model flight trap. This is a delta shaped trap covered with a sticky substance which traps insects flying or crawling into the trap. These traps were baited with Trece' Inc.'s Indianmeal moth pheromone lure, which is a rubber septum lure. Traps were used in the pet food and flour aisles and in the back storage rooms of each grocery store.

Pitfall traps

Pitfall traps were placed in aisles on both the upper and lower surfaces of the shelves at intervals of 1/4, 1/2, and 3/4 the length of the aisle. Each trap was given a unique number for location identification purposes. In areas where there was not sufficient room to place the trap on the lower surface of the shelf, traps were placed only on the upper surface. Traps were placed on all shelves in the appropriate aisles in each location. The traps were checked weekly and any insects trapped were placed in a plastic bag and the trap number recorded. Traps were then rebaited and placed back in their original location. Trapped insects were taken back to the lab and identified. Pitfall traps were also placed in back storage areas where possible under storage racks and along walls. Three hundred and three pitfall traps were used, with an average of 14.8 traps placed in the pet food aisles, 22.0 traps in the flour and cake mix aisles, and 1.3 traps placed in the back storage rooms. The low number of traps placed in back rooms was due to the lack of appropriate locations to place pitfall traps. There was also a high incidence of trap loss because this is a high traffic area.

Flight traps

Flight traps were suspended from the top shelves of pet food aisles, one trap per trapping location (1/4, 1/2, 3/4 aisle length). Traps were also distributed in back storage areas and suspended from the rafters where possible including loading areas where products were delivered and reclamation areas where broken packages and expired products were stored. These traps were also checked once a week and when insects were captured, the entire trap would be replaced with a new one. Indianmeal moth pheromone lures were placed in each trap and replaced approximately every two to three weeks. Traps containing insects were taken to the lab and the insects identified. After identification, insects were removed and the trap was relabeled for use. A total of 51 flight traps were used with an average of 3.1 flight traps used in pet food aisles and an average of 3.3 traps used in the back room per store. No flight traps were used in flour and cake mix aisles. Statistical analyses for both trap types was conducted using SYSTAT and SAS (SYSTAT Inc., 1992; SAS Institute, 1987). To determine if there were differences between the geographic locations of the stores, between the stores, between the aisles or between trap placement within the aisles, analysis of variance (ANOVA) procedures were used. Due to the nonnormality of the trap catch data, a logarithmic transformation (log (Y+1)) was used to equalize variances (Steel and Torrie, 1980). All of the data were analyzed as a split-plot, since differences between geographic locations, stores within locations, and aisles within stores were being compared. For all tables, an alpha (α) of 0.10 was used. Therefore, if the P value in the ANOVA table is less than α for a given variable, it is indicated as significant.

Results and Discussion

There was a significant difference between trap locations on the shelves. ANOVA procedures showed a significant difference between top and bottom placement with a p value of 0.0499. Pitfall traps for the surface of the shelf showed a mean catch of 75.3 insects ($\pm$ 69.9) while the underside of the shelf had a mean trap catch of 22.2 ($\pm$ 38.7) insects. Higher mean catches in traps placed on the surface of the shelf indicate that this is the proper place to put pitfall traps.

Traps showed a wide variety of insects that apparantly were endemic in most stores. Grocer perceptions did not correlate well with what was recovered in the traps. Indianmeal moths, fungus gnats (Sciaridae), moth flies (Psychodidae), and plant hoppers (Cicadellidae) were the most numerous insects trapped in flight traps (Table 3.2), whereas merchant grain beetles, drugstore beetles, and Indianmeal moths were the most numerous insect recovered in pitfall traps (Table 3.2). Indianmeal moths were trapped in all stores sampled. Flies (Tachinidae, Muscidae, Sciaridae, Psychodidae, and other miscellaneous families of Diptera) accounted for a relatively large number of insects present, but cockroaches (Blatellidae) were not abundant, with only one recovered. Glue-board traps are generally used to monitor for cockroaches and are generally placed in prepared food sections such as bakeries and delicatessens, both areas were not used in this study.

