INTEGRATED PEST MANAGEMENT CHALLENGES IN A RETROFITTED BUILDING FOR YALE PEABODY MUSEUM COLLECTIONS

LYNN A. JONES[1] AND RAYMOND J. PUPEDIS[2]

[1] *Yale Peabody Museum of Natural History, Collections and Operations, PO Box 208118, New Haven, Connecticut 06520-8118, USA*

[2] *Yale Peabody Museum of Natural History, Division of Entomology, PO Box 208118, New Haven, Connecticut 06520-8118, USA*

Abstract.—Yale University purchased the Bayer Pharmaceutical facility located in West Haven, Connecticut as part of campus expansion plans. The Yale Peabody Museum of Natural History was allocated 80,000 square feet within one of the building complexes of this facility, which originally was built in 1968. The process of converting this former manufacturing building into usable museum storage space introduced a new scenario for pest management. The goals were: to determine what pests already might be occupying the building and eradicate them, determine ways to seal out future pests, stabilize the climate to decrease pest infestation, and establish a monitoring program. Baseline pest data were collected via trapping throughout museum spaces before, during, and after retrofit construction. In conjunction with proposals from an independent, integrated pest management contractor, data from trapping were used to assess pest problems, and actions to eliminate these pests were initiated. A year-long survey of pests was performed after museum staff and collections occupied the building. The results showed seasonal variation in pest diversity and populations, which indicated the need for further building renovations to help reduce these populations. An outbreak of booklice (Psocoptera) has not responded to initial treatments and remains a concern.

INTRODUCTION

Yale University purchased the 136-acre West Haven facility in 2007 from the Bayer Pharmaceutical Company, incorporating 20 buildings, and naming it West Campus. The original purposes of these structures ranged from state of the art research laboratories to drug manufacturing production lines to an auditorium. The oldest building, circa 1968, contains spaces equaling 80,000 square feet now renovated for the Yale Peabody Museum of Natural History (YPM). These spaces originally were used as offices, drug manufacturing facilities, a cafeteria, and a warehouse; all were converted into collections and office spaces required to house an assortment of YPM specimens, artifacts, and archives. Approximately half of the YPM spaces are underneath a mezzanine, which contains a cement floored mechanical room and open areas with ducting, electrical conduit, and pipes below the roofline. All of these factors presented construction hurdles to the goal of creating a pest-resistant, climate controlled environment suitable for the storage of natural history collections.

The YPM began renovations in April 2008, starting with the demolition of office cubicles, unnecessary walls, and a kitchen. New spaces were retrofitted with new walls, new floors, electrical where necessary, and air-handling intake and outtakes. A second stage, with final electrical installation and troubleshooting occurred over an additional 3-month time frame after some collections materials had been put in place.

In total, portions of eleven different divisions moved from the New Haven campus to the renovated facilities on West Campus. Collections in the Anthropology division housed in the 175 Whitney Avenue were the first to move. Additionally, collections from the divisions of Geology, Invertebrate Paleontology, Vertebrate Paleontology, Entomology, Invertebrate Zoology, Vertebrate Zoology, and Archives housed in the Kline Geology Laboratory (KGL) building were relocated to this new facility. Packing of the anthropology collections commenced in May 2008 and packing of KGL materials began in June 2008. Both of these moves continued over a 14-month period.

Even after the building was in use there were residual issues due to the building's age and changes made during retrofitting. The major issue was leaks found throughout areas of the building and were attributed to different causes. For example, a portion of the roof over one third of the YPM total space was redone to stop leaks in the "southern" portion of the building, which decreased the frequency and severity of problems. There also were leaks related to condensation from roof drains, duct work, and machinery, including a large catch basin located above collections spaces that was found to be leaking in a number of spots. Many of these leaks have been rectified but a few still are being addressed.

The original air-handling system was designed to support the daytime activities of the pharmaceutical company. The machines originally operated for 8 hours before shutting down during off-hours. Current activities of the museum require these systems to now run for 24 hours and their efficacy in maintaining required relative humidity and temperature conditions varies. By monitoring climate data, we were able to use seasonal corrections of air-handling set points to achieve consistency.

