# Session 3

## Detection and Monitoring

### Stored Product Insects at a Rice Mill: Temporal and Spatial Patterns and Implications for Pest Management

**Sonia Lazzari[1], Flavio A. Lazzari[1], Fernanda Lazzari[1], Frank H. Arthur[2], James F. Campbell[2]***

[1]Rua dos Contabilistas, 30, 81560-110 Curitiba, PR, Brazil
[2]USDA ARS, Center for Grain and Animal Health Research, 1515 College Ave, Manhattan KS, 66502, USA
*Corresponding author: james.campbell@ars.usda.gov.
DOI 10.5073/jka.2018.463.051

### Abstract

Monitoring is fundamental to integrated pest management programs since it provides feedback on effectiveness of prevention programs and helps with targeting interventions as needed and evaluating their effectiveness. Rice mills are spatially complex facilities that have a combination of rough rice storage bins, buildings where rice is milled and processed, and warehouses and bulk storage bins where finished product is held before shipment. Each of these structures can have its own suite of insect species, different levels of risk, as well as different suites of management tools available. At a large rice mill in Brazil, stored product insect activity was monitored using food bait traps placed around rough rice receiving areas and storage bins; inside building containing white rice mill, rice flour mill, and packaging; and inside building for processing parboiled rice. The facility was monitored from 2010 to 2018 with 100 traps. Major pest species recovered at the facility included *Sitophilus oryzae, Sitophilus zeamais, Rhyzopertha dominica, Tribolium castaneum, Cryptolestes ferrugineus, Ahasverus advena*, *Oryzaephilus surinamensis*, *Typhaea stercorea, Anthicus floralis*, and Nitidulidae species. Temporal and spatial patterns in abundance were evaluated for each of the major species and for major functional groups (primary feeders, secondary feeders, and fungal feeders). Monitoring data generated was used to guide pest management programs and also provided the information needed to develop management thresholds.

**Keywords:** rice, monitoring, *Sitophilus* spp., *Rhyzopertha dominica*, *Tribolium castaneum*, spatial distribution.

### Introduction

Rice is one of the three major food crops of the world, along with corn and wheat. After harvest, rice is vulnerable to infestation by a suite of stored product insect species as it is stored and processed. Rice mills consist of a complex of structures, including structures such as metal bins or concrete elevators where rough rice is stored in bulk, the mill building where the hull and outer bran layer is removed, milled rice storage structures which are typically warehouses for packaged rice, and storage areas for waste material such as rice hulls. Some facilities also have other structures or areas where additional processing occurs such as parboiling or milling into rice flour. These different areas of a rice mill complex are all vulnerable to stored product insect infestation, although the distribution of species and their inherent risk varies with area. Integrated Pest Management (IPM) for rice mills relies on a range of tactics to deal with insect infestation issues, including fumigation of rough rice and packaged rice with phosphine, treatment of mill building and warehouses with structural treatments such as fumigants or heat or aerosol insecticides, spot and surface insecticide treatments. However, the major focus of IPM for food facilities needs to be on prevention of insects entering storage and processing areas, and ultimately into the finished product. Stored product insects can be captured in large numbers outside of rice mills (McKay et al. 2017), so understanding patterns of activity outside of rice mills and the impacts of management tactics to target these outside populations is critical.

Brazil is a top 10 worldwide rice producer and the state of Rio Grande do Sul is the largest rice producing region in Brazil. The objective of this study was to monitor insect activity in and around a large rice facility in this region of Brazil. A high density of traps in place across multiple years was used to determine the community of insect species that are active at the mill, seasonal patterns of activity, and the spatial patterns of distribution. This information is useful in determining times and areas at greatest risk and also for providing information to guide pest management programs and evaluate their success.

## Materials and Methods

Stored-product insect abundance was monitored at a large rice facility located in southern Brazil. The rice facility included rice receiving areas, drying facilities, metal storage bins for holding rough rice, a structure for white rice and rice flour milling, and packaging/warehouse, and a structure for parboil rice manufacturing. Insects were monitored using 100 food-baited cage traps [based on Throne & Cline (1991) and adapted by Pereira (1999)] placed outside around the bins and inside the white rice and parboil rice plants. The bait used in the traps consisted of 150 g of whole corn kernels, broken corn kernels, whole rice, broken rice, whole wheat, and wheat germ that had been previously sifted and frozen for 7 days at -18°C to kill any insect infesting the raw material. Personnel at the rice facility placed traps out for 15-day periods once a month and returned the traps so that the captured insects could be identified and counted. However, given the range of factors that arise from working with commercial operations, not all traps were returned for each monitoring period, there were gaps in the data collected, and for some of the early monitoring periods traps were out a couple times a month but only one of the 15-day intervals is presented here. Data are presented as the number of insects captured per 15-day period. Monitoring started in Jan 2010 and continued until January 2018.

