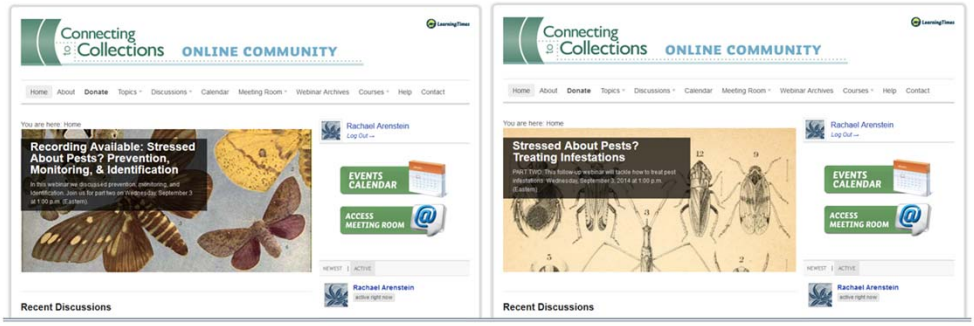
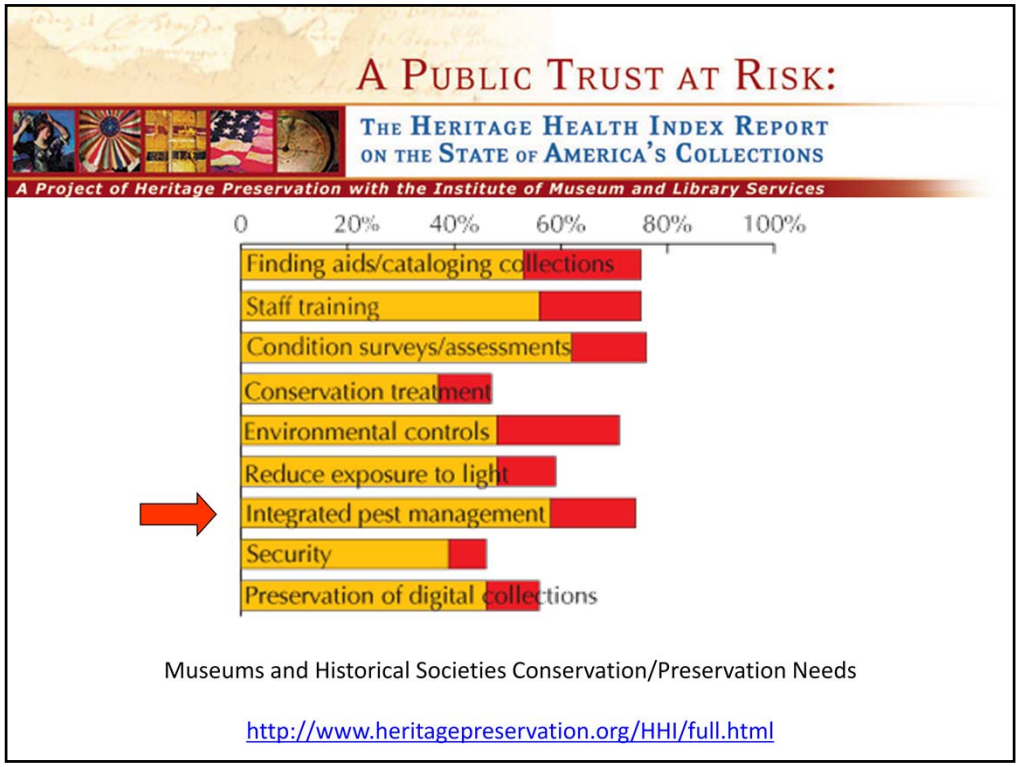
STRESSED ABOUT PESTS?
PART II – Treating Infestations



Connecting To Collections Online Community Webinar
September 3, 2014

Rachael Perkins Arenstein, A.M. Art Conservation LLC

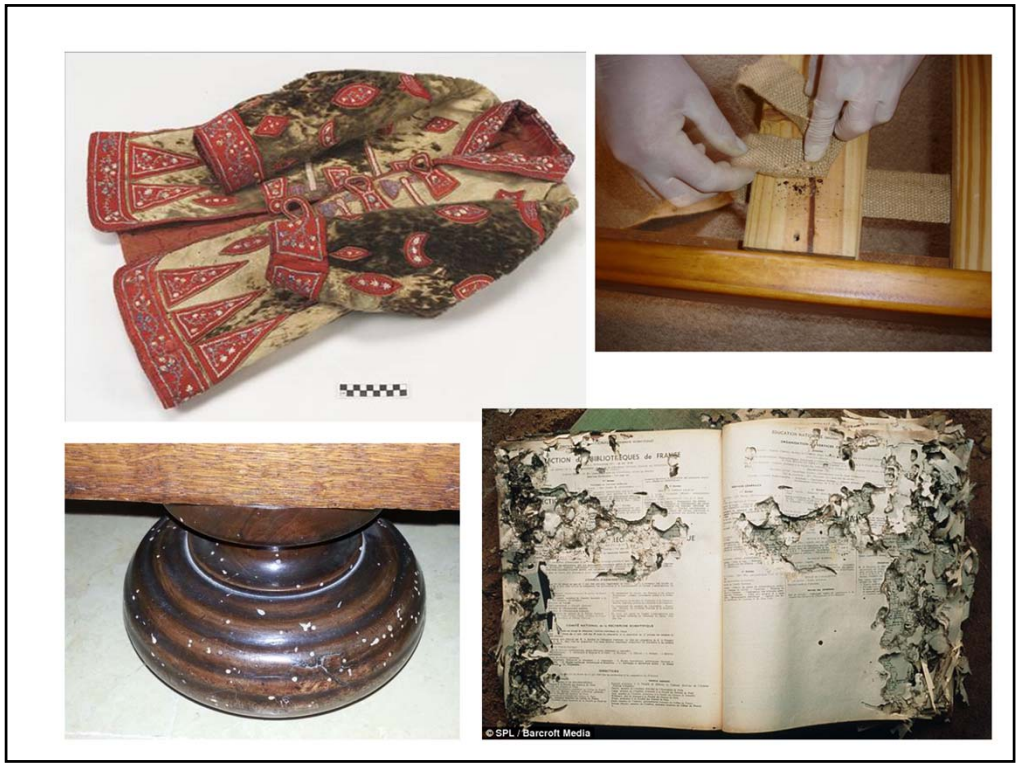
Thank you Jessica and welcome everyone to the second webinar in this short series on pest management for cultural collections.



Since this webinar is a Heritage Preservation presentation I thought it appropriate to start with some data from HP's 2005 Heritage Health Index 2005 survey. This was the first comprehensive survey to assess the condition and preservation needs of U.S. collections and it revealed that the most urgent preservation need at U.S. collecting institutions is environmental control which, for the purposes of this project, encompassed temperature, relative humidity, light, pollutants and pest control. In a breakdown that examined the needs of museum and historical societies that together account for 22% of the 4.8 billion collections items in the United States, approximately 75% of these institutions require an integrated pest management program with 20% of that being an urgent need.

HP is now gearing up for a 10 year follow up of the Heritage Health Index and it will be interesting to see what progress has been made in the past decade. Hopefully many of your institutions will be participating in this important project.

You can find summaries of the HHI indexed by topic as well as the more in depth analysis of the survey results on the HP website – http://www.heritagepreservation.org/HHI/full.html



The great need for information and assistance in this area of collection care is no surprise to anyone who has dealt with an infestation. Museum professionals including conservators, collection managers and curators increasingly know that insect and rodent pests can cause major damage to collections of all types. And… it's gross. Thus, when time, staff and resources are in short supply, pest management becomes an easy project to defer. That is… until you can't avoid it any more. And that is what we are going to talk about today!

These pictures show a few dramatic examples of pest activity or damage including:

- Top left: a fur coat which has been almost entirely denuded of its dark brown hair
- Top right: insect activity on the backing of a painting frame
- Bottom left: insect holes in wood furniture
- Bottom right: extensive damage to this book

Past Treatment with Pesticides & Chemicals

In the past, collections were commonly treated with pesticides and poisons. Over time though we've realized the damage that this has caused to the collections and the danger it poses to the environment and to us and so the arsenal of chemicals has gotten smaller. Sadly, this isn't the case everywhere and this past Fall there was a tragedy here in Israel where I am currently living where children were killed due to an inappropriately applied pesticide treatment in a home.

INTRODUCTION

What is Integrated Pest Management (IPM)?

IPM is basically a strategy that emphasizes prevention and minimizes the use of toxic chemicals to manage and eliminate pests.

As a result, over the past decades we have begun to shift from remedial chemical treatments to focusing on a range of prevention techniques that utilize knowledge of insect biology, behavior and ecology that, put together, form a strategy called Integrated Pest Management.

What are the components of an IPM Program?

A functional IPM plan works to reduce the possibility of pests accessing collections by:

1. Preventing access
2. Monitoring for activity
3. Identifying finds
4. Remediating (treating) infestations as necessary
5. Educating staff and evaluating results

Image courtesy Patrick Kelley, Insects Limited, Inc.

The components of an IPM program:

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Last week, in Part I of this webinar series Pat Kelley, Vice President of Insects Limited, discussed…

Who is on the IPM Team?