The average Indianmeal moth trap capture over time for Oklahoma City and Stillwater combined is shown in figure 3.1. The graph shows a constant population, with the average catch per trap per week to be approximately 5 insects. Figure 3.2 shows the average flight trap capture of Sciaridae per trap per week. The initial trap catch had a high population of over 100 insects captured, but as time progressed the number reduced to about 20 insects per examination.

Figures 3.3 and 3.4 show merchant grain beetle pitfall trap capture in Stillwater and Oklahoma City and show fairly consistent in-store populations during the first few weeks. In Stillwater traps, low trap catches occurred until about week 5, then the number of insects trapped increased drastically, reaching a peak of over 100 insects per trap at week 7, then the numbers decreased. The trap catch for Oklahoma City stores averaged about 30 insects per week until week 8, when the trap catch increased from about 50 insects (week 8) to about 150 insects (week 9). This trend continued until the study ended at week 10.

The incidence of drugstore beetles was negligible in Stillwater. However in Oklahoma City stores the number of drugstore beetles were initially low, had a large peak occurring at week 2, and then declined until the end of the study with a slight increase at week 10 (Figure 3.5).

Table 3.3 shows the ANOVA for the merchant grain beetle pitfall trap capture, comparing data collected from pet food and flour aisles. For the merchant grain beetle, there were significant differences between aisles. The mean trap catches per store (Table 3.4) were significantly higher in pet food aisles than in flour aisles (14.28 ± 28.53 and 0.25 ± 0.52, respectively). The majority of merchant grain beetles were caught in Oklahoma City stores, although there were no significant differences geographically between Oklahoma City and Stillwater.

No drugstore beetles (*Stegobium sp.*) were caught in Stillwater. In Oklahoma City stores there were no significant differences between aisles (p=0.32) or positions within aisles (p=0.45) (Table 3.5). The mean trap catch per store and indications that the majority of the drugstore beetles were found in the petfood aisles rather than the flour aisles (1.48 ± 4.05 and 0.09 ± 0.256 respectively) is shown in table 3.6.

Flight traps were used in only the back rooms and pet food aisles. There was a significant significance between aisles (p=0.02), but not between locations (p=0.62) for Indianmeal moths captured in flight traps (Table 3.7). Table 3.8 shows the means and standard deviation for the back storage areas and for the pet food aisles (15.52 ± 12.67 and 85.99 ± 72.33). Overall the pet food aisles were more likely to have Indianmeal moths.

Comparisons of the fungus gnat (Sciaridae) data (Table 3.9) showed no significant differences between locations (p=0.37), but did show a significance between aisles (p=0.02). Table 3.10 shows that the majority of Sciaridae were caught in the back storage areas (8.14 ± 8.94) as opposed to petfood (0.19 ± 0.42). Similar results were found for plant hoppers (Cicadellidae) where there was no significant difference between locations (p=0.89), but there was a significant difference between aisles (p=0.06) (Table 3.11). Table 3.12 also indicates that the majority of Cicadellidae were caught in the back storage areas (5.72 ± 8.46) versus petfood (0.04 ± 0.12). These findings were not surprising since Cicadellids and Sciarids are plant and fungus feeders and are more likely to be around old and decaying produce such as that found in the back and trash areas of stores. It is also likely that these insects do migrate from outside as opposed to the other insects found in this study which are more indicative of consistent in-store populations. Insect pests recovered were largely unreported as being problematic in grocery stores, but have long been known as important pests in stored products.

Distribution

The store used for the distribution study had the highest total number of insects caught throughout the earlier trapping period, and was chosen to insure finding the three key insects; Indianmeal moths, merchant grain beetles, and drugstore beetles.

The store was trapped in the bread, candy, cereals, pet food, and flour aisles with both pitfall and flight traps. The highest trap catch of drugstore beetles was in the pet food aisle, with the second largest concentration in the cereal aisle (Table 3.13). The greatest average pitfall trap catch for merchant grain beetles was in the petfood aisle, followed by the cereal aisle, the flour aisle, and finally the candy aisle (Table 3.14). The average Indianmeal moth flight trap catch (Table 3.15), indicated the highest concentrations were in the flour aisle, followed by the petfood aisle, then the cereal aisle.

No insects were ever found in the bread aisle because of the rapid rotation of bread items within a grocery store.