## Results

Across the total duration of the monitoring program, *Rhyzopertha dominica* was the most abundant species recovered, accounting for 47% of the stored-product species captured. Other pest species captured included *T. stercorea* (11%), *Sitophilus* spp. (8%), *Cryptolestes ferrugineus* (7%), *A. advena* (3%), *T. castaneum* (1%), and low numbers of *O. surinamensis* and *L. serricorne* (<1%, respectively). Sap beetles in the family Nitidulidae were the second most abundant group of insects in the samples, accounting for 22% of the species captured. Although was considerable variation in captures among years, for *R. dominica* there was a temporal pattern of greater captures during the summer months, between November and February (Fig. 1). This seasonal pattern also appeared to apply to *C. ferrugineus*, but captures of *T. stercorea* and *Sitophilus* spp. did not exhibit as strong a seasonal trend (Fig. 1). There was a significant relationship between average monthly temperature and total insect captures, with captures low and stable at average temperatures below 22°C and with peak captures around 26°C (Fig. 2).

Insect captures were greatest in the traps near the rough rice storage bins, followed by captures in traps in the receiving/drying area, with the least captures inside the rice mill and the parboil facility (Fig. 3). In the rough rice area, *R. dominica* (640±150 total adults/trap), Nitidulidae (262±106 total adults/trap), *Sitophilus* spp. (102±22 total adults/trap), *T. stercorea* (99±14 total adults/trap) and *C. ferrugineus* (75±22 total adults/trap) were the five most commonly captured species. In the receiving/drying area, *R. dominica* (273±103 total adults/trap), Nitidulidae (206±56 total adults/trap), *T. stercorea* (113±25 total adults/trap), *C. ferrugineus* (65±14 total adults/trap), and *Sitophilus* spp. (43±8 total adults/trap) were the five most commonly captured species. Inside the rice mill, *R. dominica* (34±15 total adults/trap), *T. stercorea* (29±14 total adults/trap), Nitidulidae (18±8 total adults/trap), *Sitophilus* spp. (15±2 total adults/trap, and *T. castaneum* (9±3 total adults/trap) were the five most commonly captured species. And inside the parboil facility, *R. dominica* (62±6 total adults/trap), Nitidulidae (61±24 total adults/trap), *Sitophilus* spp. (21±6 total adults/trap, *T. stercorea* (9±3 total adults/trap), and *T. castaneum* (5±2 total adults/trap) were the five most commonly captured species.

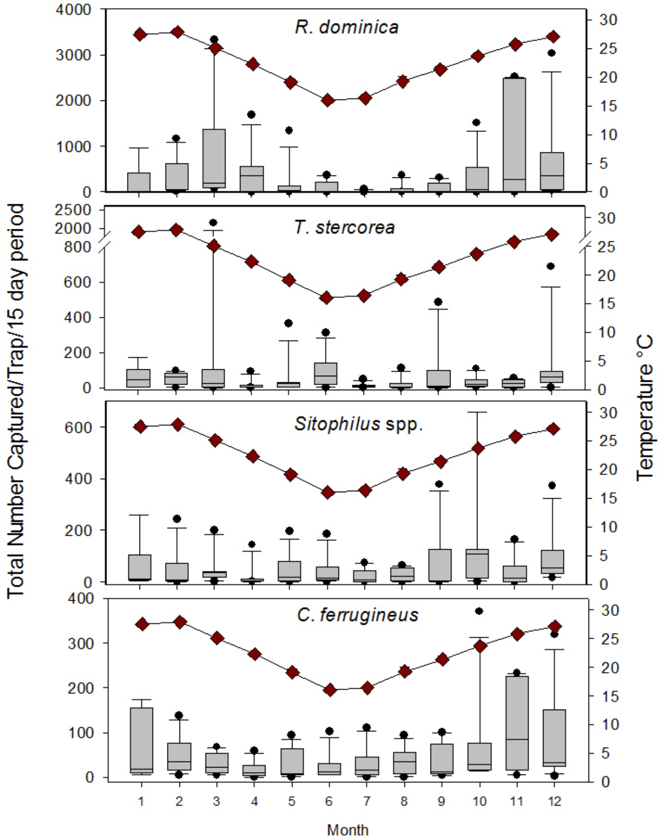


**Fig. 1** The total number of each species captured per month across the eight years study shown as box plots, with 50% of data in the box, 95% in the whiskers, and outliers shown black circles. Average monthly temperatures obtained from a nearby weather station are shown as diamonds.