Attention to integrated pest management (IPM) concerns influenced each step of construction from planning to initiation. The three basic components of IPM in a museum setting are: prevention, monitoring, and treatment (Pinniger 2001). Pest outbreaks can be prevented by excluding pests from the area where collections are stored and also by creating conditions that, while safe for the objects, are not optimal for the pests (Pinniger 2001). The methods used for monitoring pests greatly depend on the resources available to the museum. The most frequently used method is monitoring with sticky traps, designed to capture insects and rodents. These traps need to be checked and changed at regular intervals or they can become attractants for pests (Alpert and Alpert 1988). Also, objects within the collection periodically should be checked for any infestations. If there is an infestation observed within a collection, the focus turns to treatment options. Historically, pest treatment was in the form of pesticides; pesticides now generally are avoided but still are used in extreme cases. Many laws and human health issues, as well as safety of the collections themselves and the associated costs, have led IPM specialists away from chemical treatments (Strang 1992). Most museums now choose to treat infested objects through cleaning, freezing or anoxia treatments (Kelley 2005).

A successful integrated pest management program contains all of these practices and further relies on the use of staff. Collections staff need to be trained on IPM procedures that they can use in all planning and work related to the museum collections (Pinniger 2001). It is essential that all persons involved with the collections and buildings in which they are housed, are aware of the issues related to the objects being stored. The Yale Peabody Museum used staff knowledge of IPM when retrofitting the West Campus building and in maintaining a collection-safe environment. The priority for collections staff was to monitor for pests in the building that might have been residual from previous tenants. Two trapping surveys were conducted to assess pest problems.

Trapping Study 1

Sticky trap surveys were used to gain baseline data about pests and potential hotspots. One month before construction began, a series of traps was placed throughout the YPM spaces and in adjacent sections of the building. Traps were left in place for 1 week and then examined for any pests. Two months later, during construction, another 1-week trapping survey was conducted; the same locations were used for both periods, and new traps were used each time. When the major construction project was completed, an intensive 3-month trapping series was conducted. Again traps were set for 1 week before being examined; however, trap locations were changed, and no single location was used for 2 consecutive weeks.

Results and Discussion of Trapping Study 1

The initial postconstruction trap data indicated a large population of booklice (Psocoptera), isolated to one collection space and along another hallway, with peak numbers in a fluid preparation workroom. Booklice are known to damage insect collections, and other organic materials, documents, and labels are particularly of concern (Pinniger 2001). High populations of booklice indicate potentially damp and high-humidity conditions present in collections spaces. This situation initiated three responses: 1) the contracting of an outside IPM specialist to survey the building, 2) the formulation of an agendum to take immediate responses to the suggestions in the IPM report, and 3) the creation a comprehensive monitoring program.

Tom Parker of Pest Control Services, Inc. was contracted by the museum to perform a complete interior and exterior building survey to determine potential and current pest problems and look for solutions. Mr. Parker visited the West Campus facility and took a full tour encompassing 2 days. Using the initial pest trap data obtained by YPM staff and his own observations, he supplied a 38-page report, with additional informative appendices, detailing the measures that should be taken to rectify some of the problems. The major issues focused on sealing the "building envelope" and addressing the large population of booklice.

Mr. Parker's report resulted in an initial response to use a nonpesticide treatment in the building areas with high booklice concentrations. This procedure included a heat treatment in which the thermostats were set to maximum endeavoring to obtain a steady 90°F (32°C) temperature. High temperatures theoretically will decrease the relative humidity and eradicate the booklice through desiccation. Unfortunately, the heating system could not reach the optimal heat, attaining only 75–80°F (24–27°C) maxima, which were sustained for a 2-week period. In order to achieve the required temperatures, air returns were sealed and space heaters were placed in the three rooms with highest booklice densities. These rooms then reached the desired 90°F (32°C) temperatures, and conditions were maintained for 4 days to complete the treatment. Because booklice remained after the initial treatment, a second treatment course was chosen: the affected area was sprayed with a pyrethrin insecticide by a licensed pest management company at the suggestion of Mr. Parker. Pesticide treatment is in general a last resort for pest management in a museum setting; thus a pyrethrum derivative was chosen for its low toxicity. Special care was taken to treat only structural elements and not work surfaces.