- Select a point person for the IPM Team
- But everyone has a role to play.
  - Administration
  - Visitor Services
  - Building Management
  - Registrar
  - Maintenance
  - Pest Control Professional

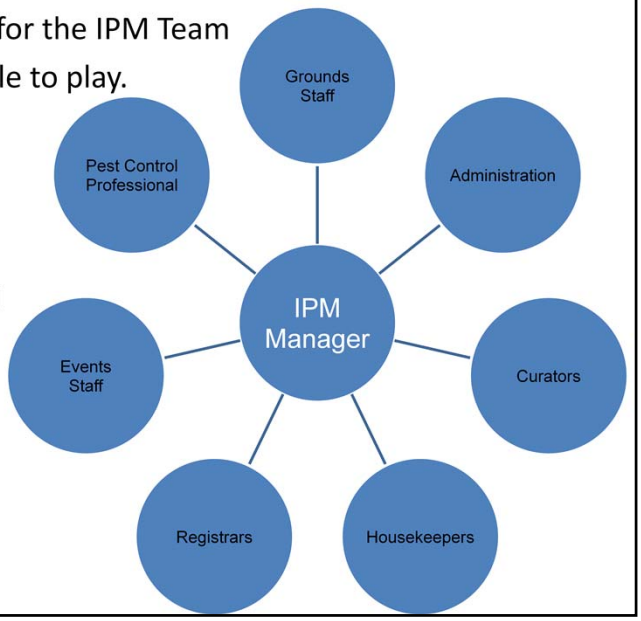


Image courtesy Patrick Kelley, Insects Limited, Inc.

Setting up an IPM team in your institution

A ¼ inch gap is all a mouse needs to enter a structure

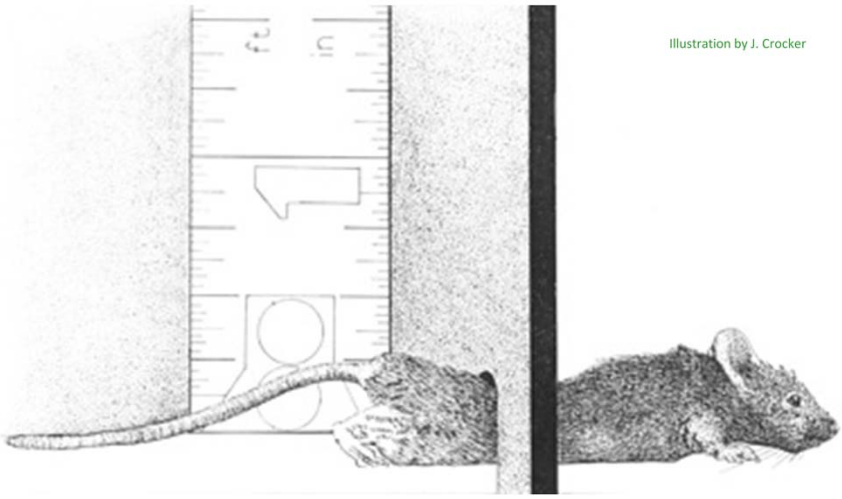


Illustration by J. Crocker

Image courtesy Patrick Kelley, Insects Limited, Inc.

Prevention tips for excluding pests from your building,

How to Use Pheromone Traps to Locate an Infestation

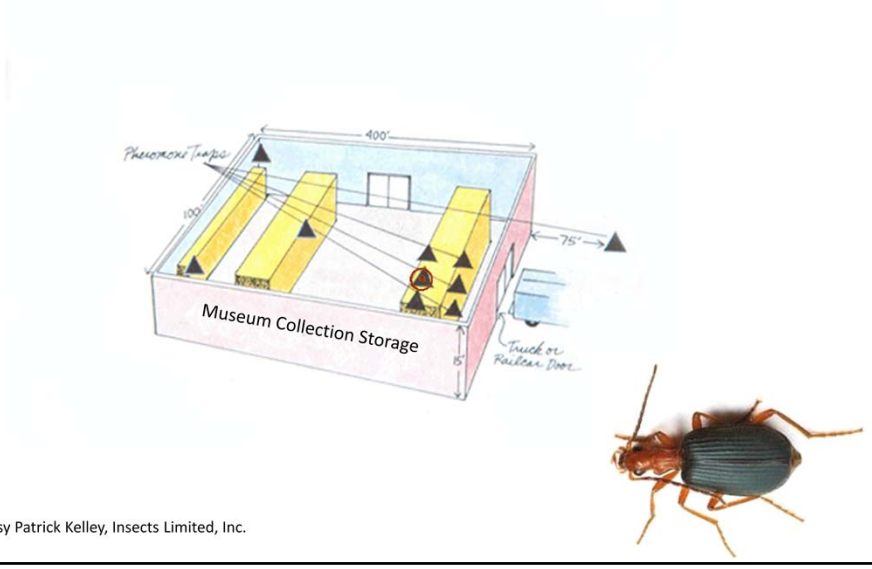


Image courtesy Patrick Kelley, Insects Limited, Inc.

How to use various types of sticky traps and pheromones to monitor for activity

Clothes Moths

Webbing Clothes Moth *Tineola bisselliella*

Casemaking Clothes Moth *Tinea pellionella*

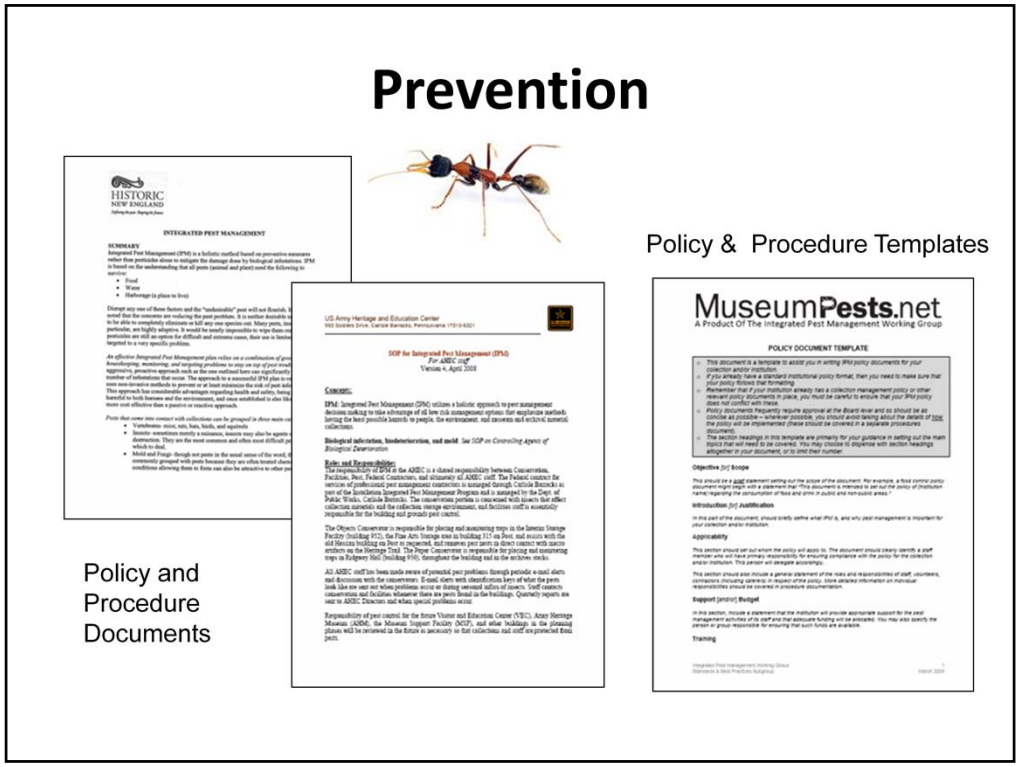
Image courtesy Patrick Kelley, Insects Limited, Inc.

And the identification of some of the most damaging museum pests.

Pat or I could easily give a one hour webinar on each of those topics. But instead of panicking that we didn't address all of your questions what we want you to know is that there is a lot of useful information out there to help you. The reason I'm here on this panel today is because of my involvement in founding the Integrated Pest Management Working Group, which is an ad hoc group of museum and pest professionals who have been meeting for the past eleven years, initially to collaborate in dealing with our own institutional pest problems, and eventually evolving into creating resources to help others identify and manage their pest issues.

We created the free PestList listserv which allows for communication on IPM concerns between 600 museum staff, entomologists and pest management professionals worldwide.

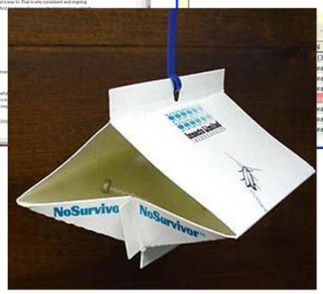
And the museumpests website with extensive information and resources for each element of a sound IPM program. So, while we can only put a small amount of information into a one hour webinar, our collective knowledge base is online – let me just show you a few resources.

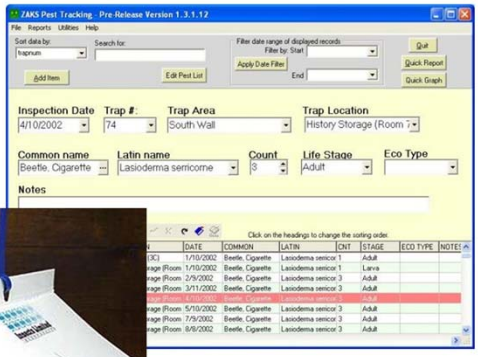


We have information on prevention techniques – both physical and procedural. Last week there were several questions on how to design buildings or spaces with IPM in mind and we have a section on the building envelope, understanding the nature and vulnerability of your collection and more…

Monitoring & Data Analysis

Monitoring webpage





Data collection tools

Tips for monitoring including trap selection, use of pheromones and aids for collecting and analyzing your data.

Identification Aids

MuseumPests.net
Integrated Pest Management Working Group

Odd Beetle
Thylodrias contractus (Motschulsky)

DANGER
Extremely Damaging Museum Pest

GENERAL INFORMATION

What makes the odd beetle so odd is its sexual dimorphism; the male and female of the species look nothing alike. Though the adult female is larviform in appearance it is characteristically different from the larvae as well. Larvae themselves do not appear sexually dimorphic. Though similar in appearance to other carpet beetle larvae the odd beetle is distinctive in that they lack long hairs at the tip of the abdomen and the upper body is not covered with short hairs. Rather a row of hairs arise at each segment as noted in the Diagnostic Morphology section. When disturbed the larvae curl into a C or crescent shape.