Conclusions

The study showed that the Indianmeal moth was abundant in all stores, with the highest number in pet food and flour aisles. Apparantly these insects are actively reproducing within most stores and attacking new material as it enters the store. Several stores apparently had endemic populations of merchant grain beetles and drugstore beetles.

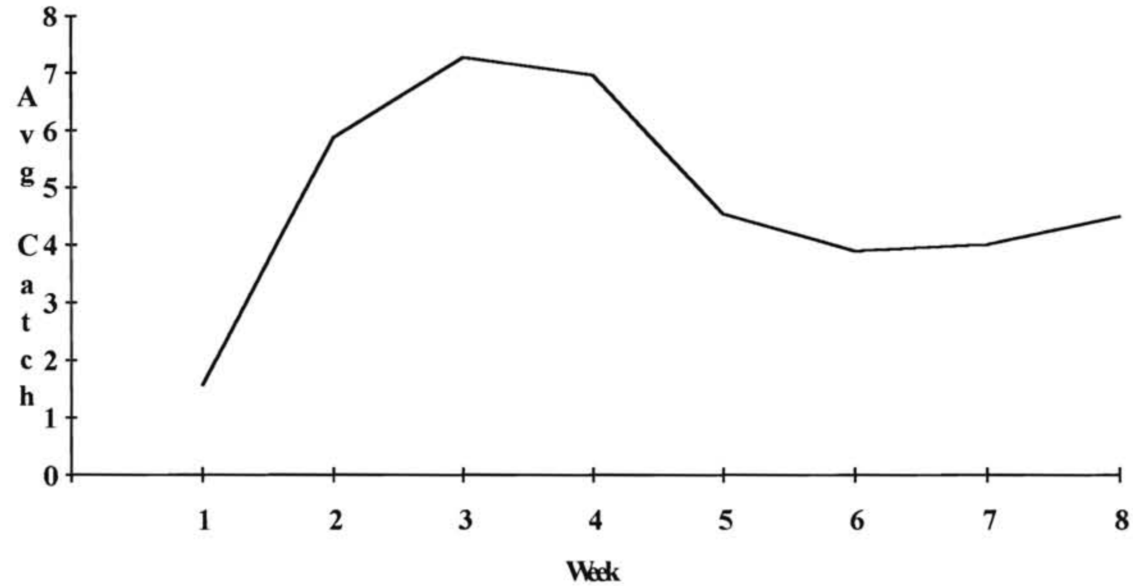
The variations in insect data between stores could be explained by factors such as the age of the store and differences between current management practices within the stores.

Traps are excellent monitoring tools within grocery stores. Trap catches demonstrated the presence of stored product pests in grocery stores even though store managers did not indicate the presence of these insects in the stores.

In order to facilitate IPM practices in grocery stores, pest control operators and store managers are going to require education and training in IPM with an emphasis on the importance of sanitation, monitoring for insect pests, and proper insect identification. Appropriate literature needs to be developed or adapted from existing materials and distributed to pest control operators and grocery store managers. Additionally, training workshops need to be conducted by various state and regulatory agencies for this specific area of pest management.

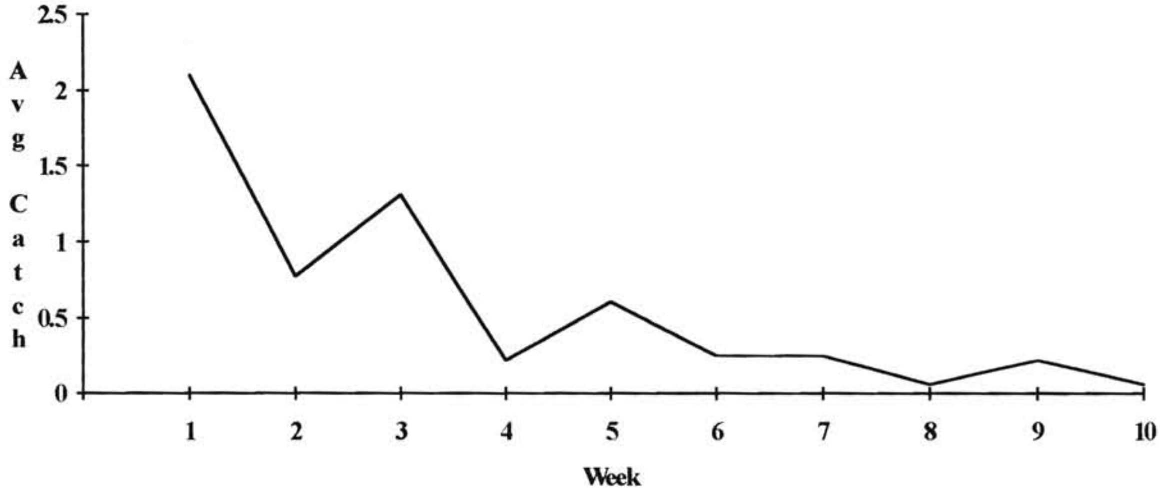
Figure 3.1, Indianmeal Moth (*Plodia interpunctella)*