Trapping Study 2

Upon full-time occupancy of the West Campus facilities, a standardized monitoring program was initiated in August 2009 to evaluate the seasonality of pest populations and any associated problems. Catchmaster Insect Trap and Monitor sticky traps with a 3 inch × 2.5 inch (7.6 cm × 6.4 cm) trapping surface were placed for an approximate 1-month period at predetermined locations throughout YPM spaces. Trap locations were chosen based on the highest potential for accidental nontarget pest entry points and target pest species hotspots, while maintaining a comprehensive sample of the YPM spaces.

After approximately 30 days, the traps were switched out with fresh ones. The used traps were then frozen to kill any live pests caught on the traps and examined as time allowed. Data collected from each trap included the date and location of the trap, as well as the taxa and their abundance. Identification of pests was made to ordinal level and noted to family or below if known by the trap examiner. Traps were examined under a stereo microscope when available; several from the first series were examined by eye.

Concurrently, Onset HOBO data loggers, model: U14-001, were installed in collections areas throughout the YPM spaces. These data loggers record temperature and relative humidity at user-chosen intervals. The software used with these devices graphs the data and also allows exportation of data into an MS Excel file.

Data loggers in YPM spaces were set to record temperature and relative humidity every 30 minutes. Data were continuously recorded and downloaded intermittently in response to observed issues for justification of climate moderation. The air-handling system is prone to influence from outdoor conditions, and seasonal adjustments are needed to maintain temperatures and humidity within safe levels. Data from the climate monitors also was used to assess whether the pest populations were responding to fluctuations of temperature and relative humidity within the rooms. This then could be used to clarify whether the insects were responding to outdoor or indoor conditions. Additionally, baseline temperature and humidity data could be correlated with different pest species outbreaks to determine their specific requirements.

Results and Discussion of Trapping Study 2

Pest issues.—Trapping in almost every space in the YPM areas of West Campus yielded some type of insect activity, from nontarget outside invaders to recognized museum pest species. Most outside nontarget insects (species not known to be pests), represented in traps included ants (Hymenoptera: Formicidae), springtails (Collembola), and ground beetles (Coleoptera: Carabidae). The infestation of booklice in the fluid hallway and the invertebrate paleontology collections room continues to be a major issue. Other problems are the continued invasion of outdoor species and the inability to stabilize climate conditions in areas near collection spaces.

Evidence of the varied carpet beetle (Coleoptera: Dermestidae; *Anthrenus verbasci*) was found on a few occasions, most often as larvae or exuvia. Varied carpet beetles are known pests to natural history collections (Kingsolver 1988). Preliminary trapping has yielded low numbers of individuals, suggesting that a problem does not exist at this point. Evidence of beetle exuvia does indicate a living population of beetles living in the building, and therefore, the potential for infestation of museum specimens exists. The areas in which varied carpet beetles were in evidence are located adjacent to collection spaces; of special concern are the entomology and vertebrate zoology collections, where increased monitoring is required. Increased cleaning of these spaces will be recommended, requiring equipment to be moved from direct contact with the floor. Once again, sealing of external doors in these spaces should reduce the food source by exclusion.

Booklice were collected in almost every room throughout the YPM spaces where trapping was conducted. Most areas had populations low enough for booklice to be of limited concern as pests. Approximately one quarter of the total space had booklice in numbers that create concern for collections. Data indicate that populations peak in these