Native to Central Asia they must be introduced in order to disperse. This is largely due to the female's inability to fly. Now widely found throughout cultural institutions and other areas, they are described as a cosmopolitan species. It is likely that the species is dependent upon humans and building environments in North America.

DIAGNOSTIC MORPHOLOGY

Adult:

- Adult Male: Resting elytra meet at along top third of length, then diverge to reveal abdomen. "Long narrow body with thin appendages
- Adult Female: Wingless and larviform shaped body
- Both: 2-3mm in length - Thinly covered with short, pale hairs- clubbed, 9 segmented antennae uniform in thickness along length. - Median ocellus

Larvae

- full size ~ 3mm
- Single transverse row of hairs across the dorsum at each segment.

SIGNS OF INFESTATION

Signs of odd beetle infestation will most likely be in the form of damage to specimens and frass, the coarse skins from larval moults. Objects and specimens with hair will often be surrounded by severed hairs along with frass. As the males can fly, in some rare instances flying adults may be observed.

FOOD SOURCES

In the past the odd beetle was often referred to as the "insect paper beetle" because of early literature describing an outbreak in insect paper permanently identifying the paper as the food source. It is now thought that the beetles were feeding on whatever was in the paper. Their primary dietary preference is dried animal matter. This makes natural history collections particularly susceptible to odd beetle infestation. This includes skins, hides, fur, feathers, insect collections, and natural fiber fabrics such as silk and wool. Infestations have been observed in collections of bird nests. Odd beetles have also been observed burrowing into bone where it is thought they are attracted to the marrow or dried tissue.

LIFE CYCLE

The life cycle of the odd beetle lasts for approximately one year or slightly longer. The eggs are elliptical and a translucent white in color. They are 1mm long. After 25 – 30 days the larvae emerge. They will live the majority of their life as larvae (242-302 days), entering a short pupae stage (7-14 days) just before adulthood. The life expectancy of the adult itself is varied, living as short as nine days or surviving as much as fifty days.

CONTROL & TREATMENT

Due to the fact that females are flightless and must be introduced into a collection, prevention is the first line of defense against the odd beetle. However, once an infestation has been found thoroughly inspect and identify the scope of the infestation. This includes all storage cabinets, dermest and/or display cases. When treating an infestation be sure to include nearby cracks and crevices where pupae may be deposited.

MuseumPests.net
Integrated Pest Management Working Group

Casemaking Clothes Moth
Tinea pellionella (Linnaeus)

DANGER
Extremely Damaging Museum Pest

GENERAL INFORMATION

Tinea pellionella is worldwide in distribution. Its common name of casemaking clothes moth comes from the fact that the larvae will carry a silken case with it throughout the entire larval stage until it finally uses the case to pupate in. The case consists of silken material produced by the larva intertwined with fibers from the material it is feeding on. As the larva grows, it will enlarge the case by making a slit on both sides of the case and inserting triangular sections of new material. In this stage (where it will increase the length of the case by adding new material to either end. If the case is removed from the larva when it is near pupation it will die. The larva will drag the case with it as it feeds. It will thrust out its head and thoracic legs and pull the case along with it. Immediately prior to pupation, the larva will often seek a protected site such as a crevice, wall or often the ceiling of the room of the infestation.

DIAGNOSTIC MORPHOLOGY

Adult:

- Body and wings are colored buff to golden with a brownish tinge
- Three dark spots on each front wing
- Wings are long and narrow
- Hind wings are fringed with long hairs
- 10 - 14 mm wingspan (3/8 - 1/2 in.)

Larvae

- Pale yellow in color when hatched
- As it ages it turns more white with brownish head
- Larva will always drag its silken case around with it

SIGNS OF INFESTATION

Unlike the webbing clothes moth, the Casemaking clothes moth larva will rarely spin a web on the material on which it is feeding. The larva of the Tinea pellionella will feed in a random pattern over its food source, pulling its case behind it. The amount of damage done to the material is based directly on how much time it spends in any one location. Fecal pellets from the feeding larvae will drop beneath the material or fall into folds and crevices in the textiles, rugs and furs. The cases for the pupating moths will often be attached to the wall or ceiling around the infested material. Sometimes the pupal cases will be attached to the material itself, attached only by a silk thread produced by the larva. Where webbing clothes moths (Tineola bisselliella) will often integrate their pupal cases into the fabric or fur that it feeds upon, the case for the casemaking clothes moth is distinctly separate if attached at all.

FOOD SOURCES

The food sources for this pest are wide. Potential foods could be any farthar material, woolens, rugs, furs, hair and furs (This includes animal mounts and fur garments). It is reported that it will also feed on spices, tobacco, hemp and skins.

LIFE CYCLE

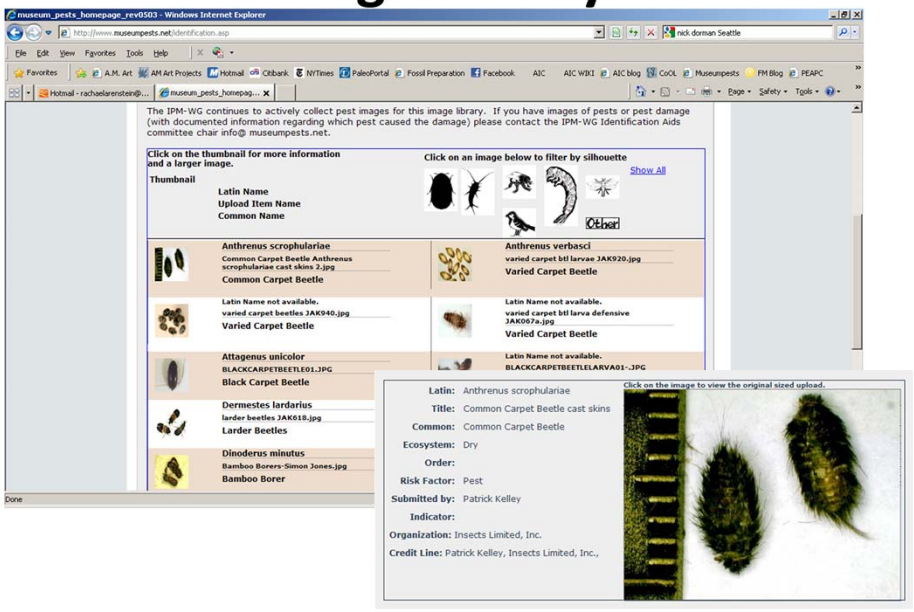
The gravid female moth will lay 37 - 40 eggs randomly over potential food sources. The eggs will hatch in 4 - 7 days. The larval stage builds a case of silk which it enlarges as it grows. The larval stage will last from 61 - 87 days. Prior to pupation, the larva will often migrate to a protected area to pupate. The whole pupation period will last 9 -19 days. The adult moths will only live 4 - 6 days. The males will be active fliers searching out the females, which generally remain stationary. A typical population will have 3 - 4 generations per year.

CONTROL & TREATMENT

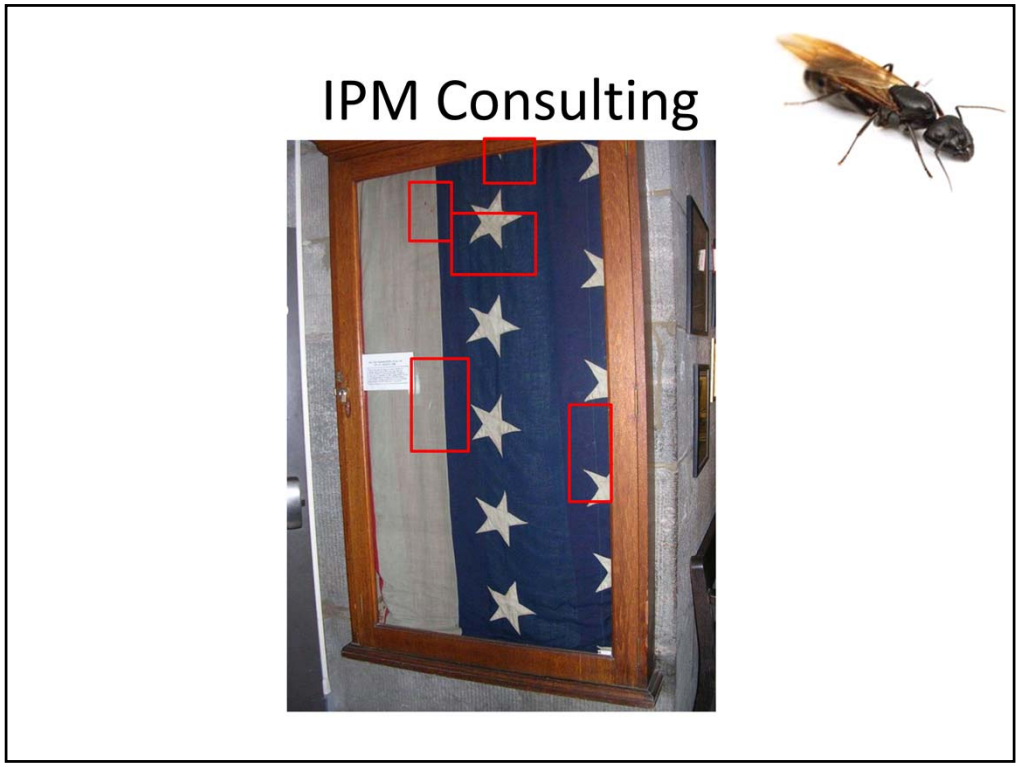
Standard control and treatment methods for museum pests will generally control this pest.