Flight Trap Capture Over Time*



* Average of 51 flight traps per week

Figure 3.2, Flight Trap Capture of Sciaridae Over Time*



* Average of 51 flight traps per week

Figure 3.3, Merchant Grain Beetle, (*Oryzaephilus mercator*)

Pitfall Trap Capture Over Time, Stillwater

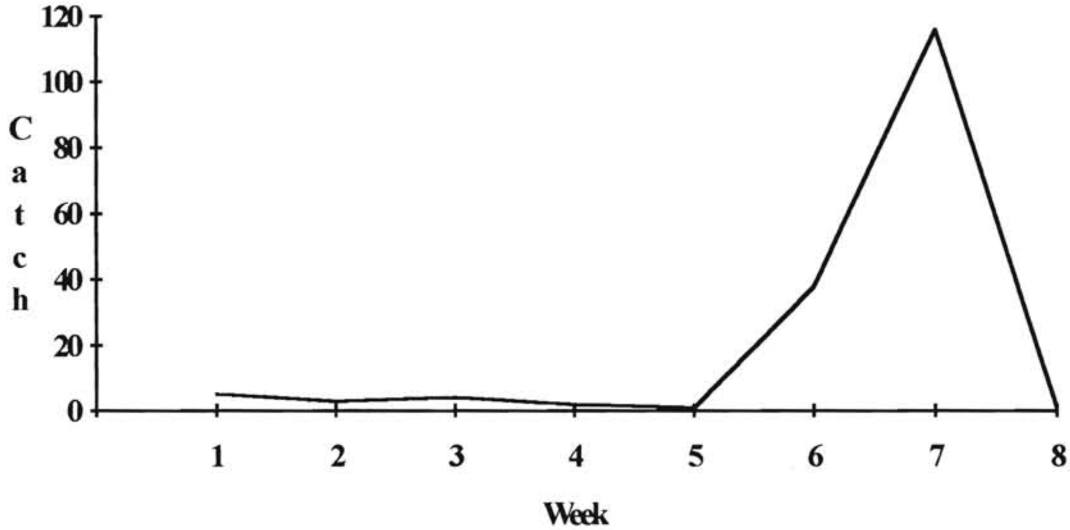


Figure 3.4, Merchant Grain Beetle, (*Oryzaephilus mercator*)