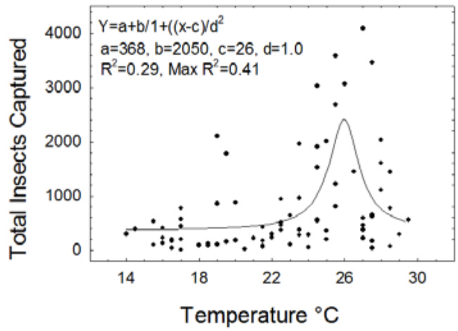


**Fig. 2** Relationship between total number of insects captured and average monthly temperatures obtained from a nearby weather station.

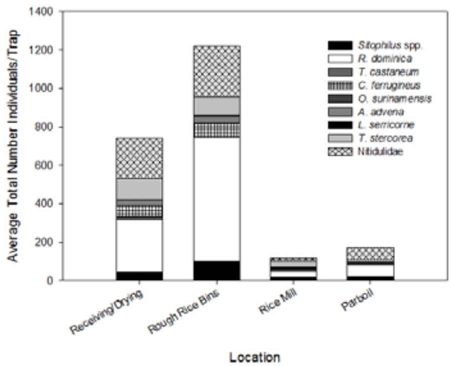


**Fig. 3** Total number of individuals of each species captured over the course of the study in four areas of the rice mill facility.

## Discussion

There were high levels of stored product insect activity throughout the rice mill facility, especially outside in the areas that handled rough rice – both the receiving and drying areas and the storage bins. Some of the major primary pest species were recovered in these areas, including *R. dominica* and *Sitophilus* spp. (*S. oryzae* or *S. zeamais*). These species were monitored outside of the rough rice bins, so it is not known how these activity levels relate to levels of infestation in the rice within the bin. Insects captured outside could originate from within the bins, from grain spillage accumulations onsite, or immigrate from offsite locations. However, these activity levels indicate the potential for insect movement into and out of the bins and potential for movement into the rice processing structures and ultimately into finished products (Campbell and Arbogast 2004; Campbell and Mullen 2004; Toews et al. 2006)

Stored product insect monitoring at other rice mill locations have indicated difference in relative species abundance, but these differences might be due to a combination of geographic location and monitoring method. In this study, food baited traps were used, but in other studies pheromone traps were used for monitoring. In Portugal, Carvalho et al. (2013), using pitfall traps with food and pheromone attractants inside a rice mill, found that *Sitophilus* spp. and *T. castaneum* were the most abundant species captured. In the USA, McKay et al. (2017) used pheromone-baited flight traps outside a rice mill and found that *Trogoderma variabile* was the most abundant species, although this species was not recovered at this rice mill in Brazil. High numbers of *Plodia interpunctella* were also captured in the McKay et al. study, and they were also present at this Brazil rice mill location, but were primarly captured in light traps and not in the bait traps. At the USA rice mill, *R. dominica* was captured in high numbers, but few *Sitophilus* spp. were captured, probably due to the monitoring method. Interestingly, at this Brazil rice mill the insect community inside the rice mill and parboil structures was similar to that in the rough rice areas, although overall numbers were much lower. In other studies, *Tribolium castaneum* is one of the most abundant and economically important pest species inside mills (Buckman et al. 2013).

Activity of stored product insects in this current study and in others has tended to show seasonal patterns. Temperatures inside rice mills tend to track those outside the mills and to be associated with levels of insect activity inside mill (Buckman et al. 2013). Captures of insects at this Brazil rice mill was associated with temperature, but rather than a linear or increasing relationship there appeared to be a threshold below which there was lower insect captures and above which there tended to be a peak in captures around 26°C. It is often difficult to determine consistent relationships with temperature (e.g., Carvalho et al. 2013; McKay et al. 2017) most likely due to other variables such as movement of grain and treatment activity having strong influences on abundance. Outside temperatures and captures of stored product insects in flight traps were positively related at a USA rice mill, but only at temperatures above 15°C and the nature of the relationship varied with species and year (McKay et al. 2017). Given the multi-year duration of this current monitoring study, it provides the opportunity to detect patterns that might otherwise be missed.