Identification aids such as our pest fact sheets that are geared to what you need to know in a museum, library or historic home environment.

Image Library

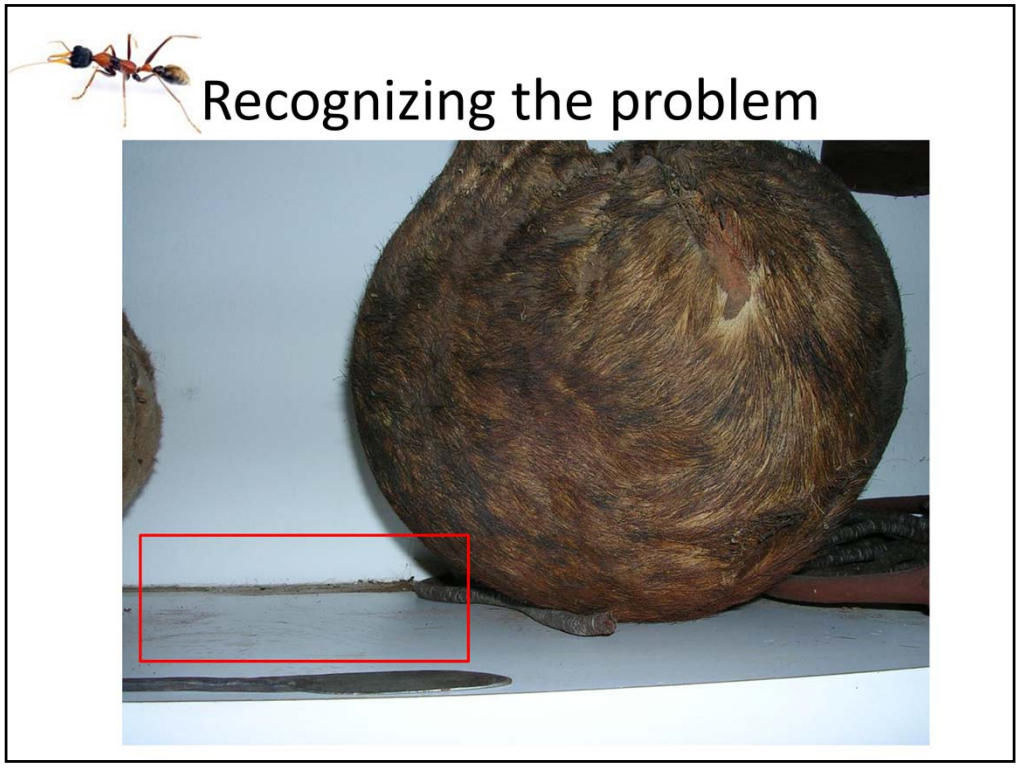


And an image library



But today our topic is remediation. And of course, on the website we continue to build up our information on choosing and carrying out remedial treatments when they are necessary. So let's talk about… how do we know treatment is necessary.

In the past 10 years in private practice my business partner Eugenie Milroy and I have worked with a large number of small to mid-sized museums and we have found that virtually every one has some sort of pest issue – whether insects or rodents. What it took us some time in the beginning of our careers in private practice to realize though was that most institutions didn't even recognize the extent of their problem or how extensive the damage was. For instance the holes in the fabric of this flag were thought to be age or even light damage, not grazing from pests.



This debris here was thought just to be dust and some loose hair rather than frass and substantial hair loss from an extensive infestation.

Institutional Challenges

- Understaffed
- Elderly staff
- Under-resourced
- Overcrowded
- Grossed out

Many of these institutions share some basic challenges:

- Understaffed
- Elderly staff
- Under-resourced
- Overcrowded
- Grossed out

Let's face it, bigger institutions have the same issues but they are acute when you have a staff of three.

Basic Mistakes

1. Bad online information

2. Inappropriate products

3. Not considering health and safety of staff

Even the institutions that are doing OK in some basic preservation categories and know that managing pests is important are making some basic mistakes:

1. They are getting bad online information – for instance using sprays meant for personal use on collection items
2. They are using inappropriate products – often thinking that natural products are safer for collections and staff
3. And they don't always recognize the dangers of products used in the past or why they shouldn't be using those pesticides now

How do we identify an infestation?

- Finding live insects or larva
- Frass (bug excrement) – which often looks like grains of sand
- Exit holes – round or oval holes seen mostly on wood artifacts
- Larval casings – look like larva but are their shed skins
- Webbing – sticky moth webbing found on textiles
- Grazing – pests eating the surface of collections

So let's talk about how we identify an infestation. We know from analyzing our website statistics that most of our new visitors are jumping immediately to the identification and solutions pages suggesting to us that they are tackling this problem out of an immediate need.

What happens if we find pests or evidence of pests in the building?

- Don't panic!
- Notify your IPM Coordinator who will contact your Pest Control Professional and/or conservator
- The IPM team will need to ask the following questions:
  - What is the pest?
  - Is it a casual visitor or is it breeding within the building?
  - How many are there?
  - If it is evidence of activity (e.g. frass, webbing, grazing) is it new or leftover from a prior infestation?
  - How many objects are affected?
  - Is the problem in the fabric of the building itself?
  - Is the problem confined to a contained area?

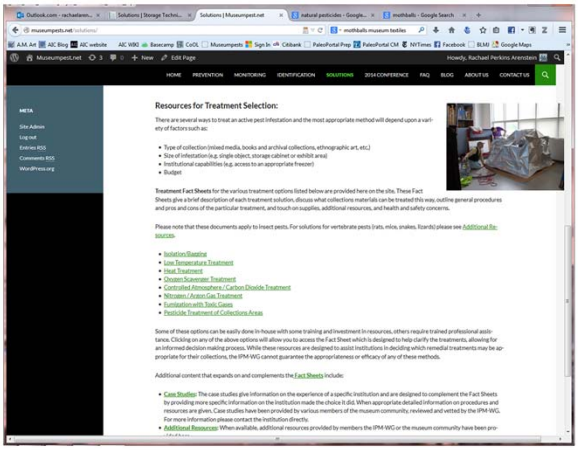
When someone in your institution calls you to say they found a bug – these are the questions that you need to ask them or yourself to figure out what the next steps are.

Treatment Options

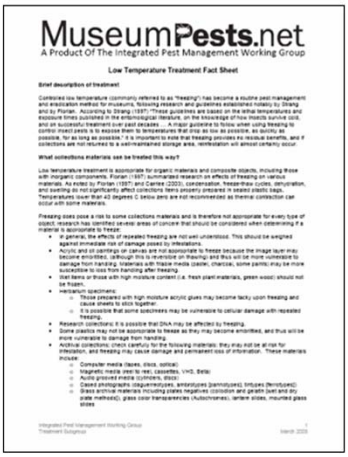
- Isolation
- Temperature Manipulation
  - Low Temperature/ Freezing
  - Heat Treatment/ Thermo-Lignum
- Anoxia
  - Oxygen Scavengers
  - Carbon Dioxide
  - Nitrogen & Argon
- Chemical Treatments
  - Pesticides
  - Fumigants

Here is a basic overview of the various remedial options. It would be impossible in one hour to teach how to conduct these treatments. What I hope you will take away from this is an understanding of some of the pros and cons of these various solutions

Solutions



Treatment fact sheets and case studies



MuseumPests.net
A Product Of The Integrated Pest Management Working Group

Low Temperature Treatment Fact Sheet

Brief description of treatment

Controlled low temperature (commonly referred to as "freezing") has become a routine pest management and eradication method for museums, following research and guidelines established notably by Strang and by Florian. According to Strang (1997) "These guidelines are based on the lethal temperatures and exposure times published in the entomological literature, on the knowledge of how insects survive cold, and on successful treatment over past decades. ... A major guideline to follow when using freezing to control insect pests is to expose them to temperatures as low as possible, as quickly as possible, for as long as possible. ... It is important to note that freezing provides no residual benefits, and if collections are not returned to a well-maintained storage area, reinfestation will almost certainly occur.

What collections materials can be treated this way?

Low temperature treatment is appropriate for organic materials and composite objects, including those with inorganic components. Florian (1997) summarized research on effects of freezing on various materials. As noted by Florian (1997) and Cairnes (2003), condensation, freeze-thaw cycles, dehydration, and swelling do not significantly affect collections items properly prepared in sealed plastic bags. Temperatures lower than -20 degrees C below zero are not recommended as thermal contraction can occur with some materials.

Freezing does pose a risk to some collections materials and is therefore not appropriate for every type of object; research has identified several areas of concern that should be considered when determining if a material is appropriate to freeze:

- In general, the effects of repeated freezing are not well understood. This should be weighed against immediate risk of damage posed by infestations.
- Acrylic and oil paintings on canvas are not appropriate to freeze because the image layer may become embrittled, (although this is reversible on thawing) and thus will be more vulnerable to damage from handling. Materials with friable media (pastel, charcoal, some paints) may be more susceptible to loss of media from repeated freezing.
- Wet items or those with high moisture content (i.e. fresh plant materials, green wood) should not be frozen.
- Herbarium specimens:
  - Those prepared with high moisture acrylic glues may become tacky upon freezing and cause sheets to stick together.
  - It is possible that some specimens may be vulnerable to cellular damage with repeated freezing.
- Research collections: it is possible that DNA may be affected by freezing.
- Some plastics may not be appropriate to freeze as they may become embrittled, and thus will be more vulnerable to damage from handling.
- Archival collections; check carefully for the following materials; they may not be at risk for infestation, and freezing may cause damage and permanent loss of information. These materials include:
  - Computer media (tapes, discs, optical)
  - Magnetic media (reel to reel, cassettes, VHS, Beta)
  - Acetic grooved media (cylinders, discs)
  - Cased photographs (daguerreotypes, ambrotypes (painted)), tintypes (ferrotypes))
  - Glass archive materials including plates negatives (collodion and gelatin (wet and dry plate methods)), glass color transparencies (Autochromes), lantern slides, mounted glass slides

The goal of the solutions fact sheets and case studies on the museumpets.net site is to help you make an informed decision about treatment in conjunction with a conservator or pest management professional.