Pitfall Trap Capture Over Time, Oklahoma City

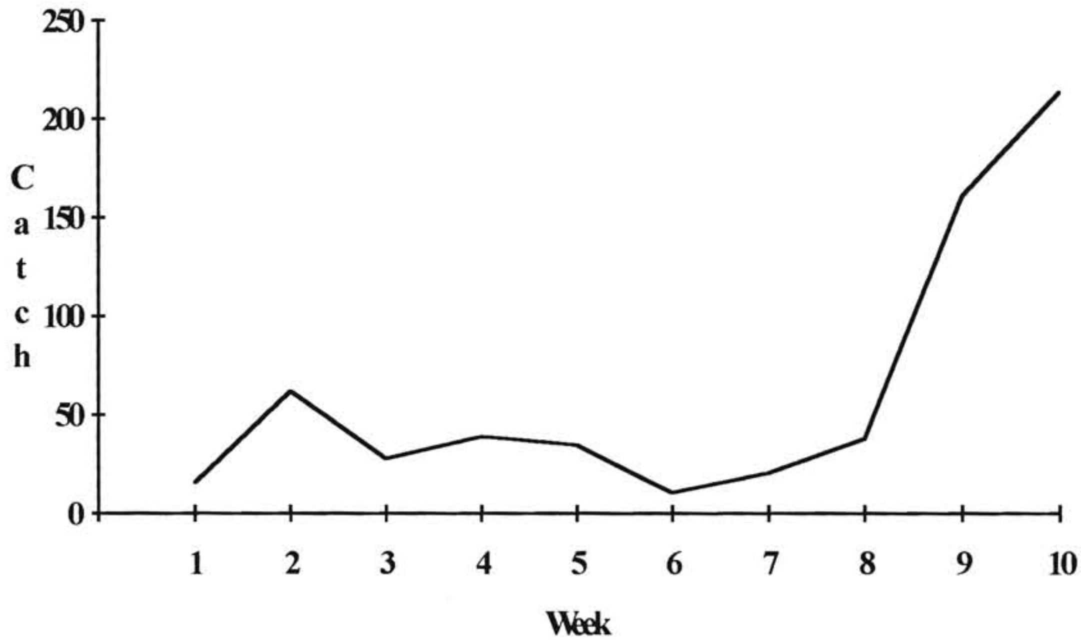


Figure 3.5, Drugstore Beetle, (*Stegobium sp.)* Pitfall Trap Capture Over Time, Oklahoma City