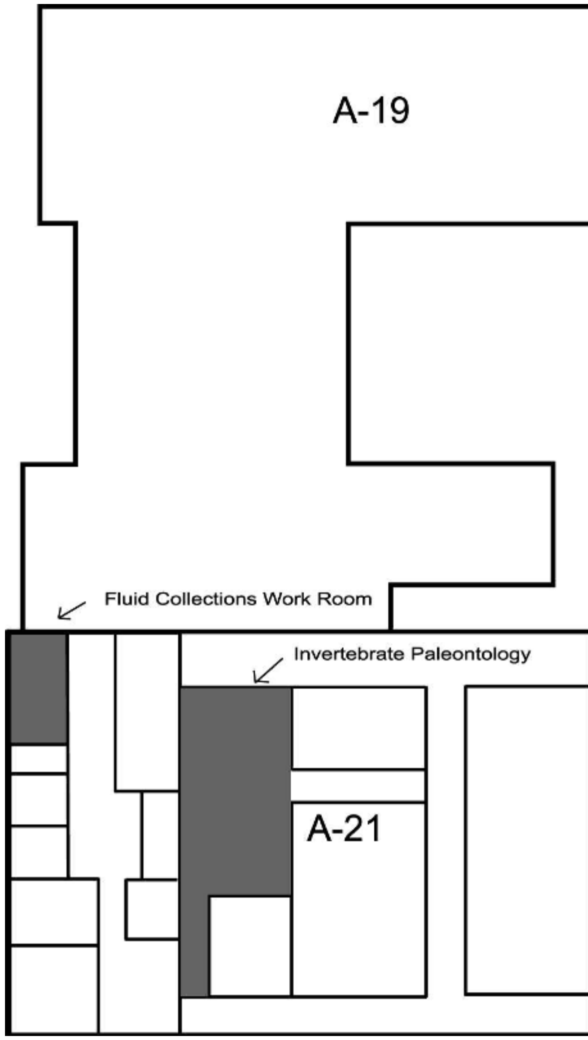

Figure 1. Yale Peabody Museum (YPM) West Campus spaces, illustrating the former building designations. Gray areas indicate booklice hotspots.

areas during the late summer into early fall, reflecting seasonal conditions and the air-handling system's inability to respond to the varying climate. The area of the YPM spaces originally designated as building A-19 (Fig. 1) had comparatively low numbers of booklice collected in traps. The overall abundance and lack of congruity in positive trapping locations indicates further measures do not need to be taken at this time.

Within the YPM area formerly referred to as the A-21 building, which was designed for drug manufacturing, a noticeable booklouse problem occurs (Fig. 1). The north side of the fluid collections hallway and an adjacent work room is one hotspot. Another hotspot is located on the south side of an adjacent hallway and in the invertebrate paleontology collections room. Most traps collected in these areas contained booklice, and included the traps with the highest number collected through out the building. One sticky trap, located to the right of the main door in the fluid collection workroom, peaked at over 500 individual booklice. These were mainly very small individuals, probably early instar nymphs. The trap to the left of the door during this same month also had 235 individuals, also with a large number of nymphs. The number of booklice in traps decreases as distance increases down the hall to the south. This hotspot does not appear to affect any areas to the north. Traps located 15 feet away showed only a slight response to this hotspot.

The invertebrate paleontology collections room also had an increased number of booklice. These also seemed be focused in the south part of the space, as well as the hallway adjacent to the southern double doors. These combined areas have the next highest density, averaging 21 insects per trap, of booklice trapped; some effect is noticed in adjacent collections rooms during peak population blooms.

Building and Operations

Although some renovation actions, such as sealing the building from the outside, have led to substantial decreases in the invasion of outside pests, open access in some areas remains. Additional measures are required to complete the exclusion process in addition to continued maintenance of previous efforts; the primary means of entrance appears to be outside doorways, through gaps under and between doors and through poor framing. Interior collections doors and door sweeps exclude the majority of the pests that enter the building but daily use can potentially increase pest access.

Within these areas another factor might contribute to this problem; during renovations, new walls were constructed, and frequently drywall used in construction still is wet. Wet drywall is a potential source of moisture for booklice. Once the drywall has fully cured and all moisture has naturally left, the habitat should no longer be optimal for this pest and the situation will resolve itself.

Parts of the fluid collections and invertebrate paleontology section of the building are directly underneath an open mezzanine that allows facilities access to the air handling, water, and steam pipes which run above the drop ceilings. The gap between the ceiling in these spaces and the roof is approximately 20 feet. Much of this space is filled with pipes, duct work, and walkways. The remainder of these areas is underneath a closed mezzanine, with air handling units and a large cement catch basin to collect condensate runoff. The open mezzanine section is not a clean area and that is a result of the following complications. Constant maintenance is required for the approximately 40-year-old systems and this area is accessed frequently by people making repairs. The roof was recently redone to fix the constant leaking occurring during winter snow melt and heavy rainstorms. During the roofing project, debris fell onto the top side of the drop ceilings. The collections spaces themselves were protected during this project by sealing the rooms with TuffWrap, sheets of a plastic material professionally installed, at the ceiling level. Finally, cleaning is not a priority because this is a mechanical area, even though it is separated only from collections spaces by a level of ceiling tiles.