Isolation & Monitoring

Why isolate?

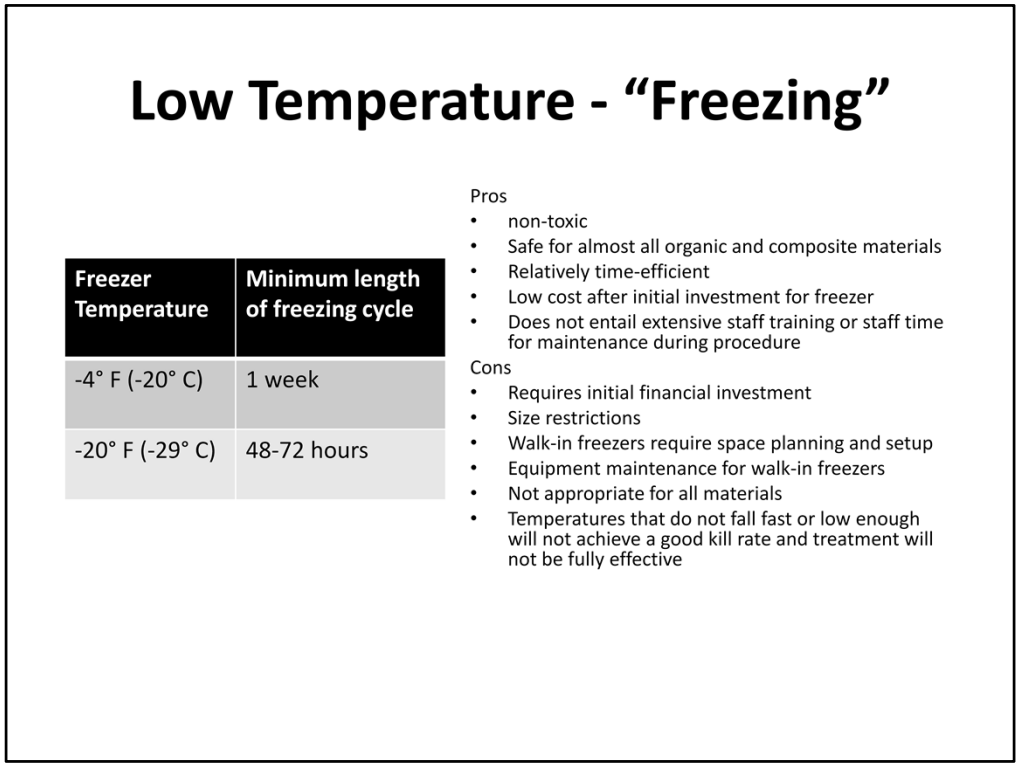
If you are have a question whether an infestation is active it is prudent to isolate the items. Many collecting institutions routinely quarantine, inspect, and clean items entering the museum to avoid introducing insect pests to the rest of the collection. Some items are relatively easy to inspect, and may not need quarantining. Others, such as those with complex structures with hidden areas, are difficult to thoroughly inspect. In these cases, isolating by bagging and monitoring is a useful procedure.

General procedures

- Item is placed on a white sheet – blotter paper, paper board, or tissue, or foam – and then sealed in a polyethylene bag.
- Over a period of several weeks or months, the item can be monitored for signs of infestation, which will be more visible on the white sheet.
- These signs can include the presence of live adults, cast-off larvae skins, or deposits of frass, webbing or casings.
- If the type of insect is known, then refer to the literature and determine the life cycle and ensure that the amount of isolation time covers the time needed for adults to hatch.

Treatment – Low Temperature "Freezing"

- Pros
  - Procedure is non-toxic to humans
  - Safe for almost all organic and composite materials
  - Relatively time-efficient
  - Low cost after initial investment for freezer
  - Some freezers can be modified to reach appropriate low temperatures
  - Does not entail extensive staff training or staff time for maintenance during procedure
- Cons
  - Requires initial financial investment
  - Some smaller freezers are not large enough for oversized items
  - Walk-in freezers require space planning and setup
  - Some maintenance is often required for large walk-in freezers
  - Not appropriate for all materials
  - Temperatures that do not fall fast or low enough will not achieve a good kill rate and treatment will not be fully effective



Freezer treatment, also called low temperature treatment: Freezing is the method of choice for treating most active insect infestations of objects.

Pros
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Recommended freezer temperatures and associated freezing cycles:
-4° F (-20° C) for 1 week
-20° F (-29° C) – for 48-72 hours
Dr. Tom Strang the conservator and scientist who has really written the book on this has re-emphasized on the PestList recently that if you are following these general guidelines that a second freezing cycle is not necessary.

The object must **rapidly** reach the freezer temperature **within six hours**, and stay at that temperature for the amount of time needed to kill insects at all life stages, such as larvae and pupae. **The time needed is dependent on the type of material being frozen and its packaging.** For example, a large package of pressed herbaria specimens will take longer to reach the freezer temperature than a single herbarium sheet.

Chest Freezer

Household Deep-Freezers:
Household deep-freezers that operate between minus 4 degrees F (minus 20 degrees C) and minus 13 degrees F (minus 25 degrees C) can be very effective, and are usually less expensive than commercial freezers. Most household freezers are “frost free” which is acceptable. While there has been some anecdotal concern about the defrost 'warming' cycles, these are of relatively short duration, and the general response time of bagged materials commonly 'frozen' is comparatively longer than the warming phase. The target insects will generally be kept cold though the cycle by the cooling or cold object and will experience the lowest temperatures the freezer can offer. They will have been immobilized early in the cooling.

Commercial freezers and Chest Freezers:
Commercial freezers and “top of the line” household chest freezers can usually achieve the necessary temperatures to ensure kill rates. Commercial “ice-cream hardening” freezers in vertical or horizontal configurations are designed to operate at minus 44 degrees F (minus 42 degrees C) and may not be much more expensive than standard commercial freezers. It is recommended that performance be monitored with a separate thermometer. Ensure that the freezer is well insulated, and provide for adequate air circulation inside the freezer around collections mate

Wrap the object in acid-free tissue paper and seal in a polyethylene bag before placing in freezer. Place flexible or delicate objects on a handling board or in a box.

Use a remote reading thermocouple or indoor-outdoor thermometer to determine if the object has reached the correct temperature.

Walk-in freezer

Walk-in Freezers:
Some walk-in laboratory freezers allow users to set the operating temperature, this can also be specified in advance when purchasing a freezer. Work with your freezer vendor/technicians to make sure you can achieve temperatures cold enough. The same guidelines about temperature apply to all types of freezers. “Air-blast” freezers are preferable because their forced air circulation increases the cooling rate. It is not necessary to set temperatures below minus 40 degrees F (minus 40 degrees C) to increase the effectiveness of using freezing to kill insects.” minus 20 degrees F within four hours. If the unit takes longer to reach this temperature then the treatment time should be increased to at least one week. Low temperatures may be compromised if doors are opened for long periods of time during loading.

Check local vendors and manufacturers for “off the shelf” and custom-designed units. Thermometers on outside of freezer to monitor interior temperature are recommended.

Walk-in freezer

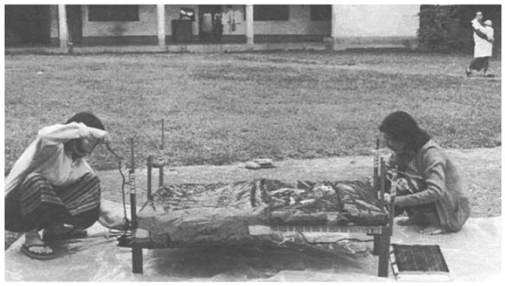
After the allotted time, remove the object from the freezer and leave in the packaging for a minimum of 24 hours, until it has reached room temperature.

If possible, isolate the object following treatment to ensure that treatment was effective.

Freezer Trucks and Frozen Food Warehouses:
Frozen food warehouses and their freezer trucks can be useful for low temperature treatment of large quantities of material or for when other freezing options are not available. The warehouse or truck must be capable of reaching and maintaining a temperature of minus 20 degrees F (minus 29 degrees C). Frozen food warehouses and freezer trucks used by frozen food processors/storage firms are designed to reach only 0 degrees F (minus 18 C) , which is cold enough to preserve food but not to eliminate the various stages of insect pests within a 72 hour period. Ideally the warehouse or unit should reach the desired temperature of minus 20 degrees F within four hours. If the unit takes longer to reach this temperature then the treatment time should be increased to at least one week. Low temperatures may be compromised if doors are opened for long periods of time during loading. Large quantities of materials should be palletized and shrink wrapped. Shrink-wrapping helps to allay fears owners of the building or truck may have about insects escaping the load during treatment. Items to be placed in modified shipping containers or freezer trucks should be placed on pallets to maximize air circulation with the unit. The unit should be loaded as quickly as possible.

Frozen Food Shipping Containers
Insulated frozen food shipping containers, which are capable of maintaining the desired 20 degrees F (minus 29 degrees C) temperature, may be available for rent from dockside firms. This option may be suitable for institutions located near seaports. Rates are usually charged on a monthly basis. The firm will transport and drop the shipping container in your parking lot and pick it up when the treatment has been completed. A steel shipping container is usually 40' long x 8' wide x 9.5' tall (roughly 3,000 cubic feet of space.) Items should be placed on pallets to maximize air circulation within the unit. The unit should be loaded as quickly as possible.