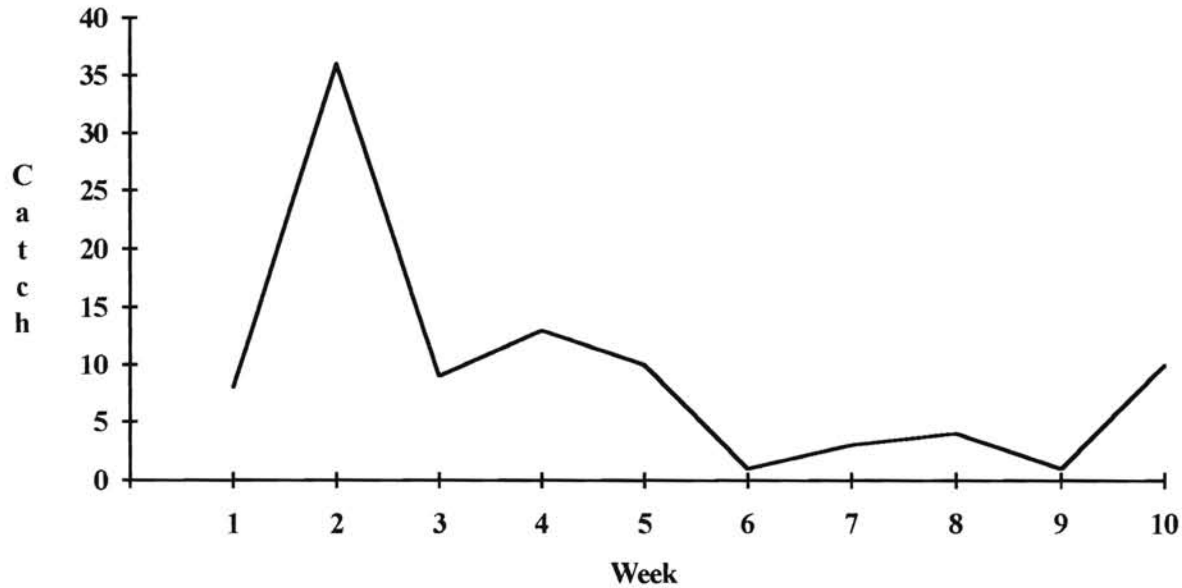


Table 3.1,Grocery Store Flight Trap Total and Average Capture

Caught	Total Amount	Avg. Trap Catch/Week
Plodia interpunctella	2732	5.357
Sciaridae	311	0.610
Cicadellidae	170	0.340
Psychodidae	51	0.100
Muscidae	30	0.060
Chironomidae	22	0.043
Pteromalidae	19	0.037
Oryzaephilus mercator	12	0.024
Stegobium sp.	9	0.018
Cryptolestes sp.	5	0.010
Culicidae	5	0.010
Drosophilidae	3	0.006
Mycetophilidae	3	0.006
Tachinidae	3	0.006
Trogoderma sp.	3	0.006
Typhaea sp.	3	0.006
Formicidae	2	0.004
Psocidae	2	0.004
Anthocoridae	1	0.002
Asilidae	1	0.002
Calliphoridae	1	0.002
Delphacidae	1	0.002
Dytiscidae	1	0.002
Empididae	1	0.002
Ichneumonidae	1	0.002
Lasioderma sp.	1	0.002
Mycetophagidae	1	0.002
Noctuidae	1	0.002
Opiliones	1	0.002
Yponomeutidae	1	0.002
Total	3397	-

Table 3.2, Grocery Store Pitfall Trap Total and Average Capture

Caught	Total Amount	Avg. Trap Catch/Week
Oryzaephilus mercator	794	0.2620
Stegobium sp.	97	0.0300
Plodia interpunctella	45	0.0150
Psychodidae	22	0.0070
Pteromalidae	16	0.0050
Sciaridae	5	0.0020
Formicidae	2	0.0010
Muscidae	2	0.0010
Tribolium sp.	2	0.0010
Ahasverus sp.	1	0.0003
Blatellidae	1	0.0003
Chironomidae	1	0.0003
Elateridae	1	0.0003
Total	989	-

Table 3.3, Analysis of Variance for Merchant Grain Beetles

Captured in Pitfall Traps

Comparing Pet Food and Flour Aisles,

Oklahoma City and Stillwater

Source	DF	Anova SS	Mean Square	F Value	Pr>F
Location	1	0.79489	0.79489	0.53	0.4945
Aisle	1	3.84211	3.84211	4.97	0.0673
Loc*Aisle	1	0.49653	0.49653	0.64	0.4535
Position	1	0.16737	0.16737	0.25	0.6239
Loc*Posit	1	1.69881	1.69881	2.57	0.1348
Aisle*Posit	1	0.34010	0.34010	0.51	0.4868
Loc*Aisle*Posit	1	2.40803	2.40803	3.64	0.0804
Error	12	7.9283	0.66069	-	-

Table 3.4, Merchant Grain Beetle Mean Trap Catch Per Store, Flour vs. Petfood Aisles

Aisle	Minimum	Maximum	Mean	S.D.
Flour	0	1.443	0.247	0.518
Petfood	0	82.916	14.277	28.526

Table 3.5, Analysis of Variance for Drugstore Beetles

Captured in Pitfall Traps,

Oklahoma City

Source	DF	Anova SS	Mean Square	F Value	Pr>F
Aisle	1	0.54811	0.50811	1.38	0.3245
Position	1	0.11829	0.11829	0.66	0.4483
Aisle*Posit	1	0.24785	0.24785	1.38	0.2849
Error	6	1.07883	0.17981	-	-

Table 3.6, Drugstore Beetle Mean Trap Catch Per Store, Flour vs. Petfood Aisles

Aisle	Minimum	Maximum	Mean	S.D.
Flour	0	0.698	0.087	0.246
Petfood	0	11.499	1.483	4.048

Table 3.7, Analysis of Variance for Indianmeal Moths Captured in Flight Traps, Oklahoma City and Stillwater

Source	DF	Anova SS	Mean Square	F Value	Pr>F
Location	1	0.40895	0.40895	0.28	0.6181
Aisle	1	9.11879	9.11879	8.96	0.0242
Loc*Aisle	1	0.14575	0.14575	0.14	0.7181
Error	6	6.10500	1.01750	-	-

Table 3.8, Indianmeal Moth Mean Trap Catch Per Store

Back Storage Areas vs. Petfood

Aisle	Minimum	Maximum	Mean	S.D.
Back	2.50	38.0	15.523	12.668
Petfood	6.381	213.90	85.993	72.326

Table 3.9, Analysis of Variance for Fungus Gnats (Sciaridae)

Captured in Flight Traps

Oklahoma City and Stillwater

Source	DF	Anova SS	Mean Square	F Value	Pr>F
Location	1	0.62710	0.62710	0.96	0.3653
Aisle	1	9.63167	9.63167	10.81	0.0167
Loc*Aisle	1	0.29310	0.29310	0.33	0.5872
Error	6	5.34844	0.89141	-	-