Understanding the stored product insect community at a location and its temporal and spatial patterns of distribution provides the foundation for IPM programs. Given the variation among locations this information is important in developing site-specific programs and for the continual evaluation of program success. The data from this study can be further evaluated to relate activity to specific locations and with management tactics implemented during the study. Understanding outside and inside insect activity can provide important insights into the sources of insect infestation and help more effectively target pest management.

## Acknowledgement

We would like to thank Pirahy Alimentos S. A., Brazil, for technical support. This paper reports the results of research only. Mention of trade names or commercial products in this publication is solely for the purpose of providing specific information and does not imply recommendation or endorsement by the U.S. Department of Agriculture. The US Department of Agriculture is an equal opportunity provider and employer.

## References

Buckman, K. A., Campbell, J. F. and B. Subramanyam, 2013: Tribolium castaneum (Coleoptera: Tenebrionidae) associated with rice mills: fumigation efficacy and population rebound. Journal of Economic Entomology 106, 499-512.

Carvalho, M. O., Faro, A. and B. Subramanyam, 2013: Insect population distribution and density estimates in a large rice mill in Portugal. Journal of Stored Products Research 52, 48-56.

Campbell, J. F. and R. T. Arbogast, 2004: Stored-product insects in a flour mill: population dynamics and response to fumigation treatments. Entomologia Experimentalis et Applicata 112, 217-225.

Campbell, J. F. and M. A. Mullen, 2004: Distribution and dispersal behavior of *Trogoderma variabile* and *Plodia interpunctella* outside a food processing plant. Journal of Economic Entomology 97, 1455-1464.

Toews, M. D., Campbell, J. F., Arthur, F. H. and S. B. Ramaswamy: 2006. Outdoor flight activity and immigration of *Rhyzopertha dominica* into seed wheat warehouses. Entomologia Experimentalis et Applicata 121, 73-85.

## From stored-product psocids to the other pests: the developments, problems and prospects on research and application of molecular identification

**Zhihong Li[1]*, Vaclav Stejskal[2], George Opit[3], Yang Cao[4], James E. Throne[5]**

[1]Department of Entomology, China Agricultural University, No. 2 Yuanmingyuan West Road, Beijing, China.
[2]Department of Pest Control of Stored Products and Food Safety, Crop Research Institute, Drnovská 507, Prague, Czech Republic.
[3]Department of Entomology and Plant Pathology, Oklahoma State University, 127 Noble Research Center, Stillwater, Oklahoma, 74078-3033, USA.
[4]Academy of State Administration of Grain, No. 11 Baiwanzhuang Street, Beijing, China.
[5]USDA-ARS San Joaquin Valley Agricultural Sciences Center, 9611 South Riverbend Avenue, Parlier CA 93648-9757, USA.
*Corresponding author: lizh@cau.edu.cn
DOI 10.5073/jka.2018.463.052

### Abstract

Psocids, beetles, moths and mites are regarded as the common kinds of stored-product pests in the world. The rapid and correct identification of stored-product pests is significant for quarantine, monitoring and control purposes. Molecular methods and techniques have been studied and applied for stored-product pest identification. Based on collection and analysis of literature in the last decade, this paper reviews the developments, questions and prospects for molecular identification of stored-product pests. As a representative model, the molecular methods and techniques for species identification of stored-product psocid pests were developed and applied systematically based on international collaboration involving China, Czech Republic, the United States and other countries. More than 10 studies on stored-product psocids related to RFLP, DNA barcoding, PCR, real-time PCR and gene chip have been published during this decade. Subsequently, DNA barcoding, PCR and real-time PCR techniques for the identification of common species of *Tribolium* and *Cryptolestes* pests of stored products have been reported by the same international team. Recently, a web system called Grain Pests DNA Barcode Identification System (GPDBIS) has been established in China using SOL SERVER and C#. Like a marathon that requires persistence, we should do our best to continue to promote research and application of molecular identification of stored-product pests with more international collaboration.

**Keywords:** stored-product pests, molecular identification, review, research, application

Globally, stored-product arthropod pests include a large number of species. The rapid and correct identification of stored-product pests is significant for quarantine, monitoring and control purposes. In recent decades, molecular methods and techniques have been studied and applied for stored-product pest identification. There is quite a substantial amount of literature related to stored-product pests and their molecular identification. In this work, literature from 1900 to 2017 was collected and analyzed using Web of Science (http://apps.webofknowledge.com/). The total count of articles on stored-product pests was found to be 32,123 whereas the total count of articles on molecular identification of stored-product pests was 179. The years with the highest counts for these two categories were 2015 and 2012, respectively. In decreasing order, countries with the most contributions to literature on stored-product insect pests were USA, China, UK and India (Figure 1).