Heat – solar bagging



This method of heat treatment developed by Dr. Tom Strang at the Canadian Conservation Institute, uses sunlight to produce the temperatures lethal to insects.

http://cool.conservation-us.org/waac/wn/wn23/wn23-2/wn23-207.html
http://www.britishmuseum.org/about_us/skills-sharing/africa_programme/east_africa.aspx

Treatment - Heat

Pros

- Inexpensive and low-tech solutions available
- Easy to conduct
- Effective over a short period of time
- Low equipment maintenance

Cons

- Not all materials may be treated this way

Objects are bagged in black polyethylene sheeting before heat treatment to stabilize the object's moisture content and thus minimize any damage which would otherwise be induced by excessive shrinkage. This bag is placed within a clear plastic enclosure that maximizes interior temperatures, delivers heat to the shade side, and screens out rain and contaminants. The object packets are then exposed to the sun, controlling maximum heat rise by the angle of incidence. Inside the packets, temperatures may rise as much as 40°F to 70° F above the outdoor environment; adult insects, eggs, and the stages in between are killed in a matter of hours, victims of increased rate of dehydration and enzymatic dysfunction. Fans should be added to ensure that the hot air circulates within the chamber. Exposure of 55^{o}C (130^{o}F) for around three hours is sufficient for eradication of all life stages of insects (Strang, 1992).

For many museum pests, the lethal temperature is 37-64 degreesC (99-147 degrees F), depending on length of exposure. http://www.birc.org/MayJune2006.pdf

Heat – Thermo Lignum

Buildings and large installations can also be heat with hot air. Roof timbers and building frames can be raised to over 55°C. However, this can also cause shrinkage and cracking and must be carefully evaluated to see if it is appropriate for the circumstances.

Thermo-Lignum is a patented and refined version of a heat treatment where the humidity is monitored and modified in the special treatment chamber by computer. In both the warming up and cooling down phases of the treatment the relative humidity is controlled in such a way as to ensure that the humidity balance is maintained. As a result no dehydration can occur. The process, in use in Europe is being used on a wide range of materials, artifacts and in-situ timbers such as roof trusses and timbered buildings.

Mark Nicholson & Werner von Rotberg, A paper delivered to the 2nd International Conference on Insect Pests in the Urban Environment, Edinburgh, July 1996
http://cool.conservation-us.org/byauth/nicholson/heatpest.html

Image from http://www.pestheat.com/page/heatingequipment.html and http://www.thermolignum.com/Treatment.html

Treatment - Anoxia

Pros

- Relatively simple and inexpensive
- Appropriate for a wide variety of collection materials
- Oxygen scavengers are not registered pesticides; no licensing is required

Cons

- Requires a relatively long period for treatment (21 days)
- Care must be taken to properly construct and seal the enclosure
- Care must be taken to select the proper oxygen scavenger.
- Not appropriate for use on materials containing Prussian

By depleting atmospheric oxygen to very low levels using reactive oxygen scavengers within an impermeable enclosure, a modified atmosphere composed almost entirely of nitrogen can be created. All developmental stages of insect pests can be eradicated if atmospheric oxygen levels within such an enclosure are maintained below 0.5% for a period of 21 days.

Most collections can be treated in this manner with the notable exception of materials containing Prussian blue dyes or pigments. Prussian blue is highly susceptible to fading and irreversible chemical change when placed in anoxic environments.

General procedures

Construct an enclosure using a low-permeability barrier film such as Marvelseal 360, Aclar, Film-Pak, or Escal. All seams should be heat sealed and checked for leakage. The enclosure should be made large enough to accommodate a 20% reduction in volume of the enclosed air without damaging the object being treated. Care should be taken not to make the enclosure too large, as this may cause an undesired increase in the equilibrium moisture content of the enclosed object during treatment.

Place the object within the barrier film enclosure along with enough oxygen scavenger (Ageless or RP) to deplete the oxygen contained within the enclosure and to account for any additional oxygen which may permeate the enclosure during treatment. It is common practice to double or even triple the calculated amount of oxygen scavenger required to ensure effective treatment. Some practitioners recommend loosely wrapping the object to be treated in either washed muslin or acid-free unbuffered tissue. Some heat is generated as the oxygen scavenger reacts with oxygen, depending on the rate of the reaction. Care must be taken to spread the packets out and not to place them directly on or next to collections items.

Carefully pull air out of the enclosure with a vacuum. Seal the final seam of the enclosure. Check the enclosure periodically for shrinkage during the first few days of treatment. If the enclosure has been constructed and sealed properly, a 20% reduction in the volume of the enclosed air mass should be observable by the third to fifth day. Keep the enclosure sealed for 21 days. After 21 days the enclosure may be opened, and the object can be removed.

Pros and Cons of this treatment

Pros

- Relatively simple and inexpensive
- Appropriate for a wide variety of collection materials
- Oxygen scavengers are not registered pesticides; no licensing is required

Cons

- Requires a relatively long period for treatment
- Care must be taken to properly construct and seal the enclosure
- Care must be taken to select the proper oxygen scavenger. Some oxygen scavengers contain an added desiccant (e.g. RP Type A), which could decrease the equilibrium
- moisture content of objects during treatment
- Not appropriate for use on materials containing Prussian blue pigments or dyes

Supplies needed

Oxygen scavenger such as Ageless or RP Systems.

- Note that while the manufacturer suggests using Ageless Eye as an indicator for oxygen levels, results are variable and it may be more practical to use an excess of scavenger for the recommended 21 days.

Low-permeability barrier film such as Marvelseal 360, Aclar, or Escal.

- There are pros and cons with each of these materials: Marvelseal is not transparent, so the object is not visible within the enclosure, but it is easier to evaluate the quality of the seal. With the transparent films Aclar, and Escal, the object is visible in the enclosure but it is more difficult to evaluate the quality of the seal because pinholes and gaps are not as visible. Finally, it takes longer to create a seal with Marvelseal than with the transparent films. Some users choose to use two barrier films: a clear film such as Aclar or Escal for the front side so that items and monitors inside the enclosure will be visible during treatment, and an aluminum barrier foil such as Marvelseal 360 for the back side.

Calculating the amount of oxygen absorber:

•The numbers assigned to different sizes of Ageless® sachets represent the amount of oxygen they will absorb, NOT the total amount of air to be treated. One sachet of Ageless© Z100 will absorb 100 mL of oxygen (as 20% of the air is oxygen, this is the amount of oxygen contained in 500 mL of air.)

•FORMULA: Volume of bag in centimeters (LxWxH) minus (weight of object in grams) divided by 5 = mL of O2 in bag

• Exercise:

Measure object to determine size of bag

OBJECT: Size: 21x16x6 cm; Weight: 300 g
Bag: 30x30x8 cm= 7200 cm3 volume
Minus 300 g= 6900
Divided by 5=1380 mL oxygen in enclosure.

How many packets of Ageless© Z100 are needed?

In practice, it is common to use at least 30% more Ageless© than is actually needed.

The numbers assigned to different sizes of Ageless® sachets represent the amount of oxygen it will absorb, NOT the total amount of air to be treated. For example: One sachet of Z100 will absorb 100 ml (0.1 litre) of oxygen- as 20% of the air is oxygen, this is the amount of oxygen contained in 500 ml (0.5 litre) of air. .

Handy rule of thumb to use when making an enclosure: it takes about six packets of Ageless© Z-1000 to remove the oxygen from one cubic foot (approximately 28 cubic litres) of air.

(VOLUME OF BAG IN CM (L X W X H) minus WEIGHT OF OBJECT IN Grams MS) / 5 = ML OF OXYGEN IN BAG

Volume of bag in centimeters (LxWxH) minus weight of object in grams, divided by 5 equals mL of O2 in bag.

Volume of bag in centimeters (LxWxH) - weight of object in grams/divided by 5 = mL of O2 in bag .

estimate the total volume of air in your package in ml. and multiply by 20%. Each Z100 packet will absorb the oxygen from 500 ml of air. When using Ageless of anoxic insect treatment or conservation applications, we recommend using at least 30% or more than the amount of Ageless® required to remove the oxygen from a high-barrier container; this will provide long-term anoxic storage conditions

Measure object to determine size of bag

OBJECT: Size: 21x16x6 cm; Weight: 300 g
Bag: 30x30x8 cm= 7200 cm3 volume
Minus 300 g= 6900
Divided by 5=1380 mL oxygen in enclosure.

How many packets of Ageless© Z100 are needed? 1380 divided by 100 – **approximately 14 packets.**

Hanwell ZerO2 / Anoxibug system

Hanwell offers a relatively new out of the box solution called the ZerO2 monitor with different size containers that work with their proprietary scavenger and their oxygen monitor. Continue to add pieces on the base sheet. Leave space for placement of the scavengers so that they do not touch the artifacts. The scavenger comes in a barrier film back (similar to Marvelseal) containing two packs of scavenger each sealed into an inner (chartreuse-colored) bag. Inside each bag is one scavenger pack for each 1 meter cubed of air.

https://www.youtube.com/watch?v=LA-wiLJCtb8
https://www.youtube.com/watch?v=Dz2FFkQH56k

Hanwell ZerO2 / Anoxibug system

- After placing the open scavengers on the base sheet place the cube over the objects. Check that the side with the window remains visible.

- Place the Zero2 monitor in the cube so it can be seen through the window. It may need to be secured to a mount to position it properly and so it does not move while sealing the cube. Place a note with the start date and time in the pocket.

- Seal the edges of the cube to the base sheet using an iron on a hot setting. Leave a small gap allowing the vacuum nozzle to be inserted.

Hanwell ZerO2 / Anoxibug system

Turn on the vacuum to start removing air from the cube.

Start of vacuuming (left)
completed (right)

Remove vacuum nozzle and seal the opening of chamber

Hanwell ZerO2 anoxic system

The oxygen monitor will flash red until oxygen drops below the required level (may take up to 72 hours)

Cube undergoing treatment.