Table 3.10, Fungus Gnat (Sciaridae) Mean Trap Catch Per Store

Back Storage Areas vs. Petfood

Aisle	Minimum	Maximum	Mean	S.D.
Back	0	23.8	8.142	8.940
Petfood	0	1.2	0.192	0.424

Table 3.11, Analysis of Variance for Plant Hoppers (Cicadellidae)

Captured in Flight Traps

Oklahoma City and Stillwater

Source	DF	Anova SS	Mean Square	F Value	Pr>F
Location	1	0.01852	0.01852	0.02	0.8924
Aisle	1	5.27828	5.27828	5.23	0.0621
Loc*Aisle	1	0.00006	0.00006	0.00	0.9942
Error	6	6.05037	1.00840	-	-

Table 3.12, Plant Hoppers (Cicadellidae) Mean Trap Catch Per Store

Back Storage Areas vs. Petfood

Aisle	Minimum	Maximum	Mean	S.D.
Back	0	22.2	5.723	8.456
Petfood	0	0.333	0.042	0.118

Table 3.13, Distribution of Drugstore Beetles (*Stegobium sp.)* in Oklahoma Grocery Stores Captured in Pitfall Traps During a Three Week Period

Aisle	Week 1 Avg.	Week 2 Avg.	Week 3 Avg.
Bread	0.000	0.000	0.000
Candy	0.000	0.000	0.000
Cereal	0.000	0.250	0.000
Petfood	0.857	1.571	1.143
Flour	0.000	0.000	0.000

Table 3.14, Distribution of Merchant Grain Beetles *(Oryzaephilus mercator)* in Oklahoma Grocery Stores Captured in Pitfall Traps During a Three Week Period

Aisle	Week 1 Avg.	Week 2 Avg.	Week 3 Avg.
Bread	0.000	0.000	0.000
Candy	0.000	0.100	0.100
Cereal	0.500	0.500	0.500
Petfood	15.142	20.571	9.428
Flour	0.000	0.166	0.166

Table 3.15, Distribution of Indianmeal Moth(*Plodia interpunctella*) in Oklahoma Grocery Stores Captured in Flight Traps During a Three Week Period

Aisle	Week 1 Avg.	Week 2 Avg.	Week 3 Avg.
Bread	0.000	0.000	0.000
Candy	1.000	0.000	0.000
Cereal	6.667	0.000	3.000
Petfood	0.000	5.000	11.667
Flour	14.333	15.333	9.333

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APPENDIXES

APPENDIX A: TELEPHONE SURVEY ADMINISTERED TO GROCERS

1. How are your Pest Control needs met?

Do our own______ Pest Control Company_____

None_____

2. If you use a Pest Control Company, on what basis is it used?

Monthly_____

Weekly_____

As Needed_____

Other (please explain)____

3. Rate the following factors considered in selecting a pest control program (1=very important,5=not considered)

_____Chemical costs

_____Application costs

_____Alternative to Pesticides

_____Effectiveness

_____Safety requirements

_____Other______________________________________

4. If pests are not controlled, what are the potential losses to your store? ($ annually)

____________Value of losses

What would be the consequences?

_____Closed for health reasons

_____Fined

_____Fired manager, etc.

_____Loss of Product

_____Decrease in Customers

_____Other______________________________

5. Which pest management methods are currently used?

Insects:	Rodents:
Insecticides_____	Traps_____
Traps_____	Baits______
Baits_____	Glue boards_____
Temperature control_____	Humane Traps_____
Dusts_____	Other_____
Screens____	Screens_____
Sanitation_____	Sanitation_____
Quick Stock Rotation_____	Quick Stock Rotation_____
Don't Know_____	Don't Know_____
Other ________________	Other__________________

6. What type of insecticides are used in your store?
   - Pyrethroids_____
   - Pyrethrins_____
   - Organophosphates_____
   - Carbamates_____
   - Chlorinated Hydrocarbons_____
   - Growth Regulators_____
   - Don't Know_____
   - Other____

7. What types of insect pests do you usually treat for?
   - Cockroaches_____
   - Gnats_____
   - Flies_____
   - Spiders_____
   - Weevils_____
   - Indian Meal Moths_____
   - Flour Beetles_____
   - Other____

8. Do you routinely monitor for insect pests?

   _____Yes _____No

   If yes,how?____

9.Do you use insect traps in the store?