Leaks are a recurring issue in many of the spaces, especially in the "A-21" area, compounding the moisture problem, reflected in the booklice population. Roof leaks mostly were fixed with the roofing project, although a few continue. Ineffectively insulated air handling duct work has resulted in leaks as temperature fluctuations create condensation, either by an absence of insulation or deterioration. Some roof drains run directly through collections spaces creating condensation and puddles; these pipes are currently being insulated. Leak locations do not correlate with booklice outbreaks and likely are not a cause for this issue, but might contribute to the high booklice populations in other sections of the building.

A more important problem is the presence of the large catch basin for the runoff of air-handling system condensate runoff. This essentially is a large cement wading pool. One of the primary leaks in a collections space is tied directly to this basin, which was empty when the systems were not in use. Once these systems are running, leaks in the basin have become apparent and are now a source of water in one collection space. These all are sources of moisture for insects, and reduce the chance of desiccation, regardless of the building's relative humidity.

Conclusions

It is imperative that additional measures are taken to exclude insects and other pests from the entire building, by "sealing the building envelope." Door jambs, door and window seals, and door sweeps all should be re-examined for access points and fixed by recaulking framing and adding or repairing existing door sweeps. All collections areas should continue to be frequently cleaned, eliminating potential food sources that entice pest species. Collections staff must maintain a vigilant eye on the work of cleaning crews to ensure its adequacy. Management also should examine the possibility of cleaning areas above the collections space, specifically the mezzanine area. As is already in progress, all leaks should be rectified immediately, not only because they provide a source of moisture for pests, but they also potentially raise humidity in collections areas. High moisture areas also encourage mold growth, which is an additional food source and enticement for numerous pest species.

Booklice are the major concern in the retrofitted YPM spaces, because these insects are a known pest on insect collections, animal hides, and papers. It is possible that this problem will resolve itself as conditions stabilize and newly installed drywall dries out. A comprehensive monitoring program must be initiated to track the booklice population fluxes. Another treatment of pesticides administered by licensed technicians should be applied just prior to the observed population peak. This should reduce the current population, and with early instar die-off decreases the next generation's numbers.

Retrofitting existing buildings for natural history collections storage is a feasible plan from an IPM standpoint with varying concerns that should be assessed before collections are put into place. As is seen from the experiences of YPM staff, additional efforts to fix existing issues can require novel methods. Final recommendations for other institutions attempting a similar project are this: existing doorways and hardware inevitably will need to be overhauled to exclude pests; air-handling systems will require constant monitoring; and large-scale projects, such as a new roof, might be necessary to rectify issues that, while manageable for a common area, are not sufficient to house collections. A preparatory period to run all of the systems to see how they respond to seasonal changes is essential to stop many leaks prior to occupation. This time interval also would allow staff a chance to gain baseline pest data and perform necessary treatments of affected areas before collections materials are exposed to the pests and the treatments. Even these additional preventative measures will not solve all issues, and monitoring and maintenance will be required to insure the preservation of the natural history collections.

Literature Cited

Alpert, G. and L.M. Alpert. 1988. Integrated pest management: A program for museum environments. Pp. 169–173 in *A Guide to Museum Pest Control* (L.A. Zycherman and J.R. Schrock, eds.). Foundation of the

American Institute for Conservation of Historic and Artistic Works and the Association of Systematics Collections, Washington, DC. 205 pp.

Kelley, P. 2005. Treatment of museum collections for pests: preserving our history. http://www.insectslimited.com/Treatment of Museum Collections for Pests-Kelley.pdf (9 June 2009).

Kingsolver, J.M. 1988. Illustrated guide to common insect pests in museums. Pp. 53–81 in *A Guide to Museum Pest Control* (L.A. Zycherman and J.R. Schrock, eds.). Foundation of the American Institute for Conservation of Historic and Artistic Works and the Association of Systematics Collections, Washington, DC. 205 pp.

Pinniger, D. 2001. *Pest Management in Museums, Archives, and Historic Houses*. Archetype Publications, London, England. 115 pp.

Strang, T.J.K. 1992. A review of published temperatures for the control of pest insects in museums. Collection Forum 8, (2), 41–67.