Other controlled atmosphere treatments can be done on a large scale with either fixed wall or flexible bubbles.

Controlled Atmosphere Treatment is sometimes inaccurately referred to as an anoxic or fumigation treatment. Because CO2 is an inert, atmospheric gas the preferred term is Controlled Atmosphere Treatment or CAT. Another associated term is hypercarbia which refers to excessive carbon dioxide as opposed to low oxygen. During the treatment process, carbon dioxide gas (CO2) is used to displace oxygen within a sealed enclosure to a percentage low enough to kill all stages of the insect life-cycle: adults, larvae, pupae and eggs. Oxygen deprivation (anoxia) leads to an increase in mortality rates, but it is desiccation, or dehydration due to increased respiration which specifically accounts for physiological death. Treatment time is typically four-weeks in the 'kill zone' range: 8.2%- 4.8% oxygen, 60% CO2 at 20-29ºC (68-84ºF). Updated methods show that treatment times can be reduced by increasing the initial CO2 to 80% within the first five days. From this point on, 14 days are necessary to kill all species. During this period it is imperative that the CO2 does not fall below 60% and temperatures do not fall below 80º F.

What materials can be treated this way?
This treatment is appropriate for most materials. Foams such as polyurethane and polyethylene have exhibited dimensional changes and distortion following treatment. This is likely caused by changes in atmospheric pressure inside the chamber. Therefore foams should not be treated using this method. Some concerns have been expressed about the formation of carbonic acid- H2CO3 within higher concentrations of CO2, and the potential for damage to sensitive surfaces, including some dyes and pigments. However this is very unlikely since carbonic acid forms in water, not in moist air. Even in water the majority of the carbon dioxide is not converted into carbonic acid and stays as CO2 molecules, as it requires a catalyst to reach equilibrium.

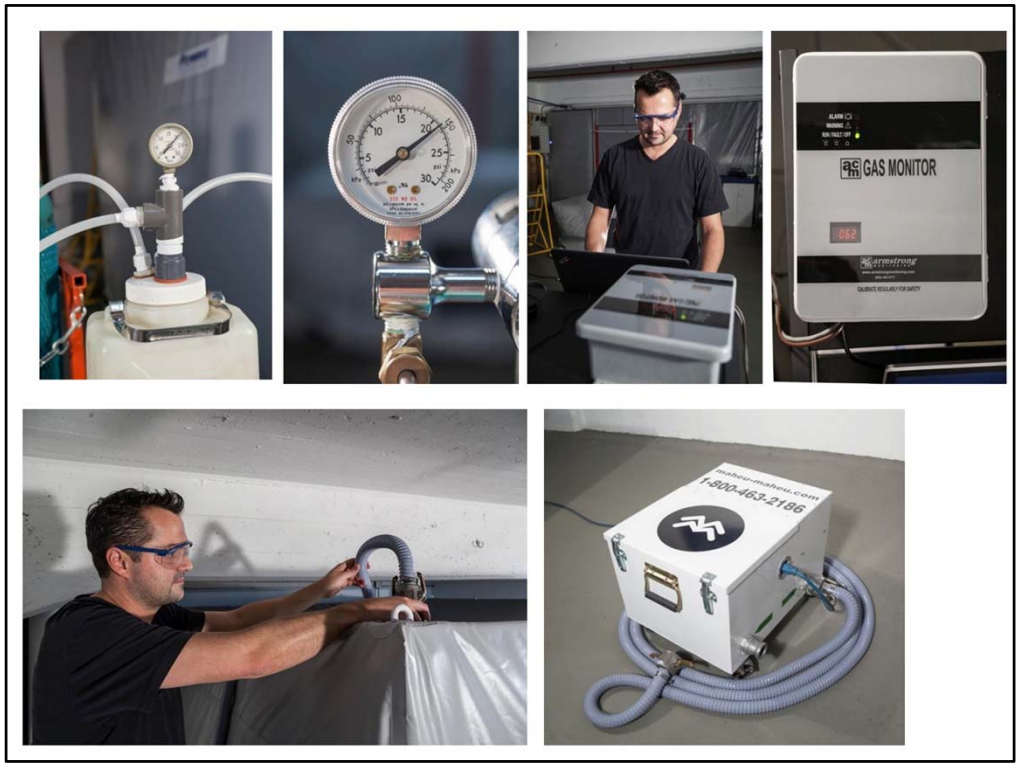
General procedures
Procedures vary depending upon the particular set-up and system. In general, the procedure entails sealing collection objects within a proprietary vapor-proof enclosure. Air is evacuated from the
enclosure with a vacuum system, and then the enclosure is filled with CO2. The pressure of the entering gas is controlled through a series of valves and meters. This process of vacuuming and filling is repeated until the CO2 level stabilizes at 60%. Typically, temperature and relative humidity inside the enclosure are monitored throughout the process. After 3-4 weeks, the CO2 gas is evacuated from the enclosure. (See Case Studies for examples).

Pros and Cons of this treatment

Pros
- Safe for all collection objects
- No 'residual' effects from treatment
- Highly effective at killing all museum pests at all stages of life cycle
- Cost effective once set up is in place
- Once the set up is in place there is no additional material waste
- Various sizes and types of enclosures can be created
- Can be set up in-house

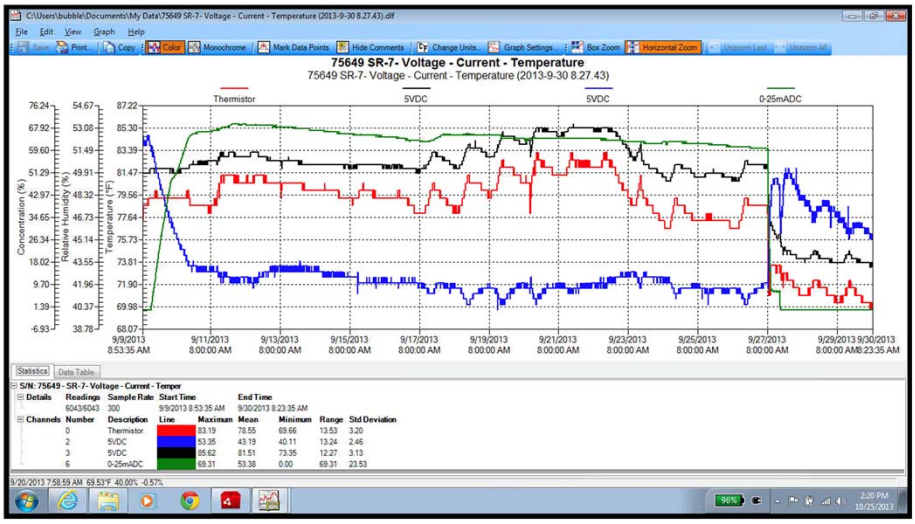
Cons
- Long treatment times required – up to four weeks
- Large, sophisticated systems can be expensive to purchase
- May require a special permit or operator's license, depending upon local regulations
- Requires additional, special equipment to safely operate and monitor – to provide for safe evacuation of CO2 gas
- Although CO2 is an inert gas, it does pose human health hazards
- The treatment must be monitored requiring staff time (e.g. to check for leaks, CO2 levels and equipment malfunctions)

Controlled Atmosphere – CO_2 Gas



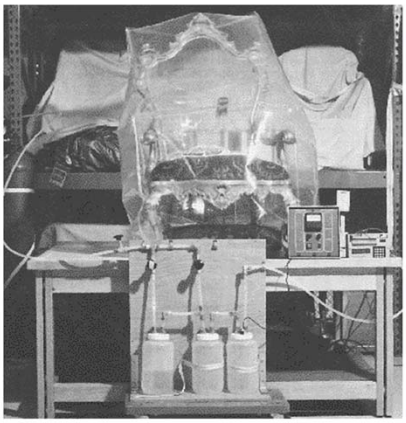
These treatments require a good bit of equipment and monitoring and you need an appropriate setup. So the ZerO2 system can be done by anyone but you need to be serious about doing regular treatments to justify purchasing and installing a system for CO2 or other gasses.

Controlled Atmosphere – CO_2 Gas Monitoring




Nortec
83.9
Actual
TEMP
FAN ON
FAN AUTO
OFF
COOL
HEAT
PSG Medallion
CEA Instruments, Inc.
CEA 066
HISTORIC
NEW ENGLAND

Controlled Atmosphere – Nitrogen & Argon



Nitrogen (N2) and argon (Ar) gas used in controlled atmospheres are effective in causing insect death within 2-6 weeks, as shown by measuring insect respiration before and after treatment providing the oxygen levels are reduced to 0.1-0.3%.The oxygen deprivation causes a disruption in the glucose production within insect bodies, and weight loss resulting in death of the insect. Rates of death vary with temperature, relative humidity, exposure time, and species type. Increasing the temperature helps reduce the exposure time for both gases because insect respiration is increased with higher temperature, causing rapid water loss. (Valentín 1993). Argon is 25-50% faster than nitrogen at killing insects. Additionally, argon kills some fungal tissue while nitrogen permits the same fungi to survive anoxia (Koestler, Tavzes, Pohleven 2004)

Modified atmospheres using nitrogen and argon are usually continuous-flow systems with soft or hard walled, vapor impermeable chambers. The continuous flow of gas initially purges the chamber of oxygen, and then maintains low oxygen levels to compensate for leaks.

What collections materials can be treated this way?
Almost all collections can be treated with nitrogen or argon. Exceptions include:
One study showed that minerals such as litharge (PbO), cinnabar (HgS), and sienna (mostly Fe2O3) do experience color change in the absence of oxygen (Arney, Jacobs, and Newman 1979), so care must be taken if this is a concern with artifacts or pigments. Prussian blue and ultramarine change but the color comes back. Changes are not noted when pigments are in mixtures, e.g., in paint films. Textiles may be the most likely to change (temporarily).