   _____Yes _____No

   If yes, what type?____

10. Do you think there is an insect pest problem in your store?

Yes_____

No_____

Unsure_____

11. Are you familiar with IPM (Integrated Pest Management) practices for controlling insect pests in your store?

Yes_____ No_____

12. Would you be interested in learning more about IPM practices?

Yes_____ No_____

If yes, in what manner? Literature_____ Workshops_____

13. Would you be willing to pay more for pest control if it involved IPM and had the potential for using less chemicals for control of pests?

Yes_____ No_____

14. Do you think your customers would feel safer knowing you are using IPM practices?

Yes_____ No_____ Unsure_____

15. How would you rate your concern for pesticides used in the store as being potential contaminants of food products sold in your store.

Very Concerned_______

Concerned_____

Somewhat Concerned_____

Not At All Concerned_____

16. Do you think your customers would be willing to purchase pesticide free produce if it meant a higher price?

Yes_____ No_____

17. Where do you think the insect pests come from?

Customer homes_____

Migrate from outside_____

Warehouse_____

Delivery Truck_____

Other____

18. How many consumer complaints about insect contamination do you receive each year?

A. 0-5_____
B. 5-10_____
C. 11-20_____
D. Over 20_____

19. if complaints are received, how are they handled?

____

____

____

20. Have you ever had produce tested for pesticide residues?

Tested Yes___ No____
Plan to Test Yes___ No____

21. Do you know how the testing is done?

_____Yes
_____No

22. If testing is done, who does it?

____

23. If you have or plan to test, how often do you intend to have the testing done?

Once a week_____
Once a month_____
Once every three months_____
Once every six months______
Other_____
Unsure_____

24. Do your contracts with brokers, distributors, or producers have any stipulations regarding pesticides or IPM practices?

No_____
Yes_____ if yes, what are they?________________________________

25. Rank in order of importance (1=most important, 6=least important) what you perceive your customers preferences/concerns are for produce.

_____ Pesticides used in growing
_____ Taste
_____ Price
_____ Appearance
_____ Potential risks from pesticides
_____ Organic/IPM grown vs. "Normal" grown produce

26. Please rate trouble spots for insect pests in your store.

1=most troublesome, 5=least troublesome

_____ Deli
_____ Canned Goods
_____ Produce
_____ Bakery
_____ Dried pet foods
_____ Back Room (Storage/Reclamation area)
_____ Trash Areas
_____ Cereals
_____ Flour, Sugar, Cake Mixes
_____ Spices
_____ Pasta
_____ Popcorn
_____ Other ______________________________________

27. What is your position in the Company?

Store Manager_____
Produce Manager_____
Owner_____
Other (specify)______________________________________

28. Where do you receive most of your information about pesticides and pesticide safety?

Scientific Journals_____
Extension Agents_____
Oklahoma State University_____
Media (Radio, T.V. Newspapers)_____
Popular Journals_____
Word of Mouth_____
Trade Publications_____
Other____ (specify)______________________________________

VITA

Raymond R. Platt Jr.

Candidate for the Degree of

Master of Science

Thesis: INTEGRATED PEST MANAGEMENT IN FOOD WAREHOUSES

Major Field: Entomology

Biographical

Personal Data: Born in Oklahoma City, Oklahoma, June 20, 1964, the son of Raymond and Charlotte Platt.

Education: Graduated from Oney High School, Albert, Oklahoma in May 1982; graduated Navy Recruit Training Command in December, 1985; graduated Naval Hospital Corps School in April, 1986; graduated Naval School of Health Sciences in August, 1986; received Bachelor of Science degree in Biology from Southwestern Oklahoma State University in December, 1992. Completed the requirements for the Master of Science degree with a major in Entomology at Oklahoma State University in May, 1996.

Experience: Worked part and full time in family pest control business since 1970; served in United States Navy from 1985 - 1990; employed by Oklahoma State University Department of Entomology as a graduate research assisstant, 1994 to present.

Professional Memberships: Entomological Society of America