Wet artifacts have the potential to reduce the effectiveness of treatment due to insect adaptation to use anaerobic respiration, although this is generally unlikely for the types of pests typically encountered for museum and library pests (Selwitz 1998).

General procedures
An anoxic atmosphere requires an enclosure, gas, and gas monitoring devices. Uses low-oxygen gas (less then 1000ppm of O2). Enclosures must be constructed of vapor impermeable materials such as steel or aluminized polyethylene and polypropylene films. There are several types of enclosures: hard-wall, soft-wall, and mobile chambers (see below.)
Procedures vary by chamber type, but all include:

- Load the chamber so artifacts cannot crush each other, accidentally shift, or be crushed by the walls of a soft chamber.
- Seal the chamber (heat-seal for soft wall chambers, zipping shut for retrofitted fumigation soft wall chambers, and closing the door on a hard wall chamber ensuring the gasketry is in good alignment and condition).
- Purge ambient air and oxygen from the chamber. Sometimes this is a two-step procedure; first, introduction of nitrogen to push out the oxygen, followed by the secondary anoxia gas like argon or nitrogen. However, in larger chambers, this additional step has not proven to be necessary since many larger chambers have constant positive pressure to maintain low oxygen levels.
- Monitor and maintain constant gas flow for the duration of the treatment, which depends on gas type and species of insect if known.
- Evacuate the anoxic gas from the chamber and returning ambient air, while observing proper safety protocols to maintain safe levels for humans.
- Examine artifacts followed by removal of dead insect debris by low suction HEPA vacuuming or using tweezers.

Pros of this treatment

- No chemical residue on artifacts.
- Appropriate for a wide variety of collection materials.
- Argon gas has the additional benefit of preventing biodeterioration by microorganisms like fungi and bacteria (Valentín 1990).
- More time-efficient than CO2 gas.
- The EPA does not currently list argon and nitrogen as a registered pesticide, so users must research and follow state guidelines for the determinations and requirements for defining what gases are pesticides and if applicator licenses are necessary. This is based on the applicator's residency and the entity that needs to perform the treatment. For the most up to date information, refer to the Federal Insecticide, Fungicide, and Rodenticide Act (FIFRA) on http://www.epa.gov/pesticides/regulating/index.htm

Cons of this treatment

- Generally, treatment with argon or nitrogen gas is more costly than treatment with CO2 gas, depending on regional rates for gas acquisition
- Nitrogen can in some cases contribute to growth of microorganisms with nitrogenase enzymes that help fix nitrogen as a fuel source. More research is needed in this area to clarify this potential issue.

http://cool.conservation-us.org/waac/wn/wn15/wn15-3/wn15-307.html
http://brooklynmuseum.tumblr.com/post/72741097774/pest-management-is-a-typical-activity-of-museum

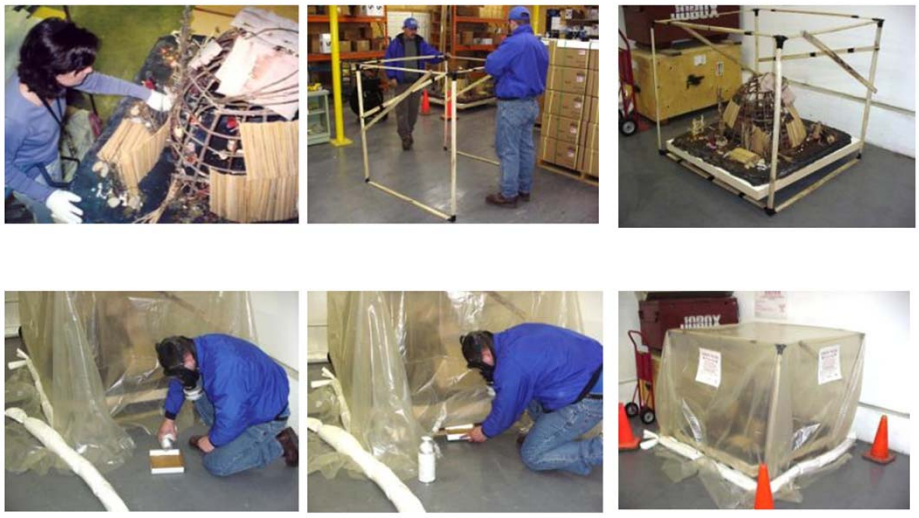
Treatment - Pesticides

Pesticide application: Pesticides have generally been phased out for museum collections as they can damage and contaminate museum objects and can affect the DNA of specimens.

However, when applied by a licensed pest management professional they are sometimes used for room/building level infestations.

There are some materials such as boric acid against silverfish, diatomaceous earth used as a desiccant or drione, a combination of silica gel and pyrethrins, that can be effective if applied safely and properly in conjunction with a professional.

Treatment - Fumigation



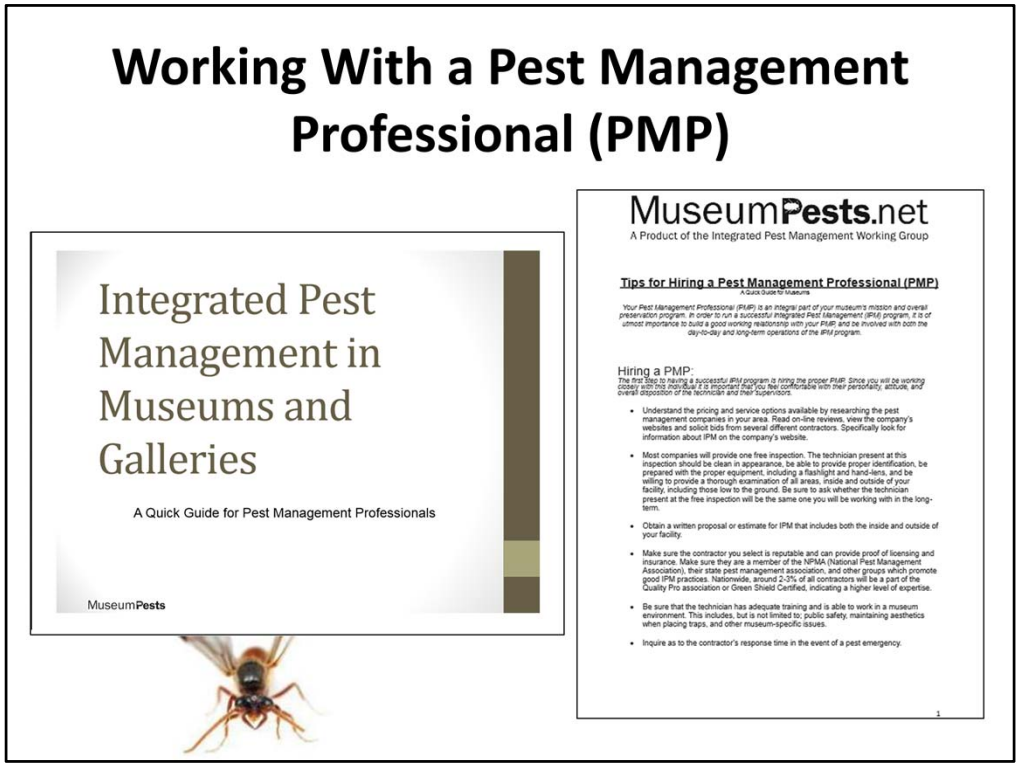
Courtesy Patrick J. Kelley, Insects Limited Inc.

Conventional chemical fumigation: Fumigants are gaseous applications of chemical pesticides – sometimes called fogging. Fumigants may damage and/or contaminate museum objects. On rare occasions, it may be appropriate to fumigate a museum space to ensure pests are removed. Most chemical fumigation requires a licensed pesticide applicator, specialized equipment and proper skills. Vikane (sulfuryl fluoride) is one product used for fumigating structures; however it will not prevent future infestations. Many other fumigants that were used in museum spaces in the past are now prohibited.

Fumigation generally involves:

- Creating a sealed environment
- Releasing the fumigant into the space
- Waiting for the fumigant to disperse through the space and acts on any infestation
- Venting the space to release the gas

Fumigation requires a licensed operator.



While some museums with vulnerable collections choose to do a portion of pest monitoring in-house, most institutions need to be working with a good pest management professional to implement their IPM plan. On the museumpests website we have several resources to help in developing a productive relationship with a PMP. There are a few key things to understand:

1. If the PMP hasn't worked in a collection setting before they may not understand your vulnerabilities and the restrictions involved in working in secure collections areas. It may take some explanation for them to appreciate that working in a museum is different than in a restaurant, office or school.
2. The institution should understand that most standard pest control contracts are for pests like rodents, roaches and ants and so the degree of monitoring for museum pests may be a higher level of service incurring higher fees.

RESOURCES

- Pest management professionals
  - Entomologists
  - Local University / Agricultural Extension
  - Pest Control Operators
- Published literature
  - Museum specific literature
  - Pest management industry books
- Web resources
  - www.museumpests.net
  - www.whatseatingyourcollection.com

CONCLUSIONS

Don’t lose faith

- Implement a yearly building inspection
- Designate one or two weeks out of a year to ensure thorough housekeeping
- Learn your bugs
- Keep records and analyze your data
- Establish action thresholds
- Develop a relationship with a conservator who has experience treating infestations and a pest management professional

ACKNOWLEDGEMENTS

- The members of the Integrated Pest Management Working Group and their institutions
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- Lou Sorkin, AMNH
- Pest images courtesy of Alex Wild www.myrmecos.net

So please add MuseumPests.net to your list of Internet favorites and come back periodically to see what's happening. Anyone who is interested in joining the group is welcome. Just send one of us an email and we'll add your name to the list.

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www.AMArtConservation.com

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Please feel free to contact me with